“Public management of scientists’ potential as a source of economic development: A bibliometric analysis”

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PUBLIC MANAGEMENT OF SCIENTISTS' POTENTIAL AS A SOURCE OF ECONOMIC DEVELOPMENT: A BIBLIOMETRIC ANALYSIS

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Abstract

Particular hopes have always been placed on the potential of scientists because they can act as a driving force for effective government. Understanding the importance of scientists ensured progress and prosperity for leading civilizations. This study aims to identify an evolutionary-chronological, geographical, and contextual scientific landscape of the development and management of the potential of scientists through a comprehensive bibliometric analysis. Initially, 5619 publications in the Scopus database were selected from 1957 to 2023. The evolution of knowledge about the importance of public administration of scientific personnel began in 1957 and reached its peak in 2019. Authors from the USA, Great Britain, and Australia have published more about the significance of managing the potential of scientific personnel, and strong schools of knowledge about scientific personnel are concentrated in the USA, France, Canada, and Australia. The analysis of the research's conceptual orientation shows that publications in environmental and social sciences dominate this sphere. In addition, the bibliometric analysis results show that public management of scientific personnel will bring benefits such as effective government policy decisions, increased innovation activity, commercialization, and improvement of the population's social life. The results of this study lay the foundation for future research that should improve the management of scientific personnel's potential.

Keywords management, public administration, economic development, scientific personnel, scientists, bibliometric analysis

JEL Classification P35, J08, O15

INTRODUCTION

Public management in science is seen as the process intended to plan, organize, coordinate, and control resources and activities to achieve scientific goals and objectives, with the scientists as the main driving force. By stimulating innovation, building research infrastructure, and developing partnerships, science management can facilitate significant scientific breakthroughs that will benefit the economy and humanity. In today's world, a competitive environment between countries seeks to improve social and economic development indicators, including the well-being of the population. In developed countries, economic performance shows growth through output and innovative products; the situation is different in developing countries; they try to create an environment where the economy will grow through innovation, technology, and finished products. However, one of the strategies to achieve economic growth is the formation and development of an optimal science policy that emphasizes the potential of scientific personnel. Full realization of the potential of scientific human resources will positively influence economic development (Rossi et al., 2024).

Governments play a crucial role in the formation of science policy and the science workforce. To address the most critical issues of economic development, it is necessary to consider the fundamental relationship between the formation and development of scientific personnel and the use of their potential to benefit effective public administration. In particular, government intervention in scientific personnel policy should include the formation of scientists, the creation of social housing and other conditions, incentivizing their activities through scientific internships and prizes, and the creation of appropriate advanced infrastructure to meet the current conditions of scientific development. Another challenge is the need for greater communication between scientists and policymakers when dealing with public administration issues. The development of public decisions involves many aspects, but scientific advice and evidence are crucial for informed decision-making. However, the mechanisms for requesting and receiving advice from the scientific community are complex, given that the knowledge required typically covers many disciplines in the natural and social sciences (Gluckman et al., 2021). Thus, the scientists' results create new knowledge and contribute to the best public solutions for public administration. Governmental management includes the harmonious development of the environment, economy, and social sphere. Public management of scientific personnel policy generally plays a vital role in achieving social and economic development goals, increasing the output of innovative products, and developing new knowledge. This aspect is critical for the development of the economy.

1. LITERATURE REVIEW

Public management of the scientific process in a country plays a vital role in developing scientific and technological potential and ensuring innovation and progress. Developing countries want to increase their GDP through innovative technologies, while developed countries look for new directions that will give them the impetus to increase their economic growth. Besides, the progressive and accelerated development of science contributes to the improvement of all productive forces, increasing the scale of production and consumption of products (works, services) and improving the standard of living and well-being of the population. In this respect, scientists are the main driving force generating new knowledge and innovation. Scientific personnel are the basis of human capital, which turns knowledge into innovation and then into the welfare of the nation (Krugman, 1979; Fagerberg, 1987). The state's scientific and human resource policies are crucial for innovation and economic development. Therefore, the state should have an effective policy for the formation and development of scientific personnel (Lyashenko & Pidorycheva, 2019; Shablysta, 2020) and the use of their results in public administration. In many countries, science workforce policy is part of public science policy because developing countries can increase the capacity of scientific personnel through government incentives and support. It means that the state is committed to creating conditions for training, retraining, and incentivizing scientific personnel, methods of funding scientists, and scientific infrastructure to keep science moving in step with global science trends. In some developed countries, the role of the state is taken over by tycoon enterprises that stimulate science and attract highly qualified scientists to enterprises to create methods, technologies, and other innovative products (Papanastassiou et al., 2009).

Scientific personnel policy in the state and regional management is understood as a consistent activity of the state and all scientific organizations to form a brilliant personnel potential in the country. The essence of scientific personnel policy in the scientific policy system is to form and create conditions for them to realize their professional potential to create new knowledge. Scientific personnel policy aims to utilize the creative potential of scientists and their ability to generate new knowledge in full, to create high-tech innovations, and to offer optimal solutions for effective public administration. Countries and individual enterprises design their scientific human resource policies to synergize scientific knowledge through huge profits. In this regard, developed countries pay more attention to the development and improvement of scientists' professional levels. Scientific policy and the policy of scientific personnel in different countries are organized in different ways. For example, in China, the United States, and the United Kingdom,

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universities are favored for training (Rong & Wu, 2020; Cao et al., 2021) and formation and development of scientific personnel; in other countries, the state forms prominent scientific organizations engaged in R&D and training of scientific personnel (Schoening et al., 1998; Demidenko, 2021; Molchanov et al., 2022). Thus, training of scientific personnel is included in the state scientific policy or educational policy of the country.

The state scientific personnel policy in post-Soviet countries shows that scientists need additional support measures to improve scientific results. The situation is different in Asian countries; for example, in Japan and Korea, scientists express satisfaction with the policies implemented by the government. Using Korea as an example, Hwang et al. (2024) studied satisfaction with student support measures in 196 scientific organizations. The results show that the allocated support measures satisfy the needs of academics in terms of salary, infrastructure, research and development organization, etc. Thus, the ongoing scientific personnel policy may not fully meet scientists' need to create new knowledge, or vice versa. Creating new knowledge requires enormous digital resources that are now available. Ogunjobi and Fagbami (2012) note the importance of public policy in the field of digital technologies, which has a positive impact on the effectiveness of researchers. Namely, scientists can keep abreast of the latest scientific discoveries thanks to high-speed Internet access and scientific databases. Thus, the importance of intervention as a supportive body of the state will increase the effectiveness of scientists.

The scientific personnel policy also notes the effective management of scientists in the gender context. According to the United Nations Sustainable Development Goals, gender inequality is felt in the academic environment where women scientists are underrepresented. Therefore, individual countries and organizations have taken measures to support women scientists. For example, the US National Science Foundation, the American Committee, the Weizmann Institute's Science Program for Women, the Association for Women in Science, and L'Oréal USA for Women in Science seek to increase the participation of women in science to exploit the potential of human capital in full. There are also studies by branches of science; for example, Ahuja (2002) and Loiacono-Mello et al. (2016) address the support for women scientists in information systems in the medical field (Pastor-Cabeza et al., 2021; Koutsouras et al., 2022). Ion and Duran Belloch (2013) targeted social sciences, while Fox (2010) researched engineering. Some studies examined the ethnicity of scientists in academia (Griffin et al., 2015). Thus, the state should pay attention to women scientists who have not yet unleashed their great scientific potential to create scientific knowledge and develop the economy.

Earlier studies showed the importance of the quality of human capital, which can improve their knowledge and skills to enhance the social and economic life in a country (Schultz, 1959; Becker, 1962; Kiker, 1966). Public policy plays a special role in the formation of high-quality human capital, and without it, the expectation of due effect may be low (Sinha, 2014). Thus, the impact of the scientific workforce on economic development is obvious, and the number of scientists can be considered as the main determinant factor that can positively influence the economy.

Prada and Cimpoeru (2019) applied a panel data regression model to research the experiences of European Union countries. The dynamics of scientists from 2003 to 2016 were one of the main determinants. The results confirm the positive relationship between the assessment factors. Similar studies were conducted in Kazakhstan, where R&D indicators, including R&D workers, positively impact economic growth dynamics (Kireyeva et al., 2021). In addition, Vinkler (2008) pays special attention to the impact of the quality of human capital on economic growth. Accordingly, an increase in the number of scientists can result in an increase in GDP. The quality of human capital is characterized by its education, flexibility, and necessary skills. In this context, scientists consider the impact of a country's intellectual capacity on economic development. Using econometric analysis, Kireyeva et al. (2022) proved that scientists, as creators of new knowledge and technologies, contribute to the growth of companies, new jobs, and increased GDP. However, the development of quality human capital requires improvement of the qualifications of scientific personnel.

The key factors of economic development are the training of qualified personnel capable of solving problems here and now and creating innovative products. Basic scientific skills instilled in schools can significantly increase the scientific level of a country, thereby increasing the number of scientists and leading to innovation and economic growth (Boggs, 2010). There is also a link between the capacity of the scientific workforce and making the right public decisions for the sustainable development of a country.

According to Schenkel (2010), there is a persistent tension between scientific information and public and political priorities in many countries. The perception and use of science is far from being practiced by the state. Numerous studies argued that it is worth listening to scientists when making public administration decisions to create more effective public policies (Lalor & Hickey, 2013). According to Hickey et al. (2013), scientific human resource development and science system reform should be considered in an integrated and interrelated manner while implementing a country's economic and social policies. Thus, future policies should take the importance of training scientific human resources into account and utilize their research outputs to generate economic benefits through the development of innovation. Current challenges are both a practical issue and an opportunity to rethink scientific personnel policy and emphasize their importance not as creators of new knowledge but as experts in managerial decision-making.

The aim of this study is to systematize the world's scientific knowledge about the public management of scientific human resources as an element of economic development, focused on the following directions: 1) evolution of scientific thought; 2) geographical location and concentration of research networks; 3) correspondence to the content and thematic focus of studies.

2. METHOD

Bibliometric analysis is used as a methodological framework. Bibliometric analysis is one of the simplest and most natural ways to determine the scientific contribution and productivity of a scientist or scientific organization. The data analysis and visualization were performed using VOSviewer version 1.6.19. The research parameters were set in the first stage of the study; Scopus was chosen as the database, and keywords included: "scientist," "management," and "policy." There were no restrictions on the choice of language. In the next step, 300,686

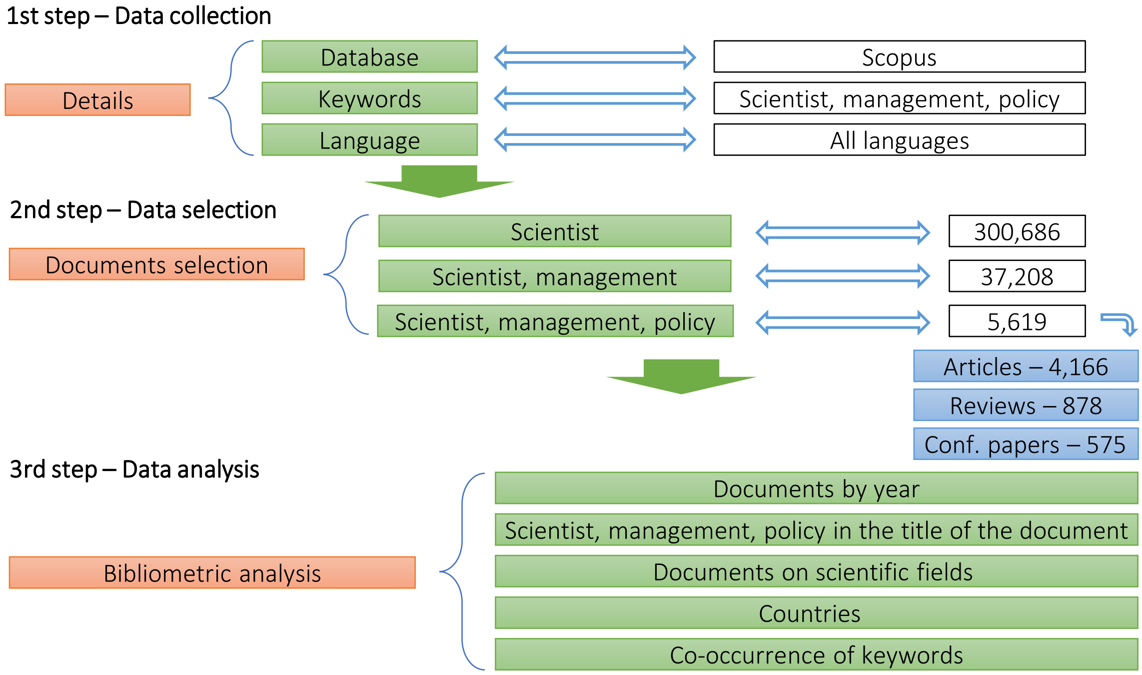

Figure 1. Research framework

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documents were identified for the keyword "scientist," 37,208 for "management," 5,619 for "scientist," "management," and "policy." They include scientific articles, conferences, and reviews. The documents were visualized and analyzed in the third stage of the study. They were considered by number by year, science areas, countries, and keywords. Data processing, analysis, and visualization were carried out using VOSviewer and Microsoft Excel software. Figure 1 visualizes the research framework.

3. RESULTS AND DISCUSSION

The study selected 300,686 publications at the first stage of the search. At the second stage, 37,208 publications with the keywords "scientists" and "management" were identified. In the third stage, 5,619 publications were identified for the keywords "scientists," "management," and "policy." Only articles, reviews, and conference papers were selected.

Figure 2 shows the popularity dynamics of this topic. The first mention of potential management by scientific personnel dates back to 1957. The popularity of research on the influence of scientists on various industries began to gain momentum in 1984 when the number of publications reached 18. The peak of publication activity occurred in 2019 when 389 publications were published. Government interference in the functioning of scientists' activities is still relevant, as evidenced by the number of publications in 2022 and 2023.

Figure 3 lists the top authors who publish frequently in the Scopus database. Cooke Steven J. from Carleton University has published 20 publications; Rudd Murray A., a Canadian independent consultant, has published 12; Bouma J., Cvitanovic C., Lach D., and Redman S. have published eight works each, and other authors have published seven or fewer publications.

Figure 2. Dynamics of publications during 2003–2023

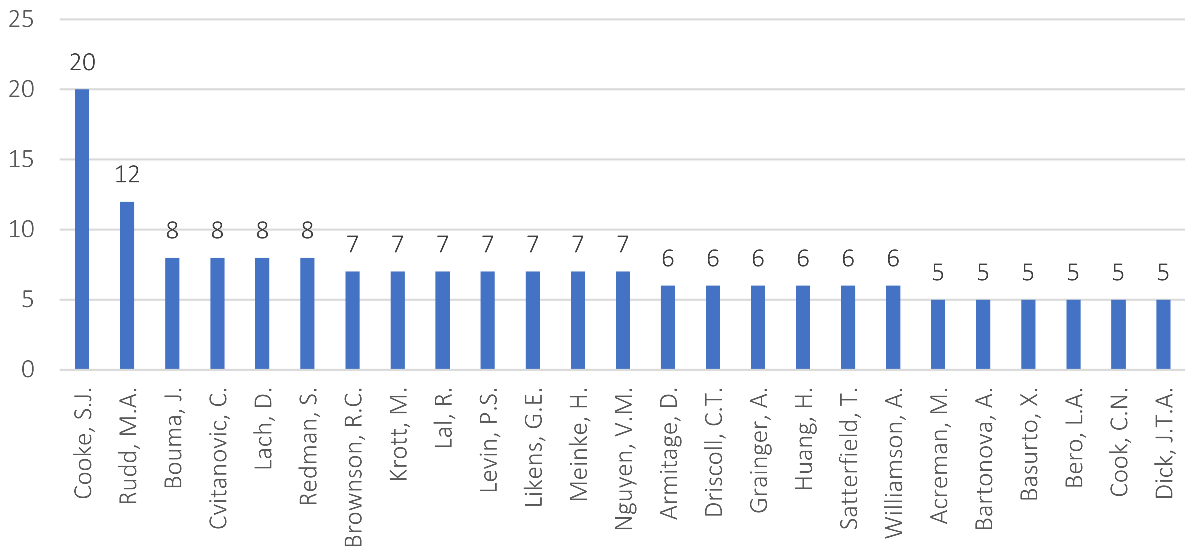

Figure 3. Top authors related to the research topic

The most popular research trend concerns the collaboration of scientists, government, and business (Brownscombe et al., 2019; Madliger et al., 2021). Academia also searches for ways to increase the level of applied science to improve the situation with commercialization. The next popular trend concerns the impact of scientists' research results on the environment (Rudd, 2015; Bouma, 2019). Effective public management of scientists' potential in this field will reduce hunger, improve water quality, mitigate the effects of climate change, and preserve biodiversity. In addition, scientists are generators of ideas for public administration policy in the interests of the country's development (Steel et al., 2000; Steel et al., 2004; Steel et al., 2010; Marshall et al., 2017; Williamson et al., 2019; Cvitanovic et al., 2021).

In terms of field of knowledge, the environmental sciences have the largest share of research papers (24%), followed by the social sciences (15%), with the agricultural and biological sciences in third place (14%). Next, the field of medicine shows 14%, Earth and planetary science – 6%, engineering – 5%, computer science – 4%, economics, econometrics and finance and business, management and accounting – 3% each. Such results indicate the need to study the importance of correctly using scientists' potential to achieve effective economic, political, and environmental government solutions (Figure 4).

Table 1 shows the number of publications by country for the analyzed period and the number of scientists per 1000 employees by country. The most significant number of publications is in the USA – 2,273, where the number of scientists per 1,000 employees is 9.95, followed by the UK – 926 publications and 9.64 scientists per 1,000 employees. The most significant number of scientists are registered in France (11.72) and the Netherlands (10.88) (Dyvik, 2024). Therefore, the study notes a directly proportional relationship between publications and the potential of scientists. In addition, the leading countries tend to have a high global innovation index and a high level of publications. Thus, it can be assumed that the high potential of scientists has a positive effect on the production of innovative products.

The next step is to consider the top institutions. The leader is the Dutch research university, Wageningen University & Research, which specializes in the areas of food, feed and biobased production, natural resources and living environment, and society and well-being. The American Washington University, with 90 publications, is in the next position. The rest of the organizations belong to France (CNRS Centre National de la Recherche Scientifique and INRAE), Canada (The University of British Columbia), Australia (Commonwealth Scientific and Industrial Research Organization), and Great Britain (University of Oxford) (Figure 5).

The mentioned organizations provide a powerful environment in which the importance of development, formation of scientific human resources of the state, and the impact of their activities on im-

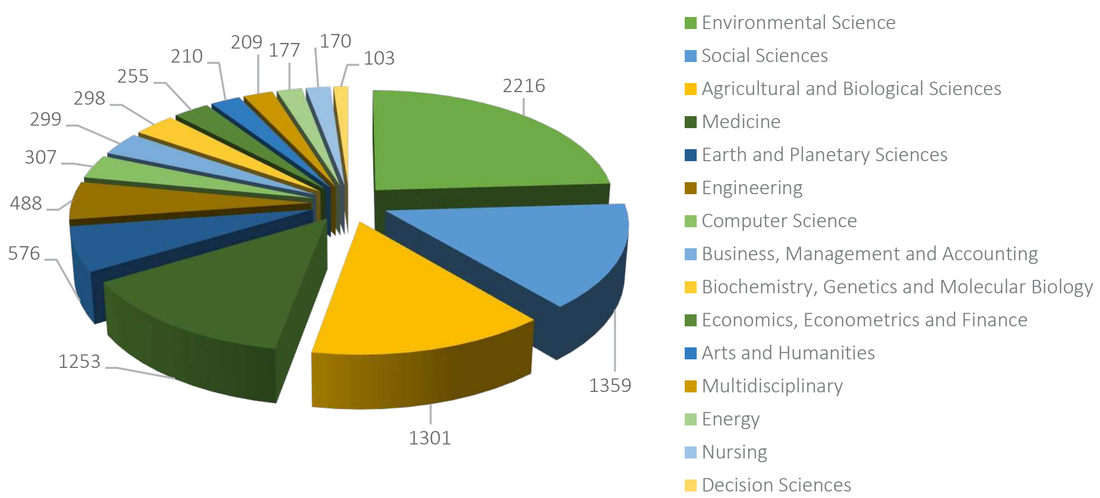

Figure 4. The subject structure of scientific publications in the Scopus bibliometric database from 1957 to 2023

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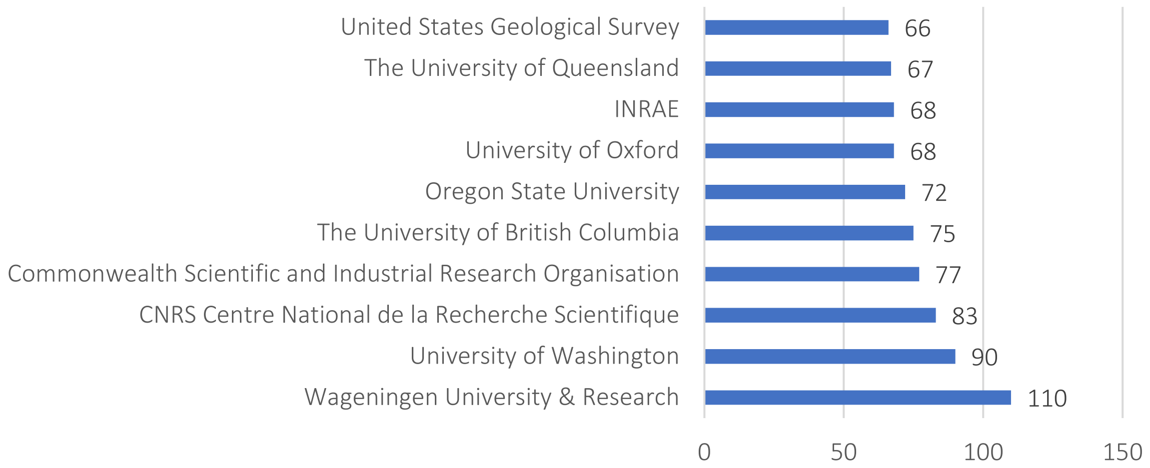

Figure 5. Institutional affiliation of scientific works

Table 1. Number of publications and number of scientists by countries of the world

Country	Number of publications from the Scopus database within the study (from 1957 to 2023)	Number of scientists and researchers per 1,000 employed (full-time equivalent), 2021
Australia	582	–
Canada	536	9.43
China	210	–
France	303	11.72
Germany	347	10.22
The Netherlands	357	10.88
Spain	213	7.72
Italy	260	6.88
The United Kingdom	926	9.64
The United States	2273	9.95

proving all aspects of public administration are noted. According to Figure 6, the United States, Great Britain, and China are interested in paying particular attention to government policies to improve the quality and potential of scientific personnel.

To understand the collaboration of scientists by countries better, VosViewer detected 12 clusters with the help of a color scheme; eight of them are shown in Table 2. The remaining clusters include Denmark, Croatia, and Turkey.

Figure 7 presents the bibliometric network of scientific papers co-authored by country in chronological order. According to the analysis, earlier studies related to the period before 2008 were conducted by the United Kingdom, Korea, Egypt, Kazakhstan, etc. More recent studies have covered Spain, Malaysia, Italy, and Austria. It is worth noting that the conclusions are based on publications included in the Scopus database.

The next step was to investigate the network of clusters of research papers on public policy

Table 2. Description of the clusters formed by the co-author countries

Clusters	Color	Countries
1	(red)	Brazil, India, Chile, Tunisia, Hungary, Nepal, Nigeria, Bangladesh, Kenya, Madagascar
2	(green)	Spain, Italy, the Netherlands, Germany, Norway, Austria, Croatia, Latvia
3	(blue)	Korea, Thailand, Malaysia, Taiwan, Japan, Bogota
4	(yellow)	France, Ukraine, Iran, Pakistan, Israel, the Russian Federation
5	(Violet)	Australia, China, Singapore, Mexico, Hong Kong
6	(pink)	The United Kingdom, Canada, Columbia
7	(light blue)	Kazakhstan, Iceland, Egypt, Arab countries
8	(orange)	Bolivia, Butane, Puerto Rico, the United States

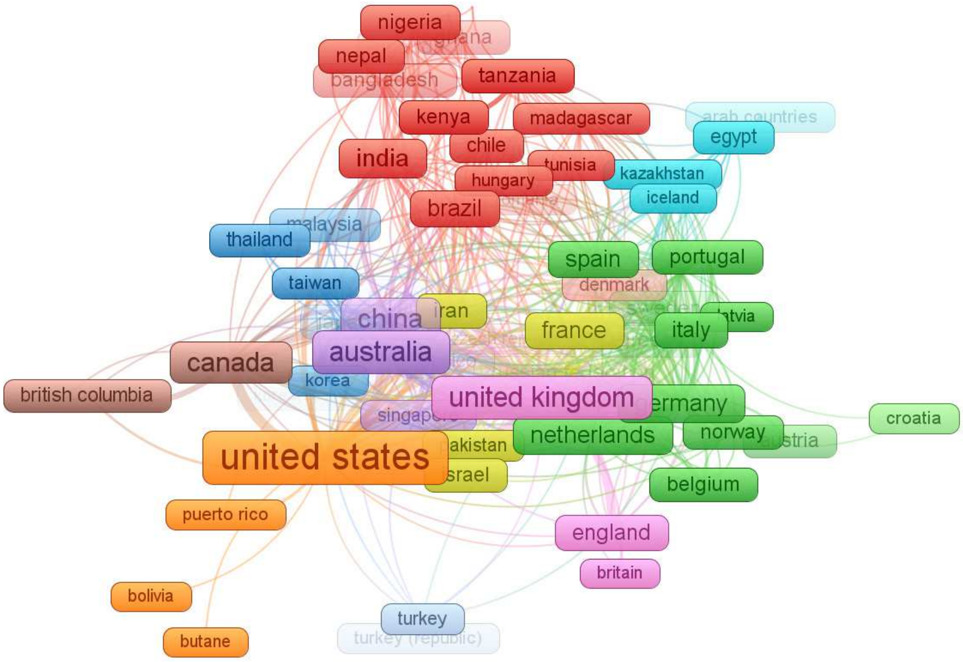

Figure 6. Bibliometric network of co-authorship of scientific papers by country

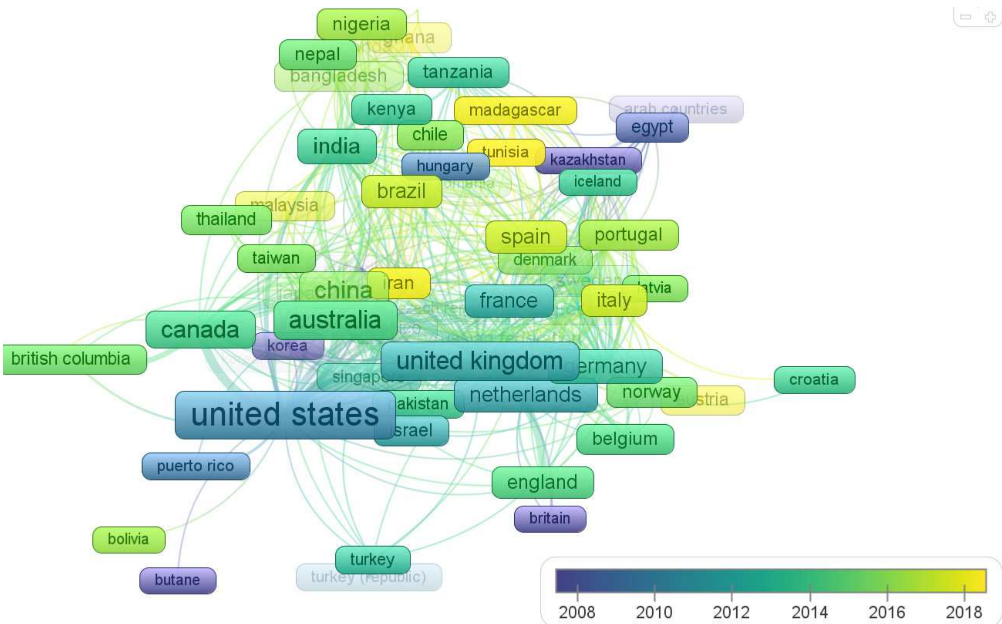

Figure 7. Bibliometric network of co-authorship of scientific papers by country in time section

management in the field of scientists formed by keywords. Six clusters were formed among the selected research papers, each with its own vector (Table 3 and Figure 8).

The largest red cluster includes scientific works devoted to policy formation, interaction of science and politics, knowledge exchange, commercialization, and technology transfer. The authors studied the potential contribution of scientists to the formation of effective policy and the interaction of science, politics, and business. In this case, scientific development will increase the level of competitiveness and will bring the development of a particular territory to another level. In this direction, there are many examples and public policies that try to commercialize scientific research. Examples of the successful commercialized scientific research projects are that of Tesla and Google.

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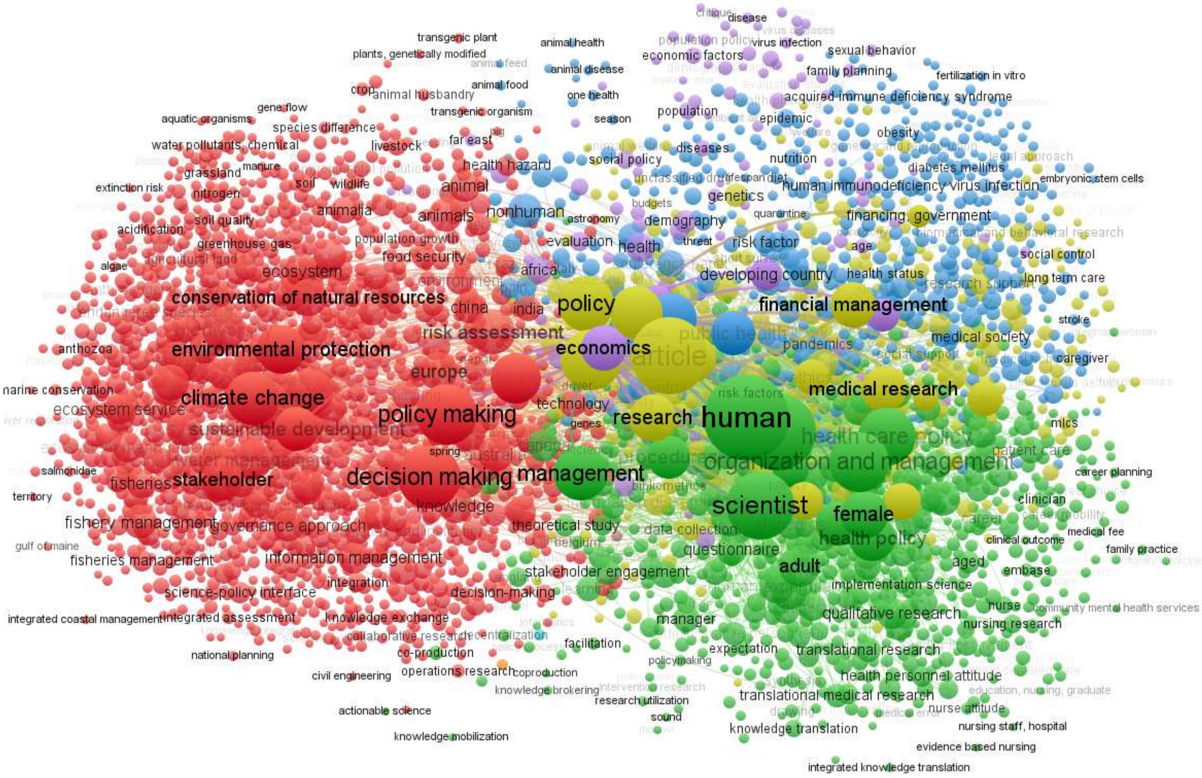

Figure 8. Bibliometric network of clusters of scientific works on the management of state policy: Formed by keywords

Table 3. Description of the clusters formed by keywords

Clusters	Color	Keywords
1	(red)	Policy making, science-policy interface, knowledge exchange, technology transfer, government approach, commercialization
2	(green)	Scientist, woman, gender bias, education, human, medicine, health policy
3	(blue)	Health care industry, medicine, quality of life
4	(yellow)	Capital financing, entrepreneurship, financial management and support, government regulation
5	(violet)	Development planning, economics, economic factors, research activities, social policy, social planning

Green cluster includes research on scientists, women in science, education, medicine, health policy, and gender bias. The third group, the blue cluster, includes publications that characterize the healthcare industry, medicine, and quality of life. The authors emphasize the importance of scientists' high potential to create evidence-based methods of treating patients, thereby creating a high-quality sphere of medical services that will ensure the population's quality of life.

The yellow cluster is devoted to a wide range of fundamental, financial, and managerial research, highlighting keywords such as capital financing, entrepreneurship, financial management and support, and government regulation. Thus, this cluster notes that the potential of scientists can create economic processes and financial actions by awakening individuals and legal entities to engage in entrepreneurial activities. The next cluster, purple, examines work on development planning, economics, economic factors, research, social policy, and social planning. This group is dedicated to scientists' contributions to the economy and social aspects of sustainable development in the country. Three small clusters are not included in Table 3. These clusters contain the following keywords: community engagement, methods, etc.

Thus, the bibliometric analysis proves the importance of policies regarding the public management of scientific personnel. For a more in-depth bibliometric analysis, this study's findings can be complemented by analyses from other scientific databases.

CONCLUSION

The paper discusses the importance of public management of the scientist's potential, who are generators of new knowledge and new management solutions, which will later lead to commercialization and optimal public management solutions. It entails the development of countries and industries and the improvement of the quality of the population's life.

The United States, the United Kingdom, Australia, and others are the leaders among the states interested in improving conditions for scientists. The identified countries are leaders in the global innovation index. Besides, the study found that scientists urge states to focus more on basic sciences to create and understand the essence and patterns of new technologies and phenomena. It was also noted that the knowledge created can benefit scientists, entrepreneurs, and the state through applied science. VosViewer software was then used to build visualized maps of the authors' collaborations by country and study keywords. The USA, UK, Netherlands, France, and the United Kingdom put more emphasis on the development of science workforce policies. In addition, 89 countries with publications on the importance of scientific personnel management were found. Further, keyword visualization showed six clusters, two of which are stressed: public management of scientists and the social and economic aspects of the importance of their development. It is worth noting that the development and research of scientific personnel leads to commercialization, stimulating economic growth in developed countries.

Although this study is similar to bibliometric analysis, it assessed the quality of articles, which is one of the strengths of this study. Still, this research has several limitations. First, a literature search was conducted in the Scopus database, but other databases were not searched. In addition, the word "scientist" was used in the keyword search; however, such keywords as "researcher" and "scholar" are also used in various contexts. However, the keyword "scientist" was chosen because it is more appropriate to describe public management of science policy. Secondly, only articles, reviews, and conference papers were selected. Overall, this study represents only a small part of the research papers on public management of scientific human resources capacity; it can also be complemented by bibliometric analyses from other electronic scientific databases, and the findings and results can be expanded upon.

AUTHOR CONTRIBUTIONS

Conceptualization: Dana Kangalakova, Zaira Satpayeva, Makpal Nurkenova, Arailym Suleimenova.
Data curation: Dana Kangalakova, Arailym Suleimenova.
Formal analysis: Dana Kangalakova, Zaira Satpayeva, Arailym Suleimenova.
Funding acquisition: Dana Kangalakova.
Investigation: Dana Kangalakova, Zaira Satpayeva.
Methodology: Dana Kangalakova, Makpal Nurkenova.
Project administration: Dana Kangalakova, Zaira Satpayeva.
Resources: Dana Kangalakova, Zaira Satpayeva, Makpal Nurkenova.
Software: Dana Kangalakova, Makpal Nurkenova.
Supervision: Dana Kangalakova.
Validation: Dana Kangalakova, Zaira Satpayeva, Makpal Nurkenova.
Visualization: Dana Kangalakova, Zaira Satpayeva, Arailym Suleimenova.
Writing – original draft: Dana Kangalakova, Zaira Satpayeva, Makpal Nurkenova, Arailym Suleimenova.
Writing – review & editing: Dana Kangalakova, Zaira Satpayeva, Makpal Nurkenova, Arailym Suleimenova.

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REFERENCES

1. Ahuja, M. K. (2002). Women in the information technology profession: A literature review, synthesis and research agenda. *European Journal of Information Systems, 11*(1), 20-34. https://doi.org/10.1057/palgrave.ejis.3000417
2. Becker, G. (1962). Investment in human capital: A theoretical analysis. *Journal of Political Economy, 70*(5), 9-49. https://doi.org/10.1086/258724
3. Boggs, G. R. (2010). Growing roles for science education in community colleges. *Science, 329*(5996), 1151-1152. https://doi.org/10.1126/science.1194214
4. Bouma, J. (2019). How to communicate soil expertise more effectively in the information age when aiming at the UN Sustainable Development Goals. *Soil Use and Management, 35*(1), 32-38. https://doi.org/10.1111/sum.12415
5. Brownscombe, J. W., Adams, A. J., Young, N., Griffin, L. P., Holder, P. E., Hunt, J. H., Acosta, A., Morley, D., Boucek, R. E., Cooke, S. J., & Danylchuk, A. J. (2019). Bridging the knowledge-action gap: A case of research rapidly impacting recreational fisheries policy. *Marine Policy, 104,* 210-215. https://doi.org/10.1016/J.MARPOL.2019.02.021
6. Cao, Q., Xie, P., Jiao, M., & Duan, W. (2021). The larger scientific and technological human scale, the better innovation effect? Evidence from key universities in China. *Scientometrics, 126,* 5623-5649. https://doi.org/10.1007/s11192-021-04019-5
7. Cooke, S. J. (2018). From frustration to fruition in applied conservation research and practice: Ten revelations. *Socio-Ecological Practice Research, 1,* 15-23. https://doi.org/10.1007/s42532-018-0002-x
8. Cvitanovic, C., Mackay, M., Shellock, R., Putten, E. I., Karcher, D., & Dickey-Collas, M. (2021). Understanding and evidencing a broader range of 'successes' that can occur at the interface of marine science and policy. *Marine Policy, 134,* Article 104802. https://doi.org/10.1016/j.marpol.2021.104802
9. Demidenko, S. Y. (2021). On the issue of the reproduction of scientific personnel. *Science Management: Theory and Practice.* https://doi.org/10.19181/smtp.2021.3.4.8
10. Dyvik, E. H. (2024, July 4). *Ranking of OECD-countries by number of scientists/researchers 2021*. Statista. Retrieved from https://www.statista.com/statistics/264644/ranking-of-oecd-countries-by-number-of-scientists-and-researchers/
11. Fagerberg, J. (1987). A technology gap approach to why growth rates differ. *Research Policy, 16*(2-4), 87-99. https://doi.org/10.1016/0048-7333(87)90025-4
12. Fox, M. F. (2010). Women and men faculty in academic science and engineering: Social-organizational indicators and implications. *American Behavioral Scientist, 53*(7), 997-1012. https://doi.org/10.1177/0002764209356234
13. Gluckman, P. D., Bardsley, A., & Kaiser, M. (2021). Brokerage at the science–policy interface: From conceptual framework to practical guidance. *Humanities and Social Sciences Communications, 8,* Article 84. https://doi.org/10.1057/s41599-021-00756-3
14. Griffin, K. A., Gibbs, K. D., Bennett, J., Staples, C. L., & Robinson, T. N. (2015). "Respect me for my science": A Bourdieuian analysis of women scientists' interactions with faculty and socialization into science. *Journal of Women and Minorities in Science and Engineering, 21*(2), 159-179. https://doi.org/10.1615/JWOMENMINORSCIENENG.2015011143
15. Hickey, G. M., Forest, P., Sandall, J., Lalor, B. M., & Keenan, R. J. (2013). Managing the environmental science--policy nexus in government: Perspectives from public servants in Canada and Australia. *Science and Public Policy, 40*(4), 529-543. https://doi.org/10.1093/SCIPOL/SCT004
16. Hwang, B. Y., Park, S. H., Lee, N. R., & Kim, T. Y. (2024). The effect of research support capability on researchers' satisfaction based on the characteristics of institutes. *Journal of Open Innovation: Technology, Market, and Complexity, 10*(1), Article 100195. https://doi.org/10.1016/j.joitmc.2023.100195
17. Ion, G., & Duran Belloch, M. D. (2013). Successful women researchers in the social sciences: A case study of Catalan public universities. *Tertiary Education and Management, 19*(1), 68-84. https://doi.org/10.1080/13583883.2012.746729
18. Kiker, B. F. (1966). The historical roots of the concept of human capital. *Journal of Political Economy, 74*(5), 481-499. https://doi.org/10.1086/259201
19. Kireyeva, A. A., Kangalakova, D. M., Ainakul, N., & Tsoy, A. (2022). Factors affecting the distribution of intellectual potential and returns in Kazakhstan. *Journal of Distribution Science, 20*(2), 55-64. http://dx.doi.org/10.15722/jds.20.02.202202.55
20. Kireyeva, A. A., Kangalakova, D. M., Kredina, A. A., Satpayeva, Z. T., & Urdabayev, M. (2021). Man-

aging research and development process in conditions of economic growth of Kazakhstan: Methods and analysis. *Problems and Perspectives in Management, 19*(3), 185-196. https://doi.org/10.21511/ppm.19(3).2021.16

21. Koutsouras, G. W., Zhang, L., Zanon, N., Lam, S. K., Boop, F. A., & Tovar-Spinoza, Z. (2022). Equity in neurosurgery: A worldwide survey of women neurosurgeons. *Journal of Neurosurgery, 138*(2), 550-558. https://doi.org/10.3171/2022.6.JNS22466
22. Krugman, P. R. (1979). A model of innovation, technology transfer, and the world distribution of income. *Journal of Political Economy, 87*(2), 253-266. https://doi.org/10.1086/260755
23. Lalor, B. M., & Hickey, G. M. (2013). Environmental science and public policy in executive government: Insights from Australia and Canada. *Science and Public Policy, 40*(6), 767-778. https://doi.org/10.1093/SCIPOL/SCT022
24. Loiacono-Mello, E. T., Iyer, L. S., Armstrong, D. J., Beekhuyzen, J. P., & Craig, A. (2016). AIS women's network: Advancing women in IS academia. *Communications of the Association for Information Systems, 38,* 784-802. https://doi.org/10.17705/1cais.03838
25. Lyashenko, V., & Pidorycheva, I. (2019). The formation of interstate and cross-border scientific-educational and innovative spaces between Ukraine and the European Union member states in the digital economy. *Virtual Economics, 2*(2), 48-60. https://doi.org/10.34021/VE.2019.02.02(3)
26. Madliger, C. L., Love, O. P., Nguyen, V. M., Haddaway, N. R., & Cooke, S. J. (2021). Researcher perspectives on challenges and opportunities in conservation physiology revealed from an online survey. *Conservation Physiology, 9*(1), Article coab030. https://doi.org/10.1093/conphys/coab030
27. Marshall, N., Adger, N., Attwood, S. J., Brown, K., Crissman, C. C., Cvitanovic, C., De Young, C., Gooch, M., James, C.P., Jessen, S., Johnson, D., Marshall, P. A., Park, S., Wachenfeld, D. R., & Wrigley, D. (2017). Empirically derived guidance for social scientists to influence environmental policy. *PLoS ONE, 12*(3), e0171950. https://doi.org/10.1371/journal.pone.0171950
28. Molchanov, I. N., Molchanova, N. P., Paleev, A. V., & Charaeva, M. V. (2022). Priorities of personnel policy in the sphere of science. *Sustainable and Innovative Development in the Global Digital Age, 3,* Article 008. https://doi.org/10.56199/dpcsebm.etkc4951
29. Ogunjobi, T. E., & Fagbami, O. O. (2012). Use of the internet by researchers in agricultural research institutes in Ibadan, Oyo State. *International Journal of Library and Information Science, 4*(4), 52-56. https://doi.org/10.5897/IJLIS11.068
30. Papanastassiou, M., Pearce, R.D., & Anastassopoulos, G. C. (2009). Globalization of technology and the movement of scientific personnel in multinational enterprises in Europe. In *The Strategic Development of Multinationals* (pp. 204-215). London: Palgrave Macmillan. https://doi.org/10.1057/9780230250482_11
31. Pastor-Cabeza, M., Torné, R., Garcia-Armengol, R., Menéndez-Osorio, B., Mosteiro-Cadaval, A., Bollar, A., Rimbau, J.M., Sarabia, R., & Rodríguez-Hernández, A. (2021). Women's role in neurosurgical research: Is the gender gap improving? *Neurosurgical Focus, 50*(3), E6. https://doi.org/10.3171/2020.12.FOCUS20911
32. Prada, E., & Cimpoeru, S. (2019). The impact of human capital on economic growth in EU-28: A panel data perspective. *Proceedings of the International Conference on Applied Statistics, 1*(1), 398-406. https://doi.org/10.2478/icas-2019-0034
33. Rong, Z., & Wu, B. (2020). Scientific personnel reallocation and firm innovation: Evidence from China's college expansion. *Journal of Comparative Economics, 48*(3), 709-728. https://doi.org/10.1016/j.jce.2019.12.005
34. Rossi, L., Pasca, M. G., Arcese, G., & Poponi, S. (2024). Innovation, researcher and creativity: A complex indicator for territorial evaluation capacity. *Technology in Society, 77,* Article 102545. https://doi.org/10.1016/j.techsoc.2024.102545
35. Rudd, M. A. (2015). Scientists' framing of the ocean science-policy interface. *Global Environmental Change, 33,* 44-60. https://doi.org/10.1016/J.GLOENVCHA.2015.04.006
36. Schenkel, R. (2010). The challenge of feeding scientific advice into policy-making. *Science, 330*(6012), 1749-1751. https://doi.org/10.1126/science.1197503
37. Schoening, N. C., Souder, W. E., Lee, J., & Cooper, R. (1998). The influence of government science and technology policies on new product development in the USA, UK, South Korea and Taiwan. *International Journal of Technology Management, 15*(8), 821-835. https://doi.org/10.1504/IJTM.1998.002641
38. Schultz, T. W. (1959). Investment in man: An economist's view. *Social Service Review, 33*(2), 109-117. https://doi.org/10.1086/640656
39. Shablysta, L. M. (2020). Vybir priorytetiv naukovykh doslidzhen v konteksti formuvannia derzhavnoi naukovoi polityky [Selection of scientific research priorities in the formation of state scientific policy]. *Educational Analytics of Ukraine, 4*(11), 5-20. (In Ukrainian). https://doi.org/10.32987/2617-8532-2020-4-5-20
40. Sinha, C. (2014). Human capital and public policy. *South Asian Journal of Macroeconomics and Public Finance, 3*(1), 125-179. https://doi.org/10.1177/2277978714525307
41. Steel, B. S., Lach, D. H., & List, P. C. (2000). The role of scientists in the natural resource and environmental policy process: A comparison of Canadian and American publics. *Journal of Environmental Systems, 28,* 113-155. https://doi.org/10.2190/83W0-0JJ6-NUEK-HMDB

 http://dx.doi.org/10.21511/ppm.22(3).2024.45

42. Steel, B. S., List, P.C., Lach, D. H., & Shindler, B. A. (2004). The role of scientists in the environmental policy process: A case study from the American west. *Environmental Science & Policy, 7*(1), 1-13. https://doi.org/10.1016/J.ENVSCI.2003.10.004

43. Steel, B. S., Warner, R. L., & Lach, D. H. (2010). Gender differences in support for scientific involvement in U.S. environmental policy. *Science, Technology, & Human Values, 35*(2), 147-173. https://doi.org/10.1177/0162243909340259

44. Vinkler, P. (2008). Correlation between the structure of scientific research, scientometric indicators and GDP in EU and non-EU countries. *Scientometrics, 74,* 237-254. https://doi.org/10.1007/s11192-008-0215-z

45. Williamson, A., Makkar, S. R., & Redman, S. (2019). How was research engaged with and used in the development of 131 policy documents? Findings and measurement implications from a mixed methods study. *Implementation Science, 14,* Article 44. https://doi.org/10.1186/s13012-019-0886-2