International Journal of Engineering & Technology, 7 (4.8) (2018) 448-453

International Journal of Engineering & Technology

Website:www.sciencepubco.com/index.php/IJET

Research paper

The Peculiarities of Production Programs Planning in the Enterprises Network

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Abstract

The operation of business networks is characterized by the complexity of the interaction of enterprises within the network. The main means of reconciling the interests of the owners of enterprises, goals and strategies of the participants are business network planning procedures. Through coordinated planning of production activities it should be possible to justify the integration options; to determine the structure of sales and purchases, the expected results of operations, as well as offers to network partners.
The article describes the models of production planning of business networks and methodology of constructing a system of coordinated planning. Using the model of coordinated production planning allows to solve the following problems consistently and iteratively: basic coordinated production planning in conditions where demand is known; optimal planning that takes into account random external demand, which results are deterministic input parameters for the first task; optimization of the system test viability of business networks by controlling domestic product prices, the results of which are inputs for the second task.

Keywords: *business networks; capacity utilization; coordinated planning; demand; modeling; production programs; supply.*

1. Introduction

The operation of enterprise networks is characterized by the complexity of enterprises interactions within the network. The main means of reconciling the interests of the owners of enterprises, goals and strategies of enterprise network members are planning procedures. By means of coordinated planning of production activities it should be possible to study the integration of options, to determine the structure of sales and purchases, the expected results of operations, as well as proposals for the network partners.

2. Research results

2.1. Modeling of coordinated of production plans network enterprises in terms of limited determinate external demand.

Interaction of enterprises business networks is due to mutually beneficial cooperation, which, however, leads to a certain mutual obligations. In each case the list of possible advantages and disadvantages of the enterprise in terms of enterprise network may be different, which is determined by the specificity of a particular network. However, we can identify a number of the most characteristic features of enterprise networks that need to be considered when planning the production activities of the enterprises included in it.
1. For companies that can sell their products to other enterprises within the network, you can distinguish the following advantages:
1.1) the guaranteed purchase price for the company's products;
1.2) the guaranteed amount of demand for the company's products, known in advance;
1.3) a priority in choosing the company as a supplier with an increase in demand for its products from other business networks.
At the same time the company, selling its products within the network, has also negative aspects of such interaction:
1.a) The obligation to sell products within the network at an agreed price in advance, when there is a possibility of its selling at higher prices outside the network;
1.b) inability to meet editorialized external demand at higher prices due to capacity utilization in service-net orders.
2. For enterprises that buy products (raw materials, components, semi-finished products) one can distinguish the following advantages in the network:
2.1) the guaranteed purchase price for the acquired products;
2.2) guarantees of obtaining necessary volumes of products by the fixed date.
At the same time the company, acquiring products within the network, has also negative aspects of such interaction:
2.a) the obligation to purchase the products in the network at an agreed price in advance, when there is a possibility of purchasing them at lower prices outside the network;
2.b) the need to purchase specified volumes of products in the absence (disappearance) of the need for it (for example, unforeseen drop in demand for this company`s products).
Taking into account a greater or lesser degree of the above mentioned conditions, let us consider the peculiarities of planning production activities of business networks in a variety of market conditions.
Let us assume:

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$Q^0_{i,x}$ – The volume of production of the *i*- enterprise network (*i* = 1, …, *n*) for the planning period to meet external demands ;i.e. the production of the form *x* (*x* = 1, …, *X*) in an amount which is sold outside the network;

$Q^l_{i,x}$ – The volume of production of the *i*- enterprise network (*i* = 1, …, *n*) for the planning period to meet the internal order of the enterprise *l* (*l* = 1, …, *n*; $l \neq i$); i.e .the production of the form x to the extent necessary for the enterprise network l;

$Q_{i,x}$ – The total production volume of the *i*- enterprise network of type product *x*;

$Q^{max}_{i,x}$ – The maximum possible output of the *i*- enterprise network of type product *x* (production capacity);

$y_{i,x}$ – The volume of the external demand for *x* products of company I In general it is assumed that the demand for the same *x* products to the enterprise *i* and for any other company, which can also produce products *x*, – is not the same. This is due to the fact that the formation of the demand for the company's products affect its image, reputation, marketing activities, etc., and not only the consumer properties of the goods.

At the first stage of formalization of the coordinated tasks of planning, we assume that the negative aspects of cooperation between enterprises in the network 1.a), 1.b), 2.a) and 2.b) are absent, that is, if possible, the company will buy products within the network; product demand has arisen within the network will be met regardless of the tactical changes in the market. Let us consider the simplest case, which, however, is the most common in view of the general market situation of overproduction of goods - when $y_{i,x} < Q^{max}_{i,x}$ for all *i* and *x*, when all the network companies are able to meet and satisfy all the external demand for their products.

Then, obviously, the total volume $Y_x = \sum_{i=1}^{n} y_{i,x}$ of foreign demand for the products of *x* can be fully satisfied with the use of production capacity of enterprise networks; wherein each of the enterprise network is able to meet fully its own demand. To plan the volume of production it is advisable to use the balance matrix models, like Leontiev model [1, 4, 6]. Let us assume: *Y* - column vector of final demand for products consisting of elements, Y_x, *x* = 1, …, *X*. We can also assume: $A=(a_{xj})_{X\times X}$ – technological matrix consisting of elements a_{xj}, which indicate how many units of *x* type must be expended to produce one unit of output *j*.

To determine how many products with regard to intermediate product must be produced by the network enterprises, use Leontiev model [6]:

$$Q = (E - A)^{-1}Y \quad (1)$$

where *Q* – the desired column vector of gross output, the elements Q_x of which are, in fact, the sum: $Q_x = \sum_{l=0}^{n}\sum_{i=1}^{n} Q^l_{i,x}$, *x* = 1, …, *X*.

The problem of the composition of values Q_x, and namely of the importance of values, $Q^l_{i,x}$, *l* = 1, …, *n*, is not considered. We assume that the company *l*, deciding what firm *i* can be ordered the required amount of *x* products uses certain individual criteria (own or network-wide). As for determining the value $Q^0_{i,x}$, , as noted above, it is determined by the demand for this type of product in the enterprise $Q^0_{i,x} = y_{i,x}$.

Local production program of the *i* individual enterprise will be determined not only by external demand, but also by domestic demand $\sum_{\substack{l=1\\ l\neq i}}^{n} Q^l_{i,x}$. Let us assume $Y_{i,x} = y_{i,x} + \sum_{\substack{l=1\\ l\neq i}}^{n} Q^l_{i,x} = \sum_{\substack{l=0\\ l\neq i}}^{n} Q^l_{i,x}$, - the amount of the final product for the company *i* of the form *x*, which it must produce. Then Y_i - column vector of elements $Y_{i,x}$, *x* = 1, …, *X*. By analogy (1) according to the formula (2) – we will get the production program for the gross output of the enterprise *i*:

$$Q_i = (E - A)^{-1}Y_i, \quad (2)$$

where Q_i – the desired column vector of gross output of the enterprise *i*, which elements $Q_{i,x}$ are the sum of: $Q_{i,x} = Y_{i,x} + Q^i_{i,x} = \sum_{l=0}^{n} Q^l_{i,x}$, *x* = 1, …, *X*.

The following should be noted. Obviously, not all kinds of products can be made using only the network resources and the production plants. Then for the model (1) the value of $I_x = Q_x - \sum_{i=1}^{n} Q^{max}_{i,x}$ will show «net imports» – the number of the type of product *x*, which must be purchased outside the network. It is advisable to make purchasing decisions of the scope of the «import» in a centralized form, leading to savings in transaction costs and resulting in savings due to volume purchases. Then «import» is distributed for businesses in accordance with their production program.

Similarly, the value of $I_{i,x} = Q_{i,x} - Q^{max}_{i,x}$ define «import enterprise» i, that is, the volume of the type of product x, which is to be bought from other businesses (inside or outside the network).

Note that in a reverse situation , when $Q_{i,x} < Q^{max}_{i,x}$ we will have a reserve capacity of the *i*- enterprise on output *x* (denoted $r_{i,x}$), that is - the volume of production *x*, that the company would make additionally to its current production program $Q_{i,x}$, i.f. $r_{i,x} = Q^{max}_{i,x} - Q_{i,x}$. Accordingly, it is possible to define the fulfillment of business network for the production of this type of product r_x ,that is the amount of product *x*, which the enterprises network might produce further in addition to the totality of the production program $r_x = \sum_{i=1}^{n} Q^{max}_{i,x} - Q_x$. It should also be noted that while local production programs (pattern 2) are not matched and an intermediate product required for the production network program (pattern 1) is not distributed over the internal orders and is not included in the production program of the local companies, then $r_x < \sum_{i=1}^{n} r_{i,x}$ .The equality $r_x = \sum_{i=1}^{n} r_{i,x}$ is performed only when the entire intermediate product is included in the local production programs of enterprises and their total is equal to the intermediate product: $Q_x - Y_x = \sum_{i=1}^{n}\sum_{l=1}^{n} Q^l_{i,x}$.

Note also that in the models (1) and (2) it was assumed that the technological matrix of the network and individual businesses are the same. In practice, this may not be entirely true, because the processes for the production of the same type of product in different plants may differ slightly (but not to a large extent). However, if it is, models (2) can use the local processing matrix of the companies, denoted, $A_i = (a^i_{xj})_{X\times X}$, *i* = 1, …, *n*. Then network matrix of technological coefficients can be obtained as the arithmetic mean of local coefficients, weighted by the volume of pro-

duction capacity of each of the companies for each type of product, $Q_{i,x}^{\max}$. Thus, if $A_i \neq A_l$ for each of $i, l = 1, \ldots, n$, then the processing network elements matrix $A = (a_{xj})_{X \times X}$ are calculated as follows:

$$a_{xj} = \frac{\sum_{i=1}^{N} Q_{i,x}^{\max} a_{xj}^{i}}{\sum_{i=1}^{N} Q_{i,x}^{\max}} \text{ for all } x, j = 1, \ldots, X.$$

To ensure the consistency of planning, enterprise i, calculating the necessary amounts required for the implementation of its program of industrial supplies $I_{i,x}$, must make a decision about their provision at the expense of formation of domestic orders $Q_{l,x}^{i}$ (within the enterprise network) or by means of purchases outside the network. To do this, it has to know:

a) models obtained as a result of the use (1) having unutilized manufacturing capabilities for the production of the product network $r_x = \sum_{i=1}^{n} Q_{i,x}^{\max} - Q_x$; or the same amount of the desired «import network» of this product $I_x = Q_x - \sum_{i=1}^{n} Q_{i,x}^{\max}$;

b) models obtained as a result of the use (2) having unutilized manufacturing capabilities for the production of the products of each company network $r_{i,x} = Q_{i,x}^{\max} - Q_{i,x}$, which you can use to make an internal order $Q_{l,x}^{i}$; or the same volume of external purchases of this product by each of the companies $I_{i,x} = Q_{i,x} - Q_{i,x}^{\max}$;

c) the stocks of this type of product in each of the business enterprise network, being ready to sell it $z_{i,x}$;

d) composite supplies of these products at all businesses of entrepreneurial networks $z_x = \sum_{i=1}^{n} z_{i,x}$.

Knowledge of items a) and d) is necessary for an overall assessment of the number of products that businesses which need it, will not be able to purchase within the network and will be forced to «import», to acquire abroad. In this case, an enterprise in need of these products, is interested as soon as possible to apply for the production of these products within the network, unless it is not done by other network companies. Knowledge of items b) and c) is necessary to estimate the number of products of this type, which can save the company and is used for making a decision on direct legal ordering of these items of a particular company. It is obvious that after the placement of orders, model 2 must be recalculated and paragraphs b) to d) must be specified.

The proposed basic algorithm of the coordinated production plans of enterprises network is valid, as stated above, on a limited deterministic external demand, which allows the company to have sufficient reserves for production and internal orders from the enterprise network. The situation becomes more complicated when an external enterprise demand approaches or exceeds the production capabilities of the enterprise and is non-deterministic. Then in the presence of the guaranteed volume of orders within the network, the company is facing a choice: to meet external orders or to provide, at least in some degree, the satisfaction of the internal.

Obviously, at the determined external demand with excess production capacity of the enterprise, the enterprise strategy is unambiguous: it is necessary to carry out those orders, which rate of profitability is higher. Such orders are obviously external orders.

In case of accidental external demand, which may exceed the available capacities of the enterprise, the company is faced with such difficulties in choosing its strategy [4, 5, 9, 10]:

a) in case of excessive load of its production capacity with marginally guaranteed volumes of production for domestic orders – the company risks a loss in the form of lost profits and image losses from external customers as unreliable producer; because of impossibility to meet external, more profitable orders.

b) Conversely, in case of conservation of reserve capacity left to serve highly profitable external orders and non-deployment of the guaranteed domestic ones- the company is at risk of losing profits from the underutilization of their capacities in the absence of external orders, as well as insure image losses in the network, which can negatively affect the volumes of guaranteed domestic orders in future periods.

2.2. Modelling of coordinated of production plans of network enterprises in terms of non-determinate external demand.

Let us consider the features of production planning enterprise network in a situation with indeterminate external demand. Let $y_{i,x}^{\xi}$ – random variable demand, which is characterized by the following parameters: $\bar{y}_{i,x}^{\xi}$ – the mathematical expectation of the demand in the planning period $\sigma_{i,x}^{2}$ – its dispersion. The distribution of this magnitude is usually not known. In some cases (in mass or volume production), it can be considered normally distributed; for single or small batch production - it is rather a uniformly distributed quantity. However, data distribution evaluation parameters can be performed on the basis of past demand periods by averaging. If the expectation of demand fluctuates from period to period it is advisable to check the tendency to its increase (or decrease), and then to predict the expectation for trend models or moving average. If there is no clear trend $\bar{y}_{i,x}^{\xi}$, variation in demand can be reduced if you choose from it the deterministic part, well-known at the beginning of the plan period. Let us examine this case in detail.

Thus a situation often takes place when at the beginning of the period the production program is based on actually made orders, or orders, the occurrence of which can be accurately predicted (because of their recurrence, the presence of arrangements, etc.). In this case, out of the total demand, observed in the previous period we can deduct the part, which was known in advance, estimating purely random component of demand $\xi_{i,x}$: $\xi_{i,x} = y_{i,x}^{\xi} - y_{i,x}$, where – $y_{i,x}$ the deterministic part of the demand. And it is for such random component that we can evaluate $\bar{\xi}_{i,x}$ and $\sigma_{i,x}^{2}$. Then the production program of previous local business periods i can be represented as the sum:

$$Q_{i,x} = y_{i,x} + \sum_{l=1}^{n} Q_{i,x}^{l} + q_{i,x}^{\xi}, \forall x. \quad (3)$$

$$Q_{i,x} = y_{i,x} + \sum_{l=1}^{n} Q_{i,x}^{l} + q_{i,x}^{\xi}, \forall x.$$

In expression (3) $q_{i,x}^{\xi}$ denotes the value of the portion $\xi_{i,x}$, of the random order, which is included in the production program to

meet the demand of the random component. Here, obviously, we have the condition $\xi_{i,x} \geq q_{i,x}^{\xi}$. Since the beginning of the plan period, the quantity $\xi_{i,x}$ is not known, respectively, the amount $q_{i,x}^{\xi}$ must be included in the production program not directly, but in the form of reserve production capacity for the production of the form *x*.

Thus, carrying out the planning of the production program in a random demand, the company must ensure that there are reserves $r_{i,x} = Q_{i,x}^{\max} - y_{i,x} - \sum_{l=1}^{n} Q_{i,x}^{l}$.

Obviously, one can increase the amount of reserves only at the expense of less profitable domestic orders $Q_{i,x}^{l}$. Conversely, increasing the portfolio of orders due to domestic guaranteed orders, the company reduces the maneuvering corridors when random demand occurs $\xi_{i,x}$.

When $\xi_{i,x} \geq r_{i,x}$ reserves become physical volumes of output $q_{i,x}^{\xi} = r_{i,x}$, and provide a high profitability of sales. At the same time there is a loss of revenue from the fact that it would be better to implement external orders, if there were more reserves. When $\xi_{i,x} < r_{i,x}$ only part of reserves will become a volume product $q_{i,x}^{\xi} = \xi_{i,x}$. The rest of reserves $r_{i,x} - \xi_{i,x}$ will bear the losses associated with downtime and underutilization of capacities ($s_{i,x}$), as well as the loss of profits from the possibility of the unused internal orders.

Let us assume that $p_{i,x}^{0}$ - selling price per unit of output x to the i- enterprise. We assume a market to have developed and prices to be stable , so the price for simplicity will be considered to be the same for all network enterprises, and then it can be described without unnecessary index: p_{x}^{0}. Thus different enterprise networks can have different cost $C_{i,x}$ of production units *x*, and respectively different profitability $R_{i,x}^{0} = \frac{p_{i,x}^{0} - C_{i,x}}{C_{i,x}}$ from the sale of one unit. Then, obviously, the profit received from the sale of one unit of output $\Pr_{i,x}^{0}$,will be different and will be connected with the selling price, cost and profitability ratios: $\Pr_{i,x}^{0} = p_{i,x}^{0} - C_{i,x} = R_{i,x}^{0} C_{i,x} = \frac{R_{i,x}^{0} p_{x}^{0}}{R_{i,x}^{0} + 1}$.

The price for the same product, if it is sold within the network is considered as the amount of p_x. Then, respectively, and profit and profitability from the sale of product unit x within the network is denoted: $\Pr_{i,x}$ and $R_{i,x}$.

Then, the objective function for the *i*- enterprise related to the maximization of the profits from the production of the product type *x*, can be represented as follows:

$$Z = \Pr_{i,x}^{0} y_{i,x} + \Pr_{i,x} \sum_{\substack{l=1 \\ l \neq i}}^{n} Q_{i,x}^{l} + \Pr_{i,x}^{0} \min(\xi_{i,x}; r_{i,x}) - \\ - \max\left(\left(\Pr_{i,x}^{0} - \Pr_{i,x}\right)\left(\xi_{i,x} - r_{i,x}\right); \left(\Pr_{i,x} + s_{i,x}\right)\left(r_{i,x} - \xi_{i,x}\right)\right) \quad (4)$$

The first item of the objective function represents the profit received from the sale of deterministic external orders, the second - from deterministic domestic ones. The third item is a random amount of profit from the sale of additional random orders at the expense of the use of available reserves of production capacities. The latter item refers to the random variable fine; if demand exceeds the given reserves, it is defined as the profit difference gained by the sale of foreign orders in comparison with domestic ones; if a random demand is less than reserves, the penalty is a loss of unplaced internal orders and idle production capacity.

For a complete description of the optimization problem let us formulate the restrictions:

1) in a limited volume production capacities:

$$y_{i,x} + \sum_{l=1}^{n} Q_{i,x}^{l} + r_{i,x} = Q_{i,x}^{\max} \quad (5)$$

2) classical restrictions on the sign of the variable:

$$r_{i,x} \geq 0 . \quad (6)$$

Thus a stochastic optimization problem (4)-(6) is given, which can be solved by classical direct methods, such as stochastic kvazigradientov method [2, 10], and can maximize the profitability of the local enterprise business network of the production program in the non-stationary demand.

This basic form of the problem can be upgraded with additional conditions and parameters:

a) as a restriction, you can use the required minimum internal orders, which the company network must perform;

b) as a restriction terms on the total maximum amounts of several different types of products that use the same production capacity can be imposed (it is considered that each type of product produced does not affect the volume of production of other types of products);

c) restrictions on the available volumes of some resources can be imposed(it is believed that all resources, raw materials, are available and can be purchased – or otherwise it should be reflected in the value of the maximum capacity);

d) as an objective function one can include penalties for non-deployment of domestic orders in the production program of the enterprise, if any, and the enterprise has obligations to fulfill prior domestic orders;

e) parameters $\Pr_{i,x}^{0}$ and $\Pr_{i,x}$ for random orders may be different from the deterministic orders, as the need for unplanned deliveries of raw materials can be reflected in their cost, which may be higher due to the higher purchase prices.

These and any other similar adjustments of the problem formulation are not difficult to formalize and include into the base setting (4)-(6). Such adjustments provide the flexibility of using the proposed model, taking into account the specificity of different operation conditions of the various business networks, but they do not require a change in the method of solving the problem and not really reflected in the increasing complexity of its decision.

In addition to the local optimization of production programs of enterprises business network the coordinated production planning task also involves ensuring the efficiency of the entire network. Current local optima plans do not provide such solutions, as the plans of some enterprises, focused on the maximization of local profits may prevent the efficient functioning of the other companies network, and even engage them in direct competition. The question arises: what is considered a criterion for the efficiency of the enterprise network as a whole. The following options can be proposed, indicating positive and negative aspects of these criteria.

1. Maximizing the total profit enterprise networks.

Positive aspects: simplicity and clarity for any economist or potential investor.

Negative aspects: the possibility of uneven distribution of profits between enterprises is not taken into account: some may have excess profits, and others may be unprofitable and do not ensure even simple reproduction. The high rate of profitability of some

enterprises may be due to low profitability of enterprises-contractors, by means of which profitable leaders «parasitize». As enterprise networks do not belong to the owner, such as holding companies, investment redistribution of profits from one company to another is not possible, the use of such criteria could lead to instability and frailty of the system.

2. Ensuring the viability of the network companies. Characteristics of the system determines the viability of its ability to be in homeostasis and save its parameters for a long time under the influence of negative environmental factors [7, 25].

Positive aspects of this criterion is that it semantically describes the mission of creating a global business network – the survival and development of all of its member companies.

The negative aspect is that it is difficult to formalize. You can suggest a few options, which to some extent reflect the aspects of vitality, but in all, there are significant disadvantages:

- The percentage of break-even enterprise users: it is uninformative, it does not consider the degree of break-even, it does not consider the importance and significance of various enterprises for the network; it may be difficult to correlate with the maximization of the total profit;
- The average rate of return on net sales of enterprises: it does not take into account the importance of different companies and products for the network; it does not take into account the specificity of the products (custom-made products due to the unstable demand should have greater profitability than the mass products relatively to the deterministic consumer goods); it does not take into account the contribution of a product (even low-profit) in the capacity utilization of enterprises;
- The average capacity utilization of network enterprises (percentage): it does not take into account the significance of various enterprises for the network; it may be difficult to correlate with the maximization of the total profit;
- The average level of investment activity of the enterprise network (e.g., the ratio of own investments in production volumes) does not consider the significance of various enterprises for the network; It does not take into account a relatively prosperous businesses that, however, don't carry out the investment activity.
- The average increase in production of enterprises networks: it does not take into account the significance of various enterprises for the network; it may be difficult to correlate with the maximization of the total profit; it will be uninformative when the productive capacity is utilized to the full.

The list goes on and on, offering other averages, however, other criteria will either reflect the concept of viability to a lesser extent, or will be more difficult to estimate, or even less will be consistent with the economic criteria of profit maximization.

1. Maximizing the synergy effects from the joint venture of enterprise network.

Positive aspect of this criterion is that it perfectly describes the practical goal of creating a business network - getting effects from joint ventures that are impossible for businesses operating completely independently.

Negative aspect is that it is also poorly amenable to formalization, as well as to ensuring the viability; and the effects obtained are difficult to reconcile with the financial performance in a simple manner. There are several possible options:

- Increase in the average rhythm of production (downtime and overtime reduction) does not take into account the significance of various enterprises for the network; it poorly correlates with the maximization of the total profit from the sale of products;
- Improving of warranty performance of orders in time, providing the necessary resources (such as the average percentage of overdue orders): formal mathematical linking of empirical indicator with the parameters of production planning is difficult; it poorly correlates with the maximization of the total profit.

Of all above mentioned criteria there are two criteria, the shortcomings of which can to some extent be ignored when using the proposed model in this section of modeling complex to ensure coherent planning. This is the average capacity utilization of enterprise network and the average increase in production of enterprises networks. Both of these criteria are to some extent related to each other, so we can choose any of them. Both of them have two drawbacks: the importance of businesses to the network and connection with the production volume are not taken into account with a profit. Nevertheless, let us focus on the examination of the first of them: the average capacity utilization – because it is much more concerned with the development of agreed plans and can be easily integrated into the model proposed above. In its present formalized form it can be shown as follows:

$$\max W = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{X_i}\sum_{x=1}^{X_i}\frac{Q_{i,x}}{Q_{i,x}^{\max}} = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{X_i}\sum_{x=1}^{X_i}\frac{Q_{i,x}^{\max} - r_{i,x}}{Q_{i,x}^{\max}},$$

where Xi – the number of products types produced by the i- enterprise.

Thus, enterprise network, as a system, is interested in ensuring its viability and stability of all enterprises network. The criterion of the viability percentage is considered to be the average utilization of production capacity. Disadvantages of this criterion can be ignored, because they are eliminated by the implementation of a model of the complex as a whole. Let us consider and refute the following points:

1. One can increase capacity utilization working at a loss, selling products below cost. So, it has nothing to do with ensuring the profitability of enterprises.

The system, maximizing the target criterion, only sets some parameters of its operation. For example, the domestic price of the products. Production program is developed by local businesses, taking into account these parameters, but following its criteria – maximizing profits. If the domestic price is below cost, or the company is profitable to produce fewer products, but at a higher price, focusing on the external customer and maintaining reserves for increasing production in case of surge in external demand – then it will not plan to release this product at a loss. Production capacity will not be utilized and the system, again maximizing its target criteria, will be forced to raise domestic prices. After a number of iterations an equilibrium point, if it exists, will be reached. At this point it will be profitable for enterprises-producers to include domestic orders in its production program, and for enterprises-consumers it will still be profitable to order within the network. The system target criterion – maximization of capacity utilization-will be reached.

2. The fact that the calculation does not take into account the importance and significance of various enterprises for the network makes the target criterion, calculated as a simple average, senseless. Different scales of production indicate that utilization of one company for the network may be more important than perhaps for a dozen others, as it can provide jobs and survival of other network companies.

If a large enterprise provides internal orders to a number of other enterprise networks, then the growth of production capacities of the enterprise will be automatically reflected in the startup of companies-contractors. Then the system target criterion will strongly be correlated with the downloading of an enterprise leader. And therefore there is no need to apply any special coefficients – in fact, the significant factor will automatically become the number of enterprises the operation of which depends on this leader. If this is not the case, and the activity of a large enterprise network does not affect the operation, and the rest of enterprises network, for example, suffer losses, then, obviously, the download of such a large enterprise can not strongly affect the viability of the network, and substantial increase in the system criterion would not happen; it would inevitably be observed if there are significant factors.

Again, regulating prices on domestic orders and maximizing its target criterion the system can achieve a reduction of internal prices for certain products, which a large company before buying them from external suppliers, will start to order within the network. Thus, there can be attained an equilibrium point at which enter-

prises-consumers will make profitable domestic orders instead of external supplies, and enterprises-producers will still be profitably guaranteed to sell products on domestic prices than rely on risky external demand. The system target criterion will be reached maximizing the average capacity utilization of the network companies.

3. Conclusions

Thus, the scientific and methodical planning of the coordinated production of enterprises business network was proposed. It is a complex of economic and mathematical models:
1) based on Leontief's input-output balance model, models determining coherent production program, taking into account the intermediate products in terms of deterministic external demand;
2) models of stochastic optimization, allowing to determine the optimum (in terms of local network profit of production facilities) distribution plan of production capacity of domestic and foreign orders;
3) optimization model of domestic prices for the products of enterprise networks, solved by heuristic methods and allowing enterprises to increase the viability of the network by maximizing its production capacity utilization.

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