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Olena Primierova
https://orcid.org/0000-0002-3967-1982

Alisa Sparish
https://orcid.org/0009-0007-3134-5860

MODELLING OF THE UKRAINIAN LABOR MARKET: SYSTEM DYNAMICS APPROACH

Abstract

The purpose of the article is to develop a System Dynamics model of the functioning and development of the Ukrainian labor market, which can subsequently be used to simulate various government decisions and policies. The Stella Architect software is used to construct the model, allowing to provide insights into the current state of the labor market and forecasts future trends, helping identify potential improvements.

The explanatory System Dynamics Model effectively demonstrates the complex interrelationships that influence the dynamics of the Ukrainian labor market. The identified balancing loops highlight key factors such as retirement, business closures, production levels, and the formation of new businesses, all of which shape labor supply and demand. Each loop illustrates how changes in one economic aspect can impact others, underscoring the interconnectedness of labor dynamics, economic growth, and business development. Furthermore, the developed causal loop diagrams emphasize the cyclical nature of these interactions, where increases in labor supply can result in higher wages and GDP, leading to further investment and business creation. This model offers valuable insights into the feedback mechanisms that may stabilize or destabilize the labor market, particularly in response to external shocks or policy interventions. In the future, the developed model can be used to test various policies for major elements of the model and to simulate its behavior.

Keywords: labor market, system dynamics, unemployment, employment, labor supply, labor demand, monetary policy.

JEL classification: J01, J40, C61, C68

Introduction and problem definition. The full-scale invasion of Russia on the territory of Ukraine significantly impacts the domestic labor market, resulting in considerable fluctuations and changes. The challenges of uncertainty during wartime, the contraction of employment opportunities, structural and qualitative shifts, large-scale flows of displaced persons, and mobilization have exacerbated employment issues. The current labor market landscape can be described as a crisis, characterized by elevated unemployment rates and an urgent need for rapid workforce retraining. Negative trends such as declining employment levels, rising unemployment, imbalances in professional qualifications, market heterogeneity, "brain drain," and increased difficulties in job placement are prevalent during this wartime period in Ukraine's labor market (Cheromukhina, 2022, pp. 41–42).

The stabilization of the labor market should become one of the most important tasks of the state policy. Maintaining an appropriate balance between the supply and demand for labor is determined by various factors, among which population size, migration, birth rate, emigration, and mortality are

significant. Therefore, modelling of the Ukrainian labor market is a vital tool for understanding complex interactions, evaluating policy impacts, and guiding strategic decisions, ultimately contributing to more effective labor market management and socioeconomic development.

Recent publications analysis. Problems of the development of the labor market of Ukraine have been studied by leading domestic scientists, such as O. Bazhenova, V. Blyzniuk, O. Cheromukhina, O. Levitska, I. Lukianenko, M. Oliskevych, O. Rudkovsky, S. Shumska, T. Vasyltsiv.

Unsolved part of the problem. Stabilizing and utilizing the available opportunities and potential of the labor markets in Ukraine require the implementation of systematic and unconventional measures within the framework of state policy (Vasyltsiv et al., 2022, p. 2). However, today in Ukraine there is a lack of a sufficient number of scientific studies related to the labor market modelling and forecasting. It is evident that under conditions of uncertainty, making accurate forecasts is quite challenging. Although, developing a theoretical model that can be used to simulate labor market development and evaluate various policies is highly relevant and necessary.

Research goal and questions. The purpose of the article is to develop a System Dynamics model of the functioning and development of the Ukrainian labor market, which can subsequently be used to simulate various government decisions and policies. The Stella Architect software is used to construct the System Dynamics model, allowing to provide insights into the current state of the labor market and forecasts future trends, helping identify potential improvements. This allows decision-makers to test various strategies and observe potential outcomes without the risks associated with real-world experimentation (Sterman, 2000, p. 22).

Main findings. The dynamics of the labor market are defined by changes in population size – population growth through natural increase or migration can lead to a rise in the labor supply, affecting market wages and unemployment rates. Similarly, levels of emigration and mortality are also important for the labor market. A reduction in population size due to emigration or an increase in mortality can impact the labor force volume and market competition.

The further dynamics of the labor market depend on enterprise activities and the creation of new jobs. Increased labor demand from enterprises promotes higher employment levels and sustains wage levels.

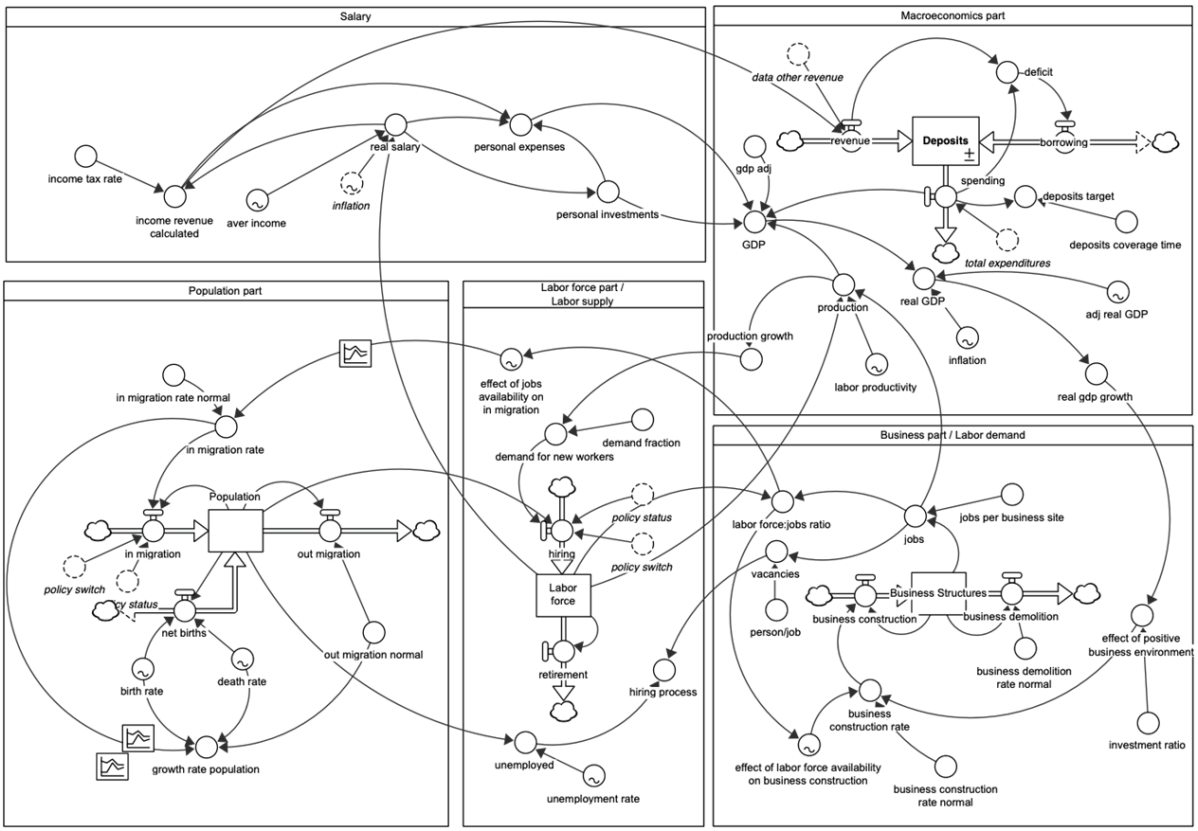

Fig. 1. System Dynamics Model of the Ukrainian Labor Market
Source: by the authors in Stella Architect

This interaction between labor supply and demand determines market wages. An increase in wages can lead to higher domestic demand and consumption, which in turn can stimulate economic development and GDP growth. Increased GDP can create additional opportunities for investment in business expansion and job creation. This, in turn, contributes to further growth in the labor supply and creates dynamics in the labor market. So, demographic trends explain only a part of the changes in the labor market, the rest are due to cyclical factors (Lukianenko, Oliskevych, & Bazhenova, 2020, p. 384).

Thus, studying labor market dynamics is crucial for understanding the economic and social processes in society and for making informed decisions in employment, social protection, and economic development. Modelling the labor market using a System Dynamics tool, taking into account the factors influencing it, can provide a higher level of understanding of the current situation and future development prospects with possibilities for improvement. The advantage of this approach lies in the ability to comprehensively study the behavior of complex systems with nonlinear causal relationships and variable structures dynamically. Numerous computer simulations using specialized software enable the identification of the most accurate configuration of its formalized structure, reflecting real trends and interconnections among elements and subsystems in both short- and long-term perspectives (Lukianenko, Wheat, & Oliskevych, 2020, p. 318).

The labor market is modelled using the Stella Architect software. The developed model consists of five parts: population, labor force (labor supply), enterprises (labor demand), wages, and a macroeconomic component, as demonstrated in Fig. 1.

The developed System Dynamics model for the analysis and simulation of labor market dynamics in Ukraine is a complex system composed of five main blocks, whose interactions reveal the intricate interplay and interdependence of key aspects of the labor market. The model was constructed using official statistical data from the Ministry of Finance of Ukraine (2024), the National Bank of Ukraine (2024), and the State Statistics Service of Ukraine (2024).

The first block, depicted in Fig. 2, represents population dynamics through natural processes — birth rates and mortality. Official data from Ukrainian state statistics are used to derive realistic population indicators. Additionally, the model accounts for migration, including both inflows and outflows, which significantly impact the overall labor force in the country.

The primary elements of the labor market are the supply of and demand for labor. Their interaction determines market wages and the level of employment in the economy. Labor supply refers to the number of individuals who are willing and able to work under certain conditions (such as wages, work schedule, and working conditions). Labor demand refers to the number of workers that enterprises and organizations are willing to hire at a given wage rate. Labor demand is influenced by the level of economic growth, investments in various sectors, technological changes, and other factors.

The second block in the model, depicted in Fig. 3, reflects the number of operating enterprises and business structures in Ukraine. This block generates demand for labor, as the development of

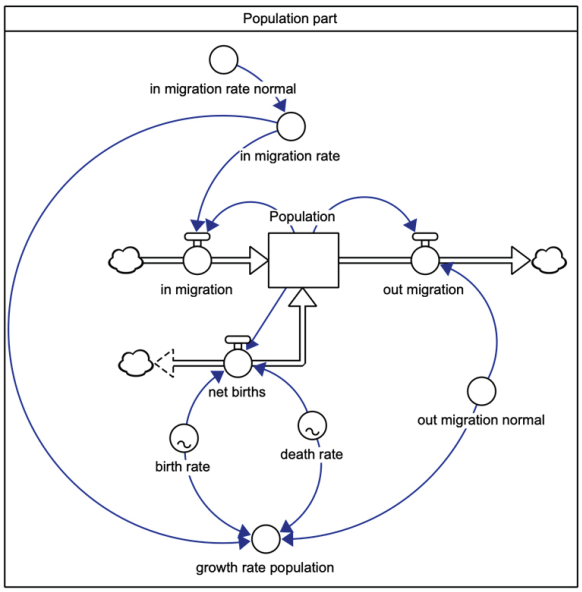

Fig. 2. Population Block of the Labor Market System Dynamics Model
Source: by the authors in Stella Architect

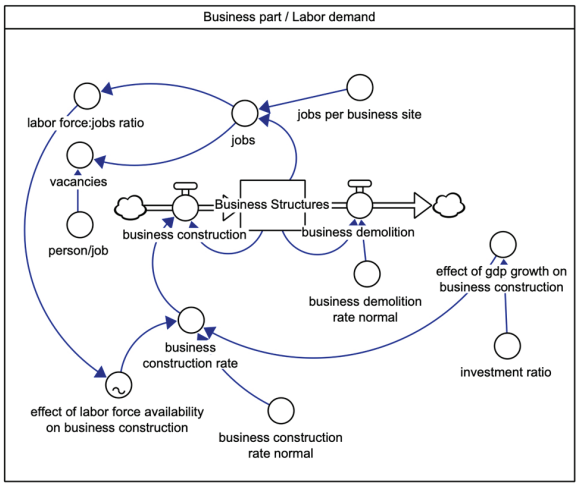

Fig. 3. Business Structures Block of the Labor Market System Dynamics Model
Source: by the authors in Stella Architect

enterprises leads to the creation of new jobs and sustains existing ones.

The interaction between the population and business structures blocks shapes the level of labor market participation, tracking employment rates, unemployment, and the filling of vacancies, as depicted in Fig. 4. The interaction between these two elements determines the employment level. For instance, when the labor supply exceeds the demand, it can lead to increased unemployment. Conversely, when the demand for labor exceeds the supply, it can promote full employment. Thus, the supply of and demand for labor interact to determine market conditions in the labor sector, including wages, working conditions, and unemployment rates. These two elements form the foundation for analyzing and forecasting labor market development.

The formation of labor market prices is the next element of the model, which considers the supply and demand for labor (Fig. 5). It determines wages, which in turn influence economic activity and consumption levels, thereby affecting the economic dynamics of the country.

The model also analyzes the relationship between the labor market and economic indicators such as GDP. It helps to understand and forecast the development of the labor market and the economy as a whole, complementing economic models and enabling informed decision-making on issues of socio-economic development in the country (Fig. 6).

The developed diagram (Fig. 7) represents the main relationships that drive the model's behaviour:

• The first balancing loop, B1, indicates that the retirement of individuals negatively impacts the overall labor force in the market. The subsequent balancing loop, B2, confirms that the closure of business structures adversely affects the total number of business entities within the economy.

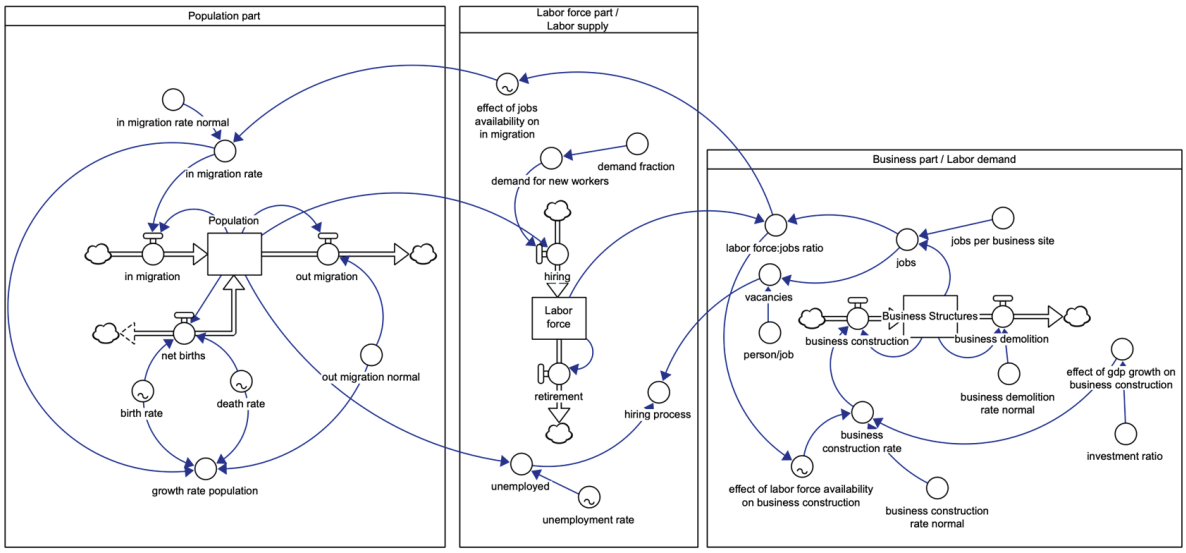

Fig. 4. Interaction of Population, Business Structures, and Labor Force Blocks in the Labor Market System Dynamics Model
Source: by the authors in Stella Architect

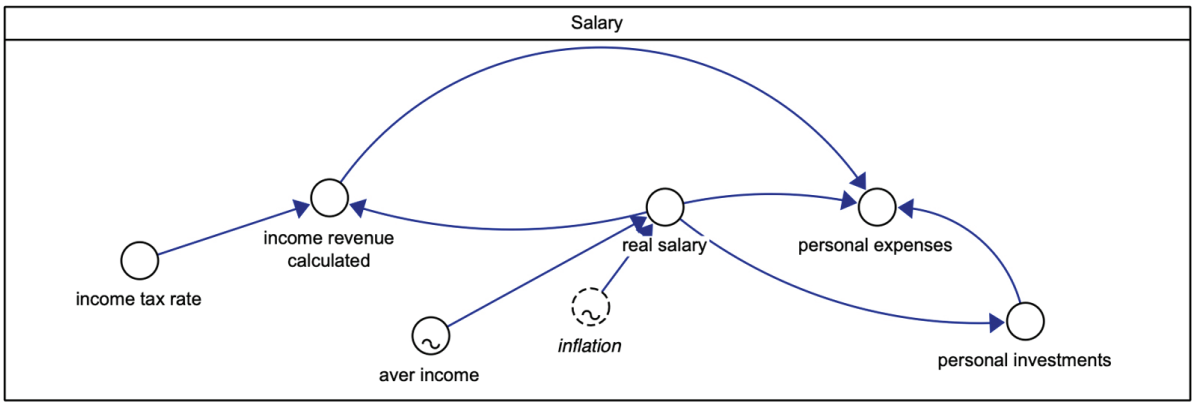

Fig. 5. Wage Block in the Labor Market System Dynamics Model
Source: by the authors in Stella Architect

• Balancing loop B3 highlights that the quantity of goods produced in the economy influences the demand for these goods, which in turn affects the demand for new workers in the labor market. This process of hiring increases the labor supply, thereby enhancing the production capacity within the economy.

• Balancing loop B4 demonstrates that the rate of new business formation in the economy impacts the creation of new business structures, which subsequently affects the overall number of business entities and alters the ratio of labor supply to each business unit, thereby influencing the rate of new business creation.

• Balancing loop B5 indicates that the overall GDP of the country, along with real GDP, influences the level of investment expansion for business development within the economy. This, in turn, affects the total number of business structures and the level of production, which also contributes to GDP growth.

• Balancing loop B6 illustrates the reciprocal relationship between the creation of new business structures and their quantity in the economy, impacting production levels. Increased production necessitates the recruitment of new workers into the labor force, triggering hiring processes that augment the total labor supply, further influencing the development of business structures in the economy.

• Reinforcing loop R1 explains how the total labor supply in the market affects wage levels and GDP, which subsequently influences investment levels for business development, leading to the creation of new business structures. This increase in production volume drives demand for new employees, activating the hiring process and enlarging the overall labor force.

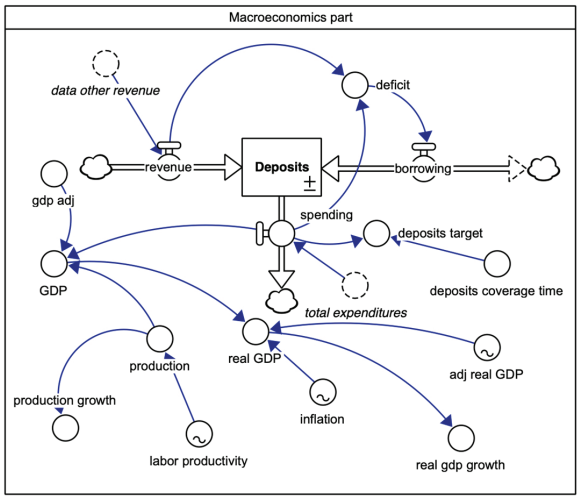

Fig. 6. Macroeconomic Block in the Labor Market System Dynamics Model
Source: by the authors in Stella Architect

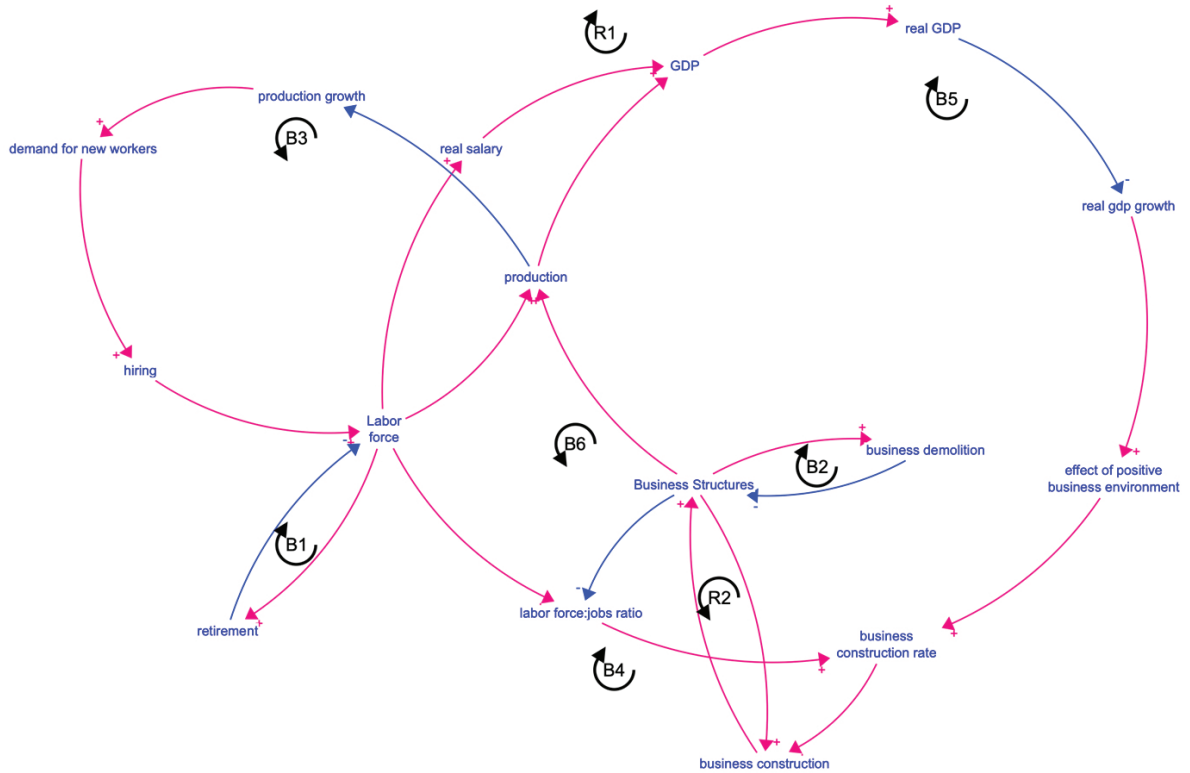

Fig. 7. Causal Loop Diagram
Source: by the authors in Stella Architect

• Reinforcing loop R2 elucidates the impact of new enterprise creation in the economy on the total number of business structures.

Conclusions and further research proposals. The explanatory System Dynamics Model effectively illustrates the intricate relationships that govern the dynamics of the Ukrainian labor market. The balancing loops identified underscore critical factors such as retirement, business closures, production levels, and new business formation that collectively shape labor supply and demand. Each loop reveals how changes in one aspect of the economy can reverberate through others, highlighting the interconnectedness of labor dynamics, economic growth, and business development. Moreover, the reinforcing loops emphasize the cyclical nature of these relationships, wherein increases in labor supply can lead to higher wages and greater GDP, subsequently fostering further investment and business creation. This model provides valuable insights into the feedback mechanisms that can either stabilize or destabilize the labor market, particularly in the context of external shocks or policy changes.

The developed model has demonstrated validity through the use of real data, enabling the identification of important interconnections within the model for the development of effective policy strategies. In the future, it is possible to test various policies for major elements of the model and to simulate its behavior. Also, the model can be developed by adding new causal sub-models, in particular those related to hostilities on the territory of Ukraine and policies of foreign countries related to Ukrainian refugees.

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Прімєрова О. К., Спаріш А. І.

МОДЕЛЮВАННЯ РИНКУ ПРАЦІ УКРАЇНИ: СИСТЕМНО-ДИНАМІЧНИЙ ПІДХІД

Метою дослідження є розроблення системно-динамічної моделі функціонування та розвитку ринку праці України, яку можна використовувати для стимулювання поведінки системи та моделювання різних урядових рішень та заходів. Для побудови моделі використано програмне забезпечення Stella Architect, що дає змогу сформувати уявлення про поточний стан ринку праці та прогнозувати майбутні тенденції, допомагаючи визначити потенційні напрями для підвищення ефективності його функціонування. Розроблена системно-динамічна модель є складною системою, що має п’ять основних блоків, взаємодія яких розкриває складну взаємозалежність ключових аспектів ринку праці: населення, робоча сила (пропозиція праці), підприємства (попит на працю), заробітна плата та макроекономічний компонент.

Пояснювальна системно-динамічна модель ефективно ілюструє складні взаємозв’язки, які зумовлюють динаміку ринку праці України. Виявлені балансуючі петлі зворотного зв’язку визначають критичні фактори, як-от вихід на пенсію, закриття бізнесів, рівні виробництва та формування нових підприємств, що в сукупності формують пропозицію і попит на робочу силу. Кожна петля показує, як зміни в одному аспекті економіки можуть впливати на інші, підкреслюючи взаємозв’язок між динамікою ринку праці та економічним зростанням. Крім того, підсилюючі петлі наголошують на циклічному характері цих взаємозв’язків: збільшення пропозиції робочої сили може зумовити зростання заробітної плати та ВВП, що, своєю чергою, стимулює подальші інвестиції та створення бізнесів. Ця модель надає цінну інформацію про зворотні механізми, які можуть стабілізувати або дестабілізувати ринок праці, особливо в умовах зовнішніх шоків або змін урядової політики.

Розроблена модель продемонструвала свою валідність через тестування на реальних даних, що дає змогу сформувати обґрунтовані висновки щодо основних взаємозв'язків у моделі та використовувати її для розроблення ефективних стратегій. Також модель може бути розширена шляхом додавання нових причинно-наслідкових субмоделей, зокрема тих, що стосуються воєнних дій на території України та політики іноземних країн щодо українських біженців.

Ключові слова: ринок праці, системна динаміка, безробіття, зайнятість, пропозиція праці, попит на працю, монетарна політика.

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Прімєрова Олена Костянтинівна – кандидат економічних наук,
доцент кафедри фінансів Національного університету «Києво-Могилянська академія»

Primierova Olena – Candidate of Economics, Associate Professor of the Finance Department,
National University of Kyiv-Mohyla Academy

https://orcid.org/0000-0002-3967-1982

o.primierova@ukma.edu.ua

Спаріш Аліса Ігорівна – магістр спеціальності «Фінанси, банківська справа та страхування»,
Національний університет «Києво-Могилянська академія»

Sparish Alisa – Master Graduate of "Finance, Banking and Insurance" specialty,
National University of Kyiv-Mohyla Academy

https://orcid.org/0009-0007-3134-5860

alisa.sparish@ukma.edu.ua