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THE NEW MODEL OF ECONOMIC GROWTH - AN OBJECTIVE REQUIREMENT FOR A PROSPERING BUSINESS

This paper substantiates the need for a transition to a new model of economic growth, determined by the levels reached by technology and science, by the challenges and objectives of social development, which necessitate the introduction of an attractive growth-generating policy at macro- and microlevels, corresponding to the abovementioned model.
The essential features of the post-industrial growth model are given, namely, competitive, sustained, manageable, continuous, intensive (resource- and cost-efficient) and effective (profitable).
A set of methodological tools is offered, including a set of indices indicating the type and nature of growth or decline of the industrial enterprise at microlevel, which would provide the opportunity for a better management of its economic development.
Some models and methods are given, meant to optimize the resources reserve, their allocation and utilization with regard to their importance in order to increase the effectiveness of the capital involved and to make production less resource- and capital-intensive.

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Economic growth and economic efficiency of production are the basis of economic growth in society. Scarce resources and the constant growth in human needs require the search for the most efficient option in using resources, so that wealth is able to grow and social needs are satisfied more fully and effectively.

On the one hand there exist very close connections and interdependence between economic growth at macro- and microlevel, on the other, there are also substantial differences as regards their nature, objectives, measurement, factors and conditions, development stages, etc. At macrolevel growth should be the object of a purposeful state policy, where the state through the 'invisible hand' creates the prerequisites for its realization. At microlevel it's an internal problem for the managers and owners, it depends most of all on their internal means and objectives, it is accomplished in an individual and unique way for each particular company, at a certain rate, there are stages of evolutionary growth, decline and stagnation, it is determined by the level of 'management services' and the increase in their quality over time, by the motivation and interaction between the interests of the various groups within the company as well as outside it and so on.

This paper seeks to identify the most important characteristic features of the new model of economic growth, which is to be affirmed as the standard at macro- and microlevel; to offer adequate indices for the estimation of the type of growth in respective economic units and to suggest the trends towards further development of company management as a major factor in the realization of the benchmark type of economic growth.

1. Models and objectives of social development at the threshold and the challenges of the new millenium

The industrial model of economic growth, which was established during the first half of the XIXth century as a result of manual labour being replaced with machines on the basis of the classical type of industrial production, has exhausted its potential. It is characterized by wasteful exploitation of natural resources, destruction and pollution of the environment, mass production, based on key technologies, insufficient levels of productivity and quality of the manufactured goods, and a highly resource-, energy-, material- and labour-intensive production. During the last few decades of the XIXth century and the beginning of the XXI century, the science and technical revolution has turned into a technological revolution, there has been a transition from the classical type of industrial production to a new type of automated and intelligent production, the core of which is the symbiosis of industrial technologies and electronics. The rapid growth of electronics, mechatronics and biotics, of the information and telecommunication technologies and their integration, of vanguard technologies and structures, intelligent types of production, effective production processes, of design (planning), production and control, and of the highly effective processes of organization, control and development of human resources, create the prerequisites for the transition to the new post-industrial model of economic development, adequate to the new objectives of social development.

During the last few decades there have also been major changes in the international environment, characterized as market globalization, trade liberalization on a global scale, further rise in competition among companies, based in different countries, spread of economic unions, the rising importance of competitive advantages of a higher rank, such as the potential of developing and implementing production of a high-tech nature, which also contains a larger intellectual component.

During the new century there are also essential changes concerning the aims of social development, of the so-called "new economy", the centre of which is the human factor, the role of creativity is heightened and defined as crucial to economic prosperity, as well as that of the innovative approach to human resources, capital and tangible assets, of knowledge, education and management of change. As regards the individual, the main goal of social development is to better cater for and satisfy the needs of people for high-quality and more accessible goods and services, to solve the issues of unemployment, raise the quality of life and healthcare, to preserve ecosystems etc.

The new challenges and aims of social development during the new century call for an active policy at macro- and microlevel in order to increase the competitiveness of the national economy, of the various sectors and firms with regard to the relations and interaction between them, in order to increase their economic potential and generate growth, adequate to the new model.

2. Connections between the growth at macro- and microlevel, types of economic growth and characteristics of the new post-industrial model

Economic growth is a complex socio-economic category. It is one of the most important stages of the economic cycle together with the stages of crisis (recession), depression (stagnation) and expansion (recovery), since it is fundamental to economic development. It is an important category of the process of reproduction, as it is not only the effect, but also a major cause of its increase. It is the result of certain laws governing the interaction between production, distribution and consumption of the final product.

Economic growth is a natural and objective process, as it is aimed not only at raising the quality of life of the members of society, but also at raising the effectiveness of the functioning of economy. At the same time it is the result of a purposeful and subjective human activity.

There exists a very close and reciprocal interrelation between the growth of an economy as a whole and that of its constituent elements. That is why growth should be treated as a complex and many-sided process, carried out in unity of the common and particular, of the whole economy and its elements, having in mind the multitude of inner relations and outer influence.

The growth of the economy as a whole is a much wider and more global process, which depends on macroeconomic factors, resources and potentials, state and foreign investment, the growth in export potential and the participation of the country in the international division of labour, the political, economic, social and technological environment. In case of a favourable industrial policy we should boost the competitiveness of the national economy, which depends on factors, such as level of state government, how efficient the functioning of the various institutions is, also that of the financial system; openness of the economy, infrastructure, level of technology, human resources, etc.

The growth of the economy as a whole is unthinkable without parallel growth of the companies, functioning in it. Quantitative and qualitative changes in company resources, potential and results multiply in the respective quantitative and qualitative changes in the whole economy. On the other hand, a growing economy creates the material prerequisites for enterprises, employees and consumers to be innovative, effective and successful in their work, thus contributing to a sustained growth and efficient employment, to better living and working conditions, to the achievement of the basic economic and social aims of society.

In addition, economic growth in individual companies is characterized by a number of features, stemming from its being considered at microlevel. In a separate economic unit it can be viewed as a complex of processes of transforming resources of material production, as a result of which the volume and the quality of manufactured goods and services rises. Resources and results are connected into a whole, there is the process of transforming the former into the

latter, and their relationship is a criterion of production efficiency and helps reveal the nature of economic growth.

The following are typical of growth at microlevel:

- it manifests itself individually, while with the economy as a whole it is identified on the basis of the law of global effect;
- companies manage their development on their own, despite the fact that the macroenvironment may have a positive or negative effect on it;
- each company may feature stages of stability and evolutionary growth as well as instability, developmental crises, depression and stagnation;
- each company is at a different stage of its development, and features a different level of development of personal and company potential, a different level of competitiveness, which entails various approaches and strategies for the accomplishment of change and economic growth;
- there is no limit as to the size of the company and the continuity of its economic growth, however, there is a limit to the scale and rate of the growth, which is different and unique for each company and depends on its inner means and limitations.

That is why the main reason, major factor and resource for economic growth at microlevel is the quality of management. The latter determines the quality of the human factor, the technical and technological level of production, the quality of the goods and services offered and ultimately the efficiency with which scarce resources are combined and utilized.

Various publications offer a multitude of different classifications of the type of growth at macro- and microlevel. Despite their cognitive value, from the point of view of the importance of growth and the possibility to precisely identify its type as well as the decrease in company activity, at microlevel for us most important are classifications according to the role of the factor (the relation "result - resources(cost) - effectiveness" and according to the added value (wealth) - (the relation "growth - effectiveness").

In companies and their divisions there can be alternating stages of growth and recession, stability and instability, something which is the result of the turbulent character of the environment and the probabilistic nature of predicting changes in it, in other words, the result of the risk typical of the environment and the management potential.

The types of economic growth and decline according to the role of the factors can be differentiated into the following groups and subgroups:

A. TYPES OF ECONOMIC GROWTH
  I. Extensive
    1.1. Fully extensive:
      a) at a constant level of the intensive factor;
      b) at a falling intensive factor or de-intensive growth.
    1.2. Predominantly extensive or extensive-intensive

II. Intensive:
2.1. Predominantly intensive or intensive-extensive
2.2. Fully intensive:
a) at a constant level of the extensive factor;
b) at a falling extensive factor or de-extensive growth.

B. TYPES OF ECONOMIC DECLINE
I. Extensive
1.1. Fully extensive:
a) at a constant level of the intensive factor;
b) at a rising intensive factor or de-intensive growth.
1.2. Predominantly extensive or extensive-intensive
II. Intensive:
2.1. Predominantly intensive or intensive-extensive
2.2. Fully intensive:
a) at a constant level of the extensive factor;
b) at a rising extensive factor or de-extensive decline.

C. NEUTRAL DEVELOPMENT - at constant levels of the extensive and intensive factors.

The above classification features the following major advantages:

- it allows for the measurement and estimation not only of economic growth, but also economic decline in company activities;
- it identifies the role of the extensive and intensive factors, which influence the growth or decline, thus revealing the type and nature of company development;
- de-intensive growth, treated elsewhere as an independent group, is in fact a variety and is included in the above classification.

The second very important classification of the types of economic growth or decline is according to the added value (wealth). It lets us estimate the effectiveness of the growth or decline, through differentiating between:

- effective or profitable growth or decline - growth is accompanied by a positive and increasing efficiency of the economic activity;
- ineffective or unprofitable growth or decline - growth is accompanied by a negative or decreasing efficiency, that is, it is carried out on the expense of efficiency, which falls below a certain minimum level.
- neutral growth or decline - company activity is inefficient, capital (wealth) remains constant

On the basis of the major classifications of economic growth, given above, as well as the new aims of social development there can be formulated the main characteristics of the new, post-industrial model of economic development being adopted by mankind at the end of the XXth and the beginning of the XXIst century, namely the model of sustained, competitive, manageable, continuous, intensive and efficient (profitable) economic growth.

Sustained growth or sustained development is gradually becoming the main goal of human civilization. That kind of growth denotes and requires the interaction between man and nature to be carried out in a way, which would allow for the preservation of nature so that it is saved for the future generations. In this highly industrialized century, and even more so in the next one, preservation of nature and the environment will be a major issue concerning the existence of mankind. That is why each organization is facing the issue of improved utilization of natural resources, reducing waste output, putting an end to harmful emissions into the air and water, limiting the negative effect on the health of the workforce, producing pollution-free products, increasing compliance with the ever-growing requirements of regulation and legislation concerning the environment.

There are many prerequisites and reasons why we need to make a transition towards a model of sustained growth, but they generally fall into two groups, namely, economic and controlling (technical). Because of this each company has to deal with the issue how to increase effectiveness while preserving the environment and thus reduce ecological and economic risk it is faced with on the one hand, and to keep and even increase its level of competitiveness in the existing economic conditions, on the other. Dealing with the issues concerning the environment in every organization is viewed from an economic standpoint and is based on the very considerations, criteria and indices that are valid for any other kind of investment - increasing profitability and reducing the risk involved in its activities.

The transition to a policy of sustained growth will provide companies with the opportunity to produce both direct and indirect economic, social and ecological effect, since they would be able to respond better to customer needs, to assume more favorable positions on the domestic and international markets, to boost their image and gain a competitive edge of a higher level.

The more important direct results are of a financial, marketing and legal nature and are connected with the following: reducing costs of input raw material, fuel, electric power, water; waste disposal and treatment; reduced expenditure due to not having to pay any punitive fees for failure to comply with harmful emissions regulations any more; freer access to bank loans; increased competitiveness on international markets; market expansion (the range effect) due to greater efficiency and higher quality of production; compliance with respective legislation and regulations; anticipatory response to future changes in legislation and its harmonization with that of the EC; reducing the risk of accidents and failures, preventing liabilities for past ecological damage etc. The more important indirect results are connected with reducing illnesses among employees, increased motivation as a result of better working conditions, management efficiency, company's goodwill etc.

Another very important characteristic of the new model is that it has to be competitive. Economic growth both at macro- and microlevel is impossible if companies do not carry out a policy of achieving long-term competitiveness. The

new aspect here is achieving competitiveness not only of the individual goods and services but of the whole organization, since this is the only way for it to gain a better image and acquire a better position on international markets. Increasing domestic competitiveness requires the identification of the key factors to success, complex and harmonious development and advancement of all management functions and especially that of innovation, increasing the level of strategic planning, harmonizing the functions of organizing, directing and controlling with the company's strategy etc.

Competitive companies will play a crucial role in achieving sustained growth, because they will be able to satisfy the tastes and preferences of consumers better and faster through the production of goods and services at affordable prices accompanied by rising efficiency and return on investment, that will be achieved through:

- decreasing resource consumption (materials, energy, water, etc.) in product manufacture while increasing their use value and shortening their life-cycle;
- raising the quality in the added value chain and at the same time satisfying customers at the lowest possible cost;
- creating and using vanguard and innovative designs, products and technologies, which raise the effectiveness of all production processes and lead to a better environmental safety and cleanliness;
- reclaiming products and recycling waste in order to solve the problem of accumulated waste output, its processing, reuse and safe disposal;
- implementing an integrated A-to-Z approach to the concept of production from raw material extraction to the utilization of the final product;
- using more effective methods of organizing production and labour, services, logistics, which would lead to decreased prime cost and shortened market realization period;
- shortening the times for implementing innovations and increasing their effectiveness and return on investment;
- combining the effect of better production capabilities and the development and implementation of innovations;
- achieving a more rational utilization of human resources through increased motivation, training, creativity and quality on the job;
- instituting more flexible ways of market satisfaction in real time through integrating the cycle "product - service" etc.

An important feature of the new model of growth is that it is (fully or predominantly) intensive growth. Implementing this model will save resources and costs as a result of their better use and more efficient utilization in the production of goods and services (with a greater added value). That is why the nature of the growth implies quality, it is resource- and cost-efficient. Depending on the kind of economized resource it can be classified as raw material-,

material-, energy-, capital- or labour-efficient economic growth. Having in mind the scarcity of resources and the need to cut expenses and achieve low-cost production it is the most suitable for the economic development of every economic unit.

The extensive or predominantly extensive type of economic growth is characterized as highly and increasingly resource- and capital-intensive, because of which it has exhausted its potential and is an ineffective or less effective type of economic development.

The new model of growth has to be efficient or profitable. Growth and effectiveness are usually inversely proportional or competing concepts - the rise in effectiveness entails a reduced growth rate and vice versa. The art of management consists in finding the right measure or proportion which would yield growth both in turnover (sales) and effectiveness. In order to measure the latter there may be used not only traditional but also new, modern criteria and indices which will be dealt with below. Efficient or profitable growth is the kind of growth which brings about a positive and increasing resource- and cost-effectiveness, that is, the return on resources and investment is growing and production is becoming less resource- and capital-intensive. That is the only type of growth that can ensure high and increasing competitiveness in the long run, since it can provide the financial resources needed for the increase in the long-term viability of the organization.

Of major importance for the new model of economic growth is that it has to be manageable and continuous. Those features stem from the new principles and formulations of the modern theory of company growth, according to which there is no limit to the size of the company or to the continuity of its economic growth, the only limitation concerns the scale and rate of the growth, which is different and unique for each company and depends on its inner potential and limitations. Diversification, mergers and take-overs are modern forms of competitive, continuous and manageable growth, and the prerequisites for that are market globalization and the internationalization of world economy. Management is a prerequisite for a continuous and harmonious growth because each company achieves growth at a rate it can afford, led by the principle of "subjective rational behaviour". Uncontrolled and unmanageable growth may expose the company to financial and other risks with grave consequences. The formula of controlled growth requires the short- and long-term balancing of the cash flows so that the necessary conditions for self-financed growth and the achievement of financial stability and independence are set. That is why a major factor in achieving economic growth is management quality.

3. On the measurement of company economic growth - agreement and interaction between traditional and new criteria and indices

Economic growth is viewed as quantitative and qualitative changes in the main resources of production and its results. In the broadest sense at macrolevel it shows the growth in national production in terms of its result. In terms of materials it is expressed as the output growth of goods and services satisfying final demand, in terms of value at macrolevel - it is given as the increase in value of the gross and net domestic product, measured through the indices of growth rate, growth ratio and average rate change. In order to compare data with that of other countries, the indices of one employee or one individual and their dynamics are used. The global approach, however, often leads to incomes being taken into account twice, which makes them less acceptable for the precise measurement of growth.

In order for the growth to be measured at microlevel there are offered various criteria and indices but there is no officially adopted system as yet. A number of authors believe that we should distinguish between qualitative and quantitative measurement of growth. The adoption of a highly detailed system of indices at company level would hamper a fast, precise, adequate and unambiguous estimation of a company's economic growth. That is why widespread support has been gained by the use of indices analogous to those at macrolevel, such as growth in turnover (total revenues), sales (gross and net), profit, market share etc., measured through growth rate, growth ratio and average rate change.

We believe measuring economic growth at microlevel only through indices related to the results of economic activity is highly insufficient. Through the use of that kind of indices only it is impossible to characterize the change in wealth (capital), which, in a market economy is expressed not only in the balance worth but also in the market worth of the company's assets. What is more, through those indices we can not measure and characterize the type of growth in terms of resource utilization and added value. The indices of company growth used and applied in practice are inadequate and do not correspond to the new principles and requirements of the modern theory of company growth and the new criteria meant to characterize the post-industrial model of economic growth.

In view of the above it is necessary to develop a set of tools to measure and estimate economic growth or decline of companies, which will be dealt with below.

In order to measure and evaluate in detail the dynamics, type and nature of growth or decline in companies, there can be used two major approaches, which make use of the following:

1. The traditional system of indices and correlations aimed at measuring and estimating economic growth.

2. A new, modernized system of indices aimed at measuring economic growth, based on the modern theory of company growth.

With each of those two approaches, indices may be grouped in the following manner:

1. Indices characterizing the dynamics of growth or decline of company activity, which, in turn, are subdivided into:

- those characterizing the dynamics of results (sales, added value, profit etc.)
- those characterizing the dynamics of capital (size, company wealth) - the change in balance value and market value of the company

2. Indices characterizing the type and character of growth:

- indicating the type of growth in terms of factors, determining it - the relation "result - resources (cost) - effectiveness";
- indicating the type of growth in terms of added value (the relation growth - effectiveness).

With the first approach the indices in group one provide information on the dynamics of turnover growth and company size, and those in group two help identify the reasons influencing growth and the level of its effectiveness.

In order to measure and estimate the dynamics of growth or decline of companies, the following indices can be used:

1. Absolute variation of the company activity result for the given period (sales, added value, net profit etc.).

$$\Delta R_t = \Delta R_{t1} - \Delta R_{t0},$$

where R_{t0}, R_{t1} are the values of the base and accounting period.

2. Index (percentage) of change and increase of the company activity result for the period

$$IR_t = \frac{R_{t_1}}{R_{t_0}}$$

$$\Delta IR_t = \frac{R_{t_1} - R_{t_0}}{R_{t_0}} = \frac{R_{t_1}}{R_{t_0}} - 1.$$

3. Average rate of change of the result for the period:

a) arithmetic mean rate of change and increase in result:

$$IR_{t_{arithm.m.}} = \frac{\sum IR_t}{n} = \frac{IR_{t_1} + IR_{t_2} + IR_{t_3} + \ldots\ldots\ldots + IR_{t_n}}{n},$$

where n is the number of years of the period

$$\Delta IR_{t\,arithm.m.} = \frac{\Delta IR_t}{n}$$

b) geometric mean rate of change in result

$$IR_{t\,geom.m.} = \sqrt[n]{IR_{t_1} IR_{t_2} IR_{t_3} .....IR_{t_n}},$$

where n is the number of increases for the period - (n-1) years.

Of the above indices the geometric mean rate is the most precise in characterizing the result growth rate for the long term.

In order to measure the change in capital (wealth) and the size of the company we propose the following indices:

1. Change in the balance value of capital for the period (BV). It is measured as the result of realized balance profit or loss for the period.

In cases where dividends are paid out, it is differentiated into balance profit after payment of dividends (Ea) and dividend payments (D):

$$BV_1 = BV_0 + E_a - D$$

$$\Delta BV(E_a) = (BV_1 - BV_0) + D$$

$$IBV_{1/0} = \frac{BV_1}{BV_0};\ \Delta IBV_{1/0} = \frac{BV_1 - BV_0}{BV_0}$$

$$IBV_{geom.m.} = \sqrt[n]{IBV_1 \times IBV_2 \times IBV_3 \times .....IBV_n}.$$

The indices given above characterize the change in balance value of the company due to the change in balance profit or loss.

2. Change in capital market value (MV). Realized through the change in economic earnings (Ee)[1] for the period as a result of the change in the market value of the company's shares.

$$MV_1 = MV_0 + E_e - D$$

$$\Delta MV(E_e) = (MV_1 - MV_0) + D$$

$$IMV_{1/0} = \frac{MV_1}{MV_0};\ \Delta IMV_{1/0} = \frac{MV_1 - MV_0}{MV_0}$$

$$IMV_{geom.m.} = \sqrt[n]{IMV_1 \times IMV_2 \times IMV_3 \times .....IMV_n}$$

The indices given above characterize the change in market value of company capital for the period as a result of change in economic profit.

[1] Economic profit is an expression of the change in economic value of the company, set as a change in market value of its ordinary shares.

The dynamics of market value and especially that of the market value/balance value ratio is a very important modern index for the estimation of the business and its growth.

In order to measure and estimate the type and nature of growth and decline using the traditional system of indices and correlations the relation "result - resources (cost) - effectiveness" can be used.

The models revealing those relations are as follows:

$$R_t = R_s \times ROI$$

$$IR_t = IR_s \times IROI$$

$$R_t = TC \times R_{tc}$$

$IR_t = ITC \times IR_{tc}$, where:

R_t, IR_t - result and index of the change in the result of economic activity (earnings, sales, added value, coverable contributions, net profit);

R_s, IR_s - resources (assets, capital) and index of their change

TC, ITC - expenditure (total expenditure or expenditure on a particular activity) and index of their change

ROI, $IROI$ - resource effectiveness and index of effectiveness change;

R_{tc}, IR_{tc} - cost-effectiveness and index of change.

A generalized estimation of the type of growth or decline through the use of the traditional system of indices and their correlations, as well as the direction of their change, is given in Tables 1 and 2.

According to the rates and direction of change of the indexes and correlations in the tables there can be identified and made an estimation of the type of growth or decline with regard to the role and aggregate effect of the major factors of production or the total costs incurred in economic activity.

In addition, there can be made an estimation of the type and nature of growth or decline in terms of added value, whereby it is characterized as effective (profitable), ineffective (unprofitable) or neutral - without any effect on the value. In order to make such an estimation it is possible to use two approaches:

a) The first is characterized as more strict towards effectiveness, the latter being estimated as positive or negative, that is, which of the following three situations is present:

$$ROI > / = / < 0$$

$$R_{tc} > / = / < 0 .$$

Table 1

Generalized estimation of the type of economic growth or decline on the basis of using resource indices in companies

Types of economic growth or decline	Direction of index change and outstrips	Correlations between indices change	Conditions
Estimation through the use of resource indices I. Types of growth 1. Extensive (resource-intensive) 1.1. Fully extensive			
a) at a constant level of the intensive factor	$IRt\uparrow, IRs\uparrow, IROI\rightarrow$	$IRt = IRs$	$IROI_{=1}, IRt, IRs_{>1}$
b) at a falling intensive factor (de-intensive growth)	$IRt\uparrow, IRs\uparrow\uparrow, IROI\downarrow$	$IRt < IRs > IROI$	$IROI_{<1}, IRt, IRs_{>1}$
1.2. Predominantly extensive (extensive-intensive)	$IRt\uparrow\uparrow\uparrow, IRs\uparrow\uparrow, IROI\uparrow$	$IRt > IRs > IROI$	$IRt, IRs, IROI_{>1}$
2. Intensive (resource-effective)			
2.1. Predominantly intensive (intensive-extensive)	$IRt\uparrow\uparrow\uparrow, IRs\uparrow, IROI\uparrow\uparrow$	$IRt > IRs < IROI$	$IRt, IRs, IROI_{>1}$
2.2. Fully intensive			
a) at a constant level of the extensive factor	$IRt\uparrow, IRs\rightarrow, IROI\uparrow$	$IRt = IROI$	$IRs_{=1}, IRt, IROI_{>1}$
b) at a falling extensive factor (de-extensive growth)	$IRt\uparrow\uparrow, IRs\downarrow, IROI\uparrow\uparrow\uparrow$	$IRt > IRs < IROI$	$IRt, IROI_{>1} IRs_{<1}$
II. Types of decline 1. Extensive (resource-intensive)			
1.1. Fully extensive			
a) at a constant level of the extensive factor	$IRt\downarrow, IRs\downarrow, IROI\rightarrow$	$IRt = IRs$	$IROI_{=1}, IRt, IRs_{<1}$
b) at a rising intensive factor (de-intensive decline)	$IRt\downarrow, IRs\downarrow\downarrow, IROI\uparrow$	$IRt > IRs < IROI$	$IROI_{>1}, IRt, IRs_{<1}$
1.2. Predominantly extensive (extensive-intensive decline)	$IRt\downarrow\downarrow\downarrow, IRs\downarrow\downarrow, IROI\downarrow$	$IRt < IRs < IROI$	$IRt, IRs, IROI_{<1}$
2. Intensive decline (resource-efficient)			
2.1. Predominantly intensive (intensive-extensive decline)	$IRt\downarrow\downarrow\downarrow, IRs\downarrow, IROI\downarrow\downarrow$	$IRt < IRs > IROI$	$IRt, IRs, IROI_{<1}$
2.2. Fully intensive			
a) at a constant level of the extensive factor	$IRt\downarrow, IRs\rightarrow, IROI\downarrow$	$IRt = IROI$	$IRs_{=1}, IRt, IROI_{<1}$
b) at a rising extensive factor (de-extensive decline)	$IRt\downarrow\downarrow, IRs\uparrow, IROI\downarrow\downarrow\downarrow$	$IRt < IRs > IROI$	$IRs_{>1}, IRt, IROI_{<1}$
III. Neutral development (stagnation, standstill) (resource-neutral)	$IRt\rightarrow, IRs\rightarrow, IROI\rightarrow$	$IRt = IRs = IROI$	$IRt, IRs, IROI_{=1}$

Table2

Generalized estimation of the type of economic growth or decline on the basis of using expenditure indices in companies

Types of economic growth or decline	Direction of index change and outstrips	Correlations between indices change	Conditions	Measurement of growth effectiveness	
				At R>/=/<0	At R>/=/Rf
Estimation through the use of expenditure indices I. Types of growth 1. Extensive (resource-intensive) 1.1. Fully extensive					
a) at a constant level of the intensive factor	$IR_t \uparrow$, $IT_C \uparrow$, $IR_{TC} \rightarrow$	$IR_t = IT_C$	IR_{TC} =1, IR_t, IT_C >1	R^n_{TC} >0 profitable R^n_{TC} =0 neutral R^n_{TC} <0 unprofitable	R_{TC} >Rf profitable R_{TC} =Rf neutral
b) at a falling intensive factor (de-intensive growth)	$IR_t \uparrow$, $IT_C \uparrow \uparrow$, $IR_{TC} \downarrow$	$IR_t < IT_C > IR_{TC}$	IR_{TC} <1, IR_t, IT_C >1		
1.2. Predominantly extensive (extensive-intensive)	$IR_t \uparrow \uparrow \uparrow$, $IT_C \uparrow \uparrow$, $IR_{TC} \uparrow$	$IR_t > IT_C > IR_{TC}$	IR_t, IT_C, IR_{TC} >1		
2. Intensive growth (cost-effective, cost-saving)					
2.1. Predominantly intensive (intensive-extensive)	$IR_t \uparrow \uparrow \uparrow$, $IT_C \uparrow$, $IR_{TC} \uparrow \uparrow$	$IR_t > IT_C < IR_{TC}$	IR_t, IT_C, IR_{TC} >1		
2.2. Fully intensive					
a) at a constant level of the extensive factor	$IR_t \uparrow$, $IT_C \rightarrow$, $IR_{TC} \uparrow$	$IR_t = IR_{TC}$	IT_C =1, IR_t, IR_{TC} >1		
b) at a falling extensive factor (de-extensive growth)	$IR_t \uparrow \uparrow$, $IT_C \downarrow$, $IR_{TC} \uparrow \uparrow \uparrow$	$IR_t > IT_C < IR_{TC}$	IR_t, IR_{TC} >1, IT_C <1		
II. Types of decline 1. Extensive (cost-intensive, costly)					
1.1. Fully extensive					
a) at a constant level of the extensive factor	$IR_t \downarrow$, $IT_C \downarrow$, $IR_{TC} \rightarrow$	$IR_t = IT_C$	IR_{TC} =1, IR_t, IT_C <1		
b) at a growing intensive factor	$IR_t \downarrow$, $IT_C \downarrow \downarrow$, $IR_{TC} \uparrow$	$IR_t > IT_C < IR_{TC}$	IR_{TC} >1, IR_t, IT_C <1		
1.2. Predominantly extensive (extensive-intensive)	$IR_t \downarrow \downarrow \downarrow$, $IT_C \downarrow \downarrow$, $IR_{TC} \downarrow$	$IR_t < IT_C < IR_{TC}$	IR_t, IT_C, IR_{TC} <1		
2. Intensive (cost-effective, cost-saving decline)					
2.1. Predominantly intensive (intensive-extensive)	$IR_t \downarrow \downarrow \downarrow$, $IT_C \downarrow$, $IR_{TC} \downarrow \downarrow$	$IR_t < IR_s > IR_{TC}$	IR_t, IT_C, IR_{TC} <1		
2.2. Fully intensive decline					
a) at a constant level of the extensive factor	$IR_t \downarrow$, $IT_C \rightarrow$, $IR_{TC} \downarrow$	$IR_t = IR_{TC}$	IT_C =1, IR_t, IR_{TC} <1		
b) at a growing extensive factor (de-extensive decline)	$IR_t \downarrow \downarrow$, $IT_C \uparrow$, $IR_{TC} \downarrow \downarrow \downarrow$	$IR_t < IT_C > IR_{TC}$	IT_C >1, IR_t, IR_{TC} <1		
III. Neutral development (stagnation, standstill) (cost-neutral)	$IR_t \rightarrow$, $IT_C \rightarrow$, $IR_{TC} \rightarrow$	$IR_t = IT_C = IR_{TC}$	IR_t, IT_C, IR_{TC} =1		

When the resource- or cost-effectiveness (return) is greater than 0, that is, it is a positive quantity, the growth or decline is estimated as effective or profitable; if it is a negative quantity - as unprofitable or ineffective, and if it equals 0 - as neutral as related to cost.

b) The second approach is characterized as more strict towards the level of resource- and cost-effectiveness. As a benchmark it takes the risk-free rate of return (R), which measures the effectiveness of the base alternative option, namely investing money (capital) in risk-free investments such as state securities, state bonds etc.

ROI >/=/< R_f

R_{TC} >/=/< R_f

With this approach, if the resource and cost rate of return is higher than the risk-free rate of return, growth or decline is estimated as effective, if it is lower - as ineffective, and if they are equal - as neutral.

In order to reveal the causes of growth and decline and the role of the main factors of production, estimation of the type of growth or decline can be made with regard to each individual factor. For this purpose an analogous system of indices and correlations can be used, built on the basis of the multiplication connections and correlations, that exist between the result of economic activity, the quantity of the invested resource or the production cost and the level of its effectiveness.

With the second approach we propose the use of a new system of criteria and indices for the estimation of effectiveness and growth in companies, namely:

1. Added economic value or return on investment (ROE). It is calculated as a difference between the return on owner's equity (ΔROE) and the risk-free rate of return (R_f), which expresses the rate of return of risk-free investment - state securities:

$$\Delta ROE = ROE - R_f .$$

The index serves to estimate the economic value of growth. Three cases are possible:

$ROE > R_f$, or ROE (+)- profitable return

$ROE = R_f$, or ROE (0)- neutral return

$ROE < R_f$, or ROE (-)- unprofitable return

The return on investment index would be:

$$IROI = \frac{ROE}{R_f} .$$

The higher the quantities of the return and the return index, the higher the economic value of growth and vice versa. The growth of those two should be ensured in long-term perspective.

Analysis shows that the use of the above criterion sets new, higher effectiveness requirements to company activity, because up to now it has been common to assume that as long as the return on owner's equity is a positive quantity, it is a good enough reason to assess the company's effectiveness as positive.

The use of the new criterion sets a new benchmark level to the company. It means that company effectiveness should be higher, or at least equal to that of the base alternative option - investing money in a bank.

The effort to achieve and assure a higher return on investment should not and can not be an end in itself, moreover it should not be a tactical, but rather a strategic requirement, since growth and effectiveness are inversely proportionate. That is why it is necessary to use this criterion in direct connection and relation to the others.

2. Added market value (ΔFMV) or the correlation market/balance value of capital. It is calculated as the difference between the fair market value (FMV)[2] of the capital and its balance value (BV) for a given period:

$$\Delta FMV = FMV - BV .$$

The added market value index would be:

$$IFMV = \frac{FMV}{BV} .$$

The index serves to estimate the market value of growth. Three cases are possible:

$FMV > BV$ or FMV / BV >1- profitable market value
$FMV = BV$ or FMV / BV =0- neutral market value
$FMV < BV$ or FMV / BV <1- unprofitable market value

The greater the correlation market/balance value FMV / BV than 1, the higher the price of shares and return on investment, the less risky the business and vice versa. The growth of the market value should also be ensured in long-term perspective.

The use of the above criterion also sets new and much higher requirements to company management. Managers are required to adopt a new attitude towards company activity, the real assets of the company (tangible assets) and its image (intangible assets). Growth and its financing are impossible, if the market value of the company is not growing at a greater rate than that of its balance value.

[2] Fair market value is the sum in exchange for which a certain piece of property will change owners, moving from the seller to the buyer, provided they do it on their own free will without any pressure being exercised upon them, and they are well aware of all relevant facts - SBO Standard, Issue 1, 1994.

3. Net current (present) value of future cash flow (earnings) (NPV). It is calculated as the difference between the discounted net cash flow and the discounted investment for a given period:

$$NPV = \sum DCF - \sum DI .$$

The index serves to estimate economic expediency (effectiveness) of investment and innovation projects. Effective growth is impossible if there is no return assured for each investment, related to each individual project and all projects in a given period. Realizing net current value means assuring a positive net cash flow, exceeding investment expenditure for the period.

Such a cash flow has to be achieved at every stage of company development, which requires of company management the balancing of both short-term and long-term investment projects. The latter would also ensure the resource for self-financing the company growth.

The earnings and investment cost cash flow index would be:

$$INPV = \frac{\sum DCF}{\sum DI} .$$

The higher the index, the higher the net current value, that is, the net effectiveness of company development.

Three cases are possible concerning the net current value (or the net cash flow):

$NPV > 0$ or $\sum DCF - \sum DI$ (+) - profitable flows

$NPV = 0$ or $\sum DCF - \sum DI$ (0) - neutral flows

$NPV < 0$ or $\sum DCF - \sum DI$ (-) - unprofitable flows

The goal of company management should be the realization of sufficient amount of net cash flow, which can be used to expand company activities.

The use of the above criterion shows that the need for long-term growth and returns should prevail over the momentary impulse to make quick profit.

4. Market growth or company growth (Δg). Can be calculated as the difference between the company sales growth (g) and that of the whole market (G):

Δg = g-G.

Three cases are possible:

g > G or Δg (+)- profitable market share

g = G or Δg (0)- neutral market share

g < G or Δg (-)- unprofitable market share

The market share index can be:

$$I_g = \frac{g}{G}.$$

The higher the market share index, the higher the rate at which company sales outgrow total market sales. The connection of this index to the previous ones can be explained as follows: company growth should influence added economic and market value, as well as the net current value and vice versa - the growth of those indices should influence the growth of company market share.

The art of management consists in finding the right correlation between those.

With regard to financing, growth can be measured not only using the above method, but also using the following formula:

$g = p \times ROE$

or

$$g = \frac{\pi_{REINV.}}{\pi_{NET}} \times \frac{\pi_{NET}}{\text{owners' eq.}} \times \frac{\pi_{REINV.}}{\text{owners' eq.}},$$

where:

p is the profit reinvestment coefficient;

g - the financially stable growth rate

$\pi_{REINV.}$ - reinvested profit

π_{NET} - net profit

owners' eq. - owners' equity.

The joint use of the new system of criteria and indices provides the possibility to relate growth to company effectiveness both in short- and long term perspective, and also reveal the possible cases of company development (Table 3).

Table 3

Company development case description

	Type of growth		
Criterion	Profitable	Neutral	Unprofitable
1. Return on investment (added economic value ΔROE)	+	0	-
2. Market/balance capital value (added market value ΔFMV)	>1	1	<1
3. Net current value (NPV)	+	0	-
Added value	Growth adds value	Growth has no effect on value	Growth decreases value

The table makes it clear that positive return on investment, positive added market value (growth in market value), and positive net current value bring about profitable growth or effective company development.

Zero return on investment, zero net current value and no added market value bring about neutral growth or neutral development.

Negative return on investment, negative net current value and negative added market value bring about unprofitable growth, which reduces capital value.

The aim of company management is the first case whereby overall growth is accompanied by growth in economic and market effectiveness (Fig. 1).

Placing the two main growth criteria - return on investment and market value on the coordinates lets us form the four possible combinations:

a) quadrant I - growth accompanied by a positive return on investment and a positive added market value

b) quadrant II - development based on a negative return on investment and a positive added market value

c) quadrant III - development based on a positive return on investment and a negative added market value

d) quadrant IV - development which features a negative return on investment and a negative added market value.

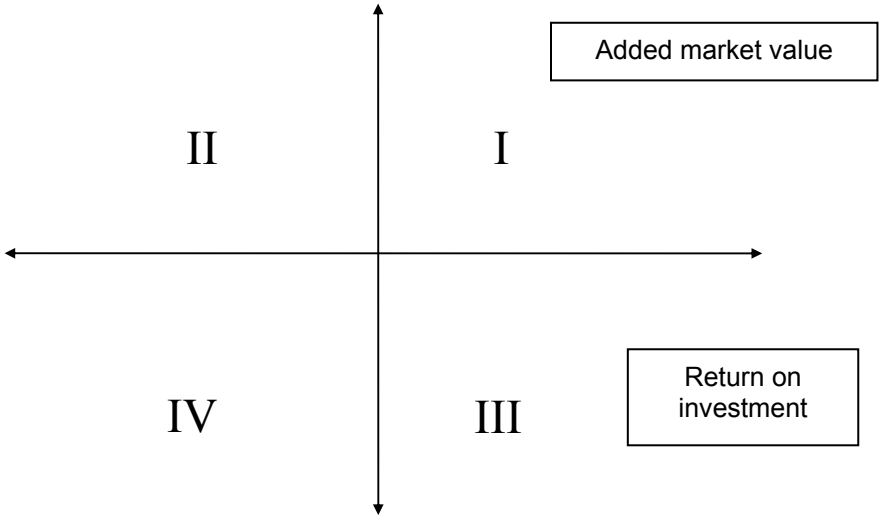

Figure 1. Growth effectiveness estimation

The most suitable model of development is the one in quadrant one, since growth is accompanied by both growth of profitability over the non-risk benchmark and growth of the company's market value. The achievement of that type of growth is testimonial to the high level of company management. The situation in quadrant

four is far from advisable, because as long as growth reduces value, that would also lead to decline and decapitalization of the company and long-term instability.

All possible cases of company development can be deduced with the help of the so-called profitability matrix (MARACON MATRIZ) (Fig. 2).

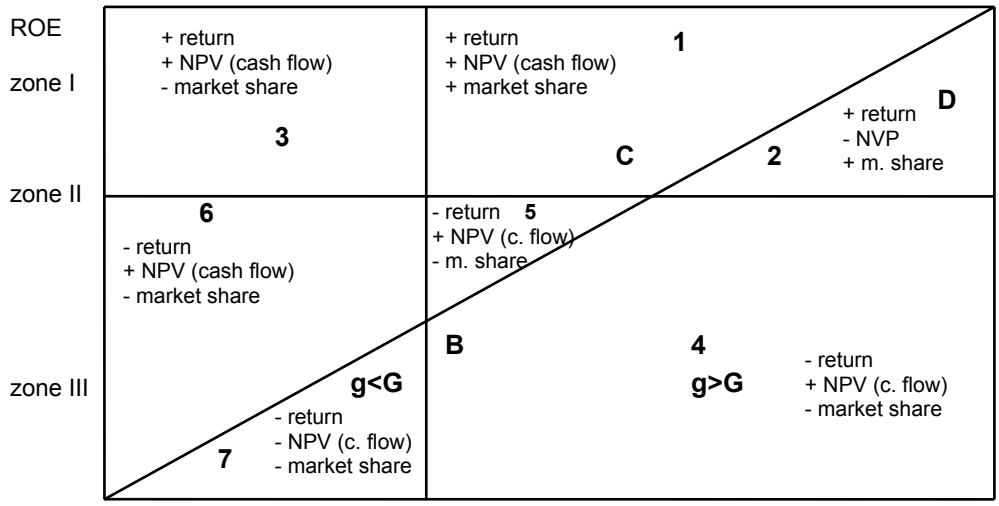

Figure 2. Profitability matrix

Analysis of the matrix leads us to the following main conclusions:

a) the matrix puts together in a system the following criteria: return on investment, net current value and market growth, that is growth of the market share. The lines in it divide it into zones and various situations in each zone;

b) zone I is the one in which the company can realize positive return on investment ($ROI > R_f$). In it the most favourable situation is situation 1, since it is only within this zone that the company achieves profitable growth. In situations 2 and 3 companies will have either a negative net cash flow, or a negative market growth;

c) zone II is formed by all points in line R_f. That is the situation in which the company will have a neutral return on investment and positive or negative market share or cash flow respectively. Point C is the point of a balanced cash flow. In it the return and the cash flow are neutral, and the market growth - profitable;

d) zone III is the zone in which the company will realize a negative return on investment, positive or negative market share and net current value. The most favourable situation here is situation 5, in which there is a negative return, but positive market growth and net current value;

e) all points to the left of the vertical line mean the company's growth is slower than that of the market as a whole, that is, it is losing its market share, all points to the right - it is increasing its market share;

f) all points above the diagonal line mean the company has a positive net current value, all points below that line - a negative net current value. All points in the diagonal line correspond to a balanced (zero) net cash flow

The matrix provides the opportunity to precisely estimate the state of a company for a given period and to set attainable short- and long-term goals.

A generalized appraisal of the changes which have taken place during the period in question can be made through the use of the general index of change concerning the particular criteria and indices discussed above:

$$I_{\text{PROF. GROWTH}} = \text{IROE} \times \text{IFMV} \times \text{INPV} \times I_g$$

The company achieving the highest general index will feature the best level of profitable growth and vice versa. The use of the elimination method (chain substitution or absolute differences) will let us calculate the quantitative effect of each factor over the resultant index, which will supply a general estimation of the level and type of growth.

The use of the traditional criteria and indices is based on methodology and effectiveness indices (resources and costs), as well as the multiplicative connection and interdependence between the result and resources (costs) and their effective utilization. That method allows us not only to determine the type of growth or decline, but also measure the effect of extensive and intensive factors on its change. A major drawback of the system is that indices lack precision as regards the results achieved by the company.

The application of the modern system of criteria and indices sets new standards to company values and introduces the modern European criteria and ideas of company effectiveness and growth, which are fully adequate to the formulation of the modern theory of growth and prevail in the stage of post-industrial development.

4. Minimizing cost and raising the effectiveness of scarce resource utilization - a prerequisite for the resource-effective type of growth

An important area of the transition to the new resource-effective model of economic growth is the effective utilization of scarce material and financial resources.

The optimization of the "supplier - producer - consumer" chain requires the use of contemporary methods and styles in mathematical modelling. That would allow the optimization of costs related to production supplies and the distribution and marketing of the final product to the end-user and the market, taking into account the effect and requirements of the

"timing" factor and the corresponding risk involved regarding the effect of all factors.

Economic and mathematical modelling should be viewed as a tool for analysis and management decision-making concerning particular processes in industrial companies. Economic and mathematical models are descriptions of quantitative correlations and interdependencies between objects in real economic processes made through mathematical means. Arriving at the optimal case in resource utilization means minimizing cost and raising effectiveness, continuously making the choice of how, where, when and what for to use scarce resources, so that we can both increase efficiency and satisfy customer needs.

There is a great variety of economic and mathematical models in the area of effective utilization of material resources, the application of which would lead to increased efficiency of the capital involved and less resource- and material-intensive production.

Of particular importance in the system of models and methods aimed at increasing the effectiveness of material and financial resource utilization are the models for optimizing the resource reserve in the process of their allocation and use.

In most economic and mathematical models for the allocation and utilization of resources, some of the parameters, set of the basis of the initial data, are determined either at a very high level of imprecision, or are of a random nature. Because of this, the optimization of resource allocation and utilization is to be done in conditions of incomplete and undefined information.

There a certain difference between the notions of imprecise parameters and unspecified parameters. Usually parameter values are determined on the basis of some primary (often statistical) information. The latter inevitably lacks full reliability, hence the change in parameter values within a certain range. With many economic problems some parameters are random quantities, the numerical characteristics of which can be arrived at (through mathematical expectancy, dispersion), as can, in some instances, their laws of distribution. The first case can be treated as the second if we assume that the deviations allowed are random quantities, distributed in the possible variation range by a certain hypothesis of the law of distribution. In view of the above we will assume that all imprecisely determined parameters are random quantities which posses definite ranges of possible practical variations.

It is possible to identify two types of problems concerning random parameter resource allocation and utilization. One of them entails temporary indefiniteness at the time when the resource allocation and utilization plan is made. Absolute clarity is possible only when the realization of the plan is begun. This type is associated with the projected plan - forecast, which can be

particularized as soon as the indefiniteness of parameters is overcome. With the second type it is assumed that parameter indefiniteness can only be resolved in the process of resource allocation and utilization itself. The second case is more often to be met with in practice. One reason is the short period of time between resource allocation and their actual utilization. During that time most of the random parameters are not realized, that is, the information needed in order to determine their real values may be acquired too late to make any corrections.

First, let us consider one possibility to evaluate the resource reserve quantity in its allocation and utilization assuming there are random parameters in the conditions. The study will be carried out with the help of the following economic problem.

Suppose we have **m** kinds of interchangeable resources, their quantities being $a_1, a_2, \ldots, a_m$. Those are used in various activities (e.g. in the production of **n** kinds of products), in output volumes $b_1, b_2, \ldots, b_n$, respectively. The following quantities are also given:

λ_{ij} - the cost of the i-th resource per unit of production of the j-th kind;

c_{ij} - the income per unit of production of the j-th kind, made of the i-th resource;

x_{ij} - the unknown number of production units of the j-th kind of production, made of the j-th resource.

The solution requires the development of such a resource allocation and utilization plan that would allow the completion of all activities in the stated quantities at a maximized revenue.

We arrive at the following mathematical model. Find the minimum of the linear function

(1) $$Z(X) = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

at the following conditions:

(2) $$\sum_{j=1}^{n} \lambda_{ij} x_{ij} \le a_i \quad (i = \overline{1, m});$$

(3) $$\sum_{i=1}^{m} x_{ij} = b_j \quad (j = \overline{1, n});$$

(4) $$x_{ij} \ge 0 \quad (i = \overline{1, m};\ j = \overline{1, n}).$$

In accordance with the above, let's assume $\lambda_{ij} = \lambda_{ij}^0 + \Delta\lambda_{ij}$, $a_i = a_i^0 + \Delta a_i$, where λ_{ij}^0, a_i^0 are the mean values of parameters; $\Delta\lambda_{ij}, \Delta a_i$ - the increase in parameters, viewed as random quantities, with symmetrical distribution patterns, set within the possible intervals $[-\Delta\hat{\lambda}_{ij}, \Delta\hat{\lambda}_{ij}], [-\Delta\hat{a}_i, \Delta\hat{a}_i]$. Thus condition (2) becomes

$$(5)\ \sum_{j=1}^{n}(\lambda_{ij}^0 + \Delta\lambda_{ij})x_{ij} \le a_i^0 + \Delta a_i \quad (i = \overline{1,m}).$$

Let us first consider a determinate approach to arriving at a stable plan. This approach differs considerably from those commonly offered in publications [1,4,10,20]. The essence of it is in the fact that the stochastic nature of the increase in $\Delta\lambda_{ij}, \Delta a_i$ is ignored and only the best possible parameter mix is considered. Thus the i-th condition (5) becomes

$$(6)\ \sum_{j=1}^{n}(1+\tilde{\lambda}_{ij})\lambda_{ij}^0 x_{ij} \le (1+\alpha_i)a_i^0,$$

where $\tilde{\lambda}_{ij} = \frac{\Delta\lambda_{ij}}{\lambda_{ij}^0}, \alpha_i = \frac{\Delta a_i}{a_i^0}$. Let's assume $\hat{\mu}_{ij} = \frac{\Delta\hat{\lambda}_{ij}}{\lambda_{ij}^0}$ and $\hat{\alpha}_i = \frac{\Delta\hat{a}_i}{a_i^0}$. Then the elements of the plan $X = \|x_{ij}\|$ satisfy condition (6), if

$$(1+\hat{\lambda}_i)\sum_{j=1}^{n}\lambda_{ij}^0 x_{ij} \le (1-\hat{\alpha}_i)a_i^0,$$

where $\hat{\mu}_i = \max_j \hat{\mu}_{ij}$. Let's also have

$$1-\delta_i = \frac{1-\hat{\alpha}_i}{1+\hat{\mu}_i}.$$

In order for the i-th condition to be stable, we need only satisfy the following inequality

$$(7)\ \sum_{j=1}^{n}\lambda_{ij}^0 x_{ij} \le (1-\delta_i)a_i^0.$$

Condition (7) makes it clear that in order to render the plan $X = \|x_{ij}\|$ stable, all we need to do is use the adjusted quantities $(1-\delta_i)a_i^0$ of the resource volumes a_i^0 instead of their mean quantities. In addition, the quantity $\delta_i a_i^0$ should be

viewed as a reserve in the case of a least favorable realization of the parameter values λ_{ij} and a_i. Theoretically such an approach to determining the resource reserve looks attractive. However, in practice its application may prove unsatisfactory, especially if the value of the coefficients δ_i becomes too high. Actually, the problem is that the probability of unfavorable realization of the parameters of the kind that would necessitate the use of the reserves is too low. Hence the risk of only partial allocation of resources and their incomplete utilization.

Let us now consider a second version of the determinate approach. Suppose the plan $\overline{X} = \left\| \overline{x}_{ij} \right\|$ of the model (1) - (4) was arrived at $\lambda_{ij} = \lambda_{ij}^{0}$ and $a_i = a_i^0$. Since it is possible to achieve equality (regarding scarce resources) in the conditions (2) at a certain value of the index i, that is

$$\sum_{j=1}^{n} \lambda_{ij} \overline{x}_{ij} = a_i^0 ,$$

then for the most unfavorable values of the parameters those equalities will be achieved at $\lambda_{ij} = \hat{\mu}_i, \alpha_i = -\hat{\alpha}_i$. In this case the left part of the condition, that is, the needed quantity of the i-th resource, will become

$$(1+\hat{\mu}_i)\sum_{j=1}^{n} \lambda_{ij}^0 x_{ij} = (1+\hat{\mu}_i) a_i^0 ,$$

and the right part, i.e. the actual quantity of the resource is $a_i = (1-\hat{\alpha}_i) a_i^0$. Consequently, in order to fulfill the i-th condition for the plan $\overline{X} = \left\| \overline{x}_{ij} \right\|$ it is necessary to reserve the additional quantity of $\overline{\delta}_i a_i^0$ of the resource, at $\overline{\delta}_i = \hat{\mu}_i + \hat{\alpha}_i$.

Let us now try to evaluate the resource reserve, needed to ensure the plan of the model with the condition of the kind (7). We expand $(1+\hat{\mu}_i)^{-1}$ into an exponential series:

$$1-\delta_i = (1-\hat{\alpha}_i)\frac{1}{1+\hat{\mu}_i} = 1-\hat{\mu}_i-\hat{\alpha}_i+\hat{\mu}_i\hat{\alpha}_i+\hat{\mu}_i^2-\hat{\alpha}_i\hat{\mu}_i^2-\hat{\mu}_i^3+\ldots$$

Through exclusion of the infinitely small members of the series we get the following

(8) $\delta_i \approx \hat{\mu}_i + \hat{\alpha}_i - (\hat{\mu}_i\hat{\alpha}_i + \hat{\mu}_i^2)$.

Therefore the difference between the coefficients determining the resource reserves δ_i and $\overline{\delta}_i$, calculated for the two versions of the determinate approach, is an infinitely small quantity of the second order. It is clear that $\delta_i < \overline{\delta}_i$. The main difference between those versions is that with the first one the optimal plan solution is arrived at a resource volume reduced by $\delta_i a_i^0$ as compared to the mean one, while with the second - at the mean resource volumes a_i. Because of this, with the first version the quantity of the reserve resources $\delta_i a_i^0$ is not taken into consideration when allocation is done but is used (fully or partially) only if necessary. With the second version the reserves $\overline{\delta}_i\, a_i^0$ can be achieved but they can be utilized gradually in the process of plan realization itself.

We will also consider the stochastic approach. This approach is based on the theoretical results of stochastic optimization [3]. Let's set $\widetilde{\lambda}_{ij}, \alpha_i$ to be independent random quantities with zero mean quantities and respective dispersions δ_{ij}^2, ν_i^2. Let $R = (r_1, r_2, ..., r_m)$ stand for the reliability, connected with the fulfillment of the conditions, $\prod_{i=1}^{m} r_i = r$.

The arrival at a r - stable plan of the model (1), (5), (3), (4) can be represented as the following set of inequalities:

(9) $$P\left(\sum_{j=1}^{n} 1 + \widetilde{\lambda}_{ij})\lambda_{ij}^0 x_{ij} \le (1 + \alpha_i)a_i^0 \right) \ge r_i \quad (\overline{i = 1, m}).$$

Lets introduce the random quantity

$$s_i(X) = \sum_{j=1}^{n} (1 + \widetilde{\lambda}_{ij})\lambda_{ij}^0 x_{ij} - 1 + \alpha_i)a_i^0 .$$

Now the set of inequalities (9) becomes

(10) $$P\left(s_i(X) \le 0\right) \ge r_i \quad (\overline{i = 1, m}).$$

In order to arrive at an effective solution of the set of inequalities (10) with respect to the members of the matrix $X = \left\| x_{ij} \right\|$ we will assume that the random quantities $\Delta\lambda_{ij}$, Δai feature normal distribution. Thus the random quantity $s_i(X)$ also features normal distribution. Using the theoretical basis of the probability theorem and statistics [7] we get the following set

(11) $\sum_{j=1}^{n} \lambda_{ij}^{0} x_{ij} \le a_i^0 - \Phi^{-1}(r_i)\sigma_{s_i}(x) \quad (i = \overline{1,m})$,

where Φ(t) is the function of distribution of the rated normal distribution, the values of which can be seen laid out in tables,

$$\sigma_{s_i}(x) = \sqrt{\sum_{j=1}^{n} \sigma_{ij}^2 \lambda_{ij}^{0\,2} x_j^2 + \nu_i^2 a_i^{0\,2}}\ .$$

When the above approach is realized in practice, for $\sigma_{s_i}(x)$ we could use the following estimation

$$\sigma_{s_i}(x) \le \frac{1}{3}\delta_i(1) a_i^0\ ,$$

where

$$\delta_i(1) = \frac{1}{1-\hat{\mu}_i^2}\left(\sqrt{\hat{\mu}_i^2 + \hat{\alpha}_i^2 - \hat{\mu}_i^2\hat{\alpha}_i^2} - \hat{\mu}_i^2\right).$$

Lets introduce the condition

(12) $\delta_i(r_i) = \frac{1}{3}\Phi^{-1}(r_i)\delta_i(1)$.

then, by using (11) we can arrive at the following sufficient condition for r_i - stable plan $X = \left\| x_{ij} \right\|$ at the i-th condition

(13) $\sum_{j=1}^{n} \lambda_{ij}^{0} x_{ij} \le (1 - \delta_i(r_i)) a_i^0$.

The sufficient condition (13) is analogous to (7), however, the values of the reserve coefficients are different. If $r_i \to 1$ then $\delta_i(r_i) \to \delta_i(1)$. Let's compare $\delta_i(1)$ to the coefficient δ_i, arrived at the determinate approach. It becomes clear that with random possible quantities of $\hat{\mu}_i, \hat{\alpha}_i$ the following inequality is satisfied $\delta_i(1) < \delta_i$. In economic research the following reliability factors are commonly used: r_i = 0.99, r_i = 0.95, etc. Those factors would be equal to the coefficients $\frac{1}{3}\Phi^{-1}(r_i)$ of equality (12), their values being respectively 0.78, 0.55, etc. Therefore even at reliability close to 1 (r_i = 0.99), the stochastic approach allows us to substantially decrease the quantity of the reserved resource.

Suppose $X = \left\| x_{ij} \right\|$ is the plan of the model (1), (13), (3), (4). The value of the overall reliability of this plan is r, i.e. the probability of satisfying all conditions equals $\prod_{i=1}^{m} r_i = r$; It turns out that in order to maximize the reliability factor r, even at maximum reliability r_i = 0.99, there should not be too many multipliers. Indeed, if $r = (r_i)^m = (0.99)^m$, then if $r \geq 0.9$, then $m \leq 10$. With many practical problems dealing with resource allocation and reserve, the number of conditions containing random parameters is too great. In order to ensure overall satisfactory reliability of the plan it would be good to set r_i = 1 for the most conditions. The choice of adequate conditions is affected by various factors, for instance the resource deficit. The greater the resource deficit, the smaller the reserve quantity that should be set. In order to identify r_i when r has been given in advance, we could use the following approach. Suppose k_i is the cost related to the increase of one unit of the i-th kind of resource. Then the cost of providing the necessary reserve quantity of the i-th kind of resource will be $k_i \delta_i(r_i) a_i^0$. The total cost of ensuring the reserve of all resources will be

(14) $K(R) = \sum_{i=1}^{m} k_i \delta_i(r_i) a_i^0$.

It is clear that the above total cost is the function of the vector's components $R = (r_1, r_2, ..., r_m)$. Actually the additional cost of ensuring the resource reserve is limited. Let $\overline{K}$ be the maximum limit of financing. Then we need to introduce the following supplementary condition

$$\sum_{i=1}^{m} k_i \delta_i(r_i) a_i^0 \leq \overline{K};$$

The component values r_i will have to be set so that the total cost, set by (14) is minimal. That would lead to the appearance of a new additional optimum criterion. Let the matrix elements $C = \left\| c_{ij} \right\|$, setting the income to be realized, also be random quantities. Then we can substitute the criterion under consideration Z(X) with its mathematical expectation value. This way we arrive at the following version of the mathematical model:

(15) $\max : MZ(X) = M\left(\sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \right);$

(16) $\min : K(R) = \sum_{i=1}^{m} k_i \delta_i(r_i) a_i^0$;

(17) $\sum_{j=1}^{n} \lambda_{ij}^0 x_{ij} \le (1 - \delta_i(r_i)) a_i^0 \quad (i = \overline{1,m})$;

(18) $\sum_{i=1}^{m} x_{ij} = b_j \quad (j = \overline{1,n})$;

(19) $\sum_{i=1}^{m} k_i \delta_i(r_i) a_i^0 \le \overline{K}$;

(20) $\prod_{i=1}^{m} r_i = r$;

(21) $x_{ij} \ge 0,\ r_i \ge 0 \quad (i = \overline{1,m};\ j = \overline{1,n})$.

It is advisable to expand the model (15) - (21) into two submodels. The first submodel will be:

(22) $\min : K(R) = \sum_{i=1}^{m} k_i \delta_i(r_i) a_i^0$;

(23) $\sum_{i=1}^{m} k_i \delta_i(r_i) a_i^0 \le \overline{K}$;

(24) $\prod_{i=1}^{m} r_i = r$;

(25) $r_i \ge 0 \quad (i = \overline{1,m})$.

Suppose $R^* = (r_1^*, r_2^*, ..., r_m^*)$ is the optimal plan of the model (22) - (25). Then the second submodel will be

(26) $\max : MZ(X) = M\left(\sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \right)$;

(27) $\sum_{j=1}^{n} \lambda_{ij}^0 x_{ij} \le (1 - \delta_i(r_i)) a_i^0$. $(i = \overline{1,m})$;

(28) $\sum_{i=1}^{m} x_{ij} = b_j \quad (j = \overline{1,n})$;

(29) $x_{ij} \ge 0 \quad (i = \overline{1,m};\ j = \overline{1,n})$.

The optimal plan of the submodel (26) - (29) will predetermine the solution of the global model (15) - (21).

Suppose the parameters c_{ij} in the target function are

$$c_{ij} = c_{ij}^0(1+\delta_{ij}),$$

where c_{ij}^0 are mean values, while δ_{ij} - random quantities with normal distribution, zero mean values and dispersion σ^2. Then the deviation, viewed as a random quantity, will be

$$\varepsilon_Z = \sum_{i=1}^{m}\sum_{j=1}^{n}\delta_{ij}c_{ij}^0x_{ij}.$$

The deviation ε_Z is the sum of the normally distributed addends $\delta_{ij}c_{ij}^0x_{ij}$. Its dispersion is arrived at through the formula

$$\sigma^2(\varepsilon_Z) = \sum_{i=1}^{m}\sum_{j=1}^{n}\sigma^2(c_{ij}^0x_{ij})^2 = \sigma^2\sum_{i=1}^{m}\sum_{j=1}^{n}(c_{ij}^0x_{ij})^2.$$

If $\hat{\delta} = \max_{ij}\delta_{ij}$, then $\sigma = \dfrac{\hat{\delta}}{3}$, hence

$$\sigma(\varepsilon_Z) = \frac{\hat{\delta}}{3}\left(\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n}c_{ij}^0x_{ij}}\right).$$

Then the possible deviation range of ε_Z will be

$$[-3\sigma(\varepsilon_Z),3\sigma(\varepsilon_Z)] = \left[-\hat{\delta}\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n}c_{ij}^0x_{ij}},\hat{\delta}\sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n}c_{ij}^0x_{ij}}\right].$$

Suppose $X^* = \left\|x_{ij}^*\right\|$ is the optimal plan arrived at with the mean values of the parameters $C^0 = \left\|c_{ij}^0\right\|$. Then the income will be

$$Z(X^*,C^0) = \sum_{i=1}^{m}\sum_{j=1}^{n}c_{ij}^0x_{ij}.$$

The random quantity ε_Z which determines the deviation of $Z(X^*,C^0)$ will vary in the range $\left[-\dfrac{\hat{\delta}}{\sqrt{2}}\left|Z(X^*,C^0)\right|,\dfrac{\hat{\delta}}{\sqrt{2}}\left|Z(X^*,C^0)\right|\right]$. The maximum absolute

value error of the criterion Z(X) will be $\hat{\varepsilon}_Z = 0,71\hat{\delta}\left|Z(X^*, C^0\right|$, and the maximum relative error - $0,71\hat{\delta}$.

The above attempt to examine the stability of the optimal program is a prerequisite for effective regulation of the resources reserve. What is more, a choice is offered between a few options in order to find the optimum quantity of resource reserve with random parameters in the optimum criterion.

There is also another advantage in the above outlined approach of expanding the global model into submodels. Viewed separately, submodels can be applied separately in order to optimize the financial resources in particular

In conclusion we would point out that at this stage there does not exist a natural market economy environment in this country, which has caused great difficulties in testing the above theoretical results. However, we remain hopeful that we will be given such an opportunity in the near future, since market economy has been accepted as having no alternative for the development of this country.