Housing cost dependence on transport accessibility territory of industrial city

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Abstract. The study the housing cost dependence on the transport accessibility of the territory of the city will improve the efficiency of the route network and will lead to a reduction in overall transportation costs. The research algorithm consisted of the following stages: data on transport accessibility were systematized; calculation of time costs assessed transport accessibility by city zones; the dependence of the cost per square meter on the time cost of movement is obtained. When assessing the impact of transport accessibility on the housing cost it is important to pay attention to the remoteness from the central part of the city, the proximity of highways, the system of access roads; the proximity of public transport stops with a large number of routes connecting different zones. The study was conducted on the example of the city of Angarsk, the reliability of the obtained results confirmed by generally accepted statistical criteria was substantiated. The availability of tools to conduct a detailed and accurate assessment of accessibility is one of the most important scientific studies in the framework of transport planning now.

1. Introduction

As part of ensuring urban development, a comprehensive and sustainable development of territories is proposed, aimed at ensuring safety and favorable conditions for human life, limiting the negative impact of economic and other activities on the environment and ensuring the protection and rational use of natural resources in the interests of present and future generations. In this regard, the priority issue is the development of public passenger transport systems and green mobility (that is, non-mechanized movements).

The priority development of public passenger transport systems is ensured by both technical solutions and urban planning. In modern foreign urban planning theory and practice, the most common urban planning decisions that ensure the priority development of public passenger transport systems include:

• multifunctional use of the territory (mixed-use development), which reduces the need for movement over long distances;
• territorial planning focused on public passenger transport (transit oriented development), including the formation of an attractive and comfortable environment in which public passenger transport infrastructure is located;
• increasing the intensity of use of territories adjacent to the corridors of public passenger transport.

With improving the availability of public passenger transport, the attractiveness of the territories increases, which causes a concentration of service sector institutions and places of employment.

In the world practice of urban planning, the accessibility of a territory is determined by the following factors: transport accessibility of territories; availability of all necessary services; the presence of a sufficient number of public spaces.

In construction, transport accessibility is a normative indicator of the time spent on transport links between different points within the group settlement systems. When designing city streets and roads, one of the key parameters determining the quality of a city’s road network is the trip time between any two points of the city [1].

On the transport side accessibility is the total time spent on travel committed for any purpose (travel to the place of work, travel on cultural and domestic purposes).

Transport security of urban and regional territories is used as one of the economic characteristics. Improving transport infrastructure is an important mechanism for implementing regional policies. Its rational use allows reducing imbalances in the territorial development of various areas of the city and the country as a whole, and increasing the attractiveness of remote and sparsely populated territories [2, 3].

However, improving transport infrastructure affects the housing cost in this area. For example, the cost of an apartment in the city of Moscow near metro stations can differ by an order of magnitude from apartments located at a sufficient distance with a similar type of housing development. The recent opening of the Central Moscow Diameter has already led to an increase in housing prices by an average of 13%. In this regard, it is important to have tools for calculating and forecasting the cost of housing based on the transport accessibility of the territory. This article presents a study of the impact of transport accessibility on the cost per square meter of housing on the example of an average city (Angarsk).

The city of Angarsk plays a crucial role in the structure of interregional transport corridors, providing links between the European part of Russia and Western Siberia with the regions of the Far East. The territory of the Angarsk urban district is spatially heterogeneous is characterized by various socio-economic, infrastructural and environmental conditions that determine the main directions and functional priorities for the development of the territory [4]. The Angarsk city district plays an important role in the economy of the Irkutsk region and makes a significant contribution to the development of the region’s competitive potential. Underestimation of the problem of determining transport demand and the compliance of local infrastructure with the socio-economic needs of society is one of the causes of economic difficulties and negative social processes. The development of the transport infrastructure of the Angarsk urban district is a necessary criterion for improving life quality of residents.

2. Theoretical basis

There are various approaches to assessing transport accessibility. One option is to define accessibility indices. Consider some of them [5-8]:

• single, arbitrary accessibility indices based on the selected landmark. These indices show the dependence of transport costs on income and take into account the minimum wage set for regions or countries. In such cases, the goal is usually to determine accessibility for low-income regions. In practice, the option is most often used when transport costs should not exceed the threshold of 10% of income. This regulatory approach, by the way, has become the standard in many countries.

The accessibility index is estimated using equations (1.2) [7]:

\[ A_{ff} = \frac{E_{pt}}{Y} \times 100 \]  

(1)

where \( E_{pt} \) – is the monthly cost of public transport; \( Y \) – is the monthly income of the family.

\[ A_{ff} = \frac{50p_{pt}}{Y_{min}} \times 100 \]  

(2)

where \( p \) – is fee on public transport and \( Y_{min} \) – is the minimum wages. Minimum wages are taken into account for a deeper analysis of affordability in low-income regions. The accessibility index
includes 50 public transport rides relative to revenue. Based on the concept of a fixed number of monthly trips, it is proposed to take transportation costs as a third (33%) of the minimum wage.

To find out what proportion of the total transport costs Blumenberg took into account all the costs involved.

The accessibility index is estimated using equation (3):

\[ Aff = \frac{Et}{He} \]  

where Et – monthly transportation costs for all modes of transport, He – represents the monthly expenses of the family.

Studies by Blumenberg (2003) – A comparison of transport accessibility in low – and high-income areas, with the aim of estimating transport costs in different countries / regions. The disadvantages of individual accessibility indices can be considered that conducting research in areas / regions with different income levels can give conflicting results. For example, in America, low-income people are more likely to use private transportation; this pattern is characteristic only for this country. In other countries, low-income people are more likely to use – public transport.

• multicriteria accessibility indicators take into account synthesized and factors capable to measure transport accessibility by alternative methods. In developing countries a fixed travel basket is proposed be used to calculate the accessibility index.

The accessibility index in this case represents the average cost of travel in public transport for a certain trip duration and the estimated minimum number of monthly trips.

The accessibility index used by Carruthers (assumes that an employee requires a package of 60 trips by public transport per month):

\[ Aff = \frac{60 \times p}{Y_{pc}^{avg}} \times 100 \]  

where \( p \) – fee in public transport, \( Y_{pc}^{avg} \) – mean income per head.

Other tools are necessary for a qualitative assessment of transport accessibility, since the use of accessibility indices alone is insufficient.

The planning structure of the city remains relevant in terms of the formation of prospective residential buildings in the southwestern part of the city of Angarsk, as well as in the formation of new quarters of medium, low-rise and individual residential buildings in the southern and western parts of the city. First of all, construction envisages the development of territories through the construction of multi – storey residential buildings in the western part of the city in microdistricts 31 and 35 and in the eastern part of the city in blocks 256, 257, 258. The development of the Novyy – 4 microdistrict is proposed taking into account the planned location of the bus station and recreation area near Elovsky reservoir.

The central position of the main residential territory of the city of Angarsk is emphasized by established industrial zones located along its southeast, south, southwest and western periphery. At the same time, between them and the residential territory, new green-sized sanitary gaps that are significant in width are preserved and are formed, providing ecological and aesthetic comfort of the residential territory. In addition, these landscaped sanitary gaps will fulfill an important function of aeration corridors – «ventilation» corridors.

The basis of the road network of the Angarsk urban district is the need to ensure stable, maximum safe and short connections of places of resettlement, places of employment and recreation.

One of the important tasks in assessing transport accessibility is transport zoning. Transport zoning is a way of dividing an urban area according to its goals. For its implementation, the following data are required:

• population of each transport region;
• cartographic material;
• location of the main objects of the city network (industrial – production facilities, housing estates, places of employment, objects of socio-cultural purpose);
• list of streets and characteristics of the carriageway received from utilities and road organizations;
• traffic management schemes on a street-road network;
• accessibility of land use;
• transport charges;
• transport and operational indicators.

Transport zoning has two main characteristics: the number of zones into which the territory can be divided, and their dimension. The more zones, the smaller their size. During the survey, the number of zones is selected depending on the objectives of the study and the required accuracy of the results.

When performing transport zoning, the following rules should be followed:
1. It is necessary to consider the transport and pedestrian accessibility of the territory within the zone.
2. When determining the boundaries of the zone, it is necessary to combine the choice with the administrative boundaries (if any). In this case, it is possible to use the available statistical information.
3. The choice of zones should take into account the territories of one purpose: (residential, industrial, recreational).

Transport zoning is a necessary procedure for modeling a network. When choosing zones, one must focus on the rules above and find a compromise between time and level of detail.

In this study, to solve the tasks posed by assessing transport accessibility and its impact on housing cost, we select zones in such a way that development covers a sufficiently large area, for example, several residential quarters / microdistricts. When dividing into zones, we try to take into account the type of development (areas with large housing stock, areas with 2- or 3-story buildings with wooden floors, one – story buildings).

Figure 1 shows the results obtained from the study.

![Figure 1. Transport zoning on the example of the city of Angarsk](image)

One of the possible methods of processing the data obtained in the framework of the study is the calculation of the recovery of the time-cost matrix, which will determine the transport accessibility of the city's districts. The calculation of the values of transport accessibility was carried out using the software product PTV «VISUM» [9]

Next, we will analyze each zone separately and get the average time spent on moving around the zone (Figure 2). The following groups were identified: high availability up to 13 min.; average availability from 13 to 17 min.; low availability over 17 min.

As a result of the survey, the following conclusion can be made, the zones with the lowest availability are zones No. 1-5, 9, 11-13, 18-24, 28. The average availability at zones No. 6, 7, 26. High availability at zones No. 8, 10, 14, 15, 16, 17, 25, 27, 29.

The time spent in cities with a population of 227 thousand people for moving from places of residence to places of work in accordance with the normative indicator should not exceed 35 minutes. [10].
The data obtained allow us to assess the impact of transport accessibility on the cost of 1 square. m. of residential premises. Alternative options for determining the connection of transport accessibility with the cost of sq.m. practically does not exist, since this is one of the main parameters of the formation of housing cost. After analyzing the real estate market of the city of Angarsk, by reviewing the cost of sq. M / r on the sites avito.ru and domclick.ru, which are currently one of the most popular electronic sites for the sale of housing, the average cost of 1 sq. m for 2020. The dependence of pricing policy on zonal division is clearly shown in Figure 2.

![Figure 2. Distribution of transport accessibility by zones in the city of Angarsk](image)

When assessing the impact of transport accessibility on housing costs, it is important to pay attention to a number of aspects [11-16]:

- remoteness from the central part of the city;
- proximity to highways;
- developed system of access roads;
- the proximity of public transport stops with a large number of routes connecting different zones;
- the presence of parking spaces, parking lots or garage cooperatives;
- proximity to places of cultural and social purposes (kindergartens, schools, medical centers, supermarkets);
- exposure to noise, vibration and exhaust gases.

Most often, in studies on this topic, the authors focus on assessing the distance from the city center, since all the main objects of gravity are concentrated there. Transport accessibility is measured by the time required to travel from a specific point in the city to the outer borders of the central region. Accessibility ranking allows you to create a reasonable zoning of the city.

As the level of transport availability decreases, there is an increase in the cost of travel to the central part of the city and the cost per square meter will gradually decrease.

The analysis showed that housing located in zones No. 8, 10, 14, 15, 16, 17, 25, 27, 29 will have the highest level of comfort in terms of transport accessibility, the least comfortable residential buildings located in No. 1-5, 9, 11-13, 18-24, 28 zones (Figure 3). Accordingly, the location of the object will determine their value.
However, it is worth noting that, despite the fact that the transport zones No. 6, 7, 26 have average transport security, the cost of one square meter is more than 33 thousand rubles, this is due to the fact that the buildings are mostly elite, and people living in that area use private transportation.

Based on the analysis of the average market value of one square meter, we can conclude that the most attractive are residential buildings located in the central part of the city.
Based on the analysis, the dependence of time costs for movement and the cost per square meter of residential real estate in the city of Angarsk was revealed. For a functional explanation of the dependence of the cost per square meter on time spent on moving for labor purposes, a trend line was drawn and the equation of this line was obtained (Figure 4).

With the increasing remoteness of the residential building from the geographical center of the city, the level of transport accessibility of the territory decreases, and as a result, the cost of one square meter decreases. So, in particular, the difference in the housing costs in the area with the best transport accessibility is higher by 28% than in the remote territory.

Going beyond the boundaries of the geometric center decreases the value of the property. However, the value of the object increases due to the benefits of location (transportation hubs, objects of social attraction) and causes an increase in its value.

The validity and reliability of the results can be confirmed by representative sample sizes, verification of experimental results by generally accepted statistical criteria.

3. Conclusion
A scientific study dedicated to assessing the transport accessibility of the city, which allows to improve the quality of service of the transport network, and to use this data for operational management and transport planning, is relevant.

In the process of the study, rules were identified that must be followed when conducting transport zoning, indices that must be taken into account when assessing transport accessibility. The more data available are the higher the quality of the studies. The level of detail is determined independently; more often, several microdistricts / quarters of the same type and building series are included in the zone.

The need to ensure stable functional connections of the central residential territory with peripheral zones (centripetal connections), as well as the need to organize peripheral connections, create a spatial basis for the development and transformation of the existing transport and architectural-planning structure of the city of Angarsk.

Depending on the availability of data on incomes and expenditures of the population, the relevance of information on the organization of the road network increases, the possibility of obtaining the most realistic estimate of transport accessibility identifying areas that require development of a route network in order to cover it with urban passenger transport.

As a result, we can conclude that increasing the level of transport accessibility of the territory is one of the key factors of economic growth. The availability of tools to conduct a detailed and accurate
assessment of accessibility is now one of the most important scientific studies in the framework of transport planning.

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