Technologies of Development Decisions Making in Residential Civil Engineering

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Abstract. Intelligent technologies of grounding the development decisions for conceptual design of residential properties are suggested. The concept of the real estate property determines a set of properties that should be possessed by property, e.g., location, infrastructure, engineering equipment, decoration, layout, etc. The problem of conceptual design of residential real estate properties is considered taking into account the consumer appeal and end-user preferences. Are methods of modelling consumer preferences, allowing to form the shape of the future building, satisfying most of the needs and desires of the real estate market? The technology is represented on the example of a ten-story residential single-entry house, where the factors influencing the choice of consumers use location, structural features, technical equipment and decoration. The competitive advantage of the conceptual design is the direct economic effect that an investor and/or developer receives as a result of saving money for constructing and promoting an item on the market. An indirect, but no less significant, economic effect is the reduction of losses arising from the disruption of the sales plan. The demand for finished premises is provided due to the account of real consumer preferences and opportunities of market participants.

1. Introduction

Recently, activities in the field of real estate construction are generally called development [1], and the construction is understood as either the industry or directly the process of creating real estate. In this paper, we will talk about strategic decisions made at the pre-investment stage by developer’s activity participants – the developers. Since the concept of strategic decisions is quite general, to specify the decisions on which property to construct, we will call development decisions.

Designing and construction of residential property should be carried out considering consumer preferences [2] since the selection of housing is made on the basis of self-perception by the consumer of the housing quality properties. Therefore, at the pre-investment stage, even before designing a real estate item, it is worth considering the concept [1, 2] of the real estate property and taking into account the factors that influence the consumer choice.

The authors believe that the conceptual design [2, 3] of real estate properties is currently in demand and understood as front end engineering design, including marketing analysis [4-6] of the real estate market and identification of consumer preferences [7-11], as a result of which such a concept (appearance) of the future building or complex of buildings and structures, including external and internal infrastructure of the property that meets most of the needs and desires of end users.
Traditional design practices for the development of the project concept [12] are based on brainstorming methods that can take into account the opinions of the project team members and only indirectly – the real preferences of end users. Modern methods of mathematical modeling consumer preferences [13, 14] are provided to shape the future building, which meets most of the needs and desires of real estate market participants.

2. Methodology
If we consider real estate under construction as a multiparameter object described with the vector of properties (location, number of floors, finish, materials, area, etc.), then integrated estimation mechanisms can be used, for example, based on objectives (criteria) trees and binary convolution matrices [2, 15]. With the help of these or other mechanisms, it is possible to formalize the procedure for selecting by consumers the real estate items on the market and their utility function.

The matrix procedure of integrated assessment is based on reducing all the essential characteristics that influence the managerial decision making to a single scale of integrated assessment (to the criterial space with metrics). In the criterial space, the heterogeneous characteristics can be compared at a qualitative level. The convolution of qualitative criteria is performed by the formation of binary convolution matrices that describe the ratio of the preferences carrier to the pair of parameters to be convoluted. A complete convolution describing the functional relationship between the integrated assessment and a set of input criteria is described by a composition of binary packages [5].

In order to convolute heterogeneous parameters, it is necessary to reduce them to a single qualitative scale. For the purposes of this study, a four-point scale \{1, 2, 3, 4\} was used, each value of which has a qualitative interpretation: 1 - low attractiveness; 2 - average attractiveness; 3 - high attractiveness; 4 - very high attractiveness. A fragment of the descriptive scales of the factors that affect consumers when purchasing housing is given in Table 1.

| Interpretation                          | low attractiveness | average attractiveness | high attractiveness | very high attractiveness |
|-----------------------------------------|--------------------|------------------------|---------------------|-------------------------|
| Design features of the house            | IV group of solidity | III group of solidity | II group of solidity | I group of solidity      |
| House infrastructure                    | non-off-the-grid house, outmoded equipment | non-off-the-grid house, modern equipment | partially off-the-grid house, modern equipment | off-the-grid house, modern equipment |
| Improvement                             | shell condition    | ordinary finish        | improved finish     | Design project / complete renovation |
| Location                                | suburb              | average distant area   | Areas adjacent to the center | downtown                |

To formalize the model of consumer preferences, the authors carried out a marketing research in the form of a social survey. Participants in the real estate market (potential buyers – preferences carriers) were asked to compare different combinations of factors and determine which combinations are attractive for them. To do this, during the survey respondents were asked the question "Is this combination of properties (factors) of the real estate item attractive for you?", which required an unambiguous answer "yes" or "no." When processing personal details, the answers "yes" were replaced with 1, "no" – with 0. A fragment of the results of the consumer survey on the attractiveness of the building is presented in Table 2.
### Table 2. Fragment of the results of the consumer survey on the attractiveness of the building.

| Left – Right | «Building attractiveness» – «Improvement» | Respondent 1 | Respondent 2 | … | Portion of affirmative answers, % | Attractiveness assessment |
|--------------|-----------------------------------------|--------------|--------------|---|----------------------------------|--------------------------|
| 1-2          | shell condition partially off-the-grid house - II group of solidity | 1 | 0 | 50 | 2 |
| 1-3          | shell condition partially off-the-grid house - I group of solidity off-the-grid house - II group of solidity | 0 | 1 | 60 | 2 |
| 1-4          | shell condition | 1 | 1 | 70 | 2 |
| 2-1          | ordinary finish modern equipment - I group of solidity | 1 | 1 | 60 | 2 |
| 2-2          | ordinary finish partially off-the-grid house - II group of solidity | 0 | 1 | 60 | 2 |
| 2-3          | ordinary finish partially off-the-grid house - I group of solidity | 1 | 1 | 80 | 3 |
| 2-4          | ordinary finish off-the-grid house - II group of solidity | 1 | 1 | 80 | 3 |
| 3-1          | improved finish modern equipment - I group of solidity | 0 | 0 | 60 | 2 |
| 3-2          | improved finish partially off-the-grid house - II group of solidity | 0 | 0 | 60 | 2 |
| 3-3          | improved finish partially off-the-grid house - I group of solidity | 0 | 1 | 80 | 3 |
| 3-4          | improved finish off-the-grid house - II group of solidity | 1 | 1 | 90 | 4 |

To determine the degree of attractiveness of combinations, the following rule was adopted:
- if less than 50% of the respondents answered in the affirmative, this combination of properties was accepted as low attractive (estimate - 1; interpretation - almost no one will buy);
- if 50% to 70% of the respondents answered in the affirmative, this combination of properties was accepted as average attractive (estimate - 2, interpretation - some will buy);
- if 70% to 90% of the respondents answered in the affirmative, this combination of properties was accepted as high attractive (estimate - 3, interpretation - many will buy);
- if over 90% of respondents answered in the affirmative, this combination of properties was accepted as very high attractive (estimate - 4, interpretation - almost everyone will buy);

The marketing research allowed to formalize possible combinations of different qualitative states of factors in the form of a matrix mechanism of integrated assessment (Fig. 1), which is a "compact" form of recording possible combinations of apartment house properties (in the example with 4 factors and 4 possible states of each factor, the full set of object properties combinations represents $4^4 = 256$ variants):
To determine the financially cost-based functions that specify the cost of providing the quality of the factors to be considered, estimates were made on the basis of uniform norms and quotations in case of a ten-story residential single-entry house with the following technical and economic indicators:

- building area: 737 m²;
- number of storeys: 10 storeys;
- house dimensions: 41x16m;
- gross building area: 6394 m²;
- total number of flats (11 on the story) – 110 flats;
- single-room – 40 flats;
- two-room – 50 flats;
- three-room – 20 flats;
- total area of flats – 4450 m²;
- living area of flats – 2711 m²;
- estimated approximate number of persons: 230 persons;
- size of a land plot for this 10-story house: 6290 m².

The results of averaged estimates (cost-based functions) are given in Table 3.

| Interpretation                        | low attractiveness | average attractiveness | high attractiveness | very high attractiveness |
|---------------------------------------|--------------------|------------------------|---------------------|--------------------------|
| Design features of the house          | 32.4               | 33.2                   | 3.2                 | 53.5                     |
| House infrastructure                   | 8.6                | 9.2                    | 8.3                 | 14.3                     |
| Improvement                           | 0                  | 3.8                    | 4.8                 | 8.2                      |
| Location                              | 3.1                | 3.6                    | 6.3                 | 5.6                      |

Table 3. Averaged summary estimate of cost-based functions (in mio. rub.)
3. Results

Normally, using the matrix mechanism of integrated assessment (see Fig. 1), it is possible to solve the inverse problem of integrated assessment - to search for a variant that provides the required value of the integrated assessment. In this paper, there is a variant of residential house construction with a given level of consumer appeal, for example, an estimate of 3, which corresponds to the fact that 70% to 90% of respondents will be satisfied with such housing. Using the method of constructing a network of strain variants [16], it is possible to determine such combinations of factors to be considered, among which there is an optimal variant in terms of the prime cost criterion. Knowing the financially cost-based functions (see Table 3), each variant can determine the total cost of providing such a set of properties (Table 4).

Table 4. Cost-based function of finite sets of variants (mln. rub.).

| Attractiveness estimation | Variant | Location | Design features of the house | Infrastructure | Improv | Total value, mio rub. |
|--------------------------|---------|----------|-----------------------------|----------------|--------|----------------------|
|                          |         |          |                             |                |        |                      |
|                          | 1       | (3.6)    | 2                           | (9.2)          | 2      | 70.1                 |
|                          | 2       | (3.6)    | 2                           | (8.3)          | 4      | 67.8                 |
|                          | 3       | (3.6)    | 3                           | (8.6)          | 4      | 52.8                 |
|                          | 4       | (3.6)    | 2                           | (9.2)          | 4      | 54.2                 |
|                          | 5       | (6.3)    | 3                           | (8.6)          | 1      | 47.3                 |
|                          | 6       | (6.3)    | 2                           | (9.2)          | 2      | 52.5                 |
|                          | 7       | (6.3)    | 1                           | (8.6)          | 2      | 51.1                 |

So, we found an optimal development solution for the construction of a ten-story apartment house in terms of the prime cost, which is satisfied by the majority of requests of potential consumers (see Table 4). This solution determines the set of properties that an item should possess; from now, such a set of properties will be called the concept or appearance of the property. The concept of a real estate item is actually a technical design assignment and a prototype of the sketch.

Table 5. Fragment of the concept (appearance) of real estate property.

| Criteria                  | Features                                      | Attractiveness estimation | Cost, mio.rub. |
|---------------------------|-----------------------------------------------|----------------------------|----------------|
| Geographical location     | areas adjacent to the center (3)               |                            | 6.3            |
| Design features           | II group of solidity (3)                       | 3 – high attractiveness   | 32.4           |
| House infrastructure      | non-off-the-grid house, modern equipment (1)  | (many will buy)           | 8.6            |
| Improvement               | shell condition (1)                           |                            | 0              |
|                           | Fragment Total value*:                        |                            | 47.3           |

Note: the table shows the total cost of providing the required attractiveness of the property only for the factors to be considered, so the table does not include the costs of connection to engineering networks, improvement, etc.
4. Discussions

The problem of conceptual design of residential real estate properties is considered taking into account the consumer appeal and end-user preferences. The competitive advantage of the conceptual design is the direct economic effect that an investor and/or developer receives as a result of saving money for constructing and promoting an item on the market. An indirect, but no less significant, economic effect is the reduction of losses arising from the disruption of the sales plan. The demand for finished premises is provided due to the account of real consumer preferences and opportunities of market participants.

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