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FINANCIAL AND CREDIT MECHANISMS FOR SUPPORTING INNOVATION-ORIENTED ENTERPRISES: THE ROLE OF FINANCIAL INSTRUMENTS

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ABSTRACT

Innovation-oriented industries are currently the key drivers of economic growth. The effectiveness of their development largely relies on the availability and structure of financial and credit support mechanisms within a country, as well as on the level of development of digital market infrastructure. This study aims to assess the impact of financial and credit mechanisms on innovation-oriented enterprises through the analysis of key financial and credit instruments using economic and mathematical modeling. The research employs correlation and regression analyses as well as ANOVA testing. The results of the correlation analysis indicate that firms' adoption of innovations demonstrates only a weak dependence on financial and credit instruments. In contrast, high-tech exports and the number of researchers engaged in R&D demonstrate a stronger relationship with access to financial resources, investment activity, and the functioning of digital market infrastructure. Regression analysis reveals that the combined effect of grants, bank lending, and investment activity significantly enhances companies' capacity to develop high-tech exports. What is more, this integrated financial and credit mechanism contributes to human capital formation in the field of research and development. The study also shows that different financial and credit mechanisms influence innovation indicators in distinct ways. In particular, domestic funding sources and government support stimulate innovation adoption, whereas bank lending and investment activity primarily promote high-tech exports and growth in the number of R&D researchers. Overall, the examined mechanisms explain 22% of the variation in high-tech exports and 40% of the variation in the number of researchers in R&D. The findings provide a foundation for designing financial and credit policies aimed at stimulating innovation activity, expanding high-tech exports, and strengthening research capacity.

Keywords: financial and credit instrument, innovation, industrial R&D, international trade, digital market infrastructure, technical cooperation grants, lending interest rate, domestic credit, gross fixed capital

JEL Classification: G21, E22, O32, O31

INTRODUCTION

The development of both internal and external innovations creates the prerequisites for stabilizing the national economy and ultimately leads to a substantial increase in its overall efficiency (Shaturaev, 2022; Sytnyk et al., 2022). Accordingly, it is crucial that innovation-oriented firms remain within the domestic economy and sustain their development dynamics, rather than relocating abroad (Buchniev et al., 2023; Davydenko & Suvorova, 2024). Achieving this obviously requires adequate access to financial resources and establishing effective financial and credit support mechanisms (Xue & Zhang, 2022; Ogbeide & Obadeyi, 2023).

However, in practice, investment firms are often reluctant to finance innovative projects at earlier stages of development. At the same time, banks are typically not willing to provide loans for early-stage or high-risk innovation projects. Against this backdrop, the state plays a crucial role in shaping and supporting financial and credit mechanisms, as it not only defines strategic development priorities but also provides direct resource

support (Borysenko, 2022). At the same time, public support may be limited, particularly under conditions of economic instability. Therefore, the integration of state, banking, as well as private financial and credit mechanisms, becomes especially important. Their combined effect can compensate for the limitations of individual financing sources and ensure more stable support for innovation activity (Mironova et al., 2022).

However, not all indicators of innovation activity respond uniformly to different financial and credit mechanisms. Moreover, the combined effect of public, banking, and private financing instruments remains insufficiently explored. This gap underscores the need to evaluate a comprehensive innovation financing mechanism that incorporates public grants alongside private and banking support tools. With that in mind, the present study advances the hypothesis that the impact of such an integrated financial and credit mechanism on the performance of innovation-oriented industries is predominantly positive. The paper proposes a novel approach to identifying the effects of financial and credit mechanisms on the development of innovative industries. Hence, it can enable the simultaneous assessment of both individual and joint impacts of financial instruments.

LITERATURE REVIEW

Modern scholarly literature examines a wide range of financial and credit mechanisms designed to support innovation-oriented industries. These mechanisms include both traditional instruments, such as bank loans and grants (Santos et al., 2024; Romero Alvarez et al., 2025). In addition, they comprise contemporary tools, including digital financial instruments, asset tokenization, and innovative platforms for attracting private investment (Romero-Castro et al., 2022; Sharafan et al., 2025). Several studies emphasize the advantages of combining conventional financial instruments with modern mechanisms; for example, Zhao (2024) highlights the role of digital credit in promoting enterprise innovation. While these approaches are largely valid, many existing studies devote insufficient attention to the quantitative assessment of synergies arising from the interaction of different financial and credit mechanisms.

For example, Arnone et al. (2024) examined the relationship between bank lending and private-sector–supported financing and technological innovation, identifying a positive effect on infrastructure development. Next, Wen and Sun (2025) demonstrated that firms' access to credit is strongly influenced by the effectiveness of cooperation between manufacturing enterprises and the financial sector. Further, similar conclusions are drawn by Yang et al. (2024), who note that both market-oriented and policy-oriented financial support significantly contribute to technological innovation. From a different perspective, Hu et al. (2025) assess the indirect impact of trade credit on innovation development, while Xiang and Zhao (2025) extend this line of research by analyzing how industrial internet platforms transform firms' access to trade lending. At the same time, the assumption that credit exerts a uniformly positive effect across all firms may be questioned, as some studies fail to account for differences in firms' financial constraints.

Overall, the reviewed literature suggests that financial and credit mechanisms alone only partially stimulate innovation activity. Their effectiveness depends substantially on the adoption of modern financial approaches and on the interaction among enterprises, the financial sector, and the state. This is supported by Karami (2025), who emphasizes that digitalization enhances innovation outcomes only when firms possess sufficient innovative capabilities and operate within a favorable institutional environment. In this light, Xiang et al. (2022) outline the role of state subsidies in intensifying firms' innovation activity through both debt and equity financing. Consequently, although individual financial and credit mechanisms contribute to the development of innovation-oriented industries, the greatest impact is achieved through a comprehensive support mechanism. However, existing studies do not adequately compare the effectiveness of individual components within such an integrated framework, indicating the need for further empirical investigation.

Empirical evidence suggests that the effectiveness of financial and credit mechanisms largely determines the level of companies' innovation activity (Wang et al., 2022; Lu et al., 2024). In fact, innovation performance is commonly assessed using indicators such as the number of firms introducing new products and processes, the volume of high-tech exports, and the number of researchers engaged in R&D activities (Lee & Kwon, 2023; Navarro Zapata et al., 2024). A high share of R&D-related indicators reflects a country's strong dependence on knowledge creation as a foundation for future economic prosperity (Yuldashev et al., 2022; StatRanker, 2025).

Despite broad agreement in the literature regarding the potential benefits of comprehensive financing mechanisms, there remains a lack of empirical research assessing their actual impact. In particular, the effects of grants, bank lending, and private financial and credit instruments on innovation-oriented firms engaged in product and process innovation, R&D investment, and high-tech exports are currently insufficiently explored. Given the above, this study addresses this gap by evaluating the impact of these mechanisms using economic and mathematical modeling.

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AIMS AND OBJECTIVES

This study aims to assess the impact of financial and credit mechanisms on innovation-oriented enterprises through the analysis of key financial and credit instruments using economic and mathematical modeling. To achieve this objective, the study addresses the following tasks:

1. To conduct a correlation analysis of innovation indicators and financial and credit variables in order to identify linear relationships.
2. To perform a regression analysis assessing the combined impact of financial and credit instruments on various dimensions of firms' innovation activity.
3. To formulate conclusions and practical recommendations based on the empirical results obtained.

METHODS

Research procedure

The research procedure comprises three successive stages (Figure 2). The proposed approach enables a systematic progression from the identification of key variables to the assessment of the nature and strength of their interactions. The empirical basis of the study consists of aggregated statistical data obtained from international organizations, reflecting key financial, credit, and innovation indicators.

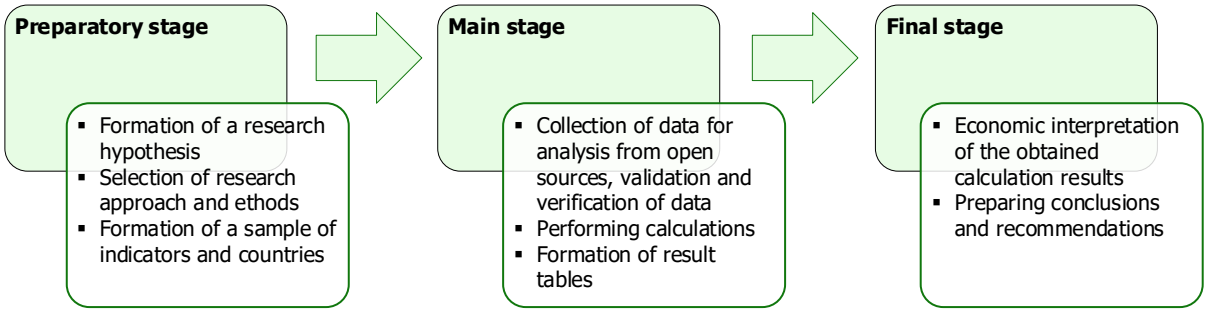

Figure 2. Research procedure.

Sampling

This study is based on country-level panel data, rather than firm-level microdata, covering countries worldwide for the period from 2004 to 2024 and includes 4515 observations. The empirical analysis covers a sample of countries for which comparable macroeconomic and sectoral indicators are available. Innovation-oriented firms are not analysed individually, but are represented indirectly through aggregated indicators reflecting innovation activity, international trade, industrial R&D, and digital market infrastructure at the national level. The data are publicly available from the World Bank (2025). A detailed list of the variables analyzed is presented in Table 1.

Table 1. Sampling of indicators for analysis.

Indicators	The essence of the indicator	Argumentation for inclusion in the study
Firms that introduced a new product/service and process, and spent on R&D	Number of firms that have implemented new products/processes and invested in R&D	Reflects the direct innovation activity of firms
High-technology exports (current USD)	Volume of exports of high-tech products	Characterizes the level of commercialization of innovations in foreign markets
Researchers in R&D (per million people)	Number of researchers in the field of R&D	Reflects the scientific and personnel basis of innovative development
Technical cooperation grants (BoP, current USD)	Scope of technical cooperation grants	Allows you to assess the role of targeted international grant support
Grants, excluding technical cooperation (BoP, current USD)	Scope of other grants	Characterizes the impact of general grant funding mechanisms

(continued on next page)

Table 1. Continued.

Indicators	The essence of the indicator	Argumentation for inclusion in the study
Gross fixed capital formation, private sector (current LCU)	Private sector investment in fixed assets	Reflects investment prerequisites for innovation activity
GDP per capita (current USD)	Income per person	It is used to control the general level of economic development
Trade (% of GDP)	Share of foreign trade in GDP	Characterizes the degree of openness of the economy
Lending interest rate (%)	Average interest rate on loans	Reflects the availability and cost of credit resources
Domestic credit to the private sector by banks (% of GDP)	Volume of bank lending to the private sector	Allows you to assess the role of bank loans in financing innovations

Methods

The study employs correlation analysis according to formula (1) to examine linear relationships among the selected indicators. Multiple linear regression analysis according to formula (2) is used to find out the combined effects of several independent variables on the dependent innovation indicators.

$$r_{XY} = \frac{\sum(X_i-\bar{X})(Y_i-\bar{Y})}{\sqrt{\sum(X_i-\bar{X})^2 \sum(Y_i-\bar{X})^2}}, \quad (1)$$

where: X_i, Y_i - observed values of variables X and Y; $\bar{X}$, $\bar{Y}$ - mean values of the variables; N - number of observations.

$$Y = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \cdots + \beta_n * X_n + \epsilon, \quad (2)$$

where: Y - dependent variable; $X_1, X_2, \ldots, X_n$ - independent variables; β_0 - intercept; $\beta_1, \beta_2, \ldots, \beta_n$ - regression coefficients; ε - random error term.

ANOVA is applied to assess model adequacy and reliability, alongside standard diagnostic tests, including the Durbin–Watson test for autocorrelation, the White test for heteroscedasticity, and variance inflation factor (VIF) analysis to detect multicollinearity.

RESULTS

At the global level, current innovation trends include an acceleration of scientific and technological knowledge exchange and transfer. In addition, the globalization of cooperation is important, manifested in a growing number of countries participating in the creation, commercialization, and acquisition of new knowledge and technologies (Leontovych & Radchenko, 2022). Nowadays, the world leaders in R&D expenditure include Israel, South Korea, Taiwan, Sweden, and the United States (Figure 1).

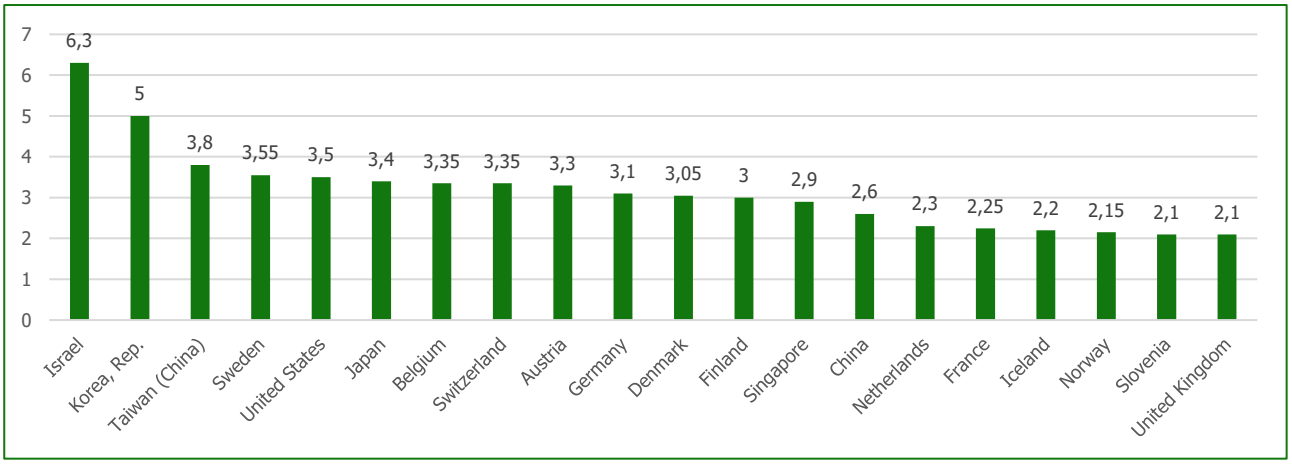

Figure 1. Top 20 leading countries in terms of R&D spending (% of GDP in 2025). *(Source: StatRanker, 2025)*

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The above analysis demonstrates a close relationship between investment in research and development and the economy's capacity to effectively foster innovative development, particularly in countries with a well-developed digital market infrastructure. Thus, at the first stage of the study, the relationships between innovation indicators and financial and credit instruments are examined using correlation analysis. The resulting correlation matrix is presented in Table 2. Two-tailed *p*-values indicate the statistical significance of the correlation coefficients and make it possible to identify relationships that are statistically significant.

Table 2. Correlation matrix between indicators of innovativeness and financial and credit instruments. *(Source: calculated by the author, by The World Bank, 2025))*

Indicators	Firms that introduced a new product/service and process, and spent on R&D	High-technology exports (current USD)	Researchers in R&D (per million people)	Technical cooperation grants (BoP, current USD)	Grants, excluding technical cooperation (BoP, current USD)	Gross fixed capital formation, private sector (current LCU)	GDP per capita (current USD)	Trade (% of GDP)	Lending interest rate (%)	Domestic credit to the private sector by banks (% of GDP)
Firms that introduced a new product/service and process, and spent on R&D	1.00									
p-value (2-tailed)										
High-technology exports (current USD)	0.02	1.00								
p-value (2-tailed)	0.22									
Researchers in R&D (per million people)	0.00	**0.26**	1.00							
p-value (2-tailed)	0.81	0.00								
Technical cooperation grants (BoP, current USD)	**0.06**	**0.18**	**-0.16**	1.00						
p-value (2-tailed)	0.00	0.00	0.00							
Grants, excluding technical cooperation (BoP, current USD)	0.01	**-0.05**	**-0.13**	**0.52**	1.00					
p-value (2-tailed)	0.45	0.00	0.00	0.00						
Gross fixed capital formation, private sector (current LCU)	-0.01	**0.21**	**0.20**	0.01	-0.01	1.00				
p-value (2-tailed)	0.64	0.00	0.00	0.69	0.50					
GDP per capita (current USD)	**-0.03**	**0.13**	**0.39**	**-0.29**	**-0.20**	0.02	1.00			
p-value (2-tailed)	0.03	0.00	0.00	0.00	0.00	0.21				
Trade (% of GDP)	0.00	**0.10**	**0.29**	**-0.13**	**-0.12**	0.00	**0.17**	1.00		
p-value (2-tailed)	0.88	0.00	0.00	0.00	0.00	0.78	0.00			
Lending interest rate (%)	**0.04**	**-0.07**	**-0.19**	**0.20**	**0.13**	-0.01	**-0.28**	**-0.12**	1.00	
p-value (2-tailed)	0.01	0.00	0.00	0.00	0.00	0.47	0.00	0.00		
Domestic credit to the private sector by banks (% of GDP)	0.01	**0.36**	**0.54**	**-0.06**	**-0.16**	**0.16**	**0.25**	**0.29**	**-0.09**	1.00
p-value (2-tailed)	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Correlations in bold are significant at the 5% level (2-tailed).										
N of valid cases = 4515.										

The number of firms that introduced new products or services and processes, as well as those that invested in R&D, exhibits a weak but statistically significant relationship with only two financial and credit indicators: technical cooperation grants (0.06) and the lending interest rate (0.04). This suggests a stimulating but limited effect of targeted financial instruments on firms' innovation activity. In contrast, high-tech exports demonstrate stronger correlations with all examined financial and credit indicators, ranging from −0.07 to 0.36. The strongest relationships are observed with domestic credit to the private sector provided by banks (0.36) and private-sector gross fixed capital formation (0.21). From an

economic perspective, this indicates that the development of high-tech exports is closely linked to firms' access to financial resources and the overall investment capacity of the economy.

The indicator "Researchers in R&D" shows the strongest correlations among the innovation variables considered, particularly with domestic credit to the private sector by banks (0.54) and private-sector gross fixed capital formation (0.20). In addition, this indicator is strongly associated with key macroeconomic variables, including GDP per capita (0.39) and trade openness (0.29). These results suggest that human capital formation in the R&D sector primarily occurs in financially developed, open, and investment-active economies.

To further examine the combined influence of financial and credit instruments on innovation indicators, regression analysis is employed. The first regression model uses the number of firms that introduced new products or services and processes and invested in R&D as the dependent variable. The results of the assessment are presented in Table 3.

Table 3. Regression analysis results for the dependent variable "Firms that introduced a new product/service and process, and spent on R&D." *(Source: calculated by the author according to (The World Bank, 2025))*

Independent variables	Coefficients	Std Err	t Stat	p-value	H0 (5%)	VIF	TOL	Beta
Intercept	0.49	0.13	3.68	0.00	Rejected			
Technical cooperation grants (BoP, current USD)	0.00	0.00	3.83	0.00	Rejected	1.48	0.68	0.07
Grants, excluding technical cooperation (BoP, current USD)	0.00	0.00	-1.55	0.12	Accepted	1.41	0.71	-0.03
Gross fixed capital formation, private sector (current LCU)	0.00	0.00	-0.68	0.49	Accepted	1.03	0.97	-0.01
GDP per capita (current USD)	0.00	0.00	-0.97	0.33	Accepted	1.23	0.81	-0.02
Trade (% of GDP)	0.00	0.00	0.53	0.60	Accepted	1.12	0.89	0.01
Lending interest rate (%)	0.01	0.01	1.75	0.08	Accepted	1.11	0.90	0.03
Domestic credit to the private sector by banks (% of GDP)	0.00	0.00	1.25	0.21	Accepted	1.20	0.83	0.02

The model includes only one statistically significant explanatory variable (Technical cooperation grants), though its effect is insignificant. Moreover, the model demonstrates very low explanatory power ($R^2 < 0.01$). These results confirm the conclusions drawn from the correlation analysis, indicating that firms' innovation activity is only weakly dependent on the financial and credit instruments considered in this study. Consequently, these instruments are not the key drivers for initiating innovation but may play a more substantial role at later stages, particularly in the commercialization and market implementation of innovations. Table 4 presents the results of the regression analysis with high-tech exports as the dependent variable.

Table 4. Regression analysis results for the dependent variable "High-technology exports." *(Source: calculated by the author according to (The World Bank, 2025))*

Independent variables	Coefficients	Std Err	t Stat	p-value	H0 (5%)	VIF	TOL	Beta
Intercept	-13335496860.62	1458468780.36	-9.14	0.00	Rejected			
Technical cooperation grants (BoP, current USD)	154683189.72	7976735.11	19.39	0.00	Rejected	1.48	0.68	0.31
Grants, excluding technical cooperation (BoP, current USD)	-7500946.93	897205.12	-8.36	0.00	Rejected	1.41	0.71	-0.13
Gross fixed capital formation, private sector (current LCU)	266987.01	22269.44	11.99	0.00	Rejected	1.03	0.97	0.16
GDP per capita (current USD)	188742.98	28742.27	6.57	0.00	Rejected	1.23	0.81	0.10
Trade (% of GDP)	15505329.71	11106456.22	1.40	0.16	Accepted	1.12	0.89	0.02
Lending interest rate (%)	-331816136.76	78226788.84	-4.24	0.00	Rejected	1.11	0.90	-0.06
Domestic credit to the private sector by banks (% of GDP)	366008420.01	18092869.70	20.23	0.00	Rejected	1.20	0.83	0.29

Compared with the model for firms that introduced new products or services and processes and invested in R&D, this specification demonstrates substantially higher explanatory power ($R^2 = 0.22$). Accordingly, 22% of the variation in high-

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tech exports is explained by the influence of the financial and credit instruments under consideration. With the exception of the trade variable, all independent variables are statistically significant, while technical cooperation grants exhibit the largest standardized effect (Beta).

These findings differ from the results of the correlation analysis, which indicated that high-tech exports are most strongly associated with domestic credit to the private sector provided by banks and private-sector gross fixed capital formation. Simple correlation analysis does not capture the joint effects of the examined financial and credit instruments. In particular, it fails to reveal that grants, when combined with other financing instruments, significantly enhance firms' capacity to invest in and expand high-tech exports. The final regression model, with the number of researchers in R&D (per million people) as the dependent variable, is presented in Table 5.

Table 5. Regression analysis results for the dependent variable "Researchers in R&D (per million people)." *(Source: calculated by the author according to (The World Bank, 2025))*

Independent variables	Coeffi-cients	Std Err	t Stat	p-value	H0 (5%)	VIF	TOL	Beta
Intercept	-316.48	40.19	-7.88	0.00	Rejected			
Technical cooperation grants (BoP, current USD)	-0.98	0.22	-4.44	0.00	Rejected	1.48	0.68	-0.06
Grants, excluding technical cooperation (BoP, current USD)	0.08	0.02	3.11	0.00	Rejected	1.41	0.71	0.04
Gross fixed capital formation, private sector (current LCU)	0.01	0.00	10.77	0.00	Rejected	1.03	0.97	0.13
GDP per capita (current USD)	0.01	0.00	18.69	0.00	Rejected	1.23	0.81	0.24
Trade (% of GDP)	2.82	0.31	9.20	0.00	Rejected	1.12	0.89	0.11
Lending interest rate (%)	-10.34	2.16	-4.80	0.00	Rejected	1.11	0.90	-0.06
Domestic credit to the private sector by banks (% of GDP)	16.76	0.50	33.63	0.00	Rejected	1.20	0.83	0.43

The presented model has the strongest explanatory power (R^2 = 0.40), which suggests that 40% of the variation in the Researchers in R&D indicator is explained by the included financial and credit indicators. According to the Beta coefficient, the dependent variable is most strongly influenced by Domestic credit to private sector by banks (0.43), and Gross fixed capital formation, private sector (0,13). Macroeconomic indicators (GDP per capita and Trade) also remain significant. This confirms previous findings about the importance of bank lending conditions, investment activity, and general macroeconomic conditions for increasing the number of Researchers in R&D.

In general, the results of the correlation and regression analyses indicate that financial and credit mechanisms, implemented through different financial and credit instruments, are not equally related to the indicators characterizing the effectiveness of innovation-oriented industries. Thus, the introduction of innovations by firms depends insignificantly on the studied financial and credit instruments, probably due to the fact that innovations are financed mainly from internal sources. High-tech exports are most responsive to a combination of financial and credit instruments, in particular grants and bank lending, which allows supporting capital-intensive and risky export-oriented innovations, especially in economies with advanced digital market infrastructure. Researchers in R&D most strongly depend on the conditions of bank lending, investment activity, and general macroeconomic conditions in countries.

DISCUSSION

The conclusions of this study on the relationship between the development of innovation-oriented industries and financial and credit mechanisms, implemented through specific financial and credit instruments, are consistent with previous research. In particular, Arnone et al. (2024) showed that there is a positive relationship between lending, infrastructure development, and creative exports. In the work of Zhao (2024), it is empirically confirmed that digital credit can indirectly contribute to the technological innovation of enterprises by reducing financial constraints and financing costs.

The results of the study also complement and expand the previous results of scientists, providing them with empirical confirmation. Thus, Wen & Sun (2025) and Karami (2025) drew attention to the need for cooperation between enterprises and the financial sector. Yang et al. (2024) also emphasized the importance of financial support and cooperation, noting that it is investments in R&D that play a decisive role in this interaction. The views of scientists are confirmed by the results

of this study, which showed that financial and credit instruments work better due to structured forms of support and access to bank financing. The relationship between the relevant indicators, identified in the work, indicates the existence of mechanisms of cooperation between the state and companies. These results are also confirmed in regional studies. Zavarská et al. (2024) showed that the main problem for the development of innovation in the EU is the lack of coordination and financial support for innovation and research activities by national governments.

The results of the study by Hu et al. (2025) showed a positive correlation between trade credit and the innovative efficiency of the firm. Scientists have proven that this tool influences product innovation through information sharing and collaborative research and development. Xiang & Zhao (2025) found that firms with limited access to bank lending receive a stronger positive effect from trade credit. The results of this work can indirectly confirm these observations, revealing a positive correlation of the indicator of trade activity with the number of researchers in R&D and high-tech exports.

In general, the results of the analysis carried out in the work showed the importance of introducing a comprehensive mechanism for supporting high-tech industries. This is shown by the results of regression analysis, which revealed that no financial or credit instrument is sufficient on its own. Instead, the combination of state grant mechanisms, bank lending, and private financing provides a more sustainable impact on innovative development. This is consistent with the results of Xiang et al. (2022), which showed a close relationship between government subsidies and increased levels of innovation through debt and equity financing.

Some studies contain certain contradictions with the author's work. Thus, Zhu & Chen (2025) showed that although sufficient access to credit resources can promote innovation, overinvestment can reduce the positive effect due to inefficient allocation of resources. Therefore, it is the expansion of credit opportunities that does not guarantee the best innovative results.

This paper examines the support of innovation-oriented industries through the prism of grants, banking, and private financial and credit instruments. At the same time, further research can be aimed at expanding the approach to the classification of financial and credit mechanisms to include digital finance, digital inclusive finance, and green investments. According to the research of Xiong et al. (2023) and Li et al. (2023), digital finance can play a positive role in stimulating innovation in various fields of activity. Ge et al. (2022) and Hu & Zhang (2023) demonstrated the effectiveness of green finance in boosting innovation activity. In general, the results obtained are of practical value, given the fact that the estimated regression coefficients allow quantifying the contribution of each financial and credit mechanism to the support of innovative industries. Also, they make it possible to establish the direction and relative strength of their influence on high-tech exports, the development of R&D potential, and the introduction of innovations by firms.

The findings of this study regarding the connection between the development of innovation-oriented industries and financial and credit mechanisms are largely consistent with prior research. For instance, Arnone et al. (2024) demonstrated a positive relationship between lending, infrastructure development, and creative exports, while Zhao (2024) empirically confirmed that digital credit can indirectly improve technological innovation by alleviating financial constraints and reducing financing costs.

That being said, the results of this study also complement and extend previous findings by providing additional empirical support. Thus, Wen and Sun (2025) and Karami (2025) emphasized the importance of cooperation between enterprises and the financial sector, while Yang et al. (2024) highlighted that R&D investments play a decisive role in this interaction. The current study confirms these conclusions, showing that financial and credit instruments are more effective when structured forms of support are combined with access to bank financing. The relationships identified in this study further indicate the existence of cooperative mechanisms between the state and enterprises. Regional studies support this observation; for example, Zavarská et al. (2024) found that the main barrier to innovation development in the EU is insufficient coordination and financial support from national governments.

It is of note that prior studies have also examined specific financial instruments. Hu et al. (2025) demonstrated a positive correlation between trade credit and firms' innovation efficiency, showing that trade credit facilitates product innovation through information sharing and collaborative R&D. Xiang and Zhao (2025) found that firms with limited access to bank lending experience a stronger positive effect from trade credit. The present study indirectly supports these findings by revealing a positive correlation between trade activity and both the number of researchers in R&D and high-tech exports.

Overall, the analysis underscores the importance of implementing a comprehensive mechanism for supporting high-tech industries. Regression results indicate that no single financial or credit instrument is sufficient on its own; instead, a combination of state grants, bank lending, and private financing provides a more sustainable impact on innovation development. These findings align with Xiang et al. (2022), who demonstrated a close relationship between government subsidies and higher levels of innovation through debt and equity financing. Some studies present results that partially diverge

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from the findings of this work. For example, Zhu and Chen (2025) showed that while sufficient access to credit can promote innovation, overinvestment may reduce its positive effect due to inefficient resource allocation. This suggests that simply expanding credit availability does not guarantee optimal innovation outcomes.

The present study focuses on the support of innovation-oriented industries through grants, bank lending, and private financial and credit instruments. This framework could be expanded to include emerging forms of finance, such as digital finance, digital inclusive finance, and green investments. Research by Xiong et al. (2023) and Li et al. (2023) indicates that digital finance can positively stimulate innovation across diverse sectors, while Ge et al. (2022) and Hu and Zhang (2023) demonstrate the effectiveness of green finance in enhancing innovation activity.

The results of this study have practical significance. The estimated regression coefficients provide a quantitative measure of the contribution of each financial and credit instrument to supporting innovation-oriented industries. They also allow for the identification of the direction and relative strength of their impact on high-tech exports, the development of R&D potential, and the introduction of new products and processes by firms.

Limitations

The limitations of the study are related to the lack of open data for individual countries and periods. Also, some of the financial and credit mechanisms are not reflected in the available statistics, which did not allow for empirically assessing their impact. In addition, regression models take into account linear dependencies, so more complex nonlinear relationships could go undetected.

CONCLUSIONS

Innovation-oriented firms play a central role in economic development, and effective financial and credit support mechanisms are critical to their competitiveness and success. The results of this study indicate that financial and credit instruments produce varying effects on innovation, but the overall impact is predominantly positive, supporting the hypothesis of the research. Specifically, the studied instruments explain 22% of the variation in high-tech exports and 40% of the variation in the number of researchers in R&D.

Firms that introduce new products, services, or processes and invest in R&D are only weakly dependent on these instruments, highlighting the importance of internal financing sources. In contrast, high-tech exports respond strongly to a comprehensive mix of financial and credit instruments, particularly grants and bank lending, reflecting the capital-intensive and high-risk nature of export-oriented innovation. The number of researchers in R&D is most strongly influenced by bank lending conditions, investment activity, as well as broader macroeconomic factors, underscoring the importance of financial depth and an open, investment-active economy for human capital development.

Regression analysis shows that the combined effect of financial and credit instruments provides a more complete picture than simple correlations alone. In particular, grants reinforce the impact of other financial instruments when applied in combination, highlighting the value of an integrated approach. Overall, the study confirms that a comprehensive financing strategy, combining public, banking, and private instruments, is essential for supporting innovation-oriented industries.

According to the results obtained, the following conclusions can be drawn:

The recommendations from the study are as follows:

1. It is expedient to promote the integrated use of financial and credit mechanisms simultaneously within the framework of the coordination of policies and special programs to support innovations.
2. It is advisable to stimulate grant financing, which directly enhances the effect of bank lending and private investment.
3. It is important to develop bank lending to the private sector through preferential rates, specialized innovative loans, and guarantees of partial coverage of risks of investment projects.
4. It is indispensable to integrate digital financial instruments, including digital platforms and tools, to increase financial inclusion and improve the efficiency of innovation financing.

The findings can inform the design of financial and credit policies aimed at stimulating innovation activity, expanding high-tech exports, and strengthening research potential. Future research should extend the analysis to include emerging financial instruments, such as digital finance, digital inclusive finance, and green investments, to assess their role in promoting innovation-oriented industries.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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ФІНАНСОВО-КРЕДИТНІ МЕХАНІЗМИ ПІДТРИМКИ ІННОВАЦІЙНО ОРІЄНТОВАНИХ ГАЛУЗЕЙ: МІЖНАРОДНА ТОРГІВЛЯ, ПРОМИСЛОВІ R&D ТА ЦИФРОВА РИНКОВА ІНФРАСТРУКТУРА

Інноваційно орієнтовані галузі є на сьогодні ключовими рушіями економічного зростання. Ефективність їхнього розвитку значною мірою залежить від наявності й структури механізмів фінансової та кредитної підтримки в країні, а також від рівня розвитку інфраструктури цифрового ринку. Мета цього дослідження – оцінити вплив фінансових і кредитних механізмів на інноваційно орієнтовані підприємства шляхом аналізу ключових фінансових і кредитних інструментів із використанням економічного та математичного моделювання. У дослідженні застосовані кореляційний і регресійний аналізи, а також ANOVA-тестування. Результати кореляційного аналізу показують, що впровадження інновацій підприємствами демонструє лише слабку залежність від фінансових і кредитних інструментів.

Натомість експорт високих технологій і кількість дослідників, зайнятих у науково-дослідній діяльності, демонструють більш сильний зв'язок із доступом до фінансових ресурсів, інвестиційною діяльністю та функціонуванням цифрової ринкової інфраструктури. Регресійний аналіз показує, що сукупний ефект грантів, банківського кредитування та інвестиційної діяльності значно підвищує здатність компаній розвивати експорт високих технологій. Ба більше, цей інтегрований фінансовий і кредитний механізм сприяє формуванню людського капіталу в галузі досліджень і розробок. Дослідження також показує, що різні фінансові та кредитні механізми по-різному впливають на показники інновацій. Зокрема, внутрішні джерела фінансування та державна підтримка стимулюють упровадження інновацій, а банківське кредитування та інвестиційна діяльність переважно сприяють експортові високих технологій і зростанню кількості дослідників у галузі НДДКР. Загалом, досліджені механізми пояснюють 22% варіації експорту високих технологій і 40% варіації кількості дослідників у царині досліджень і розробок. Отримані результати є основою для розробки фінансової та кредитної політики, спрямованої на стимулювання інноваційної діяльності, розширення експорту високих технологій і зміцнення науково-дослідницького потенціалу.

Ключові слова: фінансово-кредитний інструмент, інновації, промислові дослідження та розробки, міжнародна торгівля, інфраструктура цифрового ринку, гранти на технічне співробітництво, процентна ставка за кредитами, внутрішній кредит, валові основні засоби

JEL Класифікація: G21, E22, O32, O31

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