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PRACTICAL APPLICATION OF A SYSTEM DYNAMICS METHOD AND AGENT-BASED MODELLING FOR DEVELOPING MARKETING STRATEGIES

The article presents the dynamic approach to creating marketing strategies of regional markets' seizure. The specific feature of the suggested model is the symbiosis of two methods – agent-based modelling and system dynamics which allows expanding the scope of tasks solved in strategic marketing. On the basis of these two methods, a two-level dynamic model of regional market consumers of gas flow meters is developed, the portfolio of regional strategies is created, the investment appeal of each project on implementing the strategy is determined, ranging of markets as research objects is carried out.

Keywords: marketing strategy; agent-based modelling; system dynamics; sales system.

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ПРАКТИЧНЕ ЗАСТОСУВАННЯ МЕТОДУ СИСТЕМНОЇ ДИНАМІКИ І АГЕНТНОГО МОДЕЛЮВАННЯ ПРИ РОЗРОБЦІ МАРКЕТИНГОВОЇ СТРАТЕГІЇ

У статті представлено динамічний підхід до формування маркетингових стратегій захоплення регіональних ринків. Особливістю запропонованої моделі є симбіоз двох методів: агентного моделювання та системної динаміки, що дозволяють розширити коло вирішуваних в стратегічному маркетингу задач. На основі цих двох методів розроблено дворівневу динамічну модель регіонального ринку споживачів побутових лічильників газу, сформовано портфель регіональних стратегій, визначено інвестиційну привабливість кожного проекту з реалізації стратегії, проведено ранжування ринків як об'єктів досліджень.

Ключові слова: маркетингова стратегія; агентне моделювання; системна динаміка; система продажів.

Форм. 1. Табл. 1. Рис. 4. Літ. 11.

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ПРАКТИЧЕСКОЕ ПРИМЕНЕНИЕ МЕТОДОВ СИСТЕМНОЙ ДИНАМИКИ И АГЕНТНОГО МОДЕЛИРОВАНИЯ ПРИ РАЗРАБОТКЕ МАРКЕТИНГОВЫХ СТРАТЕГИЙ

В статье представлен динамический подход к формированию маркетинговых стратегий захвата региональных рынков. Особенностью предлагаемой модели является симбиоз двух методов: агентного моделирования и системной динамики, позволяющих расширить круг решаемых в стратегическом маркетинге задач. На основе этих двух методов разработана двухуровневая динамическая модель регионального рынка потребителей бытовых счётчиков газа, сформирован портфель региональных стратегий, определена инвестиционная привлекательность каждого проекта по реализации стратегии, проведено ранжирование рынков как объектов исследований.

Ключевые слова: маркетинговая стратегия; агентное моделирование; системная динамика; система продаж.

Problem statement. Marketing strategy has an impact on solving such problems as technical re-equipment of production, creating portfolios etc. The perspective of

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company's future, a list of company's products allows executive directors draw up a production plan on the basis of which an investment plan is later developed.

Literature review. The article presents the technology of creating a marketing strategy on the basis of dynamic approach. The combination of two methods – system dynamics and agent-based modelling – forms the basis for the suggested tool to work out a strategy. Unlike matrix methods of working out a strategy system dynamics allows examining the strategic forecasting process in a different way, more thoroughly. Presenting the environment's factors with taking into consideration nonlinearities, delays and feedbacks allows considering a situation not as a static picture, but a dynamically developing process (Martinez-Moyana and Richardson, 2013; Richardson, 2012; Kunc, 2012). One of the followers of system dynamics J. Sterman (2000) points out the top-priority advantage of dynamic models as an opportunity to see a problem in its discrepancy of factors, taking into consideration of which can completely change the situation. The author of other well-known works on system dynamics K. Warren (1999; 2002), proceeding to the develop fundamental principles of the pioneer of system dynamics, D. Forrester (2006), suggests that paying due attention to dynamic changes in the company resources' in order to select the most effective strategy is necessary.

The study purpose. The article is of a practical character and its goal is to increase the effectiveness of company's strategic planning by means of elaborating a portfolio of marketing decisions to seize regional markets. The stated goal demands solving the following objectives:

- 1) the choice of the tool for working out a marketing strategy;
- 2) modelling a situation at regional markets with the help of the created model;
- 3) the choice of the criterion for evaluating the investment appeal of each region;
- 4) assessment of the system's sensitivity to changes in variable characteristics;
- 5) defining the key points of impact upon the dynamic system with the help of the model;
- 6) working out effective marketing strategies and a portfolio of definite practical recommendations on product promotion at regional markets.

Therefore, the first issue to begin with is describing a company's situation and all the reasons that led to this condition. The company, a producer of the gas flow meters, was chosen as the research object (hereinafter referred to as "Relero"). The company was the first to produce low-vat gas flow meters and had a chance to become a leader of this segment, but the time was lost and more active competitors have already won the leading positions in this segment almost in all regions. The marketing department has the task to increase the company's presence at all regional markets, choosing the most effective marketing solutions, ranging regions by their appeal for reaching the stated strategic goal. Marketing analysts have the goal to select those leverages for dynamic system, that will allow managing with less investment, pay off in minimum time and get the maximum possible net discounted revenue. It should be mentioned, that the author of the article defines a "strategic plan" as a discrete object, that is why all the indices of effectiveness of the selected marketing strategy correspond to the system of criteria, taken by project management. The effectiveness of the suggested marketing strategy is assessed by the values of the investment volume gained in the process of marketing strategy's realization, term of recoupment, net

income and profitability. The task of determining a promotion strategy, revealing persons responsible for making decisions, organizing discussions is not set, but the problem of assessing effectiveness of alternative promotion channels, creating optimal marketing communications (by which, in particular, distributions chains of wholesale and retail sales are understood) is being solved. Each region has its own peculiarities and the product (a gas flow meter) has its own life cycle with the periods of active demand and decline. The potential capacity of consumers' segment of the present products in the region is a dynamic index, determined by the growth rates of house construction in regions, gas infrastructure development in general, and for each region in particular this index will be different. Undoubtedly, the presence of competitors in each region should be taken into account. As research has shown, the initial distribution of market shares in each region takes place in favour of either local producer, or a player who successfully built up a chain of sales.

For working out a marketing strategy in the appointed conditions options exist:

1) entry into the most effective distribution channels (for instance, each region has a gas distribution organization, responsible for distributing gas and setting up meters. To find a way out is a significant task, but for a sales manager, as a marketing analyst should be in charge of evaluating financial perspectives with the help of this model);

2) constructing its own distributive chain (the strategy of direct integration);

3) opening its own subsidiary in the region.

In the works (Wallis et al., 2004; Katalevskiy et al., 2012) the examples of using agent-based modelling as an instrument of strategy elaboration, are given. Based on the necessity of understanding the consumer behavior, the author calls for defining the criteria of making decisions concerning customer making a purchase. In addition, it is significant to take into consideration psychology and motives of buying besides the traditional macroapproach, based on determining a trend and forecasting. Elaborating a marketing strategy should start from "below", having determined motives and criteria of the customer's making a purchasing decision. The present approach provides much information on stimulating methods and sales management, but for the abovementioned tasks only, including assessment of investment in product promotion on both federal and regional levels, practical adaptation is required. Agent-based modelling allows understanding the logic of consumer behavior, contributing to development of behavioral economics methods and forecasting sales volumes to determine the leverages for stimulating sales. But apart from stimulating methods, other ways of sales management exist, including organizational ones. System dynamics, complementing agent-based modelling, considerably enlarges the horizons of effective management, providing an opportunity to find new managerial decisions. Conventionally two objects of impact for these two instruments can be pointed out: the agent (it is the customer in our example) and its characteristics are the object of impact for agent-based modelling, and the flows are considered as the objects in system dynamics. Flow diagrams, containing feedbacks, which reflect non-linearity of processes and delays, show the system's processes more accurately than the static models. Each of the two methods carries its own meaning, and altogether they enable reaching a definite synergetic effect, expanding the opportunities to find the most right combination of values of the managed parameters both in microenviron-

ment (agent environment) and in macroenvironment (flow diagrams, sales logistics, constructing the most efficient sales systems).

Therefore, unlike the models presented earlier (apart from behavioral economics, oriented on researching customer behavior) the suggested option of methodology is contributed with such economic criteria as the product's cost price, price, net profit etc. The important advantage of system dynamics is the presence of feedbacks, in particular in taking into account additional flows of customers, determined by, for example, "word-of-mouth marketing". Sales growth is suggested to contribute to transferring information on product's advantages, which is transported from people to people and generate the additional flow of customers.

Key research findings. Agent-based modelling describes the agents' behavior as the transition from one condition to another, which is marked by the map of conditions or the Statechart diagram. Figure 1 presents the diagram of conditions of customer behavior during the purchase of a gas flow meter. In the field of the diagram the main market players *Relero*, *Grand* and *Betar* are displayed, and the region, where these players are the key ones, was chosen as an example. The diagram gives conditional criteria, according to which customers make purchases: the cost of sales, the level of persuasion, implying "word-of-mouth marketing" (transfer of information from existing clients to potential ones). All the criteria have the same value. Moreover, an important criterion – recognizability – is entered, determined by the advertising impact.

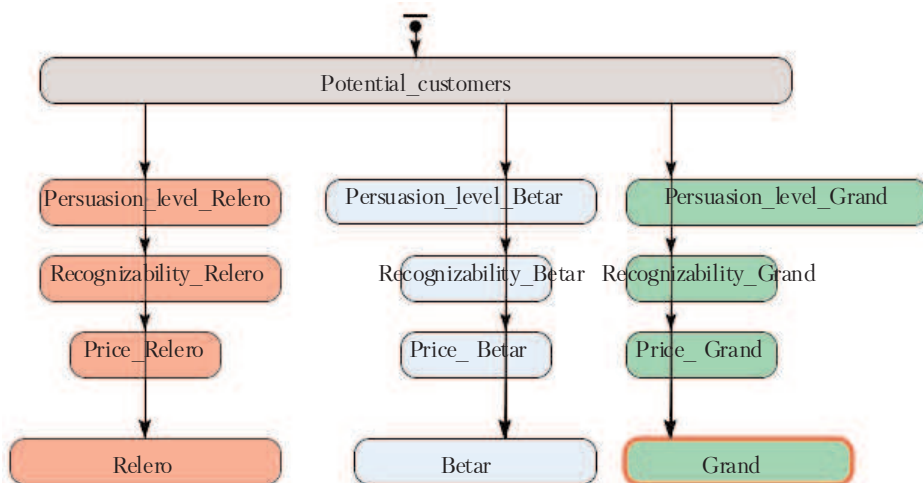


Figure 1. The diagram of conditions of the agents' behavior, drawn by the author

Competitors have a rather high recognizability, as they have already recommended themselves by advertising campaigns, conducted earlier. The diagram of conditions allows determining % of potential customers, that will transfer to the class of customers of Relero, Grand and Betar. The conditions of the transfer are the most significant according to all the criteria, and the degree of the agents' being in contact is assigned by the function of random choice *RANDOM* (modelling was conducted with use of the open analytical platform *Anylogic 6.4 Advanced*). The basis of discussions is

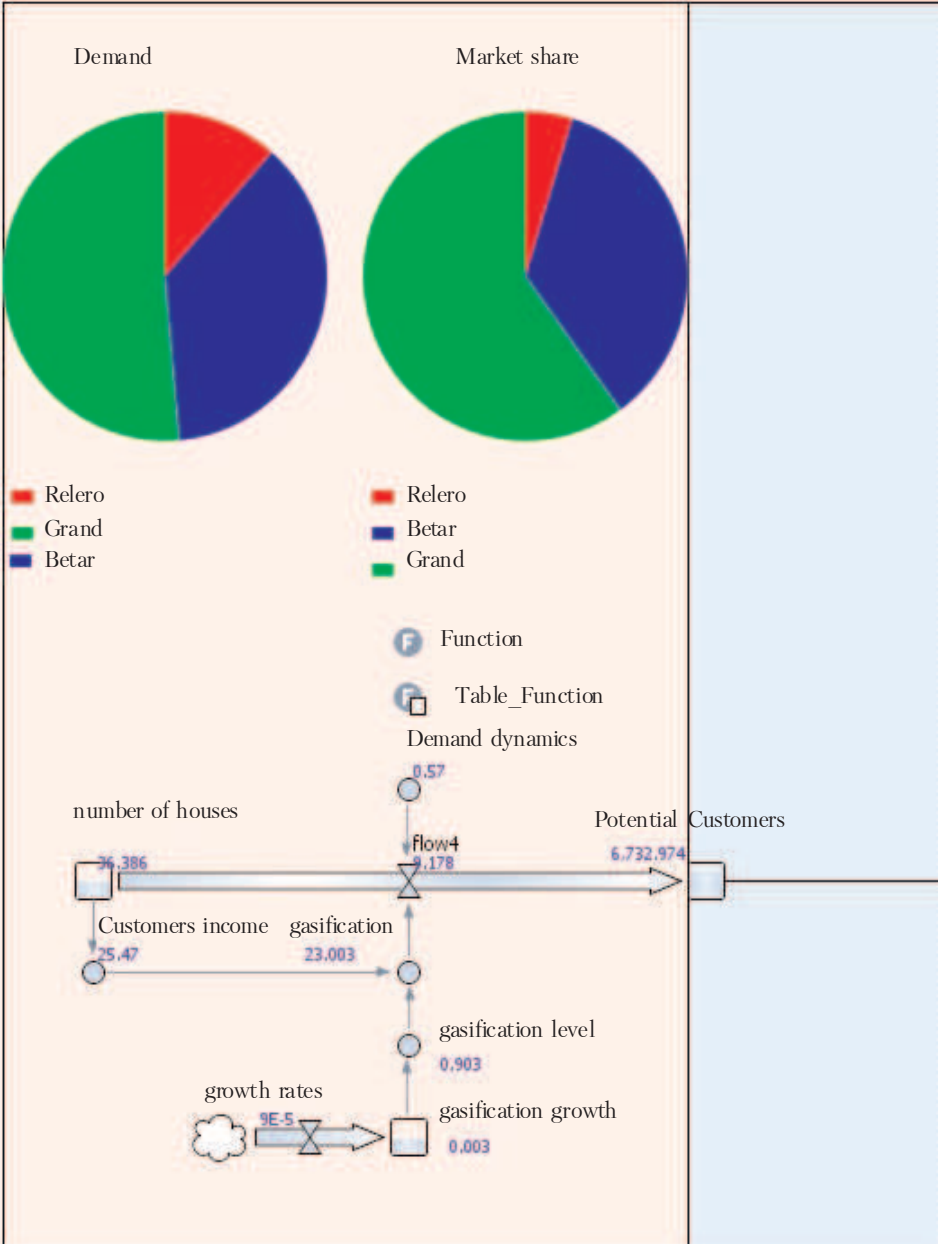


Figure 2. **Modelling a flow of potential customers**, drawn by the author

the model of Bassa diffusion and it is suggested that agents (potential customers) contacting each other by chance, gradually distribute information and persuade other agents in the necessity of purchase (Homer, 1987; Mahajan et al., 1990). Price decrease, increase in product's recognizability, "word-of-mouth marketing" contribute to the agent's transfer from the condition of a potential customer to the one of

a customer, who has already bought the product. The more competitive these factors in the company are, the more decisions potential customers will make concerning the purchase of company's product. At the stage of running the imitation model already, we get the results which can be achieved by agent-based modelling only. In particular, we can observe the discrepancy which occurred between market leaders and market outsiders and the opportunity of assessing the quantitative characteristics of the discrepancy appears. If the product is well-known and recognizable, chances for the followers to catch up with the leaders in terms of sales under tight deadlines are equal to zero. In accordance with the conducted experiments, the company's sales already existing in the region have great effect because of the connection between the customers, who have already bought the product, and potential customers, since they have a definite level of sales. Players, new at a regional market, have just begun sales and there are too few people who can transfer information about their product. Though investments in advertising can be considerable, the feedback will be received not soon. Having an idea about the advertising's effectiveness, it is possible to assess the size of the required investments in product promotion, and the contribution of agent-based modelling lies in it.

The second integral part of the model is its "systematic-dynamic" constituent, fragments of which are displayed in Figures 2–4. Figure 2 reflects external environment, connections and dependences between the factors, creating the flow of potential customers. The fragment depicts how the flow is formed, with the help of which factors it is calculated. As a starting point the population size in the region is considered, then we determine the number of houses with taking into account the degree of gas infrastructure development in the region and deducting the number of people who have already set up gas flow meters. The developed flow gets into the field of agent-based modelling ("Potential customers" Figure 1 and the right side of Figure 2 over the vertical line), in which for the set selection and with the help of the set criteria of taking a decision concerning purchase, a part of the customers moves to the customers of *Relero*, all the rest – to *Grand* and *Betar*. The specific feature of the model is that all the parameters change in time and the model allows taking all the changes into account. Consequently, the circle diagrams "Demand" and "Market share" reflect the situation in the field of agent-based modelling (shares mean the distribution of potential customers on the diagram of conditions in the inspected modelling period). Conspicuous difference between the diagrams is explained by the dynamics of the process and delay. The dynamics of a life cycle is modelled by the function "Demand dynamics" (Figure 2).

The scope of planning is equal to 60 periods, the pace of modelling is one month. All the mathematical tool, formulae and functional connections of "defense" are present. In Figure 3 the last fragment of the program interface is displayed, it depicts the organization of the sales system for each market player. In the specified fragment economic indices of the project for each market player: cost of sales, the quantity of sold products, investments in organization of sales system and advertising, net profit. The index of marketing activity is defined by the quantity of salespoints (channels of distribution), which can be varied both upwards and downwards. Moreover, the model takes into consideration investments into creating and expanding network, and allows assessing net profit. The presence of feedbacks in the "The persuasion level"

("word-of-mouth marketing") contributes to the dynamic model, and the quantitative characteristics of the factor's influence are assessed by the purchase probability, which is equal to, for example, to 0.015 and 0.02, that means that every 100 customers can convert one or two clients into real consumers, creating additional flow, proportional to the quantity of people who have already made the purchase. The research of the model conducted earlier with the persuasion power of 0.015 and 0.02 demonstrate the conspicuous influence of this factor. Dynamic delay is taken into account during modelling the effect of advertisement – there is a delay between advertisements investments and increase in sales volume which can correct the calculation of money flows. Advertisement effect cannot exist eternally: some time later if advertisement will not be repeated, sales will decrease. In Figure 4 the fragment of the model with taking into consideration the delay and the system's return to the initial condition, is displayed.

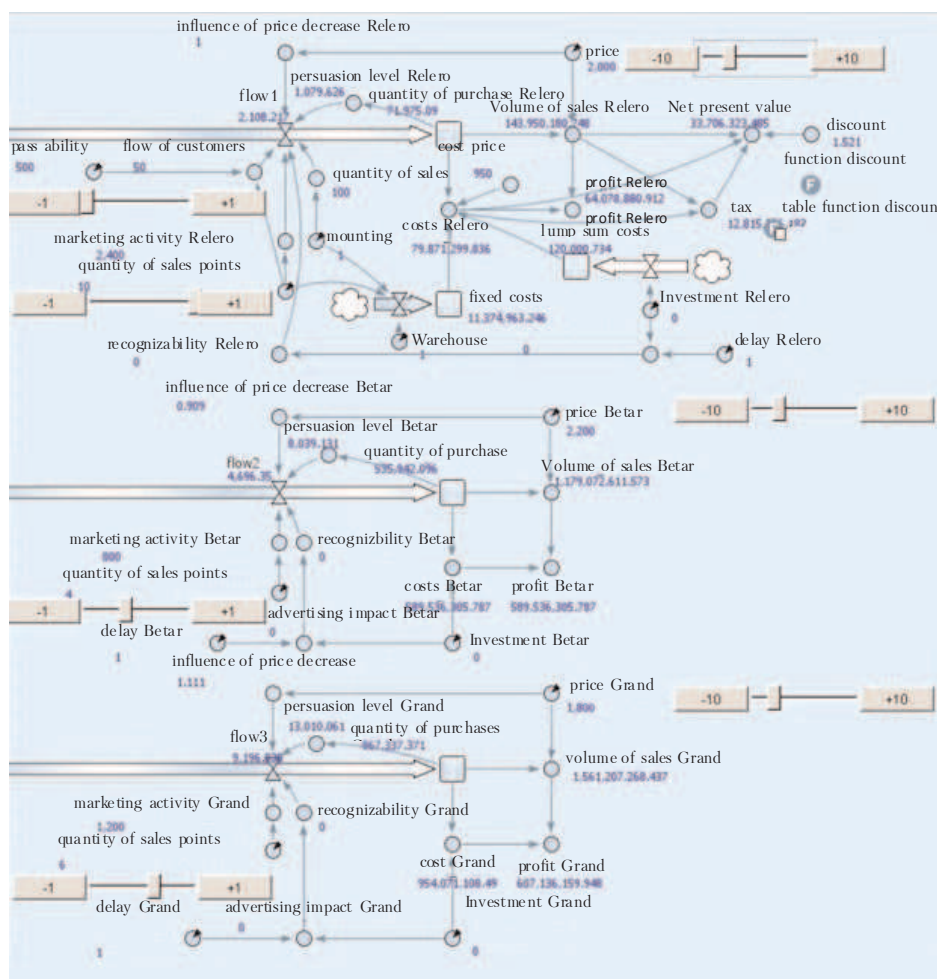


Figure 3. Modelling the sales system of the key market players,
drawn by the author

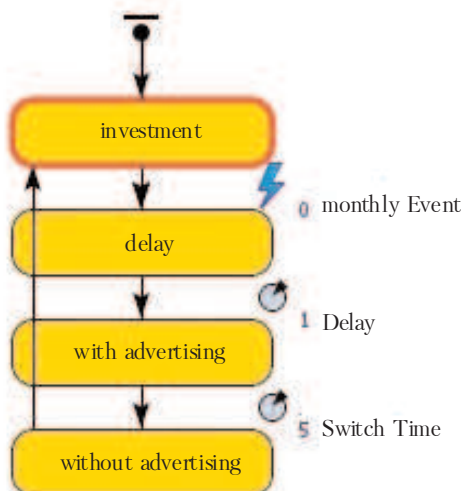


Figure 4. **Modelling the delay and advertisement effect**, drawn by the author

The modelling was conducted for 7 regions. The specific feature of each project is the fact that regional markets get saturated in accordance with various scenarios and the periods of saturation will be different. The regions with big population size, elaborated gasification programs and competitive advantages, are more attractive for investors. The expected result for the company Relero in the model is defined by the following factors:

Net discounted profit Relero = *Sales Volume Relero* – *Tax* – *Costs Relero*. (1)

where *Sales Volume Relero* – the volume of sales of the company Relero; *Costs Relero* – the amount of initial investments in net working capital; *Tax* – tax burden on the project (profit tax); *Sales Volume Relero* is the quantity of sales in Relero multiplied by the price of the product; marketing activity is equal to the quantity of Relero salespoints multiplied by the average monthly sales turnover in the region for each salespoint in this region.

In the process of the model's run the following facts were stated:

- how many salespoints are required to reach the stated strategic goal (in the discrete situation for the region this number is different);
- when market saturation occurs;
- how many investments and resources are required to realize the promotion plan in the stated initial conditions (the number of houses, gasification pace, the level of customers' persuasion, market dynamics) and if it is enough time before the demand decreases.

The result of the whole work will be a table, where indices of investment appeal of the project on the market seizure. The table will include the terms of regional market saturation, the projects' recoupment terms, and the expected values of market shares are given. However, any model, like the model suggested in the article, has definite deviations, but the ranging demands the same approach and the same model (and, consequently, the same deviations), so the mistake in the conclusions is less, than in the calculation of absolute values.

Table 1. Investment attractiveness of regions

Region	Volume of sales for the period of market saturation, mln RUB	Net discounted profit for the period of market saturation, mln RUB	The necessary investment, mln RUB	The recoupment term, months	The period of market saturation (the period when market saturation will take place)	The expected market share, %
1	152.1	28.05	2.25	10	37	6.4
2	143.4	26.47	2.25	10	35	4.9
3	202.5	48.00	-	-	60	5.8
4	28.9	3.4	0.83	13	24	2
5	121.5	28.80	-	-	36	6.9
6	133.4	24.18	1.43	11	51	8.1
7	121.5	28.80	-	-	36	7.5
8	50.7	5.86	2.05	10	17	4.4
9	21.3	5.80	0.45	2.5	19	7.3
10	299.2	41.38	3.45	16	60	46.4
11	9.7	1.66	0.25	13	28	1.1
12	165.4	39.20	-	-	28	13.1

Based on the data obtained in the process of marketing and analytical research.

According to this table the most attractive and significant regions in terms of marketing will be the regions 3, 12, 1, 2, 5, 6. The regions 11, 4, 8 can be considered as not attractive from the viewpoint of strategy. During imitation modelling useful conclusions were made concerning the correct choice of the distribution channels (the choice of the kind of a channel, investments into channels' creation, throughout capacity). The reasonability of implementing this strategy of conglomerate diversification for product's promotion in some regions (creating own mounting teams for setting gas flow meters with a lower price) was also inspected with the help of the elaborated model. The essential result was the insight into the structure of the whole system of sales. After conducting imitating research, the optimal quantity of salespoints for each region was stated.

Conclusions. Apart from practical recommendations on creating and optimal management of the systems of selling gas flow meters, several conclusions on implementing the expected methodology can be made:

1. Management of complex dynamic system demands an instrument, combining the methods of evaluating the system's effectiveness and the model of agent-based modelling. A separate implementation of every method does not allow finding an adequate decision for a investor and a project's manager. Apart from scrutinizing the motives of customer behavior, research into the flow diagrams and sales logistics is required, i.e. the systematic examination of all the processes, setting the cause-effect relationships on the whole field of the essential factors cooperation.

2. The structure of the suggested model enables creating the optimal management mechanism to control product promotion at a new market, the product's qualities, and its competitive characteristics. The feedbacks and delays play an important role in this process, and quantitative assessment of their influence allows differentiating factors of impact according to the degree of importance. The dynamic model allows setting up the cause-effect relationships between events, thus explaining the value of each channel.

3. The significant useful quality of the present model is an opportunity to create a portfolio of investments for each region on the basis of investment appeal assessment. The portfolio approach facilitates working out marketing strategies that allow seeing prospects for companies in each region and attaching priorities to the distributed financial resources, allocating them according to the periods so as to enhance the effect of presence with the help of one of the methods of influence on the market, explored in the article.

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