Training Business Simulation Game «Commercial Property Management in a Competitive Environment»

Salamatina A S1 Andronova A A¹ Alekseeva I E¹
1Department of Construction Engineering and Materials Science, Civil Engineering Faculty, Perm National Research Polytechnic University, Komsomolsky av., 29, Perm, 614990, Russian Federation

E-mail: salamatina@cem.pstu.ru, andronova@cem.pstu.ru, alekseeva@cem.pstu.ru

Abstract: The article describes the training business simulation game "Commercial property management in a competitive environment" and a special software module. The suggested business simulation game and the created computer simulator are used for training the students, who study in the field "Expertise and management of real estate property". Several examples of game scenarios and results are given to demonstrate their application in the training and educational process. The game simulator allows students to obtain the following knowledge: the commercial property management task is cognitively complex; the optimal allocation of costs for the development and promotion of commercial property depends on the objective function, which can be profit or index of profitability; for shopping centers, the optimization problem has a sustainable solution to the opponent's actions, but such solutions are unstable to the behavior of customers and their preferences; in the case where students select the minimum costs of development and promotion of shopping centers, the profit becomes negative, it explains the necessity of development and promotion of commercial property; in another case – students select the maximum cost, the effect of an "excessive utility" arises. The main result of the game-like training is that students acquire new decision-making skills in the tasks of commercial property management in a competitive environment.

1. Introduction

Nowadays, simulation modelling is widely used in the research of various phenomena and processes in construction industry. It is due to the fact that mathematical modelling is, perhaps, the only method of research because of the high cost and duration of natural experiments. Information about simulation modelling in construction industry is presented in the literature review [1]. Simulation modelling can be used for following tasks: Inventory management [2], Strategy [3], Project management [4, 5] and etc.

Another method of modelling is game simulation in the form of business games. In these games, employees of organizations or invited experts carry out certain roles, corresponding to their operational activities. In relation to construction industry, there are works [6, 7] using the simulation gaming technique. The aim of such games is developing of effective strategies for interaction between project participants, the design and construction processes of buildings and structures. In addition, this type of games is often used as an interactive method of training and education, as well as for the certification of existing employees, testing the knowledge and skills of applicants for any positions. Different scenarios can be created in a business game. All scenarios can reflect to some extent the
changes in the real world. However, despite numerous works in the field of mathematical and game modelling in the construction, the task of existing buildings and structures management were practically not considered, with the exception of few works, for example [8].

It is important that life cycle of constructed buildings is measured by decades and in some cases they are hundred years, so the actual problem is the effective management of real estate objects. A particular task of this problem is teaching and training of students and new specialists. This research, which deals with the case of commercial property management in competition conditions on an example of trade centers, is devoted to this particular task.

The task of managing shopping centers has a high degree of uncertainty that is connected with the difficulty of predicting the results of managerial and entrepreneurial activity of the management agents, increasing the number of heterogeneous economic agents and carrying out their entrepreneurial activities autonomously [8].

A key source of uncertainty is the human factor and it is required the research of the strategic behavior of the management agents of shopping centers in competition conditions.

2. Training software module

For teaching and training it is offered to use software module based on MS Excel, which is shown in the Figure 1 created by authors of work [9]. The mathematical model used in this software module is described in detail in works [9] and [10].

In the suggested business simulation game we have two competitive shopping centers (SC) \(( j \in J, J = \{1, 2\})\), each of them has three pedestrian-transport zones and their intersection forms ten sectors \((K)\). The task of SC management is formulated as a conditional optimization problem, where profit \((1)\) or index of profitability \((2)\) can be used as an objective function (OF). Constrained optimization problem have inequality constraints to the costs of SC development and promotion: a set of acceptable values \(c_{\text{y}} \in \text{C}, y \in Y\), where \(Y\) – set of managed parameters.

\[
OF = P_j(c_{\text{y}}; c_{\text{y}^{-}}) = \mu \cdot Ar \cdot n_j \left( c_{\text{y}}; c_{\text{y}^{-}} \right) - \sum_{y \in Y} c_{\text{y}} - \text{TFC}_j, \quad (1)
\]

\[
OF = RR_j \left( c_{\text{y}}; c_{\text{y}^{-}} \right) = \frac{\mu \cdot Ar \cdot n_j \left( c_{\text{y}}; c_{\text{y}^{-}} \right)}{\sum_{y \in Y} c_{\text{y}} + \text{TFC}_j} - 1, \quad (2)
\]

\(\text{TFC}_j\) – total fixed costs of the the \(j\)-th SC Manager; \(\mu\) – customer conversion ratio (the percentage of visitors who purchase something); \(Ar\) – the average amount of purchases that visitors make; \(c_{\text{y}}\) – costs of managing \(j\)-th SC for the development of managed parameters of the object; \(n_j\) – the number of attracted visitors in the \(j\)-th SC. The last one is determined by the equation:

\[
n_j = \sum_{k=1}^{10} N_k \cdot \frac{\prod_{y \in Y} Q_j(c_y)^{q_y} \cdot \prod_{ny \in NY} Q_j(c_{ny})^{q_{ny}} \cdot T_k^{-\lambda_k}}{\sum_{j=1,2} \sum_{y \in Y} \prod_{y \in Y} Q_j(c_y)^{q_y} \cdot \prod_{ny \in NY} Q_j(c_{ny})^{q_{ny}} \cdot T_k^{-\lambda_k}}, \quad (3)
\]

\(Q(c_y)\) – quality of managed parameters of object \(j\); \(Q(c_{ny})\) – quality of unmanaged parameters of object \(j\); \(T_k\) – correspondence time to \(j\)-th SC of visitors to \(k\)-th sector; \(\lambda_k\) – parameter that affects the importance of correspondence time for visitors; \(N_k\) – number of inhabitants in sector \(k\), \(k = \{1, \ldots, 10\}\); \(ny\) – parameters not controlled at the tactical and operational level; \(q_y, q_{ny}\) – power parameters. Since the number of visitors is constantly \((n_1 + n_2 = \text{const})\), and by changing the quality of SC, managers actually pull visitors from each other.

Students have role of the competitive shopping center Manager. The purpose of every player is to maximize personal profit or index of profitability in managing the costs of developing their SC. It is
worth noting that the optimal allocation of costs depends on the objective function, and may be different.

Figure 1. The display form of the player – student in role of Manager SC.
Note for Figure 1:

- changeable parameters
- automatically calculated parameters
- options costs of management the four criteria realized in the form of the dropping-out lists
- numerical data expressing the quantitative parameters of SC
- strategy performance dashboard
- quantitative characteristics of indicators of quality of SC
- histogram of the current allocation of costs on advance of the player and also the realized Decision Support System (DSS) with a possibility of the choice of criterion function for player (profit or profitability)
- automatically defined number of strategy for player at the current allocation of costs on SC development
The rules of the business game provide for the possibility of scenario modeling, during which the player searches for the optimal solution (or optimal solution in his opinion, this case is called acceptable pseudo-optimal [11] solution) on the allocation of costs for the management of the SC (see Figure 7, area 1). When searching, the changes of the resulting parameters are analyzed (see Figure 7, areas 2 and 4).

When a player makes a decision on the allocation of costs for the SC development, he can use the Decision Support System (DSS) (see Figure 7, area 3, "DSS" checkbox) to compare player’s solution with the optimal one. During the training session, the teacher is carried out so that the DSS is turned on by the player only after the decision he made.

When connecting the DSS, players can use the next options by choosing relevant ratio button.

«To show my optimal allocation of costs on development» (it is calculated without taking into account the actions of the opponent, with the settings of the game as a competitor); in this case, the optimal allocation is described by the following equation:

$$c^*_m = \arg \max_{c_m \in C_m} \left( OF \left( c_m \left| \prod_{m \in M} Q_m (C_m)^{m_2} \cdot Q_{v_2} = Q_{v_2} \right. \right) \right),$$

(4)

$$Q_{v_2}$$ – this is the quality of the opponent's SC given by the game conditions.

«To show the best strategy of the opponent» (is determined under the assumption that the strategy of the player will correspond to the optimal allocation, see the previous strategy; this mode is designed to see what the quality of opponent’ SC is beneficial to him); the best strategy of the opponent is described as follows:

$$c^{**}_m = \arg \max_{c_{m_2} \in C_m} \left( OF \left( c_{m_2} \left| c_m = c^*_m \left| Q_{v_2} \right. \right) \right) \right).$$

(5)

«To show my best response at the best strategy of the opponent» (determined by the assumption that the opponent action according to his best answer; this mode is implemented as double best response); the double best response is described as:

$$DBR_n = c_{1m}^{*} = \arg \max_{c_{1m} \in C_m} \left( OF \left( c_{1m} \left| c_2 = c^*_2 \right) \right) \right).$$

(6)

3. Scenarios of the business game

To get the best result when conducting business games it is necessary to conduct a preparatory stage. As a preparatory stage, you should use familiarization with the rules and goals of the game, the objective functions and the functional dependence of the values of the objective functions from the decisions made by a player. Also, to reduce the time of familiarization with conditions of the simulation game for participants, it is necessary to present clear and understandable guidance to it.

Information can be presented in the form of an introductory course of lectures, methodological material, as well as necessary literature.

In the preparatory stage it is necessary to inform:

- basic concepts and laws of functioning of the commercial property market;
- distinctive features of the commercial property market;
- basic provisions of management theory used in the management of commercial property;
- a shopping and entertainment complex as an object of commercial property;
- factors, affecting on consumer demand and supply;
- terms of profit, profitability and optimality.

As a result of conducting of business game, the participant should gain knowledge of methodical bases, master the skill of the search of the optimal strategy of behavior in competition conditions in the commercial property management.
Consider the basic scenarios of a business game in the process of conducting a training lesson with using a software simulator. The teacher sets the task for all students to apply the minimum cost strategy in all parameters. As a result, all students see that the shopping center is receiving losses (Figure 2).

**Figure 2.** The display form of the player with data at minimal costs.

In the next stage of the business game, the teacher sets the task for students to apply the maximum spending strategy for all parameters. As a result, all students see that the shopping center is making a profit (Figure 3).
However, students have to answer following questions: Is this the maximum profit? Is it possible to incur less management costs without losing profit? To get a clear answer to this question, the teacher suggests that students to change the quality expenses and specify instead of 400 thousand – 200. As a result, students see that when saving money for management and development, we even get additional profit (Figure 4).

This phenomenon is called "excessive utility", and then the teacher can elaborate on this concept and phenomenon, for example, give examples from the real practice of managing commercial property.

Further, the teacher offers students to try other combinations of possible controls on their own and gives time to find the best strategy.
After the students have coped, the teacher allows include the decision support system and compare the found strategy with the optimal one.

In order to clarify the meaning of the concept of optimality, the teacher talks about the task of optimization, the concept of the objective function, and draws attention to the fact that in the game played by students, profit is used as the objective function. The teacher proposes to change the objective function and see if the optimal strategy changes. To do this, it is sufficient to enable the DSS mode (Figure 5).

In order to show that the result of the management company's activities depends on environmental factors, the teacher asks all students to change the value of the two parameters in the game settings: average check and conversion rate. The average check at the beginning of the game was 500 rubles and was changed to 1000 rubles. The conversion ratio was 0.05 and became 0.10.

It turns out that the optimal strategy depends on the external environment (Figure 6).

Using the computer simulator, the teacher can show how the result of the management company's activities depends on the actions of competitors. To do this, you can change the perceived quality of
the competitor (Figure 7), specifically, to assume that the competitor will maximize his quality to unity. In this case, students will see immediately that their profit has decreased (compare Figures 6 and 7).

For the same purpose, students can be asked to exchange messages about what quality they get with their optimal strategy. And together try to find the optimal strategy.

![Graph showing promotional activity, aesthetic appearance, quality of goods, and events compared to cost and maximum profit.](image)

**Figure 5.** The display form of the player with turn on DSS checkbox.

All these actions must be performed with the DSS mode off. After making several moves, students can make certain of their profit decreases when the competitor develops his object, but their optimal strategy does not change. Thus, students get acquainted with the term of a sustainable solution, to which the teacher should emphasize and explain that strategies in the simulator are resistant to the actions of opponents, but are not resistant to changes in the level of consumption.
Business game and computer simulator of the subject area allows demonstrate the following effects:

1. The task of optimization is cognitively complex, because in the simple case – when the management strategy of the shopping center depends on four controlled parameters and, in this case, the number of strategies of each manager is 256, with 5 controlled factors, the number of strategies increases to 1024, with 6 to 4096 and etc.

2. The task of optimization depends on the objective function, in which quality profit or index of profitability can be used.

3. In spite of the fact that the optimization problem is cognitively complex, students can quickly come to a sustainable solution (stable to the changing situation, depending on the opponent's behavior).

4. In the case when the students select the maximum values of all four controlled parameters, the effect of "excessive utility" arises. In this case, there is an overspending for promotion.

5. In the case where the students select the minimum values of all four controlled parameters, the profit becomes negative, which explains the need for the development and promotion of shopping and entertainment complexes.
6. It is necessary to develop those parameters that have a greater impact on profit, that is, they are important for the consumer (the aesthetic appearance and quality of the products).

The business game shows that in the performance of the normative function, that is, the determination of the necessary actions, only quantitative methods can give an answer to the question - how much it is necessary to spend resources on the effective promotion of the commercial real estate object. Qualitative methods can give an answer to the question of what to spend, but cannot determine the size of the required resources.

References
[1] Jahangirian M, Eldabi T, Naseer A, Stergioulas L K and Young T 2010 Simulation in manufacturing and business: A review European Journal of Operational Research 203(1) pp 1-13
[2] Polat G and Arditi D 2005 The JIT materials management system in developing countries Construction Management and Economics 23(7) pp 697–712
[3] Lee S H, Pena-Mora F and Park M 2006 Dynamic planning and control methodology for strategic and operational construction project management *Automation in Construction* **15**(1) pp 84–97

[4] Love P E D, Manual P and Li H 1999 *Construction Management and Economics* Determining the causal structure of rework influences in construction **17**(4) pp 505–517

[5] Sawhney A and Mund A 1999 Hierarchical and modular modeling of structural steel erection process using Petri nets *Civil Engineering and Environmental Systems* **17**(1) pp 63–88

[6] Nassar K 2002 Simulation gaming in construction: ER the equipment replacement game *Journal of Construction Education* **7**(1) pp 16–30

[7] Zulch G and Fischer J 2003 The benefits of using a market share model in a simulation aided planning game *Production Planning and Control* **14**(2) pp 146–154

[8] Spirina V S 2017 Proof of the necessity of counting strategic behaviour of tenants at the management of commercial real estate *Proceedings of Universities. Investment. Construction. Real estate* **7**(3) pp 42–52

[9] Alekseev A O, Spirina V S and Korgin N A 2016 Commercial Real Estate Management Technology Taking Into Account Consumer Preferences *Large-Scale Systems Control* **62** pp 124-168

[10] Alekseev A O, Spirina V S and Andronova A A 2018 Theoretical and experimental study of the strategic behavior of the managers of the of shopping centers *Applied Mathematics and Control Sciences* **1** pp 91-107

[11] Burkov V N, Goubko M, Korgin N and Novikov D 2015 *Introduction to Theory of Control in Organizations* (Boca Raton: CRC Press) 346 p