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ON THE ADEQUACY OF USING SCIENTOMETRIC INDICATORS IN HIGHER EDUCATION IN KAZAKHSTAN: THE DEVELOPMENT OF GENAI AS AN ADDITIONAL INCENTIVE

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ABSTRACT

It is demonstrated that the statistics of official databases based on the Hirsch index, which reflect the performance of scholars in Kazakhstan, can be reduced to regularities corresponding to scale-free networks. This allows us to conclude that scientometric indicators such as the Hirsch index indeed capture objective processes taking place within the scientific and technological community. Supporting evidence for this conclusion lies in the fact that the principal measurable parameter of the observed regularity is numerically close to analogous parameters that characterize the behavior of systems of diverse nature. The obtained result thus provides an additional argument in favor of employing scientometric indicators to assess the significance of Kazakhstani universities. It is further shown that under current conditions, when GenAI is increasingly used in Kazakhstani universities (including in unscrupulous practices), the reliance on indicators reflecting objective processes in the scientific and technological community acquires particular relevance.

KEYWORDS: Scientometric Indicators; Scale-Free Networks; Genai; Academic Misconduct; University Rank-Ings; Humboldtian Principles.

1. INTRODUCTION

The In the Republic of Kazakhstan, debates on the appropriateness of the official use of scientometric indicators, particularly the Hirsch index, in evaluating the performance of university faculty members have been ongoing for several years. The Hirsch index (h-index), proposed by J. Hirsch in 2005, is intended to reflect the productivity of a given researcher, where h indicates that the author has h publications, each cited at least h times.

The Ministry of Science and Higher Education of Kazakhstan pursues policies aimed at stimulating scientific activity. According to current regulations, at least one third of the members of expert councils must possess a Hirsch index of 2 or higher in international citation systems such as Web of Science or Scopus and/or publications in international peer-reviewed journals [1]. Information about candidates for membership in dissertation councils must also include data on their Hirsch index in Web of Science or Scopus [2].

Despite the formal codification of these requirements, some faculty members have expressed critical views regarding their application. Opponents often cite studies questioning the adequacy of the Hirsch index and other scientometric measures as universal indicators of scientific productivity [3–6]. Skepticism toward the official use of the Hirsch index and similar indicators is also reflected in publications in Kazakhstani mass media. Several reports highlight the risks of distorting scientific assessment through excessive reliance on quantitative metrics, as well as the proliferation of publications in so-called "predatory" journals, which publish papers for a fee without proper peer review. This trend undermines the quality of research and negatively affects the national academic community [7,8].

The persistent influence of this debate on the academic community and public opinion in Kazakhstan underscores the need to seek further justification for the official application of scientometric indicators. The present study aims to analyze existing arguments and provide additional perspectives supporting the importance of these instruments in evaluating scientific activity.

Specifically, this paper demonstrates that the statistical distributions derived from official databases, which include the Hirsch indices of Kazakhstani scholars and university faculty, conform to the regularities characteristic of scale-free networks of various origins.

Systems of different natures that belong to the class of scale-free networks have been extensively studied over the past decades [9–11], beginning with the seminal work [12].

Numerous studies of networks of diverse types [13–15] indicate that the observed characteristic (typically derived from empirical data) depends on a control parameter k as follows:

$$P(k) \sim k^{-\gamma} \qquad (1)$$

where γ is a coefficient that can be determined either empirically or through simulation modeling.

The relationship described by equation (1) has been confirmed for a wide range of systems, including phone-call networks [16], ecological networks [17,18], citation and textual networks [19,20], trade networks [21,22], and others [23,24]. It has also been shown that such systems are characterized by γ values lying within a relatively narrow interval, typically from 1 to 4 (dimensionless).

The present study demonstrates that the regularity expressed by equation (1) also describes the statistical distributions constructed on the basis of the aforementioned official databases, with the coefficient γ in this case being very close to 2. Thus, it is proven that the use of the Hirsch index reflects objective processes occurring in the scientific and educational space, and consequently, there are objective grounds for its application.

Furthermore, based on the aforementioned databases and the official QS Asia University Rankings [25], an attempt has also been made to substantiate that, under current conditions, it is reasonable to reinforce policies grounded in the use of scientometric indicators. This is primarily associated with the increasing accessibility of GenAI, which necessitates a substantial reconsideration of existing approaches not only to the evaluation of students' knowledge [26–28], but also to the assessment of the quality of teaching and methodological materials prepared by faculty members of Kazakhstani universities.

2. DATA SOURCES

The open database of the National H-Index Ranking was employed, namely TOP 1000 Kazakh Scientists in Google Scholar Database 2025 [29] and TOP 1000 Kazakh Scientists in Google Scholar Database 2025 [30]. In addition, the results of the new QS Asia University Rankings 2025 [25], which included 35 Kazakhstani universities, were utilized.

3. RESULTS

Figure 1 presents the dependence of the number N of Kazakhstani scholars possessing a given Hirsch index value H on H in a logarithmic scale. The data were obtained from the aforementioned database

[29].

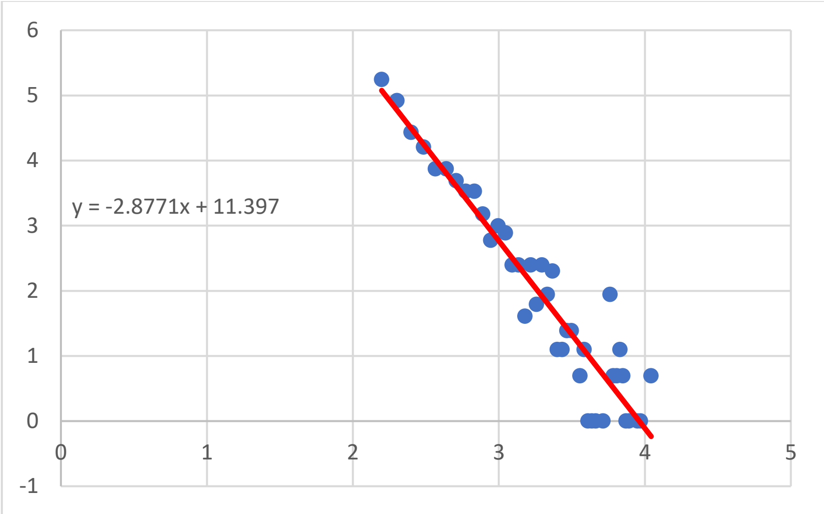


Figure 1: Dependence of the Number N Of Kazakhstani Scholars with a Given Hirsch Index H On H In a Logarithmic Scale (Based on the Database [27]).

It can be observed that this dependence is approximately linear with satisfactory accuracy, that is, it can be expressed as

$$\ln N = -\gamma \ln H + a \qquad (2)$$

The largest deviations from linearity are observed in the region of high H values. This is explained by the fact that only a few authors in Kazakhstan possess H values greater than 25, a range in which statistical regularities no longer apply.

This result makes it possible to assert that the system under consideration belongs to the class of scale-free networks. Importantly, the value of the coefficient $\gamma \approx 2{,}88$ obtained by the least-squares method, is close to the values reported in the cited works for systems of different nature.

A similar dependence, constructed on the basis of the open Google database [28], is shown in Figure 2.

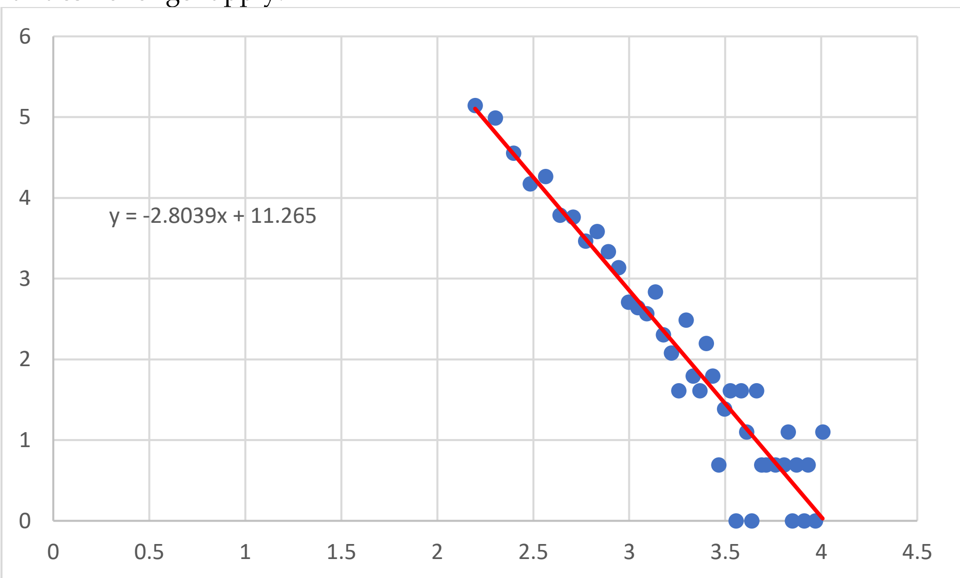
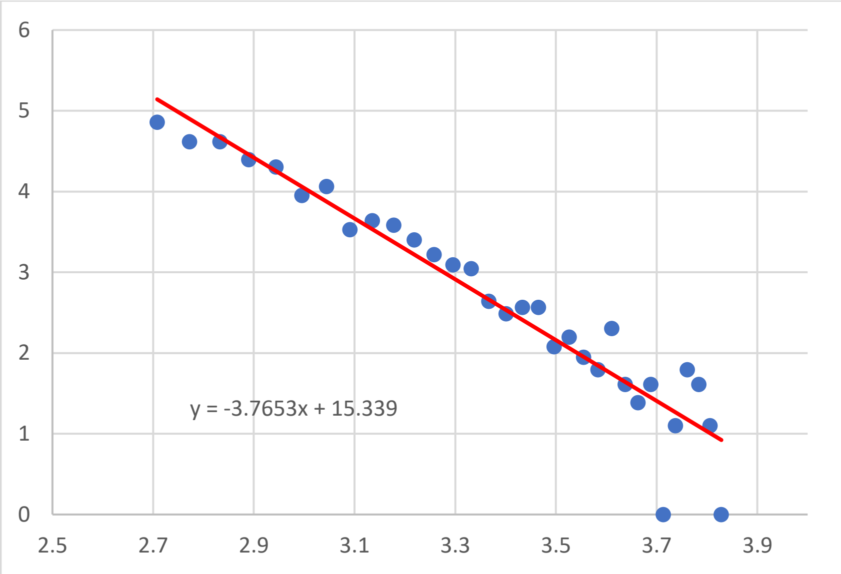


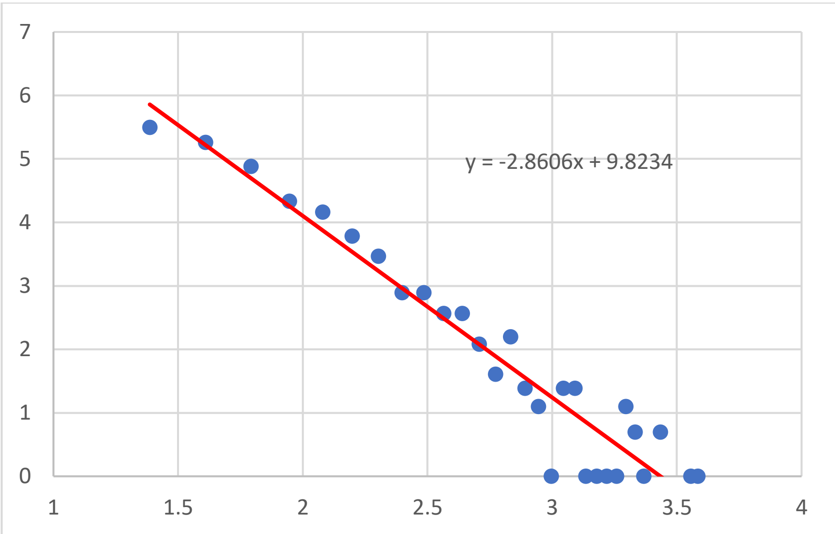
Figure 2: Dependence Of the Number N Of Kazakhstani Scholars with a Given Hirsch Index H On H In a Logarithmic Scale (Based on the Database [30]).

It can be observed that in this case as well, dependencies (1) and (2) describe the experimental data with satisfactory accuracy. Moreover, both databases employed yield approximately the same value of the coefficient γ.

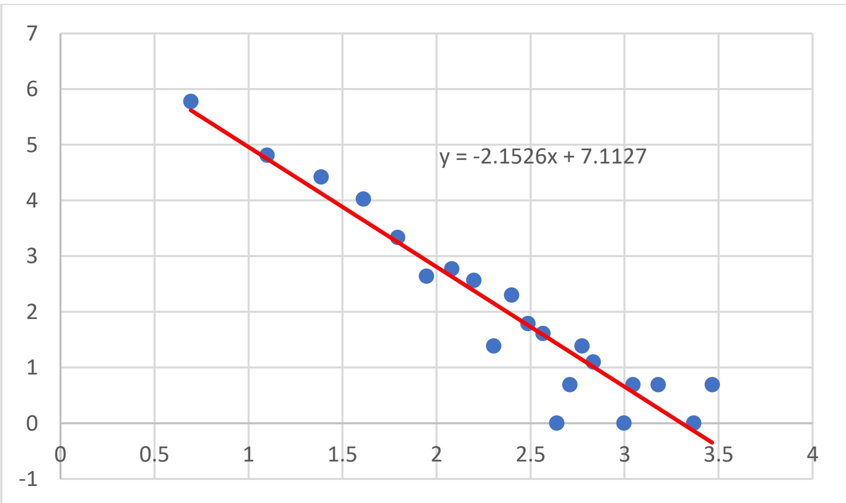
Figure 3 presents analogous dependencies for other countries of the world, constructed on the basis of the same source [30].



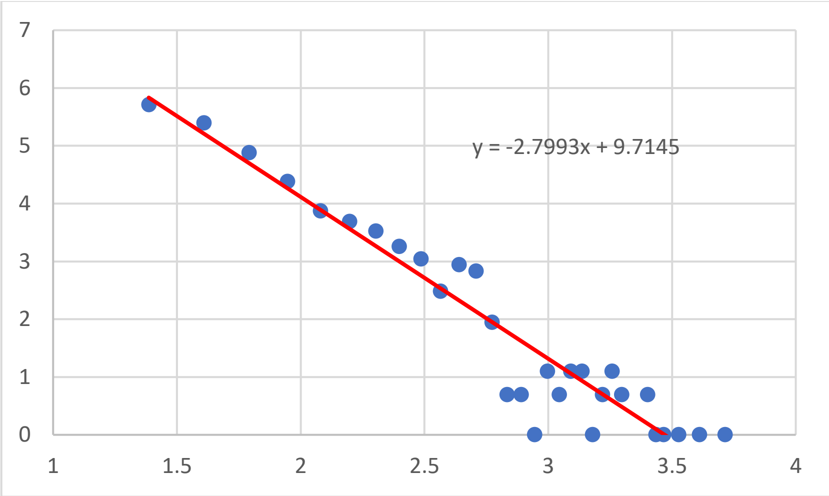
Bulgarian Scientists in Scopus International Database 2025.



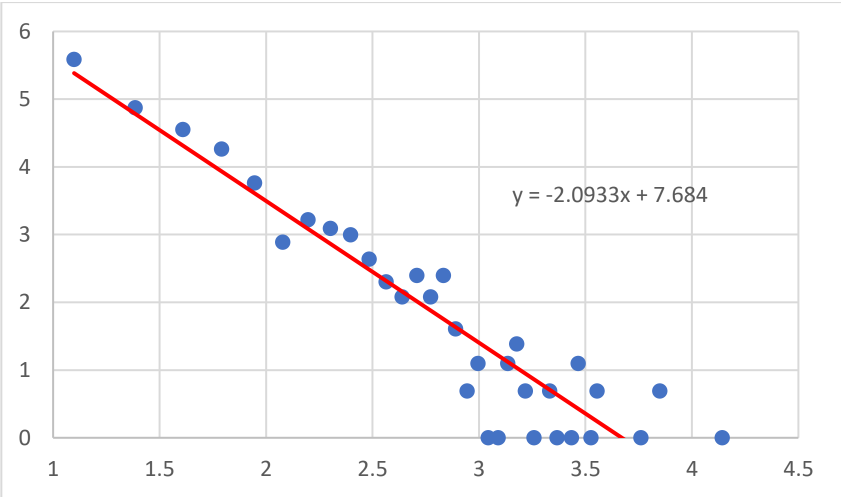
Kyrgyz Scientists in Google Scholar Database 2025.



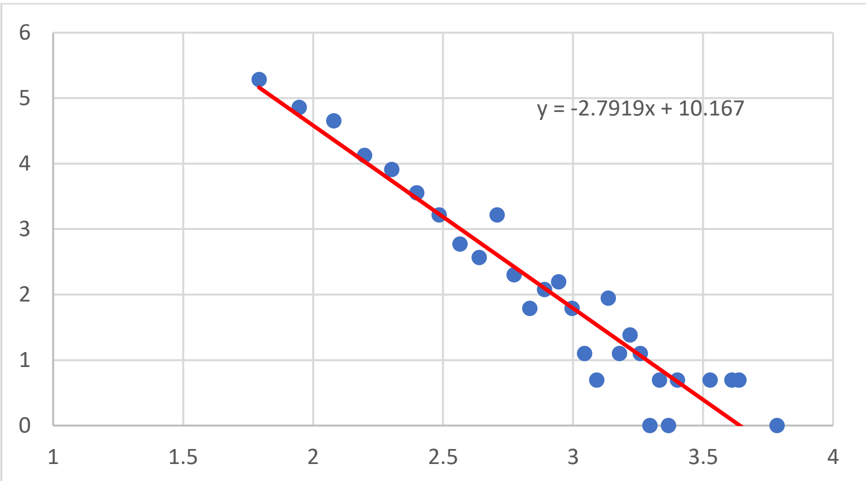
Kyrgyz Scientists in Scopus International Database 2025.



Azerbaijan Scientists in Scopus International Database 2025.



Moldovan Scientists in Scopus International Database 2025.



Moldovan Scientists in Google Scholar Database 2025.

Figure 3: Dependence Of The Number N Of Scholars Possessing A Given Hirsch Index Value H On H In A Logarithmic Scale (Based On Database [30]) For Various Countries: Bulgarian Scientists In The Scopus International Database 2025, Kyrgyz Scientists In The Google Scholar Database 2025, Kyrgyz Scientists In The Scopus International Database 2025, Azerbaijani Scientists In The Scopus International Database 2025,

Moldovan Scientists In The Scopus International Database 2025, And Moldovan Scientists In The Google Scholar Database 2025.

For clarity, Table 1 presents a comparison of the γ values obtained from the graphs in Figures 1–3. Additional data referring to other systems were also drawn from [12]. It can be observed that the obtained γ values are close to analogous indicators for systems of different nature.

Table 1: Comparison of Γ Values for Scale-Free Networks of Different Types.

Network	□□□□	□□□
Kazakhstan scientists in Scopus international database	2,88	
Kazakhstan scientists in Scopus international database	2,80	
Bulgarian scientists in Scopus	3,77	
Kyrgyz scientists in Google Scholar	2,86	
Kyrgyz scientists in Scopus international database	2,15	
Azerbaijan scientists in Scopus international database	2,80	
Moldovan scientists in Scopus international database	2,09	
Moldovan scientists in Google Scholar database	2,79	
Internet, domain	2,1 – 2,2	2,1 – 2,2
Coauthors, neuro	2,1	2,1
Coauthors, SPIRES	1,2	1,3
Phone call	2,1	2,1
WWW	2,45	2,1
Citation		3

Table 2 presents a comparison of the ranking of Kazakhstani universities (data from [25]) with the data provided in the National H-Index Ranking [29]. The universities are ordered according to the official ranking [25] (first column). The remaining columns (numbers 2–6) show the number of faculty members from each university who are included in the TOP 200, TOP 200–400, TOP 400–600, TOP 600–800, and TOP 800–1000 categories of the ranking [29].

In other words, the first thousand Kazakhstani scholars are divided into five subsets, and the corresponding statistics are presented in Table 2. Only data referring to faculty members of specific universities (officially provided in [29]) were taken into account. Individuals not affiliated with universities were excluded from this classification. Consequently, the total number (bottom row of the table) does not equal 1000.

Table 2: Comparison of the Positions of Kazakhstani Universities in the Official Asia University Rankings 2025 With the Research Productivity of Academic Staff as Measured by the Hirsch Index; TOP 1–200 N1–N2 Denotes the Number of Scholars Included in the Interval from N1 To N2 According to the Hirsch Index.

№	Organization (QS Asia University Rankings 2025)	TOP 1-200	TOP 201-400	TOP 401-600	TOP 601-800	TOP 801-1000	Total
1	Al-Farabi Kazakh National University	18	25	30	30	34	137
2	L. N. Gumilyov Eurasian National University (ENU)	7	19	17	25	16	84
3	Satbayev University	7	13	14	12	12	58
4	Abai Kazakh National Pedagogical University	1	3	4	2	2	12
5	Auezov South Kazakhstan University (SKU)	2	2	1	4	2	11
6	Kazakh National Agrarian University (KazNAU)	1	2	3	1	3	10
7	Karaganda Buketov University	0	5	4	5	3	17
8	Khoja Akhmet Yassawi International Kazakh-Turkish University	0	2	2	1	4	9
9	Kazakh-British Technical University	4	7	5	4	2	22
10	Karaganda State Technical University	0	0	0	0	0	0
11	NJSC KIMEP University	1	2	0	0	0	3
12	Saken Seifullin Kazakh Agrotechnical University	1	0	5	1	2	9
13	D. Serikbayev East Kazakhstan State Technical University	2	0	3	2	2	9
14	Kazakh Ablai Khan University of International Relations and World Languages	0	0	0	0	0	0
15	Narxoz University	0	0	0	0	0	0
16	S. D. Asfendiyarov Kazakh National Medical University	3	10	5	0	3	21
17	Almaty Technological University	0	1	0	0	3	4
18	Toraighyrov University	0	1	0	1	0	2

19	Yessenov University	0	0	0	1	0	1
20	Suleyman Demirel University, Kazakhstan	0	0	0	0	2	2
21	Semey State University named after Shakarim	0	0	0	0	0	0
22	North-Kazakhstan State University named after M. Kozybayev	0	0	0	0	0	0
23	Zhangir Khan West Kazakhstan Agrarian-Technical University	0	2	1	0	0	3
24	Korkyt Ata Kyzylorda University	0	0	0	0	2	2
25	M. Kh. Dulaty Taraz Regional University	0	0	0	0	1	1
26	Sarsen Amanzholov East Kazakhstan State University	0	1	1	1	4	7
27	K. Zhubanov Aktobe Regional State University	0	1	2	3	2	8
28	Ualikhanov University	2	0	2	0	0	4
29	I. Zhansugurov Zhetysu State University	0	0	0	0	0	0
30	Karaganda State Industrial University	1	2	0	0	0	3
31	Pavlodar State Pedagogical University	0	0	0	1	0	1
32	International Information Technology University	1	2	2	5	2	12
33	Turan University	0	1	0	0	0	1
34	Innovative University of Eurasia, Pavlodar	0	0	0	0	0	0
35	Kazakh National Women's Teacher Training University	0	0	0	1	0	1

Table 2 demonstrates that the official ranking of Kazakhstani universities shows only a weak correlation with indicators reflecting the research activity of faculty members.

4. DISCUSSION

In the contemporary context, the development of objective criteria for assessing the performance of university faculty remains a significant challenge, largely due to the accessibility of GenAI and the ambiguous consequences of its widespread use [26–28]. On the one hand, this tool exacerbates systemic problems of the Kazakhstani higher education system, which had been highlighted earlier, for instance, in [31,32]. It is no secret that GenAI can be employed in unethical ways, such as masking plagiarism.

On the other hand, there is little doubt that artificial intelligence can yield substantial benefits, particularly in generating non-trivial ideas and overcoming interdisciplinary barriers. It is widely acknowledged that, under current conditions, disciplinary fragmentation is pronounced, often leading to unnecessary expenditure of effort on processing literature, searching for analogues, and related tasks. Moreover, there are reasons to believe [33] that an excessively fragmented disciplinary structure of science contributes to crisis phenomena in this domain.

GenAI inherently enhances the permeability of interdisciplinary boundaries. Numerous examples exist in which an idea originating in one field of knowledge has proven useful in entirely different areas. Conducting patent searches or comprehensive literature reviews previously required a researcher to exert considerable effort. GenAI has significantly reduced this burden, thereby making the overcoming of interdisciplinary barriers an attainable task. This, arguably, constitutes the principal advantage of GenAI in research practice. Other positive contributions may also be noted, such as the substantial improvement in translation quality, which alleviates not only disciplinary but also linguistic barriers.

Thus, the current practice of GenAI use fully corresponds to the broader conclusion that can be drawn regarding the nature of artificial intelligence development as a whole [34,35]. Artificial intelligence, including its generative branch, is neither inherently good nor inherently evil. It is a tool that may be used either for harmful purposes or for beneficial ones [36,37]. Naturally, the literature also contains certain alarmist assessments that attempt to refute this perspective [38,39]. However, the weakness of such objections is evident, at least with respect to GenAI, since there is no doubt that it is capable of addressing one of the most pressing problems faced by the modern scientific and technological community: overcoming interdisciplinary barriers.

Consequently, there are sufficient grounds to assert that the further advancement of GenAI will continue to exert a pronounced influence on the scientific and technological community. The ambiguous outcomes associated with its increasing application make the search for objective criteria to evaluate faculty performance all the more urgent, especially for countries such as Kazakhstan. As noted earlier, the use of scientometric indicators has been subject to considerable criticism. This underscores the importance of substantiating their objective character, at least at the level of statistical regularities.

Such arguments can be advanced based on an analysis of the values of the coefficient γ, which appears in equation (2). It should be emphasized once again that this coefficient, somewhat surprisingly, remains close to values in the interval from 2 to 3 for systems of very different nature. In earlier studies of scale-free networks, attempts were made to interpret this fact through the lens of graph theory, including random graphs [40–42].

These attempts are undoubtedly valuable and merit attention. However, it should be emphasized that, unlike the study of the World Wide Web, the investigation of the regularities presented in this paper cannot be reduced solely to networks realized within the scientific and technological community. Clearly, the creation of scientific concepts depends not only on the effectiveness of an individual researcher's interactions with colleagues, but also on his or her personal qualities. Accordingly, the observed regularities inevitably reflect something far broader than merely the network structure of the research community.

A consistent interpretation of the results, particularly at a quantitative level, is not yet feasible at the present stage of research. Nevertheless, the following hypothesis may be proposed to interpret the findings at least at a qualitative level. In [43], a neural network model of society was advanced. It was demonstrated that society can be regarded as an analogue of a neural network.

Any system belonging to the class of scale-free networks, as discussed in the works cited above, may be considered as a subnet of this global neural network. In particular, if we speak about patterns reflecting citation statistics, one can distinguish a subnet associated with the scientific and technical community. If we turn to the processes underlying the creation of websites, a corresponding subnet may also be identified. Thus, society forms a definite system of mutually penetrating subnets closely interconnected with each other. From this perspective, the fact that all subnets are characterized by approximately similar numerical indicators is hardly surprising. The characteristics of the encompassing neural network determine the characteristics of each of these subnets, although certain relatively minor variations are naturally possible, as demonstrated by Table 1 above.

Furthermore, from the conclusion regarding the existence of a global neural network it follows that, in addition to the ordinary level of information processing, there must also exist a supra-personal level of information processing [43]. Indeed, as even relatively simple mathematical models show (e.g., [44]), the capacity of a neural network to process information depends nonlinearly on the number of its elements. This is also confirmed by current practice. Otherwise, there would be no rationale for constructing neural networks containing an ever-increasing number of elements [45,46]. Notably, GenAI is built upon precisely this type of neural network, which incorporates a vast number of elements.

Considering the global neural network, the above-mentioned fact implies that it acquires a new quality (in the philosophical sense of the term), which is not inherent to the relatively autonomous fragments localized within the brains of individual persons. This emergent quality generates the supra-personal level of information processing. It is worth noting that a number of mathematicians and physicists of the past intuitively acknowledged the existence of such a level. Corresponding examples are presented, for instance, in the monograph on the history of mathematics [47]. Charles Hermite (1822–1901), for example, expressed a conviction in the real existence of the world of mathematical ideas. A quotation from his letter to Thomas Jean Stieltjes, cited in [47], states:

"I am convinced that numbers and functions of analysis are not an arbitrary product of our spirit. I believe that they exist outside us with the same necessity as objects of objective reality, and we discover or uncover and investigate them just as physicists, chemists, and zoologists do."

Similar views were shared by Kurt Gödel, David Hilbert, Alonzo Church, and the Bourbaki group, who also believed that mathematical concepts and properties exist in some objective sense. Accordingly, mathematical truths are not invented but discovered, and what emerges is not mathematics itself, but human knowledge of mathematics. Such views are closely aligned with Platonism.

As noted in [48], "Many mathematicians are platonists: they believe that the axioms of mathematics are true because they express the structure of a no spatiotemporal, mind-independent realm. But platonism is plagued by a philosophical worry: it is unclear how we could have knowledge of an abstract realm; unclear how no spatiotemporal objects could causally affect our spatiotemporal cognitive faculties."

According to Godfrey Harold Hardy, mathematical theorems are either true or false, and their truth is entirely independent of whether or not we are aware of them [49]. Jacques Hadamard (1865–1963) likewise argued that although mathematical truth may not yet be known to us, it nevertheless preexists and inevitably guides us toward the path we must follow [50].

These considerations allow us to return to the role of GenAI from a somewhat unexpected perspective, although one that is closely related to earlier reflections on its capacity to overcome interdisciplinary and linguistic barriers. As already noted, in present conditions it is exceedingly difficult for an individual researcher to analyze the entirety of relevant literature. This fact reflects a broader reality: the interaction of an individual researcher with the scientific and technical community as a whole is highly constrained.

GenAI is capable of processing vast volumes of information and thus is able to interact with the supra-personal level of information processing. In this sense, it effectively becomes an intermediary between the "Platonic" world of mathematical ideas and the level of the individual researcher. More precisely, GenAI may be viewed as a mediator between two fundamentally distinct levels of information processing.

By way of illustration, it is extremely difficult for a person to engage in dialogue with entities that develop at the supra-personal level of information processing. Likewise, it is almost impossible to imagine a person engaging in dialogue with a single neuron in the cortex of their own brain. These are systems of different levels of organization. The role of GenAI as an intermediary in this context is difficult to overestimate.

Admittedly, this conclusion remains open to debate, yet it allows for the interpretation of the experimental results presented above from a new perspective. If the "world of ideas" indeed exists objectively (a hypothesis supported by considerable evidence), then the processes reflecting the interaction of this level of information processing with individuals must also have, to some extent, an objective character. In our view, this is precisely what is reflected in the results obtained in this study, according to which Hirsch index statistics across countries allow the scientific and technical community to be classified as a system of the scale-free networks type.

Let us now turn to recommendations that may be formulated on the basis of these findings, even setting aside the question of the validity of our proposed hypothesis. Specifically, the results demonstrate that the use of the Hirsch index at the very least reflects certain objective processes taking place within the scientific and technical community. At the same time, these patterns are inherently statistical.

In other words, they by no means permit us to assert with certainty that the criticism of the Hirsch index expressed in the works cited above [4–6] is unfounded. In fact, in these works the Hirsch index was primarily criticized in relation to its application to individual researchers. The objective existence of certain laws does not necessarily justify their application to individual cases.

However, when we turn to the institutional dimension, that is, when we consider the scientific and technical community of a country such as Kazakhstan as a systemic whole, the use of statistical regularities becomes fully justified. On this basis, at the very least, one may formulate recommendations pertaining to the management of the scientific and technical community as an integrated entity.

Indeed, any normative documents in practice establish specific framework constraints. They do not regulate the activity of an individual researcher but rather the functioning of the community as a whole. Consequently, it is reasonable to raise the issue of optimizing such framework constraints, drawing on the statistical regularities identified.

We believe that further research in this direction should proceed from the objective character of the regularities revealed in this study and related works. It is entirely possible that other scientometric indicators will also reflect these objective processes and that their use may prove even more appropriate. Nevertheless, this does not invalidate the problem formulation we propose.

Finally, it should be emphasized that, as evidenced by the experience of the National Scientific Councils of the Republic of Kazakhstan, there is currently an evident "oversaturation" of the review system with applications. Clearly, when the number of experts is limited (no more than 30 members in each council) while the number of applications is large (around 100 per competition), it is impossible to devote adequate attention to each individual proposal. This is due both to the factor of limited time and to the fact that the members of the National Scientific Councils serve on a voluntary basis. Under such conditions, the quality of review inevitably declines, and this applies even more strongly to the evaluation of reports on funded projects.

The criteria currently formulated in the competition documentation appear to have been chosen heuristically, since no mathematical models that would allow for the quantitative calculation of such parameters are available in the literature. Nevertheless, we believe that our results at least indicate that the development of mathematical models capable of establishing scientifically grounded criteria for grant applications constitutes a pressing task. An optimum must be found between the workload of experts, their ability to adequately evaluate submitted proposals, and the opportunities for members of the scientific and technical community to participate in the competition.

Excessively low entry requirements would result in a flood of applications, making high-quality review practically impossible. Conversely, overly strict requirements would restrict participation to only a limited group of individuals who already hold established positions in the scientific and technical community. It is essential, therefore, to identify an optimal balance. Current practice demonstrates that such an optimum is extremely difficult to determine heuristically, which makes it important to rely on objective regularities. Moreover, the first step is to recognize the existence of such regularities, some of which have been identified in this study.

This approach has another important implication. In practice, universities in Kazakhstan are largely oriented toward international rankings (one of which was used in constructing Table 2). These rankings are employed not only for positioning and promotion purposes (e.g., attracting prospective students), but also in several official tasks related to the governance of the higher education system. At the same time, the methodology of such rankings, borrowed from international practice, only partially reflects the actual conditions of the Republic of Kazakhstan, where the improvement of higher education quality remains an urgent task. It seems appropriate to shift the emphasis toward assessing the performance of the most prepared and talented students. A methodological reference point here is provided by Wilhelm von Humboldt's principles, according to which genuine higher education is inseparable from research activity. Therefore, in evaluating universities in Kazakhstan, the key indicators should be, first, the quality and productivity of the research conducted by academic staff, and second, the achievements of the most gifted students.

The results of our analysis (Table 2) confirm that this factor is insufficiently accounted for in existing ranking systems. Meanwhile, the data presented above demonstrate that the scientific and technical community exhibits the characteristics of a scale-free network. This allows us to hypothesize that the creative and research potential of students follows similar statistical regularities.

Thus, an additional argument arises in favor of transitioning to evaluation methods that incorporate the research potential of universities and the achievements of their most productive students through the use of objective and measurable indicators. While this issue requires further investigation, it is already possible at this stage to conclude that the development of adequate mathematical models enabling scientifically grounded criteria for the evaluation of universities, adapted to the specific context of Kazakhstan, is of critical importance.

5. CONCLUSIONS

The scientific and technical community, at least in the case of individual countries, should be regarded as a system belonging to the class of scale-free networks. Importantly, the regularities leading to this conclusion are derived from databases that reflect the Hirsch indices of individual researchers within specific national contexts. This makes it possible to argue that the use of scientometric indicators reflects objective processes taking place within the scientific and technical community, at least at the level of statistical patterns. Consequently, measurable indicators reflecting the research performance of university staff should receive increased attention in the construction of integrated university rankings, the development of scientifically grounded regulatory frameworks, and related tasks.

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Informed Consent Statement: Not applicable.

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Conflicts of Interest: The authors declare no conflict of interest.

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