Optimization Of Operation Program Of Manufacturing Enterprise

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Abstract: The article deals with topical issues of the manufacturing program optimization, economic and mathematical model of optimization of enterprise operations program is improved, the criterion of the target function is the optimization of income (net sales revenue). Along with restrictions on products sales, manufacturing, supply, environmental protection, the article offers to introduce restrictions to profits (operating profit on sales) which will provide for planning of maximum, minimum profit margin and defining of a planned breakeven point in natural units for multiproduct manufacturing.

Index Terms: Program Optimization, Economic, Mathematical Model.

1. INTRODUCTION

With the development of the external markets and increasing competition, the relevance of the problem of the optimization of the manufacturing program to maximize profits is continuously increasing. The enterprise can make a maximum profit by a combination of production volume in the context of nomenclature-assortment groups of products, products' price and its production and sale costs. The intensification of the domestic and world markets competition significantly influences on the formation of the domestic enterprises manufacturing program, and its development and justification methods. The complexity of this process has connected, on the one hand, with the fact that it must, in terms of volume, nomenclature, product range, timing of production, meet sales plans, and, on the other, be provided with sufficient resources of the required quality and production capacity of the industrial enterprise and its structural units. Also, there are problems with the production plan of industrial enterprises, where production includes several stages (on several lines), especially when the first production stages are faster than the following. The manufacturing program is a crucial part of the industrial enterprise's tactical plans, which interconnects the set of technical and economic calculations made in the process of their development. The validity of the manufacturing program has primarily determined by the methodological level of tools used in its formation, the level of its compliance with the current business conditions [1]. Manufacturing program is one of the main parts of the corporate development plan of a manufacturing enterprise as it shows the significant indices of its functioning which define competition ability of an enterprise on the market and the result of production capacity use. In order to implement this strategic objective, the manufacturing program of an enterprise has to anticipate the solutions of the following issues: to ensure high and stable growth rates of production turnout both in quantity and quality terms; to form nomenclature and range of products released depending on sustainable demand; to update nomenclature and range of products depending on the stages of product lifespan; to improve quality and reliability, design of products produced, to account for actions of competitors; the fullest utilization of manufacturing capacities of an enterprise and effective utilization of manufacturing potential of an enterprise in large with a possibility to ensure growth.

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2. LITERATURE REVIEW

At some point of the time, well-known foreign and national scientists have involved in the study of theoretical problems of optimization of enterprise operations program. Among them: G. Dantzigis has known as 'father of linear programming' and 'inventor of the simplex method' [2], L. Kantorovich developed a theory of linear programming to investigate a wide range of planning problems [3], F. Rothlauf describes how optimization problems can be solved and which different types of optimization methods exist for discrete optimization problems [4], O. S. Silva Filhoand F. Andresa time-discrete, constrained, Linear Quadratic Gaussian (LQG) production planning problem is formulated to develop a production plan with sub-optimal levels of production and remanufacturing for a single product [5], Longfei He, Huangli Peng, Zhanwen Niu, Haili Lu, and Xiangli Xie considered an EPL model like manufacturing system in presence of production imperfectness and stock-demand dependence simultaneously [6], Tunjo Periü, Zoran Babiü indicated that it is possible to apply the method of multiple criteria programming in dealing with the problem of determining the optimal production plan for a certain period [7] efficaciously; Yu. A. Yehupov [1], O. Orlov [8], D. Hahn [9], L. L. Lobotska [10], L. O. Yushchyshyna [11], I. I. Karpenko [12], Yu. Kharchenko [13] and others considered various aspects of optimization. Though, despite the plethora of fundamental and applied works on optimal programming, as of today, this mathematical tool has not been appropriately applied in practical works at enterprises. Every enterprise develops its manufacturing program on its own, except for governmental program and government order, the scope of which has defined according to manufacturing capacities (manufacturing potential) of an enterprise. Manufacturing program must be formed considering the results of market research and resources of an enterprise to receive the best results, i.e. to be optimal. Finding optimal solutions for optimization problems can be relatively easy if the problem is well-defined [4, p. 46]. The optimal manufacturing program is a program meeting the capacities of an enterprise and ensuring the best results of its activity under the accepted criterion. Optimization of a manufacturing program has realized to plan an optimal structure of products nomenclature and define the maximum possible overall production and economic margin of production increase. In 1939 academician Leonid Kantorovich, the Nobel laureate, offered to solve an issue of optimal plan choice with the aim of profit maximization[3]:

$$F(X) = \sum_{i=1}^{m} c_i \times x_i \to \max \qquad (1)$$

where c_i– profit on sales of i-type of production; x_i– the amount of i-type production; т – number of product types.

The model has also introduced with restrictions regarding resources, equipment working time fund, overall production of certain products. In terms of mathematical problem definition, it does not raise any doubts. Though, the author says that it is not correct to use "profit in sales of i-type of production" index in the model, and offers to apply marginal profit (level of cover) in the model of optimization of products range [8, p.241]. In the function of optimization criteria, there may also present such indices as marginal revenue and marginal costs. These indices are well-known and applied in countries with developed economies. Their application is related to the operation of the law of market economy known as "the decreasing returns law". The decreasing returns law is one of the laws of market economy consisting in the following: starting from a particular moment the sequential addition of a unit of a variable resource (e.g., assets or land) provides an additional or marginal product which decreases with a view to every following unit of a variable resource. At the initial stages, the marginal revenue may increase, but then its scope will decrease. The overall production, when the maximum marginal revenue has reached, will be final. Its further increase is inappropriate. The same is the case for marginal costs. At first, they decrease, and then they start increasing. A minimum level of operating expenses defines limited overall production. We consider that the model of operations program optimization offered by German scientists Dietger Hahn and Harald Hungenberg in their work “Planning and control. Value-oriented concept of controlling” is worth noticing [9, p. 373]. Study of this optimization model allows defining certain shortcomings, as we consider. We would like to provide a problem definition offered by authors of a standard model of linear programming. The model of operations program optimization has viewed for the manufacturing sphere, the purpose of which is to receive maximum marginal revenue within a planned period considering the restrictions on production, supply, sales and environmental protection. Planning of operations program has viewed whether there are any "pinch points" at the enterprise. Operations program has viewed separately whether there is one or several "pinch points". Absence of "pinch points" means that the capabilities of an enterprise in the course of operations program planning depend on the sales capacities. In the spheres of supply and manufacturing, the enterprise does not have any "pinch points". If an enterprise has one "pinch point", the planning of program is restricted by sales capacities and this very "pinch point" in manufacturing or supply. If an enterprise has several "pinch points", then in the course of operations program planning there must be considered sales capacities and existing "pinch points" in the sphere of manufacturing and supply. The mathematical model of an operations program in case of absence of "pinch points" was defined by Dietger Hahn and HaraldHungenberg as follows: Maximization of marginal revenue (amount of cover) is a target function:

$$DB = \sum_{j=1}^{n} \left(p_j - k_j\right) \times x_j = \sum_{j=1}^{n} c_j \times x_j \to \max \qquad (2)$$

$$G = DB - K_f G = DB - K_f \qquad (3)$$

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where DB – the overall amount of cover for operations program in a planned period; PJ – price of a production unit of j-type; KJ – variable costs per production unit of j-type; x_j – variable value of target function decision taking (volume of planned output of j-type product in a planned period); j – index of product type (j=1,2,…….n); CJ – ratio of target function (amount of cover per production unit of j-type); G – profits of an enterprise in a planned period; K_f – constant costs of an enterprise in a planned period [9, p. 357, 373].

System of restrictions:

1) on sales:

$$MA_i \le x_i \le HA_i \qquad (4)$$

where MA_j – a minimum overall sales of production of j-type, HA_j – a minimum overall sales of production of j-type;

2) on manufacturing (process utilization):

$$\sum_{j=1}^{n} b_{ij} x_j \le B_i \qquad (5)$$

where b_{ij}– a ratio characterizing the capacity of the process, B_i– marginal capacity of manufacturing unit, i – index of capacity type (i=1,2,…m);

3) on supply:

$$\sum_{j=1}^{n} e_{hj} x_j \le HB_h \qquad (6)$$

where e_{hj} – a ratio characterizing the use of a type of materials or raw material, HB_{ij} – a maximum volume of supplies of material or raw material of h-type, h – index of material type (h=1,2,…k);

4) on environmental protection:

$$\sum_{j=1}^{n} g_{sj} x_j \le BK_s \qquad (7)$$

where s – index of the type of harmful substances emissions (s=1,2,.....,q), g – the ratio of emissions;

BK – a maximum possible volume of harmful substances emissions, kg.

A maximum index of revenue has calculated as the difference between the maximum amount of cover and fixed costs in a planned period.

$$G = DB_{max} - K_f \qquad (8)$$

Where, K_f– fixed costs of an enterprise in a planned period [9, p. 357, 373].

Drawbacks of authors in compiling a task consist in the compilation of a target function. Ratios of a target function $c_j = p_j - k_j$, which have defined between a price or net profit per production unit and variable (marginal) costs of every

$$G = DB_{\max} - K_f = \sum_{j}^{n} (p_j - k_j^{pr} \times x_j - K_f - \sum_{j=1}^{n} k_j^{per}$$

production unit of every product type is not constant regarding the overall output of production x_j. Variable costs include direct costs (e.g. costs of primary materials, raw material and salaries of operations employees) and variable indirect costs (e.g. costs of electricity, maintenance and utilization of equipment, general production and economic costs), which are distributed per production unit of every time proportionately with the overall production of this type $k_i = k_i^{pr} + k_i^{per}$, where k_i^{pt} – direct variable costs, a k_i^{per} – indirect variable costs.

There exist indirect costs, for example, general production fixed and variable costs. Variable general production costs include service costs and costs for production management (production facilities, lots) which change directly (or almost directly) proportionally to the changes of scope of activity. Variable general production costs have distributed per each unit of costs along with application of the distribution basis (working hours, salary, scope of activity, direct costs) considering the actual capacity of the reporting period (in the course of planning one accounts for ratios of distribution of variable and constant general production costs per unit of distribution basis). Fixed general costs include, for example, service costs and costs for production management which remain invariable (or almost invariably) when the scope of activity changes. Fixed general production costs have distributed per each object of costs along with the application of the distribution basis (working hours, salary, the scope of activity, direct costs) in case of average capacity. The calculated ratio (normative) for fixed general production costs is multiplied by the volume of the chosen distribution basis in a certain period, and the received amount has considered as a calculated standard of fixed costs in a planned period. Fixed actual costs not exceeding the calculated standard are considered as the distribution costs and included the prime production cost, and the balance – as non-distributed fixed costs. Non-distributed fixed general production costs have included the prime cost amount of the sold products (works, services) in the period of their occurrence. The overall amount of distributed and non-distributed fixed general production costs may not exceed their actual amount. The list of fixed and variable costs has defined by an enterprise [14]. Accordingly, the target function defined by Dietger Hahn and Harald Hungenberg[15] will be as follows:

$$DB = \sum_{j}^{n} (p_j - k_j^{pr} \times x_j - \sum_{j=1}^{n} k_j^{per} \to \max \qquad (9)$$

Furthermore, actually, as, $\sum_{j=1}^{n} k_j^{per} = const$ it would be necessary to maximize the following conditional function:

, $$DB = \sum_{j}^{n} (p_j - k_j^{pr} \times x_j \to \max \qquad (10)$$

Then according to (10), the maximum meaning of revenue would be calculated according to the formula showing the difference between the maximum amount of cover and sum of all the fixed and indirect costs [16]:

(11)

As it had stated before, the authors of the model view the options of alternative programs depending on the availability /absence of "pinch points". If an enterprise does not have "pinch points", the optimal product program is defined only from sales. The maximum sales volume may be determined as the maximum production volume until there is an excess of net income over the variable costs, i.e. a definite amount of cover. One considers the following condition if, in the planned period, there is an additional order (the condition of demand increase if acceptable). Moreover, there appears "a pinch point" at an enterprise; as a decision-making criterion, the authors offer to apply the method of ranging under the percentage of amount of cover which shows the amount of cover of j production per each unit of "a pinch point" E (for example, machine hour, standard hour, quantity of materials, quantity of harmful particles) of structural production unit (production facility, lot) / type of raw material. If there are no pitch points, then the choice of alternative production program is also realized through ranging under the percentage of the amount of cover per production unit:

(12)

$$y_i^E = \frac{P_j - k_j}{b_j^E}, y_i^E = \frac{p_j - k_j}{e_j^E}, y_j^E = \frac{p_j - k_j}{g_j^E}$$

Where $b_j^E, e_j^E,$ is the time of j product processing in "a pinch point", the volume of scarce raw materials required for the production of products, emissions of harmful substances in the course of products manufacturing, respectively. In order to define the optimal structure of a program, the types of products have drop-down figure of their percentage amounts of cover.

3. RESULTS

Considering the defined existing drawbacks of this model, we would like to offer a standard model of enterprise operations program management which is also the model of linear programming. However, the principal criterion of the target function is profit optimization (net income of the sold products):

$$D = \sum_{j=1}^{n} p_j \times x_j \to \max \qquad (13)$$

where D – is a profit (net income of the sold products) in the planned period; p_i – price of a unit of product of j-type(net of VAT and indirect taxes); x_j– decision-making variable of a target function (planned volume of products of j-type in the planned period in natural units); j – index of production type (j=1,2,…….n).

The given target function is oriented at sales of ready products because the peculiarities of the production process do not allow to define precisely in terms of market an optimal operations program for a planned period, as it has offered in the previous works. The volume of income needed received from the sold products both for coverage of all expenses, receiving of profit and replenishment of circulating assets is more critical for an enterprise. Thus this is the main criterion of optimization. Moreover, all the restrictions mentioned above are acceptable for this model as well. Only along with the offered restrictions (4) – (7) we would like to offer an introduction of restrictions on a revenue (operational revenue of the product's sales):

$$PR_1 \leq \sum_{j=1}^{n}(p_j - k_j^{pr}) \times x_j - \sum_{j=1}^{n} k_j^{per} - K_f \leq PR_2 \quad (14)$$

Where PR_1, PR_2 – a planned minimum and maximum volume of revenue, respectively. A minimum volume of revenue PR_1, may be equal to the amount of pure reflection for an enterprise. The maximum volume of revenue PR_2 will be calculated based on a maximum price which a consumer may pay for a product, considering the analysis of needs and possibilities of a consumer and prices of competitors (an enterprise must have a competitive position).

One may consider an operations program oriented at a particular volume of revenue; then the restriction will be as follows:

$$\sum_{j=1}^{n}(p_j - k_j^{pr}) \times x_j - \sum_{j=1}^{n} k_j^{per} - K_f = PR_{prev} \quad (15)$$

Where, PR_{prev} – a defined amount of a planned revenue for a planned period.

If an operations program has oriented at a break-even volume of production, the restriction will be as follows:

$$\sum_{j=1}^{n}(p_j - k_j^{pr}) \times x_j - \sum_{j=1}^{n} k_j^{per} - K_f = 0 \quad (16)$$

In this case, an optimal plan will be a break-even point in natural units for all types of products (optimal assortment of products in natural units) (until this point for multiproduct production the break-even point was defined only in value terms). Options of break-even volumes of production are received utilizing realization of imitating modelling. This model of operations program optimization provides for a possibility not only to define an optimal break-even assortment of products in natural units. However, also to define an optimal need of materials, raw material, to orient at the demand of consumers, to ensure actions on environmental protection, and besides, to manage production costs of an enterprise to receive a maximum revenue. It is ensuring debt-neutral raw material supply, to control norms and standards that are important for food enterprises in terms of production of high-quality and safe-health foodstuff for people. In a simple variant along with the application of EXCEL program functions such task gives a possibility of visual control over the uploading of resources and re-planning of production tasks. The computer program for management of operations program developed based on this model has officially accepted at food enterprises of Ukraine. The result of the model examination given as an example for enterprise №1 (name of an enterprise has not disclosed), in Table I.

Table I. *Main results of testing of an operations program management model at enterprise*

Type of product	Subject to maximum revenue	Subject to defined revenue rate	Break-even condition (considering the demand)
The volume of production according to assortment, tons per year			
- butter - whey solids - cheese «Rosiiskii» (“Russian”) - dried skim milk	1500,0 0 2083,33 2276,3	1500,0 0 1272,98 2699,3	883,8 0 7,5 3359,9
Prime cost (net of VAT) pet 1 ton, UAH			
- butter - whey solids - cheese «Rosiiskii» (“Russian”) - dried skim milk	20833,33 4166,67 23166,57 11666,67	20833,33 4166,67 23166,57 11666,67	20833,33 4166,67 23166,57 11666,67
Calculated planned direct costs per production unit, UAH per ton			
- butter - whey solids - cheese «Rosiiskii» (“Russian”) - dried skim milk	18454,31 2158,74 18776,0 10824,71	18454,31 2158,74 18776,0 10824,71	18454,31 2158,74 18776,0 10824,71
Amount of planned direct costs, th. USD	91438,2	80802,1	64192,2
Amount of planned indirect costs, th. USD	2245,3	2245,3	2245,3
Amount of planned fixed costs, th. USD	4185,1	4185,1	4185,1
Planned net income, th. USD	106070,3	92232,5	70622,6
Planned operational revenue, th. USD	8201,7	5000,0	0

Because of high energy costs for production of whey solids, the management model anticipates refusal on its output. At the same time, whey solids may be used for feeding animals. The latter requires whey solids condensing.

4. CONCLUSION

The correctly calculated operations program increases revenues of an enterprise as a whole and in its separate structural units, but its incorrect formulation leads to losses. The given model of operation program optimization has oriented at the development of the economic potential of an enterprise. If an enterprise opts for one of the operations programs, it will ensure its further revenues.

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