E. P. Khomin; T. M. Borovska, Cand. Sc. (Eng), Assist. Prof.; S. P. Badiora, Cand. Sc. (Eng)

MANAGEMENT OPTIMIZATION OF DISTRIBUTED OBJECT "PRODUCTS LINE"

The system of operating simulation models of distributed object "products line" has been built, line's dynamics and statics have been investigated. Methods of local and global management of products line have been suggested and realized.

Key words: *distributed system, producer, product, consumer, operating model, simulation modeling, products line, local management, global management, stability.*

Problem set-up. The object of modeling in the given research- is simultaneously massive and practically non-investigated. Four close analogues of products line model have been found. But they are classic and not adequate to reality models. Searching system Google suggests the papers of the authors (Fig. 1). By other key words, our papers are also in the first ranks – all leading designers (developers of modeling programs) work in condition of confidentiality.

Fig. 1. Results of analogues search, examples of products line

Terms definition. In the sphere of products line design there is no definite standard terminology, like the terminology of flying vehicles, that is why we will consider the necessary terms.

Products line 1. 90% of documents in searching system belong to the class of "programming products line". They are sets of programming products for complex solution of a certain problem.

Elements of the line – are independent products, intended for joint usage. On user's level these may be sets "all for cooking borch", "everything for first grade pupil".

Products line 2. Other names are – products line, model line. It is a set of products of one specific usage, varying in quality and price. The products of one and the same designation and of one and the same price interval may form non-arranged lines in accordance with the categories of consumer's preferences. For instance, cell phones of the same price range can be manufactured for school- children, for managers, for retired persons.

Working model – is a model, written in the standards of scientific publications and executed in the environment of a certain modeling package

Technology of new models elaboration for new problems solution . According to Forrester, dispersed, describing text and visual information is collected as initial information for model construction . In the process of integration, sequential canonic stages of model formation are carried out: linguistic model, graphic model, operation model. While model constructions models – approximations are not used, models are constructed on the basis of reliable revealed "generating" mechanisms. Generalized parametrized model of certain class of objects is developed this model can be adjusted at restoration of concrete object of the class. This is not a novation but application of the principles of object-oriented programming.

Formalization of the problem of "produces – products – consumers" system modeling. We consider complex system of high dimensionality. Formally, there exist two alternatives for construction of such system model: simulation of each element of the system behavior: producer, product, consumer, simulation of complete system behavior – producers system, products system, consumer system. Practically, there exists only one alternative – construction of the system, comprising the above- mentioned models. We will consider analogues from physics: water and air can be modeled on molecular level an on the level of waves. It is known, that there exist "psychophysics", in fact, there exists "technophysics", describing regularities of functioning and development of integral engineering systems.

Aim of the given research is to create the operating model forecasting and planning of the process in the system "products line - consumers". This model – is an element of the system of models of "producers – products – consumers" class, that is: NMK – systems [1, 2]. We will divide the problem of model development into two models: model with simulation of each element of distributed system – NLmRk systems, model with simulation of all production elements, products of the line and aggregate consumers; NLmRk systems.

The necessary condition of efficient simulation model is to form already at initial stage variable and model parameters as structures, convenient for vectorization – deparallelization of computations. This is reflected at the level of models determination: Lm – is a set of products of "products line" class, Rk – is distribution of consumers according to incomes.

The task of system management: management of product line on the level "production"; management of the level "retail", management on the level "user".

Verbal model of real system. We suggest reduced verbal models of the elements

Consumer is characterized by income and disposition to consumption, awareness – the possibility to differentiate the products of various manufacturers, knowledge about the properties of the products, available experience regarding the usage of the product.

System of consumers is characterized by the volume of the given region (gravitation region), distribution of consumers by the incomes, saturation with demand and supply, dependence of selection probabilities on the level of income, rating of the products and "length and height of the shelf", structure of information exchange.

Product (brand) on the market is characterized by cost, usefulness and quality (value), supply function, model o consumption (usage) and availability of "consumers' club".

System of products line is characterized by the part of common components and common technologies in the products of the line, production costs, value certificate of the given class

products, ways of value change, rate of production mastering.

Development of operating models. Novelty of the model assumes the process of the development. Creation, testing and investigation of functional models, composing of individual models, investigation, at the last stage the complete model and service modules, needed for computational experiments are assembled. The complete systems consists of twenty basic modules. We suggest two examples of central modules: "products line" (Fig. 2) and "general membership function of consumer selection on product line" (Fig. 3).

$$LinP(Vp, Kk) := \left| \begin{array}{l} Vypad \leftarrow Vp_1 \cdot Vp_5 \cdot rnorm(Kk, 0, Vp_6) \\ \text{for } i \in 1..Kk \\ \quad cinnist_i \leftarrow \left[Vp_1 \cdot \left(1 - e^{-Vp_2 \cdot Vp_4 \cdot i}\right)^{Vp_3} + Vypad_i \right] \cdot (rnd(1) < Vp_7) \\ \quad cinnist_i \leftarrow max(cinnist_i, 0) \\ cinnist \end{array} \right.$$

We set the number of positions of product line Kk:=50; q:=1..Kk; and compose the matrix (simulations) of products line from different producers. We plot the graph and:

$$MLp := augment\left(LinP\left(Mp^{\langle 1 \rangle}, Kk\right), LinP\left(Mp^{\langle 2 \rangle}, Kk\right), LinP\left(Mp^{\langle 3 \rangle}, Kk\right)\right)$$

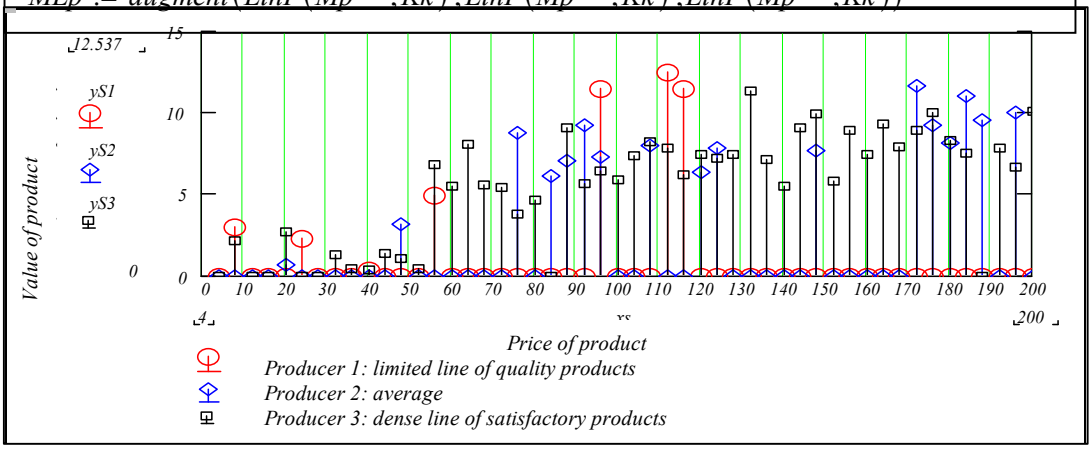

Fig. 2. Example of operating model "product line form several producers"

User's function *LinP(Vp,Kk)* generate simulation of the real line for a definite class of products, it takes vector of *Vp* parameter and the number of price intervals *Kk*. The process of consumer selection on products line radically differs from the selection process from the products of one price and value [3, 4]. This rather complex for formalization process is realized in a number of modules. Fig. 3. shows the final module having the following parameters:

Line Prod. Norm. (f. Membership func_income, _memmbership, threshopld, Numb_steps, step)

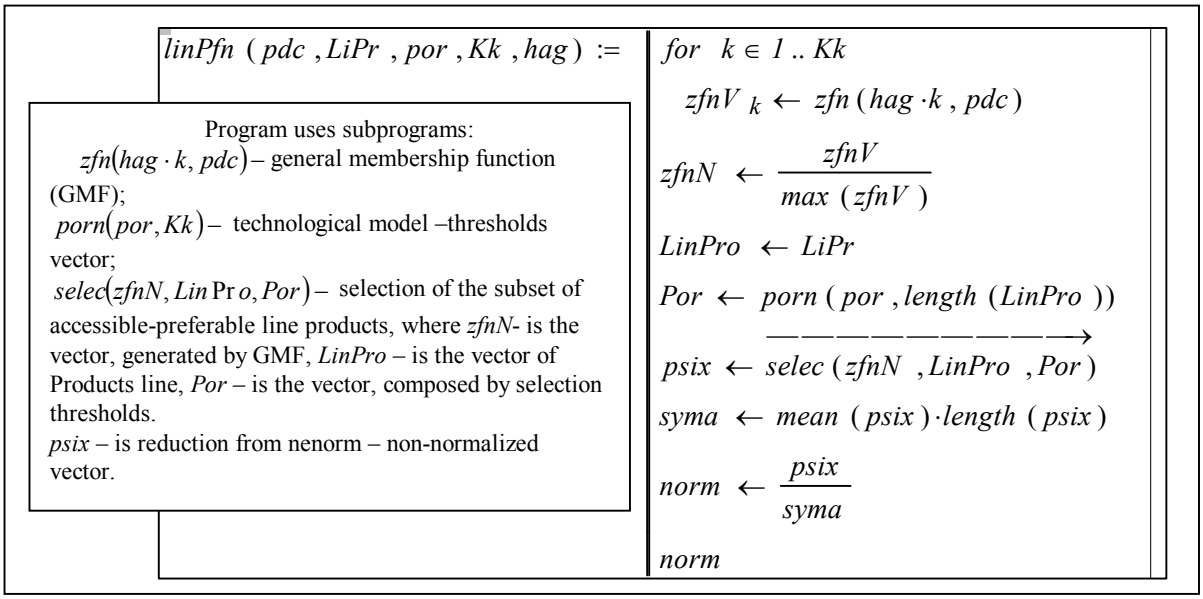

Fig. 3. Example of operation model "general membership function" for consumer selection

On the basis of the developed models of consumption dynamics and users training two alternative models of non- controllable system are developed and corresponding investigations are performed (Fig. 4, 5).

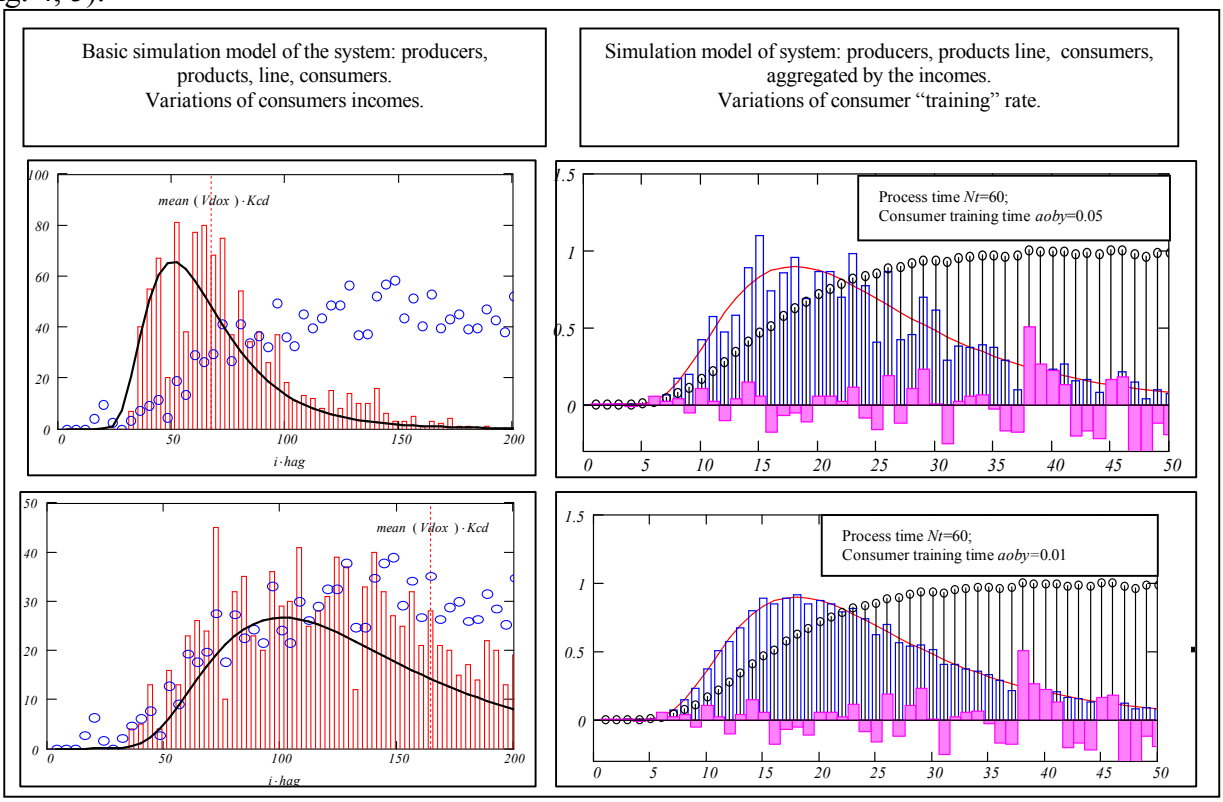

Fig. 4. Results of products line dynamics modelling by alternative models

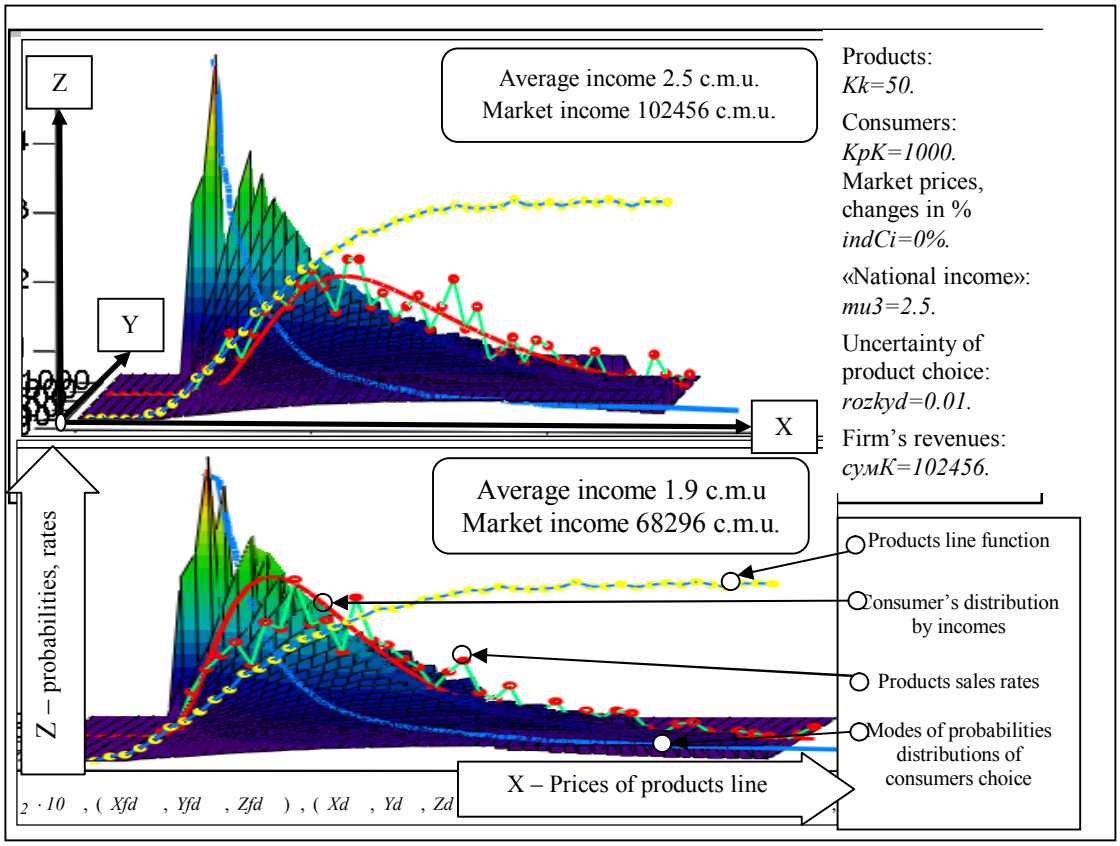

Fig. 5. Impact of average income on the state of production segment. example

Similarly, the analysis of the impact of price index change can be performed. Operation model is formed as user's function from certain parameters that is why it is not difficult to calculate the dependence of market revenues rate on price index. Figs. 6, 7 show the examples of such dependences. Within the frame of the developed model we obtain the following results: at low level of consumers' income total increases of prices leads to the fall of aggregated revenue of the market, at high level of consumers' incomes – to the growth of aggregate revenue of the market.

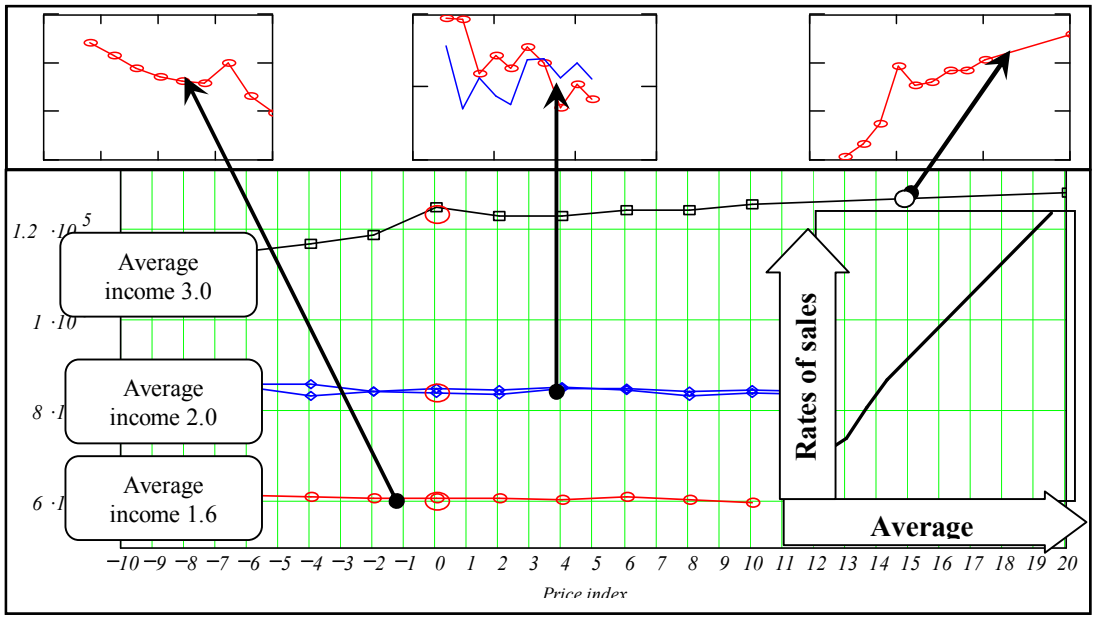

Fig. 6. Transient process in the system "products line" by alternative models

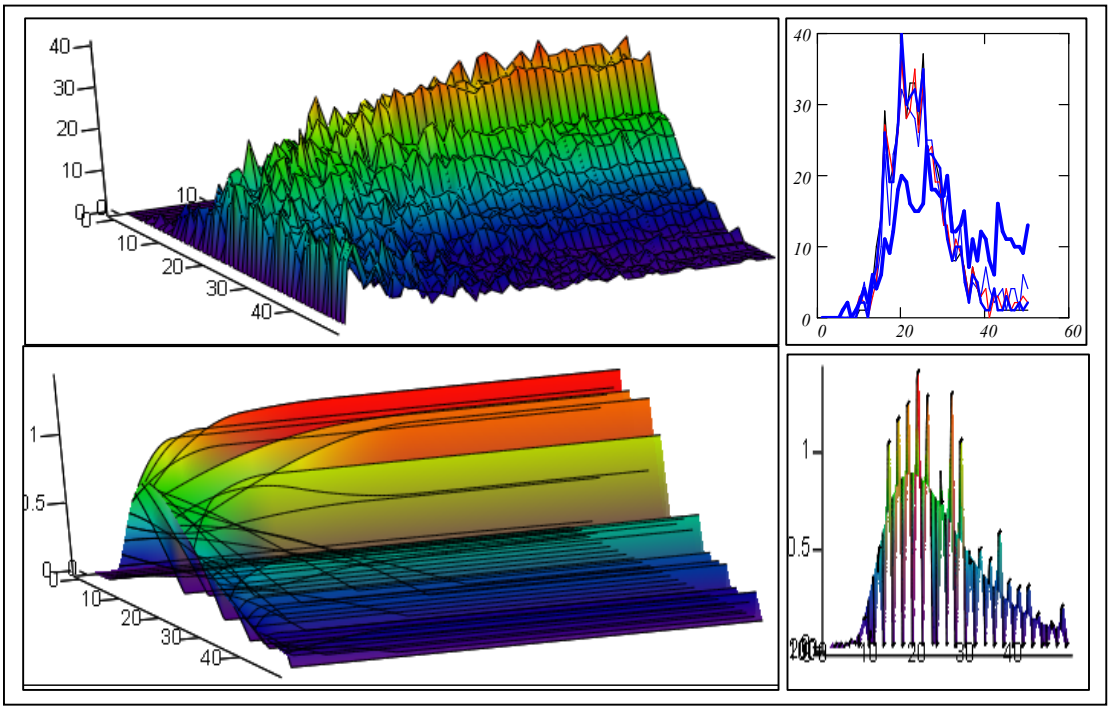

Fig. 7. Impact of line price index change at different levels of average income

Proceeding from basic alternative models and the results of their testing, we will perform the following step to formulation of the aim of given research – construction of aggregate model of the system "producers – product line - users". We introduce variables: "users", "distribution of incomes", "products line", "value-price" variable (vector) "distribution of supplies rate". Our goal is to obtain efficient operator, representing two functions in the function "distribution of line products supply rates":

$$rtP(t) = Opo(VP(t), dDk(t)), \tag{1}$$

where $rtP(t)$ – is established frequency distribution of supplies rates by prices; $VP(t)$ – are values of products, ranked by prices = "price - value" line; $dDk(t)$ is frequency distribution of consumers by incomes.

Natural process of the sales rates establishment are inertial. We will assume that there exist $rtPo$ – establishment distribution state. On its base we will develop the modal of global dynamics of the line. Established state:

$$rtPo = \lim_{t \to \infty} Opo(VP, dDk). \tag{2}$$

The dynamics of motion to the established state while the lack of line's disturbances

$$rtP^{\langle t+1 \rangle} = rtP^{\langle t \rangle} + Kg \cdot \left(\left(\overrightarrow{rtP^{\langle t \rangle} - rtPo} \right) \right) \cdot \Delta t. \tag{3}$$

Fig. 8 shows the diagram of aggregate model.

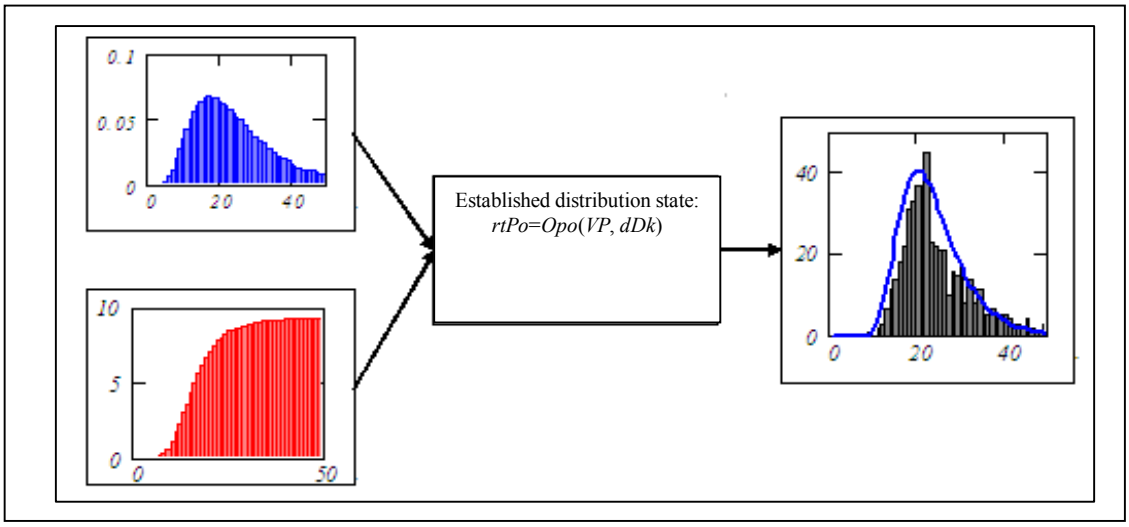

Fig. 8. Block diagram of aggregate model of products line dynamics as converter of distributions

We note that, in simulation model the random quality of users' choice is taken into account. Fig. 7 shows a number of graphs – evolution of supplies rates distribution (transient process). Fig. 8 shows the established state and "designed" "reasons" – distribution of users by the resources and products rule.

Models development of products line local dynamics. We set the training rate *aoby:=0,09*. We perform the first approximation:

$$\begin{array}{ll} exchange\cdot with\cdot neighbouring\cdot product\cdot on\cdot the\cdot left: & exchange\cdot with\cdot neighbouring\cdot product\cdot on\cdot the\cdot right: \\ \Delta levo = rtP_{k-1,t}\cdot\left(VP_k - VP_{k-1}\right)\cdot\alpha oby; & \Delta prav = rtP_{k+1,t}\cdot\left(VP_k - VP_{k+1}\right)\cdot\alpha oby; \end{array} \quad (4)$$

$$\begin{array}{c} results\ \ of\cdot exchanges: \\ rtP_{k,t+1} = rtP_{k,t} + \Delta levo + \Delta prav. \end{array} \quad (5)$$

Product management to be more precise, - line management, is realized by means of price change dp_k, value change – by means of "+50g free of change", new possibilities, which is reflected in value increment calculation dVP_k. All these types of management require expenditure, we will takes this into consideration in the model:

$$zVP_k = fzvp1\left(dVP_k\right) + fzvp2\left(dVP_k\right)\cdot rtP_{k,t}, \quad (6)$$

$$zp_k = dp_k\cdot rtP_{k,t}, \quad (7)$$

where constant and variable expenditures for the increase of products line value equal price change, multiplied by supplied rate, we will introduce corresponding functions of expenditures: $fzvp1\left(dVP_k\right)$ – are constant and $fzvp2\left(dVP_k\right)$ – variable changes.

Synthesis of management can be performed by means of such alternatives: maximum of expected increment of revenue flow; of the "pit" between two neighboring dominating element, even if in balance position or dominating position in the line.

We will introduce in the model probabilistic and determined choice of the consumer. Weak factors can influence the probabilistic choice, for instance, location of the product: small motor vehicles are better sold in roadsides shops, if they are placed on the side of the road. For small products – electric appliances – the intensity of demand depends on "height, length of the shelf".

Determined choice of the users means that the consumer remembers, after a single trial, a product, he likes or dislike, and then he concentrates on his choice. Transition to a new product requires intensive impact of information sources, the user completely trusts. We will make module "local redistribution of demand", that takes the period of modeling, function of supplies rate distribution, function of "products line" parameters of user's training process and returns the process

of sales rates redistribution during the preset period of modeling:

LokDispr=Lok3(distrib.Rate sales, Line, Training).

In the integrate model the behavior of such objects is reproduced: “producers system”, “consumers system”, “products system”. In the class “products” different by architecture products systems can be distinguished, for instance, “automobiles, accessories and services”, “product line of mobile telephones”, “product line of business – analytics programs”, “coffee line”, “text-books on modeling”.

At the expense of determined and probabilistic interactions elements form integral objects with sufficiently stable properties. These properties are usually formulated in terms of certain arrangement elements, for instance, ranks and frequency distributions, one-dimensional and multidimensional.

Search and test of development strategies for individual player. One of the peculiarities of the developed models is a possibility to allocate certain element: product, producer, consumer (cluster of consumers), and search for it optimal strategies in simulated market environment. We can distinguish two producers and simulate variants of competition and cooperation. Other similar senarios can be realized. The volume of the given paper does not allow to consider in details the results of simulation for the model “N producers, M products, K consumers”.

Conclusions. The methodology of construction mathematical models of social – technical – economic systems is suggested, system of operation models for such system is developed. Simulation module model of the system “producers, products, consumers” convenient for modifications is developed; the above – mentioned model can potentially be adjusted to the specific features of any products, consumption “training” and technologies models.

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Khomin Evgen– Post Graduate, Department of Computer Control System.

Borovska Taisiya – Cand. Sc. (Eng.), Assistant Professor with the Department Computer Control System. Vinnytsia National Technical University.

Badiora Sergiy – Cand. Sc. (Eng.), leading engineer, CKS «Automation».