PROCESS SIMULATION IN SUPPLY CHAIN USING LOGWARE SOFTWARE

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ABSTRACT: The authors present basis of simulation usage in managerial decision support focusing on the supply chain processes. In the beginning the need for simulation is presented, then advantages and disadvantages of simulation experiments and the simulation tools juxtaposition. Finally the chances of supply chain process simulation using Logware software are presented.

Key words: simulation, supply chain

JEL codes: C88

Introduction

Today high flexibility in supply chain is required because of shorter and shorter periods of order realization or wide order diversity. Adequate supply chain planning and efficient processes in supply chain can ensure the flexibility. The role of transport and other logistics processes management is extremely significant. The transport connects supply chain elements: producers, suppliers, distributors and others. The aim of transport is to deliver particular sorts and quantities of raw materials, semi-manufactures articles and products in the right time and right place for customers satisfaction. The effects of badly working logistics processes in supply chain are:

- high transportation costs;
- wastes of time and transportation means;
- high level of inventories;
- ineffective supply chain participants operations;
- long time of order realisation;
- incomplete utilisation of production capacity.

Improvement in logistics process organisation including materials or products flow often requires high investments without absolute certainty that the activities will bring the expected profits. Fortunately, there are useful tools now that can prevent spending money for misplaced activities or investments in material or products flow planning or operating. Simulation techniques used in material flow planning and operations are an effect of the IT systems evolution but not the only one. Today simulation techniques are used in logistics area for planning changes in every activity of the whole supply chain. Shapiro widely describes all systems existing in supply chain as those that can be modelled and simulated (Shapiro, J. F., 2001). They consist of supply, production, distribution, utilisation and all phases of technical systems life e.g. system planning, realisation and exploitation. They are enough various and require different software to apply, mostly.

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Simulation fundamentals

Simulation is defined as an imitation of a dynamic process that has a place in a specified system; applying a model for experiment in order to achieve information that can be transferred to 'reality' [VDI - Verein Deutscher Ingenieure: VDI-Richtlinie 3633. Erfurt. *Simulation von Logistik-, MaterialfluB- und Productionssystemen*. Grundlagen. Dusseldorf, 1992]. Simulation also can be presented as an experimentation form of a analytical model that gives answers to the question: How the analyzed system will behave in specific situation.

According Korzen and Janowski (Korzen Z., Janowski R., 1997) three types of simulation can be distinguished:

1. Simulation enabling decision effects prognosis - this type of simulation is a process phase of model construction, it is called first type simulation
2. Simulation enabling sensitivity analysis of achieved effects caused by input data change - it is called second type simulation
3. Simulation called third type simulation enables analysis of structure and model choice for output parameters and advisable input.

Simulation models can compensate for the disadvantages of analytical models, but not without sacrificing some of the advantages of the analytical models. Several methodologies have been developed to improve logistics performance and introduce supply chain management. Law and Kelton (Law A.M. Kelton W.D., 1991) also mention a number of advantages and disadvantages of simulation (Table no. 1)

Table no. 1

Advantages and disadvantages of simulation

Advantages	***Disadvantages***
• Most systems with stochastic elements are too complex for analytical evaluation. Thus simulation is the only possibility. • Simulation allows one to estimate the performance of an existing system under some projected set of operating conditions. • Alternative proposed system designs can be compared to see which best meets a specified requirement. • Better control over the experimental conditions than when experimenting with the system itself. • Allows one to study a system with a long time-frame, in compressed time, or even in expanded time.	• Each run of a stochastic model produces only estimates of a model's true characteristics for a particular set of input parameters. Thus several independent runs of the model are required. An analytical model, if appropriate, can produce the exact true characteristics. • Expensive and time consuming to develop. • The large volume of numbers produced or the persuasive impact of a realistic animation often creates a tendency to place too much confidence in a study's results. • If a model is not a valid representation of a system under study, the results are of little use.

Source: Law A.M. Kelton W.D.: Simulation modelling and analysis. 2nd Edition McGraw-Hill, 1991

Most analytical models only take a few variables into account. For example, they may look at inventory and the cost of running out of stock, but ignore other costs such as order processing, handling and transportation. Considering sets of processes in the logistics chains specifically focuses on the interrelated two-way flow of products (materials and services) and information with the associated managerial and operational activities to obtain a high degree of responsiveness.

The complexity of analysing supply chain processes is much too large for analytical models, also due to the dependent demand in the supply chains. Furthermore, probabilistic demand in supply chains modelling creates extreme modelling complexities in a multi-echelon inventory situation (Silver E.A. Pyke D.F., Peterson R., 1998).

There are many simulation computer program packages on the market and application of some can be limited for problem solving in defined areas.

Tool choice for simulation experiment realisation is very crucial and it is depended on many factors (Grzybowski A., 2002):

- User's experience
- Problem specification
- Required precision level

According to Grabara and Szopa (Grabara J.K., Szopa J., 2002) the simulation tools can be divided into five main groups with the different characteristics of: model time construction, model control, precision, required learning time, application area (see Table no. 2).

Table no. 2

Simulation tools

	Spreadsheets	**Rapid modelling tools**	**Simulators**	**Simulation languages**
Model construction time	minimum	minimum	medium	medium or long
Model control and problem complication	inefficient in dynamic problem simulation	medium	within the framework of program	excellent, in every level of system complication
Results	defined and designed by user	statistic possibilities, oriented on the report	various, depended on program, usually oriented on report	defined by the user, suitable to the problem
Precision	inappropriate for dynamic system, generally	right for the general analysis	in dependence on the assumption	excellent
Tool learning time	minimum	medium	medium	medium or long
Best results' application area	static and deterministic systems	non complicated systems, in respect of probability	medium-complicated systems, in respect of probability, specific application	complex problems, wide application

Source: Grabara J.K., Szopa J., "Importance of technical processes' simulation in engineering education" Intertech Conference, Santos, Brazil 2002

Simulation of supply chain processes using Logware

Logware is set of software programs that is useful for analyzing a variety of logistics and supply chain problems. It contains the modules that can solve among others - following problems (Ballou R.H., 2004):

- Forecasts time series data by means of exponential smoothing and time series decomposition methods;
- Determines the shortest path through a network of routes;
- Develops routes and schedules for multiple trucks serving multiple stops;
- Finds optimal inventory ordering policies based on economic order quantity principles;
- Locates a selected number of facilities by the exact center-of-gravity method;
- Solves the transportation method of linear programming;
- Solves general linear programming problems by means of the simplex method;
- Solves the mixed integer linear programming problem by means of branch and bound;
- Simulates the flow of a product through five echelons of a supply channel.

Supply Chain Simulation (SCSIM) module is computer software to mimic the actual flows of product through a supply channel having four echelons ranging from factory to customers, as illustrated in Fig. no. 1. The product flows are replicated with a Monte Carlo-type simulation. A single, or aggregate, product is used and a single facility, or aggregation of facilities, is assumed at each echelon. The objective is to simulate supply channel performance and costs when various forecasting methods, inventory policies, transportation services, production lot sizes, order-processing costs, and the like are used throughout the supply channel. Reports and graphs are used to portray supply chain performance for different simulation runs.

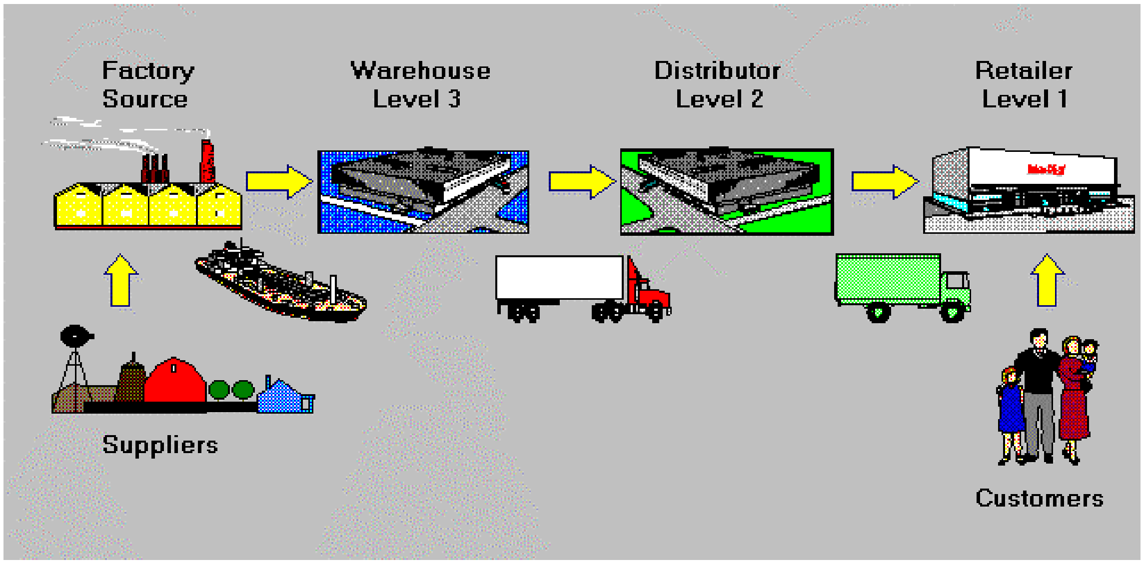

Fig. no. 1 – Supply Chain Overview

A number of assumptions have been made in the operation of this simulation. These are not under the control of the user, but they are noted here for better understanding of the action of the simulator (Ballou R.H., 2004).

- All distributions are normal with a minimum average value of 1
- Any draw on a normal distribution producing a number less than 1 is truncated to 1
- The time period is one day with a week being 7 days, a month being 30 days, and a year being 360 days
- Quantities arriving at an echelon in the channel for a particular day are added to inventory before deductions from inventory due to sales are made
- The minimum value for demand, sales, and production lot size is 1
- Product volumes are in whole numbers
- Numbers as input data or as computed values greater than 1 billion should be avoided as they may cause overflow errors
- All unfilled orders become back orders, not lost sales, until adequate inventory is available to eliminate the back orders

The data inputs consist of simulation control information, demand projection data, sales and cost data, forecasting and inventory control methods, and transportation choices with statistical performance data. Any units of product flow may be used, but control the data scaling so that the numbers are neither too large nor too small. Time is always expressed in days. Costs, revenues, and profits are expressed in $.

The input data can be divided on following groups:

- Initialization: seed number, length of simulation. selling price.

- Customer Demand Pattern: end customer demand, generate demand pattern, specify demand pattern.
- Inputs for Levels 1, 2, and 3: product item data, item value, inventory carrying cost, in-stock probability, back-order cost, customer/retailer/distributor/warehouse order filling, purchase order processing.
- Forecasting method: three forecasting methods used to project future sales at a facility are allowed. Two are forecasting from a time series and the third is a user's specified forecast -
- Reorder policy: inventory replenishment, reorder point, periodic review, stock-to-demand.
- Factory/Source: production cost and lot size. production time, purchase cost, order-filling cost.

After running a simulation, the results of simulation are available in both graphical and report forms. Various combinations of graphs and reports can be selected. A variety of reports may be selected. Within the report, results are shown as a yearly average and for the simulated period. The yearly average is the average of a result for the selected period of the report, whereas the result for the simulated period is the sum of the result values over the simulated period.

The reported financial items have the following meaning.

- Revenue. The selling price per unit multiplied by the retailer sales.
- Cost of purchased goods. The unit purchase cost times retailer unit sales.
- Gross margin. The difference between retailer sales revenue and the associated purchased goods cost.
- Production cost. Retailer sales multiplied by production cost per unit.
- Transportation costs. Transportation rate times the shipping volume moving between echelons within the channel.
- Sales order handling cost. The cost for a seller to process the sales orders received. It is the unit order filling cost times the unit sales volume.
- Order-processing cost. The cost for a facility to prepare a purchase order placed on an upstream seller. It is the purchase order-processing cost times the number of purchase orders placed.
- Inventory cost. The cost of an item in inventory times the inventory carrying cost times the average inventory level at a particular echelon.
- Back-order cost. The volume of units back ordered at an echelon times the unit back-order cost.
- Total cost. The sum of the costs for a particular echelon.
- Net profit contribution. The difference between revenue and the sum of all supply channel costs.

The reported performance items have the following meaning.

- Sales forecast. The expected sales for a particular echelon as projected by the selected forecasting method.
- Sales to channel member. The actual sales received by a channel member. This will usually be less than customer demand due to the inability to fill all of demand on request.
- Average inventory on hand. The average inventory level for the selected reporting period.
- Inventory turnover ratio. The ratio of a channel member's sales to the average inventory on hand.
- Daily back orders. A channel member's average daily back-order volume.
- Back-order occurrences. The number of back-order occurrences that took place within the reporting period.

- Average demand filled on request. A service measure expressed as a percent of echelon member demand that could be filled at the time the demand occurred. Demand is either customer demand, in the case of the retailer, or the purchase orders placed on a distributor, warehouse, or factory.
- Daily quantity on order. The average daily units placed as orders on an upstream seller that have not yet been received.
- Number of orders placed. Number of purchase orders placed on the upstream echelon for the selected period.

Conclusions

Simulation can make the research time and solution achieving shorter and more effective. Because of their possibilities and ability for verification of many alternative solutions for supply chain processes design and managing it is possible to choose the best solution without building the structures that is very expensive and time consuming. The computer support enable verification of processes and structures of supply chain in circumstances very similar to reality that allows for avoiding many expected and unexpected situations in future operations.

It can be stated that simulation is useful and effective using computer support for processes improvement but It should be remembered that there is some disadvantages. They are as follows: user large experience, reality or problems simplification with results' credibility estimation.

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