SYSTEM DYNAMICS SIMULATION MODELLING OF ORGANISATIONAL BUSINESS SYSTEM OF MANAGEMENT OF MATERIAL AND INFORMATIONAL FLOWS IN PRODUCTIVE COMPANY

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ABSTRACT

System Dynamic Simulating Modeling is one of the most appropriate and successful scientific dynamics modeling methods of the complex, non - linear, natural, technical and organizational systems. The methodology of this method, together with use of digital computer, showed its efficiency in practice as very suitable means for solving the problems of management, of behavior, of sensibility, of flexibility of behavior dynamics of very complex systems. All this is made by computer simulating, i.e. "in laboratory", which mean without any danger for observed realities.

System Dynamics simulation models of organizational business system of management of material (raw-materials, orders, money, labor, personnel, population, capital equipment: tools, units and factories e.t.c.) and informational flows in productive company will be presented in this paper. Organizational business-production system is simulated by effective scientific discipline System Dynamic and realized by Dynamo (PD4) and PowerSim program packages, also.

Due to complexity and extensiveness of business management of organizational business process, or production-distribution system global simulation models of companies are presented on the modular way, i.e. with seven relevant sub systems:

1. Production-inventory sub system;
2. Credits sub system;
3. Debits sub system;
4. Sub system of productive capacities;
5. Sub system of Cash-Flow;
6. Gross income - net income sub system;

7. Sub system of demand for organization products,

which are common structural characteristic in every productive business organization. These sub system are modeled according to its specific quality.

Keywords: System Dynamics, Modeling, Heuristics optimization, Continuous and Discrete simulation, Business System.

1. INTRODUCTION

For one productive organization which is made up of series of cause-consequence dependent sub systems, i.e. modules, which represents division based on functionality, can be told that this is complex process with large numbers of feedback loops, which are necessary to take into consideration. This interdependence sometimes effects very strongly on the final result of behavior dynamics of organizational business system. The result of dynamics behavior of business-production process can be manifested with fluctuation of relevant business variables, such as: speed of supplying raw materials, speed of arriving the raw materials, speed of finishing the final products, state of unfinished production, state of finished goods - inventory, speed of shipment, state of productive capacities), state of: credits, debt, cash-flow, gross income, net income, speed of investment new capacities police, etc.

Previously it was mentioned that business production process, i.e. production organization business production system, is made up of seven sub system (sub-models), which have direct or indirect flows influence on some or even all listed indicators i.e. production relevant variables. Meaning, it is necessary to have a priori knowledge of this business-production process in order to define relationship between these indicator-variables and between every single module. Furthermore, it is possible to detect ineffective parts of such business organization system by necessary knowledge of this business-production processes and continuous modeling with System Dynamics. Further, with simulation of dynamics processes of production organization different behavior of this organization can be predicted, as response to different stimulus, i.e. test functions. For stimulus (known test functions), i.e. inputs in such processes in consequence consideration can be taken: changes in the markets, such as increase or decrease in credits for sale products or debit of this organization, introduction of new production equipment, change of supplier of components or materials, etc… Subjecting the production organization to different scenarios which are stipulated with changes in the market production organization can become more flexible, adaptive and robust. In this paper SD-continuous model of such production organization will be presented, and also a possibility of application System Dynamics methodology for simulation of this kind of business-production systems. The paper is conceived as follows: sub systems of business production organization, entire model of productive organization system and its simulation, conclusion and used references.

2. PRODUCTION SUBSYSTEM

2.1. Mental-verbal model of the production subsystem

The "order speed" of material (**NM**) is influenced by demand for organization products (**EXPR**) which can be described as exponential average of the demand for products in last 36hrs (see graph "Demand for products" in subsystem of demand for organization products). With a larger exponential average (**EXPR**), the orders of the material (**NM**) are also larger (+), consequently with the increase of the order, the state of unfinished production will also increase (+). Increasing the quantity of finished production (**ZGR**), the quantity of unfinished production (**NP**) is decreasing (-). With a higher speed of product finishing, the supply of finished products will be higher (+) with the consequence of the increase of quantity of delivered products (+). When quantity of delivered products (**IR**) is higher, the quantity of finished products (**ZGR**) in supply is lower (-), which gives a negative (-) sign to the feedback link of FBL 1. The quantity of delivered products (**IR**) will, of course, depend on demand for products on the market (**TRAZNJA**). When the delay of the ordered material occurs, it could be described with macro function DELAY3, which as arguments takes a variable for which we describe the delay of the material flow of III order, and as a time delay parameter KP. The structural diagram and flow diagram are presented on Figures 1 and 2.

2.2. Structural model of the production subsystem

According to the described mental-verbal model it is possible to determine the system dynamic structural model of observed subsystem.

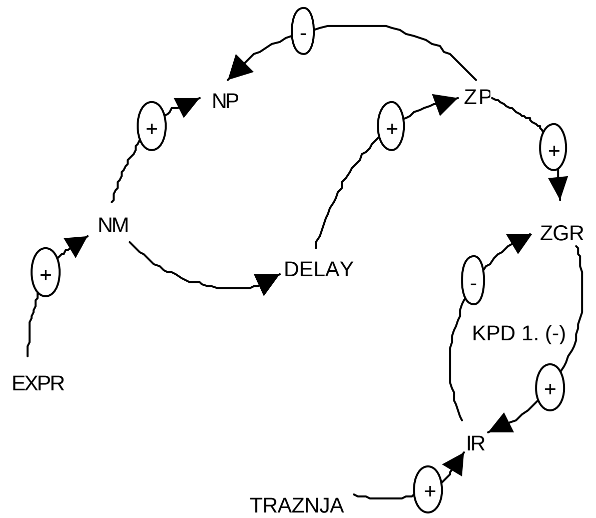

Figure 1. SD-structural flow diagram of the production subsystem

2.3. Structural flow diagram of the Production subsystem

In a similar way it is possible to present SD-simulation structural flow diagram of production model.

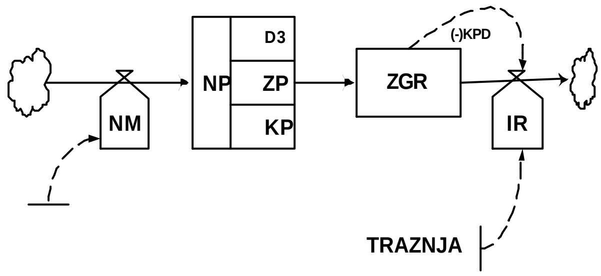

Figure 2. SD- structural flow diagram of production

2.4. SD - quantitative simulation model of the production subsystem

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* ********************************************
*         PRODUCTION SUBSYSTEM
* *******************************************
R NM.KL=EXPR.K
*
L NP.K=NP.J+(DT)*(NM.JK-ZP.JK)
*
N NP=20000
*
R ZP.KL=DELAY3(NM.JK,KP)
*
C KP=3
*
L ZGR.K=ZGR.J+(DT)*(ZP.JK-IR.JK)
*
N ZGR=4000
*
R IR.KL=CLIP^
(TRAZNJA.K,ZGR.K,ZGR.K,TRAZNJA.K)
*
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3. DEMAND SUBSYSTEM

3.1. Mental-verbal model of the Demand subsystem

The demand depends on the quantity of the delivered invoices (**FI**) meaning the higher the quantity, the higher the state of the demand (**POT**) (+). The value of the delivered invoices (**FI**) is influenced by the price of the product (**JCP**) and the quantity of the delivered products (**IR**), and the larger are those sizes the bigger is the value of the delivered invoices (+). When delivering invoices, a material delay of the III order occurs, and can be described by macro function DELAY3. The bigger the delay is, the quicker is the speed of charging the demand (**SPOT**) on the behalf of production organizations (+). The quicker the speed of charging the demand (**SPOT**) means reduction of the state of demand (**POT**), i.e. the negative sign (-). Figures 3. and 4. present structural diagrams and flow diagram of demand subsystem.

3.2. Structural model of the Demand subsystem

According to the described mental-verbal model it is possible to determine the system dynamic structural model of observed subsystem.

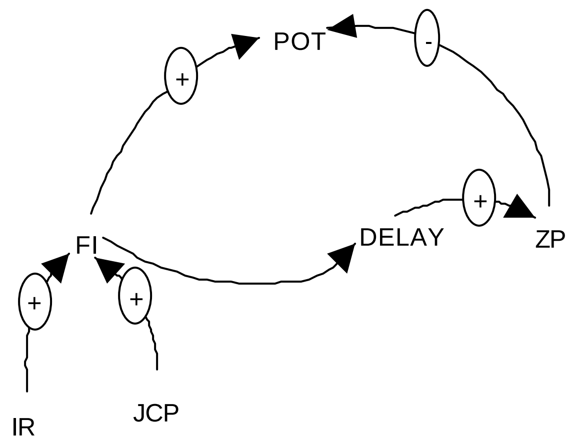

Figure 3. Structural diagram of demand subsystem

3.3. Structural flow diagram of the Demand subsystem

In a similar way it is possible to present SD-simulation structural flow diagram of demand model.

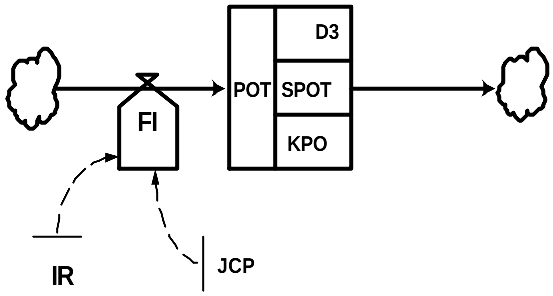

Figure 4. SD- Structural flow diagram of demand subsystem

4. DEBIT SUBSYSTEM

4.1. Mental-verbal model of the Debit subsystem

The debit of production organization (**DUG**) depends on the speed of invoice arrival (**PRF**) and also the speed of payment of the debits to the supplier (**SDUG**). The quicker the invoice arrival is, the state of debit is also higher (+). The quicker the payment of the debits to the supplier is, the state of debit is lower (-). There is a material delay between invoice arrival and payment of the debit to the suppliers and it can be described by macro function DELAY3. The higher the delay is, the speed of the payment of the debit to the supplier reduces (-). The speed of invoice arrival is directly influenced by production expenses (**TRP**) which are: acquisition of the material for the production (**NM**), variable production expenses (**VTR**) and fixed expenses (**FTR**). With the increase of all of these expenses, the production expenses, those that directly influence the invoice arrival (+), increase, as well. Based on such verbal model the structural diagram and flow diagram can be shown in Figures 5. and 6.

4.2. Structural model of the Debit subsystem

According to the described mental-verbal model it is possible to determine the system dynamic structural model of observed subsystem.

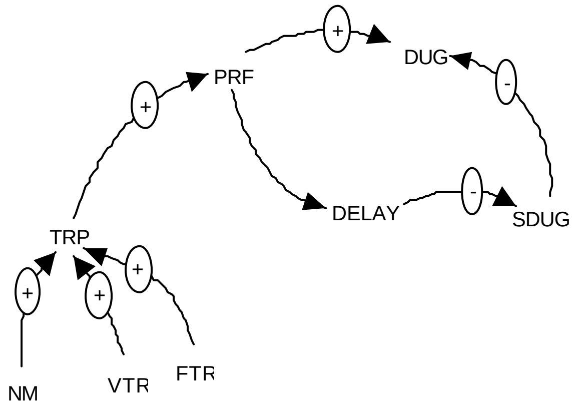

Figure 5. Structural diagram of debit subsystem

4.3. Structural flow diagram of the Debit subsystem

In a similar way it is possible to present SD-simulation structural flow diagram of debit model.

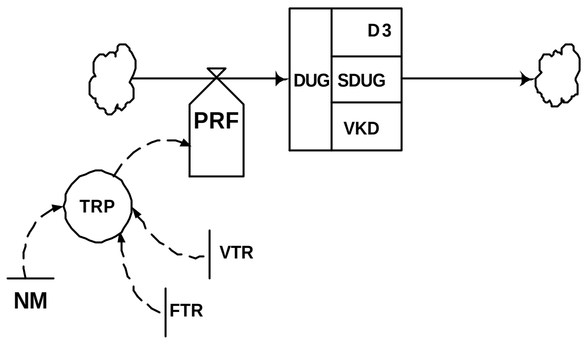

Figure 6. SD-structural flow diagram of debit subsystem

5. PRODUCTION CAPACITY SUBSYTEM

5.1. Mental-verbal model of the Production Capacity subsystem

Desired production capacity will depend on exponential average of demand (**EXPR**) and singular value of production capacities (**JVPK**), and that size can be mathematically determined by product of multiplication of last two. The higher exponential average of demand and singular capacity value means the increase of the states of desired capacities (+). Discrepancy (**RZKIS**, i.e. the difference between desired capacity state **ZELJK** and the real capacity state **SKAP**) will be higher when the desired capacity state is higher (+); increasing the real capacity state by investing in new capacities, the discrepancy reduces, i.e. by higher investment in new capacities, the real state of capacity increases (+) and the discrepancy reduces (-). The acquisition of new capacities (**NKAP**) will naturally depend on the state of existing, i.e. the writing off of the expired capacities (**FOT**). This link between acquisition of the new and the expiration of the existing can be modulated by macro function DELAY3.

5.2. Structural model of the Production Capacity subsystem

According to the described mental-verbal model it is possible to determine the system dynamic structural model of observed subsystem.

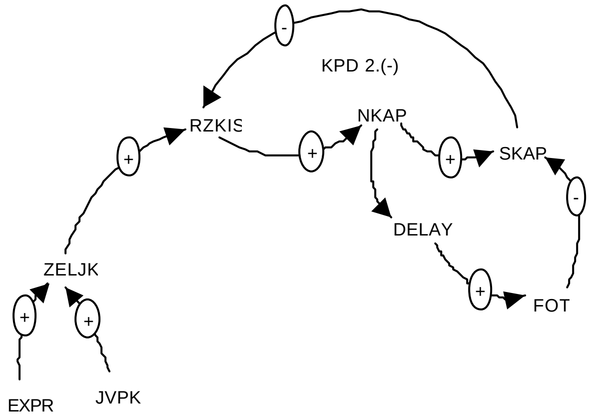

Figure 7. Structural diagram of the production capacity subsystems

5.3. Structural flow diagram of the Production Capacity subsystem

In a similar way it is possible to present SD-simulation structural flow diagram of production capacity model.

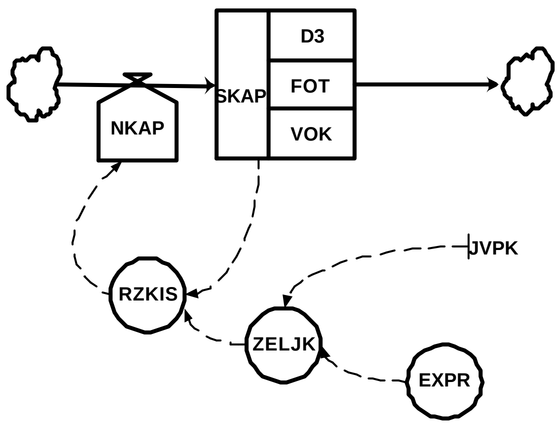

Figure 8. SD-structural model of flow diagram of the production capacities

6. MONEY ON TRANSFER ACCOUNT SUBSYSTEM

6.1. Mental-verbal model of the Money on transfer account subsystem

The amount of money on transfer account (**NNZR**) depends on deposits of money on transfer account (**UNZR**) and on payment from transfer account (**ISZR**). Payments from transfer account depend on debits state (**SDUG**) and the acquisition of new capacities (**NKAP**), i.e. the bigger the debit and the acquisition of the capacities are, the payment from transfer account is bigger (+), meaning the smaller amount of money on transfer account (-). Deposits on transfer account depend on demand state (**SPOT**), and the bigger the state is, the bigger are the deposits on transfer account (+), and consequently the amount of money on transfer account (+).

6.2. Structural model of the Money on transfer account subsystem

According to the described mental-verbal model it is possible to determine the system dynamic structural model of observed subsystem.

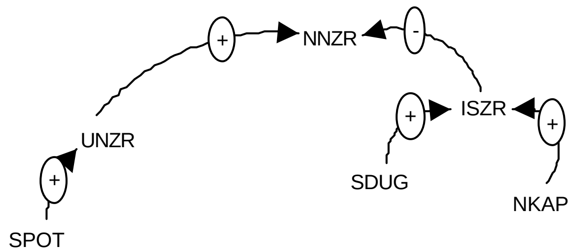

Figure 9. Structural diagram of money on transfer account subsystems

7. INCOME SUBSYSTEM

7.1. Mental-verbal model of the Income subsystem

Income (DOHODAK) depends on incomes (UP) and expenses of the production organizations (TROSK). The higher the total incomes are, the higher is the income (+), and these total incomes depend on delivered invoices (IF), i.e. more delivered invoices means higher total incomes (+). The expenses of the production organization can be reduced on expenses of the acquisition of new capacities (investment, NKAP) and the quantity of received invoices (PRF). The bigger the both of these sizes are, the expenses are bigger, too (+), and the increase of the expenses reduces the income (-).

7.2. Structural model of the Income subsystem

According to the described mental-verbal model it is possible to determine the system dynamic structural model of observed subsystem.

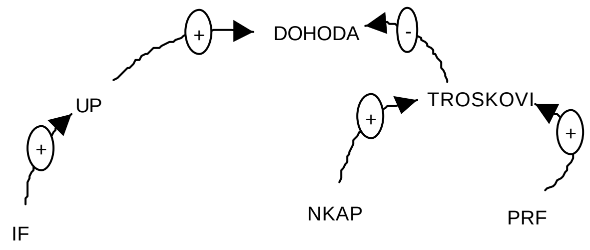

Figure 10. Structural diagram of the income subsystem

8. SUBSYSTEM OF DEMAND FOR ORGANIZATION PRODUCTS

The demand for organization product has a seasonal characteristic and can be shown by graphical preview below:

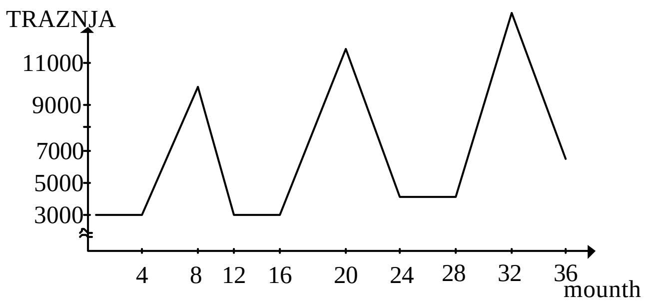

Figure 11. Demand for products

Based on such demand that can be shown by macro function TABLE, so called stimulated demand is modeled. The stimulated demand is a product of factors of delay (value 3) of the product from production department to the sales department with the demand described by upper graph.

9, SIMULATION RESULTS

Initial data of the zero scenario wrote in this program and it given those dynamical results:

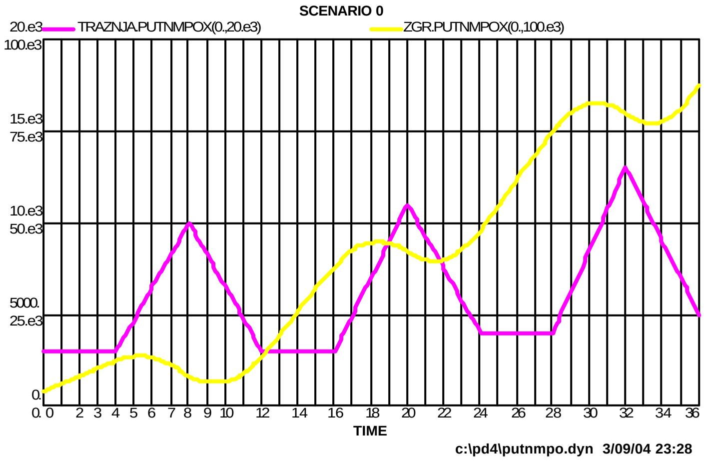

Figure 12. TRAZNJA, ZGR

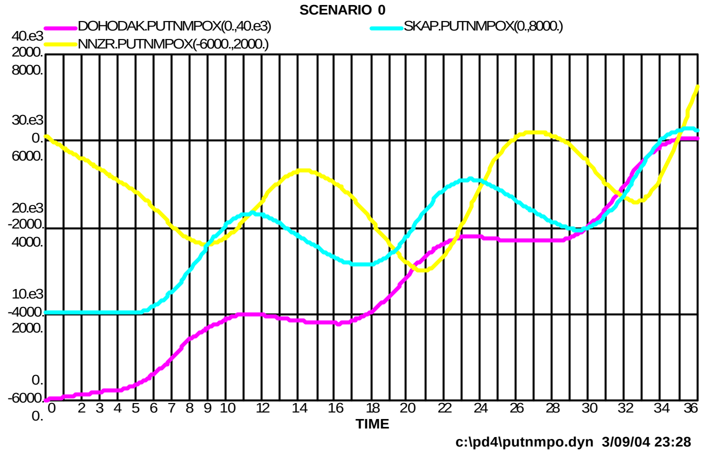

Figure 13. NNZR, SKAP, DOHODAK

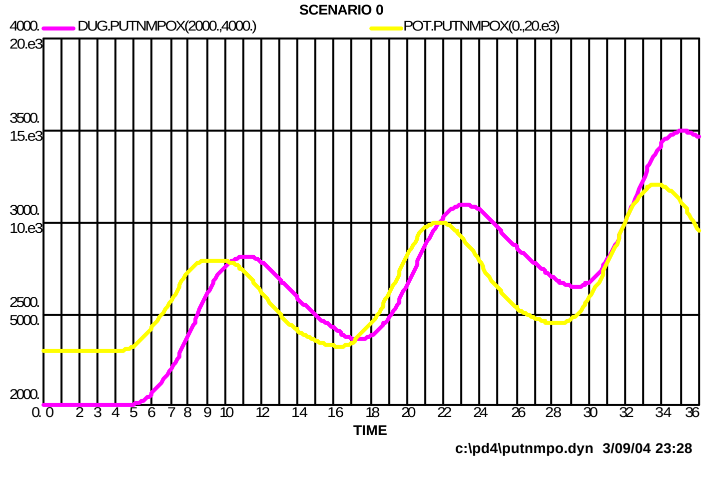

Figure 14. DUG, POT

If we analyze the results of graphical simulation of zero scenario, we will see that the Income variable shows circle dynamical oscillations and that the development strategy gives constant positive grow to the Income in the period of next 36 months. The variable SKAP (real capacity state) shows similar dynamical behavior as the variable Income, and the variable NNZR (amount of money on transfer account) is at negative level 28 months. This means that the firm has no-liquidity cash flow, but it will be changed in the positive liquidity after two or three months. The positive liquidity has really small step, but after three months it shows constant grow and development of the firm prosperity.

10. CONCLUSION

Based on ours long term experience in the application of the dynamical methodology of simulating and in this short presentation we provide every expert in need with the possibility to acquire additional knowledge about the same system in a quick scientifically based way of exploring the complex systems. It means:

"Do not simulate behaviors dynamics of complex system using so called "black box" approach, because practice of education and designing of complex system confirmed that is better to simulate using so called "white box" approach, e.g. System dynamics Methodology Approach!"

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