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*Illiashenko Sergii<sup>a, b</sup>, Shypulina Yuliia<sup>a</sup>, Illiashenko Nataliia<sup>c</sup>, Golysheva Ievgeniia<sup>d</sup>***LIFECYCLE MANAGEMENT OF PRODUCT INNOVATIONS IN ENTERPRISES  
CONSIDERING STAGE-SPECIFIC RISKS<sup>1</sup>**<sup>a</sup> National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine<sup>b</sup> University of Economics and Humanities, Bielsko-Biala, Poland<sup>c</sup> Sumy State Pedagogical University named after A. S. Makarenko, Sumy, Ukraine<sup>d</sup> Wrocław University of Science and Technology, Wrocław, Poland

This article is dedicated to developing methodological foundations for managing the lifecycle of product innovations in enterprises, with particular attention to the risks associated with each stage. It outlines the range of risks inherent at different stages of the product innovation lifecycle (PLC) and identifies the influencing factors that drive these risks. The study distinguishes between risks unique to specific stages of the PLC and those prevalent across all stages. It explores the unique manifestation of risks at each stage, proposing a method for assessing risk levels. A comprehensive set of measures is suggested to mitigate the identified types of risks. The study also introduces an approach for targeted lifecycle management of product innovations, accounting for risks at each stage. It details management procedures, including a proposed scale for determining risk levels at each PLC stage based on their unique characteristics, along with tailored actions to manage stage-specific risks. This approach aims to enhance decision-making in PLC management by addressing risks such as product obsolescence and sudden shifts in market conditions that affect all stages. The research findings advance innovation management by improving the foundation for lifecycle management of product innovations through risk identification, analysis, and mitigation at each lifecycle stage. Practical application of these findings will enable enterprises to make informed adjustments to innovation development projects during implementation and refine innovation strategies, including the suspension of current strategies and the development of new ones. Future studies should focus on establishing formalized procedures for lifecycle management of product innovations, taking into account associated risks at each stage.

**Keywords:** product innovation lifecycle, lifecycle management, lifecycle stages, innovation development, innovation risks, marketing risks.

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***Introduction and statement of the problem***

In today's economy, innovation and innovative activities hold a central role among the primary drivers of development, with their importance steadily increasing. Countries that prioritize innovation [15] tend to have highly developed national economies

and higher living standards for their citizens. However, global experience shows that innovation is inherently risky, a factor that can hinder its progress. Risks in innovative activities often lead to deviations between actual and expected outcomes, including market rejection of innovations, increased financial and time

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costs, low effectiveness, rapid obsolescence, and consequently, shortened product lifecycles (PLC). However, risk has a dual nature and should not be seen solely as a threat; it also represents an opportunity to enhance an innovator enterprise's competitive edge, strengthen its market position, and achieve high profits. Under these conditions, managing risks across all stages of the PLC for product innovations becomes crucial, taking into account anticipated threats and opportunities and their balance. This approach enables more informed decision-making in managing the development and implementation of innovation projects, leading to more effective PLC management for created product innovations.

#### ***Analysis and research of publications***

The issues discussed in this article have been the subject of numerous studies. Yankovyi O.H. and Hura O.L. [16] developed an approach to modeling the product lifecycle using S-shaped mathematical functions, allowing for the prediction and analysis of PLC parameters. Bielikova O.Yu. et al. [1] propose selecting an innovative strategy for industrial enterprises based on the stages of the PLC of their innovative products. Each PLC stage aligns with a particular strategy variant, enabling a fuller realization of available market opportunities for innovation development. Shkola V.Yu. and Kyslyi V.M. [12] developed a theoretical-methodological approach for forecasting the parameters of various types of innovations and their lifecycle stages. They also proposed a method for analyzing risk within the innovation cycle, focusing particularly on the risk of delays in development and testing stages of innovations.

Shtal T. et al. [13] developed a methodological approach to risk analysis across the PLC stages of enterprise innovation development projects, allowing for the identification of the most influential risks and the creation of measures to mitigate them. Kasianova N.V. and Yatsiuk S.S. [8] focused on innovation project risks, paying particular attention to subjective risks influenced by the qualifications and experience of those making innovation-related decisions. They proposed a broad risk assessment and management framework for innovation projects; however, risks at specific project stages were not analyzed. They developed a model based on nonlinear dynamics and synergetics, designed to simulate and forecast risks. Sokur M.B. [14] examined specific PLC risks in environmental innovation within startup projects without associating them with particular lifecycle stages, treating the risks as primarily subjective while paying minimal attention to objective risks. Pashchenko Yu.Ye. [11] investigates innovation risks in machinery enterprises, proposing risk management at

each stage of the innovation product lifecycle. He views the overall risk of a product innovation as a collection of stage-specific risks within its PLC. Dumanska I.Yu. [2] studied the influence of technological transformation processes on enterprise innovation activities, highlighting this influence's dual nature: while it offers pioneering enterprises a competitive advantage, it also accelerates the obsolescence of existing and emerging innovations, pushing innovators to introduce the next generation of innovations. Ilchuk V.P. and Shyshkina O.V. [3] explored the cyclical manifestation of risks in industrial enterprise activities, classifying risks according to lifecycle stages such as industry, enterprise, technological processes, production assets, and products. They noted the interconnection among these cycles and their impact on risk. Machac J. et al. [9] proposed a methodological approach to managing risks throughout the lifecycle of a new product, from concept creation, development, and production to market release and post-sale support. Zust S. et al. [17] developed a Monte Carlo statistical modeling approach to risk assessment at these stages, without addressing PLC stages from a marketing perspective. Nesterenko O.V. [10] suggested an approach to managing risks in industrial enterprise innovation activities that considers PLC stage-specific risk characteristics, though it does not specify risks per stage.

As revealed by the literature review, various scholars have addressed approaches to managing the PLC of innovative products and managing innovation project risks, including throughout the PLC stages of innovations. Studies have examined approaches for forecasting the parameters of innovation product PLCs, selecting enterprise innovation strategies based on the current PLC stage, and analyzing risks in enterprise innovation projects, including those specific to PLC stages of innovative products. However, the issue of managing product innovation PLCs with regard to stage-specific risks remains insufficiently explored. Addressing this gap would enhance the justification of PLC management measures for innovations, reduce associated risk levels, improve enterprise innovation efficiency overall, and support their transition to an innovation-driven development path.

#### ***The purpose of the article***

The purpose of this article is to develop an approach for managing the product innovation lifecycle (PLC) in enterprises, accounting for the associated risks at each stage.

To achieve this goal, the study establishes a set of research objectives:

– first, identify the risks at each stage of the product innovation PLC and the factors that cause them (influencing factors);

– second, develop recommendations for mitigating the identified types of risk;

– third, formulate an approach for managing the PLC of product innovations in enterprises, considering the stage-specific risks.

#### **Main material**

A systematic analysis of the objectives and essence of each stage of the product innovation PLC has enabled the identification of inherent risks and their driving factors (influencing factors). The findings are presented in Table 1, where the numbers in the first column indicate risks specific to each PLC stage: 1.1 represents the first type of risk in the first stage of the PLC, 1.2 the second type, and so on. In Table 1, a "+" symbol marks the risks and influencing factors unique to particular PLC stages. The table includes objective risks only; risks arising from the subjective

actions of individuals managing the innovation process are excluded.

An analysis of innovation practice shows that the risks of product obsolescence and sudden market condition changes listed in Table 1 are relevant across all four PLC stages. Risks 1.1 and 1.2 emerge during the first PLC stage, with findings indicating [7]:

– Risk 1.1 depends on the consumer readiness level of target customers and the degree of innovation radicalness. The lower the consumer readiness and the higher the radicalness of the innovation, the greater the risk level.

– Risk 1.2 is influenced by the innovation culture level among target consumers and the degree of innovation radicalness. The lower the innovation culture level and the higher the radicalness, the greater the risk level.

Table 1

**Influencing factors and key risks at product innovation lifecycle stages**

Risk	Influencing Factors	PLC Stages				
		Market Entry	Sales Growth	Maturity	Market Exit	
Product obsolescence risk (across all PLC stages)	Technological breakthroughs in the innovator company's field or related fields	+	+	+	+	
	Technological breakthroughs in consumer sectors					
Sudden market condition changes (across all PLC stages)	Changes in macro-environment elements: political-legal, economic, technical-technological, socio-demographic, natural-ecological, etc.	+	+	+	+	
	Changes in interactions with economic partners in the innovation process					
1.1. Consumer Rejection of Innovation	Consumer readiness level of target customers	+				
	Degree of product radicalness					
1.2. Consumer innovation unreadiness	Level of consumer innovation culture	+				
	Degree of product radicalness					
2.1. Slow sales growth	Market saturation					
	Competitor actions		+			
	Changes in consumer interests					
2.2. Sales volume fluctuations	Seasonal factors		+			
	Competitor market entry (or exit)					
3.1. Demand decline	Market saturation			+		
	Competitor actions					
3.2. Profitability decline	Competitor actions			+		
	Rising production costs					
3.3. Sales volume fluctuations	Seasonal factors			+		
	Competitor actions					
4.1. Profit decline	Sales volume decline				+	
	Profitability decline					

Source: developed by the authors based on data from [6, 8].

Based on data from literature sources and innovation practice, considering the goals and essence of the PLC stages, measures have been proposed to

reduce the levels of the types of risk presented in Table 1. A summary of these measures is provided in Table 2.

Table 2

**System of measures to reduce risk levels at product innovation lifecycle stages**

Risk	Risk Reduction Measures	Notes
Product obsolescence	Monitoring and forecasting science and technology trends in the innovator’s industry, related industries, and consumer industries. Modification/review of the innovation strategy	A methodical approach to forecasting can be found in [5]
Sudden market condition changes	Analyzing and forecasting changes in micro- and macro-environmental characteristics and their impact on market activities. Product, market, and marketing modifications	Anticipatory forecasting (short- and medium-term)
1.1. Consumer Rejection of Innovation	Developing and implementing marketing stimulation measures aimed at enhancing target consumers’ readiness	Moving target consumers to the desired state of readiness [7]
1.2. Consumer innovation unreadiness	Analyzing the innovation culture level of consumers (ideally all innovation process participants) and modifying the product innovation strategy	The level of innovation radicalness should match the innovation culture level [7]
2.1. Slow sales growth	Creating new product modifications and targeting other segments of the existing market or new markets	Meeting the needs of existing and new consumer groups better than competitors
2.2. Sales volume fluctuations	Stimulating off-season consumption, product diversification, and partner marketing	Building and maintaining a system of long-term, mutually beneficial relationships with consumers
3.1. Demand decline	Improving existing products and creating new modifications. Expanding to new markets or new segments of the current market. Enhancing marketing	Protecting and strengthening satisfactory market positions
3.2. Profitability decline	Improving production technologies, creating simplified product versions (simplified innovations), repositioning as a premium product	Reducing costs or repositioning the product
3.3. Sales volume fluctuations	Stimulating off-season consumption, product diversification, and partner marketing	Building and maintaining a system of long-term, mutually beneficial relationships with consumers
4.1. Profit decline	Reducing R&D and marketing expenses, discontinuing product production	Strategy for resource exhaustion and/or product discontinuation [4]

Source: developed by the authors.

The research results presented in Tables 1 and 2 form the basis for developing an approach to managing the PLC of product innovations, considering the associated risks at its main stages. The PLC stages, along with their characteristics and types of consumers classified by their attitude toward innovation, are shown in Fig. 1.

The following sequence and content of procedures are proposed for managing the PLC of product innovations, taking into account the associated risks

at its stages.

First. Stage of Market Entry for Innovation.

The risk level of consumer rejection of innovations (see Risk 1.1 in Table 2) depends on the consumer readiness level of target consumers (states listed according to F. Kotler):

- High risk: consumers have only a general understanding of the innovation;
- Elevated risk: consumers know the characteristics of the innovation;

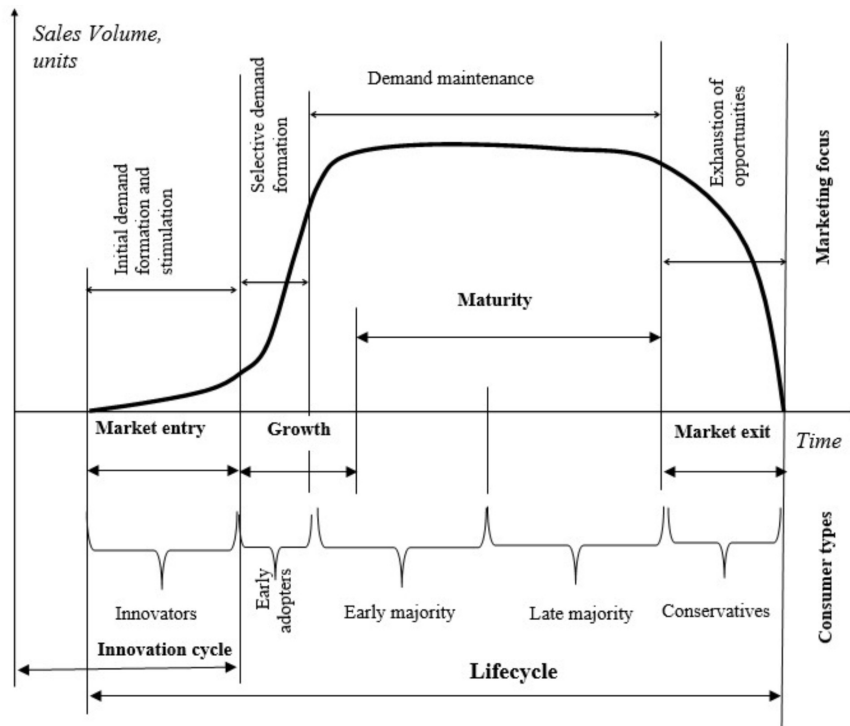


Fig. 1. Product Innovation Lifecycle Diagram ([4], modified)

- Moderate risk: consumers have a positive attitude toward the innovation;
- Moderate risk: consumers prefer the innovation over alternatives;
- Low risk: consumers are confident they need the innovation;
- Minimal risk: consumers are ready to purchase the innovation.

Consumer readiness level is determined through market research on consumers. It should be noted

that radical innovations are typically associated with elevated or high risk, standard innovations with moderate risk, and incremental innovations with minimal or low risk. Risk can be reduced by implementing a set of marketing stimulation measures to move consumers to the desired (higher) state of readiness.

The risk of consumer innovation unreadiness (Risk 1.2 in Table 2) should be assessed according to Table 3.

Table 3

**Risk Level of Consumer Innovation Unreadiness for Radical Innovations**

Degree of Radicalness of Changes	Consumer Innovation Culture		
	High	Medium	Low
Low (improving modifications of traditional products)	Minimal	Low	Medium
Medium (new products matching the best on the market)	Low	Medium	Elevated
High (new products without direct analogs, creating new needs)	Medium	Elevated	High

Source: [7], modified

Influencing consumer innovation culture, which characterizes their acceptance of innovations, readiness to adopt them, and willingness to change consumer behavior stereotypes, is very challenging. It is easier to modify innovations and align their level of radicalness with the consumer’s level of innovation culture. This approach can reduce this type of risk

(see Table 2). However, in certain cases, consumers may be willing to change their behavior stereotypes to solve pressing issues. For example, industrial consumers facing a market decline (due to technological advances) can avoid collapse and achieve innovation-driven growth by adopting radical innovations. In such cases, producers of radical product

innovations may find it worthwhile to take risks, as they could launch new production lines or even create new industries and markets, establishing stable competitive advantages.

Second. Sales Growth Stage.

The risk of slow sales growth (Risk 2.1 in Table 2) can be determined by the deviation (predicted reduction) of actual growth rates from planned targets. The level of deviation corresponding to a particular risk level (minimal, low, medium, elevated, high, etc.) should be determined individually for each innovation project undertaken by a specific innovator enterprise. This approach takes into account the risk tolerance of decision-makers (company management), which may vary between risk-averse, neutral, or risk-seeking individuals. It also considers factors such as the enterprise and its industry, the innovation and target market, and the manifestation of influencing factors (see Table 1). Based on the risk level, decisions are made regarding the degree of radicalness of product or market modification measures to reduce this type of risk (see Table 2).

The risk level of sales volume fluctuations (Risk 2.2 in Table 2) can be assessed similarly to the previous risk (Risk 2.1 in Table 2). Decisions on risk mitigation (see mitigation methods in Table 2) are made considering the factors outlined in the previous paragraph.

Third. Maturity Stage.

Risk management for Risks 3.1 and 3.3 (Table 2)

is conducted similarly to Risks 2.1 and 2.2 from the previous stage (Stage 2).

The profitability decline risk level (Risk 3.2 in Table 2) can be determined by the deviation (predicted reduction) of actual profitability from planned profitability, similarly to Risk 2.1 in Table 2. Approaches for mitigating this type of risk are listed in Table 2.

Fourth. Market Exit Stage.

The risk level at this stage (Risk 4.1 in Table 2) can be assessed similarly to Risk 3.2 in Table 2. Possible options for mitigating this type of risk and managing the PLC at this stage include: retaining the product on the market as long as profitability is acceptable, without product and marketing modifications, which reduces costs; a rapid market exit and product replacement with next-generation innovation if consumer demand persists, or exit without replacement if the demand is met in another way or no longer exists.

To account for the risk of product obsolescence (see Table 2), which applies to all stages of the product innovation lifecycle, a separate scheme has been developed, as shown in Fig. 2.

The procedures illustrated in Fig. 2 are conducted (as needed) at all stages of the product innovation lifecycle. The scheme in Fig. 2 shows the sequence and content of decision-making for managing the PLC of a product innovation.

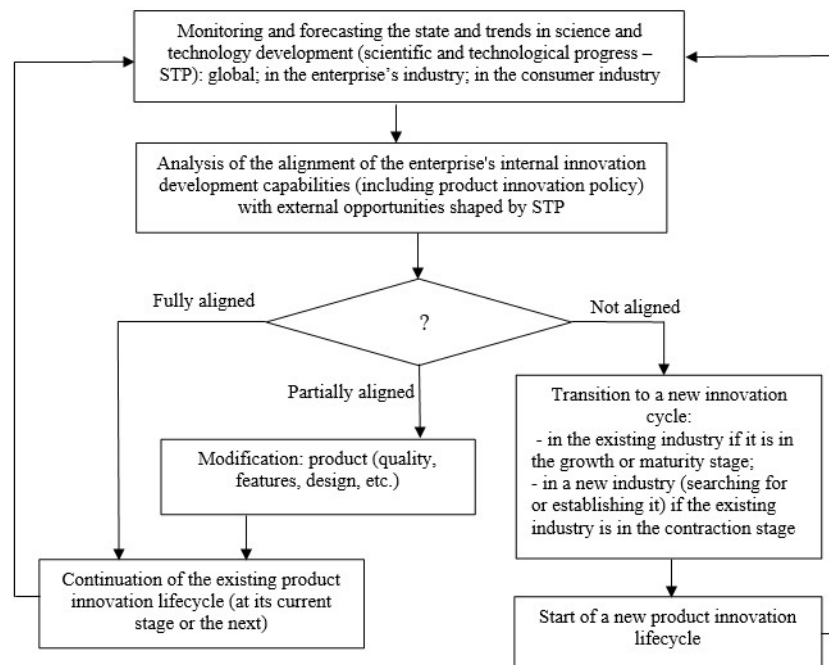


Fig. 2. Diagram of accounting for the risk of product innovation obsolescence in lifecycle management

Source: developed by the authors

The nature of management decisions is determined by the alignment between the adopted innovation development strategy and the product innovation created within its framework with the trends of scientific and technological progress (STP). Thus:

– In the case of full alignment, the obsolescence risk is minimal or low (risk level gradations are provided above), which is acceptable, and the innovation project does not require changes.

– In the case of partial alignment, the risk is moderate, necessitating risk mitigation measures, i.e., adjustments to the innovation project.

– In the case of misalignment, the risk is elevated or high, requiring a review of the adopted innovation development strategy and the initiation of a new innovation project. The existing project may continue with a transition to an opportunity-exhaustion strategy (moving to the final PLC stage). However, it may be discontinued if continuation is economically unfeasible.

A similar scheme has been developed to account for the risk of sudden changes in market conditions, which applies to all stages of the product innovation lifecycle (Fig. 3).

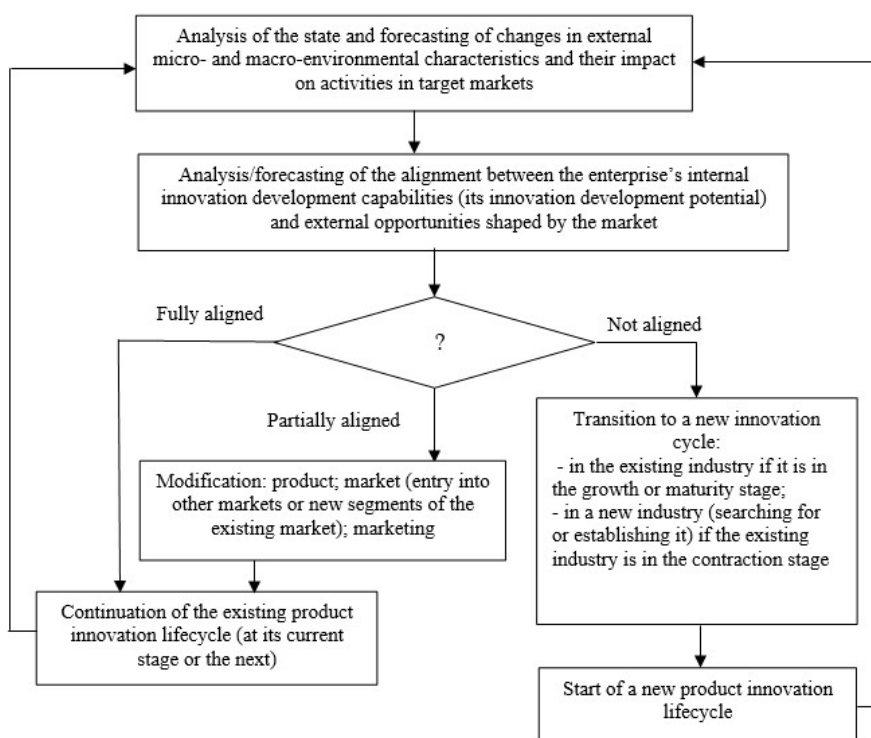


Fig. 3. Diagram of accounting for the risk of sudden market condition changes in product innovation lifecycle management  
Source: developed by the authors

According to the scheme in Figure 3, the nature of management decisions depends on the alignment between the adopted innovation development strategy and the product innovation created within its framework with the trends in market condition changes. Accordingly, possible management decisions include: continuing the implementation of the innovation project, adapting the innovation project to changing market conditions, or revising the adopted innovation development strategy and initiating a new innovation project. It is advisable to conduct this alignment analysis in relation to the forecasted market changes, i.e., to carry it out in anticipation of the

current market conditions.

The procedures outlined in Figures 2 and 3 may be performed at all stages of the product innovation lifecycle.

#### **Conclusions.**

Summarizing the above, the following conclusions can be drawn.

First. The associated objective risks at each stage of the product innovation lifecycle have been identified, along with the main influencing factors that cause them. Risks specific to certain stages and risks inherent in the entire lifecycle (across all stages) have been distinguished.

Second. The manifestation of risks at each stage of the innovation process has been investigated, and an approach for determining their level has been proposed. A comprehensive system of measures has been established to reduce the identified types of risks.

Third. An approach to managing the PLC of enterprise product innovations, taking into account the associated risks at each stage, has been developed. This approach includes: determining the risk levels at each PLC stage based on the proposed scale and the specific manifestations of each risk; specifying measures to manage stage-specific risks to address the problems (actual or forecasted) they cause and improve the substantiation of PLC management at each stage.

Fourth. The sequence and content of procedures for accounting for risks that may arise at any PLC stage of product innovations have been defined: the risk of product obsolescence and the risk of sudden changes in market conditions.

The combined results deepen the foundations of innovation management, particularly by developing an approach to improving the substantiation of PLC management decisions for product innovations through the identification, analysis, and accounting of associated risks at each stage. This will allow for justified adjustments to be made to innovation development projects during implementation, as well as to the innovation development strategies overall, including the termination of existing strategies and projects and the development and implementation of new ones.

Further research should focus on developing methodological foundations for managing the PLC of product innovations using formalized procedures that consider the associated risks at each stage.

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## УПРАВЛІННЯ ЖИТТЄВИМ ЦИКЛОМ ПРОДУКТОВИХ ІННОВАЦІЙ ПІДПРИЄМСТВ З УРАХУВАННЯМ РИЗИКІВ НА ЙОГО ЕТАПАХ

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Статтю присвячено розробленню методологічних засад управління життєвим циклом продуктивних інновацій підприємств з урахуванням супутніх ризиків його етапів. Окреслено коло супутніх ризиків етапів ЖЦ продуктивних інновацій, визначено фактори впливу, що їх спричиняють. Виокремлено ризики, що властиві конкретним етапам ЖЦ і ризики, що проявляються на усіх етапах ЖЦ. Визначено специфіку прояву ризиків з кожного з етапів ЖЦ, запропоновано підхід до визначення їх рівня. Сформовано комплекс заходів щодо зниження рівня виділених видів ризику. Розроблено підхід до цілеспрямованого управління ЖЦ продуктивних інновацій підприємств, що враховує супутні ризики його етапів. Деталізовано зміст процедур управління, зокрема: визначення за запропонованою шкалою рівня ризиків кожного з етапів ЖЦ відповідно до специфіки їх прояву; конкретизація заходів щодо управління супутніми ризиками етапів ЖЦ для вирішення спричинених ними проблем та підвищення рівня обґрунтованості управління ЖЦ на його етапах. Розроблено підхід до урахування ризиків, які проявляються на усіх етапах ЖЦ продуктивних інновацій: ризику їх морального старіння; ризику різкої зміни ринкових умов. Отримані науково-прикладні результати у сукупності поглиблюють засади інноваційного менеджменту, зокрема, з позицій підвищення рівня обґрунтованості управління ЖЦ продуктивних інновацій шляхом ідентифікації, аналізу і урахування ризиків на етапах ЖЦ. Їх практичне використання дозволить обґрунтовано вносити корективи в проєкти інноваційного розвитку на стадії їх реалізації. Вони також можуть бути застосовані для обґрунтування заходів щодо коригування стратегій інноваційного розвитку підприємств, включаючи згортання існуючих стратегій, а також розроблення і впровадження нових. Подальші дослідження повинні бути спрямованими на розроблення методичних засад управління за формалізованими процедурами ЖЦ продуктивних інновацій з урахуванням супутніх ризиків його етапів.

**Ключові слова:** життєвий цикл продуктової інновації, управління життєвим циклом, етапи життєвого циклу, інноваційний розвиток, інноваційні ризики, маркетингові ризики.

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LIFECYCLE MANAGEMENT OF PRODUCT  
INNOVATIONS IN ENTERPRISES CONSIDERING  
STAGE-SPECIFIC RISKS

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*This article is dedicated to developing methodological foundations for managing the lifecycle of product innovations in enterprises, with particular attention to the risks associated with each stage. It outlines the range of risks inherent at different stages of the product innovation lifecycle (PLC) and identifies the influencing factors that drive these risks. The study distinguishes between risks unique to specific stages of the PLC and those prevalent across all stages. It explores the unique manifestation of risks at each stage, proposing a method for assessing risk levels. A comprehensive set of measures is suggested to mitigate the identified types of risks. The study also introduces an approach for targeted lifecycle management of product innovations, accounting for risks at each stage. It details management procedures, including a proposed scale for determining risk levels at each PLC stage based on their unique characteristics, along with tailored actions to manage stage-specific risks. This approach aims to enhance decision-making in PLC management by addressing risks such as product obsolescence and sudden shifts in market conditions that affect all stages. The research findings advance innovation management by improving the foundation for lifecycle management of product innovations through risk identification, analysis, and mitigation at each lifecycle stage. Practical application of these findings will enable enterprises to make informed adjustments to innovation development projects during implementation and refine innovation strategies, including the suspension of current strategies and the development of new ones. Future studies should focus on establishing formalized procedures for lifecycle management of product innovations, taking into account associated risks at each stage.*

**Keywords:** product innovation lifecycle, lifecycle management, lifecycle stages, innovation development, innovation risks, marketing risks.

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