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MODERN PRACTICES OF RISK ADJUSTMENT IN NETWORK MODEL

The relevance of the research is because, in the modern economy, risks and the processes of their spread are an integral part of activities that encompass entrepreneurship, management processes in organizations, financial operations, production processes, project development, and implementation, as well as other areas where potential threats and uncertainties must be taken into account. The authors emphasize that the emergence of risks can take on a particularly threatening nature in network economies due to the interdependence of its participants. Therefore, the goal of the article is to study modern practices for risk adjustment in a network-based model. The study used methods such as system analysis and synthesis, as well as the comparative method. The research results allowed for the identification of several key practices that contribute to reducing risks and minimizing the processes of their spread in networked economic formations, including diversification of supply chains, creation of joint reserves and inventories, flexibility of contractual relationships, and regionalization of production. The practical value of the article lies in laying the foundation for studying the specifics and algorithms for implementing the practices mentioned above, as well as identifying conditions that contribute to enhancing the resilience of the network economy to risks and ensuring its adaptability in a dynamic environment.

Keywords: *risks, network economy, joint reserves and inventories, rapid adjustment.*

JEL classification: L00, L19, L82

Problem statement. The relevance of the research is determined by the fact that in the modern economy, risks and the processes of their dissemination are an integral part of activities that encompass entrepreneurial activities, management processes in organizations, financial operations, production processes, project development, and implementation, as well as other areas where potential threats and uncertainties must be considered. The authors draw attention to the fact that the emergence of risks can become particularly threatening in networked economies due to the interdependence of its participants. In such economies, the processes of risk dissemination can have an exponential effect, where even minor issues in one part of the network can lead to significant consequences for other participants.

For example, in networks formed by the electronics manufacturing industry, there is a high dependence of manufacturers on companies engaged in chip development and supplying components for mobile phones, computers, and other devices.

A minor disruption at one of the supply stages, for example, due to natural disasters or a technological failure at a factory, can lead to global delays in the delivery of finished products, negatively impacting a wide range of companies worldwide, from manufacturers to end consumers.

Analysis of research and publications. Among the scholars researching risk adjustment issues in the economy, Varaksin O., Pobidenna V., Grebenyk R. [2], Mostenska T. L., Skopenko N. S. [5], and Rudysh O. O. [6] can be highlighted. These researchers mainly focus on risk management to ensure the overall economic security of an enterprise and analyze ways to maintain its stability and operational efficiency.

At the same time, although the aforementioned researchers also emphasize the importance of risk adjustment for enterprises operating within a network model, these issues are mainly addressed in the context of overall economic security, rather than as a separate scientific problem.

The lack of a specialized approach to risk management in networked economies creates the need for a more detailed study of this issue.

Formulation of the article's objectives. The article aims to study contemporary practices of risk adjustment within the network model.

The paper main body. Risks in the networked economic model are potential threats and uncertainties that manifest through the close interdependence of participants in the economic network, which is driven by technological, financial, logistical, informational, and other connections. Given this inter connectivity in any network model, risks rapidly spread among the network participants, and even a minor issue in one link can lead to large-scale economic consequences for others, including not only financial crises, supply chain disruptions, and technological incidents but also the overall collapse of the network.

An example of the emergence and spread of risk in the networked economy is the situation that occurred in the automotive industry. Disruptions in the supply of microchips in 2020-2021 from Taiwan Semiconductor Manufacturing Company (TSMC) caused delays in the production of vehicles by Ford, General Motors, and Volkswagen. These manufacturers, in particular, relied on microchips for various systems, ranging from engines to safety features and information technologies.

The outlined automotive companies were forced to temporarily halt production or reduce output due to the chip shortage. For example, Ford suspended production at its U.S. plants (which were responsible for manufacturing Ford F-150 models that heavily relied on chips for management and safety systems) and reduced production by approximately 20–30% at its plants in Canada and Mexico. General Motors (GM) cut production by 20% at some of its North American plants. In Europe, Volkswagen halted part of its production at its factories in Germany and the Czech Republic. The crisis persisted until 2022, and its consequences had a long-term impact on global automotive supply chains.

Given the significant vulnerability of the networked economy to the impact of risks, modern practices for adjusting the processes of risk formation and dissemination within networked economic entities are of particular importance. The main practices that help reduce risks and minimize their spread in the networked economy include: diversification of supply chains; creation of shared reserves and stockpiles; flexibility of contractual relationships; and regionalization of production.

More detailed information on the main practices that help reduce risks and minimize their spread in the networked economy is presented in Figure 1. The outlined practices are aimed at enhancing the network's resilience to risks within a continuous risk management cycle, which includes: the risk identification stage; the risk assessment stage (for ranking risks according to their level of criticality: high, medium, low); the risk monitoring stage (to track external factors that may affect the network); the risk adjustment direction determination stage (selecting influence practices); the implementation stage of practices that help reduce risks and minimize their spread in the networked economy; and the stage for evaluating the effectiveness of risk adjustment.

Indeed, the diversification of supply chains is one of the most effective ways to reduce the network's vulnerability to external shocks by decreasing dependence on a single supplier or region, while increasing flexibility and adaptability [3]. It is important to note that this practice in the networked economy has the following features [3]:

- Multiple supply sources.
- Geographical diversity of supplies.
- Availability of alternative routes and delivery channels.
- Balancing risks and benefits from working with different suppliers.

So, if Ri is the risk associated with supplier ii, and it ranges from 1 to nn (the number of suppliers or links in the supply chain), it can be assessed through the probability of supply disruption Pi and potential financial losses Li, i.e.:

$$Ri = Pi \times Li, \quad (1)$$

where: Pi – the probability of supply disruptions from supplier i; Li – the financial losses resulting from a supply disruption from supplier ii.

Until 2021, Apple largely relied on manufacturing facilities in China, where its key suppliers, such as Foxconn, Pegatron, and Wistron, played a crucial role in assembling the company's main products, including the iPhone, iPad, MacBook, and other devices. Foxconn (Hon Hai Precision Industry Co., Ltd.) was one of Apple's primary partners, responsible for assembling the iPhone and other devices at its factories in China. Foxconn factories, particularly in Zhengzhou, Shenzhen, and other cities, serviced a large portion of Apple's manufacturing capacity. Pegatron, with facilities in Shanghai and Kunshan, also focused on assembling Apple products, including the iPhone and iPad. The third key supplier, Wistron, was responsible for assembling the iPhone and other devices at its manufacturing site in China.

However, over time, Apple began to notice growing risks associated with its excessive reliance on China, especially due to geopolitical tensions, trade barriers, and potential supply chain disruptions, which were clearly evident during the COVID-19 pandemic. This prompted the company to consider alternative locations for some of its manufacturing capacity and apply a risk optimization mathematical problem, which looked as follows [2–3]:

$$\min(x1, x2..., xn) = \sum_{i=1}^{n} \left(Pi \times Li \times xi \right), \quad (2)$$

where xi is the share of production or supply that the company receives from supplier ii, and the objective of the problem is to minimize total losses considering the probabilities of risks and financial losses.

The constraints for this problem are: $xi \geq 0$ – the share of supply cannot be negative; $\sum i = 1nxi = 1$ – all supplies must be distributed among the suppliers.

Thus, in 2022, Apple decided to significantly diversify its supply chains, including expanding production in other Asian countries such as India. Specifically, its partners,

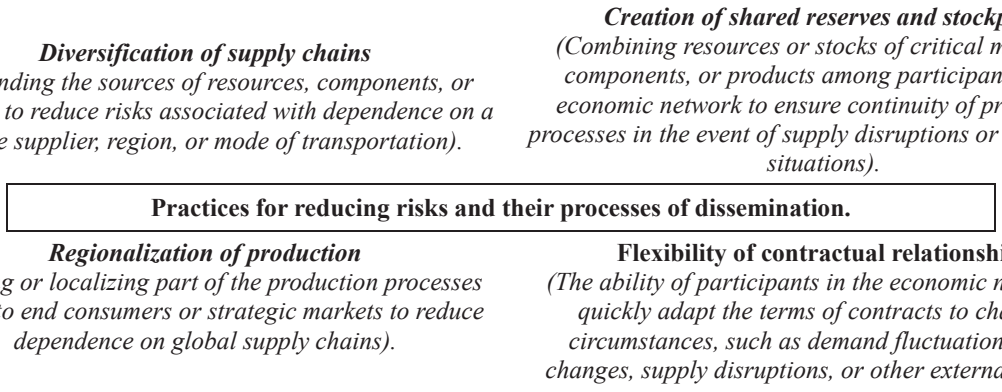

Figure 1 – Main practices that help reduce risks and minimize their spread in the networked economy

Source: compiled based on [2–3; 6]

including Foxconn, Pegatron, and Wistron, began assembling iPhones in India.

This allowed Apple to reduce its dependence on Chinese manufacturing facilities and ensure greater stability in its production processes, even when supply chain links in China were disrupted due to lockdowns or other external factors. A more detailed description of Apple's supply chain diversification practices is provided in Table 1.

Thus, since in a networked economy the activities of its participants are interconnected through complex supply chains across different regions and countries, it is not only important to maintain the continuity of production processes but also to minimize dependence on the capacities of any one region or country.

The creation of joint reserves and stockpiles is a way to reduce the network's vulnerability to external shocks by forming joint strategic reserves of critical resources or components for the network participants. This ensures the continuity of production in case of supply disruptions [1; 4].

Thus, if Ri is the risk of supply disruption for component ii, and Pi is the probability of this disruption, then the risk associated with the absence of reserves can be calculated as [3]:

$$Rshortage,\ i = Pi \times Li, \quad (3)$$

where: *Pi* – probability of supply disruption for component *ii*;

Li – potential losses due to disruption in the supply of this component.

It should be noted that this practice in a networked economy has the following features [5; 3]:

- Collective formation of reserves.
- Distributed responsibility.
- Flexibility in the use of reserves and their systematic updating.

The networked economy involves complex interdependencies among different participants in supply chains. In the case of Toyota, its production network includes numerous suppliers of electronics, batteries, and other critical components, forming a complex and interconnected system. As a result, the earthquake and tsunami in Japan in 2011 caused significant disruptions in Toyota's supply chains, revealing the critical vulnerability of its network to external shocks. Specifically, the disaster led to the temporary shutdown of factories in Toyota City (Aichi Prefecture) and in the Mie and Gifu prefectures, as well as disruptions in the supply of crucial components, which complicated the production process and resulted in financial losses.

To reduce the vulnerability of its production network to future shocks, Toyota applied a risk optimization mathematical problem, which looked as follows [3]:

$$\min(xi) = \sum_{i=1}^{n} (Pi \times Li \times xi), \quad (4)$$

where *xi* – the share of responsibility of supplier ii for replenishing the stock of component i.

The constraint for this problem was:

$$\sum_{i=1}^{n} (xi) = 1 \quad (5)$$

The constraint (4) for this problem was that the sum of the responsibility shares of suppliers must equal 1 (balanced responsibility for all participants). Therefore, Toyota implemented the practice of creating joint reserves of critical components with its suppliers, according to the specifications outlined in Table 2.

The highlighted features of the practice of creating joint reserves allow for the maximum minimization of risks associated with supply chain disruptions and external shocks [4].

The flexibility of contractual relationships is a way to reduce the vulnerability of the network to external shocks by creating the conditions for the quick revision or adaptation of contracts with suppliers on demand (especially in the case of emerging risks). Thus, a mathematical approach to the flexibility of contractual relationships can be represented through a risk function, which takes into account potential supply disruptions due to various circumstances that determine the contract terms:

$$R = P \times (C + F), \quad (6)$$

where: *C* – is the base cost of executing the contract; *F* – is the cost of adapting the contract terms, including negotiations, pricing adjustments, and force majeure conditions; *P* – is the probability that the contract will not be executed on time due to risk factors (force majeure, market condition changes, political or economic factors).

Table 1 – Apple's supply chain diversification practices

Components of supply chain diversification practice	Features of implementing the supply chain diversification practice	Features of risk adjustment
Diversification of production capacities	Expanding iPhone production in other Asian countries, particularly in India, to reduce reliance on Chinese manufacturing capacities. Apple's partners, such as Foxconn, Pegatron, and Wistron, began assembling iPhones in India, which reduced risks associated with global disruptions.	Each supplier is assigned different levels of disruption probabilities Pi, depending on factors such as region, supply quality, infrastructure reliability, and other related aspects.
Distribution of suppliers and production capacities	Choosing suppliers and partners in different regions to ensure greater stability of supply chains, particularly utilizing facilities in India for product assembly, allows Apple to adapt to changing conditions in specific regions.	
Reducing dependence on a single market or country	Expanding production chains and investing in new markets to reduce dependence on a single country, in this case – China. This contributes to greater resilience to changes in geopolitical conditions and risks associated with local crises.	
Flexibility of production processes	Increasing flexibility in production processes by shifting some of the capacities to new markets allows Apple to quickly adapt to changes in demand and external conditions, which is crucial for ensuring continuity in product supply.	

Source: compiled based on [3; 5–6]

Table 2 – Practice of creating joint reserves of critical components between toyota and suppliers of electronics, batteries, and other critical components

Components of the practice of creating joint reserves and snventories	Features of Implementing the Practice of Creating Joint Reserves and Inventories	Features of risk adjustment
Accumulation of inventories of key components	Joint inventories of microchips, batteries, sensors, and other specialized electronic components. This ensures the continuity of production in the event of supply disruptions*	Determining the point at which inventories reach a critical level that requires replenishment. Automatic updating of inventory levels based on risk forecasting and production needs.
Creation of decentralized inventories in different regions	Inventories in different regions, in volumes sufficient to minimize the risk of complete loss of access to critical components due to local crises (e.g., natural disasters)**	
Establishment of long-term supply agreements with suppliers for joint snventory creation	Long-term supply agreements with suppliers that enable the creation of stable component reserves and ensure their steady replenishment even during global crises.	

Note

**Chip suppliers ensure the storage of large chip inventories in specialized warehouses.*

***Suppliers in different parts of the world, such as Europe, North America, and Asia, create decentralized warehouses for critical components. For example, Panasonic, which supplies batteries for Toyota's electric vehicles, stores part of its inventory in regions close to Toyota's main production facilities, including North America and Europe, to respond more quickly to any supply or logistical issues.*

****Such agreements outline conditions for stable supplies even during global crises or natural disasters.*

Source: compiled based on [1; 3–4]

It should be noted that the outlined practice in the network economy has the following features [3; 6–7]:

- Force majeure provisions.
- Dynamic pricing.
- Introduction of flexible terms of performance depending on market conditions or the capabilities of network participants.
- Flexible payment models.
- Structuring agreements in such a way that they can be quickly adapted to changes by adding or removing individual modules or provisions.

In particular, Amazon has applied flexible contracts with logistics service providers. Due to significant demand fluctuations and supply disruptions, Amazon finds optimal contract terms for each supplier depending on changes in the risk probability. In this context, the following risk optimization mathematical problem was applied [3]:

$$\min(xi) = \sum_{i=1}^{n}\left(Ci \times Pi\right) + \lambda \cdot \sum_{i=1}^{n}\left(Ri \times \Delta Pi\right), \qquad (7)$$

where: Ci – the cost of the contract with supplier i, Pi – the probability of risk for supplier i; Ri – the level of contract adaptation for supplier i; ΔPi – the change in the risk probability over time for supplier i; λ – a coefficient that determines the weight of contract adaptation in the overall cost.

The constraint for this problem was:

$$\sum_{i=1}^{n} Ci \le \max.\text{budget}, \qquad (8)$$

In particular, Amazon implements the practice of finding optimal contract terms with suppliers, ensuring that changes to the contracts do not lead to violations of other key terms of cooperation.

Regionalization of production networks is a way to reduce their vulnerability to external shocks by relocating part of the production capacities closer to end consumers. Thus, to calculate the risk arising from the lack of regionalization of production networks, a mathematical algorithm can be applied, which computes the probability of supply chain disruptions and assesses the economic losses.

It should be noted that the outlined practice in the network economy has the following features [3; 7]:

- Reduction of logistics chains.
- Adaptation to local conditions.
- Investment in local production capacities.

For example, Intel, in partnership with the EU governments, is currently implementing plans to build new factories in Europe (specifically in Germany and Ireland) as part of a strategy to regionalize semiconductor production networks.

In this context, the following risk optimization problem was applied [3]:

$$\min\left(xi\right) = \sum_{i=1}^{n}\left(ci \times xi\right) + \sum_{i=1}^{n}\left(ri \times xi\right), \qquad (9)$$

where: ci – the cost per unit of product or resource related to production or delivery from region i; xi – a variable representing the amount of product or resources produced or supplied from region i. This value needs to be optimized; ri – the risk associated with supply disruptions from region i.

The constraint for this problem was: $xi \le mj$, $\forall j$.

where: mj – the maximum production volume that can meet the demand in region j.

In other words, Intel aimed to minimize total production costs and risks associated with potential supply chain disruptions while meeting demand across all regions. Specifically, in March 2022, the company began implementing a plan to build a new semiconductor manufacturing plant in Magdeburg, Germany, and is expanding its facilities in Ireland. This decision was made in the context of the global chip shortage and dependence on production capacities in Asia.

Conclusions. The study concludes that the network economy is vulnerable to various risks due to the close interconnection between suppliers, manufacturers, intermediaries, and consumers. The authors emphasize the need for the development and implementation of effective risk management strategies. Furthermore, based on the research findings, it is demonstrated that several key practices can currently be identified that contribute to reducing risks and minimizing the processes of their spread in networked economic formations. These practices include:

1. Diversification of supply chains – this practice involves creating alternative suppliers and delivery routes,

reducing dependence on individual network participants, and increasing the resilience of economic ties.

2. Creation of joint reserves and inventories – this practice ensures the possibility of utilizing accumulated resources in crises to reduce the negative impact of unpredictable events.

3. Flexibility of contractual relationships – this practice involves concluding contracts with terms that allow for quick adjustments to the terms of cooperation depending on changes in the external environment.

4. Regionalization of production – this practice involves relocating part of the production processes closer to end consumers to reduce logistical risks and improve the speed of response to demand changes.

Thus, the practical value of the article lies in laying the foundation for studying the specifics and algorithms for implementing the practices mentioned above, as well as identifying conditions that contribute to enhancing the resilience of the network economy to risks and ensuring its adaptability in a dynamic environment.

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СУЧАСНІ ПРАКТИКИ КОРИГУВАННЯ РИЗИКІВ ЗА МЕРЕЖЕВОЮ МОДЕЛЛЮ

Актуальність дослідження зумовлена тим, що у сучасній економіці ризики та процеси їх поширення є невід'ємною частиною діяльності, яка охоплює підприємницьку діяльність, управлінські процеси в організаціях, фінансові операції, виробничі процеси, розробку та реалізацію проектів, а також інші сфери, де необхідно враховувати потенційні загрози та невизначеності. Автори звертають увагу на той факт, що виникнення ризиків може набувати особливо загрозливого характеру в мережевих економіках через взаємозалежність її учасників. Відтак метою статті є вивчення сучасних практик коригування ризиків за мережевою моделлю. Під час дослідження використані такі методи) дослідження як системний аналіз та синтез, а також порівняльний метод. Констатовано, що мережева економіка вразлива до різних видів ризиків, оскільки в ній існує тісний взаємозв'язок між постачальниками, виробниками, посередниками та споживачами. Результати дослідження дозволили виділити кілька основних практик, що сприяють зниженню ризиків та мінімізації процесів їх поширення в мережевих економічних утвореннях. Диверсифікація ланцюгів постачання – є практикою створення альтернативних постачальників та маршрутів доставки, що знижує залежність від окремих учасників мережі та підвищує стійкість економічних зв'язків. Створення спільних резервів та запасів – є практикою забезпечення можливості використання накопичених ресурсів у кризових ситуаціях для зменшення негативного впливу непередбачуваних подій. Гнучкість контрактних відносин – є практикою укладання договорів з умовами, що дозволяють швидке коригування умов співпраці залежно від змін зовнішнього середовища. Регіоналізація виробництва – є практикою перенесення частини виробничих процесів ближче до кінцевих споживачів з метою зменшення логістичних ризиків та підвищення швидкості реагування на зміни попиту. Практична цінність статті полягає у формування основи для вивчення особливостей та алгоритмів впровадження зазначених вище практик, а також виділення умов, що сприяють підвищенню стійкості мережевої економіки до ризиків та забезпечують її адаптивність в умовах динамічного середовища.

Ключові слова: *ризики, мережева економіка, спільні резерви та матеріальні цінності, швидке коригування.*