Available online at www.rajournals.in

RA JOURNAL OF APPLIED RESEARCH

ISSN: 2394-6709

DOI:10.47191/rajar/v8i2.09

Volume: 08 Issue: 02 February-2022

International Open Access

Impact Factor- 7.036

Page no.- 111-119

Mathematical Models of Coordination of Population Employment in the Labor Market

Axatov A.R.[1], Nurmamatov M.K.[2], Nazarov F.M.[3]

[1]Doctor of Technical Sciences, Professor, Samarkand State University

[2]Assistant, Samarkand State University

[3]PhD., Samarkand State University

ARTICLE INFO

Published Online: 15 February 2022

Corresponding Author: Axatov A.R.

ABSTRACT

In this work, one of the most pressing issues today is the issue of intellectual modeling of employment in the labor market. The study proposes a classification of methods of labor market regulation, the structure of the conceptual model of the labor market, a stochastic mathematical model of labor market self-organization, the methodology of studying the stability of mathematical models of labor market regulation is considered and experimental results are obtained. The obtained results are compared and explained in graphs and conclusions are given.

KEYWORDS: Employment, Labor Market, Conceptual Model, Stochastic Mathematical Model, Stagnation, Probability, Self-Organization.

INTRODUCTION

The goal of concrete measures to regulate the labor market is, ultimately, to achieve its sustainability, and the specific methods of management applied in a particular sequence play an important role in this. Hence, the G goal of achieving labor market stability is the combination of all Gi goals of possible action programs to regulate it:

$$G = \bigcup_i G_i, \qquad (1)$$

here, $i = \overline{1, N}$, $N -$ the number of elementary objectives of labor market regulation.

As can be seen from the above relationship (1), the goal of each program is an integral part of the task of managing the labor market. Each program is implemented according to a scenario based on the executors of the methods of labor market regulation (M_i), - agents of the labor market (A_i) and resources (R_i). Each program is implemented according to a scenario based on the executors of the methods of labor market regulation - agents and resources of the labor market. The global goal of achieving a stable balance of the labor market is overshadowed by the composition (K) of existing regulatory methods, labor market agents and resources (material, natural, information, monetary, etc.), i.e. [4]:

$$G = K(M, A, R) \qquad (2)$$

MAIN BODY

Classification of regulatory methods. The market model of economic development adopted at the state level serves as a basis for the application of appropriate management methods that define the existing classification of labor market regulation methods - they are divided into methods of regulating labor demand, regulating labor supply and regulating labor prices (Figure 1) [2]. In turn, such regulatory methods (classes of methods) are divided into economic and administrative-legal methods in relation to the actions of labor market management.

Creating the economic conditions for the successful solution of problems arising in the labor market is the basis of economic methods of regulation.

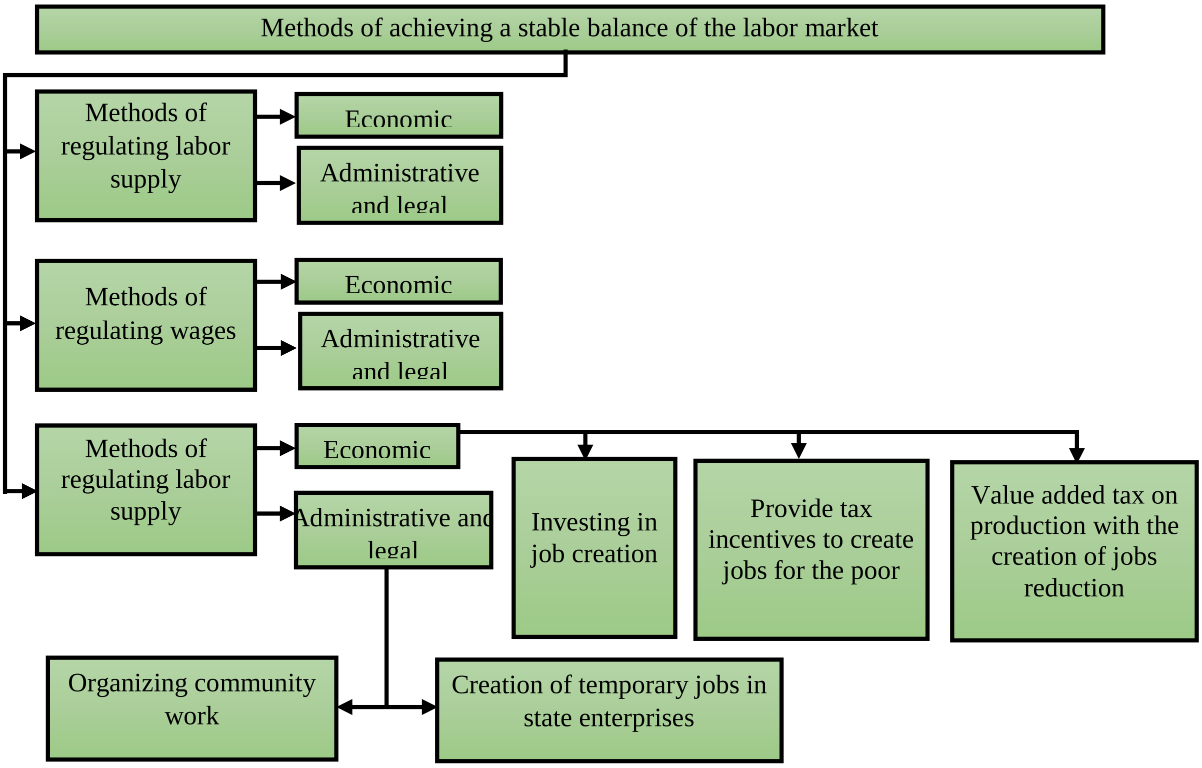

Figure 1. Classification of methods of labor market regulation

The above methods are influenced by market relations and with the help of market mechanisms. A agent L interacts with an object R resource U to obtain the result:

$$A + L + R \rightarrow U \quad (3)$$

There are three ways to use economic impact to regulate labor demand (3).

The structure of the conceptual model of the labor market. The main problem in determining the composition of the model is that, depending on the modeling objectives, the division of the whole system into its components is relative. Therefore, an important step in creating a conceptual model is to define the modeling objectives.

In this model, the global goal of ensuring a stable balance of the regional labor market is presented as a set of goals that define the methods (M), agents (A), and resources (R) used to regulate the labor market (Figure 2).

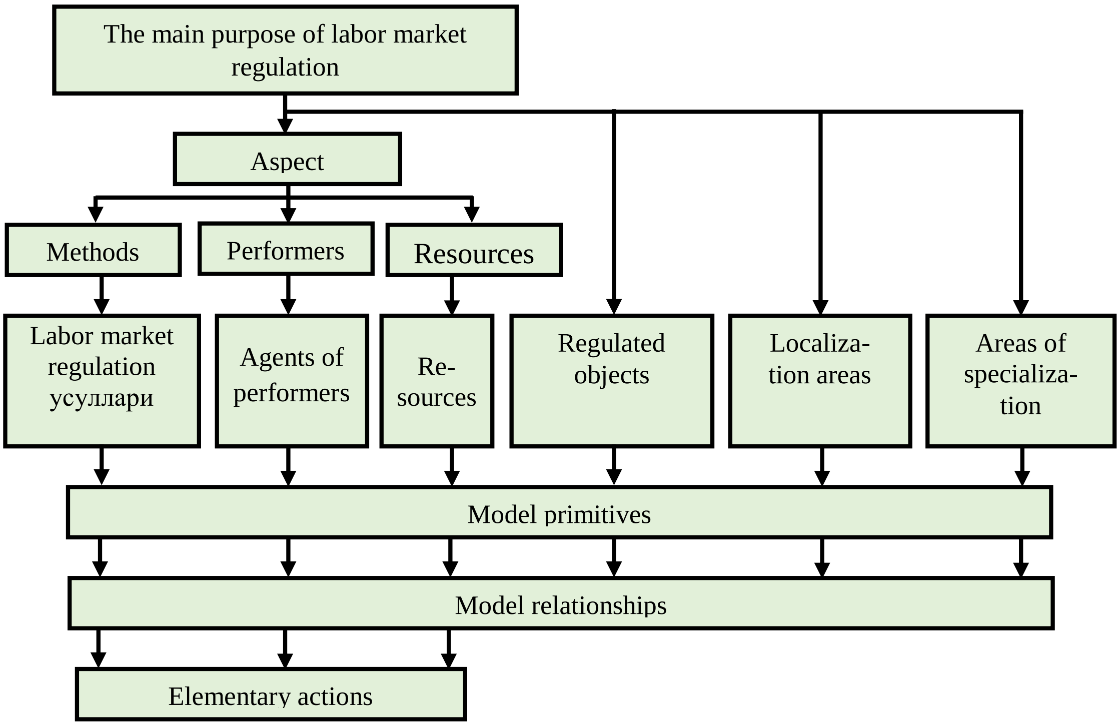

Figure 2. Conceptual model of labor market regulation

Each of the components of the conceptual model corresponds to a set of attributes, the combination of which provides a set of attributes of the model. Attribute relationships are not predefined because they are completely dependent on relevance and overlap with the corresponding relationships of the $At-$ model objectives.

Thus, the conceptual model of the labor market:

$$KM_{pt} = \{G, M, T, O, A, L, R, D, At\}, \tag{4}$$

here $G-$ the global goal of sustainable development of the labor market,

$M-$ a set of methods of labor market regulation,

$T-$ a set of localizations of affected objects,

$O-$ a set of sectoral specialties of the regional economy,

$A-$ a set of executive agents,

$L-$ a set of market objects,

$R-$ resource package,

$D-$ a set of elementary management actions,

$At-$ a set of attributes of the model.

The task of developing a conceptual model of sustainable balance of the regional labor market in the field of management of socio-economic development of the region is complicated by the fact that in this area there is no "established" system of classification of management goals and methods [6].

A stochastic mathematical model of self-organization in the labor market

Models of labor market self-organization in a particular field proposed by many foreign scholars are mainly intended to analyze the effectiveness of management decision-making and to predict the probability of the development of events in the market for a particular sector of the economy [3]. The regulatory parameters included in such models open up the possibility of studying their effects on macroeconomic processes.

The model of self-organization proposed in this work is based on the generalization of the results proposed in other works for *n* different sectors of the economy and is distinguished by the phenomenological features of the parameters [3].

The parameter $N_1^{(i)}(t)$ is the total number of specialists employed in the i-th sector of the economy per unit time *t*¸ $N_2^{(i)}(t)$ – the number of potential workers who can be involved in the i-th sector and are unemployed per unit of time *t*;

$\sum_{i=1}^{n}\sum_{k=1}^{2} N_k^{(i)}(t) = N = const$ the size of the labor market in *n* industries;

$W_1^{(i,j)}$ – the probability that an unemployed specialist in the *i*-th field probability of finding a job in time $t+dt$ from *t* in the field *j*, $W_2^{(i,j)}$ – the probability of dismissal of a specialist in the i-th field in time $t+dt$ from *t*; $i, j = 1, \cdots, n,\ t \in [0; \infty)$. In general $\sum_{i=1}^{n} W_1^{(i,j)} \neq 1,\ i, j = 1, \cdots, n$.

Suppose that the number of specialists working in the i-th sector of the economy at the initial time *t = 0* is equal to $N_{2_0}^{(i)}$, the number of potential workers who can be involved in the j-th field and unemployed at time t is equal to $N_{2_0}^{(i)}$, i.e.

$$N_1^{(i)}(0) = N_{1_0}^{(i)},$$

$$N_2^{(i)}(0) = N_{2_0}^{(i)}, i, j = 1, \ldots, n. \tag{5}$$

According to the above definitions, it is expressed in the form of a system of differential equations (6) with given initial conditions (6) describing the dynamics of redistribution of labor in n different sectors of the economy, in which the probabilities $W_2^{(i)}$, $W_1^{(i,j)}$ are considered constant quantities. The system (6a) shows that the probabilities $W_2^{(k)}$ accept zero values in all cases except for the *k*-th period of time from *t* to $t+dt$ for differential equations describing the changes $N_1^{(i)}(t)$ and the probabilities that the changes $W_1^{(i,j)}$ assume zero values in all cases except for $i = j$ for the period *t* to $t+dt$ for the differential equations describing the changes $N_2^{(i)}(t)$.

$$\begin{cases} \dfrac{dN_1^{(1)}(t)}{dt} = -N_1^{(1)}(t)W_2^{(1)} + \sum\limits_{i=2}^{n} N_1^{(i)}(t)W_2^{(i)} - N_2^{(1)}(t)W_1^{(1,1)} + \sum\limits_{i=2}^{n} N_2^{(i)}(t)W_1^{(i,1)}, \\ \dfrac{dN_1^{(2)}(t)}{dt} = N_1^{(1)}(t)W_2^{(1)} - N_1^{(2)}(t)W_2^{(2)} + \sum\limits_{i=3}^{n} N_1^{(i)}(t)W_2^{(i)} + N_2^{(1)}(t)W_1^{(1,2)} - N_2^{(2)}(t)W_1^{(2,2)} + \sum\limits_{i=3}^{n} N_2^{(i)}(t)W_1^{(i,2)} \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ \dfrac{dN_1^{(n)}(t)}{dt} = \sum\limits_{i=1}^{n-1} N_1^{(i)}(t)W_2^{(i)} - N_1^{(n)}(t)W_2^{(n)} + \sum\limits_{i=1}^{n-1} N_2^{(i)}(t)W_1^{(i,n)} - N_2^{(n)}(t)W_1^{(n,n)}, \\ \dfrac{dN_2^{(1)}(t)}{dt} = \sum\limits_{i=1}^{n-1} N_1^{(i)}(t)W_2^{(i)} - N_2^{(1)}(t)\sum\limits_{i=1}^{n} W_1^{(1,i)} + \sum\limits_{i=1}^{n-1} N_2^{(i)}(t)W_1^{(i,1)}, \\ \dfrac{dN_2^{(2)}(t)}{dt} = \sum\limits_{i=1}^{n} N_1^{(i)}(t)W_2^{(i)} + N_2^{(1)}(t)W_1^{(1,2)} - N_2^{(2)}(t)\sum\limits_{i=1}^{n} W_1^{(2,i)} + \sum\limits_{i=3}^{n} N_2^{(i)}(t)W_1^{(i,2)}, \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ \dfrac{dN_2^{(n)}(t)}{dt} = \sum\limits_{i=1}^{n} N_1^{(i)}(t)W_2^{(i)} + \sum\limits_{i=1}^{n-1} N_2^{(i)}(t)W_1^{(i,n)} - \sum\limits_{i=1}^{n} N_2^{(n)}(t)W_1^{(n,i)}. \end{cases} \quad (6)$$

Since any mathematical model certainly has a certain degree of error (not all operating conditions can be taken into account), the study of its stability is one of the important tasks of modeling.

The stability of a system of linear differential equations with a constant coefficient (6) (asymptotic stability or instability) is determined by the location of the roots of the characteristic equation of the matrix of system coefficients relative to the abstract axis.

$$\begin{cases} \dfrac{dN_1^{(1)}(t)}{dt} = -N_1^{(1)}(t)W_2^{(1)} - N_2^{(1)}(t)W_1^{(1,1)} + \sum\limits_{i=2}^{n} N_2^{(i)}(t)W_1^{(i,1)}, \\ \dfrac{dN_1^{(2)}(t)}{dt} = -N_1^{(2)}(t)W_2^{(2)} + N_2^{(1)}(t)W_1^{(1,2)} - N_2^{(2)}(t)W_1^{(2,2)} + \sum\limits_{i=3}^{n} N_2^{(i)}(t)W_1^{(i,2)}, \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ \dfrac{dN_1^{(n)}(t)}{dt} = -N_1^{(n)}(t)W_2^{(n)} + \sum\limits_{i=1}^{n-1} N_2^{(i)}(t)W_1^{(i,n)} - N_2^{(n)}(t)W_1^{(n,n)}, \\ \dfrac{dN_2^{(1)}(t)}{dt} = \sum\limits_{i=1}^{n} N_1^{(i)}(t)W_2^{(i)} - N_2^{(1)}(t)\sum\limits_{i=1}^{n} W_1^{(1,i)}, \\ \dfrac{dN_2^{(2)}(t)}{dt} = \sum\limits_{i=1}^{n} N_1^{(i)}(t)W_2^{(i)} - N_2^{(2)}(t)\sum\limits_{i=1}^{n} W_1^{(2,i)}, \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ \dfrac{dN_2^{(n)}(t)}{dt} = \sum\limits_{i=1}^{n} N_1^{(i)}(t)W_2^{(i)} - \sum\limits_{i=1}^{n} N_2^{(n)}(t)W_1^{(n,i)}. \end{cases} \quad (6a)$$

In the study (6), the characteristic polynomial stability of the matrix of system coefficients was accepted only $\operatorname{Re}\lambda_j < 0$ ReLyam = 0 satisfies the condition (this means only when (5), (6) is asymptotic stable) [5].

For high-level polynomials (6), the direct calculation of the eigenvalues of the characteristic equation of the system coefficient matrix is a time-consuming process. At the same time, the error of the obtained results increases.

Methodology for studying the stability of mathematical models of labor market regulation. In the study of the stability of the mathematical model of self-organization of the labor market for several sectors of the economy (5), (6) the conditions of the stability of the problem are expressed as follows. It is economically acceptable for $W_2^{(i)}$, $W_1^{(i,j)}$, $i, j = 1, \cdots, n$ to be invariant quantities [5].

The matrix of coefficients of the system (6) is determined by W.

$$\begin{pmatrix} -W_2^{(i)} & 0 & \cdots & 0 & -W_1^{(1,1)} & W_1^{(2,1)} & \cdots & W_1^{(n,1)} \\ 0 & -W_2^{(2)} & \cdots & 0 & W_1^{(1,2)} & -W_1^{(2,2)} & \cdots & W_1^{(n,2)} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & \cdots & -W_2^{(n)} & W_1^{(1,n)} & W_1^{(2,n)} & \cdots & -W_1^{(n,n)} \\ W_2^{(1)} & W_2^{(2)} & \cdots & W_2^{(n)} & -W_1^{(1,1)}-\cdots-W_1^{(1,n)} & 0 & \cdots & 0 \\ W_2^{(1)} & W_2^{(2)} & \cdots & W_2^{(n)} & 0 & -W_1^{(2,1)}-\cdots-W_1^{(2,n)} & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ W_2^{(1)} & W_2^{(2)} & \cdots & W_2^{(n)} & 0 & 0 & \cdots & -W_1^{(n,1)}-\cdots-W_1^{(n,n)} \end{pmatrix} \quad (7)$$

The characteristic equation for the matrix W is constructed as follows:

$$\det(W-\lambda 1)=0, \quad (8)$$

here I – $n \times n$ dimensional unit matrix. Equation (8) is equally to the following equation [37]:

$$P_n(\lambda)=\alpha_0+\alpha_1\lambda+\cdots+\alpha_n\lambda^n=0,\ \alpha_n=1 \quad (9)$$

When calculating sufficiently high-order polynomials, a very large character reserve in function values may be required to obtain approximate values of the coefficients, which is difficult to ensure in practice. Careless rounding of them during the calculation process can disrupt their interdependence and subsequently lead to incorrect values of their inherent values. The stability of a characteristic polynomial of a matrix W can be determined without calculating its eigenvalues [1].

Based on A. Stodol's theorem, it is possible to draw a conclusion about the stability of a polynomial by knowing the coefficients of the characteristic equation for the matrix W. The positivity of the coefficients is necessary but not sufficient for stability.

For the stability of Equation (9) it is necessary and sufficient that the following conditions are met by the Raus-Gurvits criterion [4]:

$$\Delta_1=\alpha_1>0,\ \Delta_2=\begin{vmatrix}\alpha_1 & \alpha_0\\ \alpha_3 & \alpha_2\end{vmatrix}>0,\cdots,\ \Delta_n=\alpha_n\Delta_{n-1}>0.$$

This criterion is used to study the asymptotic stability of (5), (6).

From an economic point of view, the stagnation of (5), (6) means that in the case of the employment rate (5), the system returns to its initial state over time with deviations not greater than (6) [5]. If the problem (5), (6) is unstable, then the small deviations of (5) also lead to a different ratio of the number of unemployed and those engaged in production in many sectors of the economy.

Forecasts can be made by analyzing the data obtained on the stable and unstable conditions of the labor market for n different sectors of the economy. The obtained forecast will help to get rid of the crisis in the labor market.

Below we consider the application of the mathematical model of self-organization of the labor market for two different sectors of the economy [8].

Let us assume that $N_1^{(i)}(t)$ is the total number of specialists working in the *i*-th field of the economy per unit of time t; $N_2^{(i)}(t)$ is the number of potential workers who can be involved in the *i*-th network and are unemployed per unit of time t;

$\sum_{i=1}^{n}\sum_{k=1}^{2}N_k^{(i)}=N=const$ n industry labor market size; $W_1^{(i,j)}$ - is the probability that an unemployed specialist in the *i*-th field will find a job in his specialty in the *j*-field for a period of time from *t* to $t+dt$, $W_2^{(k)}$ is the probability of dismissal of a specialist in the *k*-th field for a period of time from *t*; $i,j,k=1,2,\ t\in[0;\infty)$.

In general $\sum_{i=1}^{n}W_1^{(i,j)}\neq 1,\quad j=1,2.$

In accordance with the above definitions, a system of differential equations with given initial conditions (5) describing the dynamics of redistribution of labor in two different sectors of the economy is obtained with simple considerations:

$$\begin{cases} \dfrac{dN_1^{(1)}(t)}{dt} = -N_1^{(1)}(t)W_2^{(1)} - N_1^{(2)}(t)W_2^{(2)} - N_2^{(1)}(t)W_1^{(1,1)} + N_2^{(2)}(t)W_1^{(2,1)}, \\ \dfrac{dN_1^{(2)}(t)}{dt} = N_1^{(1)}(t)W_2^{(1)} - N_1^{(2)}(t)W_2^{(2)} + N_2^{(1)}(t)W_1^{(1,2)} - N_2^{(2)}(t)W_1^{(2,2)}, \\ \dfrac{dN_2^{(1)}(t)}{dt} = N_1^{(1)}(t)W_2^{(1)} + N_1^{(2)}(t)W_2^{(2)} - N_2^{(1)}(t)\left(W_1^{(1,1)} + W_1^{(1,2)}\right) + N_2^{(2)}(t)W_1^{(2,1)}, \\ \dfrac{dN_2^{(2)}(t)}{dt} = N_1^{(1)}(t)W_2^{(1)} + N_1^{(2)}(t)W_2^{(2)} + N_2^{(1)}(t)W_1^{(1,2)} - N_2^{(2)}(t)\left(W_1^{(2,1)} + W_1^{(2,2)}\right). \end{cases} \quad (10)$$

Probabilities $W_2^{(i)}, W_1^{(i,j)}$ are also assumed to be constant quantities. Such an assumption is economically acceptable.

The system of differential equations (10) takes the following form, given that an unemployed person can claim to replace a specialist working in the *i*-th network, provided that the employee is laid off, i.e. the dismissal of an employee in the *i*-th network (10):

$$\begin{cases} \dfrac{dN_1^{(1)}(t)}{dt} = -N_1^{(1)}(t)W_2^{(1)} - N_2^{(1)}(t)W_1^{(1,1)} + N_2^{(2)}(t)W_1^{(2,1)}, \\ \dfrac{dN_1^{(2)}(t)}{dt} = -N_1^{(2)}(t)W_2^{(2)} + N_2^{(1)}(t)W_1^{(1,2)} - N_2^{(2)}(t)W_1^{(2,2)}, \\ \dfrac{dN_2^{(1)}(t)}{dt} = N_1^{(1)}(t)W_2^{(1)} + N_1^{(2)}(t)W_2^{(2)} - N_2^{(1)}(t)\left(W_1^{(1,1)} + W_1^{(1,2)}\right), \\ \dfrac{dN_2^{(2)}(t)}{dt} = N_1^{(1)}(t)W_2^{(1)} + N_1^{(2)}(t)W_2^{(2)} - N_2^{(2)}(t)\left(W_1^{(2,1)} + W_1^{(2,2)}\right). \end{cases} \quad (11)$$

According to this equation, the following definition is accepted:

$$W = \begin{pmatrix} -W_2^{(1)} & 0 & -W_1^{(1,1)} & W_1^{(2,1)} \\ 0 & -W_2^{(2)} & W_1^{(1,2)} & -W_1^{(2,2)} \\ W_2^{(1)} & W_2^{(2)} & -W_1^{(1,1)} - W_1^{(1,2)} & 0 \\ W_2^{(1)} & W_2^{(2)} & 0 & -W_1^{(2,1)} - W_1^{(2,2)} \end{pmatrix} \quad (12)$$

t is well known that an important aspect of any economic system is its stability. A system will be stable if it fully meets the goals of maintaining quality without changing the structure of the system, or if it does not lead to strong changes in the structure of the system in a given set of resources (e.g., in the time interval). From an economic point of view, stagnation (10) reflects a return of the system to its initial state over time, with small deviations in the case of the employment rate (5). If the problem (5), (10) is unstable, then deviations not greater than (5) will certainly lead to a different ratio of the number of unemployed and those engaged in production in the two sectors of the economy.

To examine the problem of stagnation in the dynamics of redistribution of labor in two different sectors of the economy, we first examine the following characteristic equation:

$$\begin{vmatrix} -W_2^{(1)} - \lambda & 0 & -W_1^{(1,1)} & W_1^{(2,1)} \\ 0 & -W_2^{(2)} - \lambda & W_1^{(1,2)} & -W_1^{(2,2)} \\ W_2^{(1)} & W_2^{(2)} & -W_1^{(1,1)} - W_1^{(1,2)} - \lambda & 0 \\ W_2^{(1)} & W_2^{(2)} & 0 & -W_1^{(2,1)} - W_1^{(2,2)} - \lambda \end{vmatrix} = 0 \quad (13)$$

For probabilities, we accept the following definitions:

$$\alpha_0 = W_2^{(1)}W_2^{(2)}W_1^{(1,2)}W_1^{(2,2)} + 3W_2^{(1)}W_2^{(2)}W_1^{(1,2)}W_1^{(2,1)} + W_2^{(1)}W_2^{(2)}W_1^{(1,1)}W_1^{(2,1)} -$$
$$- W_2^{(1)}W_2^{(2)}W_1^{(1,1)}W_1^{(2,2)},$$
$$\alpha_1 = W_2^{(1)}W_2^{(1,2)}W_1^{(2,2)} + W_2^{(2)}W_1^{(1,2)}W_1^{(2,2)} + 2W_2^{(2)}W_1^{(1,2)}W_1^{(2,1)} + W_2^{(2)}W_1^{(1,1)}W_1^{(2,1)} +$$
$$+ 2W_2^{(1)}W_1^{(1,2)}W_1^{(2,1)} + W_2^{(1)}W_1^{(1,1)}W_1^{(2,1)} + 2W_2^{(1)}W_2^{(2)}W_1^{(2,1)} + 2W_2^{(1)}W_2^{(2)}W_1^{(1,2)},$$
$$\alpha_2 = W_1^{(1,1)}W_1^{(2,2)} + W_1^{(1,2)}W_1^{(2,2)} + W_1^{(1,2)}W_1^{(2,1)} + W_2^{(1)}W_2^{(2)} + W_2^{(1)}W_1^{(1,2)} + W_2^{(2)}W_1^{(2,1)} +$$
$$+ W_1^{(1,1)}W_1^{(2,1)} + W_2^{(2)}W_1^{(1,2)} + W_2^{(2)}W_1^{(1,1)} + W_2^{(1)}W_1^{(2,2)} + 2W_2^{(1)}W_1^{(2,1)},$$
$$\alpha_3 = W_2^{(1)} + W_2^{(2)} + W_1^{(1,1)} + W_1^{(1,2)} + W_1^{(2,1)} + W_1^{(2,2)}.$$

In this case (13) it looks like this:

$$P_4(\lambda) = \lambda^4 + \alpha_3\lambda^3 + \alpha_2\lambda^2 + \alpha_1\lambda + \alpha_0 = 0, \alpha_4 = 1$$

The Hurwitz matrix is written as follows,

$$M_{p_4} = \begin{pmatrix} \alpha_1 & \alpha_0 & 0 & 0 \\ \alpha_3 & \alpha_2 & \alpha_1 & \alpha_0 \\ 0 & 1 & \alpha_3 & \alpha_2 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (14)$$

According to the Raus- Hurwitz criterion, the $P_4(\lambda)$ polynomial is stable only if all major diagonal minors of the M_{P_4} Hurwitz matrix

$$\Delta_1 = \alpha_1, \Delta_1 = \begin{vmatrix} \alpha_1 & \alpha_0 \\ \alpha_3 & \alpha_2 \end{vmatrix}, \Delta_1 = \begin{vmatrix} \alpha_1 & \alpha_0 & 0 \\ \alpha_3 & \alpha_2 & \alpha_1 \\ 0 & 1 & \alpha_3 \end{vmatrix}$$

meet the following conditions (the matter (10) is asymptotic stable) [37]:

$$\Delta_1 > 0, \Delta_1 > 0, \Delta_1 > 0, \quad \text{i.e.}$$

$$\alpha_1 > 0, \alpha_2 - \alpha_0\alpha_3 > 0, \alpha_1\alpha_2\alpha_3 - \alpha_1^2 - \alpha_0\alpha_3^2 > 0,$$

RESULTS OF THE EXPERIMENT

Probabilities (5), (10) assume that the system assumes the following exact values:

$$W_2^{(1)} = 0.8,\quad W_2^{(2)} = 0.2,\quad W_1^{(1.1)} = 0.3,\quad W_1^{(1.2)} = 0.2,\quad W_1^{(2.1)} = 0.4,\quad W_1^{(2.2)} = 0.1.$$

In that case

$$\Delta_1 = 0.328 > 0, \qquad \Delta_2 = 0.382 > 0, \qquad \Delta_3 = 0.656 > 0.$$

This results in a $P_4 = (\lambda)$ polynomial stability in the given probabilities. Hence, the problem (5), (10) returns to the equilibrium state from any state of imbalance at *t*, which tends to infinity for an asymptotic constant, i.e., given probability values.

In another case, the probabilities (5), (10) assume that the system has the following values:

$$W_2^{(1)} = W_2^{(2)} = W_1^{(1.1)} = W_1^{(1.2)} = W_1^{(2.1)} = W_1^{(2.2)} = 0.9,$$

in that case

$$\Delta_1 = 41.69 > 0, \qquad \Delta_2 = 412.92 > 0, \qquad \Delta_3 = -2175 > 0.$$

Hence, for the given probabilities, the polynomial $P_4 = (\lambda)$ is unstable, which in turn indicates that the problem (5), (10) is asymptotic unstable.

The given system of initial conditional differential equations describing the dynamics of redistribution of labor in three different sectors of the economy (5) has the following form

$$\begin{cases} \dfrac{dN_1^{(1)}(t)}{dt} = -N_1^{(1)}(t)W_2^{(1)} + \sum_{i=2}^{n} N_1^{(i)}(t)W_2^{(i)} - N_2^{(1)}(t)W_1^{(1,1)} + N_2^{(2)}(t)W_1^{(2,1)} + N_2^{(2)}(t)W_1^{(3,1)}, \\ \dfrac{dN_1^{(2)}(t)}{dt} = N_1^{(1)}(t)W_2^{(1)} - N_1^{(2)}(t)W_2^{(2)} + N_1^{(3)}(t)W_2^{(3)} + N_2^{(1)}(t)W_1^{(1,2)} - N_2^{(2)}(t)W_1^{(2,2)} + N_2^{(3)}(t)W_1^{(3,2)}, \\ \dfrac{dN_1^{(3)}(t)}{dt} = N_1^{(1)}(t)W_2^{(1)} + N_1^{(2)}(t)W_2^{(2)} - N_1^{(3)}(t)W_2^{(3)} + N_2^{(1)}(t)W_1^{(1,3)} + N_2^{(2)}(t)W_1^{(2,3)} - N_2^{(3)}(t)W_1^{(3,3)}, \\ \dfrac{dN_2^{(1)}(t)}{dt} = \sum_{i=1}^{3} N_1^{(3)}(t)W_2^{(3)} - N_2^{(1)}(t)\sum_{i=1}^{3} W_1^{(1,i)} + \sum_{i=2}^{3} N_2^{(i)}(t)W_2^{(i,1)}, \\ \dfrac{dN_2^{(2)}(t)}{dt} = \sum_{i=1}^{3} N_1^{(i)}(t)W_2^{(i)} + N_2^{(1)}(t)W_1^{(1,2)} - N_2^{(2)}(t)\sum_{i=1}^{3} W_1^{(2,i)} + N_2^{(3)}(t)W_1^{(3,2)}, \\ \dfrac{dN_2^{(3)}(t)}{dt} = \sum_{i=1}^{3} N_1^{(i)}(t)W_2^{(i)} + \sum_{i=1}^{3} N_2^{(1)}(t)W_1^{(i,3)} - \sum_{i=2}^{3} N_2^{(3)}(t)W_1^{(3,i)}, \end{cases}$$

In this case, the matrix of coefficients W of the system of differential equations $W_1^{(i,j)}, W_2^{(i)},\ i, j = 1,2,3$ has the following form, taking into account the zero values of the probabilities:

$$W = \begin{pmatrix} -W_2^{(1)} & 0 & 0 & -W_1^{(1,1)} & W_1^{(2,1)} & W_1^{(3,1)} \\ 0 & -W_2^{(2)} & 0 & W_1^{(1,2)} & -W_1^{(2,2)} & W_1^{(3,2)} \\ 0 & 0 & -W_2^{(3)} & W_1^{(1,3)} & W_1^{(2,3)} & -W_1^{(3,3)} \\ W_2^{(1)} & W_2^{(2)} & W_2^{(3)} & -W_1^{(1,1)} - W_1^{(1,2)} - W_1^{(1,3)} & 0 & 0 \\ W_2^{(1)} & W_2^{(2)} & W_2^{(3)} & 0 & -W_1^{(2,1)} - W_1^{(2,2)} - W_1^{(2,3)} & 0 \\ W_2^{(1)} & W_2^{(2)} & W_2^{(3)} & 0 & 0 & W_1^{(1,3)} - W_1^{(2,3)} - W_1^{(3,3)} \end{pmatrix}$$

Probabilities (5), (6) assume the following exact values in the system:

$$W_2^{(1)} = 0.1,\quad W_2^{(2)} = 0.2,\quad W_2^{(3)} = 0.3, W_1^{(1,1)} = 0.3,\quad W_1^{(1,2)} = 0.2,\quad W_1^{(1,3)} = 0.1,$$
$$W_1^{(2,1)} = 0.4,\quad W_1^{(2,2)} = 0.1,\quad W_1^{(2,3)} = 0.5,\quad W_1^{(3,1)} = 0.6,\quad W_1^{(3,2)} = 0.2,\quad W_1^{(3,3)} = 0.3$$

In this case, the matrix of coefficients W of the system of differential equations takes the following form:

$$W = \begin{pmatrix} -0.1 & 0 & 0 & -0.3 & 0.4 & 0.6 \\ 0 & -0.2 & 0 & 0.2 & -0.1 & 0.2 \\ 0 & 0 & -0.3 & 0.1 & 0.5 & -0.3 \\ 0.1 & 0.2 & 0.3 & -0.6 & 0 & 0 \\ 0.1 & 0.2 & 0.3 & 0 & -1 & 0 \\ 0.1 & 0.2 & 0.3 & 0 & 0 & -1.1 \end{pmatrix}.$$

The characteristic equation of the matrix of coefficients W of the system of differential equations takes the following form:

$$\begin{pmatrix} -0.1-\lambda & 0 & 0 & -0.3 & 0.4 & 0.6 \\ 0 & -0.2-\lambda & 0 & 0.2 & -0.1 & 0.2 \\ 0 & 0 & -0.3-\lambda & 0.1 & 0.5 & -0.3 \\ 0.1 & 0.2 & 0.3 & -0.6-\lambda & 0 & 0 \\ 0.1 & 0.2 & 0.3 & 0 & -1-\lambda & 0 \\ 0.1 & 0.2 & 0.3 & 0 & 0 & -1.1-\lambda \end{pmatrix} = 0.$$

The characteristic polynomial is as follows:

$$P_6(\lambda) = \lambda^6 + 3.3\lambda^5 + 3.87\lambda^4 + 1.904\lambda^3 + 0.354\lambda^2 + 0.014\lambda - 0.001 = 0,\ a_6 = 1.$$

The Hurwitz matrix for the obtained $P_6(\lambda)$ characteristic polynomial is given as follows:

$$M_{P_4} = \begin{pmatrix} 0.014 & -0.001 & 0 & 0 & 0 & 0 \\ 1.904 & 0.354 & 0.014 & -0.001 & 0 & 0 \\ 3.3 & 3.87 & 1.904 & 0.354 & 0.014 & -0.001 \\ 0 & 1 & 3.3 & 3.87 & 1.904 & 0.354 \\ 0 & 0 & 0 & 1 & 3.3 & 3.87 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

M_{P_6} is the main diagonal minor of the Hurwitz matrix:

$$\Delta_1 = 0.014 > 0, \Delta_2 = 0.007 > 0, \Delta_3 = 0.012 > 0, \Delta_4 = 0.039 > 0, \Delta_5 = 0.106 > 0.$$

Hence, for the given probabilities, the $P_6(\lambda)$ polynomial is stable, and the problem (5), (6) is asymptotic stable.

Figure 3 shows a geometric interpretation of the state of a system of linear differential equations with constant coefficients.

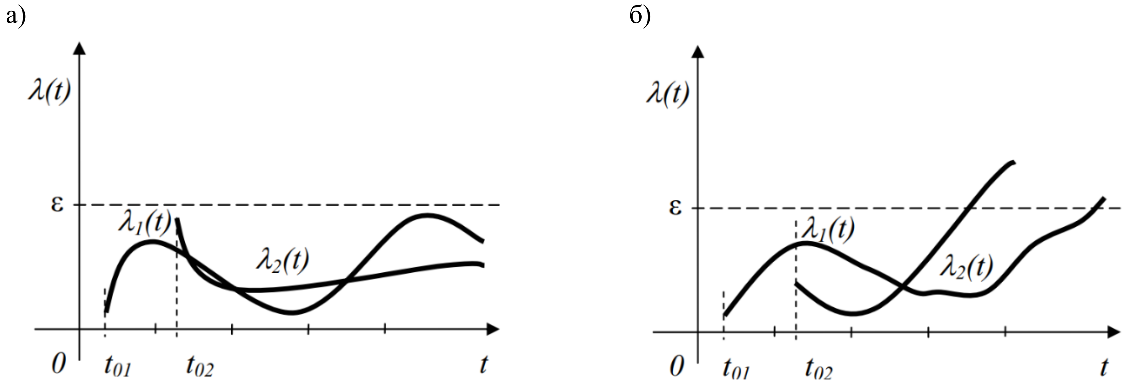

Figure 3. Phase states of a system of linear differential equations with constant coefficients: a) steady state, b) unstable state

Creating a characteristic polynomial for a given W matrix (also for cases where *n*> 3) and checking the stability is a time-consuming process. Therefore, it is advisable to use different application software packages to solve the problems of mathematical modeling of the labor market, for example: Excel spreadsheets, MathCad mathematical system, Maple, Mathematica4, Matlab packages [7].

CONCLUSION

As a result of the study, models of self-organization in the labor market of the population were studied. During the research, the stability of the models was tested experimentally, and the above models can be used in the automation of labor relationship management as a result of modulation into the information system.

REFERENCES

1. Axatov A.R., Nurmamatov M.Q. "Development of models for monitoring the social status of each person and forecasting the living conditions of the population on the basis of personal data", scientific-practical and information-analytical journal "Muhammad Al-Khwarizmi avlodlari", TUIT. - Tashkent, 2 (12) / 2020. p. 6-10
2. Vasiliev A.N. Model of self-organization of the labor market // Economics and Mathematical Methods. - 2001. Volume 37. No. 2. p. 123-127.
3. Ignatiev M.B., Putilov V.A., Smolkov G.Ya. Models and control systems for complex experimental research. -M: Nauka, 1986, 232 p.
4. Korovkin A. G., Dolgova I. N., Korolev I. B. Labor shortage in the Russian economy: macro-economic assessment. 2006. No. 4.
5. Krase M.S., Chuprynov B.P. Fundamentals of mathematics and its applications in economic education. - M.: Delo, 2003. - 688 p.
6. Nurmamatov M.Q. “Mathematical modeling and forecasting of the process of monitoring the social status and employment of the population”, Samdu scientific bulletin. Samarkand. № (3), 2020y - b. 107-113.
7. Salmanov O.N. Mathematical economics using Mathcad and Excel. - St. Petersburg: BHV-Petersburg, 2003. - 464 p.: ill.
8. Semenchin E.A., Zaitseva I.V. Mathematical model of self-organization of the labor market of a two-industry economy: Proceedings of the third regional scientific conference. - Stavropol: SevKavGTU, 2003. -239 p.