Site-selection on the basis of territorial analysis methods

Выбор участка строительства на основе методов территориального анализа

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Abstract. The object of research is the site-selection process for the rental housing construction. This form of real estate is becoming more widespread in the west, while in Russia it's development is currently on initial stage. The article proposes the site-selection solution on the basis of existing methods of territorial analysis, calculation of employment shares, location quotients, Hirschmann-Herfindahl index and Kano model application, as well as application examples of the obtained databases in the conditions of a narrowly formulated problem. The research results are the mechanisms for solving three types of problems depending on the nature of the initial data according to correspondence between the properties of the object under construction and the urban territories.

Аннотация. Объектом исследования является процесс выбора участка капитального строительства жилого здания с целью последующей сдачи в аренду. Данная форма недвижимости получает все более широкое распространение на западе, в то время, как в России только зарождается. В статье предлагается решение задачи размещения существующими методами территориального анализа, применением расчетов долей трудоустройства, коэффициентов локации, индекса Хиршманна-Херфиндаля и модели Кано, а также иллюстрируются примеры применения полученных баз данных в условиях узко сформулированной задачи. Результатом исследования являются механизмы решения трех типов задач в зависимости от природы исходных данных на основе исследования соответствия свойств строящегося объекта и территорий города.

1. Introduction

Site selection is the initial stage of any construction process. It indicates the tools of placing new objects, both for business and for government. Site selection involves measuring the needs of a new project. Rationally chosen area maximizes the profitability and efficiency of facility. It can be analyzed from several points of view, one of them is the economic analysis of regions and areas which potentially can be chosen as a site.

Each region differs from others in size, location, morphology, diversity of population and donations of factors. Due to these characteristics and some exogenous factors, the regions have become specialized in their sectors over time. Indicators such as employment share [1, 2], location quotients [3–6] and the Hirschman-Herfindahl index [7, 8] are useful tools for analyzing the level of specialization and diversification in the region in order to understand how this affects economic indicators and how it behaves with respect to the reference area. This article is aimed to apply these methods during site selection process. The scale of large Russian city Saint-Petersburg with its 111 local regions (municipal sectors) is analyzed in some parts of the article as an example.

In this particular investigation the following calculations are considered as a part of decision-making process [9]. Results of calculations are used as coefficients describing economical rationality of choosing a site for construction. Still these methods and all the formed databases may be applied in other cases. In

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our work particularly we focused on choosing a site for specific object – middle-class rental house. This type of business becomes more and more popular in European countries and United States of America [10, 11] and represented in Saint Petersburg only by one house. Population of large agglomerations such as Saint Petersburg become more convenient with sharing apartments. Renting real estate in a lot of cases becomes more profitable and thus popular than buying it for the citizens [12]. That is why we find actual our attempts to apply existing methods of territorial analysis to site-selection of this modern type of real estate. In addition to this we find it necessary to have an instrument which values the site without expert review, only on the basis of statistical data (in this article all the initial data is taken from Rosstat which is main statistical database in the country [13]). At the same time suggested methodology can be applied for large variety of cases by identifying sectors related to specific features of investigated object. From this perspective we consider the sites or generally the whole urban territory which consists of different sites the object of this research.

In this research we were interested in economic parameters of the sites. In particular we tried to evaluate numerical values for these economic parameters and different municipal authorities using methods of territorial analysis. One of the research tasks is to describe the process of creating databases of these parameters.

All the parameters mentioned above calculated for each municipal authority and investigated sector combined all together create databases of investigated city. To sum up these parameters are:

1. $Sh_{i,j}^K$ – shares;

2. $LQ_{i,j}^K$ – location quotients;

3. G_i^K – growth;

4. HHI_i - Hirschmann-Herfindahl Index.

The scale of territorial analysis provides an ability to apply such methods for other large urban territories with population over one million citizens and area more than one thousand square kilometers. Our investigation is based on comparison between the properties of municipal authorities (which consist of sites) and objects that are expected to be placed in urban area. In this case we can formulate 3 types of tasks:

- Municipal authority – object (which considers municipal authority as an input factor and provides suiting objects as an output on the basis of municipal authority parameters);
- Object + municipal authority (which compares parameters of the given municipal authority and object as an input factor and provides conclusion about their compatibility);
- Object – municipal authority (which considers object as an input factor and provides suiting municipal authorities on the basis of object properties).

While the 4 object parameters mentioned above are represented by numerical values the suitability of the sites (or a number of sites united in municipal authority) for a certain type of construction is a logical parameter of the object. We aim to identify the relation between suitability of the site and numerical parameters of the site in 3 different cases descried above.

Some examples of approaches in case of site selection are already described in investigations of one of the authors, Vladimir Badenko, Nikolay Arefiev [14–16] and W. Nann [17]. The significance of economical aspect and financial risks in real estate projects is also highlighted in the investigations of our colleagues [18]. Still such modern type of construction as rental houses are not mentioned in the previous works. Valuable contribution in the tasks of site-selection is also made by Jacek Malczewski [19–21] whose experience is also taken into account in this work. Some solution on the intersections of decision-making and site-selection cases may be found in his articles. As we focused on the real estate analysis our investigation is also based on some researches of this market provided by our colleagues [22–26]. The concept of site selection as a part of rational development process also relates to value-oriented management of investment and housing projects investigated by our colleagues [27].

As a result we find it necessary to identify the weaknesses of research in order to formulate and understand further researches that are necessary in this area. All the results concerning Saint Petersburg territories are represented in this article only as an example in order to explain the application of obtained databases in real case.

2. Methods

Analytical method of this research deals with interpretation and analysis of data related to municipal authorities of the city in order to evaluate economic parameters for the sites and to make conclusion of the site suitability during site selection process.

The source of data that can be used in developing this methodology varies due to the territory. In Europe the data is well-organized and available in Eurostat for all the regions while the Russian analogue is Rosstat. It is based on the employment statistics in territories. The following data is available for all the Russian cites and can be applied for each region. For example in the boundaries of Saint Petersburg there are 111 city municipal authorities: 81 municipal districts (some of them have names, some are called by numbers), 9 cities (Zelenogorsk, Kolpino, Krasnoe Selo, Kronstadt, Lomonosov, Pavlovsk, Peterhof, Pushkin, Sestroretsk) and 21 settlements. Databases both in Europe and in Russia are normally classified also according to the industries. In case of Russian statistics databases divide employment in following Industries:

- Industry A: Agriculture, hunting and forestry;
- Industry B: Fisheries, fish farming;
- Industry C: Mining;
- Industry D: Manufacturing Processes;
- Industry E: Production and distribution of electricity, gas and water;
- Industry F: Construction;
- Industry G: Wholesale and retail trade; repair of motor vehicles, motorcycles, household goods and personal items;
- Industry H: Hotels and restaurants;
- Industry I: Transport and Communications;
- Industry J: Financial activities;
- Industry K: Real estate transactions, leasing and provision of services;
- Industry L: Public administration and military security; social insurance;
- Industry M: Education;
- Industry N: Healthcare and the provision of social services;
- Industry O: Provision of other communal, social and personal services.

In order to clarify the application model in our investigation we focused on two main industries connected with rental house type of construction: K (real estate transactions, leasing and provision of services) and H (hotels and restaurants). The last only partly gave us representation of renting activities in the sector because we were interested only in hotel business employment, not restaurant. It also proves that Russian statistics databases do not provide actual information for such type of business activities yet. More detailed and focused data could have given more exact results and conclusions about municipal employment statistics.

On the basis of employment data we have an ability to calculate a number of parameters for investigated municipal authorities. If $E_{i,j}^K$ is employment in industry K, municipal authority i, year j then appropriate share is equal

$$Sh_{i,j}^K = \left(\frac{E_{i,j}^K}{E_{i,j}^T} \right) \tag{1}$$

where T stands for Total sum of the industries.

The created database of shares for each year, municipal authority and industry allowes us to calculate location quotients which represent a measure of relative specialization by comparing the degree of municipal authority specialization taking Saint Petersburg as reference:

$$LQ_{i,j}^K = \left(\frac{Sh_{i,j}^K}{Sh_{S,j}^K} \right) \tag{2}$$

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where S stands for reference municipal authority (Saint Petersburg) representing data for the whole employment statistics of the city.

In order to investigate growth for the past six years an useful tool is Shift and Share Analysis. Growth G_i^K for each industry and municipal authority can be calculated as follows:

$$G_i^K = \left(\frac{E_{i,2016}^K}{E_{i,2011}^K}\right) - 1 \tag{3}$$

In addition in order to make some conclusions about specialization intensity for different part of the city we have calculated The Hirschmann-Herfindahl Index. We used the freshest data available, so this index represents situation in 2016 year:

$$HHI_i = \sum_K \left(Sh_{i,2016}^K\right)^2 \tag{4}$$

Analysis of created databases and comparison of the calculated parameters for different municipal authorities give the researcher an opportunity to evaluate economical suitability of each site during site selection process. As a result it is possible to formulate recommendations for selection of the most rational site for rental house or any other specific type of construction with its specific properties.

Another possible method that can respond to the need of a decision needs process must be retrieved from different disciplinary fields, fields that already responded with proper methodologies to the need of understanding: "what user want". Kano model is part of a general strategy for assessing quality in manufacturing environment, starting from the assumption that is possible to provide a precise definition of what the potential customer wants. Application of this model is a current plan for the future research in this field.

3. Results and Discussion

All the collected data and all the calculations can be formed in a database. For each numerical parameter mentioned in the previous chapter we have a table in three dimensions: location (111 municipal authorities in case of Saint Petersburg in total), time (we collected as much data available as possible for the last six years) and industry (the full list is mentioned in the introduction). All the examples mentioned below are just pieces of information that was valuable for us in context of site-selection task for rental home.

The example of shares analysis is represented on the Figure 1. In order to form this graph we cut the comparison between Saint Petersburg and only one of the 111 municipal authorities mentioned in the database. This data can be found in the Table 1.

Table 1. Employment shares in MO "Akademicheskoye" and Saint Petersburg

| Industry		Saint Petersburg	MO "Akademicheskoye"
Agriculture	A	0.002747948	-
Fisheries, fish farming	B	0.000209577	-
Mining	C	0.000980395	-
Manufacturing Processes	D	0.153864461	0.061920173
Energy	E	0.025424909	-
Construction	F	0.041754879	-
Wholesale and retail trade	G	0.106701781	0.010248112
Hotels and restaurants	H	0.019455867	0.008144552
Transport and Communications	I	0.107680045	-
Financial activities	J	0.035154973	-
Real estate	K	0.146704026	0.147572816
Public administration	L	0.061593668	0.014131607
Education	M	0.141012052	0.466450917
Healthcare	N	0.113000463	0.216990291
Other	O	0.043714958	0.074541532
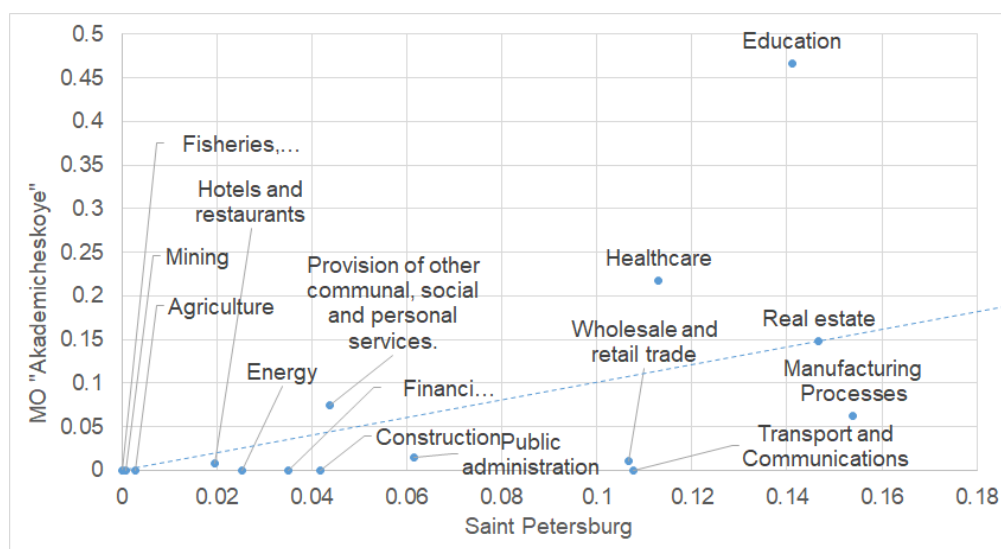
Figure 1. Shares of MO "Akademicheskoe"

This example represents a decision for the first type of tasks mentioned in the introduction (Municipal authority – object). All the industries that are situated above the bisecting line represent higher employment share than the reference area (Saint Petersburg). Assuming that we are interested particularly in municipal authority "Akademicheskoye" we can make conclusion about the industry that dominates and suppose that this region is more predisposed for such types of business activities as education and healthcare. It leads to the consequence that this municipal authority suits more for selection of the sites for types of construction connected with education or healthcare. Still one of the industries we are interested in (real estate) lies on the bisecting line thus representing normal employment for Saint Petersburg). Hotels and restaurants is slightly lower than the bisecting line. This information gives us a signal, that Akademicheskoye is not the most favorable municipal area for rental house construction. At the same time we can make conclusions that selection of sites for types of construction related to Manufacturing processes, wholesale and retail trade or public administration may be not rational due to the shares statistics of this part of the city. This leads us to conclusions about logical parameter of investigated object which is suitability of the site for specific type of construction.

The fact that some of the industries perform zero shares may be explained by lack of data about employment in these industries in Russian statistics databases.

The location quotients of the industry that we were interested in during our investigation is represented below on the Figure 2.

This graph represents a decision for the third task that is mentioned in the introduction. On the basis of Saint Petersburg example we were given real estate industry and hotels and restaurants industry as input factors. The numbers from 1 to 111 represent 111 municipal authorities in the same order that is provided by Rosstat. The graph mentioned above provides an ability to make conclusions about municipal authorities that are favorable for such type of construction. By analyzing such numerical object parameter as location quotient for two investigated industries and determining municipal authorities on their intersection we could postpone which of them suit for selection of the site for rental home type of construction linking numerical parameters of the site to its logical parameter which is suitability for specific type of construction.

Some of the municipal authorities have not provided information about 2016 year yet. That is why we can find some points on the horizontal axis in this example.

Shift-share analysis is represented on the following Figure 3. In order to form this graph we cut the comparison between Saint Petersburg and only of the 111 municipal authorities mentioned in the database. This data is presented in the Table 2.
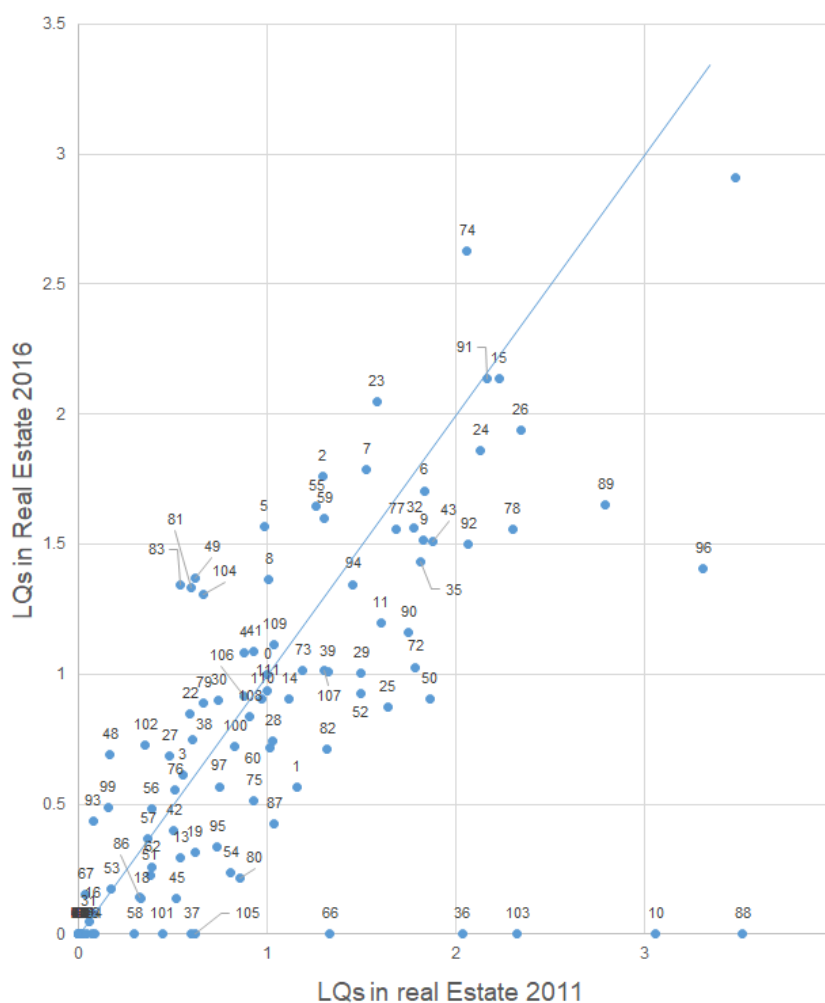
Большаков Н.С., Баденко В.Л., Челани А. Выбор участка строительства на основе методов территориального анализа // Инженерно-строительный журнал. 2018. № 5(81). С. 15–24.

Figure 2. LQ development in real estate 2011-2016

Table 2. Change in employment shares in MO "Akademicheskoye" and Saint Petersburg

Industry		Saint Petersburg	MO "Akademicheskoye"
Agriculture	A	-0.281708449	-1
Fisheries, fish farming	B	0.378504673	-
Mining	C	2.942857143	-
Manufacturing Processes	D	-0.001935493	0.654178674
Energy	E	-0.099333082	-
Construction	F	-0.02891415	-1
Wholesale and retail trade	G	0.124342169	-0.086538462
Hotels and restaurants	H	0.174659003	0.424528302
Transport and Communications	I	0.00785967	-
Financial activities	J	0.023094258	-
Real estate	K	0.102444597	-0.151890887
Public administration	L	-0.080731182	-0.15483871
Education	M	-0.035599932	0.317088029
Healthcare	N	0.038325456	0.058962885
Other	O	0.026850678	1.592870544

Bolshakov N.S., Badenko V.L., Celani A. Site-selection on the basis of territorial analysis methods. *Magazine of Civil Engineering*. 2018. 81(5). Pp. 15–24. doi: 10.18720/MCE.81.2.
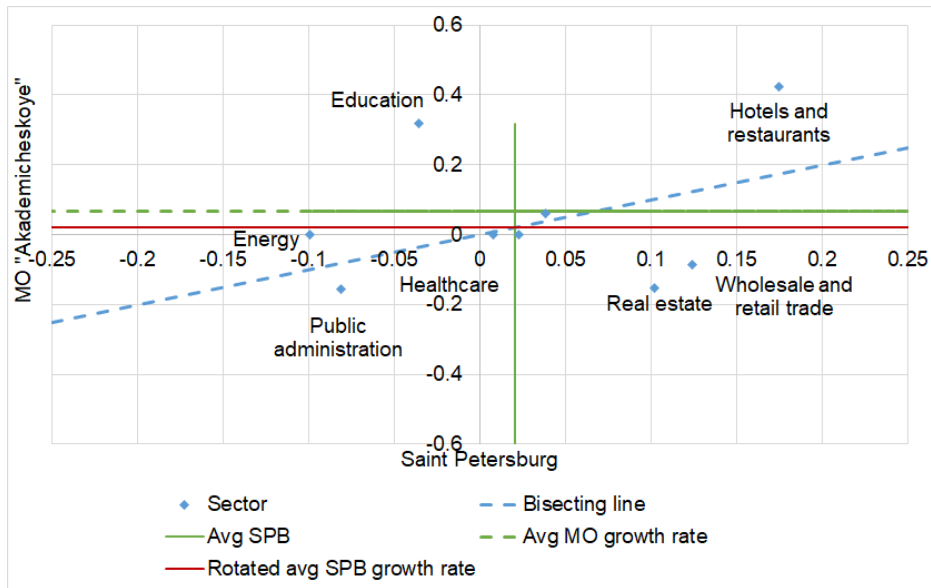
Figure 3. Shift-share analysis for MO "Akademicheskoe"

For all the determined municipal authorities and the industries we are interested it became possible to solve the second type of the tasks mentioned in the introduction. By considering them both as an input factor and using Shift-Share Analysis Chart as an instrument we can analyze the growth rate for the last 5 years comparing to the whole territory of Saint Petersburg which was chosen as a reference area. As we can see the hotels and restaurants industry performs growth rate higher than Saint Petersburg average and higher than this industry on the whole territory of the city.

Hirschmann-Herfindahl Index analysis is represented on the Figure 4.
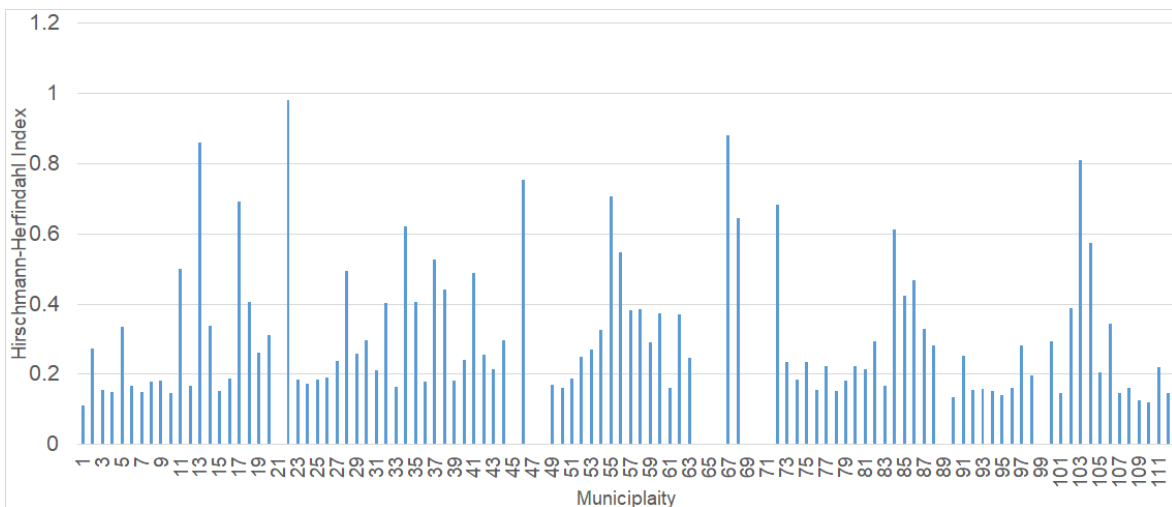

Figure 4. Hirschmann-Herfindahl Index for Saint Petersburg municipal authorities

The created databases also provide possibility to analyze intensity of municipal authorities specialization by the Hirschmann-Herfindahl Index which is another numerical parameter of investigated object. The closer it is to 1, the higher specialization of the regions in partcular industries. For example if we consider municipal authority "Akademicheskoye" we will find out that its Hirschmann-Herfindahl Index is approximately 0.3 which is a bit above average. We can explain it by the fact that this area is more specialized in education industry.

The application of the method presented in this paper, combined with the Quality Function Deployment techniques can cover almost all the complexity of the topic and completing the pattern of decision support tools for the Engineer and the project leader. The definition of the needs of the potential user is the natural complement of the research, driven to understand the potential offer in an area to rate the success of an operation in an ex-ante approach.

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21

4. Conclusions

1. The created databases of such numerical parameters of the urban sites as shares, location quotients and employment provide an ability link economical characteristics of the sites with their suitability. In our particular research we determined some areas of the city which may be selected as the site for such type of modern construction as rental houses by linking them to suitability of the site which is a logical parameter of investigated object. The technique proposed in the article is applicable for any large urban area in Russia as the Rosstat data is available. Following points refer to Saint Petersburg application in order to clarify kind of conclusions that might be identified.

2. Considering municipal authority as an input factor it is possible to provide the most suitable objects as an output on the basis of municipal authority numerical parameters. In this case it is necessary to analyze the most suitable sectors for fixed location according to database. In the introduction this task was mentioned as "municipal authority – object". The higher share in relation to reference area is represented by the municipal authority – the higher suitability of this municipal authority for relative type of construction. Visually suitability refers to the sectors which lie above the bisecting line in the shares graph.

3. Comparing parameters of the given municipal authority and construction object type as an input factors in shift-share analysis becomes possible by analyzing economic parameters of given municipal authority and sector in the related database. As a consequence it is possible to make conclusions about site suitability of the object related to particular sector in particular urban area. In the introduction this task was mentioned as "object + municipal authority".

4. An ability to choose the most suiting areas among 111 municipal authorities is provided as we were given two industries as an input factor by analyzing increase of location quotient for the last 5 years choosing the sites where this parameter is the highest. Than we analyzed selected areas more precisely in the context of particular industries with the help of shift-share analysis. All the calculated coefficients may be used as indicators in the general task of site-selection which describe economical rationality of decision-making and thus site suitability. As a result we could make conclusions that such municipal authorities of Saint Petersburg as "Adimiralteyskiy", MO 7, "Smolninskoye" perform good parameters on the intersection of real estate and hotel industries thus suiting more for rental home types of construction. This is a clear example of the third task mentioned in the introduction which is the main (object – municipal authority, which considers object as an input factor and provides suiting municipal authorities on the basis of object properties).

5. One of the weaknesses that we faced during our investigation was imperfection of databases. Some information was unavailable or not updated. The results of researches also strongly depend on the reliability of data used. The lack of content in Rosstat databases only proves the actuality of regional analysis of economical activities in Saint Petersburg. Scientific society doesn't even have an access to initial statistics about employment, labor and some other statistical data which can be used for site-selection investigations while identifying economic parameters of urban sites and municipal authorities in general.

6. In further research it will be assessed the side of the supply/demand equilibrium, understanding with qualitative-quantitative way the potential demand for the built object and the area, this typology of tools helps the researcher to overcome the market failures, or lowering the market risk of built objects, It can be studied in parallel with similar researches the possibility to adapt Kano model to the study case, providing to Engineers and Project leaders technical information for a project able to understand the market needs as well, giving completeness to the overall design.

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