The relationship between the housing cost and the transportation accessibility using the example of city Kemerovo

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Abstract. The research on the influence of transportation and urban factors and transportation time, in particular, on housing cost was done in the article. The methods of statistic analysis (Statistica; MS Excel packs) were used. The transportation mobility of city residents was characterized using city Kemerovo as an example. The model describing the influence of resident incomes and transportation time on the housing cost was designed.

1. Introduction

Due to the city development and the formation of new resident areas, the term of housing affordability has become urgent. Traditionally, housing affordability reflects only the cost of 1 square meter of housing which varies depending on a city district. Rational housing location allows gaining such planning aims as reducing transportation expenses, thus, influencing the financial state of citizens, decreasing risks of road accidents, reducing energy requirements and environment pollution [1].

Transportation costs mainly depend on housing values and are an important factor for the estimation of the city transport system but do not reflect traditional indexes of housing affordability. The hidden transportation costs affect millions of families. Such expenses include transportation costs (e.g. public transport fares and private transport expenses) and transportation time expenditure and affect the opportunity of getting higher education, commuting and traveling.

Transportation demand is known to be estimated and modeled by the level of residents’ circulation between different city districts [2-4]. The level of residents’ circulation using various means of transport has always been discussed a lot while examining the city transport system. Family incomes, the number of family members and the availability of private transport have been considered major independent variables. Transportation accessibility can also be an integral part of trip frequency analysis as trip frequency depends on transportation accessibility and the level of transport service [2, 5].

2. Materials and methods

The so-called Housing and Transportation (H+T®) Affordability Index, considered in foreign literature, provides insights into the affordability and estimates housing values as well as transportation costs [6, 7]. Taking into consideration total expenditure on housing and transportation, the index (H+T®) provides a more complete analysis of area affordability in general. Thus, it allows us to define districts requiring additional development of transport system or rational planning of district housing.

Traditionally, housing is considered affordable if its cost doesn’t exceed 30% of family incomes; however, transportation costs are the second in terms of the value for the budget of an average family
[8, 9]. Total expenditure on housing and transportation provides an enhanced picture of housing affordability. Figure 1 shows the areas of housing affordability in the United States of America taking into account and regardless of transportation accessibility [10].

![Figure 1. The areas of housing affordability: (a) without taking into account transportation accessibility; (b) taking into account transportation accessibility.](image)

Obviously, taking into account transportation accessibility gives a greater appreciation of the attractiveness of particular city districts.

The research, carried out by the Automobile transportation department of Kuzbass State Technical University [11-13], shows that average cost of 1 square meter of housing in the allocated city districts ranges from 30,000 to 54,000 rubles (Figure 2).

![Figure 2. The cost of 1 square meter of housing and the average daily transport mobility in the allocated districts of city Kemerovo.](image)

The link between the housing cost and the distance from the city centre is apparent in the figure. According to paragraph 11.2 of 42.13330.2011 “Urban development. Planning and construction of urban and rural settlements”, commuting time (one way) shouldn’t exceed 37 min. for 90% of working residents in cities where population is 500 thousand people. The commuting time for Kemerovo residents (558 973 thousand people [8]) shouldn’t exceed 37.35 min. According to the survey, the
average commuting time is 23.95 min., however, transportation time corresponds to the standards only for 65.42% residents.

The dependence of housing cost on transportation time in Kemerovo is shown in Figure 3. The derived function is presented as a second-degree polynomial trend line.

\[ y = 0.072x^2 - 0.6515x + 46.729 \]
\[ R^2 = 0.8102 \]

**Figure 3.** The dependence of housing cost on transportation time.

It is obvious that the highest housing cost in Kemerovo is in the districts, attractive in terms of transportation accessibility, and it goes down as the transportation time increases. The lowest housing cost is when the transportation time is 50 min. With further increase in transportation time, the housing cost rises due to the availability of elitist accommodation and country houses in remote districts and suburbs.

Figure 4 represents the transportation time from the particular districts to the city center and the cost of 1 square meter of housing. The most attractive districts in terms of transportation accessibility in Kemerovo are Tsentralniy, Zavodskiy, FPK, Leninskiy, Predzavodskiy, Yuzhnii, Rudnichniy and Raduga. The transportation time from the districts to the city center doesn’t exceed 37.35 min., which corresponds with the requirements of paragraph 11.2 of Set of Rules 42.13330.2011 «Urban development. Planning and construction of urban and rural settlements» [14]. At the same time the average cost of 1 square meter of housing in the listed districts is much higher than the average cost in the city. The exceptions are Rudnichniy district where the share of old housing and private houses is higher and Predzavodskiy district with a high proportion of industrial enterprises, construction companies and transport companies. The terminals of interurban transport, such as an airport, a train station and a bus station which significantly lower the cost of 1 square meter of housing are located in the territory of the district.

The residents of such districts as Shalgotaryan, Krutoy, sh. Severnaya, Kirovskiy and Kedrovka spend more than 37.35 min on their way to the city center. Notably, Raduga district is more remote from the city center than MZhK, but the transportation time for its residents is less. It is caused by a high share of private transport and the availability of a bypass. The housing cost in the mentioned above districts isn’t high and is lower than the average housing cost in the city. The exception is Shalgotaryan where new micro-districts are being built and MZhK where housing is relatively new.
Taking into account transportation and housing accessibility, we can make a conclusion that the most attractive districts in Kemerovo are Zavodskiy, FPK, Leninskiy and Yuzhniy.

\[ C = 46.3 - 0.0054x_1 - 0.027x_2. \]  (1)

The cost of 1 square meter of housing is 83.8% explained by the variation of factors. The coefficient of 1 square meter determination on the linear combination of factors is 0.7. The verification of the model is done by comparing actual and table values of the Fisher index. The actual value exceeds the critical one \( F = 2679.1 > F_{95\%} = 2.4471 \) . Thus, the equation is proved to be statistically significant. The value \( F_{sign} = 0 \) indicates the probability of \( F_{att} \) as attitude with numerator 2 and denominator 4471, having the value of 2679.1 and higher. The probability is lower than 0.05, thus, the null hypothesis can be rejected with the statistical significance of 5% and the alternative hypothesis that, at least, 1 coefficient of regression is not equal 0 can be taken.

The estimated values of t-criterion on the module are higher and those given in the table in all considered cases. This, the module coefficients are significant (Table 1).
Table 1. Analysis of variance

| Factors | $t_{estimated}$ | $t_{critic.}$ | p-value | Lower 95% | Upper 95% |
|---------|----------------|--------------|---------|-----------|-----------|
| $Y$     | 2152.003       | $F_{95 : 4469} = 1.96$ | 0       | 46.26249  | 46.34685  |
| $x_1$   | -2.0051952     | 0.04500238   | -0.01074 | -0.00012  | -0.00012  |
| $x_2$   | -73.051992     | 0            | -0.02789 | -0.02643  | -0.02643  |

The probability of t-value exceeding or equal the absolute value is less than 0.05 in all considered cases which indicates the necessity of taking an alternative hypothesis, i.e. all variables in the designed model have statistical significance.

4. Conclusion
According to the analysis results, the housing cost in the allocated transportation areas ranges from 30,000 rubles to 54,000 rubles for 1 square meter. The dependence of housing cost on the transportation time has been derived. The housing cost in the districts with low transportation accessibility is much lower than in the districts which are attractive in terms of the level of transportation accessibility. The model estimating the impact of resident incomes and transportation time on the housing cost has been designed. The obtained results can be used in transportation and urban planning.

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