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SYNERGY OF PROJECT MANAGEMENT AND TECHNOLOGICAL INNOVATIONS IN IMPROVING THE EFFICIENCY OF FOOD PRODUCTION

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Abstract.

In the face of global instability, energy crises, and military threats, traditional linear management models for food industry enterprises have exhausted their capacity. The necessity of transitioning to qualitatively new development mechanisms requires a search for synergy between rigorous technological updates and flexible project management. The integration of modern project tools into reengineering processes is becoming a decisive condition for industrial transformation, allowing for the structuring of chaotic innovation cycles and ensuring the rational use of resources within strict time and financial constraints.

The study demonstrates that the modern management paradigm requires the implementation of hybrid models, where process management guarantees stability and the project approach acts as a framework for implementing unique changes. Technological innovations—both product-oriented (creation of nutrients with specified properties) and process-oriented (implementation of heat recovery systems and aseptic filling)—are identified as the substantive core of innovation projects. Particular attention is paid to combining the Stage-Gate methodology with the Agile strategy, which transforms risky scientific research into a system of ‘controlled flexibility’. This allows for the creation of ‘minimum viable innovations’ (MVP), minimising the ‘fear of failure’ and breaking down the ‘functional silos’ of traditional hierarchies.

The research establishes that the transition to SCADA systems with artificial intelligence algorithms transforms abstract energy saving into a manageable technological process with predictive diagnostics. Practical results confirm that project-oriented reengineering ensures a leap-like reduction in resource intensity: a 15–25% reduction in energy consumption and a 3–5% increase in finished product output. Such indicators are achieved by eliminating bottlenecks in conservative structures and implementing intelligent loss-monitoring systems.

The formation of synergy between project management and technological innovation is a key factor in converting scientific novelty into strategic business resilience. The proposed model successfully resolves the conflict between the requirements of high technology and the inertia of hierarchical systems. Such an integrated approach transforms each innovation project into a powerful lever for increasing the efficiency and competitiveness of food industry enterprises in the global market.

Keywords: project reengineering; food industry; technological innovations; efficiency; energy efficiency; management synergy; agile methodologies; economic resilience; SCADA systems; Stage-Gate methodology; innovative development; business processes.

Introduction.

In the current conditions of global instability and increased competition in world markets, ensuring the sustainable development of food industry enterprises requires a transition to qualitatively new management models. Traditional methods of increasing efficiency have largely exhausted their potential, which makes it necessary to search for synergistic mechanisms for combining organisational and technological factors. The integration of modern project tools into the processes of implementing high-tech innovations is becoming a decisive condition for the transformation of the industry. The project approach allows for structuring complex innovation cycles, minimising risks, and ensuring the rational use of resources within strict budget and time constraints.

At the same time, technological innovations provide meaningful content for projects, ensuring real productivity gains and optimisation of production costs. The synergistic effect of such interaction allows enterprises not only to adapt to critical external challenges, but also to maximise economic efficiency indicators. That is why research into the methodology of combining project management and innovative development is of particular importance for the domestic food sector. The development of practical recommendations for creating such synergy forms the basis of this scientific report.

Aim of the study.

The aim of the study is to substantiate theoretical and methodological foundations and develop practical recommendations for forming synergistic interaction between project management tools and technological innovations in order to maximise the economic efficiency of food industry enterprises.

Materials and methods.

The methodological basis of the study is a systematic analysis of business processes and the concept of project-oriented management of innovative development. The work uses a set of methods: logical generalisation — to clarify the conceptual apparatus of synergy between projects and innovations; functional-cost analysis — to assess the impact of technological changes on cost standards and production costs; business modelling tools (BPR) — to reengineer production processes from the 'AS-IS' state to the target 'TO-BE' state.

The information base was provided by the results of previous publications by the authors on project reengineering, reporting data from food industry enterprises, and international management standards (PMBOK) adapted to the specifics of high-tech production. Data processing and confirmation of the synergistic effects obtained were carried out using economic and mathematical modelling.

Results and discussion.

The modern management paradigm in the food industry is based on the functioning of two fundamental, complementary systems — process and project management. Process management ensures stability, repeatability and continuity of cyclical operations, which is critical for compliance with technological regulations and food safety standards. At the same time, project management is aimed at implementing unique changes, developing the potential of the enterprise and adapting to a turbulent external environment. We view project management as a holistic management concept based on the application of specialised knowledge, methods and tools to achieve specific goals within strict resource, time and quality constraints [1].

For food industry enterprises operating in extremely difficult conditions of energy instability and military threats, the project approach serves as a stabilising framework. While process management focuses on maintaining the current state ('AS-IS'), the project approach becomes a key tool for initiating and controlling transformation processes ('TO-BE') related to the implementation of innovations [3]. In this context, reengineering is not a one-off asset upgrade, but a systematic redesign of business processes to achieve radical improvements in critical performance indicators. The transition from the 'AS-IS' to the 'TO-BE' state in the food industry is complicated by the need to maintain the continuity of microbiological and thermal processes, which requires highly accurate scheduling of each stage of the transformation. The conceptual differences between the static and target states of the business system within the framework of project reengineering are systematised in Table 1. The effective synergy of these two systems allows the enterprise not only to survive, but also to develop dynamically, turning every innovative change into a sustainable competitive advantage.

Table 1 - Comparative characteristics of business system parameters within the transition from ‘AS-IS’ to ‘TO-BE’ (compiled by the authors)

Comparison Parameter	**Traditional State (‘AS-IS’)**	**Innovative State (‘TO-BE’)**
Management model	Hierarchical (linear-functional)	Flexible (cross-functional teams)
Monitoring method	Discrete data collection and manual control	Predictive SCADA with AI algorithms
Resource logic	Linear modernisation of individual units	Project-oriented reengineering
Energy utilisation	Direct consumption (broken cycle)	Closed-loop cycle (heat recovery)
Response to demand	Static production schemes	Adaptive ‘sprints’ and MVP releases

Effective integration of management approaches is implemented through innovative projects, which we define as targeted modules for business system transformation. Such projects allow a company to go beyond routine operational cycles and make a qualitative technological leap. Technological innovations are the substantive content of such projects in the food industry. Within the scope of our research, we consider them not as a simple purchase of equipment, but as a radical change in the physical, chemical, biological, or informational methods of influencing the object of labour (raw materials).

To systematise innovative activity in food industry enterprises, it is advisable to identify two main vectors. The first direction is product technological innovations, which involve the development and marketing of products with fundamentally new properties. Examples include technologies for encapsulating nutrients or using plant isolates to create products with a specific texture and biological value. In this case, innovation directly changes the molecular structure of the final product and its consumer characteristics.

The second, equally important area is process technological innovation, which involves the introduction of new production methods and techniques. This refers to the transition to aseptic filling methods, the use of ultrasonic extraction, or the deployment of closed water circulation and energy recovery systems. The differentiation between process innovations and standard technical modernisation is based on their scientific determinism. Unlike mass-market equipment offerings, true technological innovation is always based on an intellectual component: the results of fundamental research (R&D), patented inventions or proprietary know-how.

It should be noted that in today's market, the line between product and process innovations is becoming increasingly blurred. For example, the introduction of cryogenic freezing (process innovation) directly leads to the creation of a product with a higher level of vitamin preservation (product innovation). Therefore, project management must take this multiplier effect into account at the stage of forming the project idea.

This ensures a non-linear, but rather a leap-like increase in efficiency. In particular, the reduction in energy consumption or the increase in finished product output as a result of such changes significantly exceeds the standard statistical error margin of 1-2% typical of conventional modernisation. A striking example in the food industry is the introduction of intelligent heat recovery systems. These systems allow the reuse of energy from waste steam to heat incoming raw materials, which directly transforms the economics of the production cycle.

Alongside energy optimisation, the transition from traditional monitoring methods to the deployment of SCADA systems with integrated artificial intelligence algorithms is becoming critical. Such systems provide predictive equipment diagnostics and automatic correction of line parameters in real time. It is precisely these intelligent solutions that transform the abstract concept of energy saving into a controllable technological process with guaranteed economic results. The use of machine learning algorithms within SCADA systems allows predicting potential equipment failures long before they physically occur, which is critically important for food production with a continuous cycle, where every hour of downtime leads to spoilage of raw materials. Synergy arises when project management creates a rigid organisational structure for adapting these technologies, overcoming resistance from a conservative process environment [2].

The integration of project tools into the production environment inevitably leads to the transformation of outdated management approaches. Unlike traditional modernisation, which often conflicts with linear-functional hierarchies and closed information loops, the synergy of management and reengineering provides flexibility to the organisational model [2]. The modern requirements of the innovation environment are driven by the transition to closed-loop systems and digital quality management protocols. This requires management to make decisions quickly and engage in cross-functional interaction, which cannot be achieved with a traditional pyramid structure.

The need for such profound adaptation is also linked to the critical rise in energy costs and the extraordinary dynamism of consumer demand. Static production schemes are becoming economically unviable. The novelty of modern technologies lies in their ability to self-correct and integrate into global value chains. Internet of Things (IoT) sensors integrated into equipment allow the creation of ‘digital twins’ of production lines, enabling management to simulate the results of innovation implementation in a virtual environment before making real investments. This significantly reduces the financial cost of mistakes. This requires flexibility from the enterprise, where each innovative change becomes the basis for further productivity growth and optimisation of the resource intensity of the entire business system.

The process of developing and implementing innovations is inherently chaotic and risky due to the high level of uncertainty in scientific research. In this context, the project approach acts as a structuring filter. It transforms creative, often non-linear ideas into an orderly sequence of stages with clear control points. Synergy is achieved through the application of the Stage-Gate methodology, where each step of innovation implementation is subject to rigorous verification for compliance with the strategic financial and technological goals of the enterprise [4]. The Stage-Gate methodology in our study is considered as a system of 'control gates' where a Go/Kill decision is made at each stage (Idea, Scoping, Business Case, Development, Testing, Launch). This prevents the budget from being 'spread' across unviable ideas, which in conditions of resource scarcity can be fatal for the enterprise. The algorithm for the sequential passage of an innovation project through a system of strategic and technological control filters is detailed in Table 2.

Table 2. Regulations for sequential stages and strategic filters of an innovation project according to the Stage-Gate methodology (compiled by the authors)

Project Phase	**Scope of work at the stage**	**Decision criteria / Strategic Filter (Go/Kill)**
Stage 1: Screening	Preliminary technical and strategic assessment	Alignment with energy efficiency vector
Stage 2: Business Case	Detailed ROI and payback calculations	Resource cost reduction potential >15%
Stage 3: Development	Designing and creating a pilot line (MVP)	Successful completion of laboratory tests
Stage 4: Validation	Industrial batch testing and quality audit	Compliance with HACCP and industry standards

The use of network planning and critical path analysis methods allows teams to synchronise their work, levelling out time gaps between the development of new recipes and the technical re-equipment of production lines. The project model involves breaking down a complex innovation cycle into understandable work packages. This allows management to respond quickly to deviations and reallocate resources to the most critical areas. In this way, the movement of innovative ideas takes on a vector of purposeful development [1].

At the same time, the implementation of Agile management principles as an alternative to rigid cascade planning occupies a special place in this synergy model. In the food industry, where the path from laboratory development to industrial series is accompanied by constant adjustments, flexibility becomes a critical factor. The use of an iterative approach allows a large innovation project to be broken down into short cycles — 'sprints'. This makes it possible to obtain an intermediate product and test it for compliance with quality standards even before the entire line is completely re-equipped.

The implementation of the Agile approach within reengineering allows overcoming the main problem of innovation — 'fear of failure.' Instead of lengthy system design, which may become obsolete by the time of launch, the company creates a 'minimum viable innovation' (MVP). The MVP concept in food production can be implemented by creating small-capacity pilot lines or producing limited batches of a new product to test consumer response. This transforms the linear development process into a cyclical learning process, where each sprint brings the system closer to the ideal 'TO-BE' state. The synergistic effect here is manifested in the system's ability to self-learn: each subsequent iterative step is based on the actual results of the previous one, which radically reduces the risk of financial losses.

In addition, Agile contributes to the destruction of 'functional silos'. The creation of cross-functional teams focused on a specific innovation project ensures continuous knowledge sharing and accelerates decision-making. This level of organisational flexibility is unattainable for traditional hierarchies, making agile methodologies an integral part of any efficiency improvement strategy.

The effectiveness of the synergistic management model directly depends on the quality of cross-functional teams, which are the driving force behind innovative projects. In the food industry, the formation of such teams is specific in nature, due to the high level of interdisciplinarity of processes. Unlike traditional hierarchical structures, where specialists interact only at the level of document transfer, a cross-functional project team combines the competencies of technologists, mechanical engineers, IT specialists, economists and quality control specialists (HACCP) into a single analytical node.

A key feature is the role of the technologist as a 'content architect.' In food production reengineering projects, any engineering or digital change must be verified for compliance with the biochemical standards of raw materials. Thus, cross-functional interaction avoids the gap between the technical perfection of the equipment and the technological reality of the product. For example, when implementing intelligent heat recovery systems, the team jointly assesses not only energy efficiency, but also the potential impact of changed temperature regimes on the organoleptic properties of the final product.

We identify three critical success factors for such teams in the food industry:

1. Cognitive flexibility: the ability of narrow-profile specialists to understand related constraints (an engineer must understand microbiological risks, and a technologist must understand the logic of AI algorithms in SCADA).

2. Shared responsibility for KPIs: transition from individual performance indicators to team project metrics (e.g., overall reduction in specific energy consumption per kg of product).

3. Direct horizontal communication: eliminating the need to coordinate each step with line managers, which speeds up iteration cycles (sprints) within the Agile approach.

A detailed matrix of the distribution of key functions and areas of competence within such team interaction is presented in Table 3.

Table 3 - Matrix of functional roles and areas of responsibility in a cross-functional team of an innovation project (compiled by the authors)

Team Role	Competence Profile (Hard Skills)	Key Area of Responsibility in the project
Technologist (Architect)	Biochemistry, HACCP, food engineering	Verification of technological parameters and quality
Mechanical Engineer	Industrial automation, thermodynamics	Optimisation of energy use and heat recovery
IT Specialist	Data Science, SCADA architecture	Implementation of predictive analytics and AI
Economist-Analyst	Project management, financial analysis	Budget control and economic effect assessment

It is cross-functionality that allows transforming ‘functional silos’ into a network structure, where the speed of knowledge transfer becomes a decisive factor in overcoming conservative resistance from the environment. This approach ensures not only a technological leap, but also the formation of internal intellectual capital within the enterprise, capable of independently generating innovations in the future.

The process of forming synergy between project management and technological innovations, despite its high potential for efficiency, is accompanied by a number of critical risks caused by both the specifics of food production and the extreme nature of the external environment. Systematising these risks allows management to develop preventive measures and ensure the viability of transformation processes.

The first and most significant is the technological risk of innovative solutions not matching actual production parameters. In the food industry, where the physical and chemical properties of raw materials can vary depending on the batch or season, the introduction of radical innovations (e.g., the transition to new extraction methods or aseptic packaging) can lead to unexpected changes in the organoleptic characteristics of products. To mitigate this risk, we recommend the mandatory implementation of the ‘Testing & Validation’ stage within the Stage-Gate methodology, which involves the creation of prototypes and laboratory testing before scaling up the technology.

The second vector of threats is organisational risks associated with staff resistance and a shortage of specific competencies. The introduction of Agile approaches and cross-functional teams often comes into direct conflict with the established corporate culture of conservative enterprises. Resistance to the ‘process environment’ is caused by line managers' fear of losing control and employees' neophobia. Overcoming this barrier requires the development of change management programmes aimed at retraining staff and forming a new motivation system focused on project results rather than routine performance of functions.

Infrastructure and logistics risks, which have become critical in the context of martial law, constitute a separate group. Energy instability and threats of destruction of production facilities can halt the implementation of an innovative project at any stage. Within our model, we propose the concept of ‘resource reservation’ and the development of alternative project implementation scenarios (Contingency Planning).

This includes the use of modular technological solutions that can be quickly relocated or reconfigured, as well as the integration of autonomous power supply systems into the structure of an innovative project.

The financial risks of implementation are associated with the high capital intensity of technological innovations and long payback periods in conditions of high inflation. The use of iterative modelling tools within Agile allows this problem to be partially alleviated through a ‘phased financing’ mechanism, where each subsequent investment is allocated only after the effectiveness of the previous sprint has been confirmed. This provides financial flexibility and minimises the amount of ‘frozen’ assets in the event of an unsuccessful pilot implementation.

Thus, considering risks not as obstacles but as controllable project parameters allows the ‘controlled flexibility’ model to be transformed into a reliable strategic development tool, ensuring a high level of business system adaptability to any external challenges. For a comprehensive understanding of the security architecture of the innovation process, the main categories of threats and corresponding management measures are systematised in Table 4.

Table 4 - Classification of critical risks of innovation reengineering and mechanisms for their neutralisation (compiled by the authors)

Risk Category	**Manifestation in the food industry**	**Neutralisation mechanism (measures)**
Technological	Raw material variability, sensory changes	‘Testing & Validation’ stage in Stage-Gate
Organisational	Resistance from linear managers, neophobia	Change Management and cross-functional training
Infrastructural	Energy deficits, asset destruction	Modular solutions and autonomous power supply
Financial	High capital intensity, inflation	Iterative ‘pay-as-you-go’ funding

An important element of our model is the integration of feedback mechanisms, which allows for process reengineering even at the pilot implementation stage. The synergy of project management and technological innovation creates conditions for so-called ‘controlled flexibility.’ This enables the enterprise to scale successful solutions or abandon unviable options in a timely manner with minimal financial losses. Ultimately, project management becomes an intellectual superstructure that guarantees the transformation of technological innovation into real economic stability (resilience) [3]. It is this stability that is the ultimate benefit of synergy, allowing the enterprise to maintain operational integrity even in the event of a critical power outage or disruption of logistics chains.

The economic feasibility of implementing such a model is confirmed by the dynamics of resource intensity indicators and a radical transformation of the system of technical and economic standardisation. Traditional approaches to evaluating success based solely on return on investment are insufficient because they do not take into account the effect of full optimisation of operational cycles. The key evidence of the effectiveness of synergy is a systematic reduction in the specific rates of raw material, energy and labour costs per unit of output.

According to our calculations, the synergistic effect arises not only from the introduction of new equipment, but also from the optimisation of the ‘joints’ between processes. The use of network analysis tools allows you to reduce equipment downtime by 20-30%, which is equivalent to the effect of purchasing additional capacity without real capital investment.

The use of a project-based approach allows for precise control over costs at every stage of product development. The introduction of innovations backed by predictive loss analysis leads to dramatic optimisation: energy consumption can be reduced by 15–25%, while commercial output increases by 3–5%. Such results are only possible thanks to in-depth process reengineering, which eliminates bottlenecks in hierarchical structures where uncontrolled resource losses previously occurred [3]. A comprehensive approach to creating synergy between management and technology is the only way to maximise economic effect in today's market.

Conclusion.

Maximising the efficiency of food industry enterprises in today's reality directly depends on the formation of effective synergy between radical technological innovations and project-oriented reengineering. The combination of flexible Agile methodologies with strategic Stage-Gate tools transforms the chaotic search for innovation into an orderly system of ‘controlled flexibility’ capable of mitigating management risks. Unlike typical modernisation, the innovative approach is based on a unique scientific component that creates the basis for a leap-like reduction in the resource intensity of production cycles. The practical result of such a transformation is manifested in the systematic optimisation of specific energy and raw material consumption rates, which converts technological innovation into strategic business sustainability (resilience). The proposed management model successfully resolves the conflict between the requirements of new technologies and the inertia of conservative hierarchical structures. Such an integrated approach transforms each innovative project into a powerful lever for increasing the competitiveness of the enterprise in the global market.

The established model of synergy between project management and technological innovations opens up a wide field for further scientific research in the direction of digitalisation and deepening resource efficiency. We see the development of intelligent decision support systems based on Big Data as a promising research vector, which will allow for dynamic reengineering of processes on the fly, adapting to instant changes in the energy balance of the enterprise.

Special attention should be paid to studying the impact of cross-platform integration of IoT sensors into global supply chains, which will allow expanding the boundaries of project management beyond individual enterprises to the level of network ecosystems. It is also critically important to further study the socio-psychological aspects of implementing Agile methodologies in conservative industrial environments, in particular the development of specific competency profiles for leaders of innovative projects in the food industry.

In addition, the development of the concept of ‘circular reengineering,’ which focuses on creating closed cycles of resource use (Zero Waste), deserves scientific interest. This requires the development of new metrics for assessing synergistic effects that take into account not only direct economic benefits, but also the environmental capital of an enterprise as a component of its long-term market value.

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ЦИФРОВІ УПРАВЛІНСЬКІ РІШЕННЯ В СИСТЕМІ АНТИКРИЗОВОЇ АДАПТАЦІЇ МАЛОГО ТА СЕРЕДНЬОГО БІЗНЕСУ

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Анотація. У статті досліджено роль цифрових управлінських рішень у системі антикризової адаптації малого та середнього бізнесу в умовах економічної турбулентності. Обґрунтовано доцільність упровадження цифрових технологій як інструменту підвищення гнучкості управління, фінансової стійкості та конкурентоспроможності підприємств. Проаналізовано основні види цифрових управлінських рішень, що застосовуються у діяльності малих і середніх підприємств, зокрема інформаційно-аналітичні, фінансові, операційні та комунікаційні інструменти. Узагальнено рівні цифрової трансформації бізнесу та визначено їхній вплив на процеси антикризового управління.