Journal of Management World **2025**, 1: 326-340
DOI: 10.53935/jomw.v2024i4.671

Managing Ukraine's Potential for Socio-Economic Recovery: Assessment of Challenges and Development Prospects

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Abstract. The article aims to assess the potential for socio-economic recovery of Ukraine and identify the reserves for its increase. The methodology is based on a system-structural approach using composite and recursive methods. The study includes data on Ukraine's development potential by four groups (capital, labor, entrepreneurship, innovation) and markers of socio-economic recovery (gross domestic product, labor productivity, research expenditures, budget revenues, the ratio of income to the value of enterprise assets) for 2005-2023. The article reveals that the relationship between the total potential and Ukraine's economic recovery is direct and short-term (a decrease in potential in 2007-2009, 2013-2014, and 2021-2023 by an average of 0.08 pp, 0.09 pp, and 0.8 pp, respectively, led to a decrease in the rate of socio-economic recovery by $1,300, $900, and $1,400 per capita, respectively). The rate of recovery with a 1% increase in the country's total potential is twice as fast as the rate of loss of resistance and decrease in potential. The results allow identifying areas of Ukraine's potential growth: increasing human capital investment, curbing youth migration, developing virtual employment, creating a favorable investment environment, strengthening infrastructure investment, creating a startup ecosystem, encouraging business with tax incentives, supporting export-oriented enterprises, developing innovation clusters, and digitalizing the economy.

Keywords: Capital, Entrepreneurship, Innovation, Labor, Potential for recovery, Resources.

1. INTRODUCTION

Ukraine has suffered significant losses of financial, productive, investment, and innovation capital and human resources during the war. The volumes are critical both for ensuring the economic resilience of the country and its regions at the current moment in time and building the socio-economic potential for the recovery of the territories in the post-war period. Monitoring of resource losses and opportunities for rebuilding the national economy are determined by methodological gaps due to the lack of permanent accounting by state and regional statistical offices in Ukraine, with the exception of some studies by international and national organizations and scientific institutions.

Therefore, the study of current challenges and their impact on the ecosystem and the conditions of the country's development is of existential importance for programming the socio-economic recovery, developing new structural models of the economy, and ensuring their socio-economic resilience. The selection of indicators to build an empirical indicator of the country's socio-economic recovery potential is a methodological challenge today. The development of a system of indicators that would comprehensively describe the potential of the socio-economic system with the possibility of comparative regional analysis remains a gap in the methodology of national economic development.

Given the methodological limitations of wartime, a comprehensive study of the potential for socio-economic recovery of Ukraine is of relevance, as it will serve as an information base for making effective management decisions.

2. LITERATURE REVIEW

Wars and their aftermath are of genuine interest to scholars and policymakers, especially in terms of the tactics and strategies used and, more importantly, effective tools for preserving the economy and its rapid recovery. First, it is an opportunity to test theoretical models and patterns of state regulation. Second, it is a chance to identify effective and successful practices that can be used to overcome global crises, protracted conflicts, etc. Indeed, it is well known that economic development is cyclical, and recessions and difficulties in recovery are natural. To understand which areas, require the most active state intervention, it is necessary to justify the aspects with the most serious or critical consequences for a rapid and proper post-war recovery. The results of such studies are a natural starting point, the so-called introduction to further development of public policy.

Based on the generalization of scientific research, which actually form the picture of the leading objects of protection (people, capital, and real sector enterprises (Astrov et al., 2022), industrial enterprises and labor resources (Irtyshcheva et al., 2022), housing stock, infrastructure, and production, logistics, and sales systems (Liadze et al., 2023), innovation potential as a factor of competitiveness (Pidorycheva, 2022), political and economic resilience and stability (Raik et al., 2024), as well as resources and elements of the system of the country's multi-level development (Shubalyi & Gordiichuk, 2022)), we conclude that this is a multi-component

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potential of the national economy, which is also the main condition for recovery.

All of the listed components, factors, and conditions are necessary for the preservation of the nation and its state in times of war. However, when it comes to the economic vector of resilience and recovery in a war environment, the focus is mostly on preserving business and an acceptable business environment for its operation (Bagatska et al., 2024), financial and economic resources and conditions necessary for the proper course of business processes in the real sector of the national economy, including those that are strategically important in the future and are currently prioritized (Dmytryk et al., 2024; Freudlsperger & Schimmelfennig, 2023), resources for local economic development, preservation of communities and territories where human capital, working conditions, income, and employment are becoming dominant and development of the local domestic market (Dunford, 2023), and retaining academics, scientists, innovators, researchers, and inventors in the country, in other words, retaining human resources for preserving and restoring research and innovation activities (Kravchenko et al., 2023; Prohorovs, 2022).

Logically, these factors are subject to verification and clarification in terms of the realities of the russian-Ukrainian war, its course, and its consequences for the socio-economic system of Ukraine. Therefore, the following should be considered in the first place: the rapid pace and large scale of external and internal displacement of Ukrainians (Bin-Nashwan et al., 2022), and, consequently, the visible consequences of the deepening demographic crisis and weakening of the human resource potential of the economy, the loss of highly specialized and highly qualified personnel, including academics, scientists, and researchers; capital flight and sharp deterioration of the financial component in both the private and public sectors (Goodwin et al., 2023), and problems of destruction of production and industrial potential in the east and south of the country, as well as relocation and preservation of business (Gorodnichenko et al., 2022), etc.

The generalization of the abovementioned studies, as well as the results of other studies in this area, including those of the authors, reveals the basis for identifying the following leading groups / components of the socio-economic recovery potential, which are most valuable in terms of preserving the capacity for resilience and rebuilding the national economy in the post-war period: capital resource, labor resource, entrepreneurship resource, and innovation resource.

Capital, as a set of financial and productive resources, plays a key role in the long-term socio-economic recovery and growth of the country, regions, and territories. For example, an increase in local budget revenues (per employee) contributes to an increase in labor productivity and output. Capital accumulation is determined by the level of savings and investment, so higher savings contribute to an increase in the attractive investment of the territories and, accordingly, the productive capacity of economic sectors and the financial resilience of the regions (Ilyash et al., 2021; Nikonenko et al., 2022; Zhang & Ren, 2022).

The potential for economic recovery is permanently dependent on the number of human resources and labor force, and the progress of human potential in general. Human capital, which includes knowledge, skills, experience, abilities, education, and physical and mental health, provides the basis for the functioning of all sectors of the national and local economy (Bil et al., 2021; Levytska, 2022). Reducing unemployment, improving the skills of workers, developing human capital, ensuring return migration, and curbing emigration processes, especially among young people, are important components of a successful strategy for the restoration of territories. At the same time, human resources are a source of innovation and entrepreneurship, which are the main drivers of economic growth (Aslam et al., 2023; Voznyak et al., 2023; Uddin et al., 2021).

Entrepreneurship as a key factor in economic development and recovery from macroeconomic shocks ensures the transformation of existing economic structures through adaptation to new conditions, provides the local economy with the necessary flexibility, and contributes to solving employment problems through the ability of small and medium-sized businesses to create new jobs or absorb surplus labor. As a driver of innovation, the business sector introduces new ideas, technologies, and business models that fundamentally change traditional approaches to production processes and service delivery (Panchenko et al., 2024; Vasyltsiv et al., 2021).

The crystallization of the national economy's security assets in the context of war naturally leads to the identification of those challenges that, on the one hand, cause relevant losses, and, on the other hand, pose insurmountable difficulties and threats to the country's socio-economic system. This is supported by research findings that point to vulnerability and resilience in the chains of human potential → labor resources → economic productivity → efficiency → recovery (Celi et al., 2022); challenges and opportunities for recovery in terms of the availability of labor and capital resources (Novikova et al., 2023); focus not only on the resource, but also on its spatial and sectoral location, which is important in terms of sufficient attention to preserve territories and communities, the country's comprehensive development, and the establishment of its place and links in mega-regional complexes (Panazan et al., 2023); debate: preservation of the existing vs. focusing on high-tech recovery following the trends of digital transformation of the economy and society, etc. (Vasyltsiv et al., 2022).

Ongoing scientific studies that verify both the components of the recovery potential and the consequences of their change, the efficiency of their use, and generate challenges and threats in the course of comprehensive analysis, modeling, and forecasting are of great methodological and practical importance. In particular, they confirm the role of indicators of the country's production and resource potential as determinants of national resilience (Bondarenko et al., 2021), parameters of social and demographic security of the state – in ensuring

social resilience (Reznikova & Korniievskyi, 2024), indicators of the state and structural characteristics and development trends of the business sector – in the economic security of the state (Gryshova et al., 2020), parameters of budget revenues, debt obligations, factors of macro-financial stability – in the country's resilience to the severe consequences of the war (Grytsenko et al., 2024), systemic social and humanitarian aspects and conditions – in the recovery of the country (Heyets et al., 2022), basic indicators of demographic, social, and environmental stability – in terms of following global development trends (Hryhoruk et al., 2024).

It is important to substantiate the correct vectors and elements of the model in terms of the present and future of Ukraine on the basis of identifying the leading components of the recovery potential, understanding their interrelationships with the preservation of the basic conditions of the national economy's resilience in the critically difficult conditions of a full-scale war, as well as preservation and rational use of limited resources for the purpose of expanded reproduction of the national economy in the post-war period. In this regard, significant and applicable both from the standpoint of theory and practice are the results of scientific research in human resources preservation (Hrynkevych et al., 2023), sustainable development in the economy – social sphere – environmental sustainability system (Martynovych et al., 2023), structural changes in the business sector in terms of eradication of systemic corruption, monopolization, market shadowing, raiding, tax offshoring, etc. (Mazur et al., 2024), the further increase and effective use of the innovation and technological potential of the Ukrainian economy, in particular, industry and its defense sector (Syrtseva et al., 2022) and maintaining the course of Ukraine's European integration (Raik et al., 2024; Wolczuk, 2021).

Meanwhile, there is an urgent need for further research and development of methodological and practical foundations for managing the potential for economic recovery in Ukraine.

The article aims to assess the potential for the socio-economic recovery of Ukraine and identify the reserves for its increase in the context of instability.

3. DATA AND METHODOLOGY

The methodology of multi-criteria assessment of Ukraine's socio-economic recovery potential is based on the economic growth model, which interprets the dependence of progress on four factors-components of the country's internal potential – capital, labor, innovations, and entrepreneurship. Economic recovery depends multiplicatively not only on the volume of the country's financial and production potential and the effectiveness of its realization but also on innovation, the volume and qualitative characteristics of human capital, the competitiveness and balance of the labor market, and the pace of development of the business sector. The potential for socio-economic recovery of the country is modeled as a six-component system: financial and production potential (capital component), demographic and labor potential (labor component), intellectual and innovative potential (innovations component), and entrepreneurial potential (entrepreneurship component) (Eq. 1).

$$SEP_t = \begin{pmatrix} {K^{\alpha}}_t \\ {L^{1-\alpha}}_t \\ {It}_t \\ {En^{(1-\alpha)^2}}_t \end{pmatrix} = \begin{pmatrix} {Fin^{\alpha}}_t, \quad {Man^{\alpha}}_t \\ {Dem^{1-\alpha}}_t, \quad {Lab^{1-\alpha}}_t \\ {It}_t \\ {En^{(1-\alpha)^2}}_t \end{pmatrix} \tag{1}$$

where SEP_t is the potential for socio-economic recovery of the country in period t; ${K^{\alpha}}_t$ is the capital component in period t; ${L^{1-\alpha}}_t$ is the labor component in period t; ${It}_t$ is the technology component in period t; ${En^{(1-\alpha)^2}}_t$ is the entrepreneurship component in period t; ${Fin^{\alpha}}_t$ is the financial potential of the territory in period t; ${Man^{\alpha}}_t$ is the production potential of the territory in period t; ${Dem^{1-\alpha}}_t$ is the demographic potential of the territory in period t; ${Lab^{1-\alpha}}_t$ is the labor potential of the territory in period t; α is the elasticity component.

The information and analytical basis for the study of the potential for the country's socio-economic recovery includes the components of the resource framework of economic development grouped according to the principles of validity, universality, comparability, and reproducibility (Appendix A). The systemic-structural approach to the study of the socio-economic potential of the country's recovery allows analyzing its components as interrelated elements, on the one hand, and system indicators that depend on lagged interaction with each other and with the external environment, on the other hand. This approach is based on the principles of complementarity, dynamism, and integrity.

Given the complexity of the calculations and the limited statistical data, the composite and recursive methods were used to build an empirical indicator of the country's socio-economic recovery potential. Thus, using the composite method, the potential for socio-economic recovery of the country can be studied as a complex system as a whole and its individual parts (components or subsystems) can be analyzed independently and then synthesized to form a comprehensive vision. The study of the nature of interaction between the components of the potential serves as a basis for forecasting both the country's potential in general and how factors impact it.

Meanwhile, the use of a recursive approach allows us to study the potential for socio-economic recovery of the country as a set of iterations of processes that have occurred or will potentially occur in the economic system

over a given period. The recursive method is based on the principle that each component of the potential is an element with system properties, so the repeatability of processes with a certain time lag allows us to project dynamic series, considering the condition of leveling the influence of other endogenous or exogenous factors.

Based on the recursive method, the article projects (continues the dynamic series) indicators of the components of the potential for socio-economic recovery for 2022-2023 (Eq. 2).

$$a^*_{t+1} = a^*_t \pm max\left[0, \max_{m=1,n}\left\{\frac{a_{t+m}-a^*_t}{i}\right\}\right] \quad (2)$$

where a^*_t is the potential measure of the indicator in the t period; a^*_{t+1} is the potential measure of the indicator in the t+1 period; a_{t+m} is the actual measure of the indicator in the t period, where m changes from 1 to n. Taking into account the time series of the study (2005-2023), k is 5.

It is interesting to note that the formula uses addition for indicators with a direct positive effect and subtraction for indicators with a reverse effect.

The indicators are normalized based on the variation range, which compensates for the error of linearity of economic processes (Eq. 3).

$$z^k_{it} = \begin{cases} \dfrac{x^k_{it}-\min\limits_{i=1,j} x^k_{it}}{\max\limits_{i=1,j} x^k_{it}-\min\limits_{i=1,j} x^k_{it}} \\ \dfrac{\max\limits_{i=1,j} x^k_{it}-x^k_{it}}{\max\limits_{i=1,j} x^k_{it}-\min\limits_{i=1,j} x^k_{it}} \end{cases} \quad (3)$$

where z^k_{itn} is the normalized value of the i indicator of the k component in the t period; x^k_{it} is the output value of the i indicator of the k component in the t period; j is a study period.

The coefficients of the components of the potential for socio-economic recovery are calculated as the average value of all indicators in the group, and the weighting of the components is based on the *principal component analysis*.

The dynamic series of empirical indicators of the country's socio-economic recovery potential are built based on the method of calculating the weighted linear average according to Eq. (4).

$$SEP_t = \sum_{k=1}^{l} CSEP^k_t * w^k \quad (4)$$

where $CSEP^k_t$ is the empirical value of the k component of the potential for socio-economic recovery in period t; w^k is the weighting coefficient of the k component of the potential for socio-economic recovery; l is the number of components of socio-economic recovery potential.

Gross domestic product (GDP) per capita is the main indicator of a country's economic development. In the face of macroeconomic and other shocks or loss of resilience, the growth rate of a given indicator is one of the indicators of economic development. Therefore, a marker variable was selected for each component of the potential to demonstrate economic development according to the relevant parameter, which is directly influenced by the "resource" (resource components). Thus, for the labor resource, it is the total labor productivity ($ per person employed), for the innovations resource, it is the share of research and development (R&D) expenditures (% of GDP), for the capital resource, it is the consolidated budget revenues ($ per person), and for the entrepreneurship resource, it is the return on assets ratio (coefficient) (Table 1). A recursive method was used to forecast these resulting determinants of economic recovery, which allows building a dynamic series of empirical indicators for 2022-2023.

Table 1: Markers of economic recovery in the projection of the components of Ukraine's internal potential, 2005-2023.

Year	GDP per Capita	Total Labor Productivity	Share of Research and Development (R&D) expenditures	Consolidated Budget Revenues	Return on Assets Ratio
2005	1829.2	7644.7	1.30	555.9	1.025
2006	2303.8	7603.5	1.13	727.1	1.030
2007	3069.1	7818.6	1.50	936.4	0.968
2008	3892.5	7743.5	1.27	1222.6	0.929
2009	2546.0	5380.1	0.87	760.8	0.914
2010	2974.4	6245.9	0.75	864.0	0.845
2011	3570.8	7167.9	0.65	1094.4	0.875
2012	3856.8	7751.2	0.67	1222.8	0.795
2013	4030.3	8186.9	0.70	1217.8	0.727
2014	3014.6	6429.1	0.60	892.3	0.721
2015	2115.4	4712.9	0.55	696.7	0.659
2016	2185.9	4855.5	0.48	718.0	0.639
2017	2640.3	5878.6	0.45	900.0	0.789

2018	3095.2	6781.5	0.47	1030.0	0.863
2019	3659.8	7999.7	0.43	1187.5	0.856
2020	3725.6	8452.4	0.41	1223.2	0.810
2021	4826.6	8854.0	0.38	1472.1	0.986
2022	3422.1	6640.2	0.33	1348.1	0.784
2023	3610.3	7456.2	0.35	1589.8	0.812

4. RESULTS

4.1. Ukraine's Labor Potential

The study shows that the demographic and labor potential of Ukraine showed an upward trend during the study period, with a significant decrease during the crises (2008, 2014, and 2020) and a critical decrease during the war years (2022-2023). In 2014-2015 (the annexation of the Autonomous Republic of Crimea and the russian invasion of Donetska and Luhanska oblasts), the empirical value of the demographic potential indicator decreased by 0.21 pp, which indicates significant demographic losses during this period both due to intensive migration processes and deformations of the age and gender structure of the country's population. In 2022, the indicator decreased to 0.311, reflecting the consequences of the migration crisis that Ukraine is still experiencing (Figure 1).

The empirical indicators of Ukraine's labor potential for the period under study are much higher compared to the demographic potential but also show a general downward trend after 2014 with noticeable sigmoidal fluctuations. Such a wave-like nature of the development of the country's labor potential indicates a high level of dependence on exogenous factors, and particularly the demographic resilience of the territories. A significant decline in labor potential was observed in 2008-2009 (-0.224 pp), 2014-2015 (-0.283 pp), 2020-2021 (-0.234 pp), and 2022-2023 (-0.048 pp). The decline in demographic potential was observed in the first-run lag after the crisis, while the decline in labor potential was observed after two- or three-time lags.

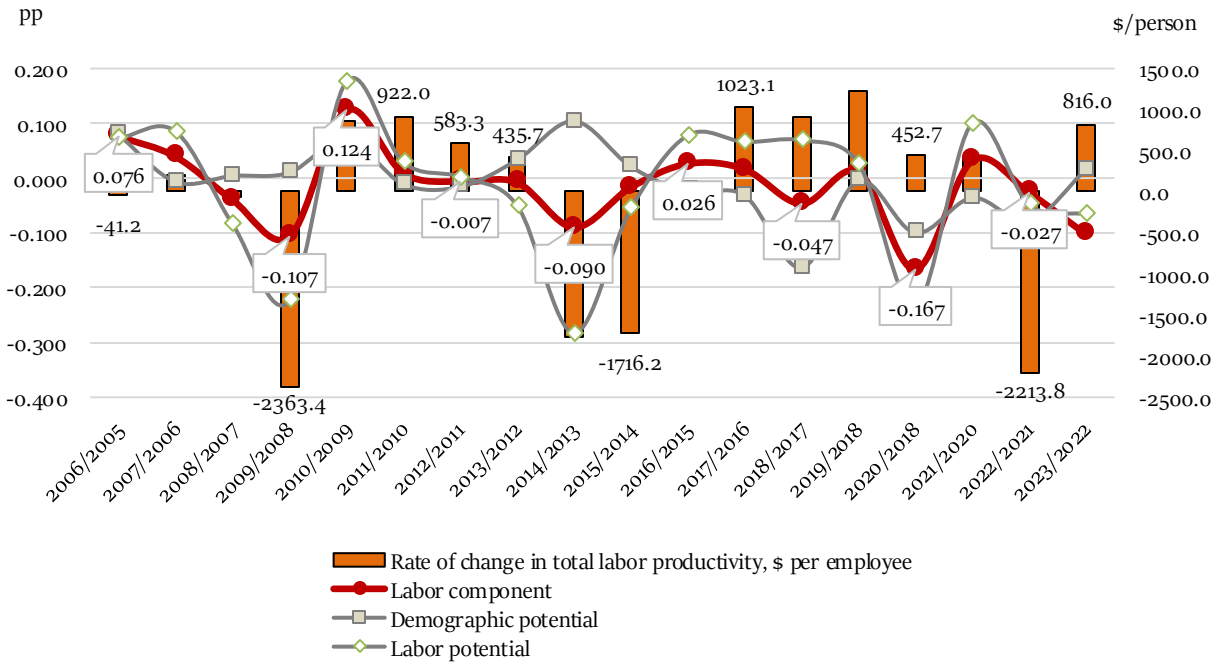


Figure 1: Potential for socio-economic recovery of Ukraine: labor component marker, 2005-2023.

A significant decrease in the labor component in Ukraine over 2005-2023 was observed in 2008-2010, 2012-2017, 2020-2021, and 2022-2023. Therefore, the decline in labor and demographic potential has a direct dynamic impact on economic development with a time lag of 2-3 years. Interestingly, the value of the empirical indicator of the labor resource in 2022-2023 decreased by 0.103 pp (for comparison, there was an increase of 0.032 pp in 2020-2021). An increase in the demographic potential was observed in 2015 to the level of 0.694, and in labor potential – in 2007 (0.793). A significant increase in the empirical indicators of demographic and labor potential occurred in 2013-2014 (rate of change – 0.104 pp) and 2009-2010 (0.176 pp).

Total labor productivity reflects the efficiency of the use of labor in the economic system of a country or region, demonstrating how much product (gross value added, $) is created per person employed. The weakening of the country's demographic and labor potential has a negative impact on labor productivity due to a significant reduction in the labor force, including young people, a decrease in the so-called "age potential," the aging of the population, and the migration crisis. Migration processes determine the reverse relationship with labor productivity, since a high level of migration abroad of the working-age population, especially of young people and highly skilled professionals, leads to a decrease in production, aggregate demand in the labor market, and innovation and investment potential, and thus a weakening of the potential for economic recovery in general.

The labor component, as an element of the potential for socio-economic recovery, demonstrated a lagged reverse effect on labor productivity. The decrease in the empirical resource indicator of 0.107 pp in 2008-2009 led to a decline in total labor productivity of $2,400 (per person employed). The increase of the empirical indicator in 2010-2014 contributed to the growth of labor productivity by an average of $647 per year. The 0.3 pp decrease in labor potential in 2014 caused a 0.1 pp decline in the labor component, which resulted in a decrease in labor productivity by over $1,700 in 2014-2015. It is worth mentioning that the increase in labor potential does not allow achieving a short-term increase in labor productivity, and the upward dynamics of demographic potential development has a dynamic impact on labor productivity with a lag of 2-3 years. The decline in the demographic potential in 2016-2019, with a significant reduction in labor potential over this period (by 0.3 pp), triggered a decline in productivity by $190 per employee per year.

The war of the russian federation against Ukraine has led to a critical weakening of the labor resource component and a decrease in labor productivity (by 0.3 pp and $2,200, respectively). In 2022-2023, the decline in labor and demographic potential was 0.1 pp, while in 2023, labor productivity increased by $816 per person employed. However, this improvement does not indicate a resumption of a stable upward trend and a return to equilibrium, i.e., the 2022 figures.

The identification of a dynamic relationship using VAR modeling between the time series of the labor component (including demographic and labor) and labor productivity confirms the thesis of lagged interactions between the indicators. Thus, a significant decrease in the labor component caused a 0.63% decrease in labor productivity in the first lag and a 1.7% decrease in the second lag. Meanwhile, a decrease in the labor resource in the first lag leads to a significant decrease in the country's total potential in the second lag by 4.5%, which indicates a complementary impact of the components on the potential of the economy (Table 2). Total potential impacts labor potential 6 times more in the first-run lag than demographic potential. In the second lag, the impact on the country's labor potential is reduced to 1.9%, while the impact on the demographic potential remains permanent. Interestingly, demographic potential (2.6%) has a greater impact on the formation and development of the labor resource in the first lag, and labor potential (1.1%) in the second lag, which indicates that the reduction of human resources leads to a significant imbalance in the labor market in Ukraine starting from the second lag.

Table 2: Empirical characteristics of the dynamic relationship of the potential for socio-economic recovery of Ukraine: labor component, 2005-2023.

Indicators of Potential	Lags	ER marker	Indicators of Potential		
		Labor Productivity	Labor Component	Potential	
				Demographic	Labor
Labor resource	lag (1)	0.633074	0.693949	0.572287	6.427305
		(2.50292)	(3.02221)	(2.35142)	(4.16330)
		[0.25293]	[1.55315]	[0.24338]	[1.54380]
	lag (2)	1.699626	4.497313	0.541525	1.901142
		(2.60165)	(3.14143)	(2.44417)	(4.32753)
		[0.65329]	[0.47663]	[0.22156]	[0.43931]
Demographic potential	lag (1)	0.365246	2.601870	0.576596	4.743114
		(1.51705)	(1.83180)	(1.42522)	(2.52343)
		[0.24076]	[1.42039]	[0.40457]	[1.87963]
	lag (2)	0.879258	1.002030	0.854854	0.854368
		(1.43583)	(1.73374)	(1.34892)	(2.38833)
		[0.61237]	[0.57796]	[0.63373]	[0.35773]
Labor potential	lag (1)	0.296201	1.864706	0.069391	2.527765
		(1.28963)	(1.55720)	(1.21157)	(2.14515)
		[0.22968]	[1.19747]	[0.05727]	[1.17836]
	lag (2)	1.062607	1.059435	0.109486	1.581485
		(1.28060)	(1.54629)	(1.20308)	(2.13012)
		[0.82977]	[0.68515]	[0.09100]	[0.74244]
Statistical significance coefficients					
Coefficient of determination		0.719497	0.799825	0.877529	0.747108
Adjusted coefficient of determination		0.438993	0.599651	0.755058	0.494216
Statistical error		0.061749	0.074560	0.058011	0.010212
F-test		2.565021	3.995641	7.165204	2.954255

Note: ER is economic recovery; calculations are made in Eviews statistical package.

4.2. Ukraine's Capital Potential

Financial capital is the foundation of economic development and recovery from macroeconomic shocks. In particular, the efficient use of investment and production potential ensures the stability of economic systems, including stimulating business activity, increasing the attractiveness of the business environment, etc. Financial support is the basis for entrepreneurship development, as small and medium-sized businesses need access to loans, investment funds, and other financial instruments to intensify and develop their activities, create new jobs, diffuse innovations, etc. Access to new sources of financial support allows small and medium-sized enterprises to increase their production and export potential, enter new market niches, etc. Meanwhile, the implementation of modern financial instruments, such as insurance, hedging, and other crisis management mechanisms, allows

business entities to reduce the impact of socio-economic and socio-political instability on the productivity and profitability of operations. This helps to reduce risks in the investment and production activities of the region, stimulating stable economic growth.

According to the study, the financial potential of Ukraine increased from 0.198 (2005) to 0.722 (2021), and the production potential – from 0.360 to 0.442 in 2005-2021. The political and financial crisis in 2014-2015 almost doubled the capital resource component, which resulted in a decrease in consolidated budget revenues by $325.5 and $195.6. per capita, respectively (Figure 2). In contrast to the labor resource component, which has a lag effect on the marker of efficiency of its use and economic development with a period of 2-3 years, the production and financial potentials are not characterized by a dynamic impact on the corresponding marker of the efficiency of the use of the capital resource (consolidated budget revenues, $ per capita).

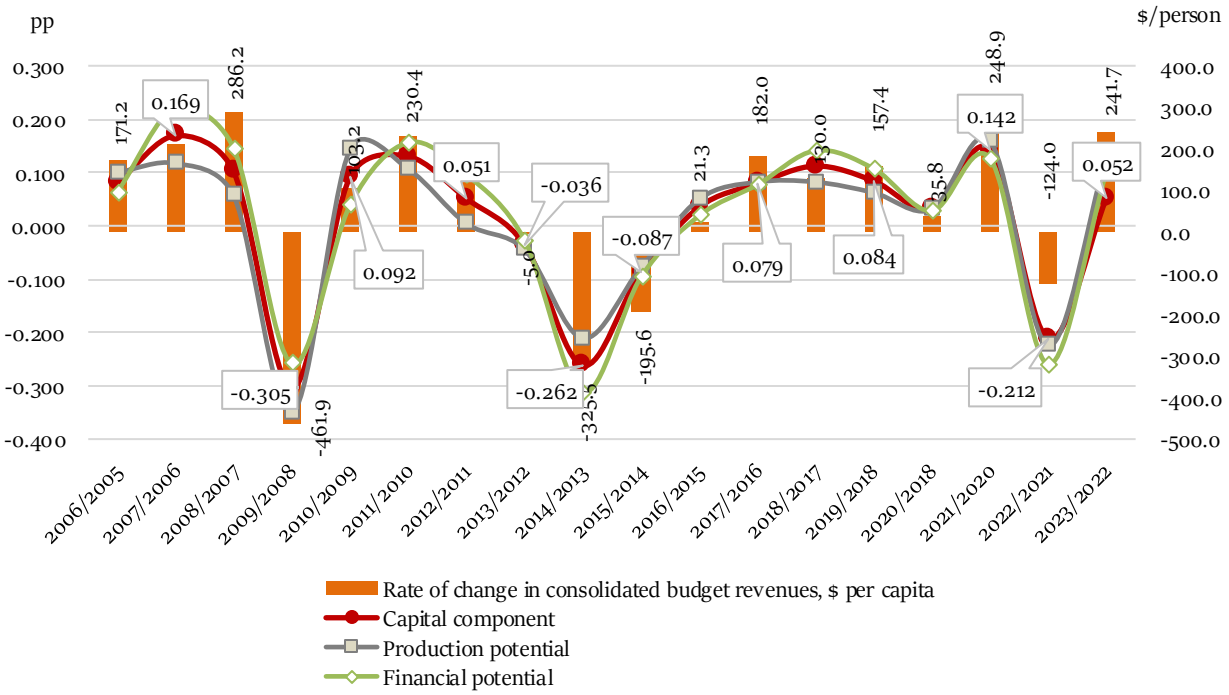


Figure 2: Potential for socio-economic recovery of Ukraine: capital component marker, 2005-2023.

Thus, a decrease in financial resources affects the potential for economic development in the event of a shock or risk. In 2008-2009, a decrease in financial and productive capital by 0.259 pp and 0.351 pp, respectively, led to a decrease in consolidated budget revenues by $461.9 per capita. In 2013-2014, a decrease in financial resources overall by 0.262 pp caused a decrease in revenues by $325.5 per capita. In 2022, Ukraine's financial potential weakened by 0.212 pp, and consolidated budget revenues decreased by $124 per capita.

The results of the VAR modeling between the time series of the capital resource component and consolidated budget revenues show that changes in financial and production potential have a stronger impact on consolidated budget revenues in the first-run lag than in the second. For comparison, the strength of the impact was 4.1% and 3.7%, respectively, in the first lag, and 0.4% and 0.6%, respectively, in the second lag. The capital resource component had a significant impact on the consolidated budget revenues in the first lag (9.7%), while the impact was 3.3 times lower in the second lag, which indicates a short-term impact of financial and production potential on the corresponding marker of the efficiency of its use in Ukraine.

Table 3: Empirical characteristics of the dynamic relationship of the potential for socio-economic recovery of Ukraine: capital component, 2005-2023.

Indicators of Potential	Lags	ER markers Consolidated Budget Revenues	Indicators of Potential		
			Capital Component	Potential	
				Financial	Production
Consolidated budget revenues	lag (1)	1.577950	3.288796	2.594784	3.768962
		(1.01362)	(1.64169)	(1.69651)	(1.66865)
		[1.55675]	[2.00330]	[1.52948]	[2.25869]
	lag (2)	2.495500	2.797305	1.800029	3.350511
		(1.24791)	(2.02116)	(2.08867)	(2.05436)
		[1.99974]	[1.38401]	[0.86181]	[1.63092]
Financial potential	lag (1)	4.164546	5.504895	5.462221	6.765179
		(1.63764)	(2.65238)	(2.74096)	(2.69594)
		[2.54302]	[2.07546]	[1.99281]	[2.50939]
	lag (2)	0.481951	3.290925	3.338696	2.634795
		(3.82364)	(6.19290)	(6.39973)	(6.29462)

		[0.12605]	[0.53140]	[0.52169]	[0.41858]
Production potential	lag (1)	3.710018	4.978046	6.074426	5.912574
		(2.73842)	(4.43524)	(4.58337)	(4.50809)
		[1.35480]	[1.12238]	[1.32532]	[1.31155]
	lag (2)	0.632369	3.764644	3.805048	3.099495
		(4.05438)	(6.56661)	(6.78593)	(6.67447)
		[0.15597]	[0.57330]	[0.56073]	[0.46438]
Capital resource	lag (1)	9.652867	13.50847	14.19069	15.91156
		(4.21491)	(6.82661)	(7.05461)	(6.93874)
		[2.29017]	[1.97880]	[2.01155]	[2.29315]
	lag (2)	2.900376	9.132868	8.801996	8.089618
		(8.00630)	(12.9673)	(13.4004)	(13.1803)
		[0.36226]	[0.70430]	[0.65685]	[0.61377]
Statistical significance coefficients					
Coefficient of determination		0.792823	0.718844	0.713808	0.718351
Adjusted coefficient of determination		0.585645	0.437688	0.427616	0.436703
Statistical error		0.069031	0.011105	0.011559	0.011342
F-test		3.826779	2.556744	2.494157	2.550524

Note: ER is economic recovery; calculations are made in Eviews statistical package.

4.3. Ukraine's Innovation Potential

At the current stage of Ukraine's economic development, innovations are a key basis for restoring the economic system aftershocks and socio-political, military, and other disruptions, ensuring the sustainability of the socio-economic system and creating a nano-economy based on intellectual resources, information technology, scientific and technological advances, as well as the production of high-tech goods and services. Innovative transformations have a powerful potential for socio-economic recovery and further development of society. They are an existential driver of progress.

The share of research and development expenditures in GDP can be considered an indicator of a country's innovative development. In Ukraine, this indicator showed a downward trend in 2005-2023. In particular, the share of R&D expenditures in 2021 was 0.38%, which is 0.92 pp less than in 2005. Thus, the pace of Ukraine's innovation potential (Figure 3) was minimal. The empirical indicator of the innovations resource component had peak values only in 2015-2016 (0.661 and 0.685, respectively). The nature of the impact of the resource components and the marker of the efficiency of its use in the economy is controversial and ambiguous, which indicates a high dependence of innovation potential on external sources of financial support. The significant growth of innovation potential in Ukraine in 2015-2019 did not lead to an increase in the share of R&D expenditures in GDP but rather to a significant decrease. This trend does not indicate the reverse influence of potential on the efficiency marker but is an indicator of the inefficiency of the implementation of innovation policy in Ukraine in general.

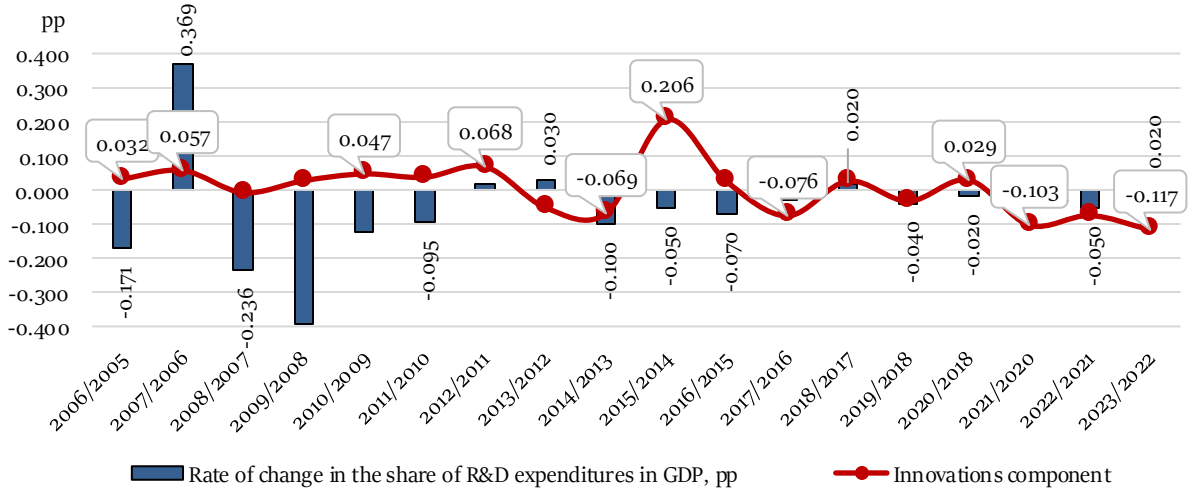


Figure 3: Potential for socio-economic recovery of Ukraine: innovations component marker, 2005-2023.

The modeling results prove the controversial and permanent impact of Ukraine's innovation potential on the relevant marker of its use efficiency (the share of R&D expenditures in GDP) (Table 4). Thus, a 1% increase in the resource component increases the share of R&D expenditures in the country's GDP by 0.8% in the first lag but decreases it by 0.2% in the second lag. The reverse effect of the resource component on the share of R&D expenditures in the country's GDP is typical for economies with low financial self-sufficiency in the innovation sector and high dependence on external sources of investment. Interestingly, the innovation potential in the long run depends on the pace of its development at the current moment as evidenced by the coefficients of the impact of the innovations resource in the temporal cut (the coefficient of impact is 2.1% in the second lag).

Table 4: Empirical characteristics of the dynamic relationship of the potential for socio-economic recovery of Ukraine: innovations component, 2005-2023.

Indicators of Potential	Lags	ER Markers Share of R&D Expenditures in GDP	Innovations Component
Share of R&D expenditures in GDP		0.862939	-0.258872
	lag (1)	(0.27160)	(0.27894)
		[3.17726]	[-0.92805]
		-0.169036	0.507385
	lag (2)	(0.28748)	(0.29525)
		[-0.58799]	[1.71848]
Innovations resource		0.110987	0.053827
	lag (1)	(0.30488)	(0.31313)
		[0.36403]	[3.36550]
		0.428037	2.106483
	lag (2)	(0.34772)	(0.35712)
		[-1.23098]	[0.29817]
Statistical significance coefficients			
Coefficient of determination		0.917930	0.628362
Adjusted coefficient of determination		0.890573	0.504483
Statistical error		0.061373	0.003032
F-test		33.55402	5.072374

Note: ER is economic recovery; calculations are made in Eviews statistical package.

4.4. Ukraine's Entrepreneurship Potential

In the context of the socio-economic, political, and military turmoil caused by the full-scale war of the russian federation, Ukraine has faced numerous challenges and risks that have both slowed down economic development and caused a significant socio-economic decline in many regions. Some of them are on the verge of a deep crisis, posing a serious threat to their economic security and resilience, as well as further growth. Against the background of these problems, the maintenance and development of the business sector, which is one of the main drivers of economic stability, becomes particularly important. Effective use of entrepreneurial potential will contribute to the capitalization of other components of the potential (capital, including investment, labor, and innovation). Building up the entrepreneurial potential in Ukraine will, in the short term, lay the foundation for post-war economic recovery and ensure sustainable socio-economic development.

During 2005-2023, the development of the entrepreneurship component was wave-like. The peak values were observed in 2018-2021 (from 0.601 to 0.742), while during the crisis periods, entrepreneurial potential in Ukraine experienced a significant decline (e.g. to 0.394 in 2009 and 0.267 in 2014). The impact of entrepreneurial capital on the market of its use in the country's economy (return on assets ratio) is dynamic, in particular with a lag of 2 - 3 years (Figure 4). Thus, the increase in entrepreneurial potential by 0.08 pp in 2015 contributed to a 0.15 pp increase in the size of assets and income of the business sector in 2017. In 2022, the entrepreneurial potential weakened by 0.13 pp, which is also caused by the unrealized migration potential of businesses from the frontline areas in the rear oblasts.

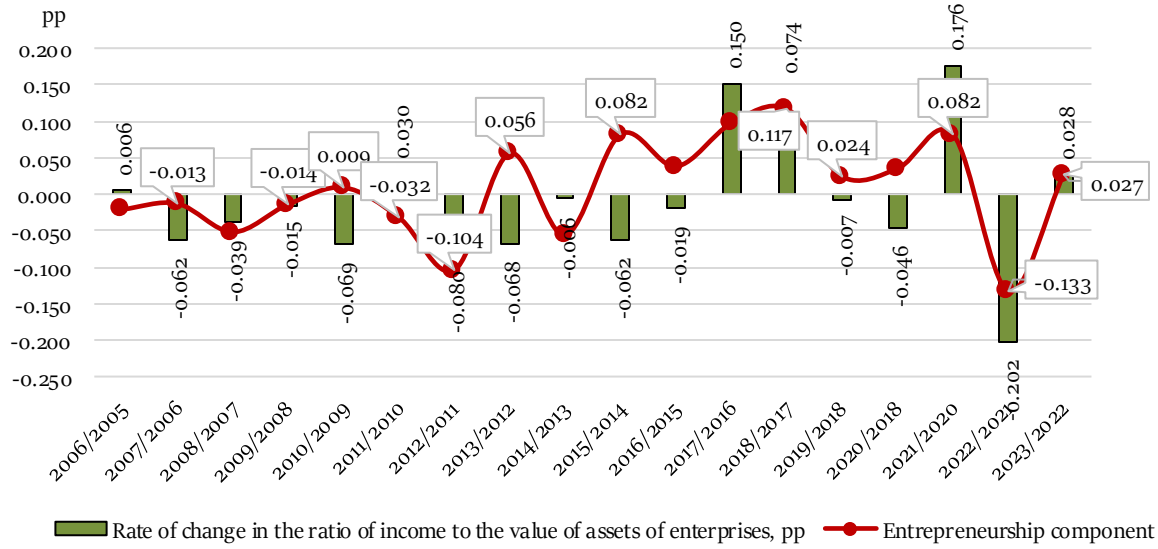


Figure 4: Potential for socio-economic recovery of Ukraine: entrepreneurship component marker, 2005-2023.

The results of the lagged complementary modeling of the impact of the entrepreneurship resource component on the resulting indicator of the entrepreneurial sector performance confirm the thesis of a direct and strong relationship between the variables under study. For example, a 1% increase in entrepreneurial potential

contributed to a 0.18% increase in business entity revenues in the first lag and a 0.07% increase in the second lag Table 5. Meanwhile, an increase in the share of income in the value of enterprise assets allows entrepreneurial potential to increase in two-run lags by 0.5% and 0.6%, respectively. Ensuring the optimal development of entrepreneurial potential is a key condition for the economic recovery of the country and its regions, which will also ensure the development of the business environment. In addition, a positive financial result contributes to the timely payment of salaries to employees, the receipt of tax payments to the budget, and the implementation of important social projects.

Table 5: Empirical characteristics of the dynamic relationship of the potential for socio-economic recovery of Ukraine: entrepreneurship component, 2005-2023.

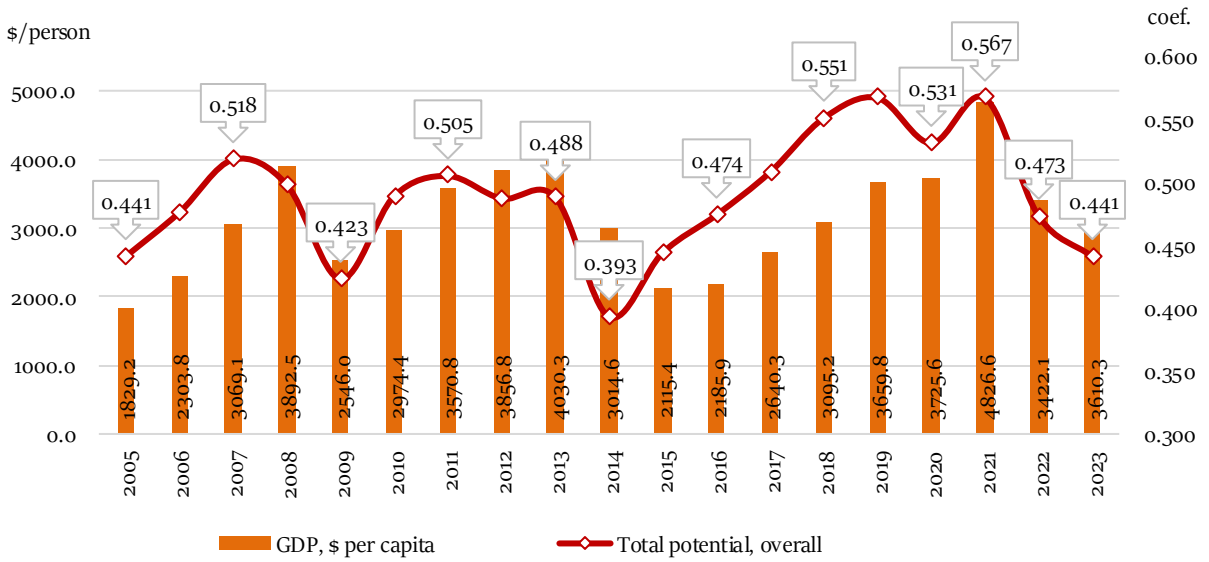
Indicators of Potential	Lags	ER Marker Return on Assets Ratio	Entrepreneurship Component
Return on assets ratio	lag (1)	0.316002 (0.27946) [1.13076]	0.508435 (0.41781) [1.21692]
	lag (2)	0.225713 (0.28361) [0.79585]	0.558292 (0.42401) [1.31668]
Entrepreneurship resource	lag (1)	0.198244 (0.17680) [1.12130]	0.622574 (0.26432) [2.35537]
	lag (2)	0.065108 (0.19886) [0.32740]	0.513594 (0.29731) [1.72748]
Statistical significance coefficients			
Coefficient of determination		0.552873	0.850066
Adjusted coefficient of determination		0.403830	0.800088
Statistical error		0.001381	0.001866
F-test		3.709500	17.00876

Note: ER is economic recovery; calculations are made in Eviews statistical package.

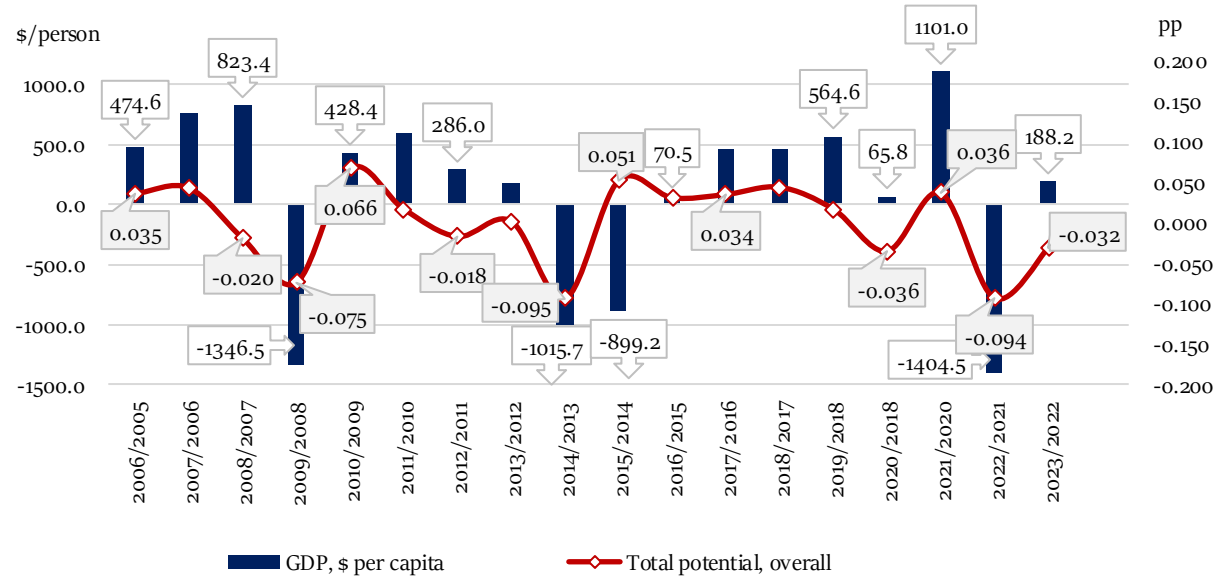
4.5. Ukraine's Total Potential

Economic growth, as a complex and multifaceted process, is also an indicator of the country's well-being. In the period of economic recovery, when the economic system is permanently transformed, the existential task is to identify the driving forces that contribute to economic development.

According to the results of the study, during 2005-2023, economic growth in Ukraine depended on a set of factors that changed in dynamics (from classical resources such as land, capital, and labor to innovation, human capital development, and education). Thus, GDP per capita is an indicator of economic development, and the rate of change in GDP per capita is an indicator of socio-economic recovery (Figure 5). The relationship between total potential and economic growth is direct and short-term, which indicates that GDP changes are similar under any potential transformation. For example, in 2014, the total potential decreased to 0.393 (compared to 0.488 in 2013), and the GDP decreased to $3,000 per capita. During 2015-2019, Ukraine's potential increased from 0.444 to 0.567, which contributed to an increase in GDP from $2,100 to $3,700 per capita. It is worth mentioning that the recovery of the economic system after a macroeconomic shock has a high degree of dynamic elasticity to changes in potential. Thus, a decrease in the empirical indicator of Ukraine's total potential in 2007-2009, 2013-2014, and 2021-2023 by an average of 0.08 pp, 0.09 pp, and 0.8 pp, respectively, led to a decrease in the pace of socio-economic recovery by $1,300, $900, and $1,400 (per capita), respectively. If the potential is increased by 0.06 pp (2010) and 0.05 pp (2015), GDP increases by $400 (per capita).



(a) GDP per capita – the country's total potential vector



(b) GDP growth rate – the country's total potential vector

Figure 5: Potential for socio-economic recovery of Ukraine: the country's total potential marker ((a) GDP and (b) GDP growth rate), 2005-2023.

The rate of socio-economic recovery in the projection of increasing the country's potential is twice lower than the rate of socio-economic regress. A 1% increase in total potential will boost the pace of socio-economic recovery by 0.78 pp Table 6; an increase in the volume of resources for economic recovery in the first lag will contribute to an increase in total potential by 0.63 pp in the second lag. At the same time, a 1% increase in GDP (per capita) allows for a 0.21 pp increase in total potential in the first lag and a 0.06 pp increase in the second lag.

Table 6: Empirical characteristics of the dynamic relationship between the total potential and socio-economic recovery of Ukraine, 2005-2023.

Indicators	Lags	Socio-Economic Recovery	Potential
Total potential		0.784199	1.236885
	lag (1)	(0.29004)	(0.88099)
		[2.70379]	[1.40397]
		0.608724	0.628942
	lag (2)	(0.26919)	(0.81768)
		[2.26130]	[0.76918]
Socio-economic recovery		0.498775	0.213423
	lag (1)	(0.14196)	(0.43122)
		[3.51340]	[0.49493]
		0.034673	0.061951
	lag (2)	(0.12414)	(0.37707)
		[0.27931]	[0.16429]
Statistical significance coefficients			

Indicators	Lags	Socio-Economic Recovery	Potential
Coefficient of determination		0.708893	0.599377
Adjusted coefficient of determination		0.611857	0.465836
Statistical error		0.027214	0.082663
F-test		7.305475	4.488340

Note: calculations are made in Eviews statistical package.

5. DISCUSSION

Ukraine's demographic and labor potentials showed an upward trend during the study period, with a significant decline during the crises (2008, 2014, 2020) and a critical decline during the war (2022-2023). The average annual rates of decline in the components of the labor resource were 0.76 pp and 0.2 pp, respectively, and in 2021-2022 and 2021-2023, the weakening of demographic and labor potentials was observed at the level of 6.3-7.9 pp and 4.8-11.4 pp, respectively. The value of the empirical indicator of the labor resource in Ukraine during the war decreased by 0.103 pp (for comparison, in 2020-2021 there was an increase of 0.032 pp). The study proves that the decline in labor and demographic potential has a direct dynamic impact on the potential for socio-economic recovery with a time lag of 2-3 years. A similar relationship was confirmed by Bilan et al. (2020), while Formánek (2019) focuses on the GDP-boosting policy in the EU countries, which includes support for knowledge-based economic activities: strengthening research and development, improving the structure of the labor force, and increasing investment in human capital.

During 2005-2023, the average annual growth rate of Ukraine's financial potential was 3.08 pp, which is 3 times higher than the growth rate of the production potential. The war has affected the financial sector's resilience and has triggered a weakening of financial potential in the face of limited financial, production, and investment resources. In 2021-2023, the production potential decreased by 4.7 pp and the financial potential – by 7.9 pp. The financial and production potential has a permanent one-year impact on the potential for socio-economic recovery, and is the basis for ensuring economic growth and the eco-state (Voznyak et al., 2019). Efficient use of investment and production potential ensures the stability of economic systems, stimulates business activity, and increases the attractiveness of the business environment (Contractor et al., 2020).

Testing of the author's methodology determined the rate of development of Ukraine's innovation potential, which was minimal during the study period (ranging from 0.250 to 0.450) with minor peaks in 2015-2016 (0.661 and 0.685). The average annual growth rate of innovation potential in 2005-2023 was 1.25 pp, and the decline in 2021-2023 was 9.6 pp. The main triggers of the regression of the country's innovation potential during the war included a critical reduction in the amount of financing of innovation activities by industrial enterprises, a significant reduction in the share of research expenditures in GDP, and the scale of intellectual and human resource emigration (Mulska et al., 2022). Building up Ukraine's innovation potential will increase the country's resource capacity for socio-economic recovery, on the one hand, and ensure resilience to macroeconomic, financial, and investment shocks, on the other (Dempere et al., 2023).

During 2005-2023, the development of the entrepreneurship resource component had a wave-like nature with maximum values in 2018-2021 (from 0.601 to 0.742). During the crisis, the rate of decline in Ukraine's entrepreneurial potential was 3.45 pp (2008-2009), 2.7 pp (2014-2015), and 5.3 pp (2021-2023). The impact of entrepreneurial capital on the potential for socio-economic recovery is dynamic, with a 2-3-year lag. Urbano (2020) proves that the effective use of entrepreneurial potential contributes to the capitalization of other components, including financial, production, demographic, labor, and innovation potentials.

The relationship between the total potential and the country's economic growth is direct and short-term (a decrease in the empirical indicator of Ukraine's potential during 2007-2009, 2013-2014, and 2021-2023 by an average of 0.08 pp, 0.09 pp, and 0.8 pp, respectively, led to a decrease in the rate of socio-economic recovery by $1,300, $900, and $1,400 per capita, respectively). The rate of socio-economic recovery with a 1% increase in total potential is twice as low than the rate of loss of resistance and reduction of the country's potential during a crisis or the onset of macroeconomic and other types of shocks. The impact of youth migration on the resource framework of economic growth is proven to be temporal, and the strength of the impact increases starting from the third lag (Staniscia et al., 2021).

6. CONCLUSION

The study aims to assess the potential of Ukraine's socio-economic recovery and identify reserves for its growth in the face of instability. The findings of the study confirm the thesis of a direct lagged relationship between the total potential of the country (formed by four resource factors – capital, labor, innovations, entrepreneurship) and the possibilities of socio-economic recovery (growth) of the country in the post-war period. The parameters of economic growth are selected for each resource component (total labor productivity – labor resource, the share of research and development expenditures – innovations resource, consolidated budget revenues – capital resource, the return on assets ratio – entrepreneurship resource).

This study shows that the decline in the total potential of Ukraine during the period of analysis led to a slowdown in the pace of socio-economic recovery (direct short-term relationship), and the rate of recovery with a 1% increase in the country's potential was half that of the rate of decline in potential during the crisis periods. Potential growth areas within the four factors-components of Ukraine's entrepreneurship potential include

increased investment in human development, re-emigration, curbing youth migration, development of the virtual labor market (labor resource), increased capital investment in infrastructure, creation of a favorable investment climate, development of the capital market (capital resource), creation of a startup ecosystem, tax incentives for small and medium-sized businesses, support for export-oriented enterprises (entrepreneurship resource), development of innovation clusters and technology parks, digitalization of the economy, and support for knowledge-intensive economic systems (innovations resource).

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APPENDIX

Appendix A: Information and analytical basis for the study of the potential for socio-economic recovery of the country: systemic and structural approach

Indicators	
Labor resource	
Demographic potential	**Labor potential**
✓ Children per 1,000 population	✓ Employment rate of the population aged 15-70, % of the total population of the corresponding age
✓ **Elderly people per 1,000 population**	✓ Labor force recruitment rate, % of the average number of full-time employees
✓ Total fertility rate	✓ **Labor attrition rate, % of the average number of full-time employees**
✓ **Mortality rate for children under 1 year old, per 1,000 newborns**	✓ **Employment rate in the informal economy, % of total employment**
✓ Average life expectancy at birth, years	✓ **Loss of working hours, %**
✓ **Out-migrants per 10,000 population**	✓ Employment rate of unregistered unemployed, %
✓ Total marriage rate per 1,000 population	✓ **Workload per vacant job, people**
✓ **Share of single-parent families with children, %**	✓ **Unemployment rate of the total population aged 15-70, % of the population of the corresponding age**
✓ **Marital instability rate, %**	✓ **Labor migration (number of work permits per 100,000 population)**
✓ **People with disabilities per 10,000 population**	
✓ Share of households with 3 or more children, %	
Capital resource	
Production potential	***Financial potential***
✓ Industrial production, $ per person employed	✓ Tax revenues, $ per capita
✓ Agricultural production, $ per person employed	✓ Non-tax revenues, $ per capita
✓ Construction work performed, $ per person employed	✓ Interbudgetary transfers (state budget), $ per capita
✓ Cargo turnover by transport, tons, per 1,000 population	✓ Capital expenditures (consolidated budget), $ per capita
✓ ICT volumes, thousand $ per employee	✓ Share of state budget loans in consolidated budget revenues, %
✓ Exports, thousand $ per capita	✓ **Debt obligations (internal and external), % of GDP**
✓ Capital investment (per capita), $	✓ Foreign direct investment (per capita), $
✓ **Depreciation of fixed assets, %**	✓ Average monthly nominal wages, $ per full-time employee
✓ Energy intensity of the economy, kg of fuel per $1 of GDP	✓ Disposable income, $ per capita
	✓ Business sector assets, million UAH, per economic entity
	✓ Remittances, $ per capita
Innovations resource	***Entrepreneurship resource***
✓ Research and teaching staff with a PhD and doctoral degree, per 100 postgraduate students	✓ MEs, per 10,000 population
✓ Researchers involved in R&D, % of the total number of employees involved in R&D	✓ SEs (including micro), per 10,000 population
✓ Share of innovatively active industrial enterprises, %	✓ Products sold by MEs, thousand UAH per capita
✓ New technological processes implemented per 100 industrial enterprises	✓ Products sold by SEs, thousand UAH per capita
✓ Innovative products sold per innovatively active industrial enterprise, million UAH	✓ Employees at SEs, % of the total number of employed
	✓ Employees at MEs, % of the total number of employed
	✓ Individual entrepreneurs, per 1,000 population
	✓ Products (goods, services) sold by individual entrepreneurs, per capita
	✓ Employed by individual entrepreneurs, % of the total number of employed
	✓ **Enterprise turnover rate**
	✓ **Business migration abroad, % of the total relocated economic entities**

Note: Indicators that have a reverse impact on the potential for socio-economic recovery are highlighted in bold; ME – medium-sized enterprises; SE – small enterprises.