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Factor Analysis of the Influence of Supply Chain Management on the Economic Dynamics of the Region

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Abstract— **The main goal of the study is to develop methodological approaches to a formalized assessment of the impact of supply chain management and its individual components on the development parameters of key macroeconomic indicators of a region (for example, investment in fixed assets). Testing the proposed research algorithms made it possible to substantiate a high level of reputation significance in the formation of regional economic growth. The implemented factor analysis provided an identification of the impact of the individual sub-indices under consideration, which form the integral value of the region's supply chain management, on investment activation processes. The Republic of Tatarstan acts as an object of the study. The subject of the research is a methodological toolkit for conducting factor analysis and assessing the impact of the region's reputation on the parameters and dynamics of investment processes. A key feature of the study is the proposed version of constructing a series of regression equations, where the region's supply chain management index is one of the exogenous parameters. The use of elimination methods has allowed the formation of a factor analysis focused on the impact of the individual components of the index under study on investment processes. On the basis of the developed methodology for the formalized assessment of the region's supply chain management, the authors have built models that assess the level of influence of sub-indices that form the basis for an integrated assessment of the territory's reputation on investment dynamics. It is advisable to use the developed methodological approaches when developing new models of economic growth under conditions of increased importance and the role of intangible production factors. According to the results of the study, the influence of each of the sub-indices under consideration on the dynamics of investment in fixed assets of the region was established, which made it possible to justify and formulate measures of state influence on the corresponding functional directions of the regional socio-economic system.**

1. Introduction

According to the research of [1-3] on the supply chain of smart phones, clothing and airplanes, reshaping the supply chain system will significantly impact investment, labor cost, intellectual property protection, production cycle and consumers for trade partners. The transition from qualitative methods to assessing the impact of the region's supply chain management on key parameters of its macroeconomic generation to quantitative ones is an extremely urgent research task. Its solution in the conditions of the transformation of the institutional and business environment within the framework of the fourth industrial revolution rapidly gathering its pace will greatly contribute not only to the formalization of methods for studying the reputation activity of territories, but also to the actualization of existing models of economic growth based on the use of intangible production factors. It should be noted that the significance of these factors is growing steadily in the face of a paradigm shift in economic development. No less important is the application of this approach in the context of the coronovirus pandemic that has been developed in 2019/2020 and substantially adjusting the dynamics of economic development of the vast majority of the states of the world and individual regions also. As the practice of self-isolation has shown, traditional material factors of production are far from the most important. The most important development driver providing, inter alia, access to a stable trajectory of socio-economic growth is the availability of sufficient supply chain management of the regions in terms of generating opportunities to overcome and / or localize the threats of the COVID-19 spread. The ability of the state and its individual territorial units to minimize the

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consequences of the spread of infection forms the corresponding image component, which subsequently inevitably affects both the speed of economic recovery and the strengthening of supply chain management, which ensures the growth of the potential for economic dynamics in the medium and long term.

Features of the influence of intangible production factors, in particular, the impact of reputation on the development parameters of the regional economy in their scientific works were considered by [4-6].

Supply chain is a dynamic process and involves the constant flow of information, materials and funds across multiple functional areas both within and between chain members [7]. To improve supply chain coordination and product quality, manufacturing firms often demand that their supply chain partners such as subcontractors or suppliers implement common processes which often require the sharing of information. Foreign researchers actively studying the reputation of business entities should include [8-10] who are well-known scientists and founders of original approaches to the study of assessing the impact of a company's reputation on the dynamics of its development

Despite the very extensive attention of Russian and foreign researchers to the problem posed, as a rule, the vast majority of works devoted to the study of supply chain management at the meso- and macrolevels focus on the qualitative side of the analysis with consideration of possible effects in the field of economic development generated by the supply chain management of the region. However, aspects of a formalized assessment of the issues addressed require additional attention.

In this regard, it seems to be an extremely important and urgent task for the theory of reputational economics to solve the problems posed through the prism of using methods of economic and mathematical modelling and designing the processes under study. However, the transition to a new research format requires, first of all, formalizing and developing tools to quantify supply chain management, which undoubtedly belongs to the category of intangible assets.

Relying on the works presented above, as well as a number of other Russian and foreign studies on this topic, the authors attempted to build a model of the supply chain management impact on the system of key macroeconomic indicators based on previously proposed methodological approaches to quantitatively assessing the reputation of territories [11, 12].

In accordance with our position, the reputation of any region is a digital reflection, a digital twin in the global information space of the organization system and the development efficiency of the real economy. In other words, supply chain management is a "digital tracing-paper" of the real sector of economy in all kinds of digital channels for information translation.

2. Methods

The algorithm for evaluating and constructing time series characterizing the values and dynamics of the region's supply chain management is presented in a concentrated form below:

Step 1. Grouping the global information space by the level of reflection of the region's reputation background

Step 2. Grouping the global information space by the degree of signal generated either at the macro- or meso- scale (federal / regional information sources).

Step 3. Determining the list of search queries that form representations (image) about the reputation of the territory (region) (Figure 1) and revealing the essence of the analysed process. At the same step, a procedure is carried out that estimates the number of queries requested by users regarding the analysed object within the estimated time period p (xi).

The reputation of the region is assessed based on 5 key sub-indices.

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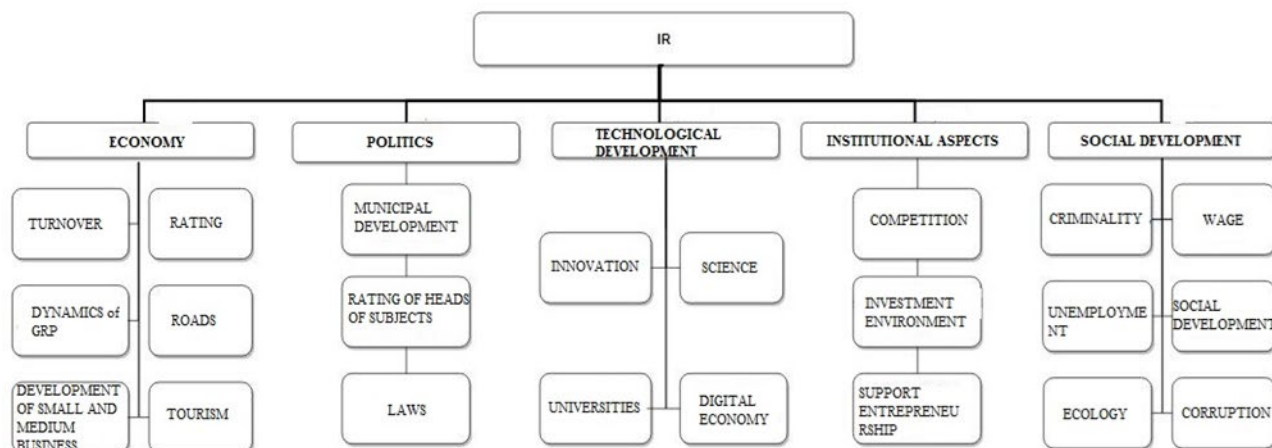

Figure 1 - The system of search queries that form representations (image) about the reputation of the territory (region)

Step 4. Identification and determination of the repository containing information retrieval systems participating in the analysis procedure in order to assess the popularity and relevance of each of them.

Step 5. Analysis and systematization of data revealing the estimates of users of the global information environment with respect to the estimated search queries (in accordance with the data presented in Figure 1) forming representations regarding the reputation of the analysed object.

Step 6. Calculation of the integral values of sub-indices characterizing the supply chain management of the region

Step 7. Calculation of the integral index of the region's supply chain management.

A more detailed description of the research methodology is presented in the works previously published by the authors. [11, 12]

Undoubtedly, it is necessary to state that the methodological approach proposed in the present work for quantitatively measuring the reputation of a territory can carry elements of discussion and subjectivity like any other new method. However, in our opinion, the components of supply chain management used in the calculations are essentially capable of determining the integral value of the reputation of the territory. It is also important to note that the tools laid down in the basis of the methodological approach for measuring the region's supply chain management are in many respects

consistent with the approaches of the Moscow School of Management Skolkovo when measuring the Digital Russia index [13]. Meanwhile, being aware of the potential on expansion of the components used in our algorithm, the methodological approach developed has all the necessary resources for optimization and improvement.

3. RESULTS AND DISCUSSION

In the complex and changeable external environment, the competition between supply and demand markets is increasingly fierce. Supply chain collaborative innovation is gradually replacing individual enterprise innovation and becoming a lifeblood of the survival and development of modern enterprises., in accordance with the obtained estimates and measurements, the values of the territory's supply chain management index (based on the example of the Republic of Tatarstan) were determined (Figure 2). The implementation of this research phase forms the prospects and basic tools for developing a series of economic and mathematical models that allow not only to assess the degree of influence of the dynamics of changes in supply chain management on the economic dynamics of the region, but also to form mechanisms for conducting a comparative analysis of the sensitivity of modern regional economic systems to traditional and non-traditional (including, of course, reputational capital) factors generating macroeconomic dynamics.
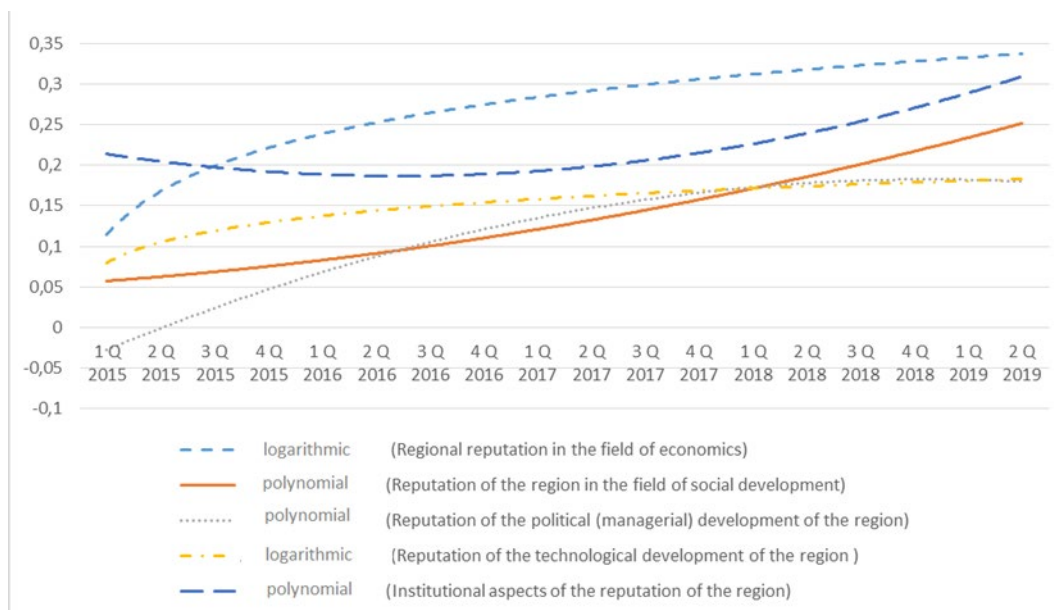
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Figure 2 - Estimated data on the supply chain management index of the Republic of Tatarstan for the period from 2013 to 2019

. In accordance with the stated research concept, a model was constructed where the role of the endogenous factor is played by investment in fixed assets (I), and the role of exogenous factors is played by the system of indicators shown below:

S - Savings in deposits and securities;

R - Weighted average interest rate in the financial capital market;

E - Balanced financial result of business entities;

K - Weighted average rate of the national currency;

P - Interest rate on credit and deposit operations

IPC - Consumer Price Index, %, to the previous year, US $

IRC - Reputational capital index of the region.

In order to build additive and multiplicative models for the analysed time series, the seasonal factor was eliminated (in particular, seasonal variations were found for series I).

Further, a regression model on the basis of the data obtained and their systematization was constructed; it meets all the signs of the statistical significance of its coefficients (including procedures for eliminating multicollinearity between the analysed

time series) (Formula 1). According to the results of the model construction, it included three exogenous factors that have a high level of connection with the endogenous parameter (Investments in fixed assets) and at the same time are characterized by a weak correlation between themselves.

The final version of the resulting model is presented below:

$Y = 89521.13 + 20024.45x_1[-1] + 0.23x_2 + 477.69x_3$

(Formula 1)

Where:

Y- Investments in fixed assets, billion roubles

X1 - Index of the region's supply chain management;

X2– Balanced financial result of business entities, billion roubles

X3 - National currency rate, roubles / dollar.

Table 1 shows the main estimates and parameters of the statistical significance of the obtained equation, the determination coefficient of which is 0.89; the parameters of t-statistics and P-Values fully satisfy the necessary criteria.

Table 1 - The main estimates and parameters of the statistical significance of the resulting equation

	Coefficients	*Standard Error*	*t-statistic*	*P-value*
Y intersection	89521.13	7536.87	11.21	0.00
Supply chain management Index	20024.45	6895.31	2.88	0.01
Balanced financial result	0.23	0.05	2.61	0.01
The official exchange rate of the US dollar against the rouble, at the end of the period, RUB / USD	477.69	159.04	3.63	0.01

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The estimates obtained demonstrate a very noticeable, if not dominant, contribution of the region's supply chain management to the formation of investment processes. For example, an increase of X1 per unit generates a quarterly increase in investment in fixed assets by 20.024.45 million roubles. Given that the total volume of investments in the Republic of Tatarstan per quarter (according to the data for 2019) is about 200 billion roubles, and it is methodologically predetermined that the range of fluctuations in the time series characterizing supply chain management is from -2

to 2 [12], reaching the maximum IRC values by the region can generate fixed capital investment growth of 40 billion roubles (about 20% of the total), and vice versa, if the value of the region's reputation index reaches its minimum level.

In accordance with the above algorithm, an important methodological aspect that forms the basis for constructing a quantitative assessment of the region's reputation is the possibility of factor analysis of the main components (sub-indices) (Figure 2), which determine the integral value of the supply chain management index influence on the dynamics of investment processes.

Table 2 - Assessment of the elasticity of the region's investment activity to the changing parameters of supply chain management

	Index value					Estimated Reputed Capital Index (Q2 2019)	The value of the coefficient of exogenous factor X1 model
	$I_{экон}$	$I_{соц}$	$I_{полит}$	$I_{техн}$	$I_{инст}$		
Scenario 1	**+10 %**	0.349	0.028	0.154	0.121	1.060	20693.04
Scenario 2	0.369	**+10 %**	0.028	0.154	0.121	1.058	20658.29
Scenario 3	0.369	0.349	**+10 %**	0.154	0.121	1.026	20069.35
Scenario 4	0.369	0.349	0.02	**+10 %**	0.121	1.038	20306.46
Scenario 5	0.369	0.349	0.028	0.154	**+10 %**	1.035	20243.94

* - IRC Baseline: 1.03 (Q2 2019)

Figure 3 presents quarterly estimates of the possible increase in investment in fixed assets due to the adjustment (growth) of the sub-indices under consideration in accordance with the stated concept of eliminating factors. The calculation was carried

out in the form of the deviation for the coefficient value at factor X1 of the constructed base regression model (20,024.45) from similar values calculated within the framework of constructing new equations taking into account the scenario-generated changes of a sub-index.
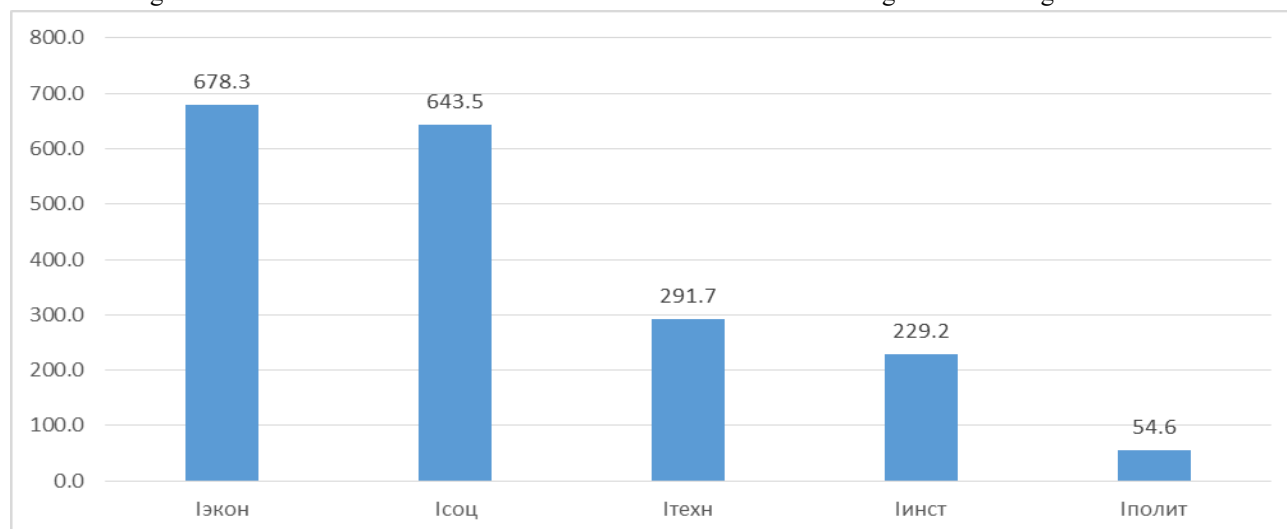

Figure 3 - Scenario analysis for the growth potential of investments in fixed assets of the Republic of Tatarstan due to the adjustment of the considered sub-indices of supply chain management, million roubles / quarter

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4. SUMMARY

The implemented calculations based on the construction of a series of econometric equations demonstrate that the factor characterizing the economic potential of the region's supply chain management has the greatest impact on the growth of investment activity in the region. Its 10% increase generates an additional investment of 678.3 million roubles per quarter. On the contrary, the lowest impact level is characterized by such a component of supply chain management as the administrative and political efficiency of its functioning (due to the increase in the value of the corresponding sub-index by 10%, the potential for investment growth is about 55 million roubles per quarter).

On the whole, the implemented analysis demonstrates that the inclusion of intangible factors of production in the economic growth model (and supply chain management is no exception here) forms a significant potential not only for understanding the prospects for the region's economic development in modern economic conditions, but also for identifying and constructing measures of state influence to the appropriate functional areas of development of socio-economic systems within the framework of the emerging supply chain management and its individual components. As proved by the constructed models, the latter significantly determine, in turn, the regional macroeconomic dynamics.

Moreover, it is also important to note that the proposed methodological toolkit for the quantitative measurement of the supply chain management of territories with the subsequent assessment of its impact on macroeconomic parameters forms a new vector for constructing prognostic models of economic growth based, among other things, on the consideration of intangible production factors.

5. Conclusion

Implementation of supply chain technology collaborative innovation not only effectively maximizes the sustainable supply chain performance, but also helps to improve the dynamic adaptability to changes in the external environment. In conclusion, we want to note that this study is an attempt to strengthen the position of formalized approaches to the study of the posed scientific and practical problem against the background of the overwhelming predominance of high-quality approaches to the

study of regional supply chain management. Undoubtedly, the constructed models and algorithms for measuring reputation can and should continue to look for directions for their optimization and calibration. However, as shown by the assessments, despite that the proposed toolkit is to a certain extent primary and elementary, its application in practice forms the potential for understanding the sensitivity of regional economic systems to their reputation activity. This, in turn, opens up new prospects for the interpretation of the analysed processes and new opportunities for holding discussion platforms on this topic.

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