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Internet Business Models and Operational Research

KEYWORDS: operational research, internet, electronic business, supply chain.

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ABSTRACT *Internet brought new business models and corresponding management methods in the ream of electronic business and digital economy. Some operational research methods used in supply chain risk management are considered and a new transshipment model is proposed minimizing total operational costs. The used ofcorporative game theory, specifically, Shapley and Myerson values has been investigated in solving problems of profit allocation stemming from joint operations of supply chain participants. Further, simulation and analysis of system dynamics models of supply chain has shown, contrary to the common view, the supply chain demand is endogenous variable.*

In this paper we consider the relationship of the digital economy and operational research,and the possibilities of application of operations research in the field of supply chain management as well as some specific models.

1. Introduction

Modern organizations in more and more countries are now, more than ever, technologically developed and economically efficient on a global free market. However, their results are generally unacceptable from the standpoint of the total global population, because they lead to increasing global economic imbalances and vibrant endanger the environment. Therefore, a new organization, first of all, must take care to be environmentally and socially sustainable and to introduce a broader set of non-financial criteria in the evaluation of its success. In this regard, the concept of the so-called. “Stakeholder” capitalism, which requires explicit consideration of all stakeholders - stakeholders, [Handy, 1994], such as:

- Customers,
- employees,
- investors,
- suppliers,
- ecology,
- society as a whole.

Soft operational research combined with critical operational research, become inevitable methodology for solving this set of modern mission of the organization. The objective function of the new organization must include the objectives of all stakeholders and soft / critical operational research indicate a clear way how it should be done practically.

New business models must take account of these requirements, and the existence of the Internet, the most democratic and widely available method of communication today, and provides practical achievement of objectives. One outstanding example of the power and properties of the Internet and related technologies, the development of electronic business (e-business), which has revolutionized the processes with business transactions, participants collaborate on a common project management and organization. First of all, e-commerce has changed the dynamics of competitive processes in all industries and has become an essential component of organizations that wish to gain competitive advantage, [Malone, 1998].

The term e-business is not synonymous with the term e-commerce relating to the retail trade with customers with the help of the Internet. E-commerce is a term that describes the use of the Internet in the planning and conduct of all activities in the supply chain.

In the early stages of the development of e-commerce, business organizations are internally developed Intranet-based on-line repository of business information, which is currently being updated and interactively browse. Such solutions have low costs and in addition to the basic purposes repository of limited function, reduced the cost of paper, printing and communicating with each of the participants in business processes. With further development, there are new applications that have enabled various organizations can mutually share information and work together on joint projects. This has led to the automation of all processes that occur within a supply chain (all processes in managing production and inventories), which is the most effective application of e-business. This required Redesigning business processes in any organization that participates in the supply chain, their mutual integration and redefining the role of all employees who participate in these processes.

Achieving these requirements and the wider adoption of e-business have enabled new technological standards in the field of seamless data exchange between organizations. These are primarily development language for XML data exchange and related successor: XSLT, XPath, XQuery, and the like, or software products based on them. Systems e-commerce are becoming more and more, based on the technology of Web services, which are comprehensive, independent and modular applications that can describe, publish, locate and call over the Internet. Web services are based on the following technologies: XML, SOAP, WSDL and UDDI and become the basis of what are called digital economy.

One of the economically most important ways of e-commerce, supply chain management, which can be defined as a set of approaches used to efficiently integrate suppliers, manufacturers, warehouses, and retail stores, so that merchandise is produced and distributed in the quantities

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and at the right time location, in order to minimize the global cost of the system consisting of the supply chain, [Mak, 2003]. This essentially means, supply chain infrastructure forms of knowledge and information that facilitates the integration of the integrated supply chain operations.

In production systems, supply chain consists of all activities that enable the delivery of products to customers. These activities include research and development, marketing, accounting, planning needs in materials, production planning, production process control, transportation and support (servicing) customers. On Fig. 1. illustrated the basic aspects of material flow in the supply chain production system (M-vendor, N-producers. O-distribution centers, P-wholesale, retail and Q-R-customers), indicating that the supply chain is a complex interaction of the number of functional entities, in order to achieve the primary objective of supplying customers with the products.

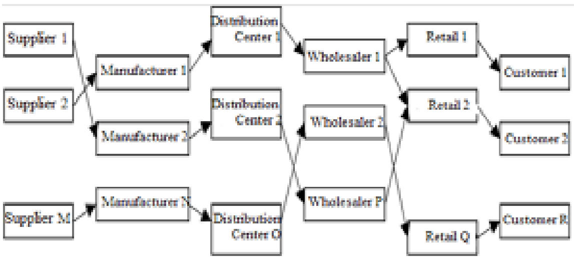


Fig. 1. The supply chain manufacturing systems

Each link in the top supply chain is susceptible to unpredictable events and finding quick answers to these events is crucial for the success and survival of firms, participants in the supply chain. There are many different exogenous events that affect the functioning of the supply chain: changes in customer orders, late delivery and price changes of individual resources, machine failure, urgent orders of important customers, and so on. The management of these events requires coordination and cooperation of all participants in the supply chain.

There are four key dimensions in which is reflected the impact of e-commerce on the integration of the supply chain (see Table 1.):

• Integration of information,
• Synchronization of planning,
• Workflow coordination,
• New business models.

Integration of information relating to the sharing of information between participants in the supply chain and includes any type of data, which could affect performance and actions of other participants in the supply chain. These are, for example, : data on demand, inventory, capacity planning, production plans, schedules, promotions, and delivery plans. This information should be up are available in real-time on-line basis, ie. available without much effort.

Synchronization planning refers to the joint design and planning of new product introductions, forecasts and maintain stocks. In essence, the synchronization of planning defines what should be done with the information available; to the mutual agreement of the participants on specific actions based on this information. The participants in the supply chain can have a coordinated plan of ordering, so that all replenishment have the same goal - to meet customer demand.

Coordination of workflow refers to the consistent and automated activities that are carried out between the participants in the supply chain. There are ready about it, not what is done with the available information, but how. For example, the procurement activities from manufacturers to suppliers can be tightly coupled so that it achieves the efficiency of time, cost and accuracy.

The adoption of e-business provides more of a gradual improvement in the efficiency. Many organizations have found new business models and even new business opportunities that did not exist before. E-commerce allows partners to redefine logistics flows so that the roles and responsibilities of participants in the supply chain are changing, in order to increase overall efficiency. The network of supply chain can jointly create new products, makes mass customization, penetrate new markets and customer segments.

Integration or cooperation can't be performed without a solid organizational links between it and the following areas:

• Channels of communication must be well defined and maintained with precisely defined roles and responsibilities.

• Measures the performance of partners in the supply chain must be specified and monitored. Partner in the chain is responsible for the other partner, and can be implemented and performance measures they are responsible for a larger number of participants. Such extended

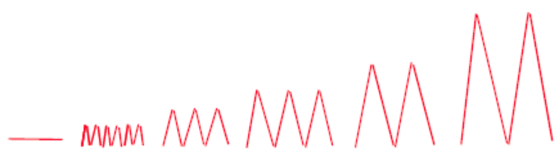
Dimensions	Elements	Use
Integration of information	* Information sharing and transparency * Direct and "real- time" access	* Reduced the bullwhip effect * Early detection of problems * Faster response * Building trust
Synchronization of planning	*collaborative planning, forecasting and replenishment *common design	*Reduced the bullwhip effect *Lower costs *Optimization of capacity utilization *Improved service
Workflow coordination	*Coordinated production planning and operations, procurement, order processing, technical modifications and design *Integrated, automated business processes	*Increased accuracy *Faster response *Enhanced Service *Former marketing *Extended network
New business models	*Virtual resources *Restructuring logistics *Mass customization *New services *Models off- and on-line	*Better use of resources *Higher efficiency *Penetration of new markets *Create new products

Table 1. Dimensions of integration of the supply chain

performance measures encourage closer collaboration and coordination.

• Uses must be defined for all participants in the supply chain, so that all risks and get equally distributed in accordance with the investment and risk of each participant.

In order to ensure that the supply chain runs true customer demand, divided in information is critical. It is the most effective way to avoid distortions of information on demand in the supply chain, ie. well-known effect of a whip (bullwhip effect). Distortion of information occurs when partners use local information to forecasted demand and forwarded them vertically partners in the supply chain; partners decide on orders based on local economic factors, local constraints and performance measures; when partners increased orders when they think they will come to a disruption in supply conditions. This distortion is amplified from one level of the supply chain and are considered to be the biggest cause of the inefficiency of the supply chain. The effect of the whip is shown in Fig.2.



Consumption consumers little great Manufacturers Suppliers Sale sale

Fig. 2. Effect of the whip

One of the important ways to fight the bullwhip effect is transparency of information, such as chain partners share information on sales, inventory, production plans, promotion plans, forecasts of demand and supply plans. Internet, with its technological capabilities, is an ideal platform for sharing information. The power of the Internet lies in the open standards that allow easy, versatile and yet secure enough access to information users with the widest array, which is very important, low cost.

One of the technical solutions for the integration of the supply chain is called. Information Node (Information Hub), which currently processes and transmits all relevant information partners in the chain, as illustrated in Fig. 3. It has options for storing and processing data and the release of information to interested participants of the supply chain.

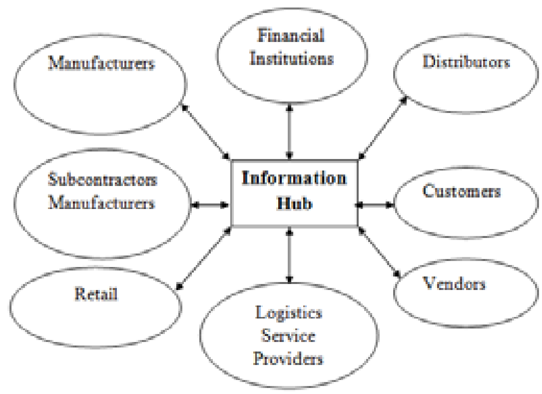


Fig. 3. Information Hub

The following Table 2. presents examples of the impact of e-commerce on the integration of supply chains and business processes. In relation to the five dimensions of integration: information integration, synchronization of planning, coordination workflow, a new business model and monitoring and measurement, considered the effects on business processes: procurement, order processing, product design and after-sales support

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Dimensions Integration	Business Processes			
	Purchase	**Order processing**	**Product Design**	**Post-sale support**
Information integration	Sharing information on suppliers	Sharing of information in the supply chain	Sharing design data, changes of product sharing plans	Sharing of customer information
Synchronization of planning	Coordination replenishment	Collaborative planning and coordination of demand and supply management	Synchronized introduction of new products and planning changes	Planning and coordination of maintenance
Workflow coordination	Procurement of paper, auctions, auto-renewal, car payment	Workflow automation contracting with suppliers and logistics services, renewing services	Collaborative change management, design	Auto-replenishment of consumables
New business models	The stock market, auctions, secondary markets	Models off- & on-line presence, restructuring of supply chains, market intelligence & demand management	Mass customization, offer new services	"Remote sensing" and diagnosis, auto-test, "downloadable upgrades"
Monitoring and measurement	Monitoring the execution of the contract	Monitorin logistics and order	Monitoring of projects	Measurement and monitoring perfromance

Table 2. Examples of the impact of e-commerce supply chain integration

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In the following we will consider several models of operational research that have been successfully used in the management of supply chains.

2. Models transport with transhipment and multiple scenarios and periods

The explosive growth in the number of Internet users, which now exceeds 3,035,749,340 users [Internetworldstats, 2014], has led to extremely wide availability of internet services to many users. This development of the Internet has significantly changed consumer behavior in the conduct purchase transactions. Possibility of online shopping has provided customers more choices and influence are increasingly demanding to meet its needs. From the seller looking for the fastest and best service, and if he's not able to provide, faces a greater risk to realize this sale perhaps, and forever lose the customer. As a result, the cost of the missing inventories are increasing. With the wide availability of the Internet growing number of customers, the company vendors must adapt to these new demands. They must develop new business models that increase the probability of product availability at the time of the occurrence of demand for them. At the same time, company vendors must continuously balance the cost of storing excess inventory.

Permitting transshipment between retailers is one way to reduce the risk of missing stocks. Reloading the process of lateral transfer of stock from the object with excess inventory to an object that has a shortfall. Transshipment of inventories among retailers is often cheaper and more desirable option than increasing the number of deliveries from suppliers. The frequency of deliveries from suppliers may be limited by minimum order quantities, long delivery time or the great distance between suppliers and distribution centers. Another important advantage of transport with transhipment sharing a common risk. Customers submit purchase orders before they know what will be the demand in the coming periods. Reloading is a method of redistribution of inventories in accordance with the realized demand. Reloading supplies, company customers avoid the emergence of cost of storage or missing inventory at the places where the realized demand deviates from planned. In this way, transferring stock represents an effective treatment method using stochastic demand and improving performance and reliability.

However, the method of loading requires increased communication and information sharing in the supply chain. Fortunately, the Internet and other technologies provide an effective means of communication of participants in the supply chain. Unlike traditional file sharing systems in the business - EDI (Electronic Data Interchange), who were able to afford only very large companies, the mechanism of exchange of information with the help of Internet technology is also available to small businesses. Accordingly, this method requires reloading the stock can easily meet with the help of the Internet.

Here we consider the impact of the method of loading the stock to the business policy of ordering and replenishment. Observers system with a single supplier, centralized distribution center and a number of retail outlets [Robinson, 1990]. Supplier periodically sends supplies to the distribution center, transhipment and resources between retail outlets is happening in the interim period between the delivery of the supplier. Decision on transhipment stocks are made at the end of each period and products which are unloaded can only be used to meet the demand in the next period. Unlike previous research will include delivery time explicitly in the model and the observed problem with several periods where reloading the stock can only be used to meet demand in future periods, which is much closer to the real problems.

The first step in the development of models for problems with trans-shipment of goods is defining the way of functioning of the supply chain. In this sense, made the following assumptions:

1. One supplier meets overall demand retail network.
2. The supplier sends the delivery network of distribution centers, which then delivers the goods to retail outlets - MP.
3. The location and number of retail stores are known.
4. The capacity of distribution centers and MP are not limited.
5. Transshipment of goods can be done between any two MP.
6. If the MP report missing stocks in period t, it is considered that there is a lost sale. In addition, there is an additional cost of losing customer loyalty.
7. Each MP meets his first demand eg reloading other MP.
8. Transhipment is going on a jay each period and used to satisfy the demand in the next.
9. The supplier delivers the goods distribution centers by the end of the period 5 (ie. At the beginning of each week, if the length of one period a day), and deliveries from distribution centers and transhipments obavljavaju in each period (ie. per day).
10. Demand is forecast so that demand is used in the past to forecast the demand for liquid.
11. Inventories between periods are modeled as a transshipment inventory of the retail facility itself.
12. Excess inventory can not be returned to suppliers.
13. Retail stores do not compete with each other.

The timber of the supply chain in accordance with the above assumptions, is shown in Fig. 4.

In this network, retail facilities receive goods before the demand is satisfied. With the passage of time, the stock in any shop used to meet demand during this period. Surplus stocks may continue to hold the stock or transhipped to other retail outlets. In both of these situations, the goods can be used to meet demand in the next period. In Fig.5. was introduced with the time course of basic events.

Based on the above, we built a model that minimizes inventory reloading the total costs incurred in the operations of a given supply chain. They include fixed costs, delivery costs, costs of keeping inventories and costs of missing inventory. The model has a number of scenarios to simulate stochastic demand. And each contains a different set of scenario definition and demand model requires a compromise solution that will be enough for every possible scenario. The final solution may not be optimal ordering policy for any individual scenario. A compromise solution is a consistent amount that should be transported from suppliers to distribution centers and from distribution centers to each of the retail facilities. These amounts are consistent with each of the scenarios. Privacy reloading is unique for each scenario and represents a mechanism of how it treats the variability of demand.

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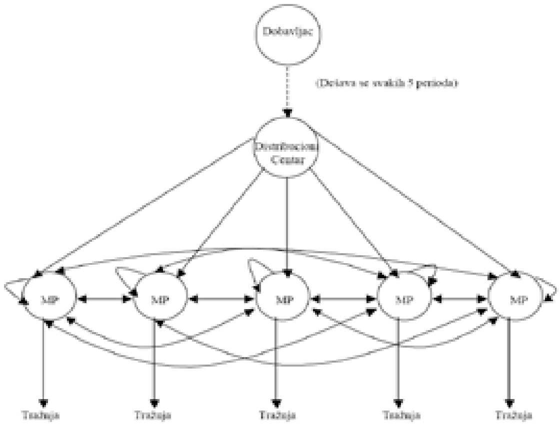

Fig.4. Topology supply chain

To investigate the effectiveness of a compromise solution, the objective function model with multiple scenarios is to minimize regret in all scenarios. Regret is defined as the difference between the cost for each scenario, using compromise and optimal cost when the problem is solved only for that scenario.

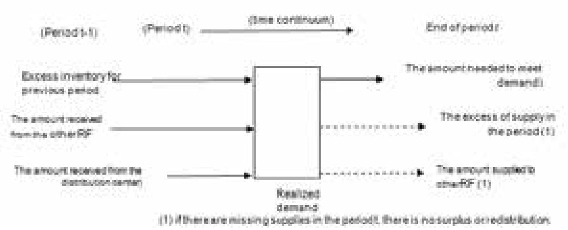

Fig.5. Time course of the supply chain

In formulating the model with multiple scenarios, we will use the following marking in accordance with the requirements modeling language AMPL [Fourer, 1993]:

Indexes and meetings

K - the set of all scenarios indexed with k
W - set of all distribution centers indexed by w,
I - a collection of all MP indexed with i and j,
T - set time periods indexed by t; t = 1 means the period

1*Inputs and parameters*
n - number of time periods,

sw - unit cost of delivery from supplier to distribution center w

B - unit cost of delivery of the distribution center w to MP and,

ij - the unit cost of reloading and MP to MP j,

in - the unit cost of the absence of stock,

gw - fixed cost associated with the location of the distribution center w

dikt - demand in MP in period t for the scenario k,

D - a factor that ensures the delivery of suppliers take place after the expiry of the five periods,

hi - initial inventories and MP,

qt = {1, if the time t period in which the supplier delivers the goods distribution centers, 0, otherwise}

w = initial stock in the distribution center w

ok = optimal solution for the scenario.

Control variables
Picto - the amount of missing stock in the MP and, at the end of period t for the scenario k;

Xijkt - quantity transhipped from MP to MP and her period t for the scenario k;

Ywit - the amount delivered from the distribution center w to MP in period t;

CORE - the amount of which is delivered by the supplier to the distribution center Wu period t;

Rk - regrets the scenario k;

Uikt = {1 if the missing MP in stock in period t for the scenario k 0 otherwise}

Model Reloading
Based on the assumptions and notation adopted, Model Reloading describes the supply chain, starting from the supplier, through the distribution center to the retail outlet. Stochastic demand in retail stores is described using a larger number of scenarios and the concept of regret was introduced earlier. Model Reloading the optimization model whose purpose is to find the optimal solution that minimizes the expected value of regret for a number of scenarios in the problem of reloading supplies.

$$\textit{minimum} \quad \Sigma_k R_k \qquad (1)$$

$$p.o.: \quad R_k = (\Sigma_w \ g_w + \Sigma_t (h_t f_{ti} + \Sigma_i (uP_{ik}^t + \Sigma_w (s_w Z_w^t + c_{wi} Y_{wi}^t) + \Sigma_j f_{ij} X_{ijk}^t))) - o_k \qquad \forall k \qquad (2)$$

$$\Sigma_w Y_{wi}^t + \Sigma_j X_{jik}^{t-1} \ge d_{ik}^{t-1} \qquad \forall k, i, t \text{ od } 2..n \qquad (3)$$

$$\Sigma_w Z_w^t \ge \Sigma_{t-5,t-1} \Sigma_i q^t d_{ik}^{t-1} \qquad \forall k, t \text{ od } 6..n \qquad (4)$$

$$\Sigma_w Y_{wi}^1 + h_i - d_{ik}^1 - \Sigma_j X_{ijk}^1 + P_{ik}^1 = 0 \qquad \forall k, i \qquad (5)$$

$$\Sigma_w Y_{wi}^t + \Sigma_j X_{jik}^{t-1} - d_{ik}^t - \Sigma_j X_{ijk}^t + P_{ik}^t = 0 \qquad \forall k, i, t \text{ od } 2..n \qquad (6)$$

$$\Sigma_j X_{ijk}^t \le D(1 - U_{ik}^t) \qquad \forall k, i, t \qquad (7)$$

$$P_{ik}^t \le d_{ik}^t U_{ik}^t \qquad \forall k, i, t \qquad (8)$$

$$\Sigma_i Y_{wi}^t \le v_w + \Sigma_{t2=1,t-1} (Z_w^{t2} - \Sigma_i Y_{wi}^{t2}) \qquad \forall w, t \qquad (9)$$

$$Dq^t \ge Z_w^t \qquad \forall w, t \qquad (10)$$

Data
When preparing the data necessary for solving models reloading the supply chain must be taken into account certain essential characteristics of the real problems. For example, it is important that the costs of insufficient stocks are reasonably higher than the cost of delivery. If the cost of missing inventory is too low, there will be no motivation restock ordering from suppliers. Similarly, the data must reflect the real fact of law that is cheaper that retail facility receives the goods directly from the distribution center, not through a series of reloading, which can be expressed by:

$c_{wj} < c_{wi} + f_{ij}, \quad \forall w, i, j$ **(Occurs every 5 periods)**

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Furthermore, to have reloads economic sense, it is necessary to ensure that the costs of transhipment be less than the cost of simultaneous storage stocks in one MP and missing inventories in the second MP. This requirement can be formulated as:

$$f_{ij} < u + f_{ii}, \qquad \forall i, j$$

After determining all parameters of cost, it is necessary to determine the most suitable way of modeling the demand. It was decided, first of all, for reasons of simplicity, that the demand in each retail store are modeled as independent random variables with normal distribution and so that every retail store has a slightly different mean and variance, considering that serve similar markets. Independence means that the forecasted demand in a single MP has no effect on the size of demand in the second. Also, it is assumed that the demand in an MP can not be transferred to others.

As an illustrative example of the supply chain, selected a network with a single supplier, a single distribution center and 5 retail stores, MP - A, B, C, D and E. Table 3. shows the parameters that were used to generate demand in any shop

MP	A	B	C	D	E
Average	100	90	90	110	130
Standard deviation	10	10	8	10	15

Table 3. Demand in retail stores

Using a random number generator in Excel, generated 50 random values of demand for each retail store, based on the data from Table 4.x. It matched the needs of 5 different scenarios, 10 time periods each. With the help of scenarios is modeled uncertainty of demand and potential variations in actual demand.

AMPL model

Model Reloading is converted to a computer executive variant using modeling language AMPL [Fourer, 1993]

Results

Model1.Pretovar.mod with input data Model1.Pretovar.dat solved by the Intel Pentium 4 (Northwood). We used GLPSOL solver, which is part of the "Open Source" package GLPK (GNU Linear Programming Kit), for solving problems of linear and mixed integer programming [GNU, 2012]. The package consists of a number of GLPK API routines written in C language and that can be called from the user application. GLPSOL solver can be used independently to solve the problem formulated in the following formats:

- LP / MIP model in GNU LP format,
- LP / MIP problem and fixed MPS format,
- LP / MIP problem free MPS format
- LP / MIP problem in CPLEX LP format,
- LP / MIP model written in GNU MathProg modeling language.

GNU MathProg modeling language is a subset of AMPL, but since it is open to the general public, there is no limit to the number of variables and constraints imposed by the student version of AMPL - 300 x 300 solved the three model variants:

1. Model1. Reloading that discusses the possibility of transshipment between retail stores.
2. Model2. without Reloading hears the case, otherwise identical to the previous one, but without possibility of reloading, that all retail outlets are independent of each other.
3. Model3. Deterministic who does not consider the coincidence of demand, as the previous two models who do it using the concept of scenarios, otherwise identical to the previous model.

The results are as follows:

1. The model had a total of 1815 variables of which are 250 and 250 binary integer and 1026 constraints. Nonzero value in the matrix has a limitation 8390th
2. The optimum value of the objective function is regrettable Total 22,896th
3. The total cost of the total complaints for the three previous cases are summarized in the following Table 4, where the difference data% compared to the cost of the deterministic case:

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	Total cost	**total regrets**	**% difference**
The case with transhipment	419863	22986	5.77 %
Case without reloading	425686	28719	5.23 %
Deterministic case	396967	-	-

Table 4. Results of optimization

It was expected that the deterministic case has the lowest total cost, since it is possible to order, knowing the exact future demand. It is not necessary to keep a security stock is r no variability in demand. It is also the easiest problem to solve. Unlike deterministic case with and without reloading must find a solution for the delivery plan that is a compromise, to best meet the expected demand and deviations from it.

In the case of transhipment between retail outlets, total expenses were slightly lower than the cost without reloading. However, better analysis of these two cases can be done by looking at the policy of keeping inventories and frequency of occurrence of missing inventory. The results of this analysis are shown in Table 5.

It can be concluded that the number of cases of missing the stocks, nearly double that in the event that transshipment is not allowed, because the MP has to meet the increased demand in the period, using supplies stored for future periods, the ktaju leads to the phenomenon of missing inventory. On the other hand, in the case of a transhipment between retail establishments allowed, MP who has a lower demand than forecast, the surplus may be shared with MP who has a shortfall. In this case, they appear new transshipment costs, but avoids the cost of keeping inventory and cost of missing inventory. Also, maximum and average value of the amount of missing inventory is much more favorable in the case of transhipment than without it.

	Number of missing the	The frequency of the absence	Max amount for the lack of	The mean value of the quantity. missing the
The case with transhipment	8	3.56 %	13	7.25
Case without reloading	15	6.67 %	40	12.8

Table 5. Analysis of optimization results

The following Table 6. are the display differences in the mean values of total inventories to a storage period in both considered cases.

	The mean value of the quantity of inventory in storage in the period
The case of transhipment	14.89
Case without reloading	27.83

Table 6. Analysis of optimization results

As seen in Table 6, there is a significant difference in the amount of inventories held in each MP. This is an important argument for the introduction of the transhipment if the MP have little capacity or warehouse products are perishable or seasonal. Another interesting feature for analyzing the behavior of safety stock, ie the extent to which systems transhipment reduce the amount of safety stock due to the common sharing of risks. The following Table 7. presents the results of the analysis.

	Total deliveries to DC	Total deliveries to MP	The mean value of deliveries to MP	The standard deviation of the delivered amount
The case with transhipment	5549	4785	106.33	21.47
Case without reloading	5556	4895	108.78	23.21

Table 7. Analysis of delivery

It can be concluded, on the basis of the above table that the quantity of the goods supplied to the DC MP and a little less in the case of transshipment. The explanation for this is located in the manner of formulating the model. Namely, the model requires an order in accordance with the previously periods. If the model would be based on the appropriate distributions of demand, then they could expect significant effects in the model of shared risk with transshipment. Also, if the input data for the distribution of demand and cost parameters were different, it could be expected a significant effect on the safety of reloading supplies.

Finally, it can be concluded that the system with transshipment in the supply chain can lead to a substantial reduction of costs in the case of random demand, especially if the cost of keeping inventory costs and missing inventories high. However it must be noted that systems with transshipment require a higher level of organization and communication among the supply chain, rather than systems without reloading.

Of course, set the model could be improved in several directions - the sensitivity analysis models on different cost parameters, the analysis of applications in various industries or products. Certainly, the introduction of a number of distribution centers and retail stores them assignments. Definitely improvement model would explicitly introduce the method of stochastic programming, rather than the method of scenarios, although the introduction of a significant number of scenarios was interesting.

3. A cooperative game theory and supply chains

It is obvious that the functioning of the supply chain important to have precisely defined policy of allocation of profits among the participants in the chain, which must ensure the sustainability of the supply chain on the basis of rational behavior of participants. Cooperative game theory provides a rational basis based to explain the behavior of participants in the supply chain and maximize global profits. A non-cooperative game theory based on the concept of Nash equilibrium in which each player maximize their individual profit without regard to other possible results of the game. Therefore, the non-cooperative game theory is not suitable for use in the supply chain or cooperative is because it allows players cooperation based on mutual binding agreements. In this way achieves a stable result, which provides the largest global gain and develop a policy of profit allocation between participants in the supply chain. Stability cooperation depends mainly from gains of each player and there is no reason to chain participants stated that cancellation of the cooperation. The resultant profit allocation algorithm provides a healthy argument to each participant in the negotiations at the conclusion of an agreement on cooperation. Solution cooperative games is obtained by calculating Shapely's value, which is axiomatically based and each cooperative game joins the precise allocation of profit according to each player's contribution to the outcome of the coalition, [Krcevinac et al, 2011].

A formal description of cooperative games

Let N denotes the set of all the players (participants in the supply chain) and V ({and}) would have earned the player and to operate alone and not as part of the chain. Accordingly, the player and must receive at least as much if they participate in the chain, which is a requirement of features superaditivnosti. Based on the characteristics super additivity, each coalition of players the game creates value that is greater than the sum of the values subcoalition that make up this coalition. For two subcoalition T and S, which are subcoalition coalition N the following applies:

$$v(T \cup N) \geq v(S) + v(T)$$

So, no coalition can not increase profits by division into two or more subcoalition. In an extreme case, the following applies:

$$v(S) = v(T) = 0 \text{ i } v(T \cup N) \geq 0$$

In situations where the order of participants in the supply chain is an important and material flow is one-way, ie, the chain has such a logical restriction, it becomes so important. Axiom chain that is applied to the characteristic function coalition games, [Thun, 2003]. This is an additional requirement that must also be met. For example, if you have three players concerned in the chain, then this condition is as follows:

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$v(\{i;j\}) \geq v(\{i;k\}) \wedge v(\{j;k\}) \geq v(\{i;k\}), \ \forall j = i+1, \ i < j < k \in N$

Axiom chain implies that the coalition participants that are directly attributable creates more value than any other coalition.

Shapely's value and its axioms

Shapely's value is a concept from the theory of cooperative games, which each coalition variant of the game is determined by a unique solution to a game axiomatically defined. It was designed using four axioms that are called axioms fair game. The first is called. Pareto axiom, which guarantees that the value of coalitions equal to the sum of winnings for each player. The entire available amount is allocated as it is done in the case of core games, [Krcevinac and others, 2011]. Distribution Shapely's values must be Pareto efficient.

The second axiom of symmetry, which requires that allocation does not depend on the identity of the players, but of values with which they contribute to the coalition. Two players, i and j, which create the same value for the coalition, get the same gain. In the event of a supply chain that is reasonable, because the contribution of the participants in the chain has to be relevant in the allocation of profits. The third axiom concerns irrelevant player and says that those players who do not contribute to the value of the games do not participate in the allocation of profits. The fourth axiom of additivity ensures that Shapely's value of a property to generate a gain that players in a complex game is equal to the sum of winnings that players get the rules out independent. This axiom provides that a participant in the supply chain must receive the same from one coalition as they got out of two subcoalition the coalition. It can be concluded that the axioms Shapely's values apply in the analysis of supply chain, providing a sound basis for determining the algorithm of allocation of profits among the participants of the chain.

Shapely's value proceeds from the contribution of players and all possible coalitions that can be formed in the set N:

price $[v(K)-v\{K-\{i\}\}]$

where v (k) value of the game coalition K in which the player participates, av {K - {and}} value games coalition K or in which the player does not participate. This article, in fact, represents a contribution - contribution from members and the value of the game. He called the marginal contribution player II can be seen as a priori expectations on the contribution of players in the coalition and expresses its expected power in the process of negotiating the rules of allocation of profits made by the functioning of the supply chain. Defines the probability p (n, k) to the player and to take part in the coalition K as:

$$p(N,K) = \frac{(K-1)!(N-K)!}{N!}$$

Then, the Shapely's value is calculated as:

$$\Phi_i(v) = \sum_{K \subseteq N-i} p(N,K)[v(K) - v\{K-\{i\}\}]$$

Calculating Shapely's value for the player and is based on the added value realized by the coalition Affiliates and players all over n! permutations. The sum of all additional value represents the value of players and Shapely. For allocation using Shapely's value is a characteristic that guaranteed that the coalition is not threatened by potential abandonment subcoalition or blocked formation of a new "grand" coalition, Pareto axiom.

To illustrate the use Shapely's value in the supply chain, consider the example of three companies: U1, U2 and U3. If you form a coalition total profit that can achieve is 100 dinars. If you decide to kooperišu only company U1 and U2, then ostvarujuprofit of 70 dinars. Similarly, firms U1 and U3 in the coalition created a total of 60 dinars profit, U2 and U3 in the coalition achieved 80 dinars. None of the firms unable to independently realize any profit.

On this basis, it is possible to form a characteristic feature of cooperative games three companies, consisting of all the possible composition of the coalition and their associated values, but without any allocation between players in the coalition, which represents the profit achieved coalition.

$v(\{1;2;3\}) = 100, \ v(\{1;2\}) = 70, \ v(\{1;3\}) = 60,$

$v(\{2;3\}) = 80, \ v(i) = 0, \ i$ Î $\{1;2;3\}$

Cooperative play has a feature super additive , because:

$v(S) = v(T) = 0 \ ; \ v(T \quad S) \geq 0$

However, it is still an open question how to split the profits to coalition participants. In the following Table 8. shows all permutations of three companies and the corresponding Shapely's value.

	contribution coalition		
permutation	U1	U2	U3
$U_1; U_2; U_3$	0	70	30
$U_1; U_3; U_2$	0	40	60
$U_2; U_1; U_3$	70	0	30
$U_2; U_3; U_1$	20	0	80
$U_3; U_2; U_1$	20	80	0
$U_3; U_1; U_2$	60	40	0
Σ	170	230	200
$\Phi_i(v)$	28.33	38.33	33.33

Table 8. Calculating the value Shapely's

Accordingly, based on the calculated Shapely's values for each firm, the allocation of profit is such that the firm U1 receives 28.33% of the total profits of the coalition, which is commensurate with its contribution to overall profit coalition. Similarly, the company U2 receives 38.33% and 33.33% firm U3.

Shapely's value, can be represented as a geometric weighted centroid of the triangle whose vertices are the three companies. The geometrical representation is given in Fig. 6

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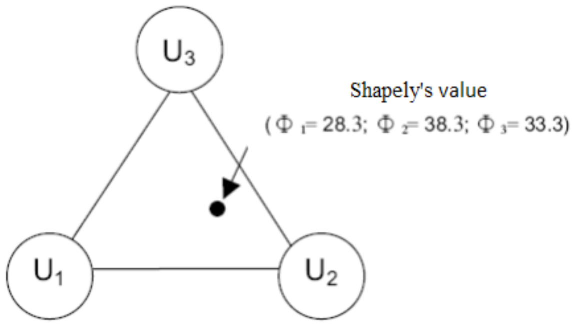

Fig. 6 geometrical representation Shapely's values

Graf cooperation

The assumption of universal cooperation, which is respected in the calculation Shapely's values may be unrealistic for practical consideration of supply chains. Therefore only is needed to consider the structure of the game in which there is partial cooperation, [Myerson, 1977]. In this analysis, we observe the set of players N and a set of unorganized pairs, different players from N and let n: m denotes a bilateral agreement on cooperation between the players is not a toy m. Any cooperative structures can be viewed as a set of these pairs that make connections in the graph cooperative games. In this approach, as opposed to Shapely's values are not considered all couples, but only those who are in cooperation. This is based on the idea that two players, although not directly related, cooperatave effectively with one another, cooperatave a challenge from them together, and are connected via a graph of cooperation.

The basic question is as a result of the game depends on the structure of cooperation? Let us introduce a mapping graph of cooperation, the so-called. vectors allocations, where Yn (g) is the gain of players nu cooperation graph g. The structure graph of cooperation and define the size of the profit for each player. Thus, in a graph, with the structure of the = {1: 2, 2: 3} b and in the graph with the structure gb = {1: 3, 2: 3} allocation rule can give the player 2 to the cooperation in the case of the graph, and are described, but in the case of a graph, as in the graph and the role of two important players in cooperation. However, regardless of the structure of the graph cooperative game value, or the value of available for allocation is the same.

$$\sum_{n=1}^{N} Y_n(g_a) = \sum_{n=1}^{N} Y_n(g_b) = v\{1,2,3\}$$

Rule of allocation for the game is super-stable if:

$$Y_n(g) \geq Y_n(g \setminus m:n) \wedge Y_m(g) \geq Y_m(g \setminus m:n)$$

where the notation "\ m: n" means that there is no direct link between the players landmine graph of cooperation. This means that a stable allocation rule has the property that two players have to have the benefit of a bilateral agreement on cooperation.

May be introduced and the rule of equality in allocation algorithm, which means that two players have the same benefits of mutual cooperation:

$$Y_n(g) - Y_n(g \setminus m:n) = Y_m(g) - Y_m(g \setminus m:n)$$

Illustrate the application of the algorithm of allocation in case of supergames, that is. Games in which true $(S \cup T) \geq v(S) + v(T)$, $\forall S, T \subseteq N \wedge S \cap T = \emptyset$). Let N = {1, 2, 3} and in characteristic function given by:

$$v(\{1;2;3\}) = 100,\ v(\{1;2\}) = 70;\ v(\{1;3\}) = 60,\ v(\{2;3\}) = 80,$$
$$v(\{i\}) = 0;\ i \in \{1;2;3\},$$

wherein at least one member says no player if the game does not have any self-gain.

It is possible coalition structures are illustrated by the graphs in Fig. 7.

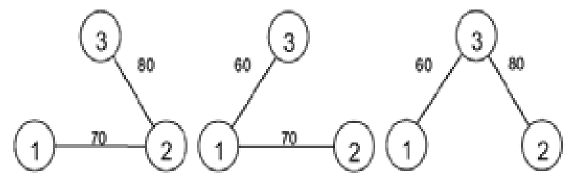

Fig.7 Graf coalition structure

Rule of allocation Y for this cooperative game:

$$Y(\emptyset) = (0,0,0), Y(\{1:2\}) = (35,35,0), Y(\{1:3\}) = (30,0,30),$$
$$Y(\{2:3\}) = (0,40,40), Y(\{1:2,\ 1:3) = (55,25,20),$$
$$Y(\{1:2\ ,2:3\}) = (18.333,58.333,23.333), Y(\{1:3,2:3\}) = (16.666,26.666,56.666)$$
$$Y(\{1:2,1:3,2:3\}) = (28.333,38.333,33.333)$$

This result implies that a player has two central player, because of its association with other players, and receives the largest share in the allocation of the results of games. This approach, as seen in the above example gives the same result as Shapely's value if each player connected directly with each other. He can be considered as improving access to over Shapely's value, because it takes into account the fact that some players are not directly related to someone else in the graph cooperative games.

Finally, tazmotrimo two structures, which have the same characteristic function:

$$v(\{i\}) = 0,\ v(\{i;j\}) = 40 \mid j=i+1 \wedge v(\{i;j\}) = 0 \mid j \neq i+1,$$
$$v(\{i,j,k\}) = \left\{ \begin{array}{l} 60,\ j = i+1,\ k = j+1 \\ 40,\ \text{other} \end{array} \right\},$$
$$v(\{i;j;k;l\}) = 80\ \forall\ i<j<k<l \in \{1;2;3;4\}.$$

Let, the structure 1 with Y1 (1: 2; 2: 3; 3: 4) is represented

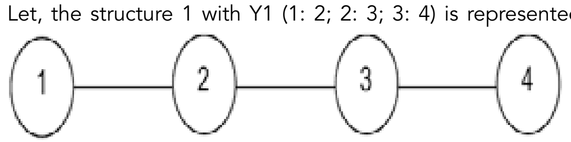

Fig. 8 . structure 1

Similarly, data structure 2 with the Y 2 (2: 3; * 2: 3; 3: 4) in which a player of the player similar to the 2 * 2, which is shown in Fig.9:

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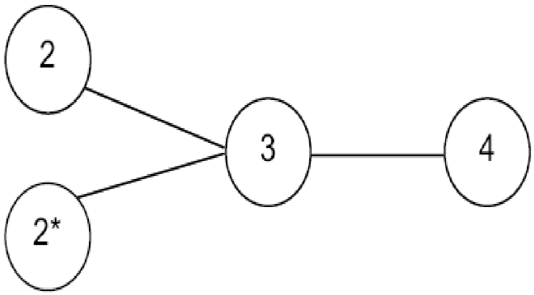

Fig.9. structure 2

Rule of allocation for the first structure, parts as a result of cooperation:

Y1=(10.8333 , 29.1 6 , 29.1 6 , 10.8333) and for the second structure: Y2=(10.8333 , 10.8333 ,41. 6 , 16. 6)

Winning allocations reflect the symmetry of a player Forward structure. Two medium-sized players in the chain receive the same, and also two external players get equal value. Intermediate players get more from outside, because of its greater connectivity with other members. This aspect of the connection between the player is even more pronounced in the structure 2, where the player gets 3 more than the sum of winnings of all the other players, because of its dominant position in the connectivity structure.

It can be concluded that the use of the theory of cooperative games and, specifically, Shapely's and Myerson suitable value in analyzing and solving the problem of allocation of profit from the joint work of chain supply chain.

4. The dynamics of the system

Modeling complex business and social systems, using the dynamics of the system proved to be very successful, [Forrester, 1991], [Sterman, 2000], [Rajkov, 1988]. Several important elements of system dynamics to enable:

- Connections type cause - effect.
- Presentation of feedback loops.
- Responses to the delay.
- Non-linear responses.
- Presentation of decision rules.

The application of system dynamics begins with the identification and presentation of the factors that influence the behavior of the system. This is done using diagrams cause - effect. In Fig.10. is shown a diagram of price impact on sales. Of course, there are other factors besides the price, which affect the size of the sale, and the price itself is influenced by many factors. The description of these many factors and their mutual influence form the model of the dynamics of the system.

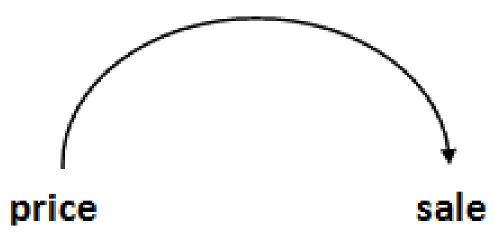

Fig. 10. causal diagram: The price effect on sales

Cause-and-effect diagrams can form a loop (circuit) that make up the so-called feedback or round feedback. For example, a lower selling price stimulates increased sales, allowing, on the basis of economies of scale, reducing unit costs, allowing further reduction in selling prices, etc. Causal feedback diagram is presented in Fig.11. This is an example of positive or reinforcing feedback loop, but it can also be a negative example. lower sales increases manufacturing costs which lead to an increase in prices, which in turn reduces the sale. and so on.

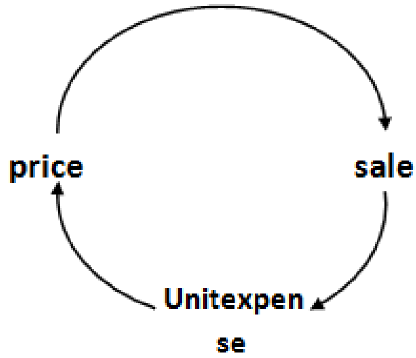

Fig.11. causal diagram: Feedback

In complex systems, the majority of factors affect a number of other, what makes the system complex. For example, in the previous case, the sale does not affect only the price but also the quality of the accompanying services. However, with the increase in sales can fall level of accompanying services, which will impact future sales. The dynamics of this situation is shown in Fig.12.

Fig.12. causal diagram: Two simultaneous feedback

The introduction of service quality led to negative or corrective feedback that has a balancing effect. The second feedback loop illustrates why lowering the sale price may be without effect if it is not accompanied by an increase in the capacity of ancillary services. The two loops can be expanded to include other factors that influence the behavior of the system, for example. higher sales increases delay delivery, which in turn, a negative impact on sales in future periods.

Many of the causal relationships that define the behavior of the system are the effects of the delay. For example, as illustrated in Fig.13., marketing activities may affect sales and income realized only after several months.

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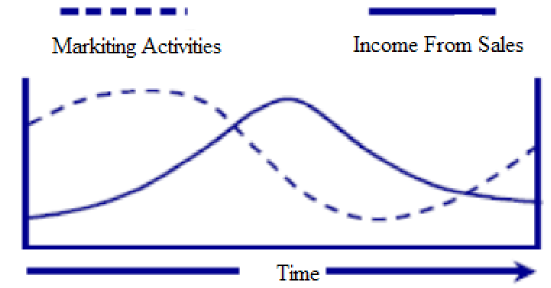


Fig.13. Delay revenue in relation to marketing

If this delay is not taken into account, can be made wrong decisions, for example to stop the marketing activities, because pto not immediately achieved the intended results.
Besides the delays, many causal relationships in real systems are characterized by non-linear response, ie. the resulting effect is not linearly proportional to the cause. Continuing the above example, the cost of marketing activities under a certain amount may have a negligible effect. Likewise, the costs of marketing above the upper limit may be of the same negligible effect. This kind of dependence on the consequences of the causes is illustrated by the so-called. S - curve depicted in Fig.14.

Non-linearity depending on the consequences of the causes is often the case, for example. effect of market share in response to competition, the effect of price variations on the importance of quality in the decision making of customers and the like. Taking account of the non-linearity is crucial in the analysis of the system and making successful decisions.

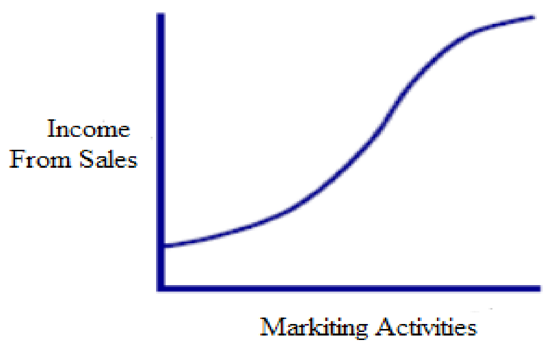


Fig.14. Example nonlinearity causes and implications: S - curve

In Fig.15. shows the generic form of causal diagrams of the dynamics of the system.

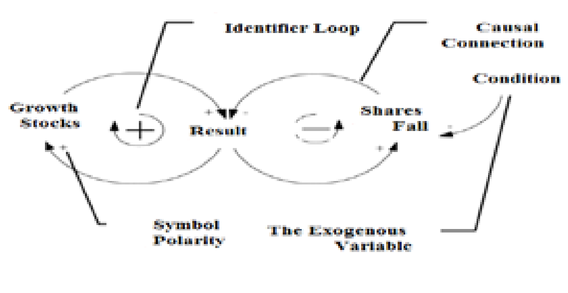


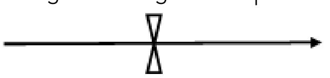
Fig.15. The generic form of cause and effect diagram

The factors or variables relevant to the operation of the system are related causal connections, indicated by arrows marked "+" or "-" to describe the polarity connections. A positive sign indicates a change in the same direction both variables in handheld and consequential, and the negative sign to reverse the direction of change. It is also used and the loop identifier which is rounded to the positive or negative sign indicating the nature of the important loops in the diagram.

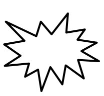
Diagram of storage and flows is a different kind of diagrams used in the dynamics of the system and includes precise and detailed information on the nature of the system which displays. The basic elements of this type of diagram using standard graphic symbols for their show are as follows:

- Warehouses, which represent graphic rectangle with characterized the state of the system at any given point in time. The funds [that are called levels, reservoirs or state variables. The value storage is continuously changing, accumulation or integration courses

- Currents, which is to announce the line with the directional valve in the direction of flow, characterized by the speed of changes in the state system. Flows changed their warehouses, and their value is correlated with the previous value of the same flow, but the value of storage and exogenous impacts affecting their value.



- Sources indicated callouts, all represent warehouses that are outside the boundaries of the system under examination and from which flow coming into the system.



- Sinks, also marked the speech bubble warehouses are outside the system considered, and that the flow coming from the observed system.
- The other variables, which indicate only the name of the diagram, which allow the inclusion of functions, constants, and other elements that are used for a more detailed explanation of the diagram. One change its value in the same way as flows - changing values warehouse and exogenous influences.

Example diagrams and flow dynamics of the storage system is shown in Fig.16. and illustrates the elementary production system.

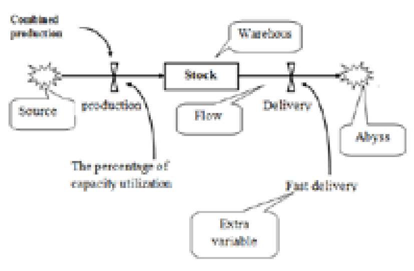


Fig.16. Example diagram storage and flows

It can be concluded that the causal diagrams more ori-

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ented towards qualitative description of the system, while warehouses and flow diagrams allow joining mathematical function diagram elements, and a quantitative description of the system, suitable for simulation.

5. The dynamics of the system and supply chains

The supply chain is a complex organizational system of multiple units: purchase raw materials, processing them into semi-finished or finished products and ship them to customers through distribution centers. Because of its potential in the research of complex systems, we consider the application of system dynamics to analyze supply chains. Typical supply chain consists of five elements: suppliers, production, distributors, retailers and customers. The integration of these elements requires the coordination function of production planning, procurement, materials management, manufacturing process, distribution, transportation, customer service and sales forecasts. The complexity of this integration becomes even greater, if the overall supply chain and supply chains include suppliers and customers through the appropriate inter organizational communications. Efficient management of the supply chain refers not only to the internal organization of the company, but also to share information with other participants in the holistic supply chain.

From the standpoint of system dynamics, supply chain consists of a feedback structure that controls the supplies and production capacity, as well as flows of products and deliveries to customers. How supply chain involves several organizations, suppliers, manufacturers, distribution channels and customers, then there are multiple chains and warehouse flows and delays due to the decision rules that control the flow. Three basic characteristics of functioning of the supply chain are: fluctuations, gain and phase delay. This significantly complicates supply chain management, and it is necessary to understand the structure and dynamics of decision-making in the area of inventory and other resources in an effort to balance production and orders. This balancing always introduces a negative feedback loop which is approaching a state system to the desired shape, with the appropriate corrective actions to reduce or eliminate the difference. There is often a delay between the corrective action and its results, and its duration depends on actions in inventory management.

It should be noted that the standard access methods system dynamics, in its first stage of problem definition, consists of [Sterman, 2000]: (1) A list of variables. (2) of the reference chart, and (3) definitions problem.

6. Conclusion

Simulation and analysis of the system dynamics model of the supply chain has shown that demand is endogenous variable, subject to the influence of internal actions, such as the variation time updates (corrections) production stocks - subassemblies, assemblies and finished products and production ramp changes. The standard assumption managers, researchers and supply chain, is that demand is purely exogenous variable whose value to affect only the changes in the market. It also shows that the oscillatory behavior of some size in the supply chain or on the reduction or elimination, may influence the appropriate changes in the strategy of some exogenous variables, such as, for example, a security stock.

The goal of research on the implementation of the system dynamics model to analyze the supply chain has been achieved in the case of hypothetical production company, formulation series of cause-and-effect diagrams and building supply chain models using simulation package Vensin. Although he built a model simplified version of phenomena in real supply chain, analysis and simulation results can help to solve the following problems:

1. Fluctuations in stocks of finished products oscillate with an amplitude that is large compared with the changes in demand and capacity.

2. Production capacity of the company relative to the desired capacity oscillates with an ever-increasing amplitude.

One of the interesting conclusions of the research is that the oscillatory behavior of demand endogenous character. Oscillation production stocks cause internal actions such as the variation time updates (corrections) production stocks - subassemblies, assemblies and finished products and production ramp changes. Increasing the covers of safety stock can be reduced or eliminated oscillations production stocks, fluctuations in demand products company and production capacity. In this way, the research in this thesis has shown that the standard methods of system dynamics can be effectively applied to the understanding and development of the system of supply chain management.

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