System approach to the evaluation of a consumer appeal for the objects on the secondary housing market

S Yu Kalashnikov*, A E Godenko, Yu S Kalashnikova, I A Tarasova
Volgograd State Technical University, Lenin avenue, 28, Volgograd, Russia

E-mail: kalashnikov@vstu.ru

Abstract. A real property item of the secondary housing market is presented in a form of a multilevel hierarchical structure. An overall evaluation of a consumer appeal for the object under the study is carried out in terms of the chosen key indicators of housing appraisal with an application of the theory of quality, which is based on the quasi-arithmetic functional mean proposed by Kolmogorov-Nagumo. The elaborated methodology allows customers to choose the best variant of a real property item taking into account architectural and constructive decision of a building, usage of construction and finish materials, accessibility of urban and transport infrastructures, ecological area, as well as personal preferences.

Introduction
Topicality of the intensive functioning and development of the secondary housing market is determined by commercial attractiveness (due to the diversity of variants) of this segment in a real estate market. Considering offers on the secondary housing market, a potential customer faces the necessity to solve a classical problem of system analysis – the problem of making decision in conditions of low formalized information. The problem-solving process is limited to a choice of one of the alternatives from a certain proposed set. To make this choice it is necessary to appraise each alternative on the basis of a well-defined aim and chosen criteria.

Fairly large number of the approaches such as paired-comparison method Saaty, the method of building general Harrington’s desirability function, the method of regret function building – Taguchi methods and others have been worked out in order to solve the problem of finding the quality of a complex object [1,2,3,4].

In the present work the methodology for quantitative evaluation of an end-use performance of the real property items (flats) based on the theory of qualities, which has been successfully applied by the authors for evaluation of objects in tasks of mechanics, chemical technology and economics is proposed [5,6,7].

The flat’s general qualities can be presented in a form of a multilevel hierarchical system, which is composed of the particular qualities, stated by the experts, according to the levels of the hierarchy by their reduction in correspondence with the quasi-arithmetic functional mean proposed by Kolmogorov-Nagumo [8, 9].

The proposed method of analysis is similar to Harrington’s and Taguchi methods, but unlike them the quality of a system on a certain level is derived from the qualities on the lower system level as the quasi-arithmetic functional mean of Kolmogorov-Nagumo
\[ M(x_1, x_2, \ldots, x_n) = f^{-1}\left( \frac{1}{n} \sum_{k=1}^{n} f(x_k) \right) \]  

(1)

The functions of the particular qualities and moderation functions are chosen by the experts according to the analysis aims.

In the proposed approach “a failure” of quality in one parameter causes a bad quality of the whole system, even if all other parameters guarantee an excellent quality. And vice versa, an excellent quality of one parameter cannot ensure a good quality of the whole system (it is necessary to improve the quality of other parameters).

**Materials and methods**

The particular qualities represent any given characteristics of a residential property which are important for a customer as they give a possibility to imagine the expected level of living standards, connected with the purchase of a flat [10]. These characteristics include performance evaluations of construction solution and construction materials of the building in whole, special arrangement of a building and a flat, indicators of accessibility of urban infrastructure and transport, indicators of an environmental compatibility and provision of urban amenities.

An overall evaluation of the projected level of consumer appeal for a flat is presented in a form of a four-level hierarchical system (figure 1)

**Figure 1.** A hierarchical system of the quality evaluation of an object.

Total evaluation of the flat \( Q \) (the fourth level) is determined by the reduction of six integral qualities of the indicators of flat evaluation

\[ Q = -\ln \left( \frac{\alpha_1 \cdot e^{-Q_1} + \alpha_2 e^{-Q_2} + \alpha_3 e^{-Q_3} + \alpha_4 e^{-Q_4} + \alpha_5 e^{-Q_5} + \alpha_6 e^{-Q_6}}{\alpha + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5 + \alpha_6} \right) \]  

(2)

1) \( Q_1 \) – the quality, which characterizes base build design is specified in a following way

\[ Q_1 = -\ln \left( \frac{1}{9} \sum_{i=3}^{9} e^{-q_i} \right) \]  

(3)
Here the particular qualities $q_{1i} = \phi(p_{1i}), i = 1..9$ are specified by the parameters:

- $p_{11}$ – an overlap material;
- $p_{12}$ – material of loadbearing constructions;
- $p_{13}$ – heat-protective qualities of enclosure structures;
- $p_{14}$ – indoor engineering network;
- $p_{15}$ – garbage disposal;
- $p_{16}$ – interior finishing;
- $p_{17}$ – condition of enclosure structures;
- $p_{18}$ – year of construction;
- $p_{19}$ – waiting period of overhaul works.

2) $Q_2$ – an integral quality evaluation of the overall building design is specified by the parameters

$$Q_2 = -\ln\left(\frac{1}{4} \sum_{i=1}^{4} e^{-q_{2i}}\right)$$

(4)

The particular qualities $q_{2i} = \phi(p_{2i}), i = 1..4$ are specified by the parameters:

- $p_{21}$ – presence of lift;
- $p_{22}$ – type of floor layout;
- $p_{23}$ – presence of facade setting;
- $p_{24}$ – floor-to-floor height.

3) $Q_3$ – the integral quality evaluation of the space planning decision of a flat is specified as

$$Q_3 = -\ln\left(\frac{1}{9} \sum_{i=1}^{7} e^{-q_{3i}}\right)$$

(5)

where the particular qualities $q_{3i} = \phi(p_{3i}), i = 1..7$ are specified by the parameters:

- $p_{31}$ – storey of a flat;
- $p_{32}$ – type of sanitary conveniences;
- $p_{33}$ – kitchen space;
- $p_{34}$ – presence of walk-through rooms;
- $p_{35}$ – presence of integral rooms;
- $p_{36}$ – intervention in initial design;
- $p_{37}$ – presence of balcony.

4) $Q_4$ – the integral quality evaluation of the accessibility of urban infrastructures is specified in a following way

$$Q_4 = -\ln\left(\frac{1}{10} \sum_{i=1}^{10} e^{-q_{4i}}\right)$$

(6)

Particular qualities $q_{4i} = \phi(p_{4i}), i = 1..10$ are specified by the parameters:

- $p_{41}$ – proximity of a business center;
- $p_{42}$ – shopping facilities;
43p – presence of a car park;
44p – healthcare facilities;
45p – proximity of cultural and entertainment institutions;
46p – presence of educational institutions;
47p – facilities for physical education and sport;
48p – recreational institutions and areas;
49p – children’s playgrounds;
50p – prestige of a district.

5) $Q_5$ – the integral quality evaluation of the accessibility of a transport system is specified as

$$Q_5 = -\ln\left(\frac{1}{5}\sum_{i=1}^{5} e^{-q_{5i}}\right)$$

where the particular qualities $q_{5i} = \phi\left(p_{5i}\right), i=1..5$ depend on the following parameters:

$p_{51}$ – the quality of routes for public transport;
$p_{52}$ – the accessibility of public transport stops;
$p_{53}$ – the accessibility of stops for long-distance transport;
$p_{54}$ – a possibility of direct trips;
$p_{55}$ – a possibility to change different means of transport.

6) $Q_6$ – the integral quality evaluation of an environmental compatibility is specified in a following way

$$Q_6 = -\ln\left(\frac{1}{6}\sum_{i=1}^{6} e^{-q_{6i}}\right)$$

The particular qualities $q_{6i} = \phi\left(p_{6i}\right), i=1..6$ are specified by the parameters:

$p_{61}$ – gas pollution;
$p_{62}$ – noise pollution;
$p_{63}$ – vibrational pollution;
$p_{64}$ – electromagnetic pollution;
$p_{65}$ – insolation;
$p_{66}$ – presence of green areas.

In the overall evaluation of $Q$ the weighting parameters ($\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6$) of the integral quality indicators of the object $Q$, can take the value less than or equal to 1 depending on the degree of supposed importance of one or another group of the integral indicators.

Each of 41 indicators $p_{ij}$ is expertly assigned a numeric value on a three-point scale, where rating 0 implies complete discordance, 1 – partial discordance, 2 – full correspondence with a statutory value of the indicator or customers’ preferences.

After that expert property evaluations $p_{ij}$ were put in correspondence with the value of a particular quality $q_{ij}$ (by expert selection of the function $q_{ij} = \phi\left(p_{ij}\right)$), to be precise: a maximum value $p_{ij} = 2$ corresponds to $q_{ij} = 1$, acceptable value $p_{ij} = 1$ corresponds to $q_{ij} = 0, 25$. To avoid the general
quality of the system being unreasonably high due to other indicators, under the critical value of the quality $p_{ij} = 0$ the particular quality was assigned a negative value $q_{ij} = -0.5$.

**Results**

The proposed methodology was tested in the quality evaluation of two pairs of alternative flats with and without consideration for weighting parameters. Two-room flats $A_i$ were chosen arbitrarily in a prestige district of the city: the first one ($A_1$) is a modern variant, close to luxury standards, located on a border of the district; the second one ($A_2$) is a full-sized standard flat of the late 50-th in a historical centre of the city.

Three room flats $B_j$ were chosen in different districts of the city: the first one ($B_1$) with improved design in an outer-lying residential district, and the second one ($B_2$) – a typical flat of late 70-th in a microdistrict in 12-15 minute transport accessibility from the centre.

The results of the evaluations of the particular qualities of the integrated indicators and general quality $Q$ are presented in the tables 1 and 2.

**Summary**

1. The proposed model of housing evaluation allows to appraise the significance of the objective indicators, which characterize the level of a consumer appeal for a flat using a unified scale.
2. The presence of weighting parameters in the model makes it possible to take into account consumer preferences in order to choose the best variant.
3. The model can be quite easily changed by adding necessary consumer qualities or excluding obsolete ones.

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