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APPLICATION OF THE DYNAMIC STANDARD MODEL IN OPERATIONAL PLANNING

Babich-Gaury A.V.[1], Babich V.V.[2]

[1] DHL Finance Services B.V. Maastricht, The Netherlands
[2] Almaty Branch of the St. Petersburg Humanitarian University of Trade Unions, Almaty, Kazakhstan
[*]e-mail: mme_kazgay@mail.ru

Abstract

The article discusses the applied aspect of the use of mathematical models in the operational management of a company, in particular in the process of operational planning. Approbation of the model based on the method of dynamic programming for a specific object of study will be carried out. The key integral indicators that affect the efficiency of company management are determined. These indicators allow determining the strengths and weaknesses in the main business processes, adjust tactical objectives and improve the decision-making process. Integral indicators can serve as quantitative guidelines when setting strategic goals and, on the basis of them, motivational operational tasks can be set, which are assessed at the end of the calendar period. The dynamic programming model allows you to determine the priority sequence of changes in controllable factors according to the level of growth rate to achieve an effective result within the framework of achieving the strategic goal of profitable sustainable growth of the company.

Keywords: economic model, law of diminishing returns, operational planning, integral indicator, rank correlation, elasticity, growth scale effect, inversion, hypothesis testing.

Аңдатпа

А.В. Бабич-Гаури[1], В.В. Бабич[2]
[1]DHL Finance Services B.V., Маастрихт, Нидерланды
[2]Санкт-Петербург кәсіподақтар гуманитарлық университетінің Алматы филиалы, Алматы қ., Қазақстан

ОПЕРАЦИЯЛЫҚ ЖОСПАРЛАУДА ДИНАМИКАЛЫҚ СТАНДАРТ ҮЛГІСІН ҚОЛДАНУ

Мақалада компанияны жедел басқаруда, атап айтқанда операциялық жоспарлау процесінде математикалық модельдерді қолданудың қолданбалы аспектісі қарастырылады. Белгілі бір зерттеу объектісі үшін динамикалық бағдарламалау әдісіне негізделген модельді апробациялау жүргізіледі. Компанияны басқару тиімділігіне әсер ететін негізгі интегралды көрсеткіштер анықталды. Бұл көрсеткіштер негізгі бизнес-процестердің күшті және әлсіз жақтарын анықтауға, тактикалық мақсаттарды түзетуге және шешім қабылдау процесін жақсартуға мүмкіндік береді. Интегралдық көрсеткіштер стратегиялық мақсаттарды белгілеу кезінде сандық бағдар ретінде қызмет ете алады және олардың негізінде күнтізбелік кезеңнің соңында бағаланатын мотивациялық жедел тапсырмалар қойылуы мүмкін. Динамикалық бағдарламалау моделі компанияның табысты тұрақты өсуінің стратегиялық мақсатына қол жеткізу шеңберінде тиімді нәтижеге жету үшін өсу қарқынының деңгейіне сәйкес басқарылатын факторлардың өзгерістерінің басымдық реттілігін анықтауға мүмкіндік береді.

Түйін сөздер: экономикалық модель, төмендейтін кіріс заңы, операциялық жоспарлау, интегралдық көрсеткіш, дәрежелік корреляция, икемділік, өсу шкаласының әсері, инверсия, гипотезаны тексеру.

Аннотация

А.В. Бабич-Гаури[1], В.В. Бабич[2]
[1] DHL, Маастрихт, Нидерланды
[2] Алматинский филиал Санкт-Петербургского Гуманитарного Университета Профсоюзов, г.Алматы, Казахстан

ПРИМЕНЕНИЕ МОДЕЛИ ДИНАМИЧЕСКОГО НОРМАТИВА В ОПЕРАЦИОННОМ ПЛАНИРОВАНИИ

В статье рассматривается прикладной аспект использования математических моделей в операционном управлении компанией, в частности в процессе операционного планирования. Проводится апробация модели, основанной на методе динамического программирования для конкретного объекта исследования. Определяются ключевые интегральные показатели, влияющие на эффективность управления компанией. Данные показатели позволяют определить сильные и слабые стороны в основных бизнес-процессах, откорректировать тактические задачи и совершенствовать процесс принятия решений. Интегральные показатели могут служить количественными ориентирами при постановке стратегических целей и на основании их могут задаваться мотивационные операционные задачи, которые оцениваются по истечению календарного периода. Модель

динамического программирования позволяет определить приоритетную последовательность изменения управляемых факторов по уровню темпа роста для достижения эффективного результата в рамках выполнения стратегической задачи прибыльного устойчивого роста компании.

Ключевые слова: экономическая модель, закон предельной убывающей отдачи, операционное планирование, интегральный показатель, ранговая корреляция, эластичность, эффект масштаба роста, инверсия, проверка гипотез.

Introduction

Operational planning is a process that takes place annually in a company that adheres to modern management methods. This process affects all divisions of the company and ends with the approval of the operating plan at the Board of Directors or Stake holder/owners management meetings.

Annual planning is about turning long-term business goals into short-term action plans for the year ahead. It contains insights from past performance and a clear roadmap with a timeline and focus points. This yearly plan should be realistic and achievable by using SMART methodology (Specific, Measurable, Achievable, Realistic, Timeboud), while also being ambitious enough to move the business forward [1].

Operational planning is a mechanism that allows to develop the main tactical steps in achieving the strategic goals of the enterprise. The digitalization of the economy and technological innovations reduced the horizons of strategic planning, especially in high-tech industries, where the nature of technology adoption to the demand, leading to the change, accelerated significantly. In connection with such changes, the accuracy and importance of operational planning has significantly increased.

An operating plan is a document that contains a detailed description of how the company's goals will be achieved in the short term context it is between 6 and 18 month. Operational planning manages upcoming events, so plans are made for short periods of time, constantly supplemented, detailed, and adjusted. The main goal of the operating plan is to ensure stable and continuous operation in the current conditions, observing the deadlines and optimal use of all resources [2].

There are various approaches to the operational planning process. In this article, we will focus on methodology based on the dynamic standard model and the importance of key indicators that characterize the significant areas of the company's activities, built in accordance with economic laws: the law of marginal diminishing returns for the short term and compliance with the growth scale effect for the long term.

Management often rejects the use of economic laws out of ignorance or underestimation of their impact on operational planning processes. Such an approach in operational planning leads, as a rule, either to the unattainability of the tasks set, or to the lack of proper planning for a particular enterprise. When developing an operating plan, the company's management must consider both macroeconomic aspects, including macroeconomic risks, and microeconomic categories, such as, the type of industry, the type of market that affects pricing and the conditions for maximizing profits in a certain type of industry. Similar models have been considered by various researchers. In particular, the work "Static and Dynamic Assignment Models with Multiple Objectives, and Some Remarks on Organization Design" This particular study analyzes the model of extended linear programming which allows vector optimizations and dynamic interactions between assigned employees and corresponding positions where the possible measures and approaches are taken into consideration [3].

As we noted above, the objectives of the operational plan follow from the objectives of the strategic plan. Your strategic plan and your annual work-plan go together. The annual work/focus plan provides the nuts and bolts of how the core business will be operated, but without having the strategic planning framework the process of annual planning will not be considered as strategic [4]. Therefore, the key indicators in the operational planning model we are considering, were selected based on the achievability of the goals of the strategic plan. Manager identifies three streams of Operational Research (OR) within the strategy research field. The first describes the 'Strategic OR' stream while traditional OR techniques such as optimization, simulation and queuing approaches are used to address operational issues and typically within the private sector, which by virtue of its size and complexity is considered of strategic importance [5].

The object of the study was the company LOTTE Rakhat JSC. Based on public reporting data published on the website of the Kazakhstan Stock Exchange, the Key performance Indicators (KPIs) of 2019-2021 were generated. Based on these data, the proposed model was tested. Since the company is a manufacturing company with its own distribution network, it was necessary to choose indicators that would cover various aspects of activity. It should be noted that the analysis of production activities includes a number of diverse indicators, the interpretation of which does not always allow one to form a sufficiently clear idea of the direction and depth of manifestation of the relationships that have arisen between various indicators. In such a situation, it

is necessary to use integral indicators, with the help of which it becomes possible to express with one coefficient the assessment of the state of the economic system of an enterprise and determine the most significant factors influencing the process of managing the economic situation of the enterprise. To form an integral indicator, you can use the dynamic standard method. We will use a linear dynamic standard - that builds a strict ordering of indicators according to their growth rates.

In studies of the use of the methodology of the dynamic standard in the management of the economic system, it is noted that the selected indicators, arranged in a ranked series, make it possible to express the dynamics of the indicators in their mutual relation. Such a ranking of indicators evaluates the properties of a controlled economic system, which cannot be provided by a single indicator. From the point of view of management, "... by controlling the dynamics of indicators, it is possible not only to determine the direction of the enterprise's movement, but also to manage this movement in order to achieve the goals" [6].

The authors of the study [7] note that the use of the dynamic standard method is not entirely appropriate for use in assessing the level of management of an economic system. In particular, they note “The variety of interpretation options that characterize the essence of the final coefficient, calculation algorithms and criteria for assessing the boundaries of interpretations allow us to conclude that at present an unambiguous method for applying dynamic standards has not been developed, which predetermines the need for further research based on a representative sample using statistical and econometric methods. However, the method of using certain economic and mathematical methods is determined by the target setting and can be applied to a specific goal, and accordingly adapted to specific tasks/processes. Economists usually distinguish between two types of efficiency: technical and capacity management. Technical efficiency refers to maximizing activities or outcomes from a fixed set of resources, while capacity management is concerned with directing resources to their most productive use to achieve the best overall benefits [8].

Life Cycle Cost evaluates the relative cost-effectiveness of alternative investments and business decisions, from the perspective of an economic decision maker such as a manufacturing firm or a consumer. Therefore, properly and fully integrating meaningful economic analysis with Life Cycle Assessment (LCA) requires going well beyond simply treating economic cost as “just another flow,” or as another property of flows, within LCA software. It requires the addition of a time dimension to the modeling; the ability to introduce and work with variables that have no causal dependence upon inventory flows; and the ability to create and work with probabilistic scenarios [9].

When we analyze the economic system, we assume that many indicators are dependent on each other. Therefore, when choosing a model, this factor must be taken into account. Rank models avoid this effect. As the author of one of the studies notes, “with strong suspicions, if we know in advance that the data are dependent, we carry out the transition from the original “continuous” data to ranks [10].

There is a certain algorithm of the dynamic standard method:

1) Based on the business model, key performance indicators are selected, which are reflected in the financial statements or are determined on its basis.

2) At the stage of operational planning, a normative rank of priority for the growth of the selected indicators is built.

3) Based on the results of the analyzed period, the actual rank of indicators is determined, which, as a rule, differs from the normative rank. The purpose of the method is such that the level of these differences should be minimal.

4) The magnitude of deviations is estimated, the main factors that do not allow achieving the planned result are determined, and a new reference rank series is built.

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Any enterprise is a complex interconnected system that includes various areas of activity. For example, an enterprise may have a production site, its own logistics and delivery system for raw materials and materials, its own distribution network, a marketing department, a financial department, and a management team. Each of the above divisions has its own goals and objectives, which should make the goals of the operational and then strategic plans achievable. To manage the company, it is necessary, according to the SMART framework, to have indicators that can assess the achievement of goals, identify problem areas and adjust plans for future periods. Accordingly, the question arises of developing such indicators that would allow for a comprehensive assessment of the level of achievability of the goals set. We propose to apply the dynamic standard method.

This method is based on a structural-dynamic model that allows describing a controlled system (enterprise) from the point of view of the integrated efficiency of using its total resources [11].

The dynamic standard model is based on the analysis of the dynamics of the company's key performance indicators, which are formed by various departments according to areas of responsibility. The model allows you to establish relationships between indicators and, most importantly, to prioritize the dynamics of each indicator, which is extremely important for choosing the best management solution. Thus, the dynamic standard model represents the normative or standardized mode of the best functioning of the enterprise to achieve the goals of operational and strategic planning. Using the dynamic standard method allows you to identify problem areas, both at the tactical and strategic levels. The identified deviations as a result of using the model make it possible to determine the priorities for regulating the control system with the diagnosis of the main indicators that gave the maximum deviations of the actual indicators from the given standard level.

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Hypothesis and model

Using the dynamic standard model involves performing a number of procedures and testing hypotheses. Firstly, a number of key indicators are selected, on the basis of which the priority rank of the growth of these indicators is built. Secondly, integral indicators are determined and, on the basis of them, the hypothesis of the significance or absence of significance of the rank correlation is tested. To apply the dynamic norm model, it is necessary to compare the actual rank with the normative one, determine the inversions and calculate the Spearman coefficient. Next, test the hypothesis about its significance. According to the theorem, if K is the Spearman correlation coefficient constructed for a sample of size n with independent components, then

$$K \mapsto N(0,\frac{1}{n-1}), n \to \infty \tag{1}$$

If K is the sample value of the Spearman correlation coefficient, then when testing the hypothesis of feature independence, the significance level is determined:

$$\alpha_{кр} = P\{|K| > |\hat{K}|\} = 2[1-\Phi(\sqrt{n-1}\,|\hat{K}|)] \tag{2}$$

In this article, we will define the Spearman correlation coefficient as follows:

$$K = 1 - \frac{6\sum y_i^2}{n(n^2-1)} \tag{3}$$

Where

n − is the sample size,

Yi = Xi-Mi – is the difference between the sequence of ranks (Xi) and (Mi) according to two features.

The calculation of inversions is based on the following condition:

$$m_i = \sum_{p=i+1}^{n} a_p = \begin{cases} 1, r_i > r_p \\ 0, r_i < r_p \end{cases} \tag{4}$$

Where

i − the place of the indicator in question in the normative series,

m − is the number of inversions for the i-th indicator,

p − places of indicators compared with the considered one,

n− is the number of indicators included in the model,

a_p− is a function that characterizes the inversion of the p-th indicator with the i-th indicator,

r_i, r_p − ranks that have indicators in the actual ordered series.

Based on the determined Spearman's coefficient, the null hypothesis about the absence of the significance of the rank correlation coefficient is tested. To test the hypothesis at a given significance level α, a critical point is determined:

$$T_{кр} = t_{кр}(\alpha, \kappa) \bullet \sqrt{\frac{1-K^2}{n-2}} \tag{5}$$

Where

n − is the sample size,

K − is Spearman's sample rank correlation coefficient,

$t_{cr}(\alpha,k)$ − is the critical point of the two-sided critical region according to the Student's distribution at thesignificance level α and the number of degrees of freedom k=n-2. Then the hypothesis about the significance of the sample Kendall's rank correlation coefficient is tested. The sample rank correlation coefficient is determined by the formula:

$$Э = 1 - \frac{4\sum m_i}{n(n-1)} \tag{6}$$

Where

n − is the sample size,

mi – ranks of i-th indicators,

E − is Kendall's sample rank correlation coefficient.

To test the null hypothesis for a given significance level α, the critical point is calculated:

$$T_{кр} = z_{кр} \bullet \sqrt{\frac{2(2n+5)}{9n(n-1)}} \tag{7}$$

Where

n − is the sample size,

z_{cr} − is the critical point of the two-sided critical region determined from the table of the Laplace function $\varphi(z_{cr})=(1-\alpha)/2$.

If the Kendall sample rank correlation coefficient is greater than the critical point, that is, $|E|>T_{cr}$ − the null hypothesis is rejected and the alternative one is accepted, which indicates a significant rank correlation.

Model Results

Based on the law of marginal diminishing returns, which is used in the short run, that is, at the stage of operational planning, the company can change one of the resources, usually the labor resource, since it takes a period of more than a year to change the amount of capital. Thus, one of the indicators will be the determination of the optimal amount of human capital. In order to optimize, it is necessary that with an increase in human capital, the ratio of the excess of the marginal product of labor over the average product of labor is observed:

$$\frac{\partial Q}{\partial L} \geq \frac{Q}{L} \tag{8}$$

Where

Q − is the volume of output,

L − is the average headcount.

To ensure sustainable profitable growth in the long run, it is necessary to observe a positive effect of scale of growth, which can be determined using the elasticity coefficient, which allows you to determine how much the rate of change in revenue outpaces the rate of change in total costs associated with operations:

$$E = \frac{\Delta R\%}{\Delta TC\%} \quad (9)$$

Where

Δ R − change in revenue in%,

ΔTS − change in total costs in%.

In order to achieve a positive scale effect, the growth rate of revenue must be higher than the growth rate of costs. Thus, based on the above ratios, we have chosen certain indicators, the growth rate of which should be set in a certain order or otherwise ranked.

The outstripping growth rate should have the volume of output and revenue, which directly affect the operating profit. This is followed by variable costs that correlate with the rate of growth in output and the rate of growth in revenue. Fixed costs must rise at a slower rate to achieve economies of scale.

Speaking about variable costs, it should be noted that in real practice, many costs attributed to fixed are conditionally fixed, which are usually reflected in accounting. Almost all companies allocate such costs as payroll. We noted above that the law of marginal diminishing returns is used to test the effectiveness of a company's activities in the short run. One of the important indicators is the observance of the condition that the growth rate of labor productivity is ahead of the growth rate of average wages. In conditions of high inflation rates, unfortunately, the reverse trend is observed. Therefore, in the list of selected indicators, we will also include the indicator of the average wage fund. Thus, for the implementation of the model, we selected the indicators of the company LOTTE Rakhat JSC, which are given in Table. 1.

Table 1. Key indicators of JSC "LOTTE Rakhat"

Indicators	*2019*	*2020*	*2021*
Sales volume (tons)	*79 154*	*73 443*	*69 292*
Revenue (thousand tenge)	*63 385 532*	*62 364 561*	*65 433 477*
Variable Costs (thousand tenge)	*(47 843 915)*	*(45 170 172)*	*(49 147 237)*
Average headcount (person)	*3 390*	*3 218*	*2 791*
Fixed Costs (thousand tenge)	*(6 987 866)*	*(8 136 502)*	*(9 104 807)*
Total Costs (thousand tenge)	*(54 831 781)*	*(53 306 674)*	*(58 252 044)*
Marginal Product Labor (tons/person)	*30,5*	*33,2*	*9,7*
Average Product Labor (tons/person)	*23,3*	*22,8*	*24,8*
Staff Salary (thousand tenge)	*(9 652 339)*	*(9 742 677)*	*(10 278 220)*
Operating profit (thousand tenge)	*8 940 988*	*9 274 481*	*8 121 432*
Growth scale effect	*0,83*	*1,73*	*0,53*

To use the dynamic norm model, the indicators we have chosen were distributed in a normative order according to the priority of growth. The indicators are given in Table 2.

Table 2. Normative rank of key indicators of the company LOTTE Rakhat JSC

Indicators	*Regulatory rank*
Sales volume (tons)	*1*
Revenue (thousand tenge)	*2*
Average Product Labor (tons/person)	*3*
Staff Salary (thousand tenge)	*4*
Variable Costs (thousand tenge)	*5*
Fixed Costs (thousand tenge)	*6*
Total Costs (thousand tenge)	*7*

Based on the data in Table 2, we will test the hypothesis about the significance of the Spearman sample correlation coefficient. The data for calculating the Spearman coefficient are given in Table. 3.

Table 3. Determination of the Spearman sampling coefficient

Indicators	*Regulatory rank*	*Growth rate 2021/2020*	*Actual rank*	*Yi*	*Inversions mi*	*Yi^2*
Sales volume (tons)	*1*	*0,9435*	*7*	*-6*	*6*	*36*
Revenue (thousand tenge)	*2*	*1,0492*	*6*	*-4*	*5*	*16*
Average Product Labor (tons/person)	*3*	*1,0878*	*4*	*-1*	*3*	*1*
Staff Salary (thousand tenge)	*4*	*1,0550*	*5*	*-1*	*3*	*1*
Variable Costs (thousand tenge)	*5*	*1,0880*	*3*	*2*	*2*	*4*
Fixed Costs (thousand tenge)	*6*	*1,1190*	*1*	*5*	*0*	*25*
Total Costs (thousand tenge)	*7*	*1,0928*	*2*	*5*	*0*	*25*
Total					*19*	*108*

Based on the data in Table 3, we determine the Spearman sample coefficient and test the null hypothesis H0:K=0 about the Spearman general rank correlation coefficient being equal to zero. According to the data presented by us, the Spearman coefficient is: K = − 0.9286. To test the hypothesis at a given significance level α=0.95, we determine the critical point:

$$T_{кр} = t_{кр}(\alpha,\kappa) \bullet \sqrt{\frac{1-K^2}{n-2}} = 2{,}57 \bullet \sqrt{\frac{1-(-0{,}9286)^2}{5}} = 0{,}4266$$

Since |K|>Tcr is the null hypothesis that there is no rank correlation between qualitative indicators, it is rejected, and an alternative hypothesis is accepted, which indicates a significant rank correlation between features. Accordingly, the indicators we have chosen do have a certain priority in the rate of change.

Analyzing the Spearman coefficient, we can conclude that the estimate of the approximation in terms of quantitative indicators is quite good. However, the actual series has a different direction of growth rate priorities in contrast to the normative one. Therefore, it is necessary to consider in more detail the factors that influenced these deviations. It should be noted that the company is growing, but its growth is not effective. In 2019 and 2021, the company experienced negative economies of scale. The reduction in costs in 2020 did not allow to overcome the rate of decline in sales volumes in physical terms, resulting in a decrease in revenue. Therefore, the company is faced with the task of achieving an increase in the rate of sales volumes, not in value terms, including the inflation component, but in physical terms.

Similarly, the hypothesis of the significance of the Kendall sample rank correlation coefficient is tested. Based on the available data, Kendall's sample rank correlation coefficient is E = − 0.8095. To test the null hypothesis for a given significance level α, we calculate the critical point:

$$T_{кр} = z_{кр} \bullet \sqrt{\frac{2(2n+5)}{9n(n-1)}} = 1{,}96 \bullet \sqrt{\frac{38}{378}} = 0{,}6214$$

Since $|E|>T_{cr}$ is the null hypothesis about the absence of the significance of the sample Kendall's rank correlation coefficient, it is rejected and the alternative one, which indicates a significant rank correlation, is accepted. The integral indicators obtained by us are quite close to unity in absolute value, which indicates a fairly stable system of operational planning at the object we are studying. Since both coefficients are significant, it is possible to determine the indicator of the quality of management of the studied object of activity:

$$K_{инт} = \frac{(1+K)(1+Э)}{4} = \frac{(1+0{,}9286)(1+0{,}8095)}{4} = 0{,}8724$$

Analyzing the obtained integral indicator of the quality of management as a whole, we can conclude that operational planning in the company is quite high. Management allows you to increase the rate of profit.

However, the outpacing growth of variable and distribution costs leads to a decrease in gross margin and the absence of profitable sustainable growth, due to the lack of economies of scale growth.

Conclusion

Summing up the application of the dynamic standard model in operational planning, a number of conclusions can be drawn:

1) The method allows you to determine the key factors affecting the company's operations, covering various business processes.

2) The selected parameters have the dynamics of change, which characterizes the achievability of the selected goals and allows you to adjust the operating plans to achieve the strategic goals of the company.

3) When choosing indicators, you can apply the rate of change of both absolute and relative values, which is very important when evaluating the effectiveness of a company.

4) The number of indicators should not expand as much as possible, since with an increase in the number of indicators, the informational validity of the dynamic standard method first increases, and then begins to decline.

5) The possibility of evaluating the effectiveness of management activities through one integral indicator, which can be included in the motivation programs for management personnel.

6) Deviations of the normative rank from the actual one make it possible to identify bottlenecks in the company's activities, take the right tactical steps and change the operating plans for the next period.

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