SIMULATION MODEL OF LOGISTICS SYSTEM

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Abstract

The goal of the article is to research the information exchange speed's influence on the effectiveness of the organization.

It is necessary to model the entire work of the logistic system in order to study the influence of the information flow. This includes raw materials supply, product manufacture, distribution on the market and selling to the end customers. The model should include all three flows that are characteristic of logistic chains: material, cash flow and information. This would allow observing its functioning in its integrity. Besides, basic indicators of effective functioning of such type of systems are the profit realized in the separate chain elements and the number of unsatisfied customers, i.e. the profits foregone.

The aim of the model is, setting different values for information exchange and procession speed, to observe the changes in the system's indicators the way they were mentioned above. The relevant conclusions would be made on the base of the received results. All the other system's parameters would have the same values within the planned numeral experiments.

Keywords: simulation model, information, logistics system.

1. INTRODUCTION

Information exchange and procession speed exercises significant influence on the logistic system functioning. A computer simulation model is elaborated to verify that statement.

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2. DESCRIPTION OF THE MODEL

The multi-agent systems software tool is chosen for the development of the model. The concrete realization is performed in NetLogo programming environment. It is meant for developing multi-agent systems and it is software with free license.

The model's graphic interface is shown on Figure 1.

The model's workspace shown in the middle of Figure 1, is divided into two zones: market – marked in blue, and production zone – marked in black.

The following agents are included in the model:

Consumer – presented in the workspace as small yellow men-figures. Each one of them has expectations about the product's price. It is generated as random number with normal distribution.

Consumers move along random trajectories within the market (the blue area). When someone of them gets in the distribution centre, he checks whether the price corresponds to his expectations, i.e. whether it is lower or equal to them. Besides that, it is checked whether the distributor has the demanded product available. If these conditions are fulfilled, the customer buys a unit of the production. No matter whether he made the purchase or not, the customer disappears from the market and a new one is generated – with a new requirement for price.
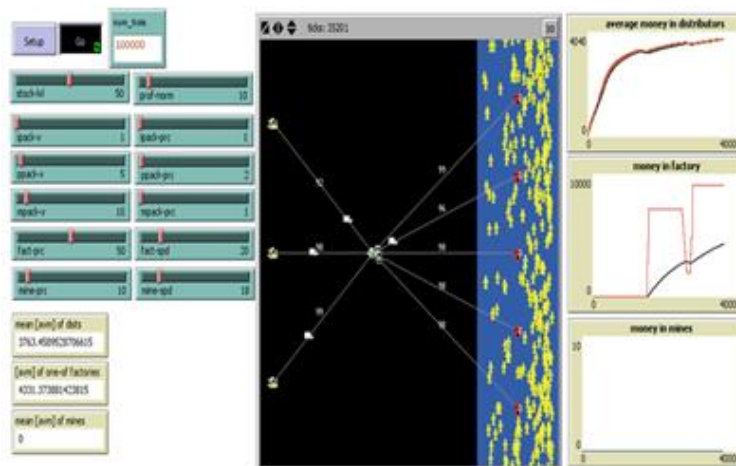

Fig.1. Model's graphic interface

Distributors – they are shown in the workspace as small red houses. In the beginning of the simulation, each distributor has certain quantity of production (50 units). When a customer purchases from the product, the availability reduces by a unit and distributor's money increase by the relevant price. When the number of available products drops under a certain level, the distributor sends an order to the manufacturer for filling up. At receiving the production, the distributor sends financial means to the manufacturer, corresponding to the product's wholesale price and to the delivered quantity. All expenses for sending information (orders), transport of material means and for financial transactions are at the expense of the distributor.

Manufacturer – he is presented in the graphic model as a factory in green in the middle of the workspace. Three types of raw material are necessary for the production of a unit of production. In the beginning of the simulation, the manufacturer preserves certain amounts ready production of each type of raw materials (500 units of each). At getting the order from the distributors, the manufacturer sends them the ordered quantities of production, by which his availability is reduced. The manufacturing starts, when it drops under a certain level. Manufacturing costs certain monetary means and in order to be realized, the following circumstances should be fulfilled: there to be availability of all necessary raw materials and the relevant financial means to be available. Besides, the raw materials stock reduces. When it reduces under certain level, an order is send to the relevant raw materials producer (supplier). At receiving the ordered items, their value has been returned as monetary reimbursement. The necessary financial means for communication are at the expense of the manufacturer.

Supplier – it is presented graphically in the model's workspace as factories in yellow. They produce the raw materials necessary for the final product. The production costs certain monetary means. Suppliers possess stock of raw materials in the beginning of the simulation. At getting order from the manufacturer, they complete it and when the level of reserve drops under certain level, they start producing. In order that to

happen they should have available the necessary financial means.

Information packages – these are the orders for supply of necessary products by the relevant agent to another agent, who possesses the necessary resource. They characterize with certain speed and cost of moving. They are graphically presented as white envelopes.

Material packages – these are material supplies in pursuance of the ordered quantities. They are graphically presented as white trucks. When the sender does not possess the necessary quantity to fulfill an order, its fulfillment stops and waits until the necessary material means are supplied.

Monetary packages – they are presented as green banknotes. These are the payments realized after receiving the ordered quantities of material resources. They transfer monetary means from the sender to the recipient. The relevant quantity of financial means is subtracted from the sender's money and at arriving is added to the recipient's money.

Connections between the agents – they are presented as straight lines connecting the separate agents in the model. They play the role of paths and possess a characteristic – length or distance between the agents, shown as a number above them.

The model's graphic interface includes, besides the graphic space situated in the middle, the following elements - Table 1.

Table 1.Logistic system simulation model graphic interface's elements

Element	Interface element's function
Button Setup	Prepares the model for work, features the separate elements in the workspace and others.
Button Go	It starts the model's work.
Field num-ticks	It sets the number of ticks (cycles), through which the model would work. When the ticks' counter reaches this value, the model stops to work.
Cursor stock-lvl	It sets in percentages the level of stock, at which reaching an order for filling up is sent. All agents use this level and the level of stock is calculated as percentage of the initial quantity, with which the simulation starts.
Cursor prof-norm	It sets in percentages norm of profit for all agents in the model. Everybody accrues these monetary means over the sold product's prime cost.
Cursor ipack-v	It sets speed of the information packages' movement. Value 1 means movement of the package at a distance of a unit for one tick (cycle) of the model's work.
Cursor ipack-prc	It sets the cost for the information packages' moving at a distance of a unit.
Cursors ppack-v and ppack-prc	It sets relevantly speed and cost of the material packages' moving.
Cursors mpack-v and mpack-prc	They set relevantly speed and cost of monetary packages' moving.
Cursor fact-prc and fact-spd	They set relevantly the necessary financial means for the production of a unit of final product and the speed for the production of a unit of final product in number of ticks. The price includes also the value of the raw materials set in the product.
Cursor mine-prc and mine-spd	They present relevantly price and necessary time for producing a unit of raw materials. It is accepted in the model that all raw materials are produced at same value and for the same time.
Deduction field mean [avm] of dists	It shows the average profit of the final product's distributors for the market.
Deduction field	It shows time-averaged value of producer's profit.

Element	Interface element's function
[avm] of one-of factories	
Deduction field mean [avm] of mines	It shows the average profit of the raw materials suppliers.
Graphic average money in distributors	It shows the passing values of distributors' profit, averaged by time.
Graphic money in factory	It shows the passing values of the available financial means in the producer (red) and his averaged by time profit (black line).
Graphic money in mines	It shows the passing values of raw materials suppliers' profit.

3. NUMERAL EXPERIMENT, RESULTS

For verification of the statement that the speed of movement and procession of information exercises significant influence upon the work and effectiveness of the entire logistic system, a numerical experiment is planned. At constant values of all rest perimeters, only the speed of moving of information packages is changing. The following indicators are chosen for starting indicators for the logistic system's work: average profit of the distributors, producer's profit, average profit of the raw materials' suppliers and number of missed sales because of lack stock in the relevant distributor.

It is planned experiments to be held at speeds of information packages moving of 1, 2, 5, 10, 20, 50,100. As far as number of elements cannot be generated as random numbers while preparing the model, for example the distances between the objects and others, three simulations are conducted for each value of speed, and the resulting values for the separate indicators are averaged.

The results of all conducted numeral experiment are shown in Table 2.

Table 2. Results of the numeral experiments

Speed of information exchange	Trials	Average profit of distributors	Average profit of producers	Average profit of suppliers	Sales forgone
1	1	4672	7863	318	4880
	2	4609	7293	316	4801
	3	4628	7631	319	4569
	Average	4636	7596	318	4750
2	1	5354	8898	618	3922
	2	5376	9023	620	4003
	3	5339	9076	615	3875
	Average	5356	8999	618	3933
5	1	6667	10787	1008	2530
	2	6643	10428	970	2488
	3	6517	9593	1024	2436
	Average	6609	10269	1001	2485
10	1	7439	10944	1283	1520
	2	7443	10242	1282	1429
	3	7650	10587	1353	1445
	Average	7511	10591	1306	1465
20	1	7840	10989	1522	917
	2	7992	10870	1492	903

Speed of information exchange	Trials	Average profit of distributors	Average profit of producers	Average profit of suppliers	Sales forgone
	3	7701	10259	1484	1001
	Average	7844	10706	1499	940
50	1	8196	11230	1671	432
	2	8323	11179	1639	438
	3	8526	10602	1651	327
	Average	8348	11004	1654	399
100	1	8499	10715	1671	234
	2	8521	10943	1674	205
	3	8632	11789	1691	288
	Average	8551	11149	1679	242

Table 3.shows the averaged values of the chosen indicators.

Table 3.Averaged indicators' values

Speed of information exchange	Average profit of the distributors	Average profit of the producer	Average profit of the suppliers	Sales forgone
1	4636	7596	318	4750
2	5356	8999	618	3933
5	6609	10269	1001	2485
10	7511	10591	1306	1465
20	7844	10706	1499	940
50	8348	11004	1654	399
100	8551	11149	1679	242

The results shown in the table are presented graphically in Figure 2.
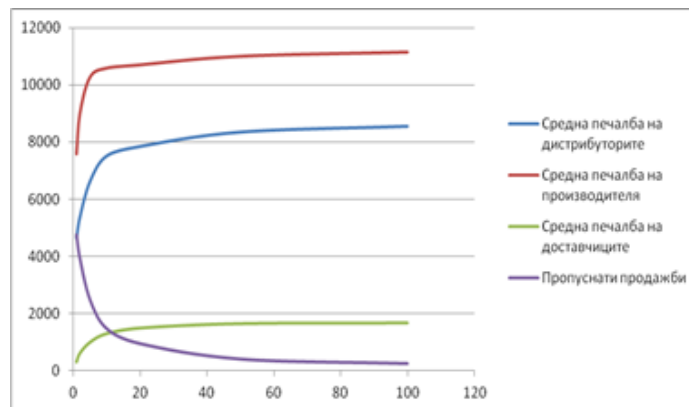

Fig 2.Graphics of the chosen indicators depending on the speed of information exchange

4. CONCLUSION

The following basic **conclusions** can be drawn from the conducted numeral experiment (Anikin, 1999a; Belozubov, Nikolaev, 2007a; Banchev, 2010a; Banabakova, 2012a; Banabakova, 2013a; Banabakova, Panev, 2012b; Banabakova, 2004a; Daskalova, Grigorova, 2012c; Dimitrov, 2010b; Baker, Fuller, 2009a; Faulkner, 2000a; Floridi, 2010c; Ganeshkumar, 2006a; Haine, 2011a; Hilbert, 2011b; Banzhaf, 1998a; Goldberg, 1989a; Michalewicz, 1999b; Mitchell, 1996a; Vose, 1999c):

The speed of information exchange and processing exercises serios influence upon the logistic system's work. The results in Figure 2. Show that the profit of the separate elements of the system increase at higher values of the information exchange speed.

"Saturation" of the starting indicators, i.e. their increase reduces at higher values of information speed (Figure 2.) when increasing he information exchange speed within the logistic system. Hence, balance between the invested means for information exchange improvement and the value of profit should be looked for.

The suggested logistic system simulation model is applicable for the Bulgarian army logistic system, too.

Is it is this option of the model, the agents would be as follows: suppliers; storehouses of the Bulgarian army; military formations; information packages; material packages; monetary packages; connections between the agents.

The goal of the simulation model would be studying the speed of information exchange and procession upon the time for execution of supplies and logistic expenses, as far as these indicators are of crucial significance for the Bulgarian army logistic system functioning.

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