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MODELING OF ERP–SYSTEMS INFLUENCE ON BUSINESS PROCESSES OF ENTERPRISES

Formulation of the problem. The problem of prediction of ERP-systems (programs for the integrated management of all resources companies) impact requires rethinking and using new approaches in the present conditions. This is due to the following factors:

increasing complexity of enterprise management systems;

increasing competition on the one hand, and the need for close cooperation between enterprises on the other;

reorientation of enterprises to fully meet the needs of consumers;

increasing complication for ERP- systems which are adapted to the new needs of management;

need to consider the introduction of quality results that often cannot be expressed in traditional terms;

presence of important subjective component in the implementation and use of such systems, which is related to the behavior of stakeholders and so on.

According to some consulting companies [1], which involved the implementation and support activities ERP-systems, only 25% of companies who have implemented similar systems, report that they have received benefits range from 50 to 100% of those planned.

Perhaps these results are related not only with the traditional difficulties that have been mentioned before, but also not quite adequate planning results. So modeling process implementation and use of ERP-systems is an important task, which, in particular, will determine the needs of businesses in the automation specific business processes and to estimate the results that can be expected.

One of the most promising approaches to solving such problems is the system dynamics methods which allow taking into account the complex nature of the elements interaction in modern production systems, their dynamics and uncertainty.

The prediction results before the implementation project is complicated by the fact that companies and their business processes are very different. However it is possible to construct a set of common reference models that describe business processes, responding to a particular type of classification that takes into account the level of influence of different modules ERP-system [2].

Analysis of recent researches and publications. ERP-system (Enterprise Resource Planning) defined as a class of information systems that provide comprehensive automation of management. Since 1990, ERP is becoming a standard automated management systems for large, and especially in international companies [3]. Later, methods and approaches that have been used to automate the business processes of large enterprises have been partially transferred in medium businesses.

Most authors think that part of the system that conforms to the ERP-systems should include:

subsystem MRP (Material Requirement Planning) + CRP (Capacity Resource Planning), which allows to perform automated planning of materials according procurement to plan production orders by customers and the optimal allocation of production capacity in manufacturing;

module SCM (Supply Chain Management), which allows to optimize inventory control and shipping logistics of the company;

module CRM (Customer Relationship Management), which automates the relationship with customers and optimizes marketing activities of the company;

module HRM (Human Resource Management), which allows to increase the efficiency of the company's personnel;

features to accelerate workflow in the enterprise and features to automate the business processes associated with the formation and analysis of cash flows.

We have studied approaches contained in [4, 5, 6], which determine indicators of companies activity that vary with the successful implementation of ERP-systems. Specifically N.A. Sari and others separate operational indicators ERP-systems which can be associated to the performance of certain business processes.They include: reducing costs (storage and processing of raw, materials and finished products, the organization of communication between members of business processes, salaries, etc.)., speeding up the production cycle and increase productivity (by optimizing logistics, optimal capacity utilization, speeding up workflow), improving the quality of information (by automating the processing and use of a single database for all business processes).

Process approach to management and business process model considered in [7, 8]. Business process model that was used in this paper is based on a typical business process model, which is developed by "Business Studio" [9].

A system dynamic approach to modeling of manufacturing systems contained in the fundamental works of J. Forrester [10] and its use in the simulation of processes associated with evaluating the impact of ERP-systems are considered in [11, 12] and others. But these works are not considered separate business processes, which makes it impossible to disclose problems that cause dissatisfaction of most business leaders with ERP-systems results.

The aim - to build a system-dynamic model for evaluating the effect of different modules of ERP-systems on the basic parameters of production and distribution company.

The work includes the following phases: study of the composition and functionality of the modern ERP-systems in general and their individual modules, build a model of typical business processes of production and distribution company, the separation of business processes that change with the introduction of certain functional ERP-system, identification of positive and negative links in the system when implementing ERP-systems, building system-dynamic model, analysis model.

The main material of research. Typical business processes of production and distribution company includes three main processes: procurement, production, promotion and sales, and three auxiliary administrative business processes - planning, personnel management, financial management. Modeling of business processes using IDEF0 notation allowed identifying business processes that will change after the introduction of a specific function ERP-system.

Subsequent detailing of each business process allowed revealing actions that will change after automation

Figure 1 shows some results identify the parameters that affect the key performance indicators of companies in each of the above business processes.

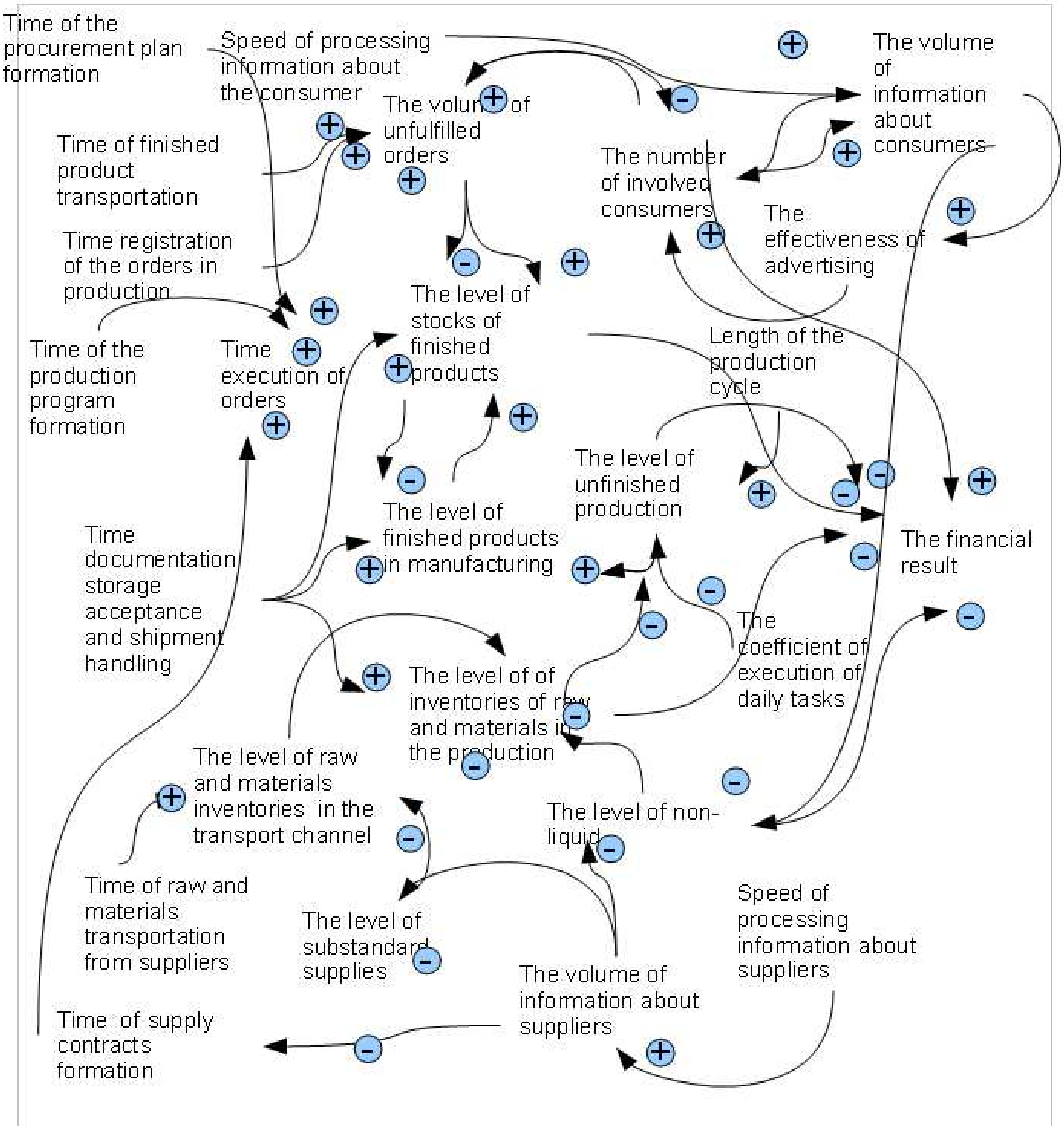

Figure 1. Causal diagram of key performance indicators of business processes with parameters of key business processes

Source: compiled by the author

Causal diagram shows not only the influence of individual parameters but also helps to understand the changes that occur in a business process, then begin to affect the performance of another business process. For example, it can be expected that the introduction of the module CRM, which allows to improve service quality and customer satisfaction, will improve the number of new customers, which will increase the number of orders and will affect the entire supply chain.

Then we give a description of the system-dynamic model that will allow explore the changes in of key business processes after implementation modules, and ERP systems in general.

Block promotion and sales.

1. Consumer behavior is modeled based on the model of product distribution by F. Bass [13].

The level of potential consumers is estimated by the formula

$$\frac{dLR1(t)}{dt} = FR1(t) - FR2(t),$$

where FR1 (t) - flow of consumers, which is given by:

$$FR1(t) = \left(LR1(t) * PR1 + LR2(t) * PR2 * LR4(t) * \frac{LR1(t)}{PR3}\right),$$

PR1 - coefficient which shows the efficiency of product advertising, LR2 (t) - level consumers who have already order this product, PR2 - parameter that defines degree of fullness of information about customers (LR4 (t)) on quality of customer service, PR3 - a parameter that shows the total volume of the consumer market and FR2 (t) - is the flow clients performing repeat purchases after the life of the product: where PR4 - the lifetime of the product.

The level of orders (real buyers) increases at the same rate, as much reduced level of potential buyers:

$$\frac{dLR2(t)}{dt} = -FR1(t) + FR2(t)$$

Level of awareness about consumers is calculated based on the fact that some of the initial volume of information (LR3) decreases with a certain speed and accumulates at the level (LR4):

$$\frac{dLR3(t)}{dt} = -\frac{LR3(t)}{PR5} * (PR5 - LR4(t)) * PR6$$

$$\frac{dLR4(t)}{dt} = \frac{LR3(t)}{PR5} * \left(PR5 - LR4(t)\right) * PR6,$$

where PR5 - is a parameter that indicates the maximum possible volume of information about consumers, PR6-rate of accumulated information about consumers.

So the effectiveness of advertising goods affects the number of potential customers and can be greatly enhanced through the use of modern tools of marketing analysis, which are part of the CRM-module of most modern ERP-systems. Also the degree of awareness of customer needs, which also increases when implementing CRM-systems also affects the number of potential customers.

2. Sales process is modeled by the following equations:

The number of unfulfilled orders from real customers on which calculated plan orders for raw and materials and formed the production program:

$$\frac{dLR5(t)}{dt} = FR3(t),$$

where FR3 (t) - flow of orders that are created per unit time, PR7-parameter which to take account of time for orders formation.

The model calculated yet another indicator of the number unfulfilled orders, which is necessary to assess the level of orders that are unfulfilled at a time.

$$\frac{dLR6(t)}{dt} = FR3(t) - FR4(t),$$

where FR4 (t) - is the flow orders executed per unit time, FR4 (t) = delay (PR8 (t), PR9), PR8 (t) - the number of units sold to consumers per unit time, PR9 - the time required for processing sales organizations.

$$PR8(t) = \begin{cases} PR10, if\ PR10 < LR7(t) \text{ и } LR6(t) \geq PR10 \\ LR6(t), if\ PR10 > LR7(t) \text{ и } LR6(t) \geq LR7(t), \\ LR7(t),\ in\ other\ cases \end{cases}$$

where PR10 is a parameter which determines the maximum amount of product that can be supplied to consumers per unit time (throughput sales department), LR7 - inventory in stock of finished goods. The formula allows taking into account that sales per unit time must be equal to the needs of the consumer, but a limited amount of goods in a warehouse or a channel sales.

3. The volume of goods in stock of finished goods is determined by the formula:

$$\frac{dLR7(t)}{dt} = FR5(t) - FR4(t),$$

where FR5 (t) - output flow that arrives at the warehouse of finished products per unit time, FP1 (t) - flow of finished goods which are shipped to a warehouse of finished products from the production structure per unit time, PR11 - the time it takes to transport these products .

4. Formation of the production program is executed periodically (once a month or a decade, according to the adopted business process) as follows:

$$PR14(t) = delay(LR5(t), PR12 + PR13),$$

$$LR5(t) = 0,$$

where PR12 – is time of production programs formation, PR13 - checking this program.

The obtained dependences show that the most effective in promoting and selling the block can be expected if implemented not only CRM-module, but the functionality of MRPII and SCM to reduce the parameters that are associated with the calculation of the production program and future performance of key business processes in sales.

Block Manufacturing.

1. The level of finished products stocks on a production stock is calculated as follows:

$$\frac{dLP1(t)}{dt} = FP2(t) - FP1(t)$$

where FP2 (t) - is the flow of finished product per unit time, $FP2(t) = delay(FP3(t) - FP4(t), PP1)$, FP3 (t) - flow of products per unit of time, FR4 (t) - flow defective products per unit time, PP1-the time needed for inspection and drawing up documents for finished products, FP1 (t) - the flow of goods that are shipped to sale warehouse, PP2 (t) - time needed to packaging and shipping of products.

2. Level of defective products:

$$\frac{dLP2(t)}{dt} = FP4(t)$$

where $FP4(t) = delay(FP3(t) * PP3, PP4)$, PP3 - percentage of defective products, PP4 - time of defects detection.

3. Inventory level of products is calculated as follows:

$$\frac{dLP3(t)}{dt} = FP3(t) - FP4(t) - FP2(t)$$

where $FP3(t) = delay\left(\frac{FP5(t)}{PP5} * PP6, PP7\right)$, FP5 (t) - flow of raw and materials that enters in production per unit of time, PP5-amount of raw and materials needed to produce per unit of product, PP6 –percentage of dayly task performance, PP7-length of the production cycle,

$$FP5(t) = delay(PP8(t) * PP5, PP9)$$

$$PP7 = PP10 - PP11 - PP12$$

where PP8 (t) - daily tasks goods, PP9 - the time needed to draw documents about raw and materials in the production process, PP10 - initial length of the production cycle, PP11 - change the length of the production cycle due to changes in load work centers, PP12 - change in length production cycle in units of time due to changes in equipment setup.

4. The level unfinished production:

$$\frac{dLP4(t)}{dt} = \frac{FP5(t)}{PP5} - FP4(t)$$

5. The level of stocks of raw and materials in the production:

$$\frac{dLP5(t)}{dt} = FS1(t) - FP5(t)$$

where FS1 (t) - flow raw and materials that are shipped in the production from block of supply per unit time.

Most of the parameters that can affect the key performance indicators in block production connect with the implementation of functions MRP and CRP. However, important effects are also changes in block sales associated with the CRM functionality and delay time that can be significantly reduced by optimizing the supply chain.

Block Purchases.

1. The volume of raw and materials stocks is estimated by the equation:

$$\frac{dLS1(t)}{dt} = FS2(t) - FS1(t)$$

where FS2 (t) - flow of raw and materials, which enters to warehouse per unit time, FS3 (t) - number of raw materials that are shipped from suppliers per unit time, PS1 is time transportation of raw and materials from the supplier, PS2 - time for registration of warehouse receiving documents, PS3 - parameter which indicates the time of shipment handling paperwork.

2. The amount of raw and materials that are in the process of transportation:

$$\frac{dLS2\,(t)}{dt} = -FS2(t) + FS3(t),$$

where $\mathrm{FS3(t) = (delay(\frac{PS4(t)}{PS5}, PS6)}$,PS4 (t) - plan of raw and materials procurement, PS5 - interval in units of time between purchases, PS6 - the time it takes to enter into supply agreements.

3. Plan procurement of raw and materials is calculated periodically, simultaneously with the formation of production program:

$$PS5(t) = delay((PR14(t) + LP2(t)) * PP5 + LS3(t) - LR5(t), PS7 + PS8)$$

where PR14 (t) - production program, which was formed in the block Promotion and sales, LP2 (t) - the level of accumulated shortage, which is formed in the block Production, PP5 - the amount of raw and materials needed to produce in unit of product, LS3 (t) - the amount of low-quality supply of raw and materials, which accumulated up to this point, LP5 (t) - inventory levels of raw and materials in manufacturing, which accumulated up to this point, PS7 - time of formation of a plan procurement, PS8 – time of checking the procurement plan. Level of substandard supply, level of inventories in the production again equated zero.

4. The amount low-quality supply is determined from the equation:

$$\frac{dLS3\,(t)}{dt} = FS4(t),$$

where $FS4(t) = delay(FS2(t), PS9) * PS10/PS11$, FS4 (t) - flow of low-quality supply of raw and materials per unit time, PS9 - the time it takes to detect low- quality supplies, PS10 - percentage of substandard supplies, PS11-index that allows to take into account the quality of information about suppliers.

5. The quality information about suppliers depends on the volume of processed information, which is determined by a similar procedure accumulation of information about consumers.

Block of Financial flows.

1. The total financial result, which is formed to assess profit system, is calculated as follows:

$$\frac{dLF1(t)}{dt} = (FF1(t) - FF2(t) - PF15 - PF20) - (FF1(t) - PF15 - FF2(t) - PF20) * PF1$$

where FF1 (t) - flow of income per unit time, FF2 (t) - flow cost per unit time, PF15 - the production costs per unit time, PF20 - ERP costs per unit time, PF1 - tax rate.

2. The flow of income per unit time is defined as:

$$FF1(t) = FR4(t) * PF2$$

where FR4 (t) - the number of executed orders per unit time, PF2 - unit selling price of the product.

2. The flow cost per unit time is:

$$FF2(t) = FF3(t) + FF4(t) + FF5(t) + FF6(t) + FF7(t)$$

where FF3 (t) - the cost of raw materials per unit, FF4 (t) - the cost of saving raw and materials, FF5 (t) - production costs, FF6 (t) - the cost of preservation finished product, FF7 (t) - the cost of sailing.

Costs associated with purchase and transportation of raw and materials can be estimated by the formula:

$$FF3(t) = FS3(t) * PS1 * PF3 + PF3 * PF4$$

where PS1 (t) - the flow of raw and materials, which are shipped by providers per unit time, PS2 –time of raw and materials transportation from the supplier, PF3 - unit cost of raw and materials transportation per unit time, PF11 - unit price of raw and materials.

The cost of raw and materials conservation are described by the expression:

$$FF4(t) = FS2(t) * PF5 * PS3$$

where FS2 (t) - the flow of raw materials that enters to the warehouse from supplier per unit time, PS3 - time of documents processing for the shipment of raw and materials to production, PF5 - cost conservation unit inventory per unit time.

Other costs are calculate similarly.

The model has been implemented in the system AnyLogic.

The parameters of business processes that change after the implementation of ERP-systems have determined. The results are shown in Table 1.

Table 1

Modules ERP-system and the business processes that they influence

ERP-module	Business-process	Parameter of business-process	ID in the model
CRM	Promotion and sales	Effectiveness ratio of advertising	PR1
CRM	Promotion and sales	Speed of information processing about consumers	PR6
CRM+MRPII	Promotion and sales	Delivery of goods to the warehouse of finished products	PR7
SCM	Promotion and sales	Time of theproduction programformation	PR11
CRM+MRPII	Promotion and sales	Time ordering to block production	PR12
CRM+MRPII	Promotion and sales	Checking production program	PR13
MRPII	Manufacturing	Time processing of raw materials to production block	PP9
MRPII	Manufacturing	Time paperwork for finished products	PP1
MRPII	Manufacturing	Change the time changeover work centers	PP11
MRPII	Manufacturing	Change the working load centers	PP12
MRPII	Manufacturing	The coefficient of execution of daily tasks	PP16
SCM	Purchases	Transportation time of raw and materials from the supplier	PS1
SCM	Purchases	Time for packing warehouse acceptance documents	PS2
SCM	Purchases	Time of paperwork warehouse shipping	PS3
SCM	Purchases	Time of contract supplyexecution	PS6
SCM	Purchases	Share substandard supplies	PS10
CRM+MRPII+SCM	Purchases	Time of procurement planformation	PS7
SCM	Purchases	Speed of processing information about suppliers	PS12

Source: created by the author

To analyze the simulation results were conducted several simulation experiments that allowed imagine the impact of individual modules of ERP-system on key performance indicators of key business processes. These key indicators were selected as follows:

1)for the Promotion and sales block - the level unfulfilled orders, the level of finished productsstocks;

2) for block Manufacturing - inventory levels of raw and materials in the production, level of finished products in the production, level unfinished production;

3) for block Procurement - the level of stocks;

4) for block Finances - the financial results.

The model unit of time was considered a one day; simulation was carried out at an interval of 600 units of time, length of time to form a production program - 30 days.

The simulation results are shown in diagrams 3-5.

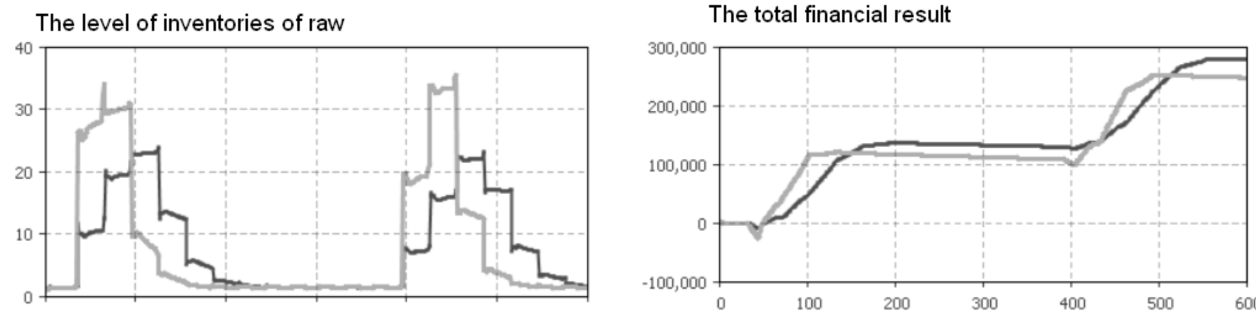

Figure. 3. Change of some indicators of business processes in the simulation implementation of CRM-module (change - lighter color)

Source: The author received in the program AnyLogic

In Fig. 3 it can be seen that by changing the parameters that apply only to the module CRM, most indicators of business processes is not improving, but can be seen somewhat faster increase financial performance.

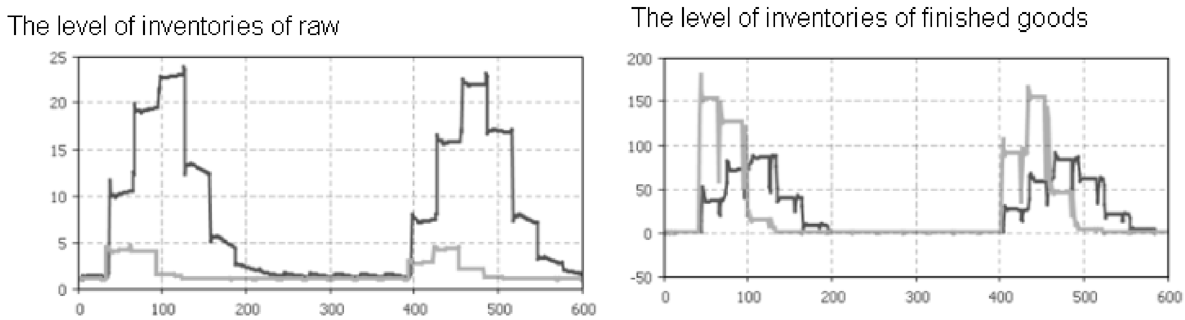

Figure. 4. Changing inventory levels after complex ERP-system

Source: The author received in the program AnyLogic

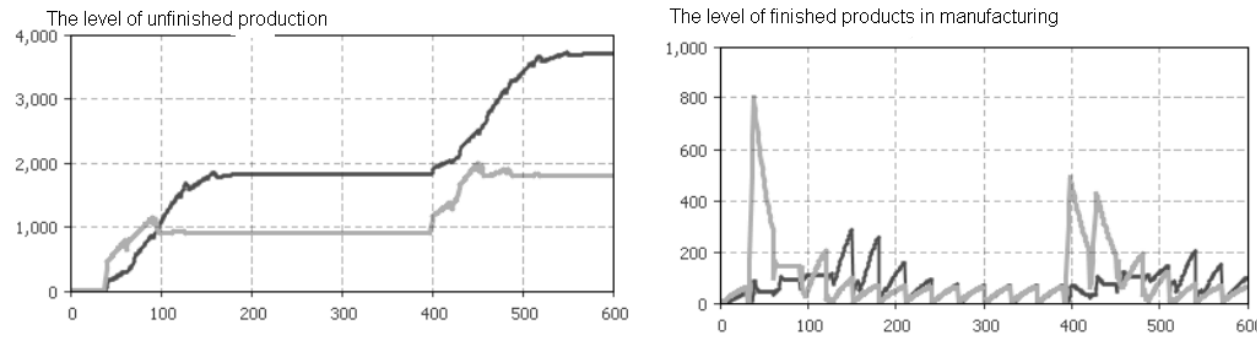

Figure. 5. Changes the level unfinished production and finished goods in production after complex ERP-system

Source: The author received in the program AnyLogic

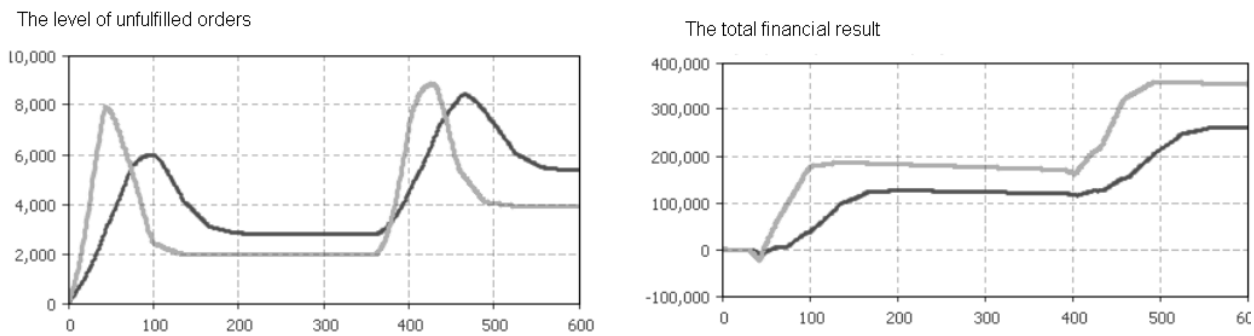

Figure. 6. Changes the of unfulfilled orders and the company's profit after complex ERP-system

Source: The author received in the program AnyLogic

In Fig. 4-6 are the results of the simulation experiments, which indicate that the automation functions are performed with the successful implementation of the modules CRM, MRPII and SCM. It improves most indicators of business processes, including inventory levels of raw and materials and finished products in the production level of unfinished production. Quality customer service improved significantly

Conclusions and further research. In this paper we described one possible approach to the evaluation of results which company can be expected after ERP-systems implementation. Building system-dynamics model, in our opinion, allows to predict the effects of implementation of individual modules ERP-system and its complex effects on the core business processes. It allows us to consider changing the key performance indicators as a result introducing such systems.

Conditional values of the parameters that were used in the model need to be clarified but results of the experiments show that the approach can be used to solve such problems.

The model can also be added by HR module and a module which allows assess the impact of modern methods of analysis of the information that is used in ERP systems on the speed and quality of strategic and tactical planning as one of the most important administrative business processes.

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Poluektova N.R. MODELING OF ERP – SYSTEMS INFLUENCE ON BUSINESS PROCESSES OF ENTERPRISES

Purpose. The purpose of the article - to build a system-dynamic model to assess the impact of the various modules of ERP-system on the basic parameters of production-sales company.

Methodology of the study. The study used the method of system dynamics. The proposed approach included the following steps: study of the composition and functionality of modern ERP- systems in general and their individual modules, building a model of typical business processes of production and distribution company, allocation of business processes, which connect with using of certain functionality of ERP-system, identification of positive and negative connections in the system Supply - Production - Sales in the implementation of the ERP-system, the construction of a system dynamic model and analysis model.

Findings. System-dynamic model, which allows predict the results of the influence of separate modules of the ERP-system and its complex impact on performance of the main business processes was built. A series of simulation experiments have confirmed possibility of measuring the effects of the implementation of ERP-systems by key indicators when changing the business processes. Strengthening effects in complex implementation of all modules of a corporate information system has been confirmed.

Originality. The developed model allows predict the effects of the implementation of information management systems, which are difficult to formalize, by identifying changes in key parameters of the effectiveness of the main business processes.

Practical value. The method can be used to predict the results that the company receives when implementing ERP-systems of any configuration. The model can be used to substantiation of a choice system configuration in its inception..

Key words: ERP- system, model, business processes, prediction, system dynamics.