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Contribution To The Investigation Of The Production Distribution System Using System Dynamics

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***Abstract*—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.

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.

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

1. Introduction

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 is presented on Figures 1.

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.

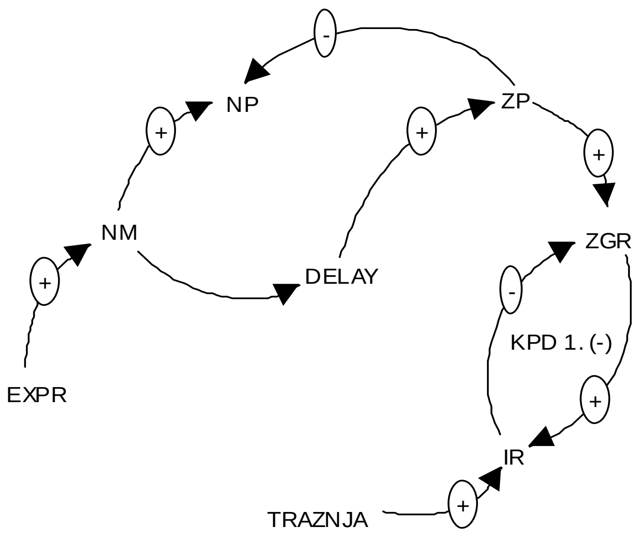


Figure 1. SD-structural flow diagram of the production subsystem

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 (-).

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.

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.

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 (+).

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 (-).

8. SUBSYSTEM OF DEMAND FOR ORGANIZATION PRODUCTS

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

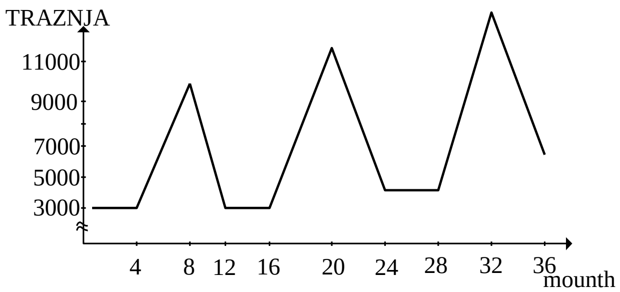


Figure 2. Demand for products

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.

Based on determinates mental-verbal and structural model, and according to the POWERSIM program graphical symbolic, it is possible to determinate complete system-dynamics model, i.e. flow diagram

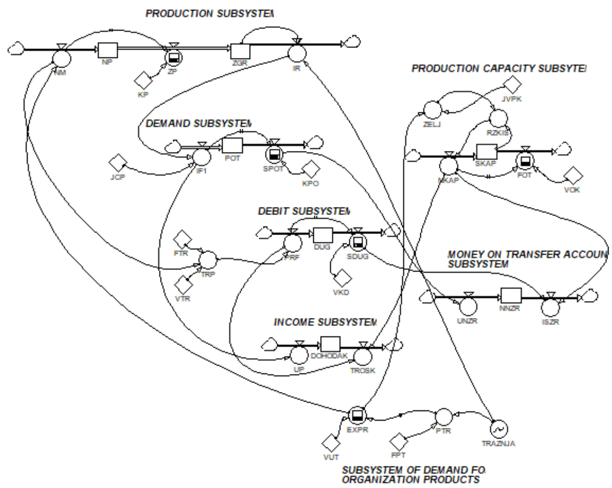
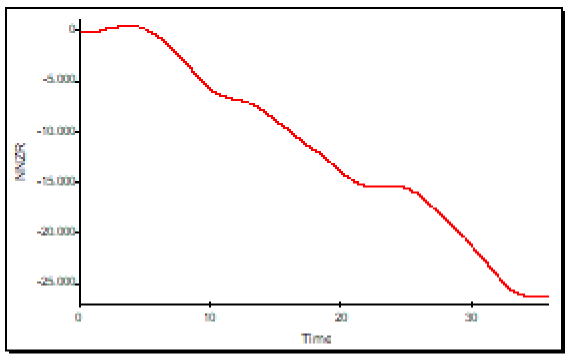


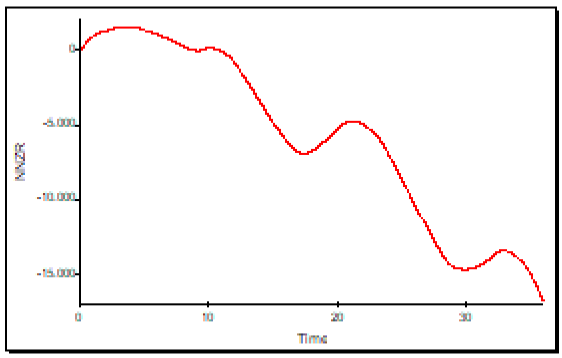
Figure 3. Global System Dynamics flow diagram in Powersim symbolic

9. SIMULATION RESULTS

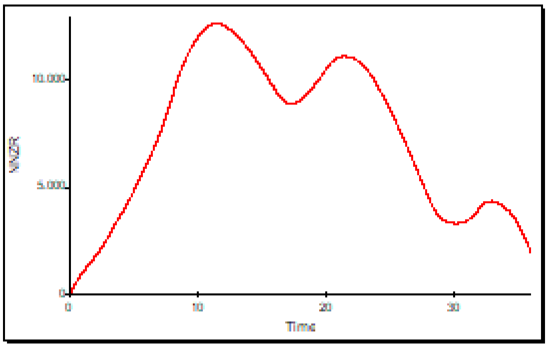
In this paper, due to the space limitation, we will show several interesting scenarios which applied to the money on transfer account, i.e. to the solvency of the business organization considering the changes of KP= production time delay parameter, VKD= debit time delay parameter and KPO=demand time delay parameter.



Scenario I: KP=3, VKD=3, KPO=3,



Scenario II: KP=3, VKD=3, KPO=0



Scenario III: KP=0, VKD=6, KPO=0

It is possible to conclude that the company model is behaving in concordance with economical regulative, and that for Scenario I (KP=VKD=KPO=3 months) dynamics of behavior of the amount of money on transfer account (**NNZR**) indicates relatively sudden fall in company solvency (after 36 months NNZR <-25.000 $). Scenario II (KP=VKD=3 I KPO=0) indicates somewhat slighter fall in company solvency (after 36 months NNZR>-15.000 $) and Scenario III (KP=0, VKD=6, KPO=0) indicates a constant trend of a significantly positive solvency which oscillates and which is after 36 months still positive!

The results are in complete concordance with the economical theory and practice which says that if KPO=0, which means if there is no delay in payment of demand, then the company solvency will be improved (reduced insolvency). Scenario III is a case where there is no delay neither in production KP=0 or in demand KPO=0, and if we increase the delay in debit payment VKD=6, then the company solvency would be constantly positive.

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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