A Multi-Criteria Analysis of Russian International and Interregional Logistics Centers

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Rinas V. Kashbrasiev, Kazan (Volga Region) Federal University, Russian Federation
Anatoly M. Shihalev, Kazan (Volga Region) Federal University, Russian Federation
Clifford A. Lipscomb, Greenfield Advisors LLC, Atlanta, GA, USA

ABSTRACT. The continuous increase of marketization of the production and consumption sectors of the Russian economy requires developing logistics and distribution systems at multiple territorial scales: international, interregional, and local. Territorial organization of logistics centers is becoming an important part of Russian logistics development and increasing economic growth. The purpose of this paper is to empirically determine the optimal location of logistics centers to ensure effective international and interregional trade flows. Using 39 variables in a multi-criteria analysis of the Russian regions, including various geopolitical, economic, geographical, macroeconomic, and technological criteria, this paper finds that the level of integration in the Republic of Tatarstan is much higher than the ratings of the other two Volga regions (Nishniy Novgorod and Samara). The conclusion is that the Republic of Tatarstan has significant competitive advantages to construct an international and interregional logistics center on its territory. Our results have important policy implications for how the Russian government allocates resources in the Volga region.

KEYWORDS: logistics, location decision, criteria for evaluating regions, Russian Regions, Samara, Nizhniy Novgorod, and Tatarstan.

Introduction

Currently transportation infrastructure and logistics development is considered in the Russian Federation as an essential condition for continued economic growth, as well as enhancing the level of interregional economic cooperation.

In general, the development of logistics systems is primarily associated with the development of a competitive market environment based on the free choice of partners, prices, and order for goods (instead of the planned distribution of products when the USSR existed). Consequently, the effective application of logistics management is possible only in overcoming the monopolization of the economy, further development of competition, and the market. The efficiency of the logistics centers is characterized by a set of indicators of the centers at a given level of logistics costs.

On the other hand, logistics development requires improving the country's transport system on the basis of a rational, territorial organization of logistics centers. The most important question here is to identify the comparative advantages of each Russian region in terms of location of the basic logistics centers (interregional or international significance) in its territory. In this regard, it seems urgent to review the process of solving the problem of optimal choice of the location of the logistics center at a given set of alternatives (i.e. regions) of the Volga Federal District, while satisfying a set of requirements (objectives, criteria).

Effective location of the logistics centers will also serve to minimize the determinants of interregional disparities.

The selected areas

The Republic of Tatarstan is one of the leading regions within the Volga Federal District [and has the highest gross regional product (GRP) in Russia]. The main industries of the republic are oil extraction, petrochemistry, mechanical engineering, electric power industry, aircraft engineering, and instrument making. Comparative advantages of Tatarstan were primarily earned due to considerable reserves of mineral resources. A unique science-educational system and recreational resources also contribute to its advantage. The republic contains a special economic zone called "Alabuga," which has been in operation since 2006. One of the best advantages of the zone is that the residents are guaranteed considerable tax privileges and steady rules of business for the entire period of existence of the zone, i.e. for 20 years (Republic of Tatarstan, 2010: p.30). Residents are granted a number of preferences: no payment of customs duties and value added tax (VAT) for foreign equipment (which is installed and used within the special economic zone) and no payment of export duties for their products. Moreover, residents shall be exempted from property and land taxes.

The Samara region also is one of leading regions of Volga Federal District (3^{rd} place on GRP). The areas of industrial specialization are the manufacturing of cars and automobile components, aerospace mechanical engineering, oil extracting and oil refining, nonferrous metallurgy, chemistry, and electric power industry. The Samara region ranks highest in Russia on manufacturing such kinds of industrial output as cars, synthetic ammonia, and linoleum. The major comparative advantages of the Samara region are the developed diversified industrial complex and large national scale plants, as well as the high-tech manufacturing industry and the essential technological potential with developed infrastructure of the innovative activity.

The Nizhniy Novgorod region is one of the leading regions within the Volga Federal District (ranks fifth in terms of GRP). Nizhniy Novgorod is an official capital of the Volga Federal District. As Russian history shows, a "capital status" automatically gives some advantages to the city and region, including centralized budget resources. An economic base of the region is manufacturing, which comprises more than 30 percent of the regional output. Leading industries in the region are a machine-building complex, aircraft engineering, shipbuilding, radio electronics, petrochemical, and wood production. Due to the region's comparatively high industrial potential, energy and transport problems can be addressed by businesses already located there.

All regions may be characterized as development oriented with strong industrial bases, large national scale plants, high export potential, and high technological potential. However, there are weak interregional economic relations between the Volga regions; this obviously restricts the economic growth of the Volga Federal District. Weak interregional relations are partly explained by the heritage of Soviet administrative-command economy and restrictive trade practices between Russia's regions in the 1990s. According to Russian State Statistics, in the 2000s, the share of Moscow and Moscow region in the interregional goods turnover of each Volga region equals 35% (Nizhniy Novgorod 32%, Samara 35%, and Tatarstan 38%); however, a share of regions in each other's turnover varies from 4% to 7%. There is much evidence of this weak cooperation in other spheres, but mainly in the road transportation sector. The road system suffers from poor maintenance; and there are places where the road system in one region does not connect to a neighboring region, e.g. between Tatarstan and Samara (Kashbrasiev, 2010: p.79). Of course, there are border crossings where roads in either region seamlessly could be joined, but it seems that interregional cooperation is so poor that roads at these border crossings are still being repaired or constructed.

Therefore, the construction and development of interregional and international logistics centers in the Volga regions hinges on interregional economic cooperation and the desire to promote economic growth within the Volga regions.

A Formalized Multi-criteria Analysis and Application

To prioritize the regions that seem best suited for the design and location of international and interregional logistics centers (LC), one approach that can be implemented is multi-criteria analysis (MCA). MCA generally is $f_i(S_i)$. Here, we specify a MCA as:

$$\langle X, R \rangle,$$

where $X = \langle x_i \rangle$, $i = 1, 2, \ldots n$. Here X refers to regions and n refers to the number of regions. Also, we define a set of criteria R, where $R = \langle r_j \rangle$, $j = 1,2, \ldots m$ and $m = 39$ (the list of criteria appropriate for location of logistic centers in the regions).

MCAs have solutions, especially in cases when the number of criteria is considered from the perspective of the *analytic hierarchy decision process* (Saaty, 1980). In our case, these criteria are the factors influencing the optimal decision regarding location of LCs among the regions.

Therefore, all schemes for MCA can be reduced to some general form:

1. Working out a list of regions-alternatives: $X = \langle x_i \rangle$, $i=1,n$

2. Working out a complete list of partial criteria $R = \langle r_j \rangle$, $j=1,m$ to assess the feasibility of location of LC

3. Mapping of a set of partial criteria on a set of regions-alternatives τ: R → X in any convenient scales for research (quantitative, ordinal, linguistic, etc.)

4. Hierarchical structuring of partial criteria

5. Creating a goal tree. Introducing a weight function

6. Evaluating alternative regions

7. Conclusions and Recommendations

1. Working out a list of regions-alternatives *X*:

In this paper, MCA is connected with a decision of a definite task: To design and construct an interregional multimodal logistics centers in the Volga region using the Federal government money according to infrastructure development project. There are 3 alternatives, the economic developed regions located on the "crossroad" of Russian and international transport corridors:

X_1 indicates the republic of "Tatarstan",

X_2 indicates the region of "Samara",

X_3 indicates the region of "Nizhny Novgorod".

2. Working out a complete list of partial criteria *R*:

In the aim of receiving the complex characteristics 39 criteria were considered. In this block, traditional indicators of region's performances, the state of their transport development, and also some new indicators of estimation LC (Blanquart and Burmeister, 2009) are presented. **Criteria Considered:**

1. Economic-geographical position (favorable-unfavorable)
2. Degree of centrality of geographical position
3. Proximity to crossing of the international transport corridors
4. Geopolitical position
5. Territory
6. Population
7. Proximity of the LC to the large centers of consumption
8. Degree of state regulation of economy
9. Government support (here – LC project by local authorities)
10. Multifunctionality of LC
11. Multimodality of LC
12. Variety of services
13. Estimated scale of LC
14. Degree of cooperation of LC into a regional economy
15. Presence of information-analytical center
16. Contribution to information (management) flow of the national economy
17. Degree of participation in the global chain of supply of goods
18. Degree of standardizing shipping
19. Degree of integration of LC
20. Goods turnover, million tons
21. LC performance
22. Reliability of LC
23. Security
24. Punctuality
25. Flexibility
26. Adaptability to the constraints (shortages of goods)
27. Adaptability to the constraints (failure of transport)
28. The length of (car) roads, km

29. The length of (car) roads paved, km
30. The length of railways, km
31. The length of navigable waterways, km
32. Rail freight turnover, billion tons km
33. Shipments of all types of transport, million tons
34. Shipments by rail transport, million tons
35. Shipments by car, million tons
36. Shipments by river transport, million tons
37. Area of warehouses, thousands sq. m.
38. Deficiency of warehouse space, thousands sq. m.
39. New warehouse spaces planned, thousands sq. m.

3. Mapping of a set of partial criteria on a set of regions-alternatives: R → X

Within the framework of MCA approach, mapping is possible in any convenient scales for research (quantitative, ordinal, linguistic, etc.). Statistical data of Federal and regional statistics, and materials of Volga region Logistics Association were used. For example:

	X_1	X_2	X_3
1.Economic-geographical position	most favorable	favorable	Favorable
23.Security	high	high	High
33.Shipments of all types of transport, million tons	240	255	71.9

4. Hierarchical structuring of partial criteria:

Category	**Criteria**
Technology (12 criteria)	The length of (car) roads, km
	The length of (car) roads paved, km
	The length of railways, km
	The length of navigable waterways, km
	Rail freight turnover, billion tons km
	Shipments of all types of transport, million tons

	Shipments by rail transport, million tons
	Shipments by car, million tons
	Shipments by river transport, million tons
	Area of warehouses, thousands sq. m.
	Deficiency of warehouse space, thousands sq. m.
	New warehouse spaces planned, thousands sq. m.
Economy (16 criteria)	Goods turnover, million tons
	LC performance
	Reliability of LC
	Security
	Punctuality
	Flexibility
	Adaptability to the constraints (shortages of goods)
	Adaptability to the constraints (failure of transport)
	Multifunctionality of LC
	Multimodality of LC
	Variety of services
	Estimated scale of LC
	Presence of information-analytical center
	Contribution to information (management) flow of the national economy
	Degree of participation in the global chain of supply of goods
	Degree of standardizing shipping
Infrastructure (2 criteria)	Degree of cooperation of LC into a regional economy
	Degree of integration of LC
Institution (3 criteria)	Geopolitical position
	Degree of state regulation of economy
	Government support (here – LC project by local authorities)
Geography (6 criteria)	Economic-geographical position
	Degree of centrality of geographical position

Proximity to crossing of the international transport corridors
Territory
Population
Proximity of the LC to the large centers of consumption

We need the hierarchical structuring of partial criteria to determine the degree of importance of the major branches of the goal tree for assessment of priority regions using Fishbone Diagram (Saaty, 1980).

5. Creating a goal tree. Introducing a weight function:

We use a weight function in order to normalize the influence of all factors on the result:

$$\sum w_j = 1$$

In this stage of research all main factors (categories 'Technology', 'Economy', 'Infrastructure', 'Institution', and 'Geography') give equal influence on the result (although it is possible when one elements have more influence than other elements in the same set). Consequently, a weigh of r_{14} (Degree of cooperation of LC into a regional economy) is 0.1 (i.e. 0.2/2=0.1), and a weigh of r_1 (Economic-geographical position) is 0.033.

6. Evaluating alternative regions:

First we must transform the initial data (in the form of quantitative, ordinal, linguistic, i.e. qualitative estimates) into only quantitative data C_{ij}. For example:

	X_1	X_2	X_3
1.Economic-geographical position	3	2	2
23.Security	3	3	3
33.Shipments of all types of transport, million tons	240	255	71.9

Then, we receive a vector-column of local priorities (U_{ij}) for each region using the following formula:

$$u_{ij} = \frac{C_{ij} - C_{ij}^{\min}}{C_{ij}^{\max} - C_{ij}^{\min}} \bullet 100\%$$

Now, as we know the values of the weights and quantities of vectors of local priorities, the integrated rating may be calculated by the formula transitive convolution. To calculate the integral rating of alternates (V_i) we use the following formula:

$$V_i = \sum_{i,j=1}^{n,m} u_{ij} w_j$$

The optimum value is found among V_i , a vector-column of priorities $V^{onm} = \max\langle V_i \rangle$. The results are reported in Table 1.

Table 1. The results of MCA

N	Regions	Integral ratings
1	Tatarstan	79.1
2	Samara	42.9
3	Nizhny Novgorod	38.1

The results suggest that the Republic of Tatarstan has a much higher rating than the other two Volga regions. In the next section, we discuss the implications of the results.

7. Conclusions and Recommendations:

The conclusion is that the Republic of Tatarstan has significant competitive advantages to construct an international and interregional logistics center on its territory. We recommend that the Russian federal government design and construct an interregional LC within the Republic of Tatarstan to take advantage of the regions relatively higher rating in the multiple dimensions modeled here.

The MCA model developed here is only one method that facilitates the comparison of so many different variables to affect government policy. Other methods (reserved for future research) that can be used to define the integral rating of the regions include data envelopment analysis (Denaux, Lipscomb, and Plumly, forthcoming) and principal components analysis (Lipscomb and Kashbrasiev, 2008). If policy analysts decide that region borders (defined exogenously in this work) become less important than, say, population centers, researchers might consider other statistical methods, such as the finite mixture model (Belasco, Farmer, and Lipscomb 2011), that can treat geographic areas endogenously. This would be particularly useful for a within-region analysis where, say, the policy analyst is trying to determine the optimal location for a new government services building and lacks data by mail or postal code.

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