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STRATEGIC UTILITY MAXIMIZING DECISIONS IN INDUSTRIAL MANAGEMENT: CRITERIA, MODELS, METHODS

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Abstract

The issue of development and implementation of industrial management models is analyzed. By comparing operation costs, advantages and disadvantages of each model are described. The article assesses investment efficiency which is influenced by decreasing costs of industrial and administrative management. According to the Bounded Rationality Principle, decisions are made under the chronic information gap and lacking information processing tools. A multi-purpose approach can be applied by large companies. Development strategy formation for a business unit is a multi-purpose task involving identification of an option of maximum (minimum) implementation of each opportunity. A solution is a behavior strategy involving a resource management method which makes it impossible to increase one vector component without decreasing the other ones. Decision efficiency assessment simulation is significant for industrial management. Planning in social and economic systems is adjustment and optimization of counter plans. Under low discrete and determined demand, business management methods show that high demand can be accurately approximated by a continuous statistical function. In management, under several restrictions, a production control task is determined by multidimensional situations of dynamic programming. Taking into account challenges of ensuring source data accuracy and formalizing strategic decision assessment and generation procedures, the approach developed by the authors will help develop acceptable management scenarios, make a compromise strategic decision in industrial management.

Keywords: Model, criteria, demand intensity, principle, management theory, rationality.

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1. Introduction

Determinate one-product manufacturing models describing a homogeneous group of products or services assume that demand is continuous, and its intensity is constant and known. The production process does not depend on demand and volume of the order. Proceeding from these assumptions, let us analyze some models.

The first model assumes that an optimum strategy should provide equal amounts of services (manufacture the same volume of goods) x at regular intervals t.

The second model assumes that demand intensity is known and constant, implementation time is constant and does not depend on demand and volumes of the order, demand is fully satisfied and discrete.

The third model assumes that demand intensity changes, and minimum production costs can be calculated by means of dynamic programming.

The fourth model assumes that demand is continuous, its intensity is known and constant, implementation time does not depend on the amount of the order.

2. Problem Statement

The business management theory takes into account different purposes to be achieved when maximizing utility. Profit extraction is an imperative. Profit is a key purpose determining long-term business behavior. The need for using a group of purposes when describing complex social and economic systems caused dominance of a multi-purpose approach in the modern theory and practice of management. The approach can be used for description of many aspects of economic activities. However, it is difficult to identify one purpose which lacks disadvantages and combines all advantages (Ying Shi, 2016).

J. March and R. Cyert say that despite the dispersion of purposes set during negotiations of different groups and coalitions, most options involve a certain set of purposes (production, sales, market development, profit increase, stock level decrease) (Zadeh, 1973).

According to the Bounded Rationality Principle, decisions are made under the chronic information gap and lacking information processing tools. Therefore, a multipurpose approach can be used as a control mechanism for large companies. Model development approaches should take into account some restrictions (staff, capital assets, financial resources, etc.). If an approach becomes significant, Lagrange multipliers can be introduced and a cost function is built. The advantage of the approach is simplicity of idea implementation. But it can be applied if demand prediction is accurate, and expected ratios of demand variation and demand satisfaction period are small.

At the early stage, the significance of simulation of business decision efficiency assessment depends on accuracy of source data and methods. Planning in social and economic systems is adjustment and optimization of counter plans. An economic entity seeks to achieve maximum effects.

Multi-purpose programming allows using a minimum number of initial conditions. To a certain extent, a random efficient plan will be developed. It can be transformed into another, more rational one. Then, a known range of transformations appears. If it is impossible to use an efficient plan, an optimum solution can be identified through the system of dual estimates (artificial prices).

A manager has to combine accurate analysis of the economic situation with psychological

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calculation to understand why the price differs from the internal cost and when it will be equal to it. However, individual behavior is not rational. A number of alternatives is large, a volume of information is great, so it is difficult to be rational. Individual choice is influenced by data and assumptions (Jian Pan, 2017). Therefore, human behavior cannot be rational. Rationality means exhaustive estimation of each alternative.

To identify the value of future consequences, imagination is required. But this assessment is imperfect. In management, a multi-step planning process can decrease potential opportunities. Special attention should be paid to such types of planning as “independent” (making large-scale decisions); “procedural” (development of decisions about mechanisms of attention concentration and information transfer according to an independent plan); “executive” (development of current decisions).

Under bounded rationality, a decision-making manager analyzes options until she finds a solution. Decisions are made for identifying satisfactory rather than maximizing solutions. To compare total values, all weighted private criteria should be homogeneous.

T.G. Baltrushevich and V.N. Livshits argue that if one private criterion exceeds the other ones, an alternative which is optimum by a general criterion and maximum efficient for one of the criteria can be selected (Baltrushevich, 1992)

Another approach, which will be described in the present article, is free from these drawbacks. It can be applied to situations when key management measures involve identification of rational utilization intensity combinations from a set of new and basic solutions. The approach helps select measures which are beneficial for each group of participants with regard to the interests of other participants, assess results of each group depending on compromise conditions.

The models are compared based on operation costs. Only key activities are optimized. Under probabilistic demand for products, both period and threshold ordering strategies can be applied. For example, the model with a periodic strategy $\left[t, G\right]$ can be analyzed if the delivery time is equal to zero. Demand distribution for period *t* is assumed known. The best result can be achieved at simultaneous minimization by t_w and $\hat{G}_w$ $\left(w = 1,..., K\right)$, where K is the number of products (services). A threshold strategy is not convenient for systems manufacturing diverse products because moments of achieving critical levels for different w are different..

3. Research Questions

Business management methods used under low discrete and determined demand show that high demand can be accurately approximated by a continuous statistical function. In management, under several restrictions, a production control task involves multidimensional situations of dynamic programming.

Under multi-channel, multi-level financing of business activities, it is important to determine a dynamic relation between specific production costs and revenues. According to G.K. Lapushinskaya, that relation can be determined assuming the response of changing costs to changing income as constant in two near periods. The assumption about an invariable response in two near analysis periods is reasonable, as business owners and managers are guided by a long-term business development strategy when determining

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directions and volumes of expenditures.

For example, if in t_1 the state of the production budget is characterized by costs P_1 and revenues $\ddot{A}_1$, and in t_2 – by costs P_2 and revenues $\ddot{A}_2$, elasticity can be calculated by formula (1):

$$\mathring{A}_{\ddot{A}}(\text{Đ}) = \frac{\ln(P_2 / P_1)}{\ln(\ddot{A}_2 / \ddot{A}_1)} \tag{1}$$

where $\mathring{A}_{\ddot{A}}(\text{Đ})$ is the elasticity of costs.

The analysis helps identify priority items of expenditures which grow when revenues decrease, or their increase is larger than an increase in revenues. According to the author, the model can have several states:

1.If a rise in business revenues is $\mathring{A}_{\ddot{A}}(\text{Đ}) > 1$, a rise in costs exceeds a rise in revenues. Therefore, priority areas of expenditures should be identified as a part of the financial policy. When $0 < E_{\ddot{A}}(\text{Đ}) < 1$, a rise in costs is smaller than a rise in revenues. $E_{\ddot{A}}(P) \approx 1$. If this trend is constant, inadequate funding of production and economic activities can be observed.

2. A decrease in revenues $\mathring{A}_{\ddot{A}}(\text{Đ}) < 0$ corresponds to a highly significant item of costs. $0 < E_{\ddot{A}}(\text{Đ}) < 1$ shows that a decrease in costs is smaller than a decrease in revenues. At $E_{\ddot{A}}(P) \approx 1$, a decrease in costs corresponds to a decrease in revenues. At $E_{Д}(P)$> 1, a decrease in costs is larger than a decrease in revenues which is a priority for manufacturing activities.

Calculation of the elasticity of costs coefficient is an important preplan analysis stage aiming to assess the feasible region. Let us assume that K billion rubles are allocated to the manufacturing-marketing cycle, including development of progressive forms of management, construction, infrastructure modernization and development of associated activities. Let us transform a typical situation into a practical model allowing company managers to make efficient utility maximizing decisions.

4. Purpose of the Study

Business management methods used under low discrete and determined demand show that high demand can be accurately approximated by a continuous statistical function. In management, under several restrictions, a production control task involves multidimensional situations of dynamic programming (Lozano, 2018; Yugang Yu, 2017).

Under multi-channel, multi-level financing of business activities, it is important to determine a dynamic relation between specific production costs and revenues. According to G.K. Lapushinskaya, that relation can be determined assuming the response of changing costs to changing income as constant in two near periods (Lapushinskaya, 2006; Zakharov, 2017). The assumption about an invariable response in two near analysis periods is reasonable, as business owners and managers are guided by a long-term business development strategy when determining directions and volumes of expenditures.

For example, if in t_1 the state of the production budget is characterized by costs P_1 and revenues $\ddot{A}_1$, and in t_2 – by costs P_2 and revenues $\ddot{A}_2$, elasticity can be calculated by formula (2):

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$$\mathring{A}_{\ddot{A}}(\text{Ð}) = \frac{\ln(P_2 / P_1)}{\ln(\ddot{A}_2 / \ddot{A}_1)} \tag{2}$$

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Calculation of the elasticity of costs coefficient is an important preplan analysis stage aiming to assess the feasible region. Let us assume that K billion rubles are allocated to the manufacturing-marketing cycle, including development of progressive forms of management, construction, infrastructure modernization and development of associated activities. Let us transform a typical situation into a practical model allowing company managers to make efficient utility maximizing decisions.

A. Standard capital capacity indices a_{kj} calculated per annual production unit by groups $(j = 1,2,...,n)$ and a_{kj}^g are given. a_j^g is the proportion of mean annual costs in the total production volume. Between the value of mean annual costs (3):

$$\left\{ \frac{x_{j1}^{(g)} + x_{j2}^{(g)}}{2} = x_{jg} \right\} \tag{3}$$

and annual production volume, one can observe relation (4):

$$x_{jg} = \beta_j x_f^{\nu_j} \tag{4}$$

where $\nu_j \approx \frac{1}{2}$, and β_j is the coefficient accumulating the effects of all cost elements.

Under known and constant demand intensity, a constant production period which does not depend on demand and order volume, and fully satisfied demand, the task can be presented as follows: x_J (production volumes) should ensure the minimum target function (5):

$$L(x) = \left\{ \sum_{j=1}^{n} c_j x_j + E \sum_{j=1}^{n} \left(\hat{k}_j x_j^{-h_j} \right) x_j + \sum_{j=1}^{n} c_{ig} x_{ig} + E \sum_{j=1}^{n} \left[\tilde{k}_{jg} \left(x_{jg} \right)^{-S_j} \right] x_{jg} \right\} \to \min \tag{5}$$

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under (6) $\sum_{j=1}^{n} a_{kj} x_j + \sum_{j=1}^{n} a_{kjg} \left(\alpha_{jg} x_j \right) \le K$, (6)

$x_J \ge 0 \; (j = 1,2,...,n)$.

There are some assumptions. In particular, distribution of investment funds in business activities is given by a linear correlation.

B. Dynamic problem setting is more preferable because investment refers to the total production volume rather than to their annual increase Δx_j. In this option, a_{kj} can be substituted for the acceleration coefficient. Then in (7),

$$\sum_{j=1}^{n} a_{kj} x_j + \sum_{j=1}^{n} a_{kjg} \left(\alpha_{jg} x_j \right) \le K \tag{7}$$

has to be presented as the relationship between $\hat{a}_{tkj} = \frac{k_{tj}}{\Delta x_{tj}}$ by separate groups of products.

Estimates of the form (8):

$$\lambda_k = \frac{d\widetilde{C}(x, \lambda_k)}{dK} \tag{8}$$

They are investment rebound effects, where $\widetilde{C}\ (x, \lambda_k)$ is the minimum C_T at given K_T, which is expressed in the value of costs $\widetilde{C}$ of business activities per one additional unit of annual investment (K). The latter are divided into two groups: costs of business processes and costs of business development.

The value of estimation λ_k shows the level of deficiency of investment in business activities. Using the analysis results, it is possible to determine the volume and areas of production investment expansion based on agreed interests of participants of business activities.

C. Consumer time loss minimization is an optimum criterion. A task of optimum distribution of investment funds by product groups *j* is of special interest.

$$\left\{ L(x, \lambda_k) = [\sum_{j=1}^{n} c_j x_j + E \sum_{j=1}^{n} k_j x_j^{(1-h_j)}] + \lambda_k [\sum_{j=1}^{n} a_{kj} x_j - K] \right\} \to \min \tag{9}$$

under $\sum_{j=1}^{n} a_{kj} x_j \le K$. As a result of task implementation, $x_J \ge 0 \quad (j = 1,2,...,n)$ should be determined to ensure minimum functional $L(x, \lambda_k)$.

Further, the tasks are combined in a complex dynamic task of prediction optimization for changing scales of business activities, and a generalized optimality criterion is introduced. A consolidated indicator of total costs can be used to compare variants of production system development. For s discrete period, the criterion takes the form (10):

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$$\widehat{L}_{T+T^*} = \sum_{t=0}^{T}\beta_t\left[\sum_{j=0}^{n}\left(c_{jt}+k_{jt}\right)Q_{jt}\right] + \sum_{t=T+1}^{T+T^*}\beta_t^*\left[\sum_{j=1}^{n}\left(c_{jt}^*+k_{jt}^*\right)Q_{jt}^*\right] + \sum_{t=0}^{T}\sum_{l=1}^{L}\alpha_{lt}u_{lt}\left(\sum_{j=1}^{n}v_{jlt}\right) + \sum_{t=T+1}^{T+T*}\sum_{l=1}^{L}\alpha_{lt}^*u_{lt}^*\left(\sum_{j=1}^{n}v_{jlt}^*\right) \quad (10)$$

where c_{jt} is the relative distribution costs of product group j in period t; k_{jt} are the specific investment funds per sales unit; Q_{jt} is the sales volume in group j; β_t is the discounting coefficient; $c_{jt}^*, k_{jt}^*, Q_{jt}^*, \beta_t^*$ are the estimates of the same parameters calculated beyond the target period and taking into account the element of uncertainty; u_{lt} is the monetary assessment of costs of marketing operations; v_{jlt} is the amount of time spent on rendering of business service j; α_{lt} is the coefficient of additional time utility; $u_{lt}^*, v_{jlt}^*, \alpha_{lt}^*$ are the similar parameters with regard to uncertainty of their future behavior.

To determine the social and economic efficiency of the company at the stage of intensive implementation of new production and organization forms of business management, a consolidated profit index can be calculated (11):

$$\breve{L}_{T+T*} = \sum_{t=0}^{T}\beta_t\sum_{j=1}^{n}\overline{p}_{jt}\lambda_{jt}Q_{jt} + \sum_{t=T+!}^{T+T^*}\beta_t^*\sum_{j=1}^{n}\overline{p}_{jt}^*\lambda_{jt}^*Q_{jt}^* - C_{T+T^*} \quad (11)$$

where $\overline{p}_{jt}$ is the mean prediction price based on the relation of demand and supply; λ_{jt} is the extra charge obtained from the solution of a system cost analysis problem as a total value of gross revenues which have to be distributed by groups of activities.

The estimates are agreed with counter offers.

5. Research Methods

In vector optimality tasks, several compromise principles and optimality options are used. However, there are some problems: contradictions between some criteria; selection of a compromise scheme and optimality principles and normalizing criteria. To solve these tasks, it is necessary to use heuristic procedures in which experts play a crucial role.

Let us analyze a vector task with normalized local non-preferential criteria. Researches on the decision-making theory describe several compromise schemes. Space E^n of strategies $X = (x_1, x_2, ..., x_n)$ moves to space E^k of criteria vector $E = (e_1, e_2, ..., e_k)$, along the coordinate axis of the latter, values of local criteria are plotted (E^n is the flat n -dimensional space).

One more approach is implementation of the principle involving identification of a key criterion. From the totality of local criteria $e_1, e_2, ..., e_k$, e_1 is singled out and taken as a priority one, and other criteria do not have to be less than the given values of e_q^3. The optimization task is reduced to the scalar formula (12):

$$optE = \max_{e_1 \in \Omega_E^3} e_1 \quad (12)$$

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where Ω_E^3 is the segment of compromise area Ω_E^k, in which $e_q \geq e_q^3, \quad q \in \overline{2,k}$.

Concession consistency principle. Let us assume that efficiency indices are located in the decreasing significance order: priority index e_1, other auxiliary indices e_2, e_3 … Each index can be maximum.

Compromise decision-making involves searching for a solution which maximizes key index e_1. On practical and accuracy grounds, concession Δe_1 is made to maximize e_2. Let us impose a restriction on e_1, so that it is not smaller than $\overline{e_1} - \Delta e_1$, where $\overline{e_1}$ is the maximum value of e_1. Under this restriction, let us search for a solution which maximizes e_2. Concession is made to maximize e_3, etc.

The approach helps determine a concession value in one index required to get gain in the other one. Freedom of decision-making can be negligible as far as solution efficiency varies insignificantly at maximum values of criteria.

6. Findings

Priority vector $V = (v_1, v_2, ..., v_k)$ of size *k* has components v_q which are binary priority relations. They determine the degree of significance of two neighbor criteria e_q and e_{q+1} from I. Value v_q shows the importance of e_q in comparison with e_{q+1}. If vectors e_q and e_{q+1} are equally important, v_q = 1.

The following order of vector setting procedures is reasonable: priority vector *I*, priority vector *V*, weighting vector Λ. The vector can be calculated using relations between components of vectors *V* by formula (13):

$$\Lambda \ \lambda_q = \frac{\prod_{i=q}^{k} v_i}{\sum_{q=1}^{k} \prod_{i=q}^{k} v_i} \qquad (13)$$

In industrial management, it is important to reason the criteria priority method.

In researches, two different approaches to priority issues are described – rigidity and flexibility principles. The first one assumes that criteria are arranged in a series of priority *I* = 1, 2, …, *k* in a significance order. They can be written as $e_1 > e_2 > ... > e_k$. Then, criteria are optimized provided that the level of less important criteria does not increase if it decreases the level of more important ones.

At first, an optimum for the most important criterion is determined. Then, its value is fixed as an additional restriction at which an optimum for the second important criterion is determined, etc. Narrowing the feasible region, one can find the only optimum solution or optimum subset of solutions. Gradual optimization is rarely used as far as the optimization by the first, the most important criterion, leads to the only solution.

7. Conclusion

As it is difficult to ensure accuracy of initial data and impossible to formalize assessment and management utility maximizing decision-making procedures, the approach will help develop acceptable management scenarios under the following conditions:

1. The system-based management approach designed to reason compromise solutions using different models;

2. The method ensures reliable transition from one vertex of a polyhedron of conditions to another one;

3. Presentation of compromise solutions as a feasible region;

4. An opportunity to use a large group of models with regard to the nature of a simulated object (e.g., when solutions are identified in a homogenous feasible region). If a restriction system is linear, the solution can be identified using only two first groups of models, if a restriction system is non-linear, the third group can be used.

5. When it is impossible to determine the relationship of local criteria, decisions are made under uncertainty. It is reasonable to use the theory of matrix games to make compromise decisions.

6. An optimality criterion is selected in two directions: specification of a global (leading) business efficiency criterion; development of a system of local criteria specifying the global one.

In industrial management, the task of identification of compromise utility maximizing decisions can be solved as follows: implementation of an idea of identification of a compromise decision which is close to suboptimum decisions; analysis of the game model as an identification method under uncertain hierarchy of local criteria.

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The issues of business management based on strategic utility maximizing decisions are not limited to identification of an efficient model and rational optimization criteria. These issues can be avenues for further research.

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