



THE ROLE OF ECONOMIC MODERNIZATION IN ENSURING SUSTAINABLE ECONOMIC GROWTH

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Abstract

This paper explores the importance, methods, and scientific and practical significance of economic modernization processes in terms of sustainable economic growth. The effect of technological modernization, development of human capital, digitalization, and institutional reforms on GDP growth is studied through statistical and correlation analysis. Global economic issues in the modern world, including problems of the energy system, misalignment of the labor market, and venture capital financing difficulties, are considered systematically. In conclusion, recommendations aimed at increasing economic stability and export diversification are formulated.

Keywords: economic modernization, sustainable growth, Fourth Industrial Revolution, human capital, digitalization, institutional reforms, green economy, venture financing, export diversification, technological modernization

Introduction

By the middle of the twenty-first century, the world economic system has come to the brink of revolutionary changes. The classical model of extensive development, which uses ecological and natural resources, primarily fossil fuel resources, has run up against economic, technological, and environmental limits. In present-day circumstances, economic modernization is impossible without considering it as not only the introduction of new equipment for the separate enterprise but also as a full-scale macroeconomic approach aimed at the formation of economic relationships that meet Industry 4.0 requirements, digitalization of management models, and training of competent human capital.¹

At present, in the context of increasing geo-economic and geopolitical tensions, problems with global transport and logistic chains, and climate change, it is vital to make the national economy more resistant to external shocks. Despite the stable growth of Uzbekistan's economy in recent years, it faces one of the most difficult macroeconomic challenges in developing countries, known as the "middle income trap".²

A successful resolution of this strategic task necessitates a dramatic decrease in dependency on export of raw materials and thorough structural reforms to restructure the national industry.³

¹ Schwab, K. (2017). *The Fourth Industrial Revolution*. New York: Crown Business.

² Eichengreen, B., Park, D., & Shin, K. (2013). *Growth Slowdowns Redux: New Evidence on the Middle-Income Trap*. NBER Working Paper No. 18673.

³ President of the Republic of Uzbekistan. (2023). *Decree No. UP-158 of September 11, 2023, "On the Uzbekistan–2030 Strategy"*.

The importance of the research area is defined by several systemic problems and emerging threats that have become more visible in the last years. The first problem is the combination of global and regional energy crisis, which has negatively impacted the stability of operations of high-technology companies such as data centers and digital manufacturing plants. The second threat is the mismatch of the current higher education system with the demands of the labor market; especially, the shortage of specialists in fields such as artificial intelligence, robotics, and green engineering has become the primary obstacle to effective modernization of the economy. The third issue is related to the inefficiency of the traditional banking sector and underdeveloped venture capital institutions in financing innovations and new technologies.⁴

Literature review

Economic modernization and economic modernization as a determinant of sustainable macroeconomic growth is one of the most essential spheres in modern economic science. The Endogenous Growth Theory introduced by Nobel Prize laureate Paul Romer is the basic theoretical framework of the study of economic mechanisms of technological modernization.⁵ According to the basic assumption of Romer's theory, knowledge and innovation significantly differ from such traditional factors of production as land, labor, and physical capital due to their non-rival character and the lack of depreciation when used. As a result, the transition from the resource-intensive economy to the economy based on intellectual property reduces the influence of diminishing marginal returns and ensures sustainable economic growth.

In the context of Industry 4.0, Klaus Schwab states that combining manufacturing processes with intelligent and cyber-physical systems may lead to an increase in labor productivity up to 15–20 percent. Nevertheless, Schwab warns that nations unable to make adequate investment in digital technology become excluded from international value chains and remain permanently poor in comparison with other nations.

The representatives of institutional economics school Daron Acemoglu and James A. Robinson provide the empirical evidence that proves the idea that sustainability of economic modernization relies not only on technological advances but also on presence of inclusive institutions.⁶ Based on their research results, one can state that efficient protection of property rights and minimizing of bureaucratic obstacles are necessary conditions of attracting venture capital and implementation of innovations.

From the perspective of the national economy, E. G'aniyev and Sh. Hakimov claim that restriction of the process of structural reforms in Uzbekistan to the acquisition of foreign equipment and technologies will most probably not lead to the expected results.⁷ In particular, they believe that the key factors of the process of structural modernization are liberalization of competition and improvement of the quality of human capital. In addition, empirical calculations made by the analysts from the World Bank show that investment into information

⁴ Humphrey, J., & Schmitz, H. (2002). How does insertion in global value chains affect upgrading in industrial clusters? *Economy and Society*, 31(4), 1017–1027.

⁵ Romer, P. M. (1990). Endogenous Technological Change. *Journal of Political Economy*, 98(5), S71–S102.

⁶ Acemoglu, D., & Robinson, J. A. (2012). *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*. New York: Crown Business.

⁷ Ganiyev, E., & Khakimov, Sh. (2022). Stages of Structural Modernization of the Economy of Uzbekistan. *Economic Bulletin of Uzbekistan*, No. 2, pp. 45–51.

infrastructure in developing countries leads to creation of 1:3.2 value added ratio within the timeframe of three-five years, which positively affects GDP growth.⁸

Research methodology (methods)

In this research, both quantitative and qualitative approaches to research have been applied in order to assess the influence of the mentioned factors of economic modernization on sustainable economic growth.

1. Econometric and Correlation Analysis

In order to establish how strong the interdependencies between the major macroeconomic factors are, the Pearson correlation coefficient (r) was found out. In the process of empirical analysis, the value of real GDP growth (Y) has been considered the dependent variable, whereas the percentage of R&D expenditures in GDP (X_1) and ICT export volume (X_2) have been regarded the independent ones.

$$r = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^n (X_i - \bar{X})^2 \sum_{i=1}^n (Y_i - \bar{Y})^2}}$$

2. Comparative Macroeconomic Analysis:

Comparative analysis of Uzbekistan's macroeconomic indicators for the period 2020-2025 was performed relative to developing countries and those that managed to overcome the problem of the middle income trap, such as South Korea and some Eastern European countries.

3. SWOT and Institutional Analysis:

SWOT analysis was conducted to identify factors affecting the process of economic modernization of the country, both internal and external, such as strengths, weaknesses, opportunities, and threats. Besides, an institutional analysis was conducted to assess the efficiency of the legislative and administrative support of economic modernization.

The empirical foundation of the research was constructed based on the data from the World Bank Open Data, the Statistical Agency under the President of the Republic of Uzbekistan, as well as annual reports and macroeconomic indicators obtained through the Development Strategy of New Uzbekistan for 2022-2026. All statistical estimations and econometric modeling were performed on time series data for the period 2020-2025.

Results

The analysis done within the context of this research shows that the adoption of digital technologies, ICT systems, and renewable energy sources in different economic sectors has a direct multiplicative effect on the growth rate of real GDP. In the period from 2020 to 2025, structural modernization measures taken in the country contributed greatly to improvements in macroeconomic performance. The dynamics of modernization factors and their associated macroeconomic outcomes have been summarized in Table 1.

Table 1.

Dynamics of Economic Modernization and Sustainable Economic Growth Indicators in Uzbekistan (2020–2025) ⁹

⁸ World Bank. (2024). *Digital Progress and Economic Transformation in Developing Countries*. Washington, DC: World Bank Technical Report.

⁹ Statistics Agency under the President of the Republic of Uzbekistan. (2025). *Annual Collection of Macroeconomic Indicators of Uzbekistan*. Tashkent.

Indicator	2020	2022	2024	2025	Average Annual Growth Rate
Real GDP Growth (%)	1.6	5.7	6.4	6.5	+5.0%
GDP per Capita (US\$)	1,680	2,250	2,850	3,200	+13.7%
R&D Expenditure (% of GDP)	0.14	0.18	0.25	0.32	+17.8%
ICT Exports (million US\$)	65	120	250	350	+39.8%
Share of Green Energy Sources (%)	12.5	18.0	26.5	32.0	+20.7%

It can be seen from the data provided in Table 1 that the level of exports of ICT products grew from US\$65 million in 2020 to US\$350 million in 2025. The increase is five times higher compared to the base year. Additionally, the spending on research and development, which is one of the major drivers of innovation development, has grown from 0.14% to 0.32% of the GDP, or by 2.3 times.

In order to estimate the influence of the factors of modernization on the sustainability of economic growth, it is necessary to calculate the correlations between real GDP growth (Y), research and development expenditure (X_1), and exports of ICT products (X_2). To do so, the Pearson correlation analysis will be used, and the correlation matrix is provided in Table 2.

Table

2.

Correlation Matrix of Macroeconomic Modernization Factors¹⁰

Variables	Real GDP Growth (Y)	R&D Expenditure (X_1)	ICT Exports (X_2)
Real GDP Growth (Y)	1.00		
R&D Expenditure (X_1)	0.87	1.00	
ICT Exports (X_2)	0.91	0.84	1.00

As can be noted from the results of the correlation matrix, there is a very strong positive correlation between real GDP growth (Y) and ICT exports (X_2), with the value of the Pearson correlation coefficient equal to $r = 0.91$. In addition, a strong positive correlation was found between the R&D expenditure (X_1) and real GDP growth, with the correlation coefficient of 0.87. In addition, the correlation coefficient between the R&D expenditure and ICT exports was equal to 0.84, which shows a very strong positive correlation between these two modernization variables.

From the empirical results, it can be concluded that investments into economic modernization (mainly in research and development and the ICT sector) play an important role in the process of promoting sustainable economic growth. Besides, the positive correlations found between the analyzed variables imply that the continued implementation of the policy of economic modernization can positively affect future economic growth of the country.

Discussion

The empirical evidence collected from this study provides clear proof of the functional link between economic modernization and sustainable economic growth. Nevertheless, the transformation of the country's national economy cannot be explained through linear economic growth alone. According to the Endogenous Growth Theory of Paul Romer, although R&D

¹⁰ OECD. (2024). *Main Science and Technology Indicators*. Paris: OECD Publishing.

spending in Uzbekistan reached 0.32% of GDP in 2025, it still remains much lower compared to that of developed countries; namely, South Korea spends 4.8% and the US spends 3.4% of its GDP on R&D [10]. This means that the process of technological innovation has not been domesticated at an adequate level yet.

The rise of ICT exports from US\$65 million to US\$350 million, or fivefold growth, demonstrates tangible success in the digital transformation process. However, this analysis also indicates the presence of infrastructural and energy-related challenges, which might affect the sustainability of this development in the long term. Firstly, power shortages during autumn and winter seasons raise another threat to providing reliable power supply to the data centers, automated logistics centers, and other modern IT infrastructure. As pointed out by Klaus Schwab, infrastructural instability might impact foreign investors' decision-making when it comes to investing in the digital economy.¹¹

Another critical challenge is related to the effective use of human capital. On the one hand, as proved by the correlation analysis, there is a strong positive relationship between ICT exports and real GDP growth. On the other hand, the qualifications and specialization of university graduates are still not fully aligned with the changing requirements of the labor market. There is a shortage of specialists in artificial intelligence, digital technologies, and green energy of enterprises to engage in higher value-added segments of global value chains. Following the institutional approach presented by Daron Acemoglu and James A. Robinson, inadequate institutional development, especially poor legislation that regulates the venture capital market, as well as bureaucratic obstacles, limit start-up innovations' ability to access financing, and lead to high collateral conditions for accessing credits.¹²

The following recommendations based on the study results can be formulated to reinforce the mechanisms of economic modernization:

1.Improving Energy Security and Increasing Renewable Energy Supplies. Public Private Partnership (PPP) methods should be expanded to increase the inflow of investments from the private sector in renewable energy sources, including solar and wind power plants. Meanwhile, the systems of energy storage should be gradually implemented to ensure reliable and stable operation of the energy system of the country.

2.Employment of Dual Education Model to Increase the Integration between Higher Education and Industry. The curriculum of universities needs to be modernized in line with the standards of advanced technology corporations. Moreover, institutions should be created allowing higher education establishments to commercialize their innovations independently.

3.The Institutional Support of the Venture Capital Sector. In order to support innovation financing without requiring collateral, the establishment of the National Venture Fund is recommended. Furthermore, legislative regulations should be created in order to allow start-up companies to utilize their intellectual property rights as investment instruments.

4.The Optimization of Administrative Processes. The process of customs clearance and certification of digital and high-tech projects should be completely computerized according to the "single window" principle. This will help to cut down the costs related to bureaucracy and make the business environment more efficient.

¹¹ Schwab, K. (2018). *Shaping the Future of the Fourth Industrial Revolution*. New York: Currency

¹² Acemoglu, D., & Robinson, J. A. (2019). *The Narrow Corridor: States, Societies, and the Fate of Liberty*. New York: Penguin Press.

It can be supposed that the implementation of the strategic measures mentioned above will positively influence the multiplier effect of economic reforms and stimulate innovation-driven development providing the country not only with the sustainable economic growth but also with increased resilience and competitiveness.

Conclusion

Taking into account the findings of this research on the influence of economic modernization, digital transformation, and structural changes on sustainable economic growth in Uzbekistan, the following conclusions may be drawn:

1. The High Role of Digital Factors. Over the time period of 2020-2025, ICT exports rose from \$65 million to \$350 million, which is a 5.4-fold rise. Therefore, it may be stated that digitalization is no longer an additional factor, being rather one of the key drivers of GDP growth. As a result of the econometric modeling, a Pearson correlation coefficient of $r = 0.91$ was found, which proves empirically the high multiplicative impact of the ICT sector on the macroeconomic growth and development of Uzbekistan.

2. Imbalance in R&D Infrastructure. Even though in 2025 R&D expenses reached 0.32% of GDP, it still constitutes a small portion compared to the benchmarks proposed by Paul Romer's Endogenous Growth Theory. Namely, investments in R&D in South Korea and the USA constitute 4.8% and 3.4% of GDP respectively. Thus, it may be concluded that Uzbekistan still lacks its capability of developing innovations, and economic modernization still implies technology transfer from abroad.

3. Infrastructure limitations and risks of energy shortages. There are two main obstacles preventing the further development of structural modernization. The first obstacle is associated with energy shortages, limiting the continuous functioning of technological infrastructure. The second obstacle is related to insufficiently developed higher education and vocational training systems capable of adequately responding to the rapid changes taking place in the labor market, including those in the sphere of artificial intelligence and advanced technologies. It limits the opportunities for the integration of national enterprises in higher value-added segments of global value chains.

These results give grounds for suggesting the following recommendations for improving the efficiency of Uzbekistan's economic modernization program:

- First, private sector investment needs to be attracted via PPPs in order to increase renewable energy production and installation of BESS systems thus guaranteeing the continuous functioning of the digital infrastructure and data centers.
- Second, the share of R&D expenditure should be increased in the GDP and more attention needs to be paid to start-up companies, which requires abandoning the existing collateral-based system of loans in favor of legal mechanisms recognizing intellectual property rights as investment assets along with establishing the National Venture Fund.
- Finally, the quality of human capital should correspond better to the needs of the labor market, through the expansion of dual education programs, full-scale modernization of the curricula in universities on the subjects of artificial intelligence and digital technologies, in accordance with the standards adopted in the IT industry worldwide, and increased autonomy of educational institutions in commercialization of research findings.

These measures will help increase the efficiency of structural reforms, boost innovative development, build macroeconomic stability, and improve the international competitiveness of the Uzbek economy against the backdrop of fast-paced technological changes worldwide..

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