Multivariate and Multicriteria Evaluation of Labour Market Situation

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Summary

Nowadays the analysts of labour markets have a lot of different data and indicators that can be used for the evaluation of the labour market and monitor its development. But such a great number of monitoring determinants can create problems both with the evaluation and with the description of the situation of the labour market. Thus it is necessary to select a limited number of important indicators. A tool that can help with the selection of these indicators is a method of multidimensional statistics – multivariate analysis. In some cases it is necessary to use only one complex indicator that can evaluate the labour market from a lot of aspects. For a solution we can use multicriteria evaluation. These methods are described in this paper. We recommend a procedure for the in-depth study of the labour market situation.

Keywords: Labour Market, GIS, Factor Analysis, Multicriteria Evaluation

JEL Classification: C, C3, C30

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Introduction

The evaluation of labour market situation is associated with analysis of reasons for existing status, prediction of future development and searching of appropriate tools, which can influence evolution positive way. The labour market is determined by a set of indicators ranging from global to local aspects and covering various economic, demographic, geographical and others factors.

The request of deeper study and associated intended application of economical and administrative tools lead to the demand of utilisation of wider spectrum of indicators, but also deployment of more advanced procedures of their processing e.g. application of multivariate analysis.

Factor analysis belongs to the most frequent used methods of multivariate analysis. It contributes to the identification of synthetic latent factors, on which relationships and behaviour of primary indicators can be studied. Following multidimensional methods of classification provide outputs suitable for regionalisation of territory (typically classification of administrative units), results of which could be applied for tailoring various economical/administrative incentive or prohibitive tools acting in the territory.

Main issue of such method's application is hidden directly in the fundament. They are based on the pure statistical approach to the evaluation, where the situation is evaluated and „weighted" on the base of measured data, calculation of artificial factors or e.g. identification of statistical significant homogenous clusters of municipalities. We are fully dependent on the measured data set used for processing; even a validation of results is applied for the same set of data. Thus the results are fixed with used data. Preprocessing with a new set of data can lead to different results and the robustness of results does not have to be satisfactory.

Although expert opinions are taking into account during the interpretation process of statistical results, still only a relatively small place remains for soft data and experts evaluation. Results can be more or less accepted by decision makers, who frequently are not confident to such artificial factors. They also pointed out issues connected with implementation of complicated sets of thresholds (aiming to for e.g. delimitation of tools acting) to the practice.

Due to these reasons one of the main practical results of multivariate analysis can be a substantial reduction of analysed data space dimensionality and selection of these indicators, which appear to be sufficient for description of labour market situation.

This step may be followed by multicriteria evaluation combining measured data with expert setting of thresholds and limits. The output of multicriteria evaluation may lead to calculation of 1 complex synthetic indicator, which is applicable for simplified evaluation of labour market situation. Such indicator can be perceived as more understandable and acceptable for decision makers.

Methodology

On the base of practical results of labour market analysis provided by a group of economists, geoinformatics and statisticians since 1998 following procedure for deeper study of labour market situation is recommended:

1. collection of wider range of descriptors including commonly used indicators of unemployment status (like rate of unemployment) as well as demographical and geographical indicators.
2. multivariate analysis – after obligatory data modification and testing provide e.g. factor analysis, or cluster analyses for regionalisation of the territory
3. selection of most significant indicators suitable for evaluation of labour market situation (based both on statistical evaluation and expert evaluation)
4. multicriteria evaluation of selected indicators – expert evaluation of weights for indicators (with respect to results of monovariate and multivariate statistical analyses), setting of thresholds or limits for impact levels, and optional synthesis to 1 indicator called e.g. „criticality" or „seriousness".

ad 1. collection of descriptors

First it is necessary to determine wide list of indicators describing the situation. The set of indicators is usually prepared according expert's opinion. In the process the utilisation of effective methodology (e.g. PSR, model developed by OECD, or DPSIR - the causal framework for describing the interactions between society and the environment adopted by the European Environment Agency) and corresponding diagram techniques may eliminate the risk of important factors omission.

The list of indicators can be divided into two categories:

A) short-term indicators

Except of unemployment rate they typically describe the unemployment structure and selected demographical factors. For unemployment structuring the share of endangered groups of people or unemployed is usually used.

Examples:

- share of number of registered unemployed older than 50 year old,
- share of number of registered unemployed with basic education,
- share of number of registered unemployed who are registered longer than 12 month,
- share of number of registered unemployed younger than 24 years (15-24 years)

B) long -term indicators

Long -term indicators describe reasons of existing labour market situation and its evolution. They mainly include demographical, economical and geographical factors.

Examples:

- demographic – share of population 0-14 year old to total number of population
- migration short-term to work – share of new registered working opening to number of economic active population, share of commuting employees
- migration long-term to move – increase of migration population to number of 1000 of population

Traffic accessibility of analysed place expressed by different indicators [5] like:

- sum of road distances to all important employers (all distances shorter than certain distance e.g. 100 km)
- sum of transport costs of public means to all important employers within 100 km
- count of connections provided by public transport to all important employers within 100 km

ad 2. multivariate analysis

Factor analysis usually follows the procedure:

1. selection of factor analysis type: aggregation of variables
2. selection of variables. Check the size of file – the count of records should exceed the number of variables more than 5 times.
3. checking initial assumptions (normality, linearity, homoscedascity, homogeneity). Make necessary transformation.
4. selection of factor method and count of factors

For factor extraction following methods can be applied: principal components, MINRES (Unweighted least squares) and maximum likelihood. We use the method of principal components. Only factors with eigenvalue more than 1 are selected.

5. selection of method for factor rotation and interpretation
   To improve interpretation of results, rotation with varimax method is used. The varimax minimises the number of variables having high absolute values of loads in the factor matrix – Kaiser's rule. Other suitable methods of factor rotation are quartimax or equamax.
6. validation of factor matrix
7. application of factor analysis results

Concerning classification methods, K-Means Cluster Analysis, Hierarchical Cluster Analysis, Q-Factor Analysis and MultiDimensional Scaling [2] are assumed to be favourite methods.

ad 3. selection of most significant indicators

According to the statistical results (e.g. factor loads) significant indicators can be selected. Results have to be examined by specialist for labour market to modify and fulfil the selection with respect to practical knowledge of suitability, validity and accessibility of such indicators.

ad 4. multicriteria evaluation of selected indicators

The simple variant of multicriteria evaluation is weighted linear combination. To each factor a certain weight w_i is assigned and all factors are standardised into the same number range (x_i). The resultant indicator is then usually designated as suitability, in this case more appropriately as "criticality" (C). [2]

$$C = \sum w_i \cdot x_i \qquad (1)$$

C – criticality
w_i – indicator weight
x_i – indicator score

If the final calculated "criticality" is to acquire values moving in the interval [0,1], it is necessary before the performance of multicriteria evaluation to standardise the input values of indicators into the same range of values, i.e. the interval [0,1]. Then the value 0 expresses the lowest rate of criticality, 1 means the highest rate of criticality. Standardisation was carried out according to the following formula:

$$X = \frac{x_{orig} - x_{min}}{x_{max} - x_{min}} \qquad (2)$$

x – standardised value
x_{orig} – initial value
x_{min} – minimum value
x_{max} – maximum value

To determine the weights of indicators Saaty's method of pairwise comparison was selected. [6]

The technique of pairwise comparison developed by Thomas Saathy in the 70's and 80's in connection with the multicriteria decision-making method called the Analytical Hierarchy Process (AHP) represents a theoretically based approach to the calculation of the weights represented by the relative importance of criteria. The weights are not assigned directly, but they represent the most suitable set of weights obtained from the eigenvectors of the square reciprocal matrix used for comparing all possible pairs of criteria.

Thus, when constructing the weights, the matrix of pairwise comparisons is used as a basis. In it, the intensity of the importance of one criterion against the others, or the relations of the importance (weight relations) of the criterion against the other criteria is expressed. For the description of the intensity (i.e. relation) of importance, values moving within the interval from 1 to 9, or 1 to 1/9 must be used.

For the assignation of weights, the following verbal comparative scale serves.

table 1 Determination of weight relations according to Saaty

	Weight of 1st factor
1st factor extremely more important than the second	9
1st factor very strongly more important than the second	7
1st factor strongly more important than the second	5
1st factor moderately more important than the second	3
1st factor as important as the second	1
2nd factor moderately more important than the first	1/3
2nd factor strongly more important than the first	1/5
2nd factor very strongly more important than the first	1/7
2nd factor extremely more important than the first	1/9

Thus if the 1st factor is moderately less important in relation to the 2nd assessed factor, it is assigned the weight of 1/3 and the 2nd factor the weight of 3. Pair weights were written into the matrix.

On the diagonal of the square matrix, the value is 1 (we compare the same factor). The matrix is symmetrical along this diagonal. With the matrix of pair weights constructed like that, the eigenvector of the greatest eigenvalue of this matrix will be calculated and from it, the set of weights will be derived.

1st case study

Analysis of labour market situation in district of Frýdek-Místek was carried out with data from labour offices from the period of 1999-2002 (see table 2).

table 2. Review of available data

MN	rate of unemployment [%]
PZ_U	Proportion of female the total number of job applicants [%]
PC0017_U	Proportion of age group below 17 years old [%]
PZ0017_UZ	Proportion of female age group below 17 years old
PC1824_U	Proportion of age group 18-24 years [%]
PZ1824_UZ	Proportion of female age group 18-24 years [%]
PC5099_U	Proportion of age group 50 and more years [%]
PZ5099_UZ	Proportion of female age group 50 and more years [%]
PCVABC_U	Proportion of job applicants with basic education to the total number of job applicants [%]
PZVABC_UZ	Proportion of female job applicants with basic education [%]
PCVH_U	Proportion of skilled job applicants [%]
PZVH_UZ	Proportion of skilled female job applicants [%]
PCVKLM_U	Proportion of job applicants graduated secondary school [%]
PZVKLM_UZ	Proportion of female job applicants graduated secondary school [%]
PCZPS_U	Proportion of handicapped job applicants [%]
PZZPS_UZ	Proportion of female handicapped job applicants [%]
PCE6_U	Proportion of job applicants registered more than 6 months [%]
PZE6_UZ	Proportion of female job applicants registered more than 6 months [%]
PCE12_U	Proportion of job applicants registered more than 12 months [%]
PZE12_UZ	Proportion of female job applicants registered more than 12 months [%]
PCKZAM9_U	Proportion of applicants requiring unqualified job (labourer) [%]

PZKZAM9_UZ	Proportion of female applicants requiring unqualified job (labourer) [%]
PCABS_U	Proportion of graduated job applicants [%]
PZABS_UZ	Proportion of female graduated job applicants [%]
PCMLA_U	Proportion of young job applicants [%]
PZMLA_UZ	Proportion of young female job applicants [%]
PCABSE6_U	Proportion of graduated job applicants registered more than 6 months [%]
PZABSE6_UZ	Proportion of female graduated job applicants registered more than 6 months [%]
PCMLAE6_U	Proportion of graduated young job applicants registered more than 6 months [%]
PZMLAE6_UZ	Proportion of female graduated young job applicants registered more than 6 months [%]

Data was standardised with Z-score to the normal distribution. The method of principal components was applied for factor extraction. Only factors with eigenvalue more than 1 were selected. The rotation with varimax method and Kaiser's rule were performed to improve interpretation of results.

Rotated Component Matrix[a]

	Component								
	1	2	3	4	5	6	7	8	9
PZVABC_UZ	,889	7,126E-03	-2,76E-02	5,292E-02	4,899E-03	,221	-9,64E-02	-,182	2,526E-02
PCVABC_U	,853	-,107	-1,10E-02	-4,74E-02	1,131E-02	,327	-3,55E-02	9,307E-02	-2,92E-02
PCVKLM_U	-,756	,109	4,226E-02	-3,01E-02	7,739E-02	,533	-5,05E-02	-2,96E-02	6,741E-02
PZVKLM_UZ	-,706	6,673E-02	-9,30E-02	,117	-1,54E-02	,385	,297	,315	,111
PZKZAM9_UZ	,679	,177	-9,10E-02	,213	-,183	-8,79E-02	-9,91E-02	,173	,104
PCKZAM9_U	,623	,134	-,135	,264	-4,31E-02	-7,56E-02	9,376E-02	,399	9,923E-02
MN	,481	-,201	-3,75E-03	2,498E-02	-8,83E-02	-,285	-,117	,419	-,138
PZABS_UZ	7,065E-02	,925	-1,21E-02	2,777E-02	,135	1,315E-02	5,929E-03	,187	-1,93E-02
PZABSE6_UZ	8,983E-02	,908	-1,92E-02	4,339E-02	9,217E-02	-7,88E-03	4,226E-02	,134	-6,12E-02
PCABS_U	-6,04E-02	,854	-9,69E-03	1,645E-02	,317	9,479E-03	-1,77E-02	-,147	1,801E-02
PCABSE6_U	-8,84E-02	,829	2,850E-02	-2,48E-02	,236	,100	-9,63E-02	-,178	-9,58E-02
PZMLA_UZ	-4,58E-02	-3,34E-02	,946	4,872E-05	-5,19E-02	-3,38E-02	1,754E-03	4,722E-02	7,490E-02
PCMLA_U	2,967E-04	5,504E-02	,941	-2,21E-02	3,664E-02	1,540E-02	-4,44E-03	2,403E-02	7,416E-02
PZ0017_UZ	-3,85E-02	-6,51E-02	,936	-3,27E-02	8,688E-03	-3,71E-02	2,314E-02	4,570E-02	6,463E-02
PC0017_U	-4,71E-02	2,424E-02	,932	-5,77E-02	8,299E-02	-4,04E-03	-1,99E-02	4,257E-03	6,231E-02
PZE6_UZ	-5,39E-02	,177	-6,43E-02	,875	2,674E-02	-,155	-1,34E-02	-3,57E-03	,108
PCE12_U	,215	-,157	2,463E-02	,858	2,510E-02	,148	,120	2,133E-02	-,157
PZE12_UZ	,235	-3,83E-02	-,120	,846	5,570E-02	-1,57E-02	7,613E-02	-,182	-4,06E-02
PCE6_U	-,148	2,297E-02	5,013E-02	,809	-,109	-2,09E-02	-,160	,317	-2,18E-02
PC1824_U	-,218	,354	9,271E-03	-5,37E-02	,840	4,945E-02	-,162	-3,42E-02	3,217E-03
PC0024	-,219	,352	,101	-5,18E-02	,836	5,375E-02	-,159	-3,68E-02	1,515E-02
PC5099_U	-,290	-,133	1,851E-02	-,174	-,675	2,823E-02	-8,00E-02	-,208	9,131E-02
PZ1824_UZ	-,150	,501	-3,41E-02	-,122	,572	5,361E-02	-5,20E-02	,306	6,058E-02
PCVH_U	7,242E-02	-5,40E-02	-7,80E-02	7,294E-02	-8,67E-02	-,906	,140	7,000E-02	-2,35E-02
PZVH_UZ	5,178E-03	-1,86E-02	,179	-6,97E-02	8,231E-02	-,922	-,159	2,885E-02	-,123
PZ_U	,360	9,495E-03	6,960E-02	-,128	,142	,520	-,297	,242	5,839E-02
PCZPS_U	-8,36E-02	-5,54E-02	4,883E-02	2,880E-02	-,166	9,580E-02	,873	,176	5,429E-02
PZZPS_UZ	-,165	-4,30E-03	-3,65E-02	-1,92E-02	-1,31E-02	-,190	,849	-,282	8,744E-02
PZ5099_UZ	-7,72E-02	-,107	-,230	-5,05E-02	-,414	-4,24E-02	5,124E-02	-,710	,123
PZMLAE6_UZ	-8,93E-03	-3,23E-02	,145	-5,03E-03	-3,29E-02	2,511E-02	-2,44E-02	-8,74E-02	,834
PCMLAE6_U	2,446E-02	-8,22E-02	9,562E-02	-6,02E-02	-3,50E-03	,145	,146	1,349E-02	,823

a. Rotation converged in 8 iterations.

fig. 1: Rotated matrix of factor loads – SPSS [1]

Finally, 3 factors were identified:

Factor A – the young
Factor B – poor education
Factor C – the long-term unemployed

Next, the closest indicators to represent individual factors were selected - "The proportion of job applicants of the age group 0-24 years to the total number of job applicants" (PC0024_U) for factor A, "The proportion of job applicants with basic education to the total number of job applicants" (PCVABC_U) for factor B and "The proportion of job applicants registered for more than 12 months to the total number of job applicants" (PCE12_U) for factor C.

After expert evaluation, the set of indicators was extended by 2 additional indicators - unemployment rate (UR) and the proportion of job applicants over 50 years to the total number of job applicants (PC5099_U).

On the basis of consultations, lower and upper limits were determined for the indicators that define the interval within which the development of values of individual indicators is probable (common in the given region and time), and that was used for standardisation (see table 3). As the minimum and the maximum value, the upper and the lower limit of indicators were then taken at standardisation.

table 3 Lower and upper limits and indication level of indicators

	UR [%]	PC0024_U [%]	PCVABC_U [%]	PCE12_U [%]	PC5099_U [%]
Lower limit	0	0	0	0	0
Upper limit	40	40	40	60	40
Indication level	20	40	30	50	35

If the indicator value is above the upper limit, we regard the situation to be very critical and the rate of criticality of 1 is assigned to the given record.

On the basis of consultations, for individual indicators the value of indication level was also determined; in case of higher values it is necessary to warn of the situation with the given indicator.

The matrices of the weights of pairs were prepared by experts.

The calculated set of weights was checked by the consistence ratio that was always 0.01 – so that models were considered to be consistent.

Further, the obtained result was consulted with experts and on the basis of this a compromise proposal of the matrix of pairwise comparison was worked out. On the basis of it, relevant weights were calculated.

The final indicator "criticality" A1 can be calculated as follows:

$$\mathbf{A1 = 0.434*UR_S+0.073*\ PC0024\_U_S+0.062*\ PCVABC\_U_S+0.278*\ PCE12\_U_S+0.153*\ PC5099\_U_S} \quad (3)$$

where UR_S is the standardised rate of unemployment,
$PC0024\_U_S$ is the standardised proportion of job applicants under 25 years to the total number of job applicants,
$PCVABC\_U_S$ is the standardised proportion of job applicants with basic education to the total number of job applicants,
$PCE12\_U_S$ is the standardised proportion of job applicants registered for more than 1 year to the total number of job applicants,
$PC5099\_U_S$ is the standardised proportion of job applicants above 50 years to the total number of job applicants.

Further, choropleth maps describing the development of criticality indicator were produced and interpreted for the observed period.

The indicator of criticality A1 at the beginning and at the end of the observed period "copies" roughly the indicator UR. However, in the middle of the observed period it seems that the indicator A1 approximates, as far as its behaviour is concerned, more to the indicator PCE12_U than the indicator UR. [1]

Similar evaluation was done for the whole MSK region.

The achieved "criticality rate A1" in comparison with the rate of unemployment provides an image more smoothed and stable in time, where microregions characterised by a serious situation in the labour market may be delimited more easily. [2]

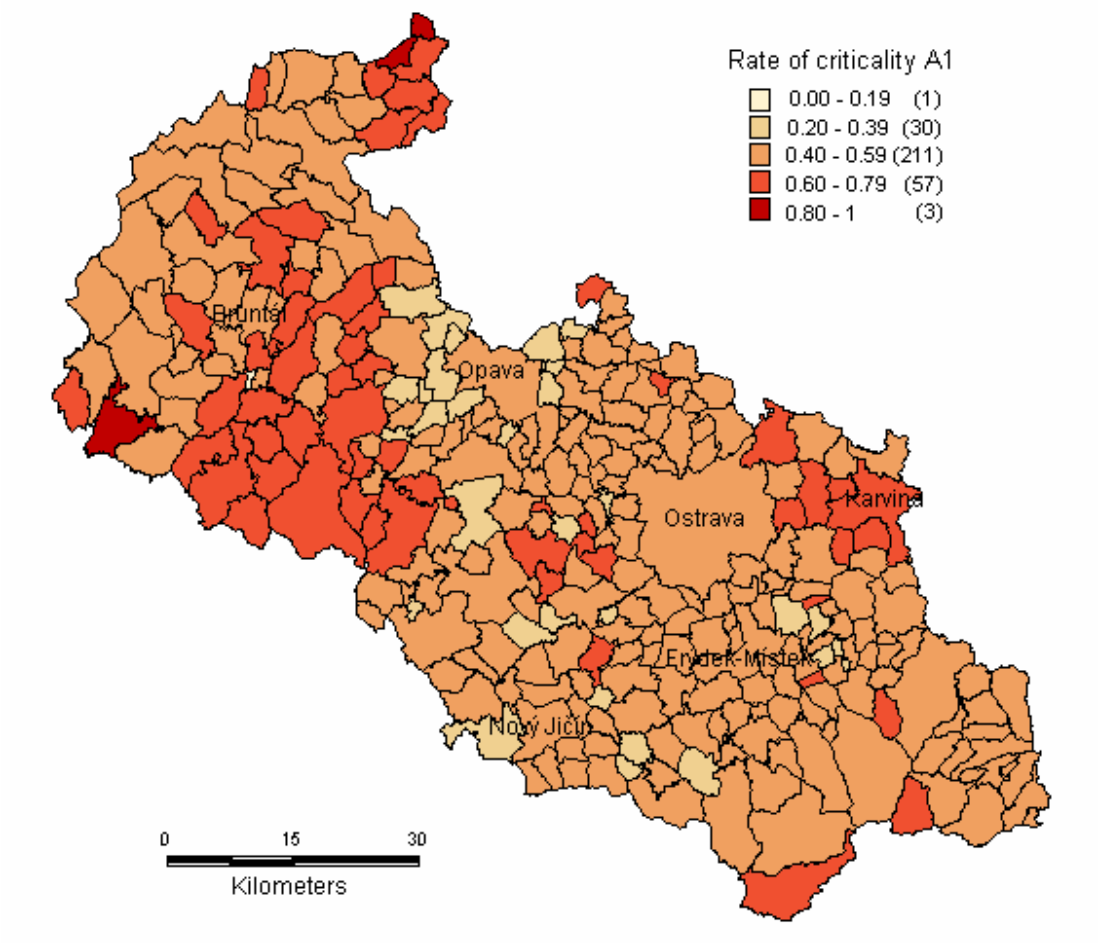

fig. 2 Rate of criticality of labour market situation in North Moravia and Silesia Region

2nd case study

For the 2nd case study, more complex set of descriptors was selected. Data describes the period 1998-2002 for 2 districts of the Czech Republic.

Set of descriptors covers unemployment level, structure, demographical and geographical factors:

- ZPCVABC_U is the standardised proportion of job applicants with basic education to the total number of job applicants,
- ZM is the standardised rate of unemployment,
- ZPCE12_U is the standardised proportion of job applicants registered for more than 1 year to the total number of job applicants,
- ZPPSS is the standardised proportion of natural increment 1998-2002 to medium population,
- ZRPML is the standardised proportion of children (0-14 years) to the total population,
- ZPC5099_U is the standardised proportion of job applicants above 50 years to the total number of job applicants,
- ZMPSS is the standardised proportion of migration increment of population 1998-2002 to the 1000 residents

- ZPC0024_U is the standardised proportion of job applicants under 25 years to the total number of job applicants,
- ZVYJEA is the is the standardised proportion of commuting (driving out for job) residents 1998-2002 to the economic active population
- ZPPMEA is the standardised proportion of new registered job vacancies to the economic active population.

Component Matrix [a]

	Component		
	1	2	3
Zpcvabc_u	.752	.425	
Zmn	.744	.317	
ZVYJEA	-.695		.368
ZRPML	.580	-.346	.384
ZMPSS	-.349		
ZPPMEA		-.632	-.631
Zpc5099_u		.614	-.393
Zpce12_u	.369	.592	
ZPPSS	.529	-.544	
Zpc0024_u	-.520		.584

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

fig. 3 Component matrix

Rotated Component Matrix [a]

	Component		
	1	2	3
Zpcvabc_u	.784		-.336
Zmn	.721		
Zpce12_u	.709		
ZPPSS		.785	
ZRPML		.740	
Zpc5099_u		-.733	
ZMPSS		-.343	
Zpc0024_u			.750
ZVYJEA			.709
ZPPMEA	-.599		-.647

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

fig. 4 Rotated component matrix

Following factors were identified [4]:

F1 - unsatisfied labour close correlated with insufficient education, higher unemployment rate and long-term unemployment. It indicates position one of the most critical group of unemployed people.

F2 – demographical factor, consisting of:

- potential of future labour force
- potential of future labour force of young people
- older applicants
- lost of labour force due to the depopulation of municipalities

F3 – migration to work, covering:

- unutilised young labour force
- dependency of residents to commute to other centres
- potential of labour force in commuting centre.

Results of the factor analysis were used for deeper study of the labour market situation and regionalisation of the territory. The detection of municipalities, which deviate from common situation, is obvious from following figures.

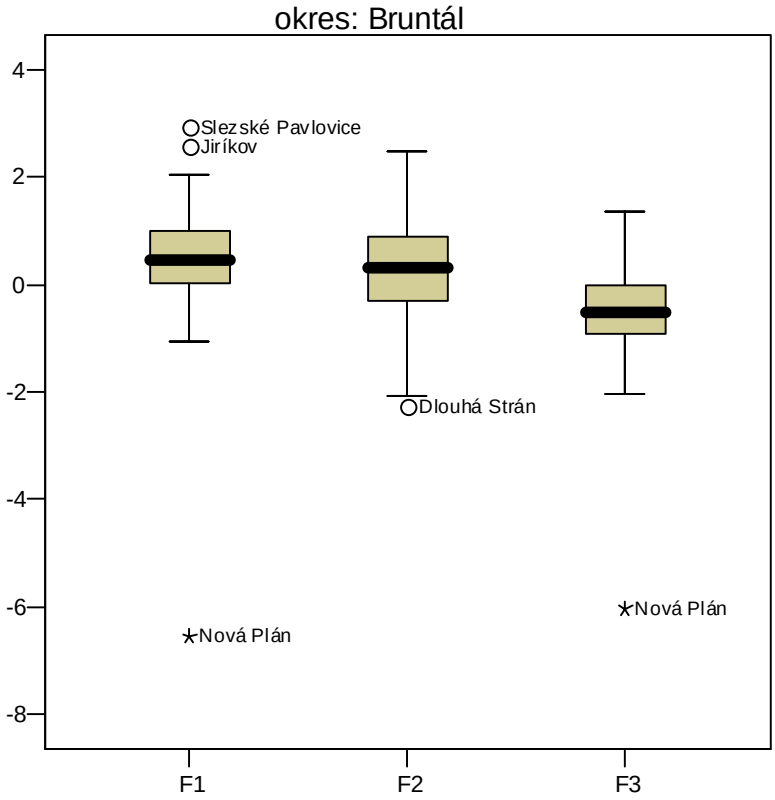

fig. 5 Outliers indicated for each factor [4]

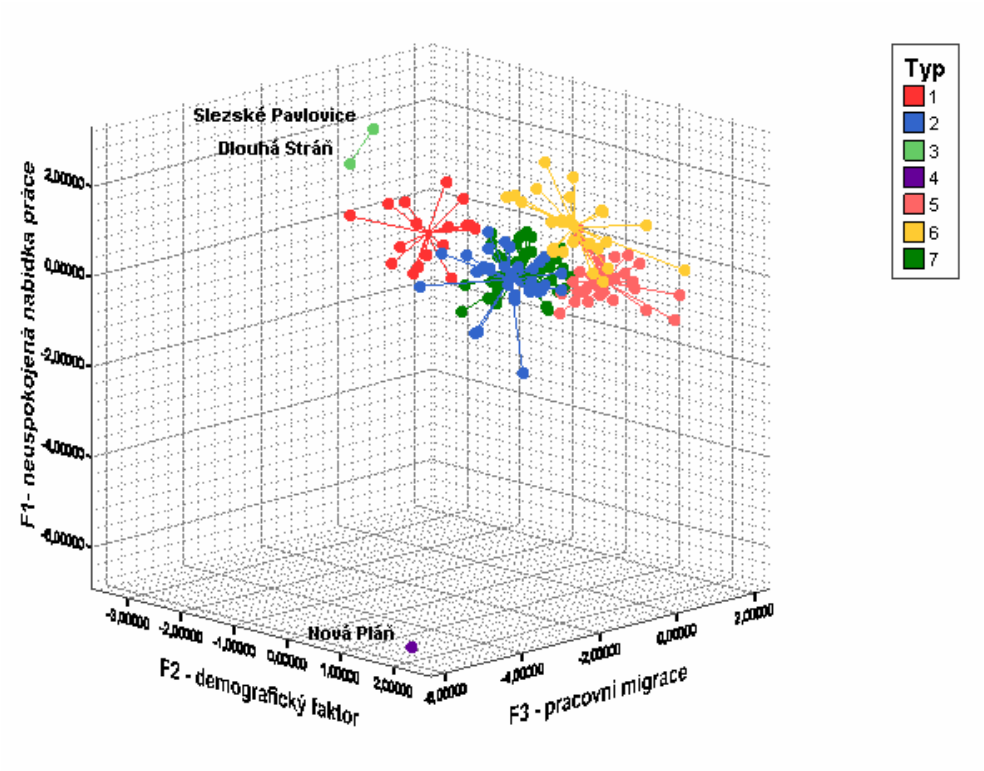

fig. 6 Result of K-means clustering [4]

Conclusion

In the last years, the Central and Eastern European countries have undergone great economical and political changes. In all transformed countries it is labour markets that represent one of serious problems manifesting themselves in an increase in unemployment as a result of changes in the structure of national economies. Primarily an increase in long-term unemployment seems to be alarming. Considerable regional and microregional differences constitute another serious problem of labour markets in individual countries.

In the framework of the examination and assessment of conditions and developments of regional labour markets, a need often appears to describe and evaluate the situation in local labour markets, i.e. to focus attention on the level of municipalities, or small territorial units, so-called microregions. The traditional evaluation of the labour market situation merely on the basis of unemployment rate does not describe well differences between individual regions.

The more comprehensive procedure can follow these steps:

1. collection of wider range of descriptors
2. multivariate analysis
3. selection of most significant indicators suitable for evaluation of labour market situation
4. multicriteria evaluation of selected indicators

Examples of utilisation of such approach are given for North Moravia and Silesia Region, where the situation is studied since 1998 with these tools.

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