KAPITEL 7 / *CHAPTER 7* [7]
MODELING OF INNOVATION ACTIVITY RISKS OF UKRAINIAN ENTERPRISES DURING MARTIAL LAW

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Introduction

In the current conditions of martial law, Ukrainian enterprises operate in an environment of increased instability, accompanied by significant economic, financial and operational risks. Despite the complexity of the situation, innovation remains one of the key factors in ensuring the sustainability of business, its adaptation to new challenges and maintaining competitiveness. However, the implementation of innovations in such conditions is accompanied by increased uncertainty, which requires special attention to the processes of identification, analysis and assessment of risks.

Effective management of innovation risks allows enterprises to respond to threats in a timely manner, optimize the use of resources and minimize possible losses. During martial law, these processes acquire strategic importance, since the ability of an enterprise to implement innovative projects and ensure its own development depends on the correctness of risk assessment. That is why the study of the risks of innovation activity of Ukrainian enterprises in modern conditions is relevant and necessary for the formation of effective anti-crisis management mechanisms.

7.1 Theoretical Foundations of Assessing Innovation Activity Risks of Enterprises

Innovative activity is a key factor in the development of modern enterprises, since it is innovations that ensure their competitiveness, adaptation to changes in the external environment and the creation of new consumer value. At the same time, the process of implementing innovations is accompanied by a significant level of uncertainty, which causes various risks – financial, technological, market, organizational and others. In

[7]***Authors:*** *Zhygalo Ivan Ivanovych*
Author's sheets: *0,50*

this regard, there is a need to form a systematic approach to assessing the risks of innovative activity, which will allow enterprises to make informed management decisions, reduce the negative consequences of uncertainty and increase the effectiveness of innovative projects.

The concept of risk in economic literature is considered as the possibility of deviation of actual results from expected ones, which is due to the uncertainty of the conditions for implementing the activity. In the context of innovative activity, risk takes on special importance, since innovations are by their nature unpredictable, associated with technological changes, new markets and non-standard management decisions.

Innovation risk can be defined as the probability of negative deviations in the process of developing, implementing or commercializing an innovative product or technology, which may lead to failure to achieve planned results or loss of enterprise resources.

Key features of innovation risks include [1]:

– a high level of uncertainty due to novelty and lack of analogues;

– the duration of the innovation cycle, which complicates forecasting;

– dependence on the external environment, in particular technological, market and regulatory;

– the non-repeatability of innovation processes, which complicates the use of typical behavioral models.

An effective risk assessment system is based on a number of principles [1]:

– systematicity – covering all stages of the innovation process;

– optimality – taking into account the cost-benefit ratio of risk analysis;

– adaptability – the ability of the model to take into account changes in the external environment;

– continuity – constant updating of information and revision of risk indicators;

– comprehensiveness – a combination of quantitative and qualitative assessment methods.

The theoretical principles of assessing the risks of innovative activities of

enterprises provide for a systematic understanding of the nature of innovation risks, their classification and the application of modern methodological approaches to their analysis. Successful implementation of innovations is possible only under the condition of effective risk management, which is based on the use of both quantitative and qualitative methods. Timely identification and assessment of risks allows reducing the uncertainty of innovation processes, optimizing the use of resources and increasing the effectiveness of innovation projects.

Scientific study of this issue creates a basis for developing practical tools that will help increase the innovative activity of enterprises and strengthen their positions in the competitive environment.

7.2 Factors and Specifics of Innovation Activity Risks of Ukrainian Enterprises during Martial Law

Under martial law, the innovative activity of Ukrainian enterprises undergoes a significant transformational impact. External threats, economic instability, disruption of logistics chains and resource limitations form a new configuration of risks, which is significantly different from the risk field of peacetime. At the same time, it is innovations that remain the basis for the survival and development of enterprises, ensuring their flexibility, stability and the ability to quickly adapt to changes. This makes it relevant to study the factors and specifics of the risks of innovative activity during martial law.

The risks of innovative activity during martial law are formed under the influence of a complex of external and internal factors that interact with each other and increase the overall level of uncertainty.

External factors [1-4]:

1. Political and military instability. The constant threat of attacks, the possibility of physical destruction of infrastructure and disruption of business processes significantly increases the risks of making any investments, especially innovative ones.

2. Economic turbulence. Inflationary processes, changes in exchange rates, and a

decrease in domestic demand increase the risks of not receiving financial results from innovative projects.

3. Disruption of logistics and international supply chains. Complicated imports of technologies, equipment, and components negatively affect the possibility of implementing scientific and technical innovations.

4. Regulatory changes. In wartime, state control is strengthened, changes in customs and tax regulations occur, which creates additional legal risks for innovative initiatives.

5. Increased competition in world markets. Some enterprises are forced to reorient themselves to foreign markets, where they face high competition and the need to adapt innovations to international standards.

Internal factors [1-4]:

1. Limited financial resources. Most enterprises face a shortage of investments, which complicates the financing of innovative projects that are long-term in nature.

2. Reduced human resources. Migration of specialists, mobilization, psychological stress and reduced labor productivity create new personnel risks in the innovation sector.

3. High level of operational uncertainty. Lack of material resources, difficulties with safe production activities and high administrative costs affect the possibility of implementing the innovation cycle.

4. Technological gap. Difficult access to modern equipment, limited research infrastructure and digital tools increases risks at all stages of the innovation process.

5. Motivational and psychological factors. Uncertainty about the future reduces the willingness of enterprises to make risky innovation investments.

In wartime, traditional risks of innovation take on new forms or are significantly amplified, which creates specific challenges for enterprises:

Technological risks. Military actions create interruptions in technological processes due to the destruction of production facilities, power outages, and cyber threats. Businesses are often forced to adapt innovations to new conditions without the appropriate technical support or equipment [5].

Specific technological risks include:

– lack of access to imported technologies;

– forced changes in technological solutions due to security restrictions;

– increased risks of cyberattacks on innovative systems and databases.

Financial risks. In wartime, innovative projects become particularly vulnerable due to:

– sharp changes in the cost of resources;

– reductions in public and private funding;

– high costs of ensuring security;

– problems with access to credit instruments.

Financial instability increases the likelihood of freezing or abandoning innovative initiatives.

Market risks. Changes in the structure of demand, a decrease in the purchasing power of the population, the relocation of markets and changing consumer priorities create additional difficulties in the commercialization of innovations.

Specific market risks are:

– inconsistency of innovations with new consumption conditions;

– reduction of the sales market due to population migration;

– emergence of new requirements for products related to safety and energy efficiency.

Organizational risks. During martial law, enterprises face difficulties in internal coordination, planning and communication due to:

– relocation of structural units;

– the need to change business models;

– difficulty in forming project teams and maintaining expertise.

Socio-psychological risks. Increased stress levels, staff fatigue, and instability of the social environment reduce the quality of management decisions, which is especially critical for innovative activities that require creativity and strategic thinking.

The risks of innovative activities under martial law are complex. The interaction of external and internal factors creates a risk multiplication effect:

– financial constraints reduce opportunities for technological development;

– personnel losses increase organizational risks;

– disruption of logistics increases time risks and reduces the competitiveness of innovations.

Thus, the risks of innovation activities during wartime are not isolated – they form a single risk system that requires comprehensive management.

During martial law, the risks of innovation activity of Ukrainian enterprises increase significantly and acquire specific characteristics due to general instability, resource constraints and transformation of the market environment. The formation of these risks is influenced by numerous external and internal factors, among which the key ones are the military and economic situation, financial instability, personnel losses, technological barriers and regulatory changes [6].

The specificity of risks during the war period is manifested in increased uncertainty, non-standard challenges and the need for rapid adaptation of enterprises. This requires Ukrainian enterprises to implement comprehensive risk management systems, use flexible innovation strategies and search for alternative sources of resources for the implementation of innovation projects.

A deep understanding of the factors and specifics of risks is an important prerequisite for ensuring the sustainability of innovation activity and the formation of an effective anti-crisis policy of enterprises in martial law.

7.3 Modeling the Interaction of External and Internal Factors That Creates a Risk-Multiplication Effect

Modeling the interaction between external and internal factors in enterprise innovation activities allows us to assess how initial risks are amplified through mutual influences, creating a risk-multiplication effect. During wartime, external threats such as disrupted logistics, economic instability, and regulatory changes interact with internal constraints of enterprises – financial, organizational, and human-resource limitations. This interaction generates cascading effects, where the impact of one risk

amplifies others, complicating the management of innovation processes [7]. Modeling these interconnections enables a quantitative assessment of risk accumulation, identification of key "critical" factors, and the development of effective management strategies under conditions of high uncertainty.

Imagine three groups of factors:

– External factors (*Z*) – e.g., disrupted logistics, exchange-rate volatility, regulatory changes.

– Financial factors (*F*) – lack of investment, rising security-related costs, reduced state support.

– Internal/organizational factors (*O*) – staff shortages, productivity decline, organizational disruptions.

Each factor creates an initial direct shock to innovation activity. However, they interact:

– external shocks increase financial stress (e.g., logistics disruption → cost escalation),

– financial stress amplifies organizational risks (resource shortage → staff cuts),

– organizational issues reinforce external vulnerabilities (reduced adaptability → loss of markets).

These interactions form reinforcing loops, producing cascading waves of risk amplification – the essence of the risk-multiplication effect.

Let the vector of direct shocks be

$$d = [d_Z, d_F, d_O]^T.$$

Interactions between factors are represented by a matrix A, where each element a_{ij} represents how much factor j amplifies factor i:

$$A = \begin{bmatrix} a_{ZZ} & a_{ZF} & a_{ZO} \\ a_{FZ} & a_{FF} & a_{FO} \\ a_{OZ} & a_{OF} & a_{OO} \end{bmatrix}.$$

The total (accumulated) risk R is the sum of the direct shock and all subsequent waves of amplification:

$$R = d + Ad + A^2d + A^3d + \cdots = \sum_{k=0}^{\infty} A^k d.$$

If the spectral radius $\rho(A) < 1$, the series converges:

$$R = (I - A)^{-1}d.$$

Intuitively: $(I - A)^{-1}$ shows how initial shocks spread and accumulate across all reinforcing loops.

Let the direct shocks be

$$d = [1.00,\ 0.80,\ 0.60]^T.$$

Let the interaction matrix be:

$$A = \begin{bmatrix} 0 & 0.20 & 0.10 \\ 0.30 & 0 & 0.20 \\ 0.20 & 0.10 & 0 \end{bmatrix}.$$

This structure ensures realistic interactions and model convergence.

Iteration 0 (initial shock)

$$R^{(0)} = [1.00,\ 0.80,\ 0.60].$$

Iteration 1 (first wave of amplification)

Compute $\Delta^{(1)} = Ad$:

– Z: 0.20 · 0.80 + 0.10 · 0.60 = 0.22

– F: (0.30 · 1.00 + 0.20 · 0.60 = 0.42

– O: (0.20 · 1.00 + 0.10 · 0.80 = 0.28

$$R^{(1)} = [1.22,\ 1.22,\ 0.88].$$

Iteration 2

Compute $\Delta^{(2)} = A\Delta^{(1)}, where\ \Delta^{(1)} = [0.22,\ 0.42,\ 0.28]$:

– Z: 0.112

– F: 0.122

– O: 0.086

$$R^{(2)} = [1.332,\ 1.342,\ 0.966].$$

Iteration 3

Compute $\Delta^{(3)} = A\Delta^{(2)}, where\ \Delta^{(2)} = [0.112,\ 0.122,\ 0.086]$:

– Z: 0.0330

– F: 0.0508

– O: 0.0346

$$R^{(3)} \approx [1.365,\ 1.3928,\ 1.0006].$$

Further iterations produce diminishing additions. The model converges to approximately:

$$R \approx [1.38,\ 1.41,\ 1.01].$$

Interpretation:

– External risk: grows from 1.00 → ~1.38 (≈38% increase).

– Financial risk: 0.80 → ~1.41 (≈76% increase – highest amplification).

– Organizational risk: 0.60 → ~1.01 (≈68% increase).

This demonstrates the multiplicative, cascading nature of interacting risks: even modest cross-factor influences can create strong cumulative effects.

Key conclusions and practical implications:

1. Risk multiplication arises from feedback loops between factors.

2. Reducing risk requires decreasing elements of matrix A – i.e., weakening negative cross-factor impacts (e.g., strengthening logistics, diversification, reserves, HR stability).

3. Alternative strategy: reduce direct shocks d via insurance, hedging, state support.

4. Identify "amplifier factors" by analyzing dominant rows/columns of A.

5. Ensure system stability: $\rho(A) < 1$ prevents exponential escalation of risk waves.

Summary and conclusions.

The study demonstrated that the innovation activity of enterprises during martial law is influenced by a complex, multi-level system of risks that combines external shocks from the war environment, financial-economic imbalances, and internal organizational vulnerabilities. The modeling showed that the overall risk pressure is not a simple sum of individual factors, but exhibits synergistic and multiplicative properties, where the interaction of risks creates amplified waves affecting the enterprise's innovation potential.

It was found that external risks — such as disrupted logistics, unstable regulatory environment, currency fluctuations, and limited access to international markets — form the initial phase of risk pressure. Financial risks (limited investment resources, rising security-related costs, and reduced working capital) amplify the effects of external threats by restricting the resources available for innovation. Organizational risks, caused by staff shortages, reduced productivity, and internal management disruptions, further increase the scale of negative effects, forming reinforcing feedback loops that enhance the enterprise's vulnerability to external shocks.

The constructed matrix model of risk interactions demonstrated that even moderate cross-factor influence coefficients can result in significant risk accumulation through repeated amplification. A numerical example showed that initial levels of external risk (1.00), financial risk (0.80), and organizational risk (0.60) led to a final risk range of approximately 1.38-1.41, representing an accumulation of 38% to 76%, confirming the multiplicative and cascading nature of risk interactions.

The modeling identified that financial risks are the most vulnerable and act as a "risk accelerator," external factors serve as triggers, and organizational factors act as amplifiers of internal effects. Their interaction forms a non-linear risk structure, complicating traditional approaches to managing innovation activities.

Thus, the modeling of innovation risks during martial law indicates the necessity of:

1. Moving from linear risk assessment methods to dynamic interaction models that account for feedback loops and the propagation speed of risks;

2. Identifying "critical" factors that act as multipliers and contribute most to systemic risk growth;

3. Developing mechanisms to reduce pressures within the interaction matrix itself (weakening elements of A), rather than only mitigating individual risks;

4. Formulating adaptive management strategies aimed at enhancing resilience, flexibility, and innovation capacity of enterprises.

The proposed model can serve as an analytical tool for forecasting risk scenarios, designing innovation management strategies, and evaluating enterprise resilience

under extreme conditions. Further development should include expanding the set of factors, integrating stochastic parameters, considering industry-specific characteristics, and creating digital simulation models.