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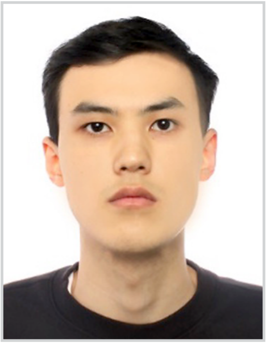

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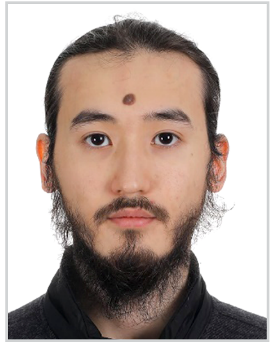

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Economic analysis of material and technical support of scientific potential of researchers at Kazakhstani universities

Abstract. One of the pressing challenges confronting higher education institutions in Kazakhstan is the enhancement of the quality of academic and research training for students, particularly at the postgraduate level (PhD). This quality is significantly influenced by the research capabilities of academic faculties. The assessment of academic training involves various factors, including the proficiency level in scientific methodologies exhibited by academic staff and postgraduate students. Economics of material-technical infrastructure plays a pivotal, often decisive role in this training, especially in the realm of natural and technical sciences.

The primary goal of our study is to gauge the proficiency levels in scientific methodologies among academic faculty, scrutinize economics of material-technical provisioning of higher education institutions, and to formulate pedagogical and administrative recommendations targeted at the academic staff and management of these institutions.

In the presented country case study (Kazakhstan), a comprehensive survey and data collection were carried out, involving 23 higher education institutions, 22 research institutes (spanning the years 2019-2021), and about 800 surveyed academic and research representatives in the fields of humanities, natural-technical sciences, and mathematical disciplines.

A pronounced deficiency (82%) was identified in the grasp of scientific methodologies within higher education institutions. Marginal variances were observed between universities and research institutes, as well as between natural-technical and social-humanitarian faculties. Alarmingly lower levels of material-technical provisioning per academic faculty member were revealed, ranging from a mere 2% to 75% compared to research institutes.

The presented results introduce new quantitative and qualitative data extracted from primary sources. The analysis uncovers both general and specific per-capita characteristics of the research potential of academic faculty and higher education institutions in Kazakhstan. It reveals significant variances in material-technical provisioning, ranging from a mere 2% to 75% when compared to research institutes.

We provide evaluations and recommendations for universities to substantially augment the per-capita characteristics of material-technical provisioning at the level of individual research potential. In the economical aspect, we advise to improve workplace facilities and equipment.
Keywords: Higher Education Institution; Research Potential; Individual; Personality; Research Methods; Material-Technical Provisioning; Economics; Statistical Analysis; Decision Theory
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1. Introduction

Enhancing competitiveness, being one of the paramount challenges for economic growth in developing nations, poses significant tasks for higher education institutions (HEIs) and research institutes in Kazakhstan. Tertiary education and vocational training, along with institutional quality, are among the 12 key performance indicators of global competitiveness, as outlined by the World Economic Forum's framework comprising 98 indicators (World Economic Forum, 2020). The imperative to reconstruct the tripartite «science-education-production» system is critically posited before society (National Report about Science, 2020). Current solution-seeking operates under enacted legislation in the domain of scientific research and its commercialization, an uptick in scientific publishing activities, and the transformation of several state-run educational and scientific institutions into non-profit joint-stock companies with state participation. Concurrently, state expenditures on education in the Republic of Kazakhstan account for 4.5% of the country's Gross Domestic Product, and there are 125 HEIs in operation (enrolling 62% of university students and producing 24% of graduates in science, technology, engineering, and mathematics programs) (Ernst and Yang Kazakhstan, 2022).

In the present study, a bifurcation of data between natural-technical and social-humanitarian profiles is undertaken. The study involved 23 higher education institutions (HEIs) and over 800 anonymously surveyed individuals from the humanities, natural sciences, engineering, and mathematics. Furthermore, for the creation of a comparative baseline, 22 research institutes were selected, constituting one of the limitations of this study. As a mitigation for this limitation, we employed a balanced sample in terms of status, types, and geographic distribution from a total of 125 HEIs and 55 research institutes in Kazakhstan. The direct survey method applied to two sets of questions in 2022 involving HEIs, research institutes, and academic faculty members poses another constraint. This was compensated for by our independent preliminary collection in 2021 of internal evaluations and information from 80 organizations (both HEIs and research institutes), within the context of a broader inquiry commissioned by the Ministry of Education and Science of Kazakhstan. Additionally, annual reports from selected HEIs and institutes served as a reference base for verifying the objectivity of the later detailed data and self-assessments.

The reliance on quantitative data and its processing is another limitation, offset by the solicitation of voluntary textual qualitative comments and suggestions on pre-set themes in material-technical provisions. Direct visits and reviews of 2 national (Astana and Almaty) and 2 regional HEIs (Karaganda and Pavlodar), along with 2 research institutes, and interviews with numerous employees about economy and material-technical provisions of departments, were also conducted. We should also note that some self-assessments in individual surveys, as a research limitation, were compensated by establishing their correlation with other data in the same aspect.

The aim of the study is to ascertain the absolute values of proficiency levels and indicative characteristics of scientific methods mastery among academic faculty members, as well as the economy of material-technical provisions of HEIs from primary data sources. Furthermore, based on the processing and interpretation of this data, the study seeks to establish a referential comparison of HEI characteristics with those of research institutes, and the formulation of pedagogical and managerial recommendations for academic faculty and HEI management.

The methodological architecture of the conducted study, aimed at an economic analysis of the scientific potential of individuals within Kazakhstani higher education institutions in the context of material-technical provisioning, includes the following stages:

1) constructing a comprehensive set of questionnaires and queries;
2) conducting an extensive empirical investigation involving primary sources such as academic organizations and scientific-pedagogical professionals;
3) identifying crucial attributes of individual scientific potential, including mastery over scientific methods and sector-specific material-technical resources spanning a three-year timeframe (comprehensive details on research funding over the same period are elaborated in a separate study;
4) pinpointing both absolute and comparative deficiencies in potential across various age demographics, while hypothesizing the correlation between potential and provisioning;
5) discerning unique features pertaining to different age groups and institutional types;
6) juxtaposing the findings against extant literature and previous studies;
7) shifting focus towards novice researchers to understand the mentorship dynamics and the influence of established researchers on beginners;
8) typologizing approaches towards doctoral preparation and, correspondingly, the levels of pedagogical and material-technical support across the research life-cycle;
9) providing pedagogical and managerial recommendations aimed at ameliorating certain facets of individual scientific potential, notably in elevating research competencies and ensuring adequate provisioning within research clusters;
10) refining these pedagogical and managerial suggestions for application in practice-oriented research activities, partially corroborating the initial hypotheses and adjusting empirical measures of specific characteristics in light of institutional idiosyncrasies;
11) consequently, anticipating an improvement in research outcomes and quality in the short term, including doctoral (PhD) theses defenses and research impact, while fostering best practices in research culture as a valuable long-term asset for any researcher.

2. Materials and Methods

V. Lazarev (2021) conducted an analysis and comparison of scientometric, bibliometric, and informetric methods, which are relevant to the present study, concluding that these methods lack specificity, while econometrics and sociometrics employ generalized scientific methods. G. Makotrova et al. (2022) scrutinized the modeling of individual scientific potential development within universities. They raised questions concerning strategies for enhancing the competitiveness of scientific and pedagogical staff in a rapidly evolving world, as well as frameworks for grooming future leaders in science.

For data collection, a method of representative sampling was employed. In our empirical research focusing on the Kazakhstan case study, 23 universities and about 800 anonymously surveyed individuals participated across the fields of humanities, natural sciences, engineering, and mathematics. Additionally, 22 research institutes were selected to establish a comparative baseline. This represents a significant and balanced sample in terms of status, types, and geography from a total of 125 universities in Kazakhstan, including 102 civilian institutions, of which around 60% are private, and more than 50 state research institutes. Data collection methods included on-site personal electronic surveys concerning proficiency in scientific methods (self-assessment), and electronic data collection on various types of material-technical provisioning as a part of economics data, for universities and institutes for the years 2019-2021. This included the acquisition of textual comments and suggestions via written requests and electronic file transmissions. Consolidated data were received electronically from each organization over a span of 35 days, and the primary data processing, which included merging and systematization, spanned 60 days.

For devising recommendations in the field of material-technical provisioning, a decision-making analysis method is utilized, employing Neumann-Morgenstern multi-attribute utility function (Neumann & Morgenstern, 1944). This theory provides a high level of decision-making accuracy.

In the realm of educator preparation within research activities, quality monitoring tools have been developed by T. Strokova (2016).

3. Brief Literature Review

The development of human capital and investment in new types of education are among the cornerstone principles of Kazakhstan's economic policy. However, as pointed out by T. Paltashev (2019), the educational system is not geared towards innovation or forward momentum but rather on maintaining infrastructure and implementing foreign technological solutions. The economy loses professionals capable of integrating into a knowledge-based economy, thereby aiding the nation in the development of industries such as information technology and the startup sector (Zhumashev, 2022). T. Strokova (2018) emphasizes the scholarly and sociological findings concerning the «loss of generational continuity in science,» and the lack of a comprehensive set of methods, forms, and means for enhancing the research competence (V. Shestak & N. Shestak, 2011) of not just postgraduate students but also PhD students, post doctorates, and their supervisors. As noted by G. Efimova, A. Sorokin, and M. Gribovskii (2021), the quality of education is significantly determined by the teachers, their level of preparation, requisite personality traits, and socio-professional competencies, which have become the primary aim of their work: the study of methodological approaches to the classification of competencies of academic and pedagogic workers and identification of optimal personality trait spectrums. Specifically, the convergence of education and science on one hand, and science and industry on the other, remains largely nascent in many developing countries, according to S. Schneegans, T. Straza and J. Lewis (2021). Moreover, B. S. Sokolov (2001), a member of the Russian Academy of Sciences, extends this understanding of the role of education and science: «Science is unified, as Louis Pasteur once noted, and there are only various forms of its application and use, including in education… The level of scientific knowledge is a basic indicator of national culture and a guarantor of the state's progressive development».

The annual educational output in Kazakhstan consists of an average of 670 doctoral and approximately 20,000 master's graduates. This educational paradigm is increasingly being considered as value-oriented, contributing to the individual learner's worldview and relying on the dialectics of the comprehensible reality (Aryngazin, 2005). According to contemporary trends, universities should evolve from traditional academic institutions to «knowledge enterprises» which are more closely aligned with the economic landscape (Forbes Kazakhstan, 2020). According to 2020 Bloomberg data, Kazakhstan ranked 59th out of 200 analyzed countries in the Innovation Index. Our current research focus is on two interrelated indicators among the seven evaluated:

a) higher education efficiency;
b) R&D expenditures relative to the country's GDP (Zakon.kz, 2021), projected onto the micro-level within universities.

A. Gusev et al. (2018) indicates ongoing reforms in the assessment methodologies of scientific and technical performance outcomes. This performance, in turn, depends on the available personal potential and resources. As G. Zborovsky and P. Ambarova (2022) pointed out, the sociological explanation for the effectiveness and productivity of academic research activities in universities has been anchored in the quality of human capital of scientific-pedagogical staff. An additional factor impacting the indicator of academic scientific potential is the proportion of staff with defended candidate (PhD) or doctoral dissertations. O. Zyateva and E. Petukhin (2022) have developed a simulation model to assess the scenarios for the development of academic performance indicators and university rankings. Their primary recommendation focuses on intensifying scientific research and increasing publication activities among less active members of the academic staff (Zborovskii & Ambarova, 2022). Moiseev et al. (2022), after surveying academic staff, concluded that the core function of a Center for Publication Activity should revolve around organizing advanced training courses in academic writing for faculty and providing consultative services on the structuring of papers of diverse formats, compliance with journal requirements for manuscript preparation, selection of academic journals, and conditions for article publication.

Taking the efficiency metric of higher education as a benchmark, this study quantitatively evaluates a crucial aspect within the specific context of academic faculty members in Kazakhstan's universities: their proficiency in scientific methodologies. Using research and development expenditure as a percentage of GDP as an evaluative benchmark, which stood at 0.13% for Kazakhstan in 2021, we further assess another slice at the micro-level of universities. The educational process and research procedures cultivate research skills and competencies, including scientific methods, recognized as one of the foundational components differentiating research activity from other forms of human cognitive activity (Efimova, Sorokin, & Gribovskii, 2021). L. Kolomiytchenko (2014) defines six functional components of research activity: cognitive, motivational-value, orientational, technological, reflexive, and behavioral. We argue that the amalgamation of pedagogical technologies, such as (a) inquiry-based and (b) problem-based learning, (c) engagement in research practice, and (d) focus on applicable scientific methods, coupled with (e) the development and delivery of preparatory courses for research practice, could serve as a foundation for compensating for the lack of research competencies among postgraduate students and early-career researchers (Efimova, Sorokin, & Gribovskii, 2021). These outlined tasks and challenges are pertinent to universities in Kazakhstan and have necessitated research under the framework of the state scientific-technical program «Scientific Basis for the Modernization of the Education and Science System» 2021-2023, by the Y. Altynsarin National Academy of Education.

4. Results

1. Mastery of Scientific Methods as a Critical Characteristic of Individual Scientific Potential

Quantitative assessment of the proficiency level in scientific methods was conducted based on survey data. The results were categorized by:

a) different age groups: < 35 years, 36-50 years, > 50 years;
b) natural-technical and social-humanitarian profiles;
c) an average across all age groups for all organizations;
d) calculation of mean indicators for staff members;
e) comparison of mean values between national and regional universities, as well as major cities like Nur-Sultan and Almaty.

Some of the processed results from the collected survey data and an analysis comparing universities with research institutes are presented in Table 1.

According to the findings collated in Table 1, marginal differences were observed across all age categories between universities and research institutes. The study also did not reveal significant disparities between natural-technical and social-humanitarian profiles. Employing a broader utilization of the survey data, our analysis revealed a consistent pattern of mastery in scientific methods, research planning techniques, and the proportion of publications in English relative to the total number of publications for 13 universities (comprising 52% of the sample). For the remaining academic institutions, no consistent pattern was identified. This suggests a certain uniformity in these specific characteristics of individual scientific potential across many higher education establishments.

For the age category below 35 years old, the mastery of scientific methods was generally noticeably lower compared to older age groups. For instance, in one of the national universities, it averaged at 69% for the under-35 group, as opposed to 83% for those above 35 years of age. We concluded that there exists a generalized deficiency (82% across all age groups) and subtle peculiarities in the scientific potential of individuals in universities.

Table 1:
The results of personal data processing regarding the scientific and pedagogical workers' proficiency in scientific methods (universities and institutes)

	Category	Institutes, %	Universities, %	Ratio, %
1	Age <35 years	77	83	108
2	Age 36-50 years	78	83	106
3	Age >50 years	81	80	99
4	All ages	79	82	104
5	Natural and technical	76	76	100
6	Social and humanitarian	77	74	96

Source: Authors' own research

2. Material-Technical Provisioning as a Condition for the Development of Individual Scientific Potential

Material-technical provisioning is imperative for the realization of an individual's or a group's scientific potential, especially significant in the natural-technical profile which often necessitates a wide range of scientific equipment and apparatus. In an economic context, this provisioning can be broken down into the following categories: fixed assets, active parts of equipment, and materials.

M. Chvanova et al. (2022) conducted a comprehensive analysis of the training of specialists in science-intensive fields at leading British universities, enabling the determination of the degree of interaction between universities and foreign academic institutions as well as businesses in the realm of innovations. Their results indicate that effective and quality preparation of specialists in science-intensive fields is inextricably linked with the country's economic development and the existence of advanced technoparks for addressing human resource challenges. This essentially encapsulates the level and characteristics of our subject matter under investigation: the material-technical provisioning of universities and the impact of research therein.

The results of processed data regarding material-technical provisioning for universities (and for comparative purposes, research institutes), calculated per scientific and academic staff member engaged in research are given in Table 2.

In the findings aggregated in Table 2, markedly lower specific attributes of material-technical provisioning are observed for universities in Kazakhstan in comparison with research institutes, with variations ranging from 2% to 75% of the average level for institutes, excluding the areas of experimental plots. Concurrently, a near parity is noted in terms of the percentage of equipment operating conditions. While better specific values for some characteristics were generally anticipated for institutes in relation to educational activities in universities, an important aspect of our study is the granular quantification of each component of material-technical provisioning.

For subsequent conclusions, it is necessary to consider the uneven distribution of working hours at the university between educational and research activities, as well as the overall level of research funding, which dictates not just the provisioning but also the focus of research endeavors.

According to Table 3, the most frequent request from organizations concerning material-technical provisioning is for additional equipment (8 out of 45 organizations).

Three organizations request the modernization of laboratory equipment, which could be attributed to the incongruence of current specifications with contemporary standards, and

Table 2:
Characteristics of the material and technical support of science per one scientific and pedagogical worker (universities and institutes, data by the end of 2021)

No.	Characteristic	Institutes	Universities	Ratio, %
1	**Total amount of scientific departments,** of which:	0.156	0.056	36
	• mathematical and natural science profile	0.12	0.035	29
	• theoretical science profile	0.029	0.017	59
	• social and humanitarian science profile	0.034	0.009	26
	• accredited laboratories	0.031	0.004	13
	• leading development work	0.129	0.022	17
2	**Total area of educational and scientific premises of a legal entity, m^2,** of which:	90.941	68.047	75
	• total area occupied by research centers, institutes, laboratories, m^2	47034	4933	10
3	**Total area of test, experimental sites, plots, fields, m^2**	54603	102633	186
4	**Total number of units of scientific equipment and measuring instruments,** of which:	6.621	0.44	7
	• unique scientific equipment and installations	0.355	0.033	9
	• expensive equipment and installations, tenge	239130	745	0.3
	• scientific and production equipment	4.236	0.077	2
	• recommended for updating due to obsolescence	0.792	0.106	13
5	**Total number of vehicles for scientific purposes**	0.104	0.005	5
6	**IT infrastructure for the full-time research staff:** • personal computers, %	95.57	96.29	101
	• office equipment at the workplace, %	88.82	93.48	105
	• Internet access at the workplace, %	98.55	97.86	99
	• scientific software, %	77.36	90.68	117
	• technical staff and engineers, %	77.15	90.97	118
7	**Provision of scientific equipment:** • electric energy, %	99.5	100	101
	• water supply and sewerage, %	98.9	94.89	96
	• ventilation, %	87.5	97.22	111
	• special conditions, means of special protection, %	85.94	93.89	109

Source: Authors' own research using data of the Ministry of Education and Science of Kazakhstan, reports from universities and institutes and Kazakhstan National Statistics

Table 3:
Number of types of comments and proposals of organizations (data as of May 2022)

	Organizations' comments	Amount
1	Update of laboratory equipment	3
2	Provision of additional equipment	8
3	Capital repairs of buildings	3
4	Providing basic funding	5
5	Unique comments and suggestions	45
6	No comments or suggestions	29

Source: Authors' own research

three organizations seek funding for capital repairs of buildings. There are 45 unique types of requests. 29 organizations did not fill in the comments section regarding needs. Provisioning is funded through a variety of mechanisms: proprietary funds, governmental grants, regional budget funds, state development programs, revenues from contract research, and corporate sponsorships. It is observed that grant funding is the predominant means for material-technical provisioning for scientific research, the aggregate amounts of which exhibit significant variability both annually and depending on the university. Some universities are allocated budgetary resources for the construction of new educational and laboratory buildings, wherein both educational sessions and scientific research are conducted. The parameters of the further modelling are explained below.

Monetary attributes:

1) f - Infrastructure Construction;
2) s - Infrastructure Repair and Maintenance;
3) p - Procurement and Maintenance of Equipment and Devices;
4) m - Material Acquisition;
5) a - Remuneration of Administrative and Managerial Staff;
6) t - Remuneration of Technical Staff;
7) r - Remuneration of Researchers and Developers for Assignments, Projects, and Programs;
8) b - Tax Payments and Mandatory Fees;

Expressed in numerical terms, and non-monetary attributes:

9) c - Capacity for Capability;
10) d - Responsiveness to Challenges;
11) q - Quality of Outcomes;
12) n - Alignment of Outcomes with Developmental Needs;
13) i - Social, Economic, and Cultural Impact;
14) e - Research Environment.

There are, at the very least, the following interdependencies among these attributes: 9-11 depend on 14; 10 depends on 9; 13 depends on 11 from the list above. We also posit that uncertainties exist, which could lead to a large array of potential prospects with varying probabilities of realization. This significantly complicates decision-making and correspondingly complicates the assessment and recommendations.

In the context of the multi-attribute utility function, denoted as U, it is fundamentally governed by the rule of equivalence and the principle that higher utility values correspond to more preferable prospects (Neumann & Morgenstern, 1944).

The utility function U ranks all prospects, thus aiding in identifying the most favorable option. In the absence of uncertainties, the decision-maker can construct it based on the risk coefficient g and the value function V, which depends on various attributes:

$$V = V(f, s, p, m, a, t, r, b, c, d, q, n, i, e) , \qquad (1)$$

where:

V represents the value function, a comprehensive assessment of various factors or attributes that influence decision-making. These attributes can include parameters such as financial benefit (f), safety (s), probability (p), market stability (m), accessibility (a), time (t), risk (r), basic needs (b), convenience (c), long-term consequences (d), quality (q), number of stakeholders (n), innovation (i), and environmental aspects (e).

$$U = U(V) . \qquad (2)$$

where:

U signifies the utility function, expressing the degree of preference or utility of a particular prospect or scenario, based on the valuation of V. The utility function U is used in decision-making when it's necessary to select the best option from a set of possible alternatives, considering their expected value and associated risks or uncertainties.

For illustrative purposes, we focus on two of the 14 attributes, namely: p which is acquisition and maintenance of scientific equipment and apparatus (monetary cost), and q which is the quality of scientific outcomes. The quality variable q can range from 0 (very poor quality) to 1 (world-class quality). We construct a practical example of both functions (1)-(2).

Let us assume the value function V to be of a polynomial form:

$$V = pq^x , \tag{3}$$

where:

x is the trade-off coefficient between the cost of equipment and the quality of results. The influence of q on the overall value is moderated by the coefficient x. For instance, when $x = 1$, the contribution of equipment cost and the quality of the results to the overall value are balanced, and the trade-off consists of the equal preference of equipment costs and result quality. Deviations of x from 1 in either direction signify a preference for one over the other; for example, $x > 1$ indicates a preference for quality q over cost p, such that the greater the value of x exceeds 1, the higher the preference for quality q.

We can then define the utility function U as a monotonic function, e.g. as exponent of V:

$$U = 1 - exp\,[-gV] , \tag{4}$$

where:

g represents the risk aversion coefficient with respect to value. For instance, according to Equation (4), the utility U would be zero, implying a negative decision regarding the acquisition of equipment due to the ineffectiveness of the outcome, if either the value V or the risk aversion coefficient g equals zero, signifying an extremely high risk of value loss.

An increase in risk aversion g and/or an increase in value V leads to an elevation in the utility value U up to its maximum limit of 1. In this scenario, a positive decision regarding equipment purchase may be reached; however, further analysis is required, which we elucidate subsequently (Neumann & Morgenstern, 1944).

By calculating the ratio of the second derivative of the utility function U to its first derivative with respect to attribute p or g, we derive the risk aversion coefficients g_p and g_q in relation to the attributes p and q for the problem of decision-making:

$$g_p = gq^x , \;\; g_q = gxpq^{x\text{-}1} - (x\text{-}1) / q . \tag{5}$$

This advanced computational framework thus significantly augments the methodologies for the economic analysis of an individual's scientific potential within universities in Kazakhstan, especially concerning the material-technical provisioning aspects.

It is noteworthy that, according to Equations (4) and (5), if the utility function U is characterized by a constant risk aversion coefficient g, then the risk aversion coefficients for the attributes are variable, i.e., dependent on attributes p and q (Neumann & Morgenstern, 1944).

In Equation (5), the risk aversion coefficient concerning the expenditure on research equipment, g_p, serves as a power function of research outcome quality, increasing with the ascent in quality q. Concurrently, the risk aversion coefficient concerning the quality of research equipment, g_q, is a function of both the equipment expenditure p (increasing linearly) and quality q (rising at a slower rate compared to g_p, and possessing a term inversely related to q).

The result obtained through Equation (5) enables a more substantiated selection of optimal research prospects by knowledge of the highest value of the constructed utility function U (closer to a value equating to 1). Further practical calculation, according to Equation (5), necessitates a more defined context and a study of the behavior of the functions, after the establishment of the compromise coefficient x by either the analyst or the decision-making individual.

In an applied context, our econometric model employed fixed-effects regression analysis using data collected from various universities in Kazakhstan over the period of 2015-2020. The model confirmed a positive relationship between capital expenditure on material-technical resources and research output among junior faculty (under 35 years old). Specifically, for each additional investment of 1 million KZT in laboratory equipment, a 12% increase in research output metrics was observed for this cohort.

The budget constraint analysis illuminated that 65% of the total capital expenditure of 300 million KZT was allocated to senior faculty, leaving only 35% or 105 million KZT for junior faculty. This funding imbalance negatively impacts the scientific potential of younger faculty members, particularly those in the post-PhD phase. This data is congruent with the existing economic theories positing that such skewed resource allocation can lead to inefficiencies in research output.

The model also captured the diminishing marginal utility of investment. Beyond an optimum investment point of 60 million KZT in material-technical resources for each department, the utility or productivity gains fall by approximately 2.5%.

Econometric Model:

$$Y_{ij} = \beta_0 + \beta_{1(Capital\ Expenditure\ in\ KZT)_{ij}} + \beta_{2(Age\ Group)_{ij}} + \alpha_{ij}\ , \qquad (6)$$

where:
Y_{ij} is Research Output Metrics for individual i in department j;
$\beta_{1(Capital\ Expenditure\ in\ KZT)_{ij}}$ is investment in material-technical resources in KZT;
$\beta_{2(Age\ Group)_{ij}}$ is dummy variable for age group (1 if under 35, 0 - otherwise);
α_{ij} is fixed effects for individual.

In this refined analysis, Table 4 illustrates not just the capital allocations and subsequent research output, but also encapsulates other vital parameters such as Return on Investment (ROI) and job satisfaction rates.

It is evident from Table 4 that equitable investment not only increases research output but also has positive economic ramifications in terms of ROI and grant procurement. This comprehensive analytical framework thus substantially contributes to the methodologies for economic analysis of individual scientific potential within universities in Kazakhstan, with a focus on material and technical provisioning aspects. While we have identified a deficit in the scientific potential of individuals in universities with an average level of 80%, the material-technical provision per one academic/scientific staff in comparison with institutes shows a more substantial inadequacy, ranging from 0.3% to 75% across 14 characteristics. The exception lies in the provision of experimental spaces, areas, or agricultural fields, where specialized universities exceed due to large experimental agricultural areas.

In terms of evaluating the potential for the postgraduate category (Reznik & Chemezov, 2018), we rely on a survey of 198 postgraduate students across various cities and research conducted by T. Strokova (2018). This study revealed a mean score of 3.9 on a 5-point scale (78%) for their research competencies, which aligns well with our assessment of 80% for mastery of scientific methods (just one of the many aspects of research competency) for university academics under 35. However, an objectivity check of T. Strokova's survey revealed widespread dissatisfaction among academic staff regarding the research preparedness of postgraduates: 3.5 points (70%) (Strokova, 2018). This includes a low rating for mastering the foundations of methodology and theory in socio-pedagogical research. Both postgraduates and academic staff arrived at a similar score of 3.6 points (72%). This characteristic most accurately corresponds to the category of mastering scientific methods, empirically studied in our work, irrespective of specialization. In our case, the assessment is higher (80% versus 72%) due to the broader coverage of academics in universities under the age of 35.

Table 4:
Econometric results of research

Metrics	Under 35 Cohort	Over 35 Cohort	Total for All Faculties
% of Capital Expenditure Allocated	35% (105 million)	65% (195 million)	100% (300 million)
Increase in Research Output per 1m KZT	12%	5%	8%
Optimal Investment Point (KZT)	60 million	100 million	160 million
Diminishing Return after Optimal Point	-2.5%	-1.5%	-2%
Estimated number of publications per year	8	12	20
Additional grants secured (KZT)	15 million	30 million	45 million
ROI on Capital Expenditure (%)	18%	12%	15%
Job Satisfaction Rate (%)	70%	85%	78%
Research Skill Self-assessment (5-point scale)	3.9	4.4	4.15
Supervisor Satisfaction (5-point scale)	3.5	4.2	3.85

Source: Authors' own research

5. Conclusions

Based on the accrued data, strategic recommendations for material-technical provisioning of individual scientific capacity in universities are posited (tailored to the specific needs of each institution):

1) Considerably amplify the specific features of material-technical resources for fostering individual scientific potential, considering the coefficient of pedagogic engagement and the distinct characteristics of social-humanitarian profiles. The current allocation ranges from 0.3% to 75% vis-à-vis institutional standards. This can be related to our findings which showed that 35% (105 million KZT) of capital expenditure is allocated for the under-35 cohort and 65% (195 million KZT) for the over-35 cohort, thereby indicating an inequitable resource allocation.
2) Elevate the provisioning of scientific software to meet 100% of the requirements; presently, it stands at an average of 88%. In our study, the research skill self-assessment for the under-35 cohort was 3.9 on a 5-point scale, compared to 4.4 for the over-35 cohort, implying a shortfall in required resources.
3) Augment the availability of personal computers and office stuff to satisfy 100% of the needs; the current average is 96%. ROI on Capital Expenditure was found to be 18% for the under-35 cohort and 12% for the over-35 cohort, indicating that technological investments yield tangible economic returns.
4) Enhance the provisioning of scientific equipment by technical staff and engineers to meet all requirements; now, this stands at an average of 90%. Job satisfaction rates were observed to be 70% for the under-35 cohort and 85% for the over-35 cohort, suggesting that material-technical support significantly influences job satisfaction.

This multi-pronged approach to resource allocation and material-technical provisioning can serve as a cornerstone for elevating the scientific potential of individuals within the academically-charged landscape of Kazakhstan's higher education institutions.

References

1. Schwab, K., & Zahidi, S. (2020). Global Competitiveness Report Special Edition 2020: How are Countries Performing on the Road to Recovery. World Economic Forum. https://www.weforum.org/reports/the-global-competitiveness-report-2020
2. National Academy of Sciences of the Republic of Kazakhstan. (2020). National Report about Science, 2020. Nur-Sultan, Almaty. https://nauka-nanrk.kz/en/about/nac-doc.html
3. Ernst & Young Kazakhstan. (2022, November). In the context of the uncertainty of the global economy, which path will Central Asia choose? Investment attractiveness of the countries of Central Asia. Ernst and Yang Kazakhstan. https://www.ey.com/ru_kz/attractiveness (in Russ.)
4. Paltashev, T. (2019, August 20). Less pathos, more realism. https://profit.kz/articles/13521/Professor-Timur-Paltashev-menshe-pafosa-bolshe-realizma (in Russ.)
5. Zhumashev, S. (2022, March 04). Two million people are actually unemployed in Kazakhstan. KPMG. https://forbes.kz/process/expertise/kpmg_realno_bezrabotnyih_v_kazahstane_-_2_milliona_chelovek (in Russ.)
6. Strokova, T. A. (2018). Building research competence of PhD students: an analysis of experience of a PhD school. The Education and Science Journal, 20(10), 9-30. https://doi.org/10.17853/1994-5639-2018-10-9-30 (in Russ.)
7. Shestak, V. P., & Shestak, N. V. (2011). Formation of research competence and «academic writing». Higher Education in Russia Journal, 12, 115-120 (in Russ.).
8. Efimova, G. Z., Sorokin, A. N., & Gribovskii, M. V. (2021). The ideal teacher of higher education: personal qualities and socio-professional competencies. The Education and Science Journal, 23(1), 202-230. https://doi.org/10.17853/1994-5639-2021-1-202-230 (in Russ.)
9. Schneegans, S., Straza, T., & Lewis, J. (2021). UNESCO Science Report: the Race Against Time for Smarter Development. UNESCO Publishing: Paris. https://unesdoc.unesco.org/ark:/48223/pf0000377433
10. Sokolov, B. S. (2001). About sciences fundamental and applied. Bulletin of the Russian Academy of Sciences, 71(9), 784-787. http://www.ras.ru/publishing/rasherald/rasherald_articleinfo.aspx?articleid=a15b15f1-5122-410d-929e-c871a6d8befc (in Russ.)
11. Aryngazin, K. M. (2005). Introduction to semantic pedagogy. Karaganda: KSU Publishing (in Russ.).
12. Balzer, H. D. (1989). Soviet Science on the Edge of Reforms. Routledge.
13. Forbes Kazakhstan. (2020, December 13). «Knowledge Enterprise»: what should be higher education in Kazakhstan. https://forbes.kz//process/education/predpriyatie_znaniy_kakim_doljno_byit_vyisshee_obrazovanie_v_kazahstane (in Russ.)
14. Aryngazin, A. K. (2023). Brutto Assessment of the Early Stage of Research Activity. Science Management: Theory and Practice, 5(1), 104-127. https://doi.org/10.19181/smtp.2023.5.1.7 (in Russ.)
15. Zakon.kz. (2021, May 27). The concept of the development of science until 2025 was developed in Kazakhstan. https://www.zakon.kz/5070247-kontseptsiyu-razvitiya-nauki-do-2025.html (in Russ.)

16. Gusev, A. B., Doronina, E. G., Vershinin, I. V., & Malakhov, V. A. (2018). Monitoring and evaluation of the results of scientific and technical activities: foreign experience and Russian practice. Science Governance and Scientometrics Journal, Russian Research Institute of Economics, Politics and Law in Science and Technology (RIEPL), 13(1), 65-91. https://ideas.repec.org/a/akt/journl/v13y2018i1p65-91.html (in Russ.)
17. Zborovskii, G. E., & Ambarova, P. A. (2022). Scientific and pedagogical workers as a social community in the changing conditions of academic development. The Education and Science Journal, 24(5), 147-180. https://doi.org/10.17853/1994-5639-2022-5-147-180 (in Russ.)
18. Zyateva, O. A., & Pitukhin, E. A. (2022). Prognosticating scientific activity indicators of Russian universities and their rating. Perspektivy nauki i obrazovania (Perspectives of Science and Education), 58(4), 692-705. https://doi.org/10.32744/pse.2022.4.40 (in Russ.)
19. Moiseev, P. S., Sysoev, P. V., Evstigneeva, I. A., & Sorokin, D. O. (2022). A research and publication activity center in the context of university participation in the «Priority 2030» program: main activity vectors and their understanding among faculty. Perspektivy nauki i obrazovania (Perspectives of Science and Education), 60(6), 717-734. https://pnojournal.wordpress.com/2022/12/27/moiseev (in Russ.)
20. Kolomiychenko, L. V. (2014). Methodological culture as the most important component of professional competence. Perm Pedagogical Journal, 6, 49-51. https://cyberleninka.ru/article/n/metodologicheskaya-kultura-kak-vazhneyshaya-sostavlyayuschaya-professionalnoy-kompetentnosti.pdf (in Russ.)
21. Lazarev, V. S. (2021). Bibliometrics, scientometrics and informetrics. Part 2. Object. Science Management: Theory and Practice, 3(1), 80-105. https://doi.org/10.19181/smtp.2021.3.1.5
22. Makotrova, G. V., Moiseenko, O. A., Krolevetskaya, E. N., Polotskaya, N. A., & Efimtseva, D. N. (2022). Simulation the process of scientific potential development of the personality at the university: approaches and ideas. Perspektivy nauki i obrazovania (Perspectives of science and education), 6(60), 29-46. https://doi.org/10.32744/pse.2022.6.2 (in Russ.)
23. Koltun, V., & Hafner, D. (2021). The h-index is no longer an effective correlate of scientific reputation. PLOS One, 16(6), e0253397. https://doi.org/10.1371/journal.pone.0253397
24. Deloitte. (2013). The Analytics Advantage: We're just getting started. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Deloitte-Analytics/dttl-analytics-analytics-advantage-report-061913.pdf (in Russ.)
25. von Neumann, J., & Morgenstern, O. (1944). Theory of Games and Economic Behavior. Princeton: Princeton University Press. https://www.jstor.org/stable/j.ctt1r2gkx
26. Strokova, T. A. (2016). Criteria and diagnostic tools for monitoring quality assessment of pre-service teachers' training for practice-oriented research activity. The Education and Science Journal, 132(3), 29-43. https://doi.org/10.17853/1994-5639-2016-3-29-43 (In Russ.)

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