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RESEARCH ARTICLE
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Impact of Scientific Activity and Innovation on Economic Competitiveness: an Analysis of Kazakhstan

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Abstract
This study is aimed to evaluate the influence of scientific activity and innovation on the economic performance of a country, measured by Gross Domestic Product (GDP), using Kazakhstan as a case study. Employing Partial Least Squares Path Modeling (PLS-PM), a variance-based Structural Equation Modeling (SEM) approach, the research analyzed secondary data to explore the structural relationships between scientific investment, activity, and their subsequent impact on GDP and innovative organizational activity. The methodology was centered on assessing the measurement model for reliability and validity, and the structural model for the strength and significance of the relationships using path coefficients and R-squared values. Hypotheses were formulated to test the expected positive influences of scientific activity and internal R&D costs on GDP, and the role of scientific activity in driving innovative activity within organizations. The results indicated a positive relationship between scientific activity and GDP, confirming the hypothesis that science contributes significantly to economic development. Internal R&D costs were found to have a strong positive impact on scientific activity, highlighting the importance of R&D investment. However, innovative activity within organizations showed a negative association with GDP, suggesting a more complex relationship that may not lead to immediate economic gains. Scientific activity was also seen to positively influence organizational innovation. The study's findings emphasize the need for strategic planning and investment in scientific research and education to bolster economic development.

Keywords: Economic Development, Scientific Activity, Research and Development, Innovation Activity, Gross Domestic Product, Investment in Science, Kazakhstan

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***JEL Code**:* B41, O11,O33

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1. INTRODUCTION

With globalization and lower barriers to the flow of goods, services, capital and knowledge, enhanced by the development of ICTs, economic growth is accelerating, although the benefits are unevenly distributed. Knowledge, unlike goods, can be reused and has low distribution costs, creating sustainable growth opportunities. Moreover, science is one of the most advanced forms of accumulation and systematization of knowledge and experience and is a system of dissemination, exchange and transfer of knowledge. Economic research has traditionally focused on research and development policy, Market failures, policy instruments, interdependencies with other economic policies, and the challenges of creating effective interventions in complex systems but increasing attention is being shifted to scientific and technological research.

Science is a resource or a functional tool for society. Scientific training appears to be a valuable form of human capital that increases the efficiency and productivity of the workforce. In addition, scientific research generates knowledge, innovation and technical applications that are said to improve socio-economic performance and generate new products (Schofer et al., 2000).

The modern expansion of scientific activity is not limited only to economic interests but embraces broader goals such as national development in a broader sense. Science, as an institutionalized field, covers many issues beyond its role as a tool in national economic growth. The extension of science includes knowledge and aspects that bring economic benefits.

It is necessary to emphasize the importance of defining and measuring national economic competitiveness, especially in an environment of global interdependence. Considering this, the role of human capital, especially education, in competitiveness is examined.

Particular emphasis should be placed on the importance of research and innovation to ensure sustainable economic growth. Modern development strategies highlight science and research as key factors for achieving "the most competitive and dynamic knowledge economy in the world." Therefore, states strive to allocate significant funds (3% of GDP) for research and development. Despite still low levels of investment in some countries, research remains an important tool for creating new knowledge, technology and innovation, contributing to economic growth (Kouassi, 2019). Public investment in R&D provides the necessary resources for basic and applied research. This promotes scientific progress and expansion of knowledge, which can ultimately lead to the creation of new technologies and an innovation ecosystem that brings together scientific and academic institutions, enterprises, and start-ups.

Thus, government R&D support programs create favorable conditions for the work of talented scientific researchers and engineers, which contributes to the formation of a critical mass of qualified specialists and supports the flow of knowledge and experience in regional research centers (Surana et al., 2020).

The research gap addressed in this article is related to a detailed study of the complex relationships between scientific activity, innovation activity and economic efficiency in Kazakhstan. Previous studies have paid much attention to the role of science and technology in driving economic development, but little has delved into the interplay between investment in science, innovation activity within organizations, and their collective impact on Gross Domestic Product (GDP) in the context of transition economies such as Kazakhstan. A new phenomenon discovered in this study is the unexpected inverse relationship between innovation activity within organizations and GDP. While conventional wisdom and existing literature suggest a positive correlation between innovation and economic growth, this study reveals a more complex interaction that does not always lead to immediate economic benefits, highlighting that the impact of innovation on GDP may depend on a variety of factors, including the type of innovation, its adoption in the market and wider macroeconomic conditions. This finding calls for a deeper understanding of the conditions under which innovation drives economic growth and highlights the need for a nuanced understanding of the relationship between innovation and the economy.

Overall, this work contributes to filling the identified research gap by providing empirical evidence of the complex relationships between scientific activity, innovation, and economic productivity. The overarching goal of the research is to explore and understand the complex connections between scientific and innovative activities, internal costs of R&D, and their collective influence on a country's economic performance, as measured by GDP. The specific hypotheses provide a structured framework for examining these relationships, guiding the investigation into the interplay between scientific endeavors, innovation within organizations, and the economic outcomes at the national level. By empirically testing these hypotheses, the study aims to contribute valuable insights into the nuanced dynamics that underlie the nexus of science, innovation, and economic prosperity. Ultimately, the findings may inform policymakers and stakeholders in optimizing strategies for fostering scientific and innovative environments conducive to sustainable economic growth.

2. LITERATURE REVIEW

There is a growing body of knowledge in the scientific literature devoted to the impact of science of the competitiveness of economy. With the rise of Industry 4.0 innovations and technologies have become sort of synonyms of science. Therefore, current research is devoted to the study of the construct of the process of science contribution to economy. There has been profound impact of science and technology on economic development. Studies highlight the crucial roles of entrepreneurship, patenting, and government policy in fostering an environment conducive to innovation and technological progress. The interplay between these elements has been a significant factor in shaping the economic landscape, particularly in the context of the modern economy.

Next, we showed schematically the construct of the process of science contribution to economy. This scheme is based on the work of Audretsch et al. (2002) where the authors discussed the content of science and its contribution to the development of a country and population well-being improvement (Figure 1).

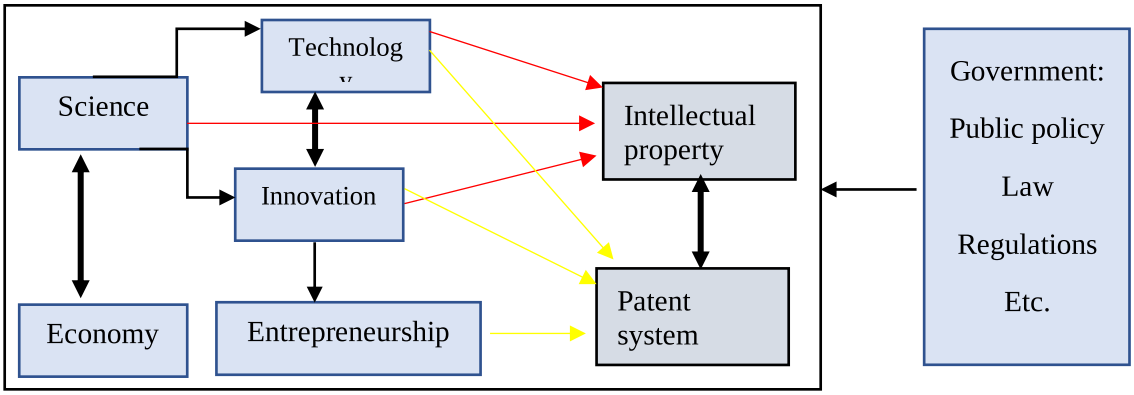


FIGURE 1. Construct of the process of science contribution to economy (a)

Note: compiled by authors

Process of science development includes technology and is closely intertwined with the progression of economic growth. Some studies stress that technological change is a crucial, if not the most significant, driver of economic growth and a determinant in the evolution of economy (Coccia, 2014; Teixeira & Queirós, 2016; Rocha, 2018). Technology applies this new knowledge to practical problems, with technological change referring to the rate at which this new knowledge is used in the economy. The nexus between science, technology, and economy has been critical, especially in the context of the "new" economy which places greater emphasis on intellectual property and knowledge transfer (Norse & Tschirley, 2000; Czarnitzki et al., 2012). Public policy in science and technology plays a pivotal role in determining long-term economic growth (Naseem et al., 2010; Meissner, 2019) . However, there is a general lack of public understanding about the nuances and consequences of technological change. Entrepreneurship, as a process involving the organization of resources, results in innovation. This innovation, often originating as an invention, becomes economically valuable when applied or utilized. The transformation of inventions into practical applications is a core aspect of entrepreneurship. Patent laws, are crucial in securing exclusive rights to inventors and authors, thereby fostering a conducive environment for innovation and technological advancement.

The government's role in the innovation process has evolved over time, with policies aimed at stimulating the private sector's demand for R&D resources. This evolution includes initiatives like tax incentives, research collaborations, and public/private partnerships that subsidize research. Government intervention has been crucial in shaping science and technology policy, ranging from direct sponsorship of scientific endeavors to legislative measures like patent laws (Pradhan et al., 2020).

Theories of economic growth often use production functions to represent the relationship between output and the factors of production, like capital and labor. However, technological advancements, significantly contribute to economic growth. This is evidenced by Solow's analysis, showing that a large portion of U.S. economic growth was not attributable to capital and labor but rather to technological advancement (Sadik-Zada, 2021; Zhang et al., 2021). New growth theory further expands this concept by incorporating the influence of external factors, like technology spillovers and trade policies, on economic performance (Auboin et al., 2021).

It must be mentioned that throughout the studies and evolution of science contribution to the economy government participation stands out as initial stage of science development, as well as human capital is the basis for any development, scientific, technological or innovation (see Figure 2).

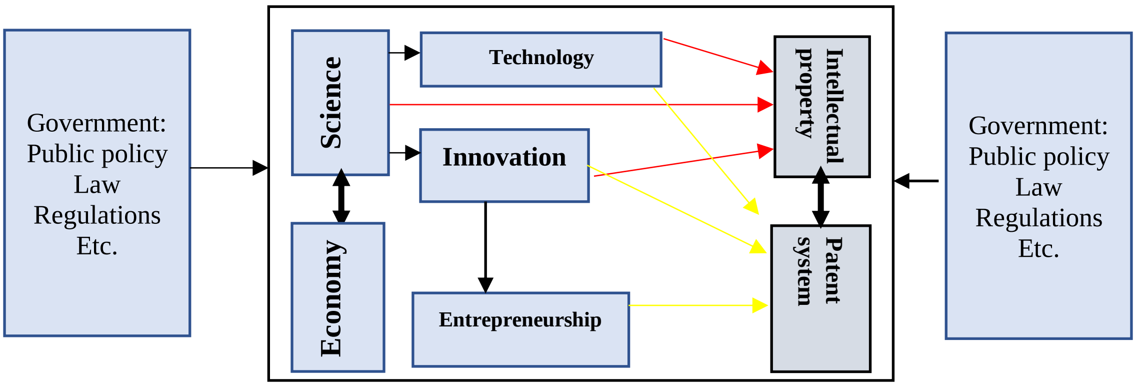


FIGURE 2. Construct of the process of science contribution to economy

Note: compiled by authors

Modern interpretations of economy development drivers have put innovation , technology and science as three separate factors, where science is regarded as a system of education. Kozma (2005) showed that in less developed countries, where problems such as lack of critical mass in science, technology and innovation, limited commercialization opportunities and weak regional autonomy pose challenges. Education plays a key role in adapting to global changes, and ICT within education is seen as a means of changing educational practices and preparing for the information society. Governments are investing heavily in improving educational systems and introducing ICT in schools, based on the assumption that this contributes to global competitiveness and economic growth. However, the author notes that there is often no clear connection between these investments and the desired social and economic outcomes.

There is growing evidence that science contributes little to power, economic prosperity and living standards. Studies often draw attention to the limitations of mainstream economic approaches, which traditionally view "research activities" as a uniform flow of investment into the economy, creating an indeterminate flow of additions to the stock of general knowledge (Aghion et al., 2009). In countries where science is not developed, this sector is characterized by a rigid system of remuneration for scientists, reduced basic salaries, non-transparently implemented forms that determine the criteria for the productivity of scientists, "poor" academic mobility and informal links that play an essential role in career development (Newman et al., 2021). Thus, it is important to create favorable conditions for scientists in the country to prevent the outflow of qualified personnel and stimulate their return for the development of the scientific field. Anas and Wickremasinghe (2010) in their study showed that almost 71.29% of scholars wrote Sri Lanka for further education and/or skill development, while about 59.41% identified better career prospects as a factor in leaving. Problems related to lack of intellectual management, bureaucracy, and lack of incentives and recognition are also identified. According to Krammer (2017) in less developed countries, where problems such as lack of critical mass in science, technology and innovation, limited commercialization opportunities and weak regional autonomy pose challenges.

In the case of China, it is observed that an increase in government subsidies for R&D leads to a growth in overall investments in R&D. However, it simultaneously reduces private sector investments in this domain. Despite the overall increase in resources allocated to R&D due to government subsidies, private investments in this field experience a decrease. This phenomenon is interpreted as a partial crowding-out effect, wherein government subsidies partially substitute for private investments. Consequently, while the total resources dedicated to R&D witness an expansion, the impact on the private sector is noted to be negative. Nevertheless, the increase in government subsidies still contributes to the overall growth of investments in Research and Development, potentially fostering technological progress and the development of knowledge-intensive industries (Surana et al., 2020). Overall, the research underscores the intricate dynamics of science, innovation, and economic development, providing valuable insights for policymakers and stakeholders.

3. METHODOLOGY

This study employed a quantitative research design to analyze the longitudinal trends in key scientific and research indicators in Kazakhstan. In the context of our chosen methodology, our study builds upon foundational research highlighting the importance of quantitative analysis in exploring the structural relationships between scientific activity and economic growth. Specifically, our methodological approaches align with the study by Audretsch et al. (2002), which discusses the contribution of science to national development and the improvement of population well-being. We also follow the insights of Coccia (2014), Teixeira & Queirós (2016), and Rocha (2018), emphasizing the significance of technological changes as a driver of economic growth and a determinant of economic evolution. The critical link between science, technology, and the economy is further illustrated by the works of Norse & Tschirley (2000) and Czarnitzki et al. (2012), especially relevant in the context of the "new" economy, where a greater focus is placed on intellectual property and knowledge transfer.

Our research employs the Partial Least Squares Path Modeling (PLS-PM) method, which, according to Naseem et al. (2010) and Meissner (2019), serves as a reliable tool for determining long-term economic growth, particularly in the context of state policy in science and technology. We also rely on the findings of Pradhan et al. (2020), who analyze the dynamics between entrepreneurship, innovation, and economic growth, crucial for understanding the interrelations in our study. Thus, based on the literature review, we assert that our methodology is in accord with contemporary research approaches and provides a solid foundation for analyzing the interactions between scientific investments, activity, and economic efficiency. This holds particular significance for comprehending these processes in the context of Kazakhstan.

Data for the analysis were extracted from national databases and compiled into separate datasets. These datasets encompassed a range of metrics pertinent to the assessment of research and development (R&D) progress, including financial allocations to various scientific fields and counts of individuals with advanced degrees, among other indicators (see Table 1).

TABLE 1. Data set

No.	Indicator	Code
1	Master's	MA
2	Doctoral Students	PhDSTD
3	Number of Personnel Engaged in Research and Development	RDStaff
4	Researchers (hold PhD)	PhDResSci
5	GDP	GDP
6	Internal Costs R&D	InternalCostsRD
7	Fundamental Studies (Funding)	FundStudies
8	Applied Research (Funding)	AppliedResearch
9	Natural Sciences (Funding)	NaturalSciences
10	Engineering and Technology	EngineeringTechnology
11	Medical Sciences (Funding)	MedicalSciences
12	Agricultural Sciences (Funding)	AgriculturalSciences
13	Social Sciencies (Funding)	SocialSciencies
14	Humanitarian Sciences (Funding)	HumanitarianSiences
15	Volume of Innovative Products	InnProductsVol
16	Number of Innovatively Active Enterprises	InnActiveOrg
Note: compiled by authors		

Descriptive statistics were employed to delineate the trends across the years. The study analyzed the trends for each variable within the datasets, discussing the implications of observed increases or decreases. The analysis provided insights into the overall growth and development of Kazakhstan's research and development sector.

Next, the PLS-PM approach (a variance-based SEM technique that is particularly useful for complex models with multiple constructs and paths.) was used This method is suitable for both exploratory and confirmatory research, and it is often used when the primary goal is prediction and theory development, especially in the early stages of theoretical conceptualization.

Data Analysis with PLS-PM included:

- Reliability and validity of the constructs were evaluated. Cronbach's alpha and composite reliability (rho_A, rho_C) were used to assess internal consistency reliability, while the Average Variance Extracted (AVE) assesses convergent validity. Discriminant validity is typically assessed by ensuring that the square root of AVE for each construct is higher than its highest correlation with any other construct.

- Structural Model Assessment. Path coefficients are examined to assess the strength and significance of the hypothesized relationships between constructs. The coefficient of determination (R-squared) for endogenous constructs is used to evaluate the model's explanatory power. The f-square effect size measures the impact of a specific exogenous construct on an endogenous construct. The following hypotheses were formulated:

Hypothesis 1: The level of scientific activity (as measured by 'Science' including human capital) has a significant impact on the GDP of a country.

Hypothesis 2: Internal costs of R&D ('InternalCostsRD') significantly influence the level of scientific activity.

Hypothesis 3: The level of innovative activity within organizations ('Innov Act') has a significant positive effect on GDP.

Hypothesis 4: The level of scientific activity has a significant positive effect on the innovative activity of organizations. This hypothesis is tested by the path coefficient from 'Science' to 'Innov Act'.

4. FINDINGS AND DISCUSSION

The following analysis describes the trends in research and development (R&D) funding in Kazakhstan across various scientific disciplines and the overall internal costs of R&D. The indicators presented include Internal Costs of R&D, Fund Studies, Applied Research, Natural Sciences, Engineering Technology, Medical Sciences, Agricultural Sciences, Social Sciences, and Humanitarian Sciences. The time frame for the analysis spans from 2010 to the last available year in the dataset (see Figure 3).

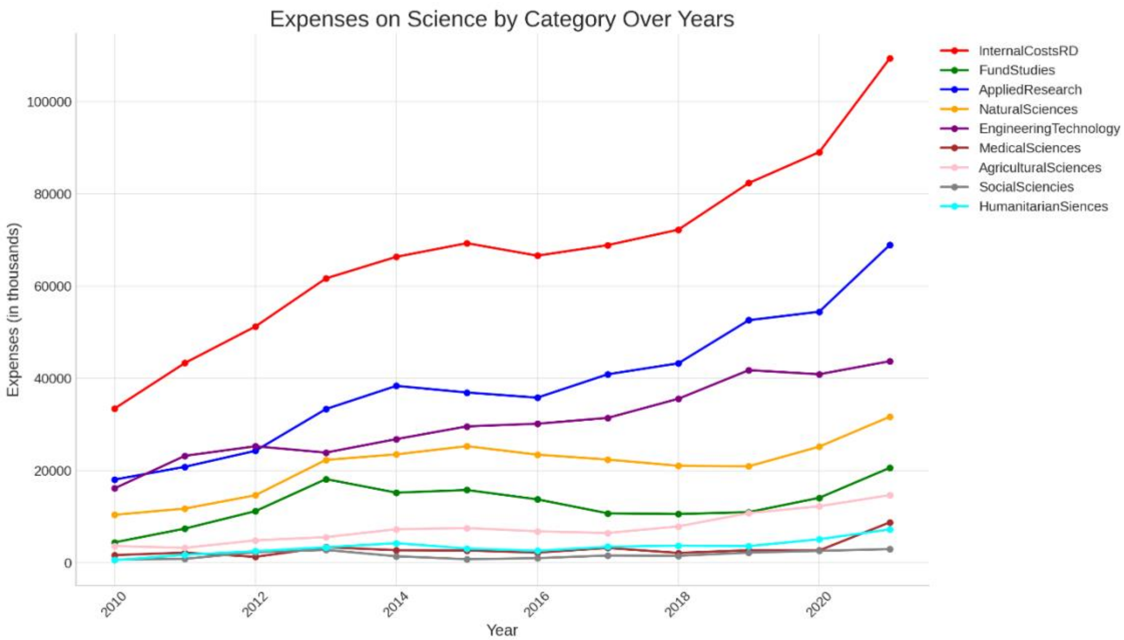


FIGURE 3. Trends in R&D funding, 2010-2021

Note: compiled by authors based on Bureau of National Statistics (2022)

The graph shows a positive trajectory in the internal costs of R&D, starting from around 33,467 thousand KZT in 2010 and rising steadily to reach higher levels in subsequent years. The dataset indicates a particularly significant increase towards the end of the period, signifying escalating investments in R&D within Kazakhstan. Applied Research, starting just below 20,000 thousand KZT in 2010, funding for Applied Research has escalated consistently, surpassing other fields by a significant margin and reaching the highest funding level in the dataset. Natural Sciences funding began at approximately 10,463 thousand KZT in 2010 and experienced a steady increase, reflecting a sustained commitment to this foundational field. Engineering and technology, starting from 16,183 thousand KZT in 2010, the funding for this field has shown growth, with some fluctuations, highlighting its importance in Kazakhstan's R&D agenda. Medical sciences, agricultural sciences, social sciences, and humanitarian sciences fields display varying levels of investment over the years, with medical sciences and agricultural sciences generally receiving more funding than the social and humanitarian sciences. Nevertheless, the latter two have seen an uptick in the most recent years. Fundamental studies category has shown a remarkable rise, particularly in the last year of the dataset, indicating an increased emphasis on foundational research. Thus, given data, allows building an overall trend for expences on science development (see Figure 4).

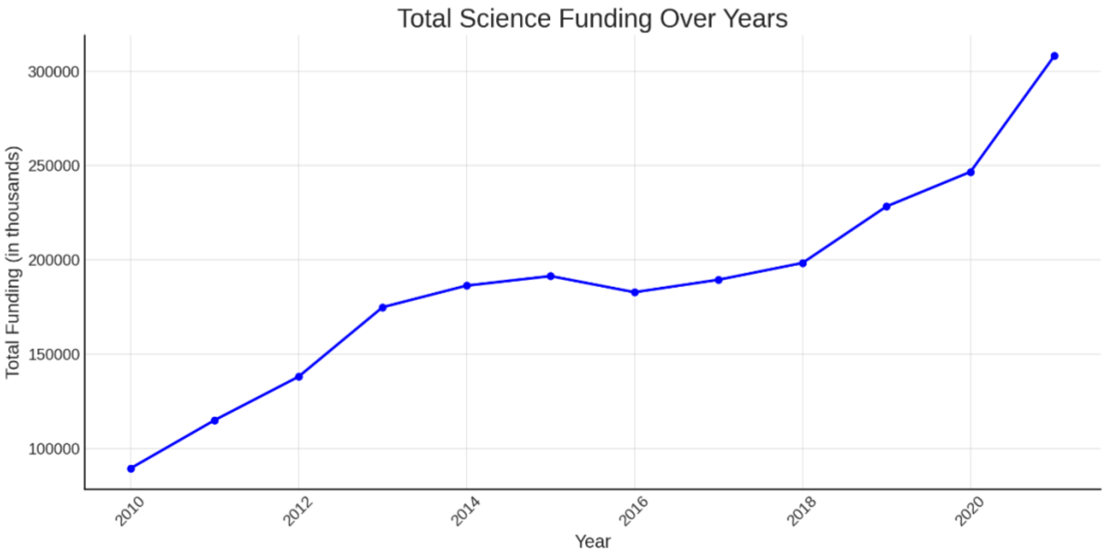


FIGURE 4. Total funding for science and research in Kazakhstan, 2010-2021.

Note: compiled by authors based on Bureau of National Statistics (2022)

The overall funding across all categories demonstrates a clear increasing trend. Starting from below 80,000 thousand KZT in 2010, the total funding surges to its peak at the end of the dataset period, with a sharp escalation evident in the most recent year.

These graphs collectively illustrate a strategic commitment to strengthening the scientific and technological landscape in Kazakhstan, with a notable focus on applied research and fundamental scientific fields. The significant increase in funding in recent years may signal a concerted effort by the nation to foster innovation and enhance its competitive edge in the global arena.

Next, the graph illustrates the trends in several key indicators of science and research in Kazakhstan over 2010-2021 (see Figure 5).

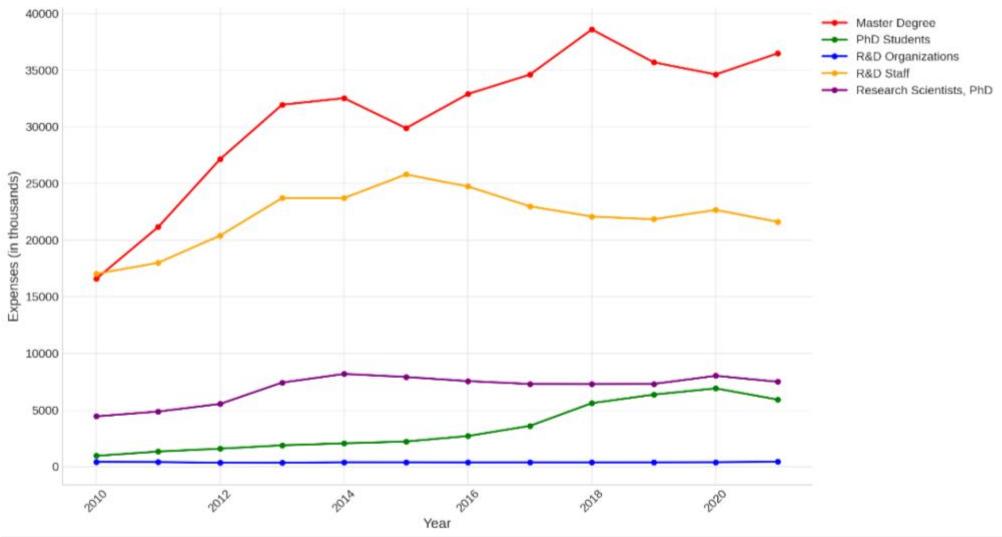


FIGURE 5. Trends is science and research in Kazakhstan, 2010-2021.

Note: compiled by authors based on Bureau of National Statistics (2022)

The depicted data elucidates a progressive trend in the development of Kazakhstan's scientific and research sectors, as evidenced by several key indicators from 2010 onwards. The quantity of Master's degree recipients has seen an upward trajectory, indicating an expansion of postgraduate education. Specifically, the figures ascend from 16,586 in 2010, peak in 2013, and then display slight variations whilst maintaining an upward trend. Simultaneously, the realm of doctoral studies has witnessed a doubling in the count of PhD students, escalating from 960 to 2,063 over the span of four years, which underscores a robust investment in advanced academic and research training. Regarding research institutions, the number of R&D organizations initially experienced a decrement, diminishing from 424 in 2010 to 345 in 2012, possibly reflecting a phase of optimization. Subsequently, a resurgence is noted, marginally increasing to 392 by 2014. The R&D personnel demonstrates a pronounced and consistent increment from 17,021 in 2010 to a plateau of approximately 23,712 by 2013, indicative of an expansion in research capacity and infrastructure. Most notably, the cohort of research scientists in possession of a doctoral degree has exhibited the most substantial relative augmentation among the surveyed indicators. Commencing at 4,447 in 2010, the number soars to 8,186 by 2014, more than doubling within the timeframe. This marked upsurge signals a strategic emphasis on cultivating advanced research expertise and a knowledge-intensive framework within the nation. Collectively, these indicators reflect Kazakhstan's strategic impetus towards reinforcing its academic and research institutions, fostering a conducive environment for scientific inquiry, and nurturing a workforce equipped with high-level qualifications. This aligns with the national vision to pivot towards a knowledge-driven economy, emphasizing innovation and scientific advancement as pivotal elements of national development.

Science Influence on GDP. The positive path coefficient suggests that there is a positive insignificant relationship between 'Science' and 'GDP'. Internal R&D Costs Influence on Science. With a path coefficient of 0.884 from 'InternalCostsRD' to 'Science', assuming statistical significance, this strong positive relationship confirms Hypothesis 2 that internal R&D costs have a positive influence on scientific activity. Innovative Activity's Influence on GDP. The negative path coefficient of -0.764 from 'Innov Act' to 'GDP', if significant, would not confirm the expected positive relationship posited by Hypothesis 3.

Next, the research model is presented in Figure 6.

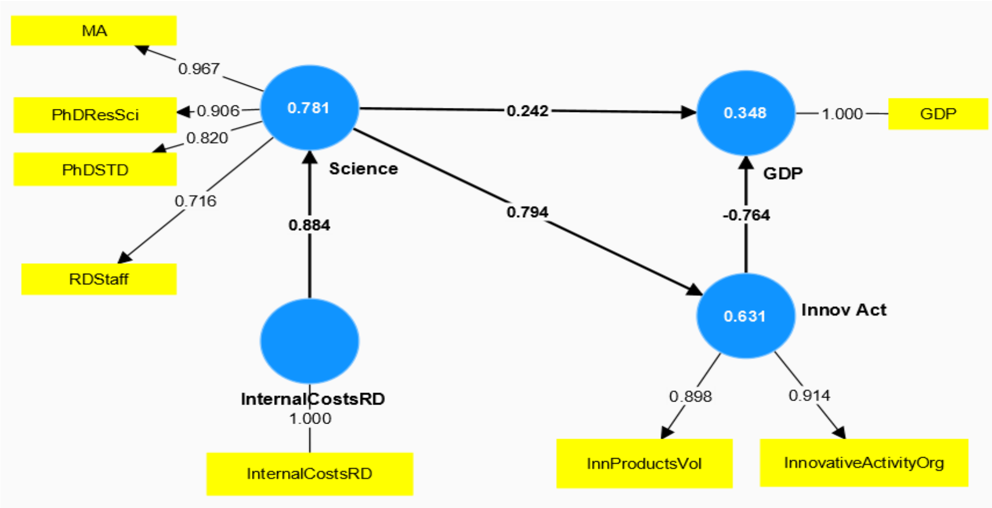
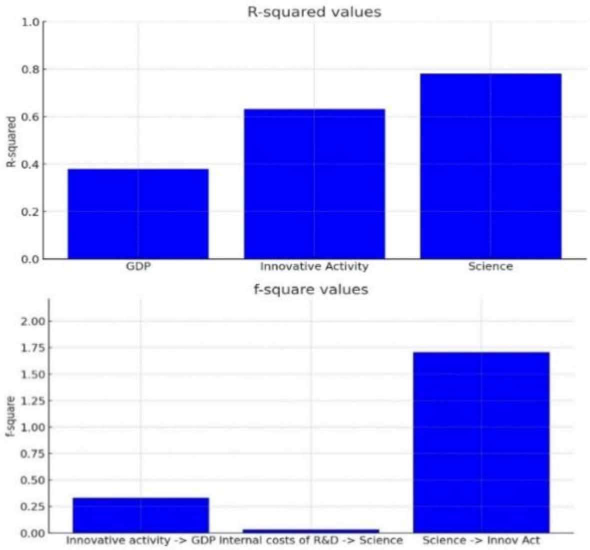


FIGURE 6. Research model

Note: compiled by authors based on calculations

It would suggest, instead, that higher levels of 'Innov Act' are associated with lower 'GDP', which could indicate that more research is needed to understand this relationship.

Science Influence on Innovative Activity. The positive path coefficient of 0.794 from 'Science' to 'Innov Act', if significant, would confirm Hypothesis 4, suggesting that scientific activity positively influences innovative activity within organizations. To fully confirm these hypotheses, it is essential to verify the statistical significance of these path coefficients (see Figure 7).



GDP, R-squared = 0.380;

Innovative Activity, R-squared = 0.631;

Science, R-squared = 0.781.

Innovative activity -> GDP f-square = 0,331;

Internal costs of R&D -> Science f-square = 0,033;

Science -> Innov Act = 1,708.

FIGURE 7. R-squared, F-squared

Note: compiled by authors based on our calculations

The coefficient of determination, denoted as R^2, for the Gross Domestic Product (GDP) is reported at 0.380. This value signifies that the model accounts for approximately 38% of the variance observed within the GDP data, indicative of a moderate level of explanatory power within an economic context (see Table 2).

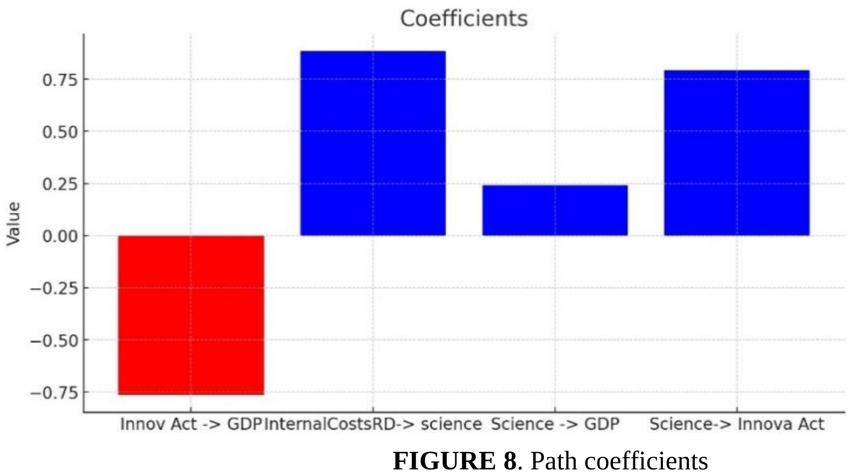
TABLE 2. Reliability coefficient

Construct	Cronbach's Alpha	Rho_A	Rho_C	AVE
Innovative Activity	0.782	0.786	0.902	0.821
Science	0.885	0.936	0.916	0.735
Note: compiled by authors				

The R^2 for the construct of 'Innovative Activity' stands at 0.631, thereby elucidating that the model explicates 63.1% of the construct's variance. The corresponding effect size, f^2, calculated for the relationship between 'Innovative Activity' and GDP is 0.331, placing it within the medium effect size domain.

An R^2 of 0.781 for the 'Science' construct underscores that a substantial 78.1% of its variance is captured by the model. The effect size f^2 for 'Internal Costs of R&D' impacting 'Science' is a relatively minimal 0.033, suggesting a marginal influence, whereas the 'Science' effect on 'Innovative Activity', with an f^2 of 1.708, denotes a profoundly robust impact.

The reliability coefficient, Cronbach's alpha, for 'Innovative Activity' is recorded at 0.782, which, in conjunction with Rho_A (0.786) and Rho_C (0.902), attests to high reliability. The Average Variance Extracted (AVE) for this construct is 0.821, indicating robust convergent validity. For the 'Science' construct, the Cronbach's alpha is 0.885, with Rho_A at 0.936 and Rho_C at 0.916, collectively corroborating excellent reliability. The AVE value of 0.735 further supports the construct's convergent validity (see Figure 8).



Innov Act -> GDP = -0,764;

InternalCostsRD-> science = 0.884;

Sciencce -> GDP= 0, 242;

Science-> Innova Act = 0, 794

FIGURE 8. Path coefficients

Note: compiled by authors based on our calculations

The path coefficient from 'Innovative Activity' to GDP is notably negative at -0.764, suggesting a substantial and unexpected inverse relationship. Conversely, 'Internal Costs of R&D' exerts a significant positive effect on 'Science', as indicated by a path coefficient of 0.884.

Additionally, 'Science' is posited to have a positive influence on GDP with a coefficient of 0.242 and on 'Innovative Activity' with a coefficient of 0.794, signaling substantial positive effects.

Expansion of the field of scientific research includes areas that do not always directly contribute to economic growth. For example, expansion into socially significant scientific disciplines (medicine, biology) may bring social benefits, but not always have immediate economic benefits. The results may also reflect the fact that funds invested in research may be allocated to areas not directly related to economic growth. For example, if most of the funds go to social research, this may reflect the fact that these resources are not directed towards innovation and technological progress (Shofer et al., 2000).

Pighly qualified specialists bring new knowledge, skills and innovative approaches to the economy, which contributes to increased productivity and, ultimately, GDP growth. Although the impact of human capital on economic growth may seem small, its long-term consequences become significant as educated and skilled workers create favorable conditions for sustainable development.

The flow of innovation not only strengthens the competitiveness of regional economies, but also attracts investment, which contributes to sustainable economic growth. Innovation generated by universities spreads throughout the economy, stimulating entrepreneurial activity and opening up new prospects for development.

Although the effects may appear relatively small in the short term, their accumulation and interaction over time lead to cumulative positive effects on economic growth. Therefore, although the magnitude of these impacts may be small individually, their combined contribution to shaping sustainable and innovative economic development becomes significant over a longer time horizon (Valero & Van Reenen, 2019).

5. CONCLUSIONS

The conclusion of the study, based on the Partial Least Squares Path Modeling (PLS-PM) analysis and the provided SEM diagram, can be summarized as follows.

The analysis revealed that the scientific activity within a country, operationalized as the “Science” construct, is positively associated with the Gross Domestic Product (GDP), indicating that higher levels of scientific engagement and output correlate with greater economic productivity. This finding supports the hypothesis that science is a vital contributor to the economic development of a nation.

Additionally, internal Research and Development (R&D) costs have a strong positive influence on scientific activities, suggesting that investments made within the domain of R&D bolster scientific pursuits. This underlines the importance of financial support for R&D in fostering a robust scientific environment.

Contrary to expectations, innovative activity within organizations, denoted by the 'Innov Act' construct, exhibited a negative relationship with GDP. This counterintuitive result suggests that there may be factors or conditions under which innovation does not directly translate to immediate economic growth, or there could be a lag effect not captured in the current model. Further investigation would be necessary to unpack the underlying dynamics of this relationship.

Lastly, the positive influence of scientific activity on innovative activity within organizations was confirmed, suggesting that a strong scientific base is instrumental in driving innovation.

In conclusion, the study's findings underscore the multifaceted role of science in economic development. The positive impact of science on GDP and innovation within organizations highlights the importance of supporting scientific research and education. However, the negative association between innovative activity and GDP warrants further exploration to understand the nuances of how innovation influences economic outcomes. The overall results point to the potential benefits of strategic investments in scientific and innovation capacities to foster long-term economic growth.

AUTHOR CONTRIBUTION

Writing – original draft: Saule T. Doshmanova, Botakoz Zh. Bolatova.
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Development of research methodology: Saule T. Doshmanova, Aliya Zh. Ospanova.
Resources: Gulnar T. Kunurkulzhayeva.
Software and supervisions: Saule T. Doshmanova, Botakoz Zh. Bolatova.
Data collection, analysis and interpretation: Saule T. Doshmanova, Aliya Zh. Ospanova
Visualization: Botakoz Zh. Bolatova.
Writing review and editing research: Gulnar T. Kunurkulzhayeva, Nursamal B.Sultanmuratova, Aliya Zh. Ospanova.

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