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MULTI-CRITERIA DECISION MAKING FOR SMART SPECIALISATION IN SERBIA

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Abstract: *Smart Specialization Strategy (S3) is in process of creation in Serbia. S3 methodology is based on rigorous concept for selection of priority sectors in one region or country, relying on high values of location quotient (LQ>1.5) calculated for (at least) single criterion representing available indicators of economic, scientific and innovation performance. In addition to this concept, valuable for identification of limited number of priority sectors, analysis with multiple criteria which allows creation of ranking list of all active sectors in country based on aggregation using Multiple Criteria Decision Making (MCDM) methods is conducted as well. This paper presents both methodological approach and first empirical results of S3 process in Serbia using Compromise Programming as one among numerous quantitative analytical tools of MCDM.*

Keywords: *Smart Specialization Strategy, MCDM, Serbia.*

1. INTRODUCTION

The Government of the Republic of Serbia has created an Interministerial Working Body (IWB) in early 2017 to develop a Research and Innovation Strategy for Smart Specialization (RIS3). The European Commission's Joint Research Centre (JRC) has supported these processes in partnership with the government of Serbia in developing RIS3.

The first action of the IWB was establishment of the Analytical and Operational Team. The most important task of the operational team is to prepare policy activities and to communicate with government institutions, research and innovation stakeholders, private sector, civil society representatives and JRC. The key activities of the analytical team are data collection, quantitative and qualitative analyses necessary for building a strong evidence-base for RIS3. The JRC has engaged Fraunhofer (FhG) ISI Institute from Karlsruhe as an expert support for the analytical team.

The paper presents some of the methodological aspects as well as the first results of realization of the RIS3 in Serbia achieved in 2017.

2. METHODOLOGICAL NOTES

2.1. The S3 methodology

Methodology for creation of smart specialization strategy is well defined procedure published as a guide for experts and practitioners in EU member countries, following the obligatory status of S3 in EU (S3 Platform, 2012). The concept of "smart specialisation" was developed within the EU research and innovation policy framework by the expert group *Knowledge for Growth* (Foray, D., David, P.A. & Hall, B., 2009) and has rapidly been implemented in EU policy. Elaborated by a group of academics in 2008, it very quickly made a significant impact on the policy audience, particularly in EU, as part of the preparation of the new Cohesion Policy for 2014–2020. Smart specialisation strategies should be used in regions to concentrate resources to a few key priority areas and business sectors. They should also be a key element in developing multi-level governance for integrated innovation policies and have to be closely linked with other policy domains and require an understanding of regional strengths relative to other regions and possible gains for inter-regional and transnational cooperation (European Commission, 2010).

To support national and regional actors in the process of developing RIS3, the European Commission has established the S3 Platform in Seville as support for information, seminars, peer reviews and guidelines providing six practical steps for designing national or regional RIS3 (S3 Platform, 2012):

- Step 1 – Analysis of the national or regional context and potential, in relation to other nations and regions;

- Step 2 – Governance: ensuring participation and ownership – set up an inclusive structure and incentives for securing broad stakeholder involvement;
- Step 3 – Vision – produce a shared vision among stakeholders – elaboration of an overall vision for the region;
- Step 4 – Prioritisation – Identification of priorities – selection of a limited number of priorities for regional development;
- Step 5 – Policy mix – Definition of a coherent policy mix, road maps and action plans – combination of a mixture of policy measures and support them with road maps or action plans to secure implementation;
- Step 6 – Evaluation and monitoring – Integration of monitoring and evaluation mechanisms – developing of systems for continuous and evidence-based monitoring of the process and follow up on results and effects, in order to learn and revise the policy mix.

Implementation of the RIS3 concept in Serbia in year 2017, among organisational issues, practically was realisation of the Step 1 – quantitative analysis of all available statistical data in order to identified priority sectors in economy of Serbia. JRC and FhG experts have developed more instrumentalised procedures for analysis of economic, scientific, and innovative potentials of four out of five statistical regions in Serbia:

- Region RS11: Belgrade
- Region RS12: Vojvodina
- Region RS21: Šumadija and Western Serbia
- Region RS22: Southern and Eastern Serbia
- Region RS23: Kosovo – data are not available.

Detailed roadmap for pursuing smart specialisation in 2017-2018 was adopted jointly by IWB and JRC with five major phases which are above mentioned steps re-arranged for implementation in Serbia (JRC and IWB, 2017):

1. Preparatory stage: preparing organisational resources necessary for effective cooperation.
2. Mapping economic, innovative and scientific potential: multi-dimensional quantitative analysis showing strongest sectors and areas of science at regional level.
3. Entrepreneurial discovery process: qualitative analysis and organized dialogue with business sector, representatives of the research community and public authorities – organized separately for each of the smart specialisation areas.
4. Establish monitoring and evaluation system: a system of input, output, context and result indicators (monitoring) and ex-post impact assessment (evaluation) that will be used to assess progress and results of the implementation of the RIS3; this must be based on a clear intervention logic stemming from the strategy.
5. Develop an implementation system: definition of organizational structure able to deliver the implementation of S3 strategy and sound financing system to enable the implementation.

The second phase which is realisation of the step 1 in original guide has become key activity of the analytical team, JRC and FhG experts. For the purpose of mapping, external experts have defined three sets of indicators and procedures for quantitative analysis. Three sets of indicators are data with detailed subdivision by economic/scientific field of activity, for most indicators according to NACE 3-digit categories (NACE is the acronym for "Nomenclature statistique des activités économiques dans la Communauté européenne"; EC, 2009), for scientific activity according to Web of Science/Frascati classifications (Kroll at all, 2017):

1. Economic Potential
    - employment, according to 2011-2016 labour force survey data
    - exports, according to 2012-2016 national export statistics.
2. Innovative Potential
    - innovating firms, according to the 2010-2014 national innovation survey
    - patents, according to indicators developed by the Mihajlo Pupin Institute, based on data provided by the Intellectual Property Office.
3. Scientific Potential
    - publications, according to indicators developed by the Faculty of Physics and Mihajlo Pupin Institute based on data collected by the Faculty of Physics

Priority sectors in one region are identified according to their *specialisation proper*, i.e. an in relative terms higher importance of the sector in the regional economy than is standard for the economy. Typical measure to determine this specialisation in literature is the *Location Quotient* (*LQ*) that contrasts the share of a sector in the local economy with the share of a sector in the national economy. It can reveal what makes a

particular region “unique” in comparison to the national average. Example of calculation of *LQ* is given in formula 1 for economic indicator of employment:

$$LQ = \frac{\frac{e_{NACE\ X}}{e_{total}}}{\frac{E_{NACE\ X}}{E_{total}}} \quad (1)$$

$e_{NACE\ X}$ = (sectoral) employment in particular region
e_{total} – total employment in particular region
$E_{NACE\ X}$ = (sectoral) employment in the country
E_{total} – total employment in the country

Following the notion of identifying potential priority domains for smart specialisation by focusing on those in which a region is specialised, included are only NACE sectors with a location quotient of more than 1.5 i.e. the ones that hold at least 1.5 times of the share in the regional economy than in the national economy.

Statistical Office of the Republic of Serbia provided data for all requested indicators of economic and innovative potentials which indicate a high level of compliance with international standards. Nevertheless, calculation of the *Location Quotient* for four statistical regions with condition $LQ \geq 1.5$ have produced only few priority sectors performing at least 1.5 times the share in a regional economy than they do in the national economy but only for one or, and in very rear situations, for two indicators out of set of 6 indicators in all three predefined potentials (economic, innovative, scientific). Although situation with small number of identified priority sectors makes process of decision making rather simplified, use of single criterion – one indicator instead of all six indicators – criteria provide rationale for extension of basic S3 approach with implementation of multiple criteria aggregation in mapping exercise.

2.2. The MCDM for S3 methodology

Since decision-making problem involves greater number of criteria that must be respected, it is necessary to use multi-criteria decision-making methods. According to its characteristics, decision-making belongs to multi-criteria decision making that is used in circumstances where there are greater numbers of criteria, in order to get an optimal solution. Multi-criteria analysis will not get the best solution since the ideal solution to the problem of multi-criteria decision making does not exist. It focuses on the so-called "compromise" solutions, which take into account the preferences of all decision-makers, making concessions between the criteria.

MCDM methods are frequently used to solve real-world problems with multiple, conflicting, and incommensurate criteria. Each method provides a different approach for selecting the best among several preselected alternatives (Janic and Reggiani, 2002).

MCDM has grown as a part of operations research, concerned with designing computational and mathematical tools for supporting the subjective evaluation of performance criteria by decision-makers (Zavadskas, Turskis, & Kildienė, 2014). In the decision making approach, the selection is made from amongst the decision alternatives that are described by their attributes. Over time, a large number of MCDM techniques and approaches have been proposed, which are different in their theoretical background and the type of obtained results.

Introducing multiple criteria analysis as extension of the basic S3 quantitative analysis, the Ideal Point Method (IPM) Compromise Programming is applied (Zeleny, 1976). In the following model, preferences are fully cardinal in character, though in a fuzzy and adaptive way. The model is based on the ideal alternative, providing the highest score with respect to all individual attributes considered. Adaptive information gathering and an evaluation process are thus initiated. Partial decisions are made, inferior alternatives removed and post-decision dissonance reduction ensues. We allow for a re-adjustment of attribute weights, displacement of the ideal and new pre-decision conflict formation. Such man-machine interactive procedure leads to a decision in a finite number of iterations.

The model is implemented as follows: a set *A* of *n* objects is compared with respect to *m* criteria. All objects are compared with an object that has ideal values for all *m* criteria, a so-called ideal (a reference object). A point in *m*-dimensional space represents each object from the set *A*. The point representing the ideal object is referred to as the ideal point. The distance *d* (usually geometrical, as recommended by the author) of each point from the ideal one is calculated (see formula 2). The object that is the nearest to the ideal, i.e., that whose distance from ideal point is the shortest, is the best object. Calculated distances may be

corrected by specifying different weights of criteria. The calculated distance could be used for forming a ranking list of objects.

In this method, single indicators (economic, innovation, etc.) for sectors in observed regions are analysed in a coordinate system which axes are just these indicators. The values of a single indicator for sector are the coordinates of the observed sector in the space of available indicators.

The ideal point in this coordinate system is a sector with specially defined values of a single indicator, so it can be referred to as an '*ideal sector'*, or, more appropriate for this analysis, a '*reference sector'*. The value of a single indicator for a reference sector may be defined in several ways, for example: (a) an unachievable, practically unrealisable value, (b) an imagined target value that is hard to realize, (c) a desired, realizable value for a particular indicator, etc.

$$d_i = \sqrt[1/L_p]{\sum_j k_j \times \left(\frac{IC_j - C_{ij}}{(C_{ij})_{max}} \right)^{L_p}} \quad ; \quad j = 1,..., m \; ; \quad i = 1,..., n \tag{2}$$

where: ***ICj*** - a ***j***-th single indicator for '*reference sector'*, ***Cij*** - a ***j***-th single indicator of an ***i***-th observed sector, k_j - a weighting factor of a ***j***-th single indicator; ***m***– number of single indicators; ***n*** – number of observed sectors; ***Lp*** - used metrics, d_i – calculated distance for ***i***-th sector from *reference sector*. For the case *Lp*=2, the formula becomes a calculation of *Euclidean distance* between the observed and '*reference sector*', and this case is used by analytical team. It is important to note that weighting factors (*k*) are not under the *Lp*-degree (*Lp*=2). This is to avoid dependence of the aggregate distance on the number of indicators.

3. PRELIMINARY RESULTS

Selection of priority sectors using *Location Quotient* for four statistical regions with condition $LQ \geq 1.5$ have produced the following priorities (Kroll at all, 2017):

- Region RS11: Belgrade
  - Computer Programming and ICT
  - R&D and Technical Consultancy
  - Creative Economy
  - Monetary Intermediation
  - Potentially emerging innovative sectors: Beverages, Pharmaceuticals, Electrical Components, Transport Equipment
  - Science based sectors: various

- Region RS12: Vojvodina
  - Automotive
  - Agricultural Economy (including processing industries)
  - Petrochemical Industry
  - Plastics Industry
  - Potentially emerging innovative sectors: Agricultural Machinery, Measurement Instruments
  - Science based sectors: Computer Science, Telecommunications

- Region RS21: Šumadija and Western Serbia
  - Agri-/Horti-/Silvicultural Economy (including processing industries)
  - Automotive
  - Textile Industry
  - Plastics Industry
  - Metal Industry
  - Potentially emerging innovative sectors: Special Purpose Machinery
  - Science based sectors: mechanical engineering, pharmacy

- Region RS22: Southern and Eastern Serbia
  - Agri-/Horticultural Economy (including processing industries)
  - Textile Industry
  - Rubber Industry

- Electrical Engineering
- Potentially emerging innovative sectors: Food Products, Medical and Dental
- Science based sectors: electrical engineering

In addition to above listed priority NACE sectors, use of Compromise Programming have produced five ranking lists of sectors: four ranking lists for regions and fifth ranking list for Serbia (Tables 1, 2, 3, 4 and 5; data for year 2016, excerption – only first ten NACE sectors-groups are listed).

Table 1: Ranking list of NACE sectors-groups in Serbia total – excerption, year 2016

Rank	NACE Sectors – Groups
1.	J62.0 - Computer programming
2.	M73.1 - Advertising
3.	M71.1 - Architectural and engineering activities
4.	A1.1 - Growing of non-perennial crops
5.	G46.9 - Non-spec. wholesale trade
6.	M71.2 - Technical testing and analysis
7.	C28.2 - Manufacture of other general-purpose machinery
8.	C26.5 - Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks
9.	C10.8 - Manufacture of other food products
10.	M72.1 - R & D - Natural Science

Source: Analytical team, internal working documents, 2017

Ranking list of NACE groups in Serbia based on aggregation (Table 1) shows that the first three positions have the following groups: J62.0 - Computer programming, M73.1 – Advertising and M71.1 - Architectural and engineering activities. Among 10 top-ranked NACE groups the following sectors are prevailing: J - Information and communication (1 group identified ranked as the 1st), M - Professional, scientific and technical activities (4 groups, ranked as the 2nd, 3rd, 6th and 10th), A - Agriculture, forestry and fishing (1 group, ranked as the 4th), G - Wholesale and retail trade; repair of motor vehicles and motorcycles (1 group, the 5th position) and C – Manufacturing (3 groups ranked as the 7th, 8th and 9th).

Table 2: Ranking list of NACE sectors-groups in Region RS11: Belgrade – excerption, year 2016

Rank	NACE Sectors – Groups
1.	C26.3 - Manufacture of communication equipment
2.	J58.1 - Publishing of books etc.
3.	C26.2 - Manufacture of computers and peripheral equipment
4.	C27.4 - Manufacture of electric lighting equipment
5.	D35.1 - Electric power generation, transmission and distribution
6.	C20.2 - Manufacture of pesticides and other agrochemical products
7.	C20.4 - Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
8.	J62.0 - Computer programming
9.	C26.5 - Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks
10.	C28.2 - Manufacture of other general-purpose machinery

Source: Analytical team, internal working documents, 2017

In Belgrade region, ranking list of NACE groups based on aggregation indicates that dominant groups are from manufacturing sector (C) and information and communication (J). These results can be considered as partially in line with identified priority sectors using Location Quotient , since NACE groups identified according to Compromise Programming method are also included in two priorities identified using LQ: Computer Programming and ICT and Potentially emerging innovative sectors: Beverages, Pharmaceuticals, Electrical Components, Transport Equipment.

Table 3: Ranking list of NACE sectors-groups in Region RS12: Vojvodina – excerption, year 2016

Rank	NACE Sectors – Groups
1.	C28.1 - Manufacture of general-purpose machinery
2.	C28.3 - Manufacture of agricultural and forestry machinery
3.	C22.2 - Manufacture of plastics products
4.	C25.2 - Manufacture of tanks, reservoirs and containers of metal
5.	C10.4 - Manufacture of vegetable and animal oils and fats
6.	C10.9 - Manufacture of prepared animal feeds
7.	C15.1 - Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harness; dressing and dyeing of fur
8.	C32.9 - Manufacturing n.e.c.
9.	C23.1 - Manufacture of glass and glass products
10.	C30.9 - Manufacture of transport equipment n.e.c.

Source: Analytical team, internal working documents, 2017

According to the rank list of NACE groups, Region of Vojvodina is characterised with dominant presence of groups exclusively from the manufacturing section. Manufacturing section is also dominant in identified priority sectors using LQ, but they also include Science based sectors: Computer Science, Telecommunications.

Table 4: Ranking list of NACE sectors-groups in Region RS21: Šumadija and Western Serbia – excerption, year 2016

Rank	NACE Sectors – Groups
1.	C20.5 - Manufacture of other chemical products
2.	C25.4 - Manufacture of weapons and ammunition
3.	C26.1 - Manufacture of electronic components and boards
4.	C27.3 - Manufacture of wiring and wiring devices
5.	C28.9 - Manufacture of other special-purpose machinery
6.	C10.5 - Manufacture of dairy products
7.	C25.9 - Manufacture of other fabricated metal products
8.	E38.1 - Waste collection
9.	C14.1 - Manufacture of wearing apparel, except fur apparel
10.	C20.3 - Manufacture of paints, varnishes and similar coatings, printing ink and mastics

Source: Analytical team, internal working documents, 2017

Table 5: Ranking list of NACE sectors-groups in Region RS22: Southern and Eastern Serbia – excerption, year 2016

Rank	NACE Sectors – Groups
1.	C12.0 - Manufacture of tobacco products
2.	C13.2 - Weaving of textiles
3.	C15.2 - Manufacture of footwear
4.	C26.7 - Manufacture of optical instruments and photographic equipment
5.	M75.0 - Veterinary activities
6.	C23.3 - Manufacture of clay building materials
7.	C29.3 - Manufacture of parts and accessories for motor vehicles
8.	J58.2 - Software publishing
9.	C27.3 - Manufacture of wiring and wiring devices
10.	C21.1 - Manufacture of basic pharmaceutical products

Source: Analytical team, internal working documents, 2017

In terms of comparing Compromise Programming method results and priority sectors using LQ, similar conclusions can be made for region of Šumadija and Western Serbia and region of Southern and Eastern Serbia. Namely, ranks of NACE groups in these two regions show dominant presence of manufacturing section, while priority sectors identified using LQ include also other economic sectors: Agri-/Horti-/Silvicultural Economy; Science based sectors: mechanical engineering, pharmacy; Electrical engineering.

4. CONCLUDING REMARKS

Realisation of smart specialisation strategy for the Republic of Serbia is in the second year of activities, but only with completed either first step out of six steps proposed by the S3 Guide, or second phase out of five proposed by the roadmap for Serbia. Third phase is crucial for success of the S3 process; third phase is so called *Entrepreneurial discovery process* (EDP), or dialogue between all stakeholders and qualitative analysis of proposed priority NACE sectors-groups and ranking lists of NACE sectors in regions and for Serbia in total. Dialogue between business sector, research community and public authorities should be organised under the situation of well-structured and fact based decision making process were the "wishes" must be faced with reality presented in figures and facts. The smart specialisation is, in fact, development of sectors of economy based on knowledge, i.e. new industrial policy relying on integration of R&D and innovation with business (European Commission, 2017). Therefore, only NACE sectors already integrated with adequate R&D community which is big and competitive enough to solve all development challenges, could be selected as priority sectors of economy in final S3 document.

Results of applying Compromise Programming method on NACE groups of Serbian economy in 2016 have shown that the first three positions have the following groups: J62.0 - Computer programming, M73.1 – Advertising and M71.1 - Architectural and engineering activities. Among 10 top-ranked NACE groups the following sectors are prevailing: J - Information and communication (1 group identified ranked as the 1st), M - Professional, scientific and technical activities (4 groups, ranked as the 2nd, 3rd, 6th and 10th), A - Agriculture, forestry and fishing (1 group, ranked as the 4th), G - Wholesale and retail trade; repair of motor vehicles and motorcycles (1 group, the 5th position) and C – Manufacturing (3 groups ranked as the 7th, 8th and 9th).

Extension of the single-criterion based selection of NACE sectors (basic S3 process) with ranking list of all NACE sectors-groups created with all available criteria (Compromise Programming aggregation and ranking) which presents economic, scientific and innovative potentials, should be a basis for meaningful EDP dialogue.

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