Assessment of regional development strategy in the context of economy digitization on the basis of fuzzy set method

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Abstract. At the present day the issues of creation and implementation of strategies for the social-economical development of the regions under conditions of digitization are not practically developed, and there is no offers for evaluation formalization of strategic targets achievement, which could be used in the future for automation of strategic management of regions. Proposed in this work is an approach to solution of these two tasks with the use of modern tools including adaptation of the balanced system of indexes (BSI) for regional development: increase of innovative activity and human capital quality, creation of efficient social-economical system of territories development, arrangement of conditions for creation and development of innovative digital economy. Formalization of strategic targets evaluation was carried out with the use of a fuzzy set method. The Extreme North region — the Yamalo-Nenets Autonomous District (YNAD) — appears for the research object.

1. Introduction

This work is concerned with formalization of the Extreme North regions development strategy on the basis of a fuzzy set method [1]. The concept of regional indicators (CRI) [2] is a methodological base of development strategy creation in this research. The use of fuzzy set models and obtaining the aggregated evaluations on the basis of the existing indicators set, which differ in properties and units of measurement, makes it possible to simplify the analysis procedure and to classify the research objects by a complex of significant parameters and to compare them with the specified accuracy degree [3]. Besides, the fuzzy logic allows for complete application of the knowledge of experts by representation of their evaluation in the form of a structured text which can be formalized in the future. In the course of previous investigations the analysis was performed of the aggregated indicators evaluating each component of the Yamalo-Nenets Autonomous District development strategy (YNAD) by targets and selected indicators [4]. Proposed in this research is formation and calculation of the integral index of strategy evaluation. The main purpose of the YNAD strategy is increase in the innovative activity of the regional enterprises and development of the human potential, which, in its turn, leads to creation of conditions for appearance and development of innovative digital economy and creation of efficient social-economical system of the YNAD territories development. It is proposed to use 'Level of achievement of strategic regional targets' index as an integral index. The RF Extreme North regions appear as the research object. The peculiarity of these territories is a low level of social development, but hereby an extreme degree of mineral resources availability.

Thus, the purpose of this research is development and practical use of the region development strategy evaluation under conditions of economy digitization on the basis of a fuzzy set method.

2. Literature review

At the present time, one of the topical questions concerning the social-economical development of the Russian regions is creation of a development strategy with account of the economy digitization. Described in the 'Digital dividends' report are the leads the digital technologies establish for the economy [5]. At the present time, many investigations are aimed at answering a number of questions concerning the digital economy for solution of regional tasks, namely, what project can be the drivers for digital transformation of regional industry, what is a connection between the digital transformation of industry and digital economy and other branches of economy [6]. The issues concerning optimization of resources application in the digital economy are being considered [7]. The attempts to distinguish the digital economy implementation criteria are being made [8].

Some part of studies is dedicated to investigation of the RF Arctic regions digitization [9]. In particular, the forecasts of IT implementation in the production processes of the Arctic area corporate structures are being made, which shall contribute in the increase of efficient work of the Arctic economy base sector.

However, at the present day the issues of creation and implementation of strategies for the social-economical development of the regions under conditions of digitization are not practically developed, and there is no offers for evaluation formalization of strategic targets achievement, which could be used in the future for automation of strategic management of regions. Proposed in this work is an approach to solution of these two tasks with the use of modern tools including adaptation of BSI [10] for regional development, as well as the fuzzy set method of formalization of strategic targets evaluation. The fuzzy set theory was proposed in the classical work of L. Zade [2]. This approach is widely used at the present time for solution of tasks concerning evaluation of different social and economic indexes [3, 11, 12].

3. Method

The systematic, comparative and content analysis belonging to the category of qualitative methods can be specified as a method to be used to achieve the goal of the present research. The methodological base for the calculations performed in the article is methods of statistical information acquisition and processing, expert procedures, fuzzy logics for evaluation of aggregated indexes of the strategy components, as well as a concept of the regional indicators complex (CRI) for development of strategic charts [1].

Possibilities of a fuzzy set evaluation for calculation of integral economic indicators are limited by a lack of expert and statistical information necessary for research execution.

4. Results

In the frames of CRI concept the general chart of YNAD development strategy targets was formed with account of demands in digitization (figure 1).
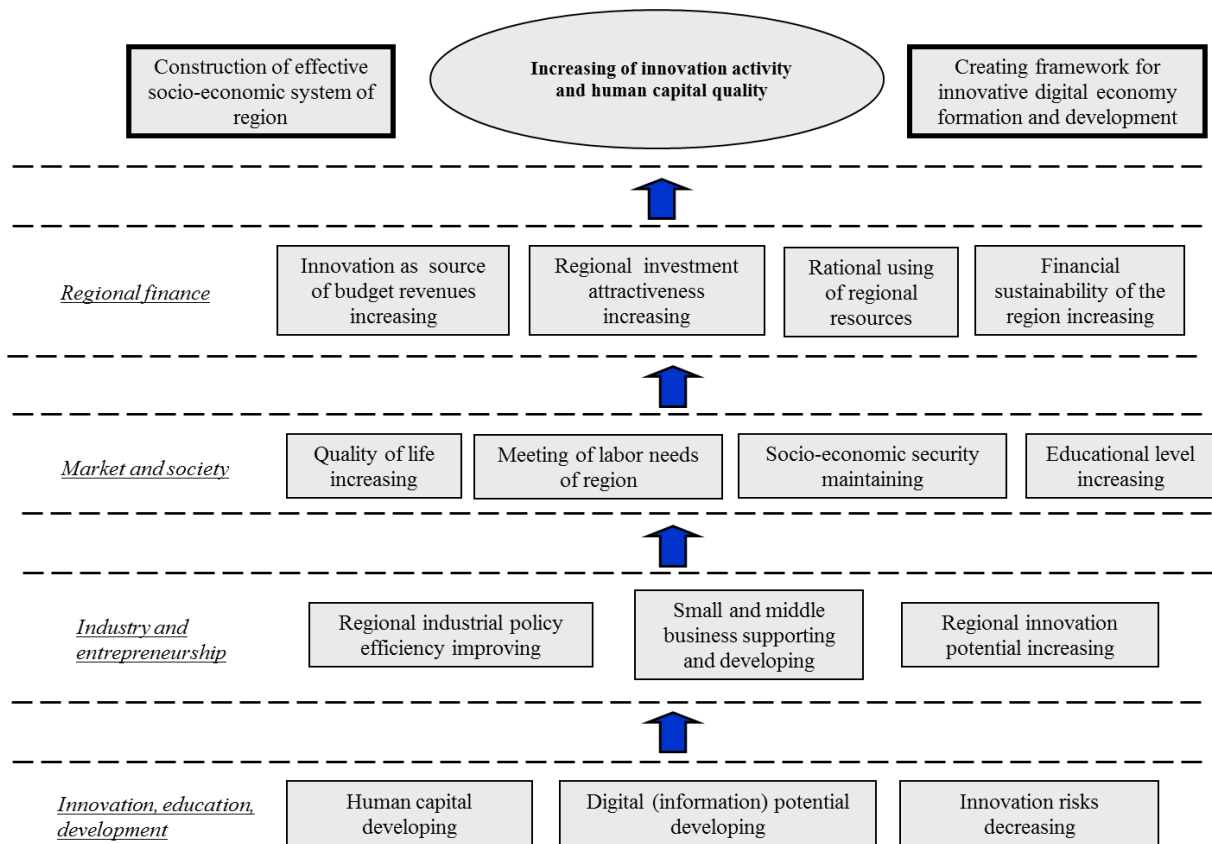
Figure 1. General strategic chart of YNAD development.

Further, on the basis of this general strategic chart the charts containing the sets of indicators for strategy implementation by four strategy components have been created: 'Education, development, innovation', 'Industry and entrepreneurship', 'Market and society' and 'Regional finance' [13–20]. The indicators by each component and target form a basis for general evaluation of the results of strategy implementation and are given in table 1.

Table 1. Indicators of strategy implementation.

Targets of strategy implementation	Indicator
Education, development, innovations	
Development of informational (digital) potential	Number of innovative activity subjects, unit per thous. of citizens
	Number of scientific and technical activity of AD, unit per thous. of citizens
	Share of district budget costs for scientific and innovative activity, %
Development of human (intellectual) potential	Number of Yamal authors publications in the index-linked scientific magazines, per 100 investigations, units
	Coefficient of invention activity, units
	Level of human potential in the region
Decrease of innovative activity risks	Risk level of innovative project implementation in YNAD
	Level of social strain
	Quality of innovation policy in the region
Industry and entrepreneurship	
Increase in efficiency of regional industrial policy	Investments to main capital per one citizen
	Volume of consolidated budget incomes

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	Share of profit-making enterprises
Development and support of small and medium-size business	Number of small and medium-size enterprises
	Average weighted index of investment risk
Development of innovative-industrial potential	Number of persons involved in economy
	Volume of goods and services production per one citizen
Market and society	
Meeting the regional demands in labor resources	Share of economically active population in the total population of the region
	Share of labor migrants (foreign citizens having a work permission or patent) in the general population of economically active population
	Average age of economically active population
Support of social-economical safety	Investment climate
	Level of social-political strain
Improvement of the life quality of citizens	Expected life time
	Average consumption expenditures per capita (monthly)
Increase of population educational level	Share of specialists with higher education in economically active population
Regional finance	
Rational use of regional resources	GDP per capita
	Population average income
	Life quality
Finding ways to increase regional income through implementation of innovations	Incomes of consolidated budget subject
	Balanced financial result of organizations
Increase of financial stability in the region	Creditability of regions
	Financial risk
Increase of regional investment attractiveness	Investment attractiveness
	Investments to main capital per capita

The aggregated indicators of the strategy component evaluation were calculated for each component on the basis of fuzzy set method (table 2).

Since the indicators differ by their nature, the conclusions on achievement of the regional strategic targets can be made on the basis of the available data. However, the aggregated indicators reflecting the social-economical development of the region can be calculated on the basis of the available indicators.

The calculated value makes it possible to determine a degree with which the indicator belongs to a certain group of the classifier.

Table 2. Calculated values of aggregated indicators by strategy components for YNAD[b].

Strategy component	Aggregated indicator	Value
Education, development, innovations	Level of regional innovative development Y_1	0.42
Industry and entrepreneurship	Level of regional industrial development Y_2	0.41
Market and society	Level of total regional labor potential Y_3	0.54
Regional finance	Level of regional financial potential Y_4	0.64

[b] Data for calculation are acquired by the authors with the use of [21–24], as well as with the help of expert questionnaires.

The integral indicator of the strategy evaluation 'Level of the regional strategic targets achievement' $\hat{Y}$ is determined as per the formula:

$$\hat{Y} = \sum_{i=1}^{4} Y_i$$

where Y_i — values of aggregated indicators by four components of the strategy in the region. The integral indicator domain [0;4]. The calculated value of indicator for YNAD is 2.01.

On the assumption of membership function the indicator values can be classified by the offered scale (table 3).

Table 3. Classification of the regional strategic targets achievement level.

Category	Criterion	Range of values, y	Membership function
Low $0 < y < 1.33$	Low level of strategic targets achievement: absence of newly implemented innovative technologies, low indicators of industry development, absence of the necessary number and quality of labor resources for regional development, low level of financial resources provision in the region.	$0 \le y \le 0.67$	1
		$0.67 < y < 1.33$	$\mu_1 = \dfrac{1{,}33 - y}{0{,}67}$
Below average $0.67 \le y < 2$	Level of strategic targets achievement is not sufficient: low level of innovation technologies development, low indicators of industry development, insufficient number and quality of labor resources, insufficient provision of the region with financial resources		$1 - \mu_1 = \mu_2$
		$1.33 \le y < 2$	$\mu_2 = \dfrac{2 - y}{0{,}67}$
Average $1.3 \le y < 2.67$	Average level of strategic targets achievement: availability of unitary innovative technologies implemented, RF average indicators of industry development, average provision with labor resources (amount of resources is sufficient, but quality of resources does not correspond to business demands, and vice versa), financial resources are sufficient for implementation of regional development targets		$1 - \mu_2 = \mu_3$
		$2 \le y < 2.67$	$\mu_3 = \dfrac{2{,}67 - y}{0{,}67}$
Above average $2 \le y < 3.33$	Level of strategic targets achievement is high: great number of innovative technologies being implemented, indicators of industry development level are above average in RF, sufficient number and quality of labor resources, provision of the region with financial resources for implementation of development targets is above average		$1 - \mu_3 = \mu_4$
		$2.67 \le y < 3.33$	$\mu_4 = \dfrac{3{,}33 - y}{0{,}67}$
High $2.67 \le y \le 4$	Extremely high level of strategic targets achievement: development of breakthrough innovative technologies, leading indicators of industry development in RF, availability of sufficient number and quality of labor resources, complete self-sufficiency of the region concerning financial resources		$1 - \mu_4 = \mu_5$
		$3.33 \le x \le 4$	1

According to the membership function, the YNAD belongs to 'Average level' group of the regional strategic targets achievement with a probability of 98%, and to 'Above average' group with a probability of 2%. These conclusions are enforced with the previous analysis of the regional development level. In truth, the region has certain difficulties in implementation of the innovative-industrial potential due to the climate pattern. The region is able to maintain the high enough level of financial provision and to attract qualified labor resources on the back of the large producer companies functioning. However, the amount of labor resources is limited.

5. Conclusion
Thus, the strategic chart of regional development was formed in the work with account of demands in the economy digitization; on the basis of this chart, the indicators for achievement of each strategic

sub-target were selected; the aggregated indicators by each component were calculated on the basis of fussy set method; the integral indicator of strategy evaluation and its classification scale are proposed on the basis of aggregated evaluations. Application of fuzzy logics for evaluation of the regional strategic targets achievement level made it possible to combine statistical data and qualitative evaluation of experts in a single integral indicator. The indicator reflecting the regional strategic targets achievement can be used as an indicator of social-economical policy in the region. It can also be selected as one of the parameters for monitoring and comparative analysis of social-economical development in different RF regions, as well as for drawing up the regions rating. Integral indicator calculations for other regions in the RF Arctic area are planned to be carried out in the future.

Acknowledgments

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