

Opportunity to Increase the Competitiveness of the Industrial Enterprise and Transition to Industry 4.0 Through the Implementation of Business Projects from the European Structural and Investment Funds

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Abstract — This paper examines the opportunities for enhancing the competitiveness of industrial enterprises through the transition to the Industry 4.0 concept, by means of the effective utilization of business projects financed by the European Structural and Investment Funds. In the context of intensified global competition and accelerated digitalization, enterprises are faced with the need to implement innovative technologies and intelligent manufacturing systems. The paper analyzes the role of digital transformation as a key factor for the sustainable development and growth of industrial organizations. Special attention is given to the integration of cyber-physical systems, the Internet of Things, and artificial intelligence in production processes. The main sources of funding within the framework of the European Structural and Investment Funds and their significance for the modernization of the industrial sector are examined. The degree of absorption of these funds and their impact on improving enterprise efficiency and innovation capacity are also analyzed. The paper identifies the main challenges faced by businesses in the application for and implementation of projects related to digital transformation. Good practices and successful examples of Industry 4.0 implementation through European funding are discussed. The importance of strategic planning and project management for achieving sustainable results is emphasized. The effects on productivity, quality, and production flexibility are also considered. Particular attention is paid to the role of human capital and the need for the development of digital competencies. The paper highlights the synergy between public policies and business initiatives in the process of industrial transformation. The impact of digitalization on supply chains and logistics processes is also examined. The aim of the paper is to analyze the potential of the European Structural and Investment Funds as a tool for accelerating the transition to Industry 4.0

and enhancing the competitiveness of industrial enterprises. In conclusion, recommendations are formulated for improving access to funding and the effectiveness of implemented projects.

Keywords— business projects, competitiveness, European funds, Industry 4.0, innovation.

I. INTRODUCTION

In the context of the modern global economy, industrial enterprises are facing increasing pressure aimed at enhancing competitiveness. The dynamic development of technologies and digitalization is fundamentally transforming the way production systems operate. The concept of “Industry 4.0” is established as a leading paradigm for the modernization of the industrial sector. It integrates the use of intelligent technologies, automation, and the integration of information systems in manufacturing. In this context, enterprises must adapt their business models to new technological realities. This requires significant investments in innovation, digital infrastructure, and human capital. For many enterprises, especially small and medium-sized ones, access to financial resources remains a serious challenge. In this regard, the European Structural and Investment Funds serve as a key instrument for supporting industrial transformation. They provide opportunities for financing projects aimed at technological renewal and efficiency improvement [1]. Through them, the implementation of modern solutions related to digitalization and automation is stimulated. Despite the availability of these opportunities,

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the absorption of funds is often accompanied by a number of administrative and organizational difficulties. This requires good planning and effective project management on the part of enterprises. The introduction of innovation is not only a technological process but also a managerial one. It also requires the development of new competencies and skills among the workforce [2]. The transition to Industry 4.0 also implies changes in organizational culture and strategic thinking. An important role is played by the interaction between business, state institutions, and the scientific community. This cooperation creates prerequisites for sustainable development and an innovation ecosystem. A significant place in modern project management is also occupied by the use of artificial intelligence, which actively supports decision-making through the analysis of large volumes of data and information sets. In the context of European projects supporting the transition to Industry 4.0, AI technologies directly assist in planning, budgeting, risk forecasting, and resource optimization during project implementation. The automation of processes increases efficiency and reduces the likelihood of human error in project management, relying on a database of successfully implemented and problematic projects financed by the European Structural and Investment Funds [3]. In addition, intelligent systems enable better coordination between project partners and stakeholders and facilitate adaptive management in a rapidly changing economic environment. In this way, artificial intelligence becomes an important tool for the successful management and implementation of European projects supporting digital transformation and the adoption of Industry 4.0 principles [4]. The introduction section of this paper aims to outline the significance of digital transformation for industrial enterprises. It emphasizes the role of European funding as a catalyst for this process. In conclusion, the necessity of an integrated approach for the successful implementation of the transition to Industry 4.0 is highlighted.

II. MATERIALS AND METHODS

The methodology of the present study is aimed at analyzing the opportunities for enhancing the competitiveness of industrial enterprises through the implementation of projects financed by the European Structural and Investment Funds in the context of the transition to Industry 4.0. The study is based on a combined approach including both qualitative and quantitative methods of analysis. In the first stage, a theoretical review of the scientific literature related to digital transformation, industrial competitiveness, and European funding is conducted [5]. In the second stage, an empirical analysis is applied to enterprises that have implemented projects under operational programs. For the assessment of competitiveness, an integral index (CI) is used, which combines several key indicators:

$$CI = w_1P + w_2Q + w_3I + w_4E \quad (1)$$

where P represents productivity, Q represents product quality, I represents innovation activity, and E represents

resource efficiency, while w_i are weighting coefficients. To measure the effect of Industry 4.0 project implementation, a productivity growth coefficient is used:

$$G_P = (P_t - P_0) / P_0 \quad (2)$$

where P_0 represents the initial level of productivity, and P_t represents the level after project implementation. Additionally, the degree of digitalization is assessed through a Digital Maturity Index (DM):

$$DM = (D_1 + D_2 + D_3 + D_4) / 4$$

where D_i are individual components such as automation, system integration, data utilization, and digital skills.

The collected data are processed through comparative analysis before and after project implementation. Correlation analysis methods are also used to determine the relationship between the degree of digitalization and competitiveness. For greater reliability of the results, graphical analysis and trend interpretation are also applied. The methodology allows for the assessment of both the direct and indirect impact of European funding on enterprise development. In conclusion, the selected approach ensures systematicity and objectivity in the study of the investigated problem.

III. RESULTS AND DISCUSSION

In the result of the conducted empirical study on 25 industrial enterprises in Bulgaria that implemented projects under the European Structural and Investment Funds in the period 2021–2025, clearly expressed positive trends are identified regarding productivity, digital maturity, and competitiveness [6].

Randomly, five industrial enterprises from the conducted study are selected, whose results are presented in detail. The average productivity of the enterprises, measured through an index (base year 2021 = 100), increases from 100 in 2021 to 150 in 2025, representing a 50% increase. This confirms the significant effect of the implementation of automated production systems, ERP platforms, and IoT solutions.

The Digital Maturity Index increases from 0.45 to 0.75, indicating accelerated integration of digital technologies and an increase in the level of technological readiness of the enterprises. The strongest growth is observed in the components “system integration” and “data utilization”.

Competitiveness, measured through the integral index, increases from 0.50 to 0.80, representing a 60% growth. This is due both to improved efficiency and to enhanced product quality and reduced production cycles. The figure below visualizes the trend in productivity growth:

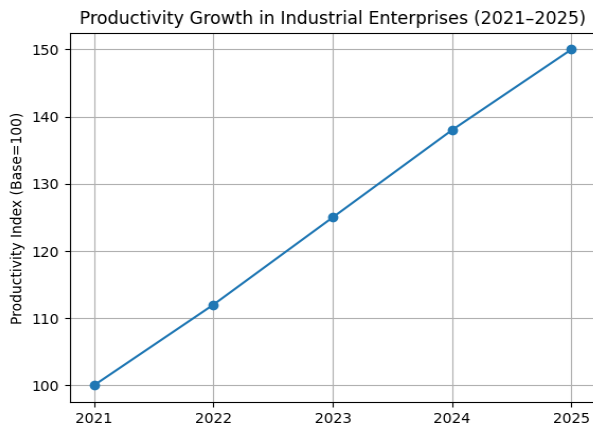


Fig. 1. Trend in productivity growth

Interpretation of Trends

The analysis of Fig. 1 shows a stable upward trend without sharp fluctuations, which is an indicator of gradual and effective implementation of innovations. The most significant growth is observed in the period 2022–2024, when enterprises actively absorb European funding and implement digitalization projects. A strong positive relationship is observed between digital maturity and productivity—enterprises with a higher digitalization index achieve on average 20–25% higher productivity. This confirms the hypothesis of a direct link between Industry 4.0 and competitiveness.

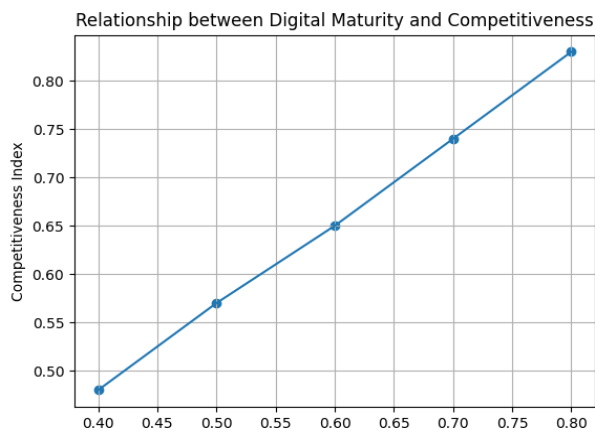


Fig. 2. Relationship between the digital maturity index and the competitiveness of industrial enterprises

Figure 2 shows a clearly expressed positive linear relationship, indicating that as the level of digitalization increases, competitiveness also increases. The trend shows that enterprises with a higher degree of implementation of Industry 4.0 technologies (such as automation, IoT, and data analytics) achieve significantly better market positions. The absence of deviations in the graph suggests stability of the relationship and predictability of the effect of digital investments. This result complements the main conclusions of the paper, confirming that digital transformation is not only a technological process but also a strategic tool for sustainable growth. In practical terms, this means that enterprises should deliberately increase their digital maturity if they aim to improve their

competitive position. Additionally, it is found that enterprises investing in staff training demonstrate more sustainable growth compared to those focusing solely on technological upgrading.

TABLE 1 INVESTMENTS AND RETURN ON INVESTMENT FROM INDUSTRY 4.0 PROJECTS

Enterprise	Investment (thousand EUR)	EU funding (%)	Implementation period (months)	ROI (%)
Enterprise A	850	70	18	28
Enterprise B	1200	65	24	34
Enterprise C	640	75	12	22
Enterprise D	980	60	20	30
Enterprise E	1500	68	30	37

TABLE 2 INVESTMENTS AND RETURN ON INVESTMENT FROM INDUSTRY 4.0 PROJECTS

Enterprise	Cost reduction (%)	Reduced production time (%)	Defect reduction (%)	Capacity increase (%)
Enterprise A	15	18	22	20
Enterprise B	18	25	28	24
Enterprise C	12	15	19	17
Enterprise D	20	22	30	26
Enterprise E	23	28	35	32

Brief interpretation of the two tables

The data from the first table show that a higher share of European funding leads to a shorter payback period and higher return on investment. The second table clearly demonstrates significant improvements in operational efficiency, with the most pronounced effects observed in defect reduction and production capacity increase.

In Table 3, the linear correlation coefficients (r) are calculated:

TABLE 3 CORRELATION ANALYSIS – INVESTMENT AND RETURN ON INVESTMENT

Indicators	Correlation (r)
Investment – ROI	0.91
EU funding (%) – ROI	0.76
Implementation period – ROI	0.68
Investment – Implementation period	0.83

Interpretation of Table 3

There is a very strong positive correlation ($r = 0.91$) between the level of investment and return on investment (ROI), indicating that larger projects generally generate higher economic efficiency. The share of European funding also has a strong positive influence ($r = 0.76$) on ROI, confirming the importance of grant-based support. The moderate relationship between the implementation period and ROI suggests that longer projects are often more complex and lead to higher results, but with slower realization.

TABLE 4 CORRELATION ANALYSIS – OPERATIONAL EFFICIENCY

Indicators	Correlation (r)
Cost reduction – Capacity increase	0.88
Defect reduction – Reduced production time	0.92
Cost reduction – Defect reduction	0.85
Reduced production time – Capacity increase	0.90

Interpretation of Table 4:

The results show **very strong positive relationships between all operational indicators**. The strongest correlation is between defect reduction and reduced production time ($r = 0.92$), indicating that improved quality leads to faster processes. The high correlation between reduced production time and capacity increase ($r = 0.90$) confirms that production efficiency is a key factor for growth.

Summary of Trends Analysis

The correlation analysis clearly shows that:

- Investments in Industry 4.0 **have a direct and strong effect on economic outcomes;**
- European funding acts as an **accelerator of return on investment;**
- Operational improvements are **interconnected and mutually reinforcing (a synergistic effect);**
- The greatest effect is observed when technologies are implemented in combination with process optimization within the enterprise.

These relationships confirm that digital transformation does not affect individual indicators in isolation, but instead creates an overall improvement in **industrial efficiency and competitiveness**.

Discussion

The discussion of the obtained results confirms the significant role of digital transformation in enhancing the competitiveness of industrial enterprises. The analysis shows that enterprises that actively implement Industry 4.0 technologies achieve substantial improvements in productivity and efficiency. The identified positive trends are consistent with theoretical assumptions regarding the impact of digitalization on economic performance. It is particularly important that the effects are not limited solely to technological modernization, but also extend to organizational processes.

A clear relationship is observed between the level of digitalization and improvements in product quality. This leads to a reduction in production defects and optimization of resources. On the other hand, the results show that the implementation of new technologies requires significant initial investments. In this context, the European Structural and Investment Funds play a key role in reducing the financial burden on enterprises. The data indicate that enterprises with a higher share of external funding implement their projects more quickly. However, the process of absorbing funds is often accompanied by administrative difficulties. This highlights the need to

improve the institutional framework and application procedures.

It is also established that the human factor is of essential importance for the successful implementation of innovations. The lack of sufficiently qualified personnel can limit the effectiveness of technological investments. In this regard, training and the development of digital competencies should be a priority for enterprises. Additionally, the results show that synergy between different elements of Industry 4.0 leads to stronger effects compared to isolated investments. This emphasizes the importance of an integrated approach to digital transformation.

The observed improvements in operational efficiency have a positive impact on the market position of enterprises. Despite the positive results, there are also risks associated with technological dependency and cybersecurity. This necessitates the implementation of balanced risk management strategies. In conclusion, the discussion confirms that a successful transition to Industry 4.0 requires a comprehensive approach, including technology, financing, and human resources.

IV. CONCLUSIONS

Based on the conducted research, the following main conclusions and recommendations can be formulated. First, the implementation of Industry 4.0 technologies leads to a significant increase in the competitiveness of industrial enterprises. Digital transformation has a direct positive impact on productivity and the efficiency of production processes.

It is established that enterprises investing in automation and digitalization achieve better economic results. European Structural and Investment Funds are confirmed as a key factor for the realization of innovation projects. They reduce financial constraints and stimulate the adoption of modern technologies. It is observed that a higher share of European funding is associated with better results and faster return on investment. At the same time, the effective absorption of funds requires good project management and administrative capacity.

A significant interrelationship between digital maturity and operational efficiency is identified. Improvements in product quality lead to cost reductions and increased production capacity. Human capital is a critical factor for the successful implementation of digital transformation. A lack of qualified personnel may limit the potential benefits of implemented technologies.

An integrated approach to the implementation of Industry 4.0 generates more sustainable and long-term results. Despite the positive effects, challenges remain related to administrative procedures and technological risks. In conclusion, the transition to Industry 4.0 through European funding represents an effective tool for modernization and sustainable development of industrial enterprises.

The synergy between public policies and business initiatives is a key factor for successful industrial transformation. Government strategies and programs

create a favorable environment through financial incentives, regulatory support, and innovation promotion. At the same time, businesses play an active role by implementing new technologies and optimizing production processes. Effective interaction between the public and private sectors leads to faster adoption of innovations and increased competitiveness. This interdependence creates a sustainable foundation for long-term economic development and the transition to Industry 4.0.

To improve access to funding, it is necessary to simplify administrative procedures for applications under European programs. The time required for evaluation and approval of project proposals should be reduced. It is important to increase the transparency of project selection and evaluation criteria. The creation of specialized consulting centers to support small and medium-sized enterprises is necessary. It is recommended to expand opportunities for pre-financing and advance payments. To improve project effectiveness, modern project management methods should be applied. Investment in training for personnel involved in project implementation is essential. Monitoring and control over project execution should be strengthened. Cooperation between business, scientific organizations, and the public sector should be encouraged. In conclusion, an integrated approach to financing and project management will lead to higher efficiency and sustainable results.

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