SECTION I. ECONOMIC THEORY

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OPTIMIZATION AND RESOURCE DISTRIBUTION MANAGEMENT IN A NATIONAL ECONOMY: THE CHOICE OF STRUCTURE

Oleg S. Sukharev
ORCID ID: 0000-0002-3436-7703, Researcher ID: C-3767-2018, e-mail: o_sukharev@list.ru

Institute of Economics of the Russian Academy of Sciences (32 Nakhimovskii Prospekt, Moscow, 117218, Russia)

The purpose of the research is to develop resource management tools aimed to appropriately distribute the resources and to justify the ways for copying with the structure choice problem as regards the Schumpeterian approach to the economic development. The methodology of the research includes the Schumpeterian economic growth model, structural analysis, and conventional optimization methods, in particular the gradient projection method which gives alternatives for optimization task solution algorithms. These methods are applied to show the structures with the maximum profit and minimum risk in resource distribution in the national economy, which underlies the resource distribution management task. A model of interaction between the old and new combinations which are officially provided as investments into the old and cutting edge technologies was proposed within the Schumpeterian economic growth model. The economy restructuring was defined as the evolutionary changes of its structure under Joseph Schumpeter's theory, and the modes of the economic dynamics were identified from the correlation between the effects of creative destruction and combinatorial augmentation. The article describes the results of the optimizational simulation which prove that the Schumpeterian economy restructuring provides the prerequisites for new combinations which enhance the possibilities for their own development and for the development of the old combinations. The correlation between the profit and risk rates or expert decisions could become a criterion for decision making at a characteristic point. This fundamentally improves the quality of the managerial decision justification at different levels of an economic body which faces structural tasks of resource distribution. A structural choice problem together with its solution makes the priority task in the economic development of the managed system relevant. The research concludes that the structural policy is an essential element in the strategy aimed to develop a new model of the economic development of Russia, because, in fact, institutional changes and measures taken to create the business environment with no restructuring of the sectorial economic proportions look like the palliative aid with no prerequisites for the new type of economic growth. The research is seen to be promising in finding the particular solutions for resource distribution among the sectors and activity types according to the target functions of the economic system development. What is more, this issue updates the task to identify the impact of new combinations on the exising combinations, as well as to examine the factors which determine this impact. It would also be relevant to find the characteristic points of resource distribution for the particular tasks in the management of the national economy, e.g. state programs, which would enable the stakeholders to develop qualitative (expert) approaches to justify the resources distribution in an economic system.

Keywords: economic growth, innovations, risk, resource management, resource distribution, profit, Schumpeterian approach to restructuring, structural choice, optimizational models, gradient projection method.

ОПТИМИЗАЦИЯ И УПРАВЛЕНИЕ РАСПРЕДЕЛЕНИЕМ РЕСУРСОВ В НАЦИОНАЛЬНОЙ ЭКОНОМИКЕ: ВЫБОР СТРУКТУРЫ

Олег Сергеевич Сухарев
ORCID ID: 0000-0002-3436-7703, Researcher ID: C-3767-2018, e-mail: o_sukharev@list.ru

Институт экономики Российской академии наук (Россия, 117218, г. Москва, Нахимовский проспект, 32)

Цель исследования состоит в разработке инструментария управления ресурсами в условиях решения вопроса об их оптимальном распределении и обосновании способов преодоления проблемы «структурного выбора» с позиции шумпетеровских представлений об экономическом развитии. Методологию исследования составляет шумпетеровская теория развития, структурный анализ и методы условной оптимизации, в частности метод проекций градиента, для которого предложены варианты алгоритмов решения задачи оптимизации. Применение этих методов позволило показать структуры распределения ресурсов в национальной экономике, обеспечивающие получение наибольшего дохода в условиях минимального риска, что выступило основой формулирования задачи управления распределением ресурсов. В рамках шумпетеровской теории развития предложена модель взаимодействия старых и новых комбинаций, которые в формальном виде представляются через инвестиции в новые и старые технологии. Дана трактовка реструктуризации экономики как эволюционного изменения её структуры по Й. Шумпетеру и выделены режимы экономической динамики по соотношению эффектов «созидательного разрушения» и «комбинаторного наращения». Получены результаты оптимизационного моделирования, подтверждающие, что шумпетеровская реструктуризация экономики состоит в обеспечении условий для появления новых комбинаций, которые расширяют возможности для развития не только себе, но и старым комбинациям. Критерием принятия решения в «характерной точке» может быть оценка соотношения темпа роста дохода и риска либо принятие экспертных решений. Это принципиально повышает качество обоснования управленческих решений на разных уровнях экономической организации, в которых возникают структурные задачи распределения ресурсов. Проблема «структурного выбора» и ее решение актуализируют задачу формирования приоритетных направлений экономического развития управляемой системы. Основной вывод исследования заключается в том, что структурная политика является обязательным элементом стратегии формирования новой модели экономического развития в России, поскольку использование институциональных изменений и мер по созданию среды для бизнеса без реструктуризации секторальных экономических пропорций, по сути, играет роль паллиативной помощи, не обеспечивая формирование предпосылок для экономического роста нового качества. Перспективу исследования составляет поиск конкретных решений распределения ресурсов между секторами и видами деятельности согласно целевым функциям развития экономической системы. Кроме того, при такой постановке вопроса актуализируется задача определения влияния новых комбинаций на функционирование уже существующих кобминаций, а также исследования факторов, определяющих характер такого влияния. Полезным видится поиск «характерных точек» распределения для конкретных задач управления национальной экономикой, например государственными программами, что позволит разработать качественные (экспертные) подходы обоснования распределения ресурсов в хозяйственной системе.

Ключевые слова: экономический рост, инновации, риск, управление ресурсами, распределение ресурсов, доход, шумпетеровский подход к реструктуризации, структурный выбор, оптимизационные модели, метод проекции градиента.

Introduction

According to Joseph Schumpeter, the evolution of economic systems is seen as a cascade of permanent changes in their structures [1–4] or an ongoing transformation of the economy [5; 6], including reform based transformations. Today, this understanding of economic change has been significantly broadened by considering many institutional factors of economic growth [7–9] and its structural aspects [10–13]. These aspects cannot be ignored as regards governance issues at the macroeconomic level.

Originally, agriculture was known to be[1] formed as an economic sector providing the

[1] Of course, the background of the sectors referred here is characteristic for the developed countries. Even now there are agriculture-based countries, and the share of industry in the created product is not high. In this case, the development of agriculture depends on the purchase of technologies (means of production) supplied by industrially developed countries – agricultural countries. The same applies to the countries specializing in the extraction of raw materials (mono-export countries).

population with work, food and clothing [14]. Technological development accelerated due to the expanding need for means of production (including agriculture) became the basis of industrialization. Moreover, at first, agriculture still contributed the most into the income. However, over time, the correlation began to change in favor of industry, which share in the product being created steadily increased in the countries that used new technologies and actively developed capitalist institutions. As a result, the industry began to dominate by expanding its needs, and the share of agriculture decreased significantly. To support the industry, the service sector responded by developing the infrastructure, and the diversified social life determined the transaction activities and economic sectors. Over time, the industry conceded to the transaction sectors as regards the share of the created product. Again technological development which brought computers and new means of communication and socializing, contributed to the fact that industry productivity increased unprecedentedly, freeing up the labor force engaged in production and redirecting it to the transaction sectors. It does not mean at all that there were no services when agriculture dominated or industry began to develop (industrial revolutions), but their share in the created product was very small. The evolution of technology and institutions changed the relationship between the three sectors. The development of these sectors definitely required resources, which expanded the scale of the raw materials sector. The influence of the raw materials sector in many developed countries is still not defined (by their share in GDP), although the dynamics of raw material prices, undoubtedly, strongly affects the economic development of both particular countries and the world economy as a whole. The transformation noted above associated with a change in the dominance of a particular activity, economic sectors, in fact, is a good example of Schumpeter's economic evolution, as it appears in the idea of a change in structure (by the share of each sector in GDP).

In addition to the macrostructural aspect, the economic evolution, according to J. Schumpeter, is reflected in the changes in the economic structure, in particular, a set of new combinations that affect the existing structure [4; 15]. To make changes efficient and successful, the already existing combinations should accept a new combination which can be a new technology, and the development of this new combination should be supported by adequate resources. In this regard, the evolution is determined mainly by the development of new resources (combinatorial augmentation) rather than by the resource diversion from previous combinations (creative destruction). The effect of 'combinatorial augmentation' is especially pronounced when two or more technologies can be combined without a significant additional resource, which will ensure revitalization of the old combinations and create prerequisites for the replication of new combinations, supporting the dynamics of economic development. The effect of 'combinatorial augmentation' is the most indicative in the field of knowledge, where it is accumulated and acts as a source of structural changes and of future economic growth. Knowledge reproduction, its dissemination (replication) depends on the educational institutions [16]. Economic growth depends on how new combinations appear, as well as, for example, on fiscal policies that support Schumpeter's new combinations, innovations [17; 18] and R&D investments [19], institutional changes [20–23], and others. For a long time, the structural changes have not been considered to be a part of the economic growth theory [24], not to mention the analysis of new combinations impact on the economic structure and growth.

Now it is worth focusing on the approach to examine structural changes, economic growth, and the impact of the structural dynamics on the growth. Let us formulate a Neo-Schumpeterian economic growth model with new combinations that borrow a resource from the previous combinations and develop a new resource which can already be considered as a new combination [4]. We will consider the change in the economic structure as the 'Schumpeter restructuring'.

The Schumpeter approach suggests considering structural changes through changing combinations. At the same time, this process is accompanied by the movement of resources, including labor resources, from old combinations to new ones (‘creative destruction’), as well as the creation of new types of labor and labor resources for new production, which is considered to be ‘combinatorial augmentation’ [21].

Managing an economic structure involves solving the problem of allocating resources between the elements that make up the structure. This is one of the most difficult decision-making processes. The reason is not only that it is difficult to predict the costs which the changes in the existing structure entail and how a new structure will function, but also the existing structure can resist the changes, and this inertia neutralizes the policy measures aimed at the existing structure. The reason for this annulment can be either the inefficiency of the current policy measures or the counteracting effect of the economy. Thus, structural policy depends on the current macroeconomic policy and the existing economic structure. Resource allocation, including investments, budget distribution (for the public sector), is a real challenge since this will also affect the movement of labor and lead to structural changes. A resource in an economy always has its monetary value. Therefore, its movement depends on the current amount of income and risk. These two factors determine agents’ choice in distributing the available resources, strongly influence their decisions. Figure 1 illustrates resource allocation structure which is presented at the level of macrostructural management and concerns resource movement management in the economic sectors.

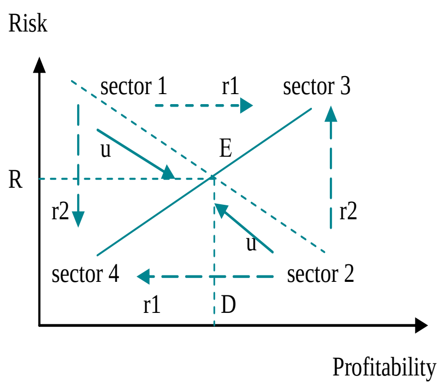

Fig. 1. **The problem of structural choice**

Рис. 1. **Схема структурного выбора**

As can be seen from Figure 1, the economy is represented by two basic sectors 1 and 2, which can be taken as manufacturing and raw materials and transaction (the transaction sector is united with the raw materials sector for the purpose of the research). The total amount of the products created by the sectors gives the gross domestic product of the country. Sectors or activities are located along the solid line in Figure 1, sector 3 and sector 4. In this case, the higher profitability leads to greater risk, and the low profitability to lower risk.

Figure 1 shows the following correlation: higher level of income results in greater risk, less income – less risk (this is marked by the solid line). However, such an economic structure is possible (the dashed line in Figure 1), when the lower profitability corresponds to a greater risk and the higher profitability to a lower risk. This initial structure gives rise to at least three alternatives of structural dynamics, which determines structural choice reflected in the macroeconomic decisions. This structure consists of the introduced sectors: the manufacturing sector is characterized by high risk and relatively low returns, while the transaction and raw materials sectors show the opposite trend. This situation could be altered by structural changes arising from the movement of resources described in this article. It can be caused by a certain set of management actions.

First of all, the dynamics along the *uu* lines, when the profitability of manufacturing sector increases, the risk decreases, while the transaction and raw materials sectors show the reverse trend.

Secondly, the dynamics along the *r1r1* lines (Fig. 1) increases the profitability of manufacturing sector, decreases the transactional and raw materials sectors with the same risks.

Thirdly, the dynamics along the *r2r2* line, when the risk in the transaction and raw materials sectors increases at the same profitability, decreases in manufacturing sector.

It should be noted that different dynamics do not solve the problem of choosing the structure ‘more income – more risk', because you can give such a distribution that there is less risk and less income.

The decision can be made if you accurately predict the scope of changes in the parameters and motivations driven by the agents to start these changes. However, this factor is difficult to predict, therefore, structural choices, as well as changes in the structure are always accompanied by high uncertainty. Taken into account the reasons mentioned above, one of the conceptual options for solving structural management problems is seen to be a Neo-Schumpeterian approach. We will try to review its logic and application tools as regards the management problem in the next chapter.

Theory of restructuring and management of development

Development management cannot avoid questions of influence on the economic structure, since development can be considered as a change in the structure or a set of structures. The Schumpeter approach can play a significant role in representing the development as a process of changing structures. Therefore, the management of development and resource allocation among the structure elements should be considered in terms of changing combinations within the existing effects of creative destruction and combinatorial augmentation.

The structures in the economy are changed or transformed as new combinations spring up, there are five basic types, according to the theory of J. Schumpeter [4]. In this regard, economic development can be structurally analyzed by covering various types of combinations, as well as by exploring the resource distribution among these types and among new and existing combinations (technologies, sectors of the economy). A new combination (*In*) can receive a resource from two main sources, firstly, from old combinations and, secondly, creating a new resource for itself. This can be expressed in a formula *In=R1+R2*, where In is the full resource obtained by the development of a new combination, *R1* is the value diverting resources from the old combination resource, *R2* is the value of a newly created resource. If the total resource used by the old combination is *Is*, then *R1=αIs*, but the created resource can be represented by *R2=μIn*, where *α* is the share of the abstract resource from the old combination, *μ* is the share of the newly created resource from the total resource received by the new combination. Whence it follows that *In=Isα/(1-μ)*. Let us denote the rate of resource diversion from the old combination *Vα=dα/dt*, the resource creation rate for the new combination is *Vμ=dμ/*dt. The value *Vα* characterizes constructive destruction, *Vμ* is the combinatorial augmentation. By differentiating *In=Isα/(1-μ)*, we arrive at the equation for changing the resource of a new combination:

$$\frac{dI_n}{dt} = \eta(t) \cdot \frac{dI_s}{dt} + V_\alpha \cdot I_s \cdot \chi(t) + $$
$$+ V_\mu \cdot \eta(t) \cdot \chi(t) \cdot I_s$$
$$\eta(t) = \frac{\alpha(t)}{1-\mu(t)};\ \chi(t) = \frac{1}{1-\mu(t)} \qquad (1)$$

This equation is obtained under the assumption that the effects of creative destruction and combinatorial augmentation are not related. If we unite the effects, then $\alpha = z(\mu), V_\alpha = \frac{d(\mu)}{dt}$. The resource of the new combination will take the form $I_n = \frac{I_s \cdot z(\mu)}{1-\mu}$. Then the above equation (1) includes the coupling function of the effects *z(μ)*.

In relation to the movement of labor resources, the above estimates will look as follows: $\alpha = \frac{l_{sn}}{L_s}$ is the correlation between the number of people employed in the old types of labor (l_{sn}) that are transitioning to new types of labor and the total number of people employed in the old types of work (*Ls*); $\mu = \frac{l_n}{L_n}$ is the correlation between newly trained workers in new types of labor (*ln*) and their total number in these types (*Ln*). Then, similarly to the above, we can write:

$$L_n = \alpha \cdot L_s + \mu \cdot L_n, \text{ whence } L_n = \frac{\alpha \cdot L_s}{1-\mu}.$$

The structure of similar combinations, as well as all the selected types of combinations, will determine both the dynamics of structural changes and the economy growth.

Various economy growth modes arise with different relative dynamics of the parameters α and μ. Table 1 describes these modes with the growth mode to be determined by either 'creative destruction' or 'combinatorial augmentation'. The dynamics model is adjusted to the rates of resource diversion and creation.

Table 1. **Modes of economic development**

Таблица 1. **Режимы экономического развития**

Mode	Main speaker mode	Kind of dynamics	Dynamics characteristic
Creative destruction (more resources are diverted than created)	$\alpha>\mu$	$V\alpha>V\mu$	Growth due to the old combination, the new one is derived from the resource diversion
		$V\alpha<V\mu$	The desire to create a resource for a new combination (switch the speaker mode)
Combinatorial augmentation (more resources are created than diverted)	$\alpha<\mu$	$V\mu>V\alpha$	Growth due to a new combination, a resource is created for it
		$V\mu<V\alpha$	The striving to ensure that resource diversion from the old combinations to 'creative destruction' (switching the speaker mode)

Table 1 considers the structural problem of economic development within the Schumpeter's ideas about development theory. Two main types of dynamics are possible within the 'old – new' combination approach due to either the old or new combination. But resource diversion and creation of a new resource for development involve two more options given the correlation between the rates of diversion and resource creation. These rates are determined by institutional prerequisites.

An economy can be represented by two sectors that exchange products and resources. For example, Figure 2 shows the manufacturing and transaction and raw materials sectors. In the institutional aspect, this risk-profitability correlation shapes a rule that determines the movement of resources[1] between these sectors. Figure 1 on the left illustrates the overflow scheme. The effect of 'creative destruction' works when labor and capital move to a less risky and highly profitable sector. In other words, this rule is an inducing condition for the movement of resources.

However, each sector has its own set of new and old combinations which differ in risk and profitability, which requires detailed elaboration of the conditions for the movement of resources (Fig. 3). As a result, new combinations in manufacturing sector may or may not be reduced, and this depends on what resource remains in the manufacturing sector. Therefore, the effect of blocking new combinations in the manufacturing sector generates a systemic restriction of economic development, provided it is still accompanied by violations in the emergence of new combinations and in the transaction and raw materials sectors.

As can be seen from Figure 3, combinations of the manufacturing sector can provide a resource for either the new or old combination of the transaction and raw materials sectors. Separately, each combination of manufacturing sector can provide a resource for the combination of the old and new of transaction and raw materials sectors, and each combination of manufacturing sector can give a resource to all combinations of the transaction and raw materials sectors.

Figure 2 on the left illustrates an option to restructuring the economy along two

[1] The following activities are included in the manufacturing sector: D – Manufacturing; F – Construction. The transaction and raw materials sectors include the following activities: A – Agriculture, hunting and forestry; B – Fishing, fish farming; C – Mining; E – Production and supply of electricity, gas and water; G – Wholesale and retail trade; repair of motor vehicles, motorcycles, household products and personal items; N – Hotels and restaurants; I – Transport and Communications; J – Financial activities; K – Transactions with real estate, rent and services; L – Public administration and military security; social security; M – Education; N – Health and social services; O – Other utilities, social and personal services.

contours, when resources are moved from one sector (manufacturing) to another sectors (transaction and raw materials) – k_1, or in the opposite direction – k_2. The development along the first contour implies equalization of risks and profitability. Both contours fit into the logic of 'creative destruction'. The creation of a resource, including the use of reserves, also leads to new combinations. Such actions can reduce the difference in risk and profitability between sectors, also affecting the movement of resources between sectors. Figure 1 on the right shows 'resource creation'. It may be, for example, returning to the capital of the country, including offshore capital, some part of the reserves, additional lending capacity of the banking systems, as well as other tools aimed to reduce risk in the manufacturing sector.

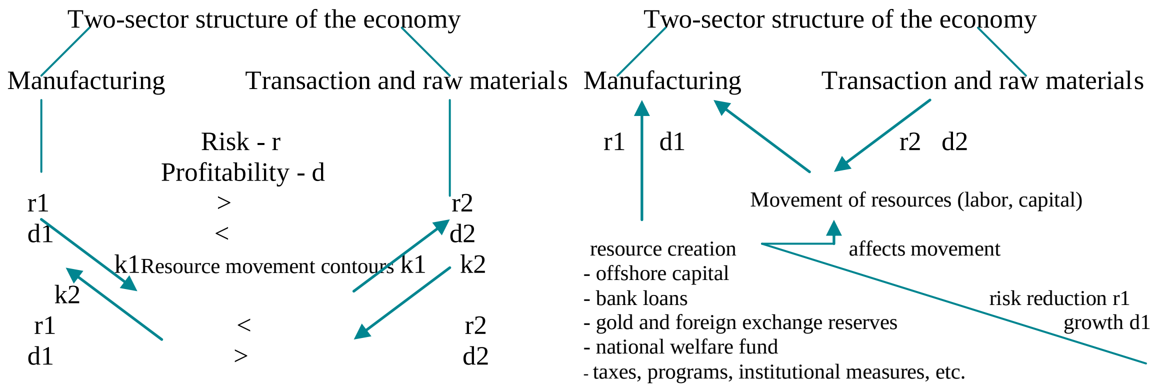

Fig. 2. **Model of 'creative destruction' (left) and 'combinatorial augmentation' (right) in a two-sector model of the economy**

Рис. 2. **Модель «созидательного разрушения» (слева) и «комбинаторного наращения» (справа) в двухсекторной модели экономики**

Note: r1 and d1 are the risk and profitability in manufacturing sector; r2 and d2 are the risk and profitability in transaction and raw materials sectors; k1 and k2 are the arrows indicating the movement of resources from sectors.

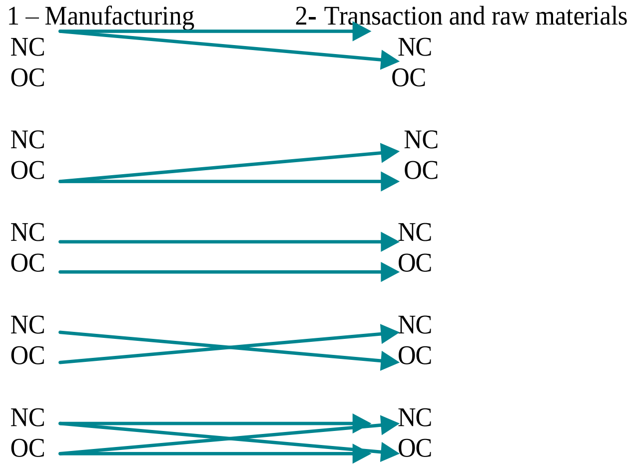

Fig. 3. **Diverting resources from the new (NC) and old (OC) combinations in the structure of manufacturing and transaction and raw materials sectors**

Рис. 3. **Схемы отвлечения ресурсов от новых и старых комбинаций, составляющих структуру обрабатывающего и трансакционно-сырьевого секторов**

Note: the arrows indicate a possible movement of the resource by the new and old combinations of two sectors

Structural change can be represented as the ratio of old and new combinations, for example, of technology, formally expressing the process of their interaction through investment in this and that type of technology. The distribution of investments will mean the existing structure, where one type of technology can dominate and require a large amount of investment. In turn, investment makes a certain contribution to the overall economic growth rate. In this regard, the contribution of new technologies and old technologies to the growth rate is different. The correlation of these contributions sets the mode of technological renewal, dependent on many factors and current circumstances of economic development.

The Schumpeterian restructuring of the economy requires new combinations which express the content of structural transformation, change the relationship between activities and sectors, risks in them and profitability rather than just stimulating the emergence of new combinations that, within the existing economic structure, will run out of steam without giving anything to the overall dynamics of the economy. Figure 4 shows the result of improvement (the criterion is the maximization of total income/profit) in the distribution of 100 unit investments between the manufacturing and transaction and raw materials sectors (the estimates were taken for Russia), set by profitability from 2005 to 2017.

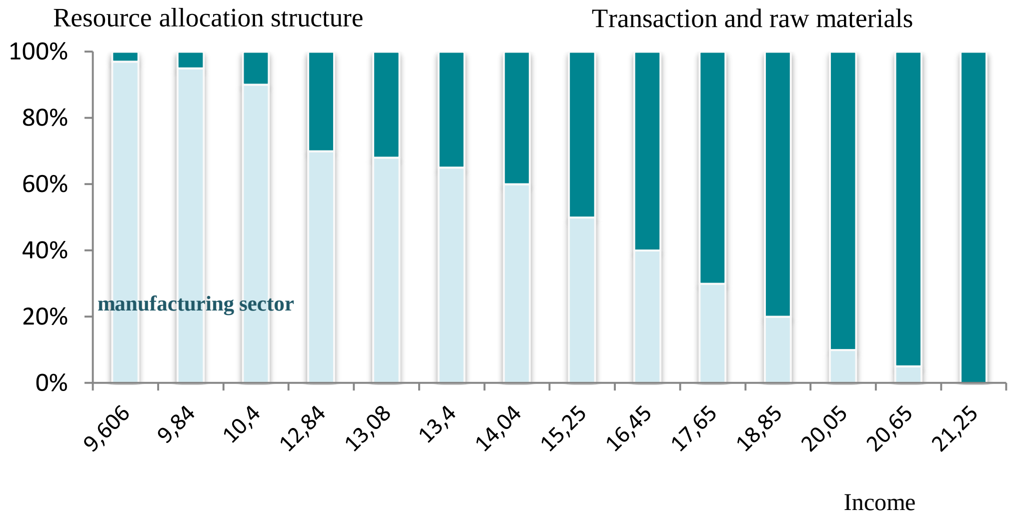

Fig. 4. **Distribution structure for investments and expected income**

Рис. 4. **Структура распределения инвестиций и ожидаемого дохода**

As can be seen, the smallest profit will be obtained if the manufacturing sector receives the largest resource, the largest profit will arise if the transaction and raw material sectors receive the largest resource. The above rule of correlation between risk and profitability of sectors works. Its presence leads to the need for additional efforts to adjust the situation. So in this case, a standard set of tools cannot do without applying structural policy measures.

The paper [25; 26] describes the distribution between five and six resource allocation objects. Improvement models show that the sixth combination that appears when the resource, let's say, expands, not only gets a smaller amount of resource when the value of the shared resource is smaller, but also provides an additional resource relative to the previous situation for old objects.

Therefore, one of the central tasks of macroeconomic policy can be considered to be a stimulation of new combinations, leading to restructuring, which will increase the contribution to the growth rate of not only new, but also old combinations.

As we can see, the adequate profitability share in the optimization model can develop new combinations, and when the total resource is expanding, the existing combinations can receive more resources, while a new combination gets less resources, unlike the first alternative (when the total resource is not expanding). At the same time, the problem of making decisions about the resource distribution, including management decisions at the macro level – which development options to support – remains and has significant uncertainty [19].

The new combination can be identified with the new technology, the old combination – with the old technology. This approach can then be applied to managing the resource allocation between two types of technologies and technological development.

For new technologies, the following is typical: a greater risk corresponds to a greater resource, and a lower risk corresponds to fewer resources. For older technologies, the reverse is true: less risk means more resources, and more risk means less resources. Thus, agents take risks with new technologies, and this is typical for the manufacturing sector.

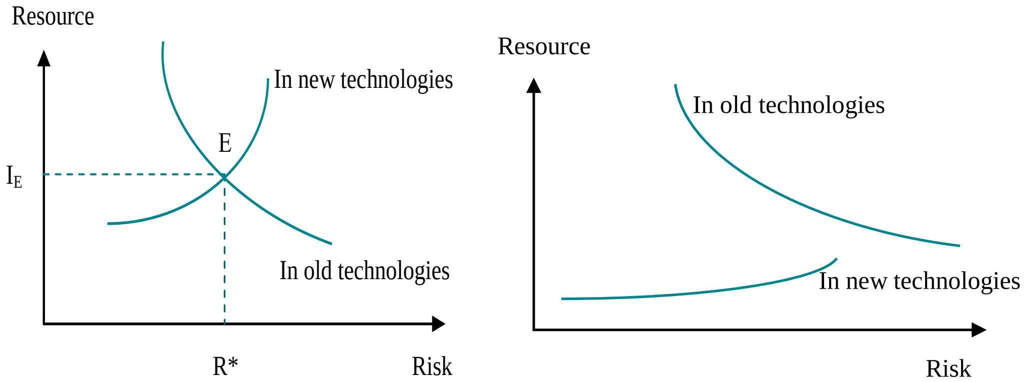

Fig. 5. **Resources in old and new technologies and risk (two options)**

Рис. 5. **Вложение ресурса в старые и новые технологии и риск (два варианта)**

Figure 5 shows the pattern of changes in resources between sectors. The E-point represents an equal preference between resources in old and new technologies. Risk R* can be defined as the risk of an equivalent technological choice, which corresponds to the amount of RE resources directed either to new or old technologies in one or another economic sector. For some economies, these lines (Fig. 5, right) do not intersect, because the amount of resources in new technologies is significantly smaller than the amount of resources in old technologies. Therefore, there is no point of equivalent technological choice. Moreover, preference is given to old technologies. Theoretically, the point of equal choice can correspond to a very large amount of risk.

Thus, the structure of technologies is formed not only because of the impact of risk, but also due to the needs of the sectors. Greater risk blocks resources in old technologies, but is justified relative to new technologies.

The structural resource dynamics is determined by many conditions, not just risk. However, risk is an institutional parameter, since it can be affected by changing rules, introducing government incentives, and creating development programs.

Macroeconomic policy can also affect risk, since it is related to the interest rate (a higher interest rate corresponds to a higher risk), which will also affect profitability. Therefore, changes in the economic structure can be achieved by a system of institutional adjustments and other macroeconomic policies. This is the content of macro management. Straightening the risk between sectors will lead to straightening the difference in their profitability, change the ratio in the distribution of resources, and can improve the growth parameters. The change in risk will cause the work force to change the scale of its move from old industries to new industries, opportunities for training new personnel for new types of activities will be expanded. Therefore, it is possible to manage the structure of labor distribution and labor markets through institutional influences that are aimed at reducing risk.

Having revealed a characteristic point (where the choice is ambiguous) of the resource allocation structure, which is determined by the decisions made, among other things, we will show the main content of structural choice and structure management.

Optimization of resource allocation: structure choice management

Let's consider the problem of ambiguity in the structural choice of resource allocation for the selected objects in the economy. The objects can be economic sectors, priority directions of development or planned reforms, etc. It is important that they cover the same period of time and are characterized by the amount of return per one invested unit of resource. A resource can be defined as financing or investment, or the total resource invested in the sector, direction of development, which has a monetary value.

Let's imagine that the government services have identified several priority areas for economic development. Let there be (estimated) the amount of return per monetary unit investments for each priority area or sector. These directions cover four equivalent time periods in their implementation and can be considered as objects (A, B, C). Then depending on the amount of return you can consider various options for optimizing this structure of economic activity by the amount of income and risk.

Since there is a value of return for each object, and the initial distributed resource is known, it is possible to define the task of searching for such a distribution that would give the greatest income or the least risk in the development of this economy. By counting on some expected profit, you can get a change in risk based on the income maximization (I) and risk minimization (II) models. The gradient projection method is used for optimization [27].

The numerical resource allocation optimization program implements the algorithm shown in Figure 6 (the arrow indicates the direction of the algorithm steps, the optimization method-gradient projections).

It is essential to prepare the initial data, determine the value of the return per unit of the invested financial resource, provide data input, including setting the starting point from which the descent to the optimal solution begins, as well as limitations. By changing the constraints, it is possible to obtain options for the optimization problem, because a given objective function (maximizing income and minimizing risk), naturally, have different solutions, which can then be interpreted to the nearest restrictions.

Optimization models require further interpretation of the result obtained with their help. The numerical algorithm of this block was not included in Figure 6, but the significance of this stage of work becomes decisive in the application of the mathematical apparatus of any complexity and purpose. In addition to the interpretation of the results, which we will take here as an example below, developing a set of objects, that is, the selection of objects that will participate in the analysis, by which the resource is distributed is an important aspect. The goals of research definitely determine this set, but a set of industries, sectors, corporations, projects can be considered as an object, the development of which is outlined by the total resource absorbed by them and the effectiveness of each functioning object.

This algorithm was applied to solve the problem of optimizing the distribution of resources according to the criterion of maximizing income and minimizing risk. Next, the problem of correlating the results of the two models with the two specified criteria arises, since the resource distributions give different structures (Fig. 9–10). In addition, the greatest income is obtained with a decrease in diversification in the resources distribution between objects (at the given levels of profitability), and the minimum risk, on the contrary, is associated with an increase in diversification in the resource distribution (Fig. 10).

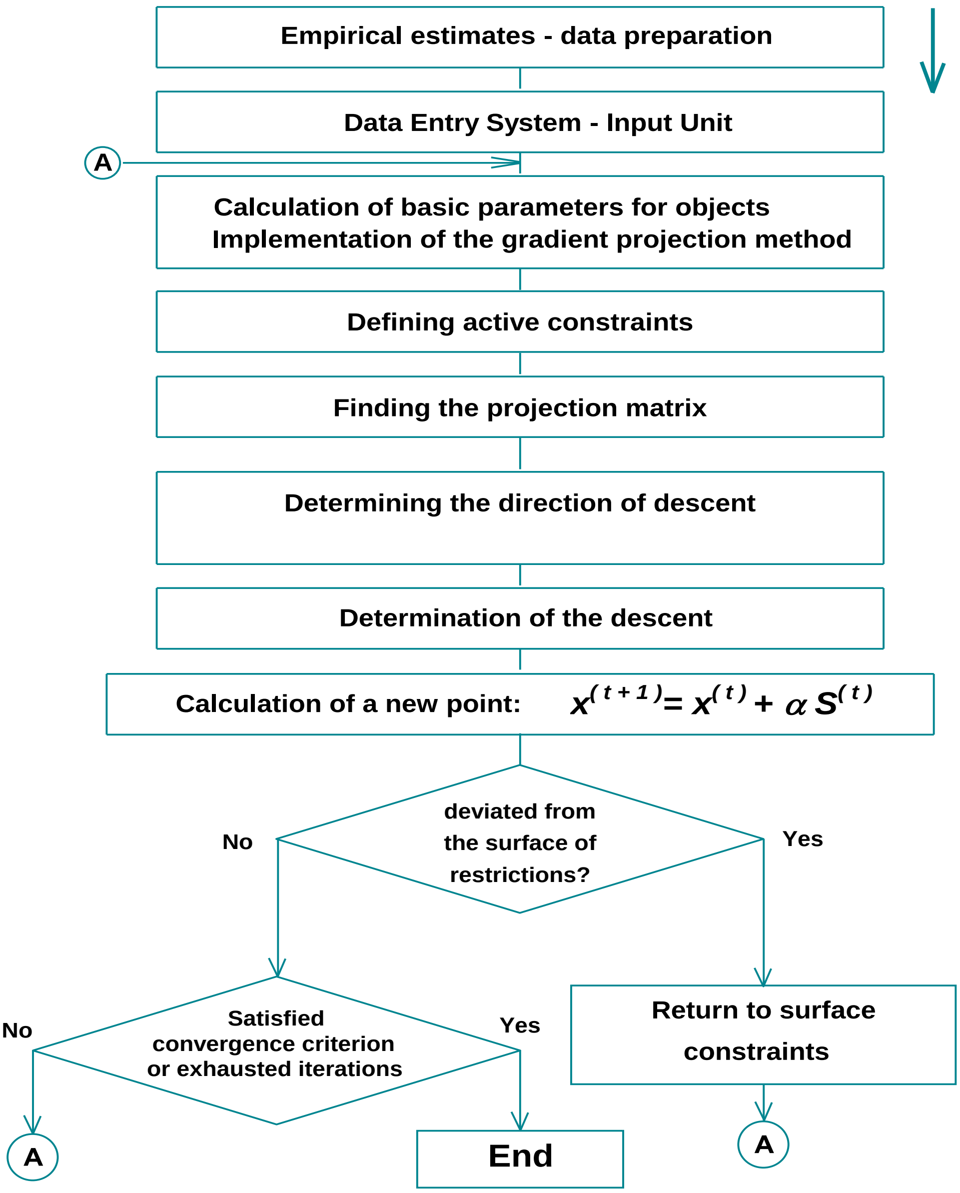

Fig. 6. **Algorithm for developing a numerical portfolio optimization program***

Рис. 6. **Алгоритм разработки численной программы оптимизации портфеля**

* Source [26; 27].

Thus, there is a problem of structural choice, which arises both at the macroeconomic level (when allocating resources between sectors, pursuing a structural policy) and at the microeconomic level, in particular, this concerns the structure of employment at the firm, the structure of income distribution, the structure of the market, where a company is functioning. In these cases, there are many tasks aimed to correlate the guaranteed profit and risk, which are two agents' determinants for their motivation in certain business activities.

Having received the resource, an object somehow uses it, creates a certain amount of product that is sold on the market. To produce this product, it also requires operating costs, which, together with the amount of investments, make up the full costs of this object. Then, when the created product is purchased on the market, this object receives income, the ratio of which to the total amount of costs or invested resources is the amount of return per unit of investment. You can also consider current costs as an element of invested funds, immediately evaluating precisely this value in the framework of the portfolio distribution task. However, the situation is being dynamically adjusted, as there are changes in the market, often not depending on the given portfolio object. For this reason, the value of the return on the invested unit of the resource (the effectiveness of this object) is constantly changing, which should affect the optimization process. If we build the optimization with recalculation of the profitability of portfolio objects, linking the return to the amount of invested resources that affect production, costs, and therefore the total return, the recalculation of returns in the presented algorithm in Figure 6 can spawn a cycle as in Figure 7. Thus, since recalculation of the return value can be looped by the optimization algorithm (Fig. 7) at each iteration, the scenario approach will also be appropriate to apply in the framework of portfolio analysis, as well as the 'input-output' method.

Thus, optimization can be performed in a static mode, that is, with the same values of return on the invested resource for all objects of the portfolio, but these values themselves can change, giving different optimization results – the total risk for the expected income, and the structure of resource allocation. Optimization can be performed for each case of the return value, when the value itself for all objects will change at the same time intervals (or over the entire interval). Then you can build a map of 'distribution structures' for different values of return to understand how the choice will change with the changes in the object efficiency (profitability). These estimates can be performed by iterating over options, assuming that for some objects the return is a function of the invested resource, and for some objects it is not. In this case, the value of the return of certain objects will change, while maintaining the value of the return for other objects.

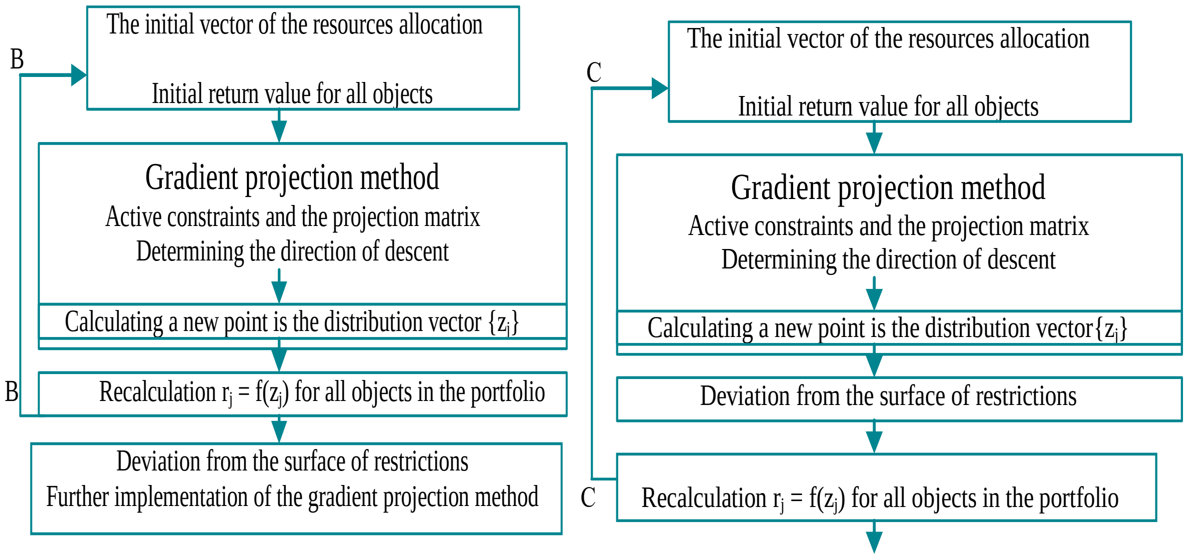

Fig. 7. **Cycle in the optimization algorithm by the gradient projection method**

Рис. 7. **Цикл в алгоритме оптимизации методом проекций градиента**

If the optimization algorithm provides recalculation of the return value for all objects, and then, according to the algorithm of the gradient projection method, we determine the deviation from the descent surface by following the necessary steps of this method, this can give a cycle along the BB line (Fig. 7, left). The recoil values will be changed, again a new distribution point will be selected, for which its own return values will again arise if there is a relationship between the return value and the invested resource for each object. If the conversion of the recoil value is carried out after the new point has shown approaching or moving away from the optimum one, that is, not at the BB level (Fig. 7, left), but at the CC stage (Fig. 7, right), new recoil values will be obtained, for which you have to look for a new descent and evaluate the deviation from the surface of the constraints.

Thus, embedding the gradient of recoil recalculation into the projection method does not solve the problem, although the CC version is slightly more adequate, since it already estimates the deviation from the surface of the constraints and it is possible to recalculate the scale of the return with the existing relationship between recoil and investments. If the relationship between the return and the value of the investment of resources for each object exists, then it is revealed for the previous period, since there are no data for the future period. The question of whether it is valid to transfer such a dependency to a future period remains. This circumstance emphasizes the relevance of applying the scenario approach when return values on an invested resource are specified for portfolio objects. This approach is quite acceptable to obtain options for 'structural choice'. Next, the problem of determining and refining the decision-making criteria arises, and, up to the criterion, including qualitative assessments given by experts, a choice of resource allocation option can be made.

Figures 8–10 [26] illustrates the result of applying optimization models as a function of changes in income and risk from the resource implementation in three sectors or areas (considered as objects).

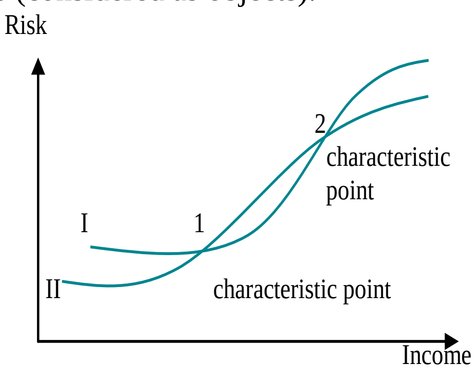

Fig. 8. **Income and risk of economic development under the model of income maximization (I), risk minimization (II)**

Рис. 8. **Доход и риск развития экономики по модели максимизации дохода (I), минимизации риска (II)**

Figure 8 shows that the expected return increases with the risk for each of the optimization models. At the intersection point for each model, the same combination of expected income and risk is obtained (two 'characteristic points' for two optimization models). They are not helpful in our choice in favor of a particular resource allocation structure obtained from the model under the criterion of the highest income or lowest risk, and even the criterion of the income and risk correlation, since these values are the same for each of the models at the 'characteristic point' (Fig. 8). The choice of distribution structure is unlikely to be clear, when the smaller amount of income corresponds to a smaller risk (to the left of the intersection of curves I–II), and the larger amount of income – a greater risk (to the right of the intersection of curves I–II). Which distribution to choose, with less income and less risk, or with more income and more risk, also creates a decision-making task. This decision depends even on the agent or agents who will make this choice, on their risk aversion. For a given amount of income outside the intersection, the greater the risk is, the distribution is obviously less preferable, the less the risk is, the more preferable it is. However, even in this case, there may be ambiguity if the risk values do not differ much, so that the decision maker perceives this risk in approximately the same way.

The economic meaning of the characteristic point is the ambiguity of 'structural choice'. In other words, it is not clear which resource allocation is preferable. Up to the intersection point number 1 in Figure 2 of line III, the resulting distributions under the income maximization model are unacceptable, since the risk is higher than under the risk minimization model (II). To the right of the intersection point number 1, on the contrary, distributions obtained by the risk minimization model give a greater risk than by the income maximization model (for a given value of return). Therefore, the most appropriate distribution structure for choosing the first model is income maximization. However, after the second 'characteristic point' (Fig. 8), the first model provides more risk for the same amount of income, so, all other things being equal, the best choice is the second model (II). This method of analysis is of high importance when evaluating the entire range of government activities, especially when implementing public programs and projects.

Of course, there is the problem of whether the expected income is achievable, where the optimization results for different models overlap. There may be solutions that the lines do not intersect, and then it will be necessary to evaluate the proximity of these lines, the smallest distance between them. The application of these decision-making criteria will become even more complex. However, when considering various scenarios for the implementation of public projects and development programs, as well as corporate programs covering various areas of diversified business, it is possible to identify an acceptable spread of expected income, based on the expected rate of economic growth (by evaluating the contribution to the growth rate and proposed activities according to the ongoing structural analysis) [28].

Efficiency is assessed based on the income and costs that are known, including the income at a specific point, but the objects of the system will receive different amounts of resources, and this will fundamentally affect their development and future contribution to economic growth.

Therefore, the 'structural choice' is best performed by using certain criteria for qualitative assessment for the development of facilities and institutions and separately for each priority area or project. It is also useful to obtain various scenarios for further impact of the selected resource allocation structure (investment) on the functioning of economic sectors and types of activities, projects or priority areas.

Figures 9–10 show the result of optimization (in the course of computer simulation of models), that is, the structure of resource distribution under the income maximization model (Fig. 9) and risk minimization (Fig. 10) from the value of the expected income from distribution (for a given value of return) for three objects.

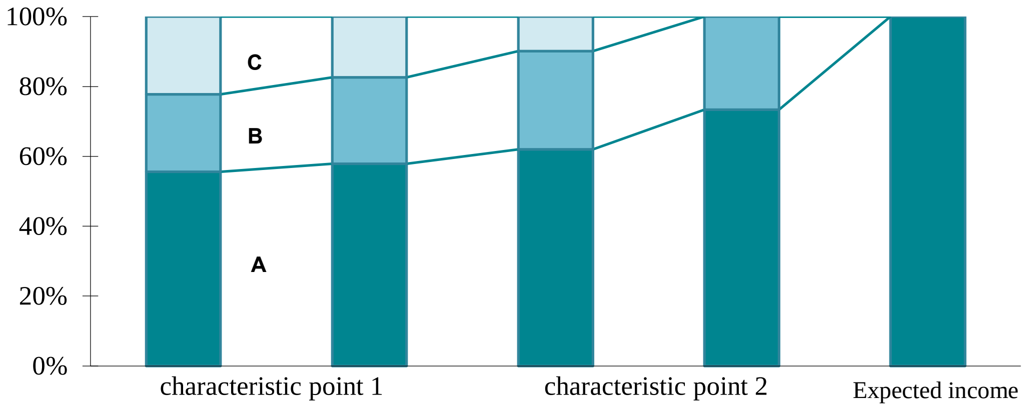

Fig. 9. **Resource allocation based on the income maximization model (I)**

Рис. 9. **Распределение ресурсов по модели максимизации дохода (I)**

The characteristic points indicated in Figures 9–10 reflect a situation where total income and risk are generated by different resource allocation structures. According to the model of maximizing income and minimizing risk, economic objects do not get the same resources at specific points. Moreover, with the growth of expected income, the first model (income maximization) reduces the diversification of the economy. This situation corresponds to the greatest risk.

According to the model of minimizing aggregate risk (Fig. 10), the highest expected return is achieved with greater diversification. The risk is also the greatest. Therefore, both lowering the distribution diversification and increasing it may not reduce the risk. Of course, it should be taken into account that the refusal to allocate resources in priority areas for the first model is not taken into account in the optimization itself. But in practice, through feedback channels, this circumstance can greatly affect the amount of return, changing it not in the direction of increase, which will affect the overall value of the return of the remaining directions of resource allocation, the achievability of a certain amount of income.

Thus, optimization models give a static picture. However, they are useful in identifying the existence of a structural choice problem, and in identifying scenarios for the use of resources in priority areas of implementation.

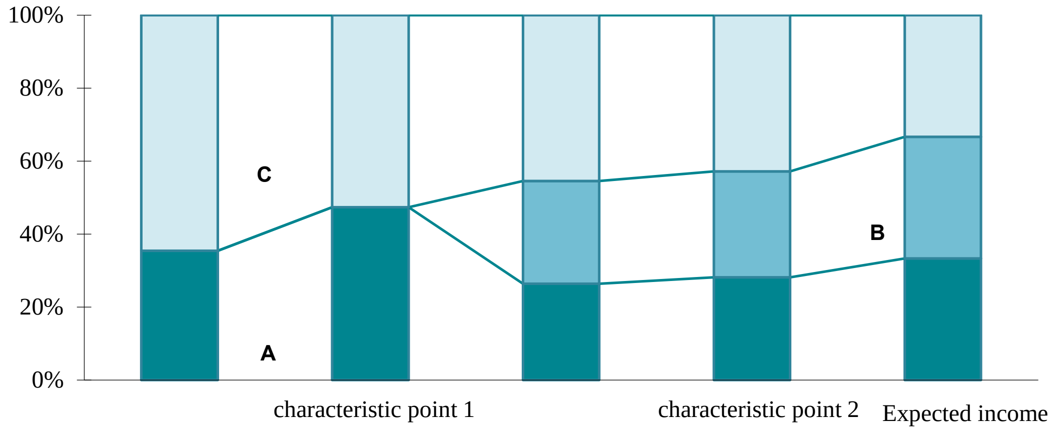

Fig. 10. **Structure of resource allocation based on the risk minimization model (II)**

Рис. 10. **Распределение ресурсов по модели минимизации риска (II)**

Based on the given examples of rationalistic criteria driven decision-making and taking into account the uncertainty of choice at characteristic points and even outside of them, we understand the need for additional criteria to choose the structure of resource allocation. They can consist in evaluating the functioning of individual objects, directions when allocating a particular resource.

For example, social indicators of development can be applied as criteria for decision-making. In this case, the value of the return, the multiplier effect can be adjusted taking into account these additional criteria.

However, the application of optimization clearly shows the urgent need to remove the structural choice uncertainty. Investment, saturation of resources in some priority areas or markets can weaken other areas. These opportunity costs and the additional effect hidden in the nature of resource allocation are not taken into account today when making decisions. Due to the opportunity costs, the potential of some projects may be weakened, while others may be strengthened. This in itself creates an additional structural transformation.

One of the possible solutions to the 'characteristic point' problem is to estimate the growth rate of income and risk at this point and its surroundings. Then, all other things being equal, the structural choice can be reduced to such a distribution of the resource that gives a positive and increasing rate of income growth in the vicinity of the characteristic point and a negative rate of risk growth. In addition, decision-making at a specific point and beyond may involve expert procedures, reviewing alternatives with a point system (for example, the Board calculation method), and applying other procedures to justify the choice and final design of a management decision.

If the situation in the economy is not located at a characteristic point, then the problem of making a decision about the allocation of resources is still on the agenda. The fact is that the decision-maker has a choice between high income and low risk [29; 30]. Two solutions with different risks and different resource allocation structures may correspond to a certain amount of expected income. In theory, the lowest risk should be chosen for the same income, but if the methods of qualitative assessment (expert) are used in the selection, and the value of the expected risk slightly differs, the result cannot be unambiguous. You can choose a solution that involves a lot of risks for a single income, but can lead to a significant change in the quality of functioning of the managed economic system.

Real management tasks may resemble what was demonstrated above in optimization models, but they may be even more uncertain, since the rationalistic criteria in the models are used in management practice with known limitations, including irrational choice when making a decision.

From the perspective of developing an efficient economic policy, the problem of stimulating the development of new industries has always been and continues to be a kind of a stumbling block. No universal management recipes have been developed yet. Apparently, they cannot be offered due to the specifics features of new activities that generate high market uncertainty. However, it is clear that it is the labor resource which is adaptable, able to service and solve problems to maintain efficiency that new industries and technologies need. New personnel can be trained for new types of work, but they can be obtained from the existing personnel that need to be diverted from current activities and re-trained for new types of work. Both processes usually occur synchronously and require appropriate solutions, such as determining the required number of retrained and re-trained personnel. This number is determined by the scale of development of new activities. Moreover, the combinatorial augmentation, that is, the training of new personnel, depends entirely on the ability of the educational system to respond to the development of new types of work.

This shows the differences in the existing structures and labor markets, which must be taken into account when developing and making decisions on the economic development of countries in their interaction. The proposed approach can be applied both at the level of macroeconomics and at the level of a company, a large firm where new and old types of work are being developed. Management is based on identifying the state of dynamics in order to suggest ways to create a new labor resource and retraining and use the existing labor resource in new types of work. This creates a mechanism for managing the restructuring of the economic system of various scales and complexity.

Conclusion

Discussed economy restructuration requires innovative approaches in management. The ambiguity of decisions arises when rationalistic decision-making criteria are used, which is very clearly seen when simulating decisions under optimization models (which embody the rationalistic criterion). At the same time, we conclude that there is an objective limitation of rationalistic criteria, and even their inconsistency, if, say, two or more rationalistic decision-making criteria are used. Neo-Schumpeterian-type models showing structural changes on empirical material do not solve the problem of criterion and choice at a ‘characteristic point’, but they show serious differences in the existing structural dynamics.

The choice of structure is not obvious, and this is confirmed by rationalistic criteria based analysis. This ensures the uncertainty of labor markets and development prospects. There was no purpose to give answers to all possible questions regarding the decisions made. The presented analysis and models give reason to believe that management cannot neglect these aspects. Now it treats them very cool, does not take into account. Therefore, the study may proceed by determining the mutual influence of the considered processes of the influence of combinations and the applied instruments of economic policy aimed at supporting the economic development of each country.

The most relevant conceptual findings can be presented in two main approaches.

Firstly, managing economic development at the macro level involves solving structural management problems related to determining the optimal allocation of resources. However, general optimization models presented by V.L. Kantorovich and T. Kupmans [31–33] do not provide unambiguous solutions precisely when solving the problem of structural choice.

Secondly, decision-making in restructuring involves choosing the direction for the flow of resources, and the parameters of profitability and risk are necessary, but not sufficient for making a decision. A particularly difficult decision is found at a characteristic point where different distribution structures give the same profitability and risk level. This requires adaptation and application of additional methods in management-expert, forecast, comparison of the rate of change in income and risk, assessment of the quality of the managed system, or special parameters that characterize the usefulness of resources according to this very distribution. This approach can be applied under the Schumpeter's theory of development management.

The governing influences affecting the resource movement within the economy are likely to change the differences in risk and profitability between activities. This cannot but affect the motives of agent behavior and decision making. Consequently, the result of the damping of risks in the manufacturing sector (industry) can increase mobility of resources (labor and capital) in the direction of the industrial economy, which will increase the contribution of high-tech industries to growth, and eventually enhance the ability of technological renovation. Government institutional adjustments, including the implementation of large-scale national projects, can be considered as tools for pursuing this macroeconomic policy. The multipurpose aspect of macro control requires contradictory tools of action, as well as development goals. This circumstance can be strong in the sense of influencing the feedback channel on the implemented economic policy measures and depreciate them. A model or strategy of economic growth that neglects the structural dynamics of the elements of a growing system will turn out to be a very short euphoria, since the established and changing structural and institutional quality of the economy will nullify the government efforts in a short time. In the future, manufacturability scope in the 'speculative flywheel' of each economy will be relevant and influence further technological progress. It is this structural relationship that determines the current period of economic development of the world system. The transformation of this structure, the strength of which is laid down and generated in its elements, means no more but the Schumpeterian evolution of the world economic system, which encompasses individual countries to different degrees and with particular acuity given the previous stages of development.

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Information about the Author

Sukharev Oleg Sergeevich – Doctor of Economics, Professor, Chief Researcher, Institute of Economics of the Russian Academy of Sciences (32, Nakhimovskii Prospekt, Moscow, 117218, Russia; e-mail: o_sukharev@list.ru).

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Сведения об авторе

Сухарев Олег Сергеевич – доктор экономических наук, профессор, главный научный сотрудник, Институт экономики Российской академии наук (Россия, 117218, г. Москва, Нахимовский проспект, 32; e-mail: o_sukharev@list.ru).

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