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Model Planning Production and Logistics Activities in Business Networks

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Abstract

This paper deals with the issue of production planning and inter-company logistics activities when collaborating on the implementation of contracts in business networks. The first part introduces the issue, sets parameters of inter-company logistics, methods for evaluation of alternatives for inter-company transport and setting parameters for production planning. There is also a case study, "Optimizing capacity utilization of machines in the production process variant", in which is tested whether it is possible to use simulation tools to effectively search for advantageous variants of production from different perspectives. The paper concludes with a summary of the issue and proposed methodology.

Keywords: Business network; logistics; logistics methods; simulation; planning

1. Introduction

Currently, with the customer having an ever stronger position in the market, it is important for industrial enterprises to be subordinate to the requirements of the market. The customer requires a wide range of products, flexible delivery time, low prices, innovations of product, all while maintaining the required quality. The market is mostly dominated by large firms; for small businesses to compete in this environment, it is necessary to cooperate and thereby compensate for their disadvantages by exploiting their possibilities. This therefore gives rise to various types of network organizations (e.g. clusters), where companies can develop activities that could not be carried out by a small business. Within these network organizations it is advantageous to co-operate in the manufacturing

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process of their products and reap the benefits of this cooperation. The advantages of this cooperation may be a broader portfolio of products, lower production costs, more efficient use of capacity, increase in the volume of completed contracts, etc.

1.1. Business networking

To increase the competitiveness of small and medium-sized enterprises, it is a great opportunity to create a network organization. If you want to create a long-term bond, an appropriate form of association is for example a cluster. One possibility is cooperation on the implementation of production orders. Network organizations exist in two forms - horizontal and vertical. In the vertical network organization can be seen an analogy with the supplier-customer chain (SCM), which is addressed in detail in the current literature. In contrast, a horizontal network organization is an opportunity to look for tools to support the planning and management of the implementation of orders. Therefore, we shall further focus on cooperation in production in horizontal networking organizations that are made up of small and medium-sized enterprises. [3]

1.2. Inter-company logistics

To ensure cooperation on the implementation of contracts in business networks, it is necessary to ensure the effective functioning of inter-company logistics. To effectively set up an inter-company logistics network, the company is required to determine the input parameters of transport. Input parameters are primarily:

- transportation costs,
- characteristics of vehicles - capacity, speed, loading area, etc.,
- length of transport routes.[1]

1.3. Methods of evaluation of variants

In logistics, there are several problems that businesses must currently solve in practice. These problems include stockpiling, distribution system, material flows, etc. This group of problems includes finding suitable variants for inter-company transport in the network organization. These problems can be solved by using logistic methods. Among the logistics methods are analytical methods, mathematical methods, graphical methods and graph theory, simulation methods, etc. [2]

Of these, we focused on three groups of methods - mathematical methods, graphical methods and simulation methods. Mathematical and graphical methods were chosen because they are easy to use. These methods belong to the discipline of operational research. Some of the basic areas of operations research involved in solving logistical issues are distribution models, inventory management, optimization in graphs, etc. Not all the listed areas are suited to evaluating variants of inter-company transport in networked companies. The following areas are suitable for inter-company transport:

Graph optimization
- Optimal network linking
- Shortest network linking
- Optimal network linking

Distribution models
- Transportation problems
- Assignment problems
- Travelling salesman problems

Simulation methods in logistics are particularly suitable for the study of complex logistical systems where it is possible to test the behaviour of the proposed system and evaluate its optimality for example on the basis of

assessment of the cost and performance data parameters. The use of simulation is one of the suitable methods for finding optimal variants of realization in the network business. [4,6,7]

The aim is to find methods for solving transport between businesses and especially for evaluating alternative inter-company transport in the network businesses. Each of these methods is designed to solve different problems in inter-company transport. The choice of the method depends mainly on whether we are working with transport costs and time of transport (transport distances). Although these methods are used for finding optimal transport options, not all are suitable for the evaluation of alternative inter-company transport. Basic methods for the evaluation of alternative inter-company transport in network companies is given in Table 1.

Table 1. Overview of logistics methods and their appropriateness for the evaluation of transport variants.

Method of evaluation of transport variants	Costs	Time	Practicability
Optimal network linking	Yes	Yes	No
Shortest network linking	Yes	Yes	Partial
Network maximum flow	No	No	No
Transportation problem	Yes	Yes	Yes
Assignment problem	Yes	Yes	No
Travelling salesman problem	Yes	Yes	Yes
Simulation	Yes	Yes	Yes

For each method it was decided, on the basis of its processing of input parameters, whether or not it is suitable for evaluation of alternative intercompany transport.

Optimization methods in the graphs are specialized tasks that work with a low number of parameters, so they can be used for solving boundary and specialized (additional) problems - such as finding a suitable route between two points in the network (the shortest path in the network). Another possibility is to use them as steps for finding the optimal solution when the individual variants are gradually evaluated from different perspectives. Then the methods may serve as a "sieve" to reduce the number of options that will be evaluated at the end of the procedure.

In contrast, the methods of linear programming work with multiple operating parameters, and therefore would seem to be an appropriate basis for a method of finding the optimal route for transport in a network of enterprises. This is due mainly to the variation of the transport problem. First, it is advisable to use a multi-dimensional transportation problem, since, if it is decided to manufacture the product using more members of the organization network, transport will take place between two or more points.

The last category, simulation methods, are suitable for solving a wide variety of problems, not only logistics, so their use for finding an optimal alternative for inter-company transport in the network is the best.

1.4. Production and production planning

In the introductory section we have seen that it is appropriate for small and medium-sized enterprises to form themselves into business networks and collaborate on the execution of contracts. Undertaking detailed production planning is appropriate for cooperating on unique (piece to small-scale) production to order, since there will be a requirement that a large number of different and clearly defined procedures will be carried out in the production system. To evaluate whether the production plan has been chosen appropriately, production parameters are used - quality, time, cost and production capacity. [9]

2. Case study

The aim is to distribute production into individual products (contracts) between individual members of the network organization. It is compared whether it is better to produce a product within one company, or to transfer some operations to other members of the network organization. The main evaluation criteria are quality, time and cost. The main part is transport between businesses, which has a significant influence on time and cost criteria.

Therefore, the "Case Study: Optimizing variant scheduling using simulation", was carried out which created a model of production using simulation software, where it is possible for the technological operations to use more types of machines (workstations) with different parameters, and find the option with the lowest production costs and the shortest production lead time. Therefore, a simplified model was defined which manufactured more products in the same establishment where the individual technological operations can be implemented on multiple machines (workstations). The model ignores handling between machines (work) and it is observed whether it is possible to find the quickest or cheapest production variant. Therefore, the model parameters are defined as follows:

- Production includes 32 workstations, which can be interchanged in the technology groups.
- The company produces 10 kinds of product.
- Technological process of production contain 5 to 30 operations - 75% of the operations have 2 variants, 30% of the operations have 3 variants
- Parameters operations - used workplace, production time and setting.

First, a model of production was created, where we sought answers to the following questions:

- How will input and output of products be implemented in the model?
- How will the movements of products according to production processes be implemented in the model?
- How will manufacturing costs and throughput time be calculated?
- How will times be set for settings and production for the various production operations and workplace?
- How will the most advantageous production variant be determined?

During the creation of the model all these questions were answered. Standard software components were used for the model, as well as tables with data on the production process and dispatch of orders to manufacture, and methods (simple programs) for refining the behaviour of the model. It was also necessary to set up an optimization algorithm in order to generate each production process scenario. The input parameters of the algorithm were variants of production and the time between inputs of each product - there was a total of up to 112 input parameters.

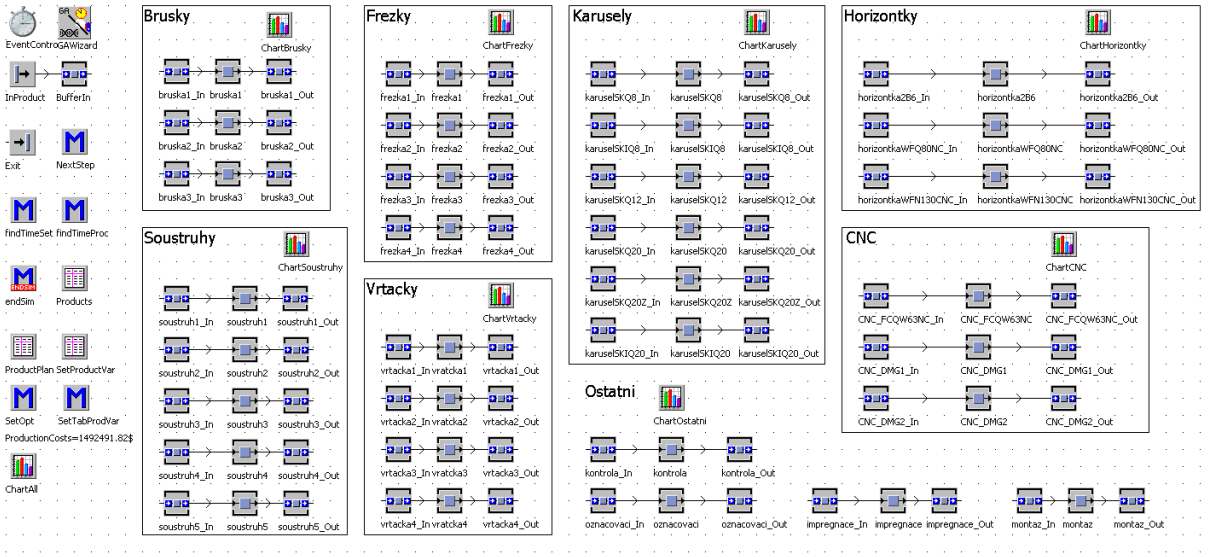

Fig. 1. Simulation model of production.

When evaluating the model we followed the total production cost and lead time of production. We also monitored during the evaluation of the model the changes of the load at workplaces. Results were compared between the initial non-optimized models and the optimization with different optimization goals and optimization parameters. The starting model is the model before optimization, where all steps of the technological process are set as variant1, times of inputs of all products are 10 minutes.

Table 2. Comparison of variants model .

Comparison of variants model	Costs [$]	Lead time of production [dd:hh:mm:ss]
No optimization	2 114 131,50	69:20:37:16,08
Optimization parameter: variants of the process		
Optimizing production costs	1 723 829,93	40:08:31:55,56
Optimizing lead times of production	2 131 733,70	14:03:38:00,60
Optimizing production costs and lead times of production	1 952 149,27	14:19:15:40,14
Optimization parameters: variants of the process and frequency inputs		
Optimizing production costs	1 732 730,35	34:08:03:07,56
Optimizing lead times of production	2 123 240,18	14:18:22:19,50
Optimizing production costs and lead times of production	1 927 432,67	15:10:41:10,50

Table 2 shows the comparison of different variants and how optimization is used to achieve significantly better values that correspond to the type of optimization. It is obvious that you can save from a few percent to tens of percent of the cost, and lead time of production can be reduced by more than 50%. It was also interesting to compare the utilization of production variants of the model where the optimization leads to a better distribution of production and higher utilization of production. The creation of this model verified that for searching for the best variant of production, it is possible to use simulation tools and optimization algorithms. The results of this chapter clearly show that the optimization algorithm allows us to find the most suitable variants for production. We can use the experience of working on this model to create the model of production in a network of businesses.

3. The proposed methodology

This research deals with network organizations (e.g. clusters). The aim is to find whether it is advantageous to produce products involving different members of a networking organization. It is thus concerned with the interconnection of multiple production systems in the network organization (see Fig.2).

The inputs to determine the optimal variants are parameters and the disposition of each technology in enterprises and parameters of technologies used for transport between the firms in the network organization. Technological parameters include a technology list (the list of technologies available to individual companies), the capacity of technology, quality of technology, time demands of production using the relevant technologies, etc. The parameters of transport include vehicle type, length of route, capacity of transport, transport time, transport costs.

Since these contracts can be accessed, as for individual projects, we use the project triangle in evaluating variants, where the basic criteria are quality, time, resources and costs. [8]

The evaluation process of variants is shown in a simplified form in the following steps in Fig 3. The first step will be to analyse the technological process of production and disposition of technology in individual companies. On the basis of this analysis will be made any combination of the production processes. As the number of these combinations would be too large to evaluate and may contain unrealistic combinations, the number of variants is reduced based on limiting conditions (such as the execution time of the contract, the capacity of the technology, etc.). The last step will be to compare the reduced variants and select the best. [5]

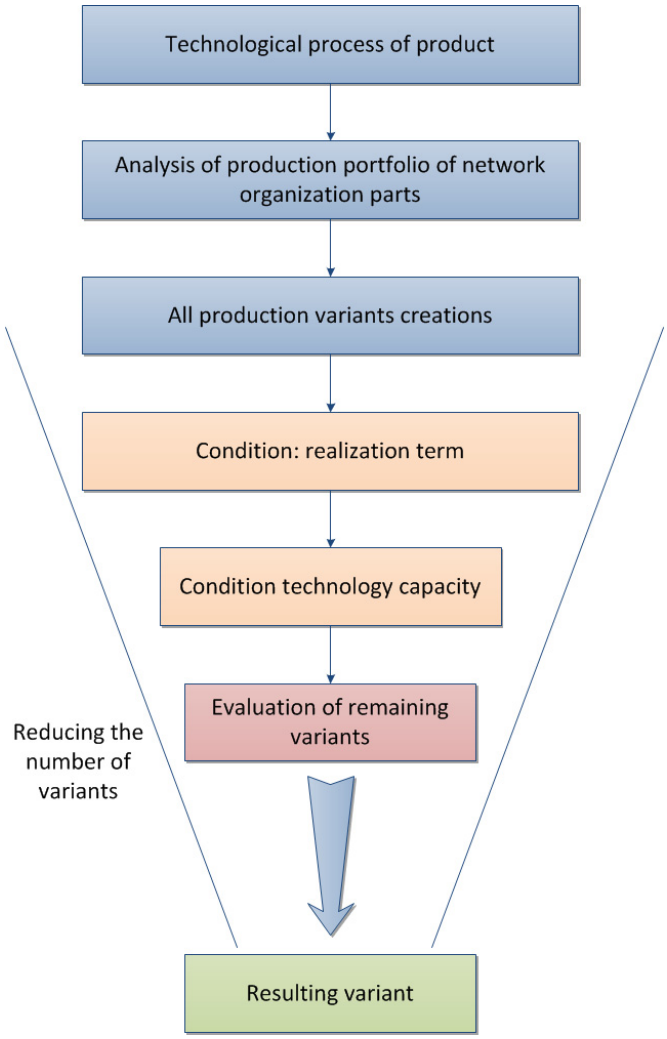

Fig. 2. Procedure for selecting the best variant of production in network organization.

4. Conclusion

Small and medium-sized enterprises operating independently in the market today do not have such great power as larger companies. Therefore, it is appropriate for them to associate into larger units such as by creating a cluster. The enterprise network is one of the possibilities of cooperation in order processing - production of products. The areas of cooperation for processing of orders (non-recurrent production) at the horizontal level of the cluster is currently not being dealt with. This co-operation in production brings clear benefits to the entire network of businesses and individual members of the network. These benefits include cost savings, contract performance, increased product portfolio, increased production capacity, more uniform distribution capacity, etc. The disadvantages on the other hand are increased demands on production planning and control.

It must also not be forgotten when working on order processing to ensure inter-company transport networks within enterprises. It is necessary to design an effective mode of transport between companies, to ensure continuity of production. Therefore, another disadvantage of cooperation on the implementation of contracts is the increased demand on the internal logistics of network businesses - transport between businesses.

Both drawbacks - demanding production planning and management, and transport between network businesses - can be eliminated by using an appropriately designed tool. The most appropriate tool for planning collaboration in processing orders appears to be the use of simulation methods.

The next step is to create a detailed methodology that will determine the most appropriate mode of production in the network business. Thus providing a production plan that is best for the whole network and individual businesses.

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