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The Science Impact on Country's Socio-Economic Development

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Abstract

Studies that address the issues of statistical measurement, algorithms, and methods of analysis and assessment of the science impact on a country's socio-economic development are still poorly developed. The degree of research in this area, taking into account the Kazakh specifics, is extremely low. The aim of this study is to research the assessment methods of science impact on the country's social and economic development and conduct an appropriate assessment using the example of Kazakhstan. The conceptual framework of the methodology is the Impact Assessment Model which assesses the science impact on the development of the country through input (science development) and output (social and economic development) parameters. The information base includes the statistical data from the Bureau of National Statistics for the period from 2011 to 2020. The research results show that the assessment of the science impact can be performed at different levels, as well as different goals, objectives, technological trajectories, and economic results that countries strive to achieve. There are index and econometric methods, microeconomics, case studies, patent and bibliometric studies and surveys to assess the science impact. Each has its own advantages and disadvantages. Today the potential of Kazakhstani science has not yet been revealed and the results of scientific research are used not enough in solving applied problems of the social and economic development of Kazakhstan. The scientific results obtained in the research course can be applied in the activities of Kazakhstani Ministries and can be used in the educational process.

1. INTRODUCTION

The society's evolutionary development originates from scientific and technological progress (STP). There was an evolution of the economists' views on scientific, technical, and innovative activities along with the intensive scientific and technological progress in the XX century. The ideas about the impact of scientific and technological progress on economic growth were laid down herein by Solow (1956) and Swan T.W. (1956) where it was considered an exogenous factor. While the endogenous growth theory put forward the idea that STP is endogenous and is explained by the accumulation of knowledge through research, development and innovation (Romer's (1990) model, Schumpeter's (1934) innovation theory, Aghion-Howitt's (1992) model, Grossman-Helpman's (1994) model, etc.) and technology diffusion (Barro-Sala-iMartin's (1995) model, etc.).

Endogenous growth theories have shown that economic growth depends on investment in research and development. R&D investments by firms and public research organizations are essential elements in increasing new technologies, labor productivity, country competitiveness and economic growth within national innovation systems (Coccia, 2018). Besides, such processes contribute to increased production as new inventions and ideas are generated with various beneficial fall-outs. These fallouts may include increased productivity, the accumulation of new technologies and knowledge, improved quality of life, and the creation of new jobs that are expected to have a positive impact on the social and economic growth of the country. It should be noted that R&D affects the country's social and economic development in several ways: they contribute to an increase in the productivity level at the same level of costs for research and development potential; ensure economic growth through the production of new products with higher added value; enhance the competitiveness of the national economy at the international level; contribute to the formation of fundamentally creative technologies that contribute to an increase in the social and economic development level.

The development of the economy and changes in the development of society under the science impact, the growth of budgets for scientific programs, and competition for scientific leadership give rise to the problem of assessing the effectiveness of science and its impact on the country's social and economic development. An objective study of the science impact on the country's social and economic development in modern conditions will make it possible to correctly substantiate the key directions in the development of scenarios, recommendations, and mechanisms to enhance the science's influence and increase its effectiveness for economic growth and the formation of a knowledge-based economy.

But universal parameters intended to assess the quantitative relationship between R&D expenditures and the required economic growth have not yet been determined. Many assessment methods and models differ from each other in the method of calculation, structure, and the ratio of quantitative and qualitative parameters used. Based on the foregoing, this study aims to research the assessment methods of science impact on the country's social and economic development and conduct an appropriate assessment using the example of Kazakhstan. It is assumed that a number of tasks will be solved to achieve this goal, i.e, the following algorithm to conduct research will be applied: a literature review of methods intended to assess the science impact on socio-

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economic development (Section 2), justification of the optimal methodology for analysis (Section 3), analysis, collection and processing of statistical data on science impact on the socio-economic development of Kazakhstan (Section 4) with the presentation of relevant conclusions (Section 5).

2. LITERATURE REVIEW

Numerous attempts to identify the relationship between parameters such as return on investment and productivity have yielded positive but widely diverging results (Tsipouri, 2001). Assessment of the science impact is challenging for several reasons: first, a long period of time can elapse between a scientific hypothesis, experiment, discovery, scientific theory and its application in society; secondly, the science influence can be broad and difficult to measure for different branches of science; third, the science impact can be indirect, non-linear and cumulative.

It is possible to assess the science impact at different levels:

- depending on the subject of assessment: individual (individual scientist), collective (team of authors, research group), institutional (scientific organization, government body and development institute in the area of R&D);

- depending on the object of assessment: mini- (scientific article), micro- (scientific project, scientific program), meso- (a separate branch of science), macro- (science of the country and its regions), global (world science).

Traditionally, the scientific impact is assessed at the level of the scientific system as a whole, individual organizations, and programs. Assessing the science impact at the country level is possible in the sectoral and regional context.

The impact is inherently more difficult to measure than direct R&D results, so it should be borne in mind that the metric is a parameter, not an absolute measure of impact. There are four approaches to the selection of parameters (Bhalla & Fluitman, 1985): input parameters and output parameters; use parameters and impact parameters; quantitative and qualitative parameters (objective and subjective parameters); micro and macro level parameters. Any parameters chosen to track the impact should be as accurate as possible to show the specifics of the research object. Impact assessment is closely related to the availability of data, both those that describe the scale and direction of scientific activity, and the economic or social factors on which it appears. At the same time, the data must comply with the following principles: openness, accessibility, transparency and reliability of data; comparability of data and results over time for correct comparisons; maximum relevance of the data, i.e. data related to the characteristics of the development of science, economic and social development.

When a method is chosen to assess the science impact on social and economic development, the analysis period should also be taken into account. Thus, some R&D may have an immediate impact, while others may have a certain time lag of impact. Thus, the impact on the reputation of the country or the attraction of talented researchers and professionals in other fields can materialize faster than the introduction of developed new technologies. A registered patent may not have an immediate impact until a product/process is developed from it that can then generate income and create jobs. It should be noted that at least a three-year waiting period is required because it takes some

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minimum time for the technology or technological infrastructure to be disseminated widely by the R&D agency (Tassey, 2003).

Today, various methods are used in world practice to assess the science impact on the country's social and economic development (GRC, 2019; Alibekova et al., 2020), i.e.: econometric, patent, index, case study (case study), survey (survey), bibliometrics and financial analysis.

In economic research, four main criteria are used to analyze the structure and measure the contribution of industries, including science and industries of the knowledge economy (Martin & Irvine, 1983):

1) labor one, based on the analysis of changes in employment in sectors of the economy, including in the knowledge-intensive sector (the number of scientists per 1,000,000 persons, etc.);

2) economic one, focusing on the study of the contribution of knowledge-intensive industries in value terms to the creation of GDP (the share of R&D expenses, etc.);

3) technological one, taking into account the country's ability to create technological innovations (the number of patent applications under the Patent Cooperation Treaty (PCT), etc.);

4) spatial one, implying a measurement of the level of technological globalization (index of economic complexity, etc.).

Econometric estimation methods using exogenous growth models in various modifications are widely practiced. Without dwelling on the classic works of the founders of the endogenous growth theory, in particular, works on the study of the R&D impact on economic growth, let us consider modern research. So, under the predictive model, Todosiychuk A.V. (2005) multivariate statistical analysis showed that there is a close relationship between GDP and investment in R&D; an increase in investment in R&D by 1% increases GDP by 0.14%. Dikusar A.I. and R. Kuzhba (2015) based on a quantitative analysis of the relationship between the social and economic development level of society (assessed by HDI - Human development index) and the level of its scientific development (assessed by scientometric parameters based on the information model of science), revealed the presence of a positive feedback between them, both for the EU countries and for the countries of the Commonwealth of Independent States (CIS). At the same time, the EU countries have not only the highest values of these indices but also a stronger relationship between them. The features of the modern development of science in the studied groups of countries indicate positive trends in the mutual science influence and the social and economic development level in the EU countries and negative trends (a decrease in the contribution to the world information process) in the CIS countries.

One of the assessment methods is also the construction of an integral index. So, Pilipenko G.M., Naumenko N.Yu. and Fedorova N.Є. (2018) built an integral development index that includes 5 sub-indices describing the economic, environmental, political and legal, social and socio-cultural subsystems, as well as the integral index of science to assess the science impact on the process of social and economic development. Using the sample correlation coefficient that characterizes the degree of linear correlation, they quantified the relationship between the two indices in different groups of countries (highly developed, middle-income, underdeveloped and post-Soviet).

The foundations intended to analyze the science impact are also laid down in patent research (GRC, 2019). There are certain features of assessment of the science impact on the country's social and economic development in patent research. Thus, patents may not always be good parameters to assess impact, since there is no international patent office, the protection of patents remains with national jurisdictions. The United States and Europe have defined the patentability of new life forms differently, with the result that patent registries in these jurisdictions will differ, even if the innovation results are the same. The filing fees, including transaction costs, at the European Patent Office are much higher than in the United States, and this partly explains why the number of patents filed in Europe is lower than in the United States. Besides, half of US patent applications are filed by residents of countries other than the United States. Therefore, an attempt to assess and compare the science contribution and innovation to the social and economic development of countries based on the analysis of patents does not always lead to results that correspond to reality (Steil et al., 2002).

Econometric models, patent research and integral indices are used mainly to assess the science impact on social and economic development at the macro level. The OECD proposes to be guided by three parameters to assess the success of research activities in a particular country: patent statistics, technological balance of payments, and trade statistics in sectors that are active in terms of research. While each of these parameters is not entirely perfect in isolation, together, they can shed light on the real state of affairs in terms of specific R&D results in a given country.

Since the 1980s, the OECD countries have been gradually developing a fundamentally new management system for scientific organizations that has determined the development of new methods intended to assess the science impact. Under the new system - "performance-based funding system" - scientific organizations are financed by assessment of the quality of their work, for which the interested parties conduct a special assessment of the scientists' work. As a rule, the assessment initiator is the main donor from the state. In the Netherlands, for example, it is the Ministry of Education and Science, in Italy - the Ministry of Universities, Scientific and Technological Research, in the UK - there are four councils intended to finance education. R&D funding organizations when they work with a portfolio of grants, in the short term perform research to assess the science impact. Basically, this assessment is performed at the project level: preliminary analysis (ex-ante impact analysis) or during/after the implementation of the initiative (ex-post impact assessment). Either various scientometric methods, or more traditional peer review, or a combination of both are used as an assessment tool (OECD, 2020).

Microeconomic modeling is an ideal approach to assess parameters of the science impact, since the relationships between inputs, outputs and outputs are well defined. For example, case studies (case studies), surveys, financial analysis based on research projects and programs. Case analysis is best suited for situations where the use of quantitative assessments is unlikely, or when quantitative analysis alone will not provide a balanced view of the value being created. The case-based approach includes a detailed description of how the impact of research findings on economic policy is created through interviews with stakeholders. Case analysis results tend to be qualitative in nature but can

also be quantitative. The survey of project researchers should include a question about potential users of the research results that should then be interviewed.

One of the methods of financial analysis and assessment of the science impact at the project level is the assessment of the return rate on R&D results, based on the calculation of three parameters, i.e.: net present value, the ratio of benefits and costs, and the internal return rate. Each of these parameters provides a solution to a specific problem: determination of the absolute value of the economic benefits produced, comparison of projects, measurement of the return on investment over a period of time, respectively. For example when the impact of a scientific project is assessed the calculation of the return on investment in research is important (Passani et al., 2014), this is a method from corporate finance. It is calculated as a weighted sum of three indices:

1) internal return on investment, showing the financial sustainability of the project and measuring the financial return for the consortium partners;

2) external return on investment that determines the net benefits that the project brings to society as a whole;

3) the social impact index, covers all impacts caused by a scientific project that cannot be measured in monetary terms and can be easily converted into economic/financial values.

The science impact can be assessed not only at the level of scientific projects and programs but also at the level of organizations, in particular, research centers. When the value generated by a research center is measured, both the results it produces and the impact it can have on policymaking should be considered. It is important to keep track of research results, as any public fund administrator needs to know what they are purchasing for the funds and whether the value for money is reasonable. The number of users of research results also provides useful information about the quality and relevance of what the research produces.

Evaluation of institutional and individual research results is an important component of evaluation of the effectiveness and impact of research. However, today there are no internationally recognized standards that enable an objective assessment of the scientific results of individual researchers (L'Académie des sciences de l'Institut de France, 2011). It should also be borne in mind that the volume of scientific research has increased significantly in recent years. With an abundance of scientific information, the use of quantitative bibliometric strategies enables one to work to weed out significant work, assess their effectiveness, and find the basic structure of the relevant field. Bibliometrics use mainly three methods: the subjective methodology of organized literature, meta-analysis using a quantitative approach, and scientific mapping to structure and improve scientific disciplines. Within the framework of bibliometrics, the published work is evaluated by the influence (impact factor) of the magazine, the total number of citations, the average number of citations per article and per author, the average number of citations per year, the number of authors per article, Hirsch index, etc. These metrics are used to assess individual, team and institutional research. There are also alternative metrics (altmetrics): the number of downloads of material on social networks, views, comments, quotes, etc. They can be calculated in publicly available scientometric resources, databases and academic social networks (Google Scholar, ResearchGate, Mendeley,

etc.). Altmetrics enable to measure the level of attention to the results of scientific work, their distribution (reposts in social networks, discussions on blogs and forums, mention in the news) and the impact on society (the use of scientific publications in expert opinions and government documents) (Majeed & Ainin, 2020).

Thus, there are various methods and models intended to assess and to analyze the science impact on the country's social and economic development, each of which has its own disadvantages and advantages (Table 1).

TABLE 1. Advantages and disadvantages of existing models and methods intended to assess the science impact on the country's social and economic development

No.	Method/ Model	Advantage	Disadvantage
1	2	3	4
1	Econometric	Statistical analysis of large databases, presenting an overall picture of statistical patterns, focusing on scale models (macroeconomic level), showing economic benefits and fall-outs by assessment of the influence of some factors on others	Methodological limitations, simplified assumptions about reality, the impossibility to assess the impact of all factors on the process of technical development, innovation and commercialization
2	Case study	The possibility of detailed analysis, a better understanding of the use of research results funded from private and public references, with specific examples	Narrow picture of reality, high costs of money and time to conduct an assessment, difficulty in generalization of research results, focus on the best and most successful projects
3	Survey	The possibility of detailed analysis, the possibility to identify new facts, taking into account the opinions of different stakeholders, information from persons directly related to the country's science and social and economic development	Subjectivity of assessments, limited knowledge of technology and research, conflict of interest, favoritism, superficial expertise, high costs of money and time to conduct a survey
4	Bibliometrics	Ease of assessment, fast assessment speed, availability and open access to data for assessment, availability of automated calculation programs	Potential unreliability of citation rates, susceptibility to manipulation, a measure of the use of an article rather than quality or significance; dependence of the citation rate of an article not only on its significance but also on the location of the author, prestige, language and accessibility of the published magazine
5	Patent	Availability and openness of data	Differences in patent registries in different jurisdictions, different filing fees and transaction costs in different patent offices

1	2	3	4
6	Index	Consideration of many different factors, the ability to determine the level of influence due to the presence of a threshold scale	Low level of information content
7	Financial analysis	Determination of financial benefits	Low level of data transparency, impossibility of using at the macro level
Note: Compiled by the authors based on references (Martin, 2007; Salter & Martin, 2001; Thorne, 1977; Seglen, 1992; Martin, 1996; Martin & Irvine, 1983)			

A review of the theory and methodology of issues of the science impact on the country's social and economic development indicates the absence of a universal mechanism, a single method or model to assess the scientific impact. This is due to the fact that the assessment of the scientific impact can be performed at different levels, as well as different goals, objectives, technological trajectories, and economic results that countries strive to achieve. None of the parameters or assessment methods can take into account the diversity and complexity of the technological outputs of R&D programs; accurately describe the processes by which the influence itself occurs; estimate the time lag of the influence; to cover the final economic and social results in full. There are index and econometric methods, microeconomics, case studies, patent and bibliometric studies, and surveys to assess the science impact. Each has its own advantages and disadvantages. In general, economic research uses labor, economic, technological and spatial criteria to analyze the structure and measure the contribution of industries, including those of the knowledge economy. Despite the differences in the methods used, there are certain methodological elements that are common to all studies: the definition of criteria to select assessment objects; determination of the time period for the assessment; determination of a common analytical approach; determination of an analytical framework for retrospective impact assessment; determination of the scale and scope of research within the chosen analytical approach; determination and selection of metrics/parameters; selection of a method intended to assess metrics; integration of metrics into the analysis framework.

3. METHODOLOGY

The research question of this study was the following: how does science impact on Kazakhstan's social and economic development?

The hypothesis of this study is that there is a positive relationship between Kazakhstan's science and social and economic development, but science is not the main factor in socio-economic development in Kazakhstan

The descriptive survey research design was adopted as the study guide to assess the science impact on Kazakhstan's socio-economic development. The conceptual framework of the methodology intended to assess the scientific impact proposed by the authors is the Impact Assessment Model that assesses the science impact on the development of the country through input (resources) and output parameters (result, effect, impact), where the parameters of science development are input metrics,

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parameters of social and economic development are outcome and impact metrics (Figure 1).
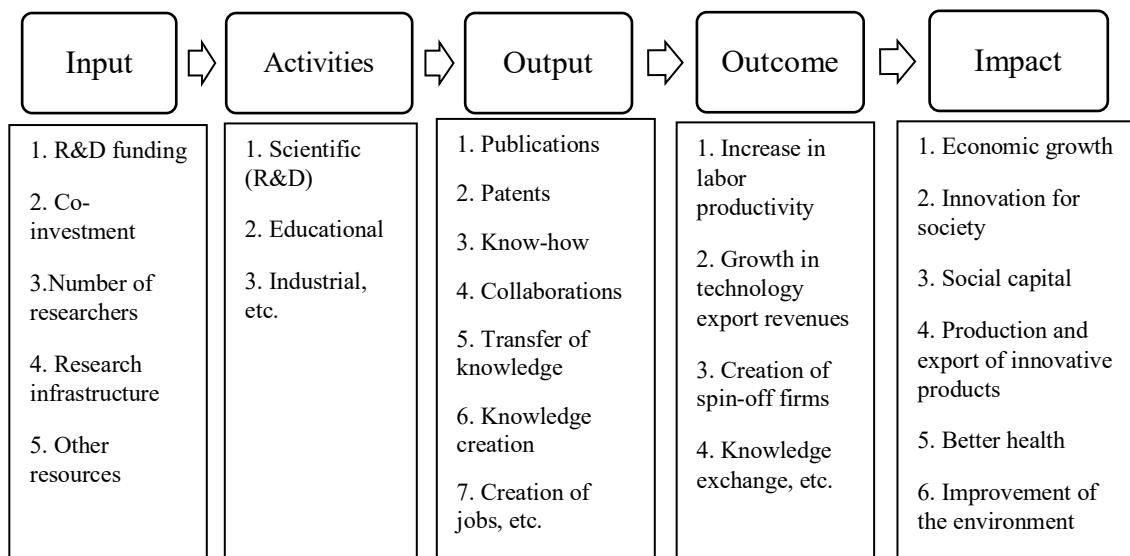
Input		Activities		Output		Outcome		Impact
1. R&D funding 2. Co-investment 3.Number of researchers 4. Research infrastructure 5. Other resources	⇨	1. Scientific (R&D) 2. Educational 3. Industrial, etc.	⇨	1. Publications 2. Patents 3. Know-how 4. Collaborations 5. Transfer of knowledge 6. Knowledge creation 7. Creation of jobs, etc.	⇨	1. Increase in labor productivity 2. Growth in technology export revenues 3. Creation of spin-off firms 4. Knowledge exchange, etc.	⇨	1. Economic growth 2. Innovation for society 3. Social capital 4. Production and export of innovative products 5. Better health 6. Improvement of the environment

FIGURE 1. Model intended to assess the science impact on the development of the country

Source: OECD (2019)

The author's methodology intended to assess the science impact on the country's social and economic development is proposed with a mechanism that includes the following stages of work:

1) analysis of the absolute and specific parameters for the development of science in the country;

2) analysis of absolute and specific parameters of the country's social and economic development;

3) analysis of derived parameters of direct and indirect science influence on the country's social and economic development;

4) generalization of the results obtained.

This mechanism enables all interested parties (executors, authorized body, research organizations and development institutes) to receive information with varying degrees of detail. The four-stage mechanism makes it possible to comprehensively assess the factors of science impact and obtain structured information on the parameters of science and social and economic development and their connection. The methodology proposed by the authors contains the following general methodological elements:

1) Determination of criteria for selection of assessment objects. The assessment objects are the development parameters of the country's science and social and economic development for a certain period of time.

2) Determination of the time period for the assessment. Proceeding from the fact that the ideal time to conduct a study of economic impact is 3-10 years after a significant

impact on the market has begun, the author's methodology proposes to consider a period of 10 years (from 2011 to 2020) that will enable studying the dynamics of changes in the science impact on social and economic development.

3) Determination of the general analytical approach. The general analytical approach is expressed in the mechanism to assess the science impact on the country's social and economic development that includes four stages of the work specified above.

4) Define an analytical framework for retrospective impact assessment. The analytical framework for a retrospective assessment of the science impact on the country's social and economic development will be based on the analysis of time series for the last 10 years preceding the assessment period.

5) Determination of the scale and scope of research within the chosen analytical approach. The methodology proposed by the authors is based on a quantitative study. The author's methodology intended to assess the science impact on the country's social and economic development includes a system of parameters covering quantitative parameters.

6) Definition and selection of metrics/parameters. In the context of the transition to a knowledge-based economy, a new system of parameters should be used to quantify the science impact on the country's social and economic development, based on a comparison of parameters characterizing its input and output, as well as its internal structure. The collection of quantitative data is performed by a desk method.

Parameters structured within the framework of the system meet national and international standards and meet the requirements to form parameter systems, such as relevance, reliability, adequacy, objectivity, unambiguity, sufficiency, formalization, etc. At the same time, the system of parameters for each of these subsystems was built by the authors taking into account the following principles:

- Openness, accessibility, and transparency of statistical materials. All used data are posted on the official website;

- Comparability of data and results over time. We used only those parameters that can be compared with each other that enable correct comparisons;

- Maximum relevance of parameters, taking into account the form factors of a knowledge-based economy. Only those parameters are applied that are relevant to the characteristics of the development of science, economic and social development.

7) Choice of a method intended to assess metrics (calculating parameters). In the methodology proposed by the authors, the system contains both main parameters, the values of which are formed during the collection process, and derived parameters (relative, specific, synthetic, etc.) determined on their basis. The main method is economic and statistical analysis.

The information base of the study included secondary data: statistical data from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms, the National Bank, the National Institute of Intellectual Property of the Ministry of Justice of the Republic of Kazakhstan, The World Bank, the World Intellectual Property Organization, the United Nations Industrial Development Organization, as well as international indices of scientific and social and economic development (Competitiveness Index, Global Knowledge Index, Country & product complexity

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rankings, etc.), materials of scientific and practical conferences, periodicals and Internet resources. Microsoft Excel program was used to process statistical data.

Thus, the methodology proposed by the authors to assess the science impact on the country's social and economic development is aimed to analyze science as a whole as a sector of the economy. It takes into account not only the impact on the economy but also on social development that has not been studied previously.

4. FINDINGS AND DISCUSSION

The development parameters of Kazakhstani science (Table 2) and social and economic (Table 3) development were analyzed for the period from 2011 to 2020.

TABLE 2. Parameters of the scientific development in the Republic of Kazakhstan, 2015-2020

Parameter	2015	2016	2017	2018	2019	2020
1	2	3	4	5	6	7
Number of applications for PCT patents, units	24	21	27	16	27	30
Gross R&D expenditures, million tenge	86,572.9	89,509.8	92,732.5	99,706.7	118,070.7	116,742.9
Internal R&D expenditures, million tenge	69,302.9	66,600.1	68,884.2	72,224.6	82,333.1	89,028.7
Number of organizations engaged in R&D, units	390	383	386	384	386	396
Number of researchers, thousand persons	18	17	17.205	17	17	18
Number of PhD students, thousand persons	2.219	2.71	3.603	6	6	N/A
Payments for the use of intellectual property, USD	149,088,505	126,873,670	117,050,999.3	167,710,230	141,320,590	146,183,995

1	2	3	4	5	6	7
Number of scientific and technical articles, units	1,171.06	1,601.18	1,958.82	2,367.46	N/A	N/A
Amount of R&D services provided, million tenge	104,332.0	114,491.6	118,575.0	118,083.1	130,434.5	108,291.3
R&D import volume, million USD	9.3	12.7	10.1	12.0	15.3	18.3
R&D export volume, million USD	5.6	6.3	5.7	5.5	7.0	21.3
Sub-index "Research, Development and Innovation" of the Global Knowledge Index	N/A	N/A	14	16	14.5	14.5
Note: Compiled by authors						

Under the sub-index "Research, Development and Innovation" of the Global Knowledge Index, Kazakhstan has a low level of scientific potential. For the period from 2011 to 2020 an increase in scientific potential was recorded due to a twofold increase in gross R&D expenditures and over 2.3 times in internal R&D expenditures, an increase in the number of researchers by 63.64% and PhD students by 4.5 times. At the same time, there is a decrease in the number of organizations performing R&D by 16 units, i.e. 3.89%. It should be noted the rapid growth of publications of Kazakhstani researchers, starting from 2016: the average annual growth rate for 2011-2018 amounted to 25.64%. This was largely influenced by the current state policy in the area of training scientific personnel, obtaining academic titles and degrees and changes in the requirements in the competition documentation for participation in competitions for scientific projects of grant and program-targeted funding. The average number of PCT patent applications filed is 22 that is very low. The amount of payments for the use of intellectual property for the period from 2011 to 2020 increased by 51.6 million USD and amounted to 146.2 million USD in 2020. The amount of R&D services provided for the period under review increased by 30.06%. Until 2020, Kazakhstan was practically a net importer of foreign R&D and technologies, there was a negative balance of payments under license agreements that indicates a lack of its own scientific potential to meet domestic needs for research and development. In 2020, the situation changed, R&D exports exceeded

imports. During this period, there is a tendency to reduce imports against the background of an increase in R&D exports, so the average annual growth rate of these parameters was -16.6% and + 4.29%.

Under the prosperity index in 2020, the economic development level in Kazakhstan was above average, while it was average in 2011. Positive dynamics of economic development can be traced in such parameters as GDP, GDP per capita, the volume of innovative products, investments in fixed assets, the volume of manufacturing products, labor productivity in industry and the volume of production (export) of ICT, the average annual growth rate of which for the period from 2011 to 2020 amounted to 9.61%, 8.25%, 21.94%, 9.37%, 10.67%, 4.11% and 4.28% (1.65%), respectively. At the same time, there is an annual decrease in the volume of foreign direct investment by an average of 4.19%.

The number of innovatively active enterprises increased by 2 622 units, i.e. 5.27 times. While the number of enterprises that created new technologies and equipment, decreased by 28 units, i.e. by 10.81% compared to 2013. However, the growth in the number of innovatively active enterprises did not contribute to a significant increase in the added value of medium and high-tech production that in 2011 amounted to 13%, and in 2018 - 14.51%. At the same time, there is a decrease in the volume of exports of high-tech goods and services, the maximum value of which was in 2012 (3,571.4 million USD), against the background of an increase in its share in the volume of exports of the manufacturing industry from 25.68% in 2011 to 29.78% in 2020. These changes are characterized by an increase in the parameters of the country's economic complexity and competitiveness, however, an increase in the intensity and competitiveness of the Republic's industry has not been noted. So, for the period from 2011 to 2020 the intensity index of industrialization and industrial competitiveness remained practically unchanged.

Under the social progress index in 2020, the social development level of Kazakhstan was high, while it was above average in 2011. The positive dynamics of social development can be traced in such parameters as the average per capita nominal cash income of the population and the average monthly nominal wage per employee, the average annual growth rate of which for the period from 2011 to 2020 amounted to 9.61% and 8.99%, respectively. Within the period from 2011 to 2017, there is a decrease in the poverty level from 5.5% to 2.6%, since 2018 this parameter has increased to 5.3% in 2020. The number of employed persons during the period under review increased by 430.4 thousand persons, the unemployment rate decreased 5.4% to 4.9%. Under the data of 2020, crime decreased by 21.29% compared to 2011, the peak of registered crimes occurred in 2015 and amounted to 386,718 units.

In the healthcare sector, the following trends are noted: from 2011 to 2019 the number of hospital beds decreased from 117.7 thousand. up to 96.3 thousand units However, in 2020 their number increased by 32.4% compared to 2019, amounting to 127.5 thousand units. The overall mortality rate fell between 2011 and 2019 from 8.72 to 7.19, however, in 2020, its growth is noted to 8.6. The same situation is observed in terms of maternal mortality: from 2011 to 2019 a decline from 17.4 to 13.4 and a sharp increase in 2020 to 36.5. This is also due to the current epidemiological situation in Kazakhstan and the measure. At the same time, there is an almost twofold decrease in infant mortality from 14.91 to 7.77. In the field of education, there is an increase in the number of students in

general education schools against the background of a decrease in the number of students in colleges and universities.

Analysis of the derived parameters of the direct and indirect science influence on the country's social and economic development. We analyzed the parameters of the direct and indirect science impact on the social and economic development of Kazakhstan (Table 4) that made it possible to determine the role of science and assess its contribution to the social and economic development of the Republic.

TABLE 4. Derived parameters to assess the science impact on the social and economic development of the Republic of Kazakhstan, 2015-2020

No.	Index	2015	2016	2017	2018	2019	2020
1	Share of domestic R&D expenses to GDP, %	0.17	0.14	0.13	0.12	0.12	0.13
2	Share of R&D services provided in GDP, %	0.26	0.24	0.22	0.19	0.19	0.15
3	Share of R&D in export, %	0.01	0.02	0.01	0.01	0.01	0.04
4	Share of R&D in export of services, %	0.09	0.1	0.09	0.07	0.09	0.42
5	Share of innovative products in GDP, %	0.92	0.95	1.55	1.72	1.6	2.43
6	Share of innovatively active enterprises, %	8.1	9.3	9.6	10.6	11.3	11.5
7	Share of researchers in the total number of employed in the economy, %	0.22	0.2	0.2	0.2	0.2	0.21
8	Share of organizations engaged in research and development, %	0.18	0.16	0.15	0.14	0.13	0.12
9	Profitability/efficiency of R&D, %	150.54	171.91	172.14	163.49	158.42	121.64
Note: Compiled by authors							

The share of domestic R&D expenses in GDP is very low and for the period from 2011 to 2020 decreased from 0.15% to 0.13%. The maximum value - 0.17% - fell on the period from 2013 to 2015. The share of R&D services provided in the structure of GDP in 2011 was 0.29%, in 2020 - 0.15%. The maximum value of this parameter was in 2012 and amounted to 0.32%. At the same time, there is an increase in the share of R&D both in the overall structure of Kazakhstani exports and in the structure of exports of services. However, the share is just as low. In 2020, the share of R&D in the country's exports amounted to 0.04% and 0.42% in the structure of services exports. The average annual growth rate was 7.18% and 2.56%, respectively. For the period from 2011 to 2020 there is a double increase in the share of innovative products in the structure of GDP: from

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0.84% to 2.43%. The share of innovatively active enterprises increased over the period under review, while the share of organizations engaged in R&D in the overall structure of the country's enterprises decreased from 0.23% to 0.12%. At the same time, the share of researchers in the total employment structure increased from 0.14% in 2011 to 0.21% in 2020 but it still remains low. It should be noted that in 2011, for 1 tenge of internal R&D costs, there were 2.18 tenge of R&D services provided that speaks of a high level of cost efficiency. However, in 2020, 1 tenge of internal R&D costs accounted for 1.22 tenge of R&D services rendered.

General trends in the scientific and social and economic development of Kazakhstan were determined based on calculation of the average values of the growth rates of parameters of scientific and social and economic development (Figure 2).
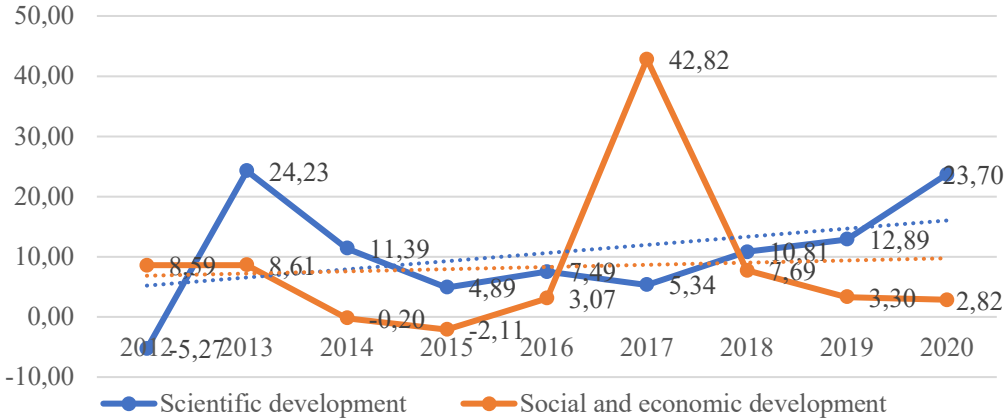

FIGURE 2. Trends in scientific and social and economic development of Kazakhstan, 2011–2020, annual growth in %

Note: Compiled by authors

There are ups and downs in the development of science and technology against the background of sustainable social and economic development within the period from 2011 to 2019 in Kazakhstan. Under the average annual growth rate, the trend in the parameters of scientific and technological development is 1.6 times higher than in the parameters of social and economic development but it is less stable. It is possible to refer to the intellectual and innovative potential, economic potential and scientific personnel potential among the factors that make the greatest contribution to the scientific, technological and social and economic development of Kazakhstan. The science development parameters are still not significant factors in the social and economic development of Kazakhstan. The development pace of the scientific and technological sphere of Kazakhstan and its structure do not meet the tasks of modernization and the growing demand from the economy in full, including the world, for advanced technologies and qualified personnel. This situation has serious consequences for the development of the country's scientific and technological potential. First of all, this is a

lag in the processes of digitalization and the transition to a new technological order, the destabilization of society in the regional and social sections, the widespread use of outdated and environmentally hazardous technologies, etc.

The scientific development rate is higher than the social and economic development rate in Kazakhstan. There is a close positive relationship between the country's science and social and economic development. The main factors that influenced the trend of scientific and social and economic development of Kazakhstan are an increase in the number of scientific and technical articles, PhD students, a decrease in imports, an increase in domestic R&D costs, an increase in the volume of innovative products and manufacturing products, an increase in the number of innovatively active enterprises. Analysis and comparison of average values of growth rates of scientific and social and economic development parameters in Kazakhstan indicate that science and social and economic development are closely related, there is a positive correlation.

5. CONCLUSIONS

The research goal has been achieved. The tasks set in the study have been completely solved using statistical data from the World Bank, the World Intellectual Property Organization, the Bureau of National Statistics, the National Bank, etc. A comprehensive study of the scientific, technological and socio-economic development of Kazakhstan was performed. Based on the analysis of parameters of Kazakhstani science and socio-economic development, the tendencies of the socio-economic and scientific-technological development of Kazakhstan are revealed, the factors influencing the dynamics of the indicators of the development of science, economy and society of the country are determined. In the course of the study, the level of influence of science on the socio-economic development of Kazakhstan was determined.

The following conclusions have been made based on the study performed:

Firstly, there is no universal mechanism to quantify the science impact on the country's social and economic development. The reasons for the lack of a unified methodology intended to assess the science impact are as follows:

1) a long period of time can pass between a scientific hypothesis, experiment, discovery, scientific theory and its application in society;

2) the science influence can be very broad and difficult to measure for different branches of science, and also its science influence can manifest itself indirectly, be non-linear and cumulative;

3) different goals, objectives, technological trajectories and economic results that countries strive to achieve;

4) the possibility to assess the science impact at various levels.

None of the parameters or assessment methods can take into account the diversity and complexity of the technological outputs of R&D programs; accurately describe the processes by which the influence itself occurs; estimate the time lag of the influence; to fully cover the final economic and social results.

Secondly, Kazakhstan has a low level of scientific potential, however, for the period from 2011 to 2020 its stable growth is observed. In recent years, there has been an interest in Kazakhstani science from other countries. Since 2020, there has been a positive

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balance of technology balance. While the economic development level and social progress in the country is characterized as high and above average, respectively. The main parameters of the social and economic development of Kazakhstan show positive dynamics. However, during the period under review, there has been an increase in the parameters of the country's economic complexity and competitiveness, however, an increase in the intensity and competitiveness of the Republic's industry has not been noted. There is a low patent and innovation activity in the country, showing the effectiveness of the Republic's science as low. The scientific and technological development of the country has not contributed to the rapid growth of the high-tech and innovative sectors of the economy. There is an increase in the quality of life of the population in the country but no direct science influence has been identified. However, funding for medical sciences remains at a low level that becomes a threat to the development of modern domestic medical technologies that, as a result, may lead to an increase in mortality among the population.

Thirdly, the level of knowledge-intensiveness of the economy in Kazakhstan is very low. Today the potential of Kazakhstani science has not yet been revealed and the results of scientific research are not used in solving applied problems of the social and economic development of the Republic. Increase of funding for R&D, development of scientific infrastructure, building up scientific personnel potential, increasing requirements for the quality of R&D and other measures to increase the efficiency of R&D can help to increase the science impact on the social and economic development of the Republic, not only in quantitative but also in qualitative terms, providing both direct and indirect impact on the economic and social process in the country.

The collected statistical data will serve as a database on the scientific, technological and social and economic development of Kazakhstan for the period from 2011 to 2020. The scientific results obtained in the research course can be applied in the activities of the Ministry of Education and Science of the Republic of Kazakhstan, the Ministry of National Economy of the Republic of Kazakhstan, the Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan, the Ministry of Digital Development, Innovation and Aerospace Industry of the Republic of Kazakhstan, as well as other departments and organizations. The materials contained herein can be used in the educational process.

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