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ELECTRE III APPROACH AS A TOOL FOR MIGRATION PROBLEMATIC

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Abstract: *Internal migration is one of the most fundamental responses to different development dynamics of regions. In the most advanced societies, inter-regional migration is an important mechanism through which labor resources are redistributed geographically in response to changing economic and demographic forces. In this paper, we present the possibility for the use of multiple criteria decision aiding (MCDA) techniques, namely, ELECTRE III, as a tool for the problems related to the internal migration issues. To show the effectiveness of MCDA methods in this type of problems we use Serbian districts data, define criteria based on academic literature regarding determinants of internal migrations and develop a ranking of districts according to their migration potential. In that way, we show regions with strong emigration and immigration potential in the next period. Most importantly, ranking procedure will yield districts with the worst potential and show where should be policymakers' focus.*

Keywords: *multiple criteria decision aiding, ELECTRE, internal migrations, SRF method*

1. INTRODUCTION

Economic globalization has contributed to manifold transformations across the globe over the past decades. It has changed the patterns of socio-economic development in many cities and localities and turned these into places of origin or destination of ever more intensive flows of both internal and international migration. This outcome is compounded by the opposite effects of technological development in terms of the increase of distant work, and the increase of labor mobility, including mass migration and brain drain. Lastly, this phenomenon gives rise to the paradox of regionalization within globalization and fourth industrial revolution, characterized by the creation of economically integrated regions.

Regional centers are nowadays seen as the destinations of migration, where job opportunities and social networks tend to concentrate (Fauser, 2015). He states that the same global transformations that have attracted migrants to cities have simultaneously displaced many people from poorer regions. The Rural-urban discourse of migration has been studied extensively among economists. A vast literature in economic development sees internal migration as the central feature of future growth (Chernina et al., 2014). In most advanced societies, interregional migration is a major mechanism through which labor resources are redistributed geographically in response to changing economic and demographic forces (Greenwood, 1997). Chen and Rosenthal (2008) argue that the willingness of households to migrate is a primary driver of regional shifts in the supply of labor and the local level of human capital. Milanovic (2015) claims "migration is one of the most efficient ways of resolving global inequality". It is important to note that only around three per cent of the world's population – about 210 million people – are international migrants (Geddes and Korneev, 2015) and that most migratory flow happens within the country (Bell et al., 2015). Therefore, the effects of internal migration come as a result of labor market polarization and different development dynamics of regions as one of the most fundamental responses to the effects of technological transformations on employment.

Specific reaction of the different local labor markets to technological change has been widely documented. Local labor markets that have more jobs specialized in routine tasks have differentially adopted information technology, reallocated low-skill labor into service occupations, experienced earnings growth at the tails of the distribution, and received inflows of skilled labor (David and Dorn, 2013). Beaudry et al. (2010) show that localities with different levels of educational attainment adjust differently to a technology revolution, with more educated metropolitan areas having adopted new technologies faster, and experiencing a greater increase in the return to skills.

One of the most important issues that largely influences different positions and perspectives of the regional labor markets is technology's potential to substitute work. Academic literature shows that recent technological change has been skill-, routine-, and capital-biased. Digitalization tends to substitute for workers engaged

in routine tasks, which are carried out by following well-defined procedures. On the other side, tasks that require intuition, creativity, complex social interaction and higher levels of perception and manipulation are still difficult to automate. In many advanced economies, significant expansion of employment at both ends of the skill spectrum were registered, at the expense of employment in middle-skill occupations. A surge in low-skill service jobs can be explained by the fact that higher incomes increase the demand for some of the services requiring low-skilled workers, and the manual non-routine tasks that are prevalent in the service occupations are not easily substitutable by computers (David and Dorn, 2013). However, rapid technological advances (artificial intelligence, use of big data, sophisticated algorithms, robotics, etc.) will probably soon make possible to automate an even wider set of manual tasks, which will make low-skilled workers even more vulnerable. The impact of contemporary technological changes on the labor market of a particular region depends on a large number of factors, while among the most important ones are economic structure and qualifications and occupational structure of the labor force. The unfavorable structure can lead to rising regional inequalities, which can reinforce internal migration, and in that way, make these disparities even larger.

The aim of this paper is to investigate the level of internal migration potential in Serbia and determine zones with a potential for large emigration and immigration in the next period. The focus of this research will be Serbian districts (NUTS 3 regional level). Migration potential will be obtained with the help of the ELECTRE III method as we want to define ranking of districts according to the selection of criteria that will represent determinants of migration potential. Earlier efforts to assess potentials and perspectives of regional labor markets in Serbia have been conducted by Arandarenko (2006) and Arandarenko and Jovicic (2007).

The paper reads as follows. Next section will explain methodological concepts of ELECTRE methods, whereas in third section we define main drivers of migration potential and define criteria. Results are presented in the fourth section, while final remarks are provided in the last section.

2. METHODOLOGY

Migration perspectives of the Serbian districts will be observed using ELECTRE III methodology as a convenient setting for the creation of their ranking according to migration potential. We will briefly describe general concepts of ELECTRE methods, starting with notation and afterward develop outranking relation of the method. The problem of the weights' choice for the model is explained in Section 2.2.

2.1. Notation and basic ELECTRE concepts

Consider decision aiding context in which we are facing with following (Greco et al., 2016):

(i) $A = \{a_1, a_2, ..., a_m, ...\}$ – set of potential alternatives defined in the problem,
(ii) $G = \{g_1, g_2, ..., g_n\}$ – coherent family of n pseudo-criteria,
(iii) $w_1, w_2, ..., w_n$ – corresponding weights for each criterion,
(iv) $g_k(a_i)$ – performance of alternative a_i relative to criterion g_k,

Without loss of generality, we can assume that decision maker wants to maximize performance on each criterion. In order to compare two alternatives, ELECTRE methodology introduces *indifference* and *preference* thresholds q_k and p_k for each criterion such that $p_k \geq q_k \geq 0$. These thresholds are introduced to take into account the imperfect character of the data from the computation of the alternative performances $g_k(a_i)$ as well as the arbitrariness that affects the definition of the criteria (Almeida-Dias et al., 2010; Roy et al., 2014). Based on the definition of such thresholds, the ELECTRE methods are handling the following preference situations concerning the comparison of two alternatives (Almeida-Dias et al., 2010; Figueira et al., 2013):

(i) *Indifference* corresponds to a situation where there are clear and positive reasons that justify an equivalence between the two alternatives (it leads to a reflexive and symmetric but not necessarily transitive binary relation). We will claim that there are no significant differences between two alternatives related to criteria k if $|g_k(a) - g_k(a')| \leq q_k$. In such a case we will see these alternatives as indifferent and denote it as aI_ka'. The subset of all criteria for which aI_ka' will be denoted by $C(aIa')$.
(ii) *Strict preference* corresponds to a situation where there are clear and positive reasons in favor of one (identified) of the two actions (it leads to a nonreflexive and asymmetric and usually transitive binary relation). In a modeling sense, we will claim that alternative a is strictly preferred to alternative a' on criterion k if $g_k(a) - g_k(a') > p_k$ and we will denote it as aP_ka' while $C(aPa')$ will be the subset of all criteria for which aP_ka'.

(iii) *Weak preference* corresponds to a situation where there are clear and positive reasons that invalidate strict preference in favor of one (identified) of the two alternatives, but they are insufficient to deduce either the strict preference in favor of the other alternative or indifference between both actions, thereby not allowing either of the two preceding situations to be distinguished as appropriate (it leads to a nonreflexive and asymmetric but not usually transitive binary relation). Formally, this is considered to be true when $q_k < g_k(a) - g_k(a') \leq p_k$ and this difference represents an ambiguity zone. The advantage of a over a' is too large to conclude about an indifference between a and a', but it is not enough to conclude about a strict preference in favor of alternative a. This means that there is a hesitation between indifference and strict preference. We will denote it as aQ_ka' while $C(aQa')$ will be the subset of all criteria for which aQ_ka'.

The aforementioned binary relations can be grouped into one partial outranking relation S_k comprising the three corresponding situations, $S_k = P_k \cup Q_k \cup I_k$ where aS_ka' means that alternative a is *at least as good* as alternative a' on criterion k. What we want to measure is the level of the statement aSa' for the whole set of criteria. Clearly, coalition of criteria for that statement is the union of the subsets already defined, that is, $C(aSa') = C(aIa') \cup C(aQa') \cup C(aPa')$. However, when we want to define an overall measure in order to determine if relation aSa' is valid, we have to take into account even situations where $a'Q_ka$. *The Concordance index* measures the strength of coalition in favor of the assertion $aSa^{'}$. Formally,

$$C(a,a') = \sum_{\{k:g_k \in C(aSa')\}} w_k + \sum_{\{k:g_k \in C(a'Qa)\}} \varphi_k w_k. \tag{1}$$

Function φ_k measures the potential of statement that alternative a is indifferent to alternative a'. This function, therefore, should converge to one, as values of a and a' approach to each other, while it should go to zero as the difference $g_k(a^{'}) - g_k(a)$ approaches p_k. Formally:

$$\varphi_k = \frac{p_k - [g_k(a') - g_k(a)]}{p_k - q_k}. \tag{2}$$

The important feature of the ELECTRE methods is the principle of rejection of hypothesis if a large resistance exists, no matter how large the Concordance index is (Stamenković et al., 2016). When there is such a criterion g_k which strongly opposes to the fact that a is at least as good as a', g_k puts veto to this assertion. This principle is incorporated in the *Discordance index*. It represents the amount of discordance of criterion k on the fact that a is at least as good as $a^{'}$. Of course it should not be neglected even if there is enough evidence in favor of aSa'. Discordance index is defined as

$$d_k(a,a') = \begin{cases} 1, & \text{if } g_k(a') - g_k(a) > v_k \\ \dfrac{[g_k(a') - g_k(a)] - p_k}{v_k - p_k}, & \text{if } p_k < g_k(a') - g_k(a) \leq v_k \\ 0, & \text{if } g_k(a') - g_k(a) \leq p_k \end{cases}.$$

Finally, taking into account both concordance and discordance index we have to incorporate these measures into a final value that will denote final recommendation regarding the relation between each pair of alternatives. We want to derive a measure upon which we can decide whether *a outranks* a' i.e. aSa'. Fuzzy measure obtained through multiple criteria aggregation procedure named *credibility index* takes into account all the concordance and discordance values for each criterion and builds a final measure

$$\sigma(a,a') = C(a,a') \prod_{\{k:d_k(a,a') > C(a,a')\}} \frac{1 - d_k(a,a')}{1 - C(a,a')}. \tag{3}$$

Crisp relation can be easily created using the credibility index values. Let λ denote the threshold credibility level, the minimum degree of credibility, which is considered or judged necessary by the decision maker to validate or not the statement a outranks a'. In other words, we will consider that alternative a outranks alternative a' for credibility level λ if $\sigma(a,a') \geq \lambda$. Also, for the same level λ we can say that a is preferred to a' if $\sigma(a,a') \geq \lambda$ and $\sigma(a',a) < \lambda$ and also we can impose *incomparability* among alternatives if neither $\sigma(a,a') \geq \lambda$ nor $\sigma(a',a) \geq \lambda$ holds. ELECTRE III builds outranking relation upon such crisp relation and creates final ranking based on upward and downward distillation (Roy, 1978).

2.2. The SRF method for weights elicitation

The problem in MCDA methods application related to real-life problems is often elicitation of weights for the defined set of criteria. One of the potential ways for inferring weights is a revised Simos procedure (Simos, 1990) defined in Figueira and Roy (2002) and called SRF. The idea of the procedure is the following. The DM is asked to rank the cards representing criteria from the least important to the most important. Criteria that are considered as equally important are getting the same rank. Moreover, if the DM wishes, he can put one or more blank cards between two successive subsets of criteria. The greater the number of blank cards separating two sets of indifferent criteria, the greater is the difference of importance between these sets of criteria (Corrente et al., 2016). The main distinction from the Simos method is that now DM is asked to state how many times the best criterion is more important than the worst one in the ranking. This value will be denoted by z. Following Corrente et al. (2016), let us denote with $I = \{1,...,m\}$ the set of considered criteria and let L_1 be the set of least important criteria, while L_v is the set of most important criteria, $L_1, L_2, ..., L_v \subseteq I$, $L_i \cap L_j = \emptyset$ for all $i \neq j$, $i, j = 1,..,v$. Assume that the number of blank cards between sets L_k and L_{k+1} is e_k, $k = 1,...,v-1$. Using such information obtained from the DM, a non-normalized weight for each criterion j is obtained as

$$w'_j = 1 + \frac{(z-1)\left[l(j) - 1 + \sum_{s=1}^{l(j)-1} e_s\right]}{v - 1 + \sum_{s=1}^{v-1} e_s}, \tag{4}$$

where $l(j)$ represents the rank of importance to which criterion j belongs. The obtained weights are therefore normalized so that they sum up to 1. For new advances on SRF method see Corrente et al. (2017).

3. CRITERIA FOR SELECTION – DETERMINANTS OF MIGRATION

Academic literature devoted to drivers of migrations is extensive and works in a manifold, sometimes opposing, which is another proof related to the validity of multiple criteria decision aiding approach as we intend to do. MCDA offers a solution to the problem facing opposing criteria that is the case when it comes to internal migrations problem. Theoretical models stem from gravity models based on population size and distance to extended models that include economic and labor market characteristics, and further to the more sophisticated models that encompass individual characteristics that determine propensity to migrate, like age and educational level. Empirical studies are in case of our research even more important as econometric studies defined drivers of migration based on all possible scenarios affecting internal migrations and we can find effects of technological development, economic factors, urban-rural divide or the effects of amenities and housing market.

Beside the, already mentioned, rural-urban aspect of internal migration, an interesting interregional flow of migration concerns interurban internal migration. This aspect is predominantly important in advanced economies, where the share of urban population is already high and there is little scope for further urbanization. Evidence points that there are large disparities in population growth of cities in industrialized countries: while some cities suffer from ongoing population decline, others have experienced increasing numbers of inhabitants (Buch et al., 2014). Growth or decline of cities' populations is mainly driven by migration flows (Buch et al., 2014; Chen and Rosenthal, 2008). The attractiveness of cities and regions from the migration point of view is determined by economic and non-economic factors. Economic factors encompass employment opportunities, regional wage differentials, housing market characteristics, other forms of expected income, etc., while non-economic factors refer mostly to local-specific amenities like climate, natural attractiveness, theaters, universities, accessibility, etc. The same authors find that small cities in Germany are, ceteris paribus, marked by less net in-migration than large cities, which points to specific benefits of living in large cities. It is important that local governance and urban planners distinguish main factors that drive internal migrations, since the ability to attract residents plays a fundamental role for cities' and regional prospects (Rodríguez-Pose and Ketterer, 2012).

As expected, high earnings and vast employment opportunities encourage people to move whereas high prices of houses discourage individuals to move. Academic literature confirms that specific housing conditions (regarding house prices, rents, and home-ownership rates) are known to affect labor market rigidities (Lux and Sunega, 2012). Previous research in the field led to the following selection of criteria that will be used in our study. Such selection will include the importance of all selected determinants of migration such as economic and labor indicators, housing market and amenities or demographic factors that might have a prevalent role.

All the criteria are presented in Table 1. We can see that the economic aspects, maybe the most important ones, are observed through indicators such as average wage, employment, but also with a gross regional product that will count for overall economic activity in the district. Housing is the important part of all the studies regarding internal migration and, therefore, it is observed in our analysis through the level of construction in the district (constructed dwellings per 1000 inhabitants), but in parallel, we will observe the possibility of citizens to acquire these dwellings. This is done by calculating the number of square meters that can be bought by average age in each district. Quality of life within each district is observed by the quality of medical service and, as well, by observing the life expectancy at birth. Urban agglomeration measure is the percentage share of urban population in the district divided by the total urban population in all districts as our proxy to the urban-rural aspect we discussed earlier. Also, index of the modern road surface is measured as the length of modern road surface divided by the total area of the district. The second column in the table describes preference direction for each criterion.

Table 1: Criteria based on determinants of migration

Criterion	Direction
Gross regional product per capita (GRPpc)	[max]
Employment rate (ER)	[max]
Unemployment rate (UR)	[min]
Average wage per employee (AWpE)	[max]
Share of young population (YP)	[min]
Average age (AA)	[max]
Life expectancy at birth (LEaB)	[max]
Urban agglomeration measure (UAM)	[max]
Square meters that can be bought by average wage (SfAW)	[max]
Constructed dwellings per 1000 inhabitants (CD)	[max]
Number of medical doctors per 1000 inhabitants (MD)	[max]
Share of children in pre-primary education, aged 0-3 (CPE)	[max]
Index of modern road surface (IMRS)	[max]

4. RESULTS

Based on the criteria defined in Table 1 we evaluate performance for each district in the Republic of Serbia. All indicators are presented in Table 2. Threshold values are set taking into the account overall situation in Serbian economy and industry. When it comes to weight elicitation we applied SRF method. Average wage per employee is selected as the most important criterion and we set one blank card between average wage and employment rate as the second most important one. This is largely in line with theoretical assumptions - a person, when deciding whether to move (within a country, as we only consider internal migrations) will primarily focus on employment possibilities (which is shown by employment rate), but prospective earnings in the destination region will also have a significant impact on his/her decision. After another blank card we set GRPpc, UAM, and SfAW, and after that follows UR and CD. To conclude, the last level of importance is reserved for the rest of defined criteria. The last part of the selection is in line with the description done in Section 3.

Results of the SRF method and thresholds values are presented in Table 3.

Using all the defined values we can now apply ELECTRE III method and use both distillations to get the final ranking of the Serbian districts according to internal migration potential. The calculation was conducted using open source software for MCDA methods, Diviz. Rankings are defined as presented in Table 4 as well as in Figure 1.

5. DISCUSSION AND CONCLUSION

Large regional disparities in Serbia lead, among other things, to significant internal migration flows. Internal migrations, on the other hand, reinforce existing regional disparities by causing the lack of human capital in the underdeveloped regions, which makes this issue extremely important to policymakers and their efforts to achieve a more balanced regional growth and development. Although net migration rates show previous trends in internal migration flows, it is important to predict the direction of these flows in the near future. The main

Table 2: Table of indicators

	GRPpc	ER	UR	AWpe	YP	AA	LEaB	UAM	SfAW	CD	MD	CPE	IMRS
Belgrade	7844.19	42.70	18.80	55551	16.92	42.10	76.26	31.48	0.41	2.40	3.60	29.42	96.62
Bor	3970.48	37.80	16.90	45581	16.21	45.25	74.88	1.66	0.98	1.20	3.30	18.14	28.36
Braničevo	4031.51	46.40	11.00	43761	17.02	44.69	73.98	1.66	0.61	0.70	2.50	18.00	49.18
Central Banat	4095.35	42.80	14.10	39054	17.39	42.99	73.44	2.22	0.70	0.60	2.20	10.66	26.02
Jablanica	2427.07	45.00	18.90	33502	17.97	43.05	74.82	2.19	0.53	0.60	2.70	9.91	36.44
Kolubara	3805.23	51.50	13.20	39404	16.81	44.14	75.04	1.72	0.54	1.00	2.40	16.87	53.30
Mačva	3042.39	46.30	15.70	36233	17.08	42.93	74.21	2.04	0.55	1.20	2.20	13.01	46.12
Moravica	4097.67	47.70	13.60	38103	16.47	44.09	75.67	2.68	0.54	1.60	2.30	25.70	43.76
Niš	3466.09	38.00	24.70	37993	17.12	43.60	75.80	4.99	0.44	1.80	4.00	16.75	43.36
North Bačka	4241.66	45.60	10.70	39216	17.48	42.66	73.72	2.82	0.77	0.50	2.20	20.41	21.51
North Banat	3564.43	40.50	14.90	38630	17.31	43.29	72.54	2.18	1.23	0.30	2.40	12.73	29.57
Pčinja	2169.64	36.30	15.80	33054	21.71	39.15	74.25	2.14	0.50	1.20	2.70	11.22	29.91
Pirot	4573.39	39.40	20.90	39548	15.91	46.06	76.24	1.35	0.70	0.90	2.90	13.70	24.47
Podunavlje	2088.24	40.70	18.90	39183	17.94	42.72	74.57	2.43	0.60	0.90	2.30	16.06	65.78
Pomoravlje	3264.48	38.30	19.00	34767	16.93	44.53	74.76	2.28	0.52	1.70	3.00	16.43	44.11
Rasina	2756.29	46.70	15.20	35224	16.44	44.47	75.87	2.10	0.51	1.00	2.20	18.18	45.27
Raška	2490.64	40.60	21.60	35103	19.44	39.22	75.46	3.85	0.44	2.10	2.50	15.97	36.12
South Bačka	6111.22	44.50	15.90	47445	18.10	41.04	74.99	10.15	0.47	1.40	3.10	37.63	29.93
South Banat	3888.30	38.40	20.90	45928	17.27	42.61	74.02	3.94	0.67	0.70	2.50	14.03	19.21
Srem	4083.75	40.60	18.30	39195	17.40	42.78	74.66	3.18	0.63	1.10	1.90	20.65	25.43
Šumadija	4450.43	41.00	20.00	39026	17.10	43.16	75.60	4.46	0.43	1.20	3.20	20.48	53.30
Toplica	2688.59	43.50	17.50	33569	17.86	43.64	73.97	1.07	0.83	0.70	2.70	10.96	28.47
West Bačka	3559.20	38.20	20.30	37593	16.78	43.99	73.85	2.36	0.80	0.40	2.20	14.37	25.01
Zaječar	3264.52	36.30	15.50	36716	14.68	47.12	74.31	1.62	0.65	0.80	3.30	22.14	31.18
Zlatibor	3660.73	45.60	15.00	37875	17.31	43.31	76.34	3.43	0.46	1.70	2.50	19.91	41.94

Table 3: Thresholds and weights for each criterion.

	GRPpc	ER	UR	AWpe	YP	AA	LEaB	UAM	SfAW	CD	MD	CPE	IMRS
q	480	2	2	5000	1	2	1	2	0,2	0,4	0,5	4	10
p	1700	5	5	9000	3	4	2,5	4	0,3	1	1	10	15
v	4800	10	10	15000	5	none	none	none	none	none	none	none	none
w	1.67	2.33	1.33	3	1	1	1	1.67	1.67	1.33	1	1	1

Table 4: Final ranks of Serbian regions.

Region	Rank	Region	Rank
Belgrade	1	Podunavlje	11
Bor	5	Pomoravlje	10
Braničevo	3	Rasina	7
Central Banat	8	Raška	13
Jablanica	12	South Bačka	2
Kolubara	2	South Banat	11
Mačva	7	Srem	11
Moravica	4	Šumadija	6
Niš	8	Toplica	11
North Bačka	5	West Bačka	13
North Banat	10	Zaječar	9
Pčinja	14	Zlatibor	5
Pirot	10		

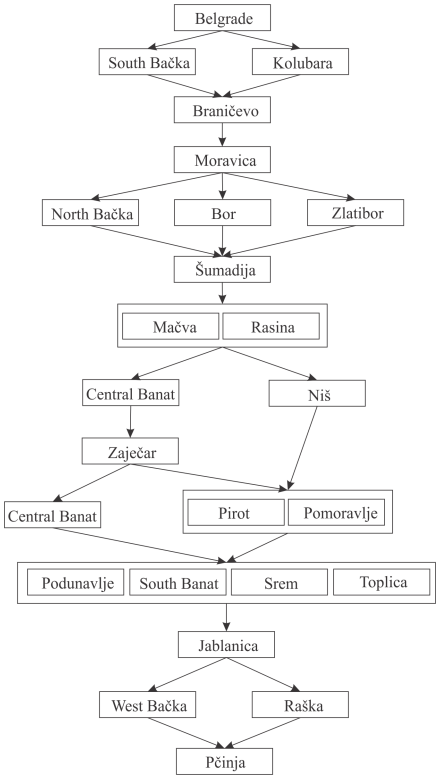

Figure 1 Ranking of Serbian districts.

aim of this paper was to present the potential of MCDA methods and show their effectiveness in this line of research. Using ranking technique, ELECTRE III, we measured the migration potential of each district on the basis of the main internal migrations determinants.

The results clearly indicate that the Belgrade will continue to attract most of the citizens, followed by Novi Sad region (South Bačka district). According to the obtained rankings, Pčinja district has the worst position (14th), while Raška and West Bačka district are in the 13th place. Some of the districts have unexpectedly good rankings (like Kolubara district). This is partly the result of the data on the employment rate, which is calculated according to Labour Force Survey (LFS) and, according to LFS methodology, it encompasses total employment in line with ILO (*International labor organization*) definition. Apart from the persons who have contracted employment and work with enterprises, institutions or other organizations or are active within private unincorporated enterprises, according to this definition, employed persons include several more categories. Included in the statistics are also individual farmers, unpaid family workers/supporting household members, as well as the persons who found and made an agreement (verbally or in written) on casual job conduct without contracting employment, and to whom the subject jobs were the only source of subsistence. Therefore, these data do not relate only to the formal employment status, while it is reasonable to assume that only higher quality jobs have stronger attractive power for potential internal migrants. One of the possible avenues to get more accurate rankings is to include some quality of employment aspects in the analysis. Maybe the most important findings are not the districts with strong immigration potential but the awareness which districts have the largest potential for emigration. These are the regions where there is the biggest expectation of the net outflow of citizens and policy measures need to be directed to those regions as the most critical ones.

Future research within this direction will opt to include other MCDA methods to defined migration potential of districts or even municipalities. Sorting approach might be a good direction for future research as the categories might be defined in line with migration potential showing either immigration or emigration status of districts. Also, additional work on criteria is also needed, and modern approach such as multiple criteria hierarchy process (Corrente et al., 2012) might be the right direction.

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