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A DATA-DRIVEN MODEL FOR RISK MINIMIZATION AND INNOVATION-DRIVEN ECONOMIC GROWTH

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A B S T R A C T

The research aims to identify the most effective concept for minimizing risk in the context of catalyzing economic growth and develop scientific, methodological, and practical recommendations for applying this concept to Uzbekistan's economy through 2030. Drawing on statistical data from Central Asian countries for 2020–2024, the authors developed a Central Asian model of innovative economic growth. This model mathematically expresses the patterns of changes in innovation activity practices as the use of alternative risk management tools intensifies. The model led to an original and innovative conclusion that the self-formation of risk management is the most effective concept for minimizing risk in the context of fostering economic growth. Its theoretical significance lies in the creation of a conceptual vision for systemically minimizing economic, globalization, climate, and technological risks in an era of heightened economic turbulence, thereby enhancing the adaptive capacity of the innovative economies of Central Asian countries, particularly Uzbekistan, to high levels of business risk. The authors developed risk minimization forecasts according to the state-regulated risk management concept and the alternative concept of self-formed risk management. The research offers scientific, methodological, and practical recommendations for applying the concept of self-formed risk management to Uzbekistan's economy through 2030 to achieve absolute operational and political stability in the country's regulatory environment for entrepreneurship. These original recommendations are of empirical value because they are expected to simplify risk mitigation and accelerate the growth of Uzbekistan's innovative economy during the specified period.

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1. INTRODUCTION

Risk is one of the central categories in economic science. Risk serves as a crucial factor in economic practice, shaping its intensity, outcomes, and effectiveness. The third decade of the 21st century has emerged as a period of heightened economic turbulence, marked by an especially high level of business risk. This is due to the fact that, for the first time in contemporary economic history, critical risks have intensified across a broad spectrum of economic activity.

One such area is economic risk. In terms of the scale of recession, the current decade may well surpass the Great

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Depression and the global financial crisis of 2008. Today's economic instability stems not only from the collapse of financial bubbles but also from additional sources, such as the critical levels of the national debt in several developed countries (most notably the USA) and the restructuring of global financial relations framed within the broader trend of de-dollarization.

Another key area comprises the risks of globalization. The network of sanctions that now permeates international economic relations has erected substantial barriers to transnational trade and has initiated a long-term trend of fragmentation and reconfiguration of global supply and distribution chains. Free trade based on international labor division was once a means of mitigating the risks of declining national economic efficiency. Nowadays, it has become a source of risk, particularly in the form of potential shortages when import deliveries of goods and production factors are disrupted.

Simultaneously, total protectionism remains unachievable and impractical. As a result, countries worldwide are compelled to adapt their foreign trade flows to the constantly shifting realities of global markets to secure and maintain competitive advantages. A third domain of risk is climate-related. Climate change is now acutely felt and universally recognized as a serious threat to global civilization. To mitigate this threat, a global climate agenda has been adopted, accompanied by national decarbonization programs.

Although the origins of COVID-19 have yet to be irrefutably confirmed and remain a matter of scholarly debate, several respected researchers suggest that climate change may have contributed, if not directly to the emergence of COVID-19, then at least as an indirect factor in the onset of the COVID-19 pandemic and the rise of numerous other zoonotic diseases. Regardless of its cause, COVID-19 triggered an unprecedented spike in economic risks, stemming from the destabilization of healthcare systems and the widespread lockdowns imposed worldwide.

A fourth domain includes technological risks. The overlapping of the Fourth and Fifth Industrial Revolutions represents a period of rapid technological advancement. The accelerated pace of technological shifts, even in societies predisposed to change, demands greater attention to social adaptation. In more traditional socio-economic systems, this transition can cause economic disruption and widespread public unrest.

In this context, today's economic landscape requires a heightened focus on risk management. The growth and development of national economies under the current status quo depend directly on the effectiveness of risk minimization strategies. However, the challenge lies in the uncertainty about which alternative risk minimization strategy best supports current economic growth and should, therefore, be considered and prioritized.

The lack of robust scientific and methodological support hinders the fight against risks and slows the progress of the modern economy. This underscores the relevance of the present research, which aims to identify the most effective concept for minimizing risk in relation to catalyzing economic growth and develop scientific, methodological, and practical recommendations for applying this concept to the economy of Uzbekistan through 2030.

2. LITERATURE REVIEW

The theoretical foundation of this research is the theory of risk as a factor influencing economic activity and an object of management within economic science and practice. The principles of this theory are presented in the works of Ergasheva et al. (2023), Eshov (2020), Gu et al. (2023), Litvinova (2022), Prusak & Jabłoński (2024) and Mitsas et al. (2022). Within the framework of this theory, two alternative concepts of risk minimization in the economy have emerged. Each offers its own interpretation of the nature of risk, prescribes a distinct approach to risk management, and shapes a corresponding economic growth paradigm. These concepts are compared in Table 1.

Table 1. Comparative analysis of alternative concepts of risk minimization in the economy

Criteria for comparing concepts	Concepts of risk minimization in economics	
	The concept of state regulation of risk	The concept of risk management self-formation
Theoretical foundation of the concept	mercantilism, Keynesianism	classical political economy, institutionalism
Interpretation of the essence of risk	Risk is a cause of instability of the economy and a barrier to its development (negative interpretation of risk)	Risk is a manifestation, a reflection of instability of the economy, and a stimulus, a catalyst for its development (positive interpretation of risk)
Purpose of risk management	Restoration of a favorable business climate in the economy, its stabilization	Overcoming threats to innovation, managing change on the path of progress
Subject of risk management	Government regulators of the economy	Innovative enterprises
Risk management toolkit	Maintaining a transparent and stable status quo by ensuring the rule of law and high-quality state regulation of the economy	Stimulating "healthy" competition in the economy and creating a favorable business climate that encourages innovative activity of entrepreneurship
The paradigm of economic growth from a risk perspective	Economic growth is achieved through risk avoidance by preserving traditions	Risk is necessary for economic growth achieved through innovation

Source: Developed by the authors.

According to Table 1, the first concept is associated with state regulation of risk. This concept can be considered traditional because it supports established practices and was the first to emerge historically, drawing on the foundational principles of early economic thought, particularly mercantilism, which advocates protectionism, and Keynesianism, which views government spending on risk mitigation and subsidies for entrepreneurial risk management as investments in economic development.

In this concept, risk is interpreted as a source of economic instability and a negative factor that hampers the development of economic systems. The approach to risk management focuses on restoring a favorable business climate and stabilizing the macroeconomic environment. The key actors in risk management are government regulators.

The risk management toolkit aims to maintain a transparent and stable status quo. It includes ensuring the rule of law (Gr_1) (Mkrtchyan et al., 2024) and high-quality government regulation of the economy (Gr_2) (Polovtsev et al., 2023). The paradigm of economic growth within this concept holds that growth is achieved by avoiding risk: it is believed that entrepreneurial innovation requires the prior minimization of risk.

The second concept is that of self-formed risk management. It is named so because it emphasizes market self-regulation and views risk as a natural condition of the economy – an inherent component and a normal feature of economic activity. This concept is grounded in the principles of classical political economy (where the market environment is seen as natural, economic development is cyclical, and crisis phases are accompanied by elevated risk levels, with minimal state intervention) and institutionalism (which attributes the effectiveness of risk mitigation to the strength of economic institutions).

In this framework, risk is seen as a manifestation and reflection of economic instability and a stimulus and catalyst for development, offering a positive interpretation of risk. The approach to risk management focuses on overcoming threats to innovation and managing change along the path of economic progress.

The primary agents of risk management are innovation-driven enterprises. The toolkit aims to promote healthy competition and foster a favorable business environment that encourages entrepreneurial innovation through operational (SFr_1) (Astanakulov et al., 2022) and political (SFr_2) (Ostrovskaya et al., 2017) stability in the regulatory landscape for businesses. The economic growth paradigm under this concept asserts that risk is essential for economic growth, which is achieved through innovation.

Regardless of the specific concept of risk minimization, in the current context of an innovation-driven economy, what matters most for national economic systems is not mere GDP growth in quantitative terms (as a source of short-term benefits) but innovation-based economic growth that provides long-term advantages by enhancing national competitiveness and securing stronger positions in global markets.

The literature review revealed that existing academic research identifies the following indicators of growing innovation activity as signs of successful risk minimization in the economy:

- An increase in the share of venture capital in the structure of innovation financing (IEG_1) (Raymbaev et al., 2017; Nosirov et al., 2023);
- Greater R&D collaboration between enterprises and universities (IEG_2) (Bezrukova et al., 2016);
- Higher labor productivity as a result of implementing innovations in entrepreneurship (IEG_3) (Baratova et al., 2023);
- Growth in the share of high-tech industries within the national industrial structure (IEG_4) (Shaturaev, 2023);
- An increase in GDP at constant prices (IEG_5) (Bogoviz et al., 2018; Dhar et al., 2023; Popkova et al., 2018).

Nevertheless, despite the abundance of available publications, which suggests a high degree of scholarly engagement with this issue – the contribution of risk management practices aligned with these alternative risk minimization concepts to the growth of the innovative economy remains underexplored and largely unknown.

The identified gap in the literature has led to the formulation of the research question (RQ) addressed in this research: which risk management toolkit – ensuring the rule of law (increasing Gr_1) and high-quality government regulation of the economy (growth in Gr_2) in line with the state-regulated risk management concept, or maintaining operational (increase in SFr_1) and political (growth in SFr_2) stability of the regulatory environment for entrepreneurship in accordance with the self-formed risk management concept – makes the greatest contribution to the growth of the innovative economy (i.e., the increase in IEG_{1-5})?

Drawing on the works of Islam (2025), Jha et al. (2024), Kirikkaleli and Kalmaz (2024), and Liang et al. (2024), which emphasize the advantages of market freedom in maintaining entrepreneurial adaptability in a high-risk business environment, this research puts forward hypothesis (H): that the growth of innovation activity in the economy is more strongly driven by the maintenance of operational and political stability in the regulatory environment for entrepreneurship, in line with the self-formed risk management concept. The research is dedicated to testing this hypothesis using the case of

Uzbekistan, with reference to the empirical experience of Central Asia.

3. MATERIALS AND METHODS

To examine the experience of Central Asia, the research forms a sample of four countries from this geographic region for which the necessary official statistics are available for 2020–2024 (Table 2). The hypothesis of this research is tested using regression analysis to determine the dependence of the innovative economy (IEG_{1-4} based on the materials from WIPO (2024) and IEG_5 based on the materials from International Monetary Fund (2025) on a set of factors: the rule of law (Gr_1), and the quality of government regulation of the economy (Gr_2) as per the state-regulated risk management concept, as well as operational (SFr_1) and political (SFr_2) stability of the regulatory environment for entrepreneurship, in line with the self-formed risk management concept, based on data from WIPO (2024).

Table 2. Coping with risk and innovative economic growth in Central Asia in 2020–2024

Country	Year	Operational stability for businesses, score 0-100	Policy stability for doing business, score 0–100	Rule of law, score 0–100	Regulatory quality, score 0–100	GERD financed by business, %	University-industry R&D collaboration, score 0–100	Labor productivity growth, %	High-tech manufacturing, %	Gross domestic product, constant prices, percent change
		SFr_1	SFr_2	Gr_1	Gr_2	IEG_1	IEG_2	IEG_3	IEG_4	IEG_5
Kazakhstan	2020	69.6	80.6	35.4	45.5	47.4	40.9	3.0	9.6	-2.6
	2021	69.6	80.6	35.3	47.1	47.4	36.0	0.9	13.5	4.1
	2022	69.1	41.0	35.8	48.4	47.4	29.6	2.2	15.3	3.2
	2023	50.0	35.5	25.5	44.4	47.4	20.3	1.6	15.3	5.1
	2024	57.3	38.2	30.2	41.5	47.4	23.9	1.8	14.1	4.8
Kyrgyzstan	2020	53.6	71.5	23.0	32.6	6.4	28.9	3.4	2.7	-7.1
	2021	50.0	71.5	17.3	34.4	6.9	28.3	0.5	2.4	5.5
	2022	47.3	32.1	22.0	34.8	6.9	24.4	1.7	2.1	9.0
	2023	19.4	25.4	8.3	27.1	6.9	6.0	0.0	1.8	9.0
	2024	28.7	32.5	10.9	25.2	6.9	19.7	0.2	2.1	9.0
Tajikistan	2020	58.9	60.8	13.2	14.1	1.6	49.0	4.6	2.8	4.4
	2021	58.9	60.8	14.4	17.1	1.6	47.2	4.7	2.8	9.4
	2022	56.4	55.6	14.5	19.5	1.6	38.3	5.7	2.6	8.0
	2023	33.3	56.1	5.0	12.9	0.0	31.0	5.3	2.6	8.3
	2024	36.7	55.5	7.8	10.4	0.0	29.9	4.7	2.6	8.4
Uzbekistan	2020	64.3	69.8	18.7	12.7	42.4	0.0	4.7	22.8	1.6
	2021	64.3	69.8	19.1	17.5	42.4	0.0	4.6	24.0	8.0
	2022	65.5	69.2	18.5	21.3	42.4	56.0	4.7	27.3	6.0
	2023	48.6	73.3	13.8	27.0	42.4	62.4	5.0	24.8	6.3
	2024	54.7	73.2	19.3	27.4	42.4	60.3	3.9	23.1	6.5

Source: Developed by the authors based on the materials from the International Monetary Fund (IMF) (2025) and WIPO (2024).

Hypothesis H is considered confirmed if, in the resulting econometric model, the share of positive regression coefficients for the factor variables SFr_1 and SFr_2 is greater than that for the factor variables Gr_1 and Gr_2. Based on the Central Asian model of innovative economic growth, two alternative forecasts are developed for such growth in Uzbekistan through 2030:

1) A risk minimization forecast aligned with the state-regulated risk management concept, achieved through the establishment of the full rule of law (maximizing Gr_1) and the highest attainable quality of government regulation (maximizing Gr_2);
2) A risk minimization forecast aligned with the self-formed risk management concept, achieved through the attainment of absolute operational (maximizing SFr_1) and political (maximizing SFr_2) stability of the regulatory environment for entrepreneurship.

To generate these forecasts, the projected values of the factor variables are substituted into the regression model of the Central Asian innovative growth framework. The expected increase in innovation economy indicators (IEG_{1-5}) in Uzbekistan is then compared across the two forecast scenarios. In this way, the impact of adhering to different risk minimization concepts on the growth of Uzbekistan's innovative economy is determined.

4. RESULTS

As a result of the regression analysis of the data from Table 2, the following Central Asian model of innovative economic growth was obtained:

$$\begin{cases} IEG_1=-13.96+0{,}04SFr_1+0.12SFr_2+1.74Gr_1-0.17Gr_2, \\ IEG_2=-46.51+1{,}60SFr_1+0.28Fr_2-4.47Gr_1+2.30Gr_2, \\ IEG_3=1.83+0.08SFr_1+0.01SFr_2-0.06Gr_1-0.09Gr_2, \\ IEG_4=-7.96+0.31SFr_1+0.06SFr_2+0.02Gr_1-0.04Gr_2, \\ IEG_5=8.31+0.24SFr_1-0.14SFr_2-0.71Gr_1+0.21Gr_2. \end{cases} \quad (1)$$

Model (1) revealed that in Central Asia, a one-point increase in the operational stability of the regulatory environment for entrepreneurship leads to a 0.04% rise in the share of venture capital in innovation financing, a 1.60-point increase in R&D collaboration between enterprises and universities, a 0.08% increase in labor productivity resulting from innovation in entrepreneurship, a 0.31% growth in the share of high-tech industries within national industry, and a 0.24% increase in GDP at constant prices.

It was also found that an improvement in the political stability of the entrepreneurial regulatory environment results in a 0.12% increase in the share of venture capital in innovation financing, a 0.28-point rise in R&D collaboration between enterprises and universities, a 0.01% increase in labor productivity due to innovation, and a 0.06% growth in the share of high-tech production in the industrial structure.

Simultaneously, strengthening the rule of law by one point contributes to a 1.74% increase in the share of venture capital in innovation financing and a 0.02% rise in the share of high-tech industries. In turn, improving the quality of government regulation by one point leads to a 2.30-point increase in R&D collaboration between enterprises and universities and a 0.21% growth in GDP at constant prices.

Thus, in the resulting econometric model (1), the proportion of positive regression coefficients for the factor variables SFr_1 (100.00%) and SFr_2 (80.00%) is greater than for the variables Gr_1 (40.00%) and Gr_2 (40.00%). Consequently, hypothesis H is confirmed.

Based on the Central Asian Model (1) of innovative economic growth, the authors developed two alternative forecasts of such growth in Uzbekistan through 2030. To this end, the projected values of the factor variables were substituted into the regression equation of the Central Asian model of innovative growth.

The forecast of risk minimization in accordance with the state-regulated risk management concept, achieved by establishing full rule of law (Gr_1=100) and the highest attainable quality of government regulation (Gr_2=100) is presented in Figure 1.

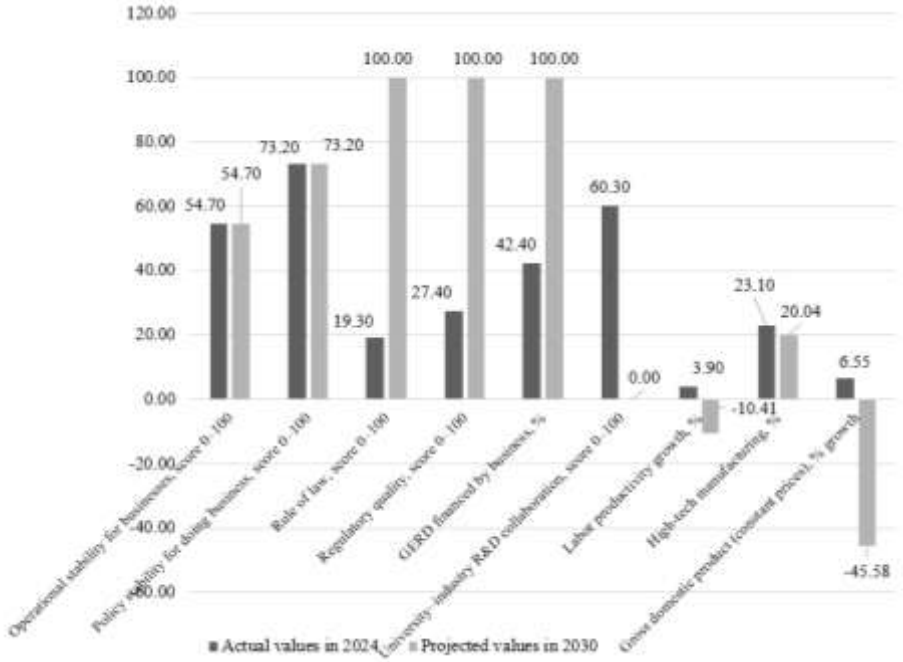


Figure 1. Forecast of Uzbekistan's innovative economic growth under risk minimization based on the state-regulated risk management concept through 2030. Source: Developed by the authors.

As shown in Figure 1, under the scenario of risk minimization in accordance with the state-regulated risk management concept through 2030, the following increases in Uzbekistan's innovation economy indicators are expected:

- Strengthening the rule of law by 418.14%;
- Improvement in the quality of government regulation by 264.95%.

According to this forecast, the projected consequences of adhering to the state-regulated risk management concept for the growth of Uzbekistan's innovative economy include the following:

- Elimination of the share of venture capital in the structure of innovation financing;
- A complete decline in R&D collaboration between enterprises and universities;

- A dramatic drop in labor productivity resulting from innovation in entrepreneurship by 366.98%, from 3.90% in 2024 to -10.41% by 2030;
- A reduction in the share of high-tech industries in the national industrial structure by 13.24%, from 23.10% in 2024 to 20.04% by 2030;
- A sharp decline in GDP at constant prices by 796.23%, from 6.55% in 2024 to -45.58% by 2030.

An alternative forecast, based on risk minimization through the self-formed risk management concept, achieved by attaining absolute operational (SFr_1=100) and political (SFr_2=100) stability of the entrepreneurial regulatory environment, is presented in Figure 2.

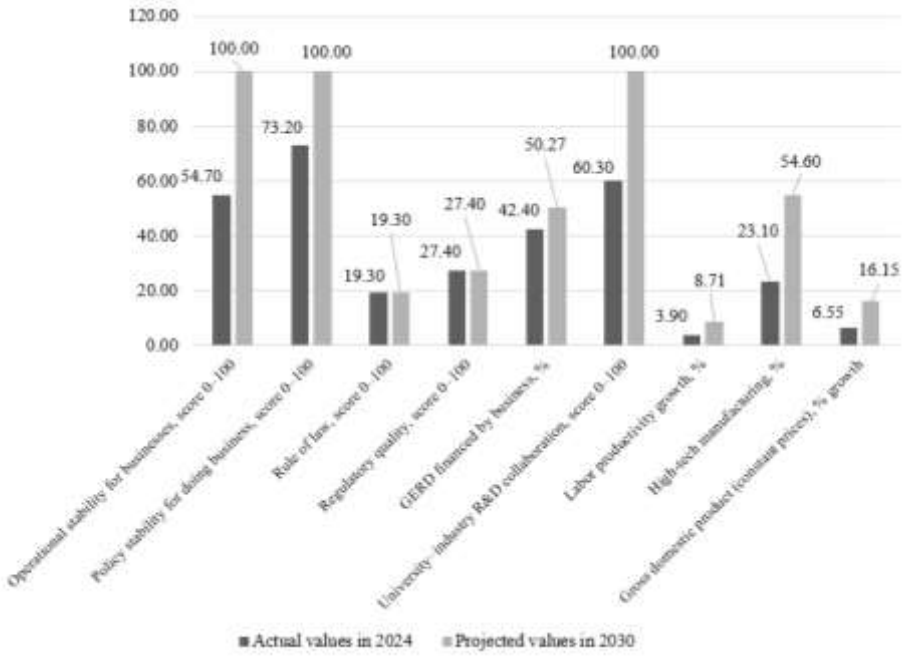


Figure 2. Forecast of Uzbekistan's innovative economic growth under risk minimization based on the self-formed risk management concept through 2030. Source: Developed by the authors.

As shown in Figure 2, under the risk minimization scenario based on the self-formed risk management concept through 2030, the following increases in Uzbekistan's innovation economy indicators are expected:

- An 82.81% increase in operational stability of the regulatory environment for entrepreneurship;
- A 36.62% increase in political stability of the regulatory environment for entrepreneurship.

According to this forecast, the projected outcomes of following the self-formed risk management concept for the growth of Uzbekistan's innovative economy include the following:

- A 65.84% increase in the share of venture capital in the structure of innovation financing, from 42.40% in 2024 to 50.27% by 2030;
- A 239.75% increase in R&D collaboration between enterprises and universities, from 60.30 points in 2024 to 100.00 points by 2030;
- A 123.44% rise in labor productivity resulting from innovation in entrepreneurship, from 3.90% in 2024 to 8.71% by 2030;
- A 136.38% increase in the share of high-tech industries in the national industrial structure, from 23.10% in 2024 to 54.60% by 2030;
- A 146.69% increase in GDP at constant prices, from 6.55% in 2024 to 16.15% by 2030.

Thus, adherence to the self-formed risk management concept is more favorable than reliance on the state-regulated risk management concept because it is associated with an acceleration (rather than a deceleration) of innovative economic growth in Uzbekistan.

5. DISCUSSION

The results obtained in this research contribute to the literature of Ergasheva et al. (2023), Eshov (2020), Gu et al. (2023), Litvinova (2022), and Mitsas et al. (2022) by advancing the theory of risk as a factor influencing economic activity and an object of management within economic science and practice. Specifically, the research clarifies the contribution of risk management practices aligned with alternative risk minimization concepts to the growth of the innovative economy.

Using the example of Central Asia, particularly Uzbekistan, the research substantiates that the risk management toolkit within the state-regulated risk management concept, including the enforcement of the rule of law (contrary to Mkrtchyan et al., 2024) and high-quality government regulation (contrary to the findings of (Polovtsev et al., 2023)), has a limited and weakly expressed impact on the growth of the Central Asian innovation economy.

It also confirms that the risk management toolkit associated with the self-formed risk management concept, one that promotes entrepreneurial innovation through operational (supporting the findings of (Astanakulov et al., 2022)) and political (supporting the findings of (Ostrovskaya et al., 2017)) stability of the regulatory environment, has a significant and clearly defined impact on the growth of the region's innovative economy.

Thus, supporting the findings of Islam (2025), Jha et al. (2024), Kirikkaleli and Kalmaz (2024), and Liang et al. (2024), the research proves hypothesis H: the growth of innovation activity in the economy is more strongly determined by maintaining operational and political stability in the entrepreneurial regulatory environment in line with the self-formed risk management concept. In doing so, the research contributes to the ongoing scholarly discourse on risk minimization in the economy, complementing the research of Baratova et al. (2023), Bezrukova et al. (2016), Bogoviz et al. (2018), Dhar et al. (2023), Nosirov et al. (2023), Popkova et al. (2018), Raymbaev et al. (2017), and Shaturaev (2023).

6. CONCLUSION

This research concludes that self-formed risk management represents the most effective concept for minimizing risk in the context of catalyzing economic growth. This conclusion is scientifically substantiated through the Central Asian model of innovative economic growth developed in the research, which mathematically expresses the patterns of change in innovation activity practices across Central Asia as the application of alternative risk management tools intensifies.

Based on the model, forecasts were made for risk minimization according to the state-regulated risk management concept and the alternative self-formed risk management concept. Scientific, methodological, and practical recommendations were developed for applying the self-formed risk management concept to Uzbekistan's economy through 2030, focusing on achieving absolute operational and political stability in the country's regulatory environment for entrepreneurship.

The theoretical significance of the author's fundamental conclusions and methodological developments lies in their contribution to forming a conceptual vision for systemically minimizing economic, globalization, climate, and technological risks in an era of heightened economic turbulence. They also aim to enhance the adaptability of the innovative economies of Central Asian countries, particularly Uzbekistan, to high levels of business risk. The practical relevance of the results stems from their potential to simplify risk mitigation and accelerate the growth of Uzbekistan's innovative economy through 2030.

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