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THE COMPARISON OF RESEARCH UNIVERSITIES AND THEIR PRINCIPAL INDICATORS WITHIN THE CONTEXT OF MONGOLIA

Abstract. A research university plays a vital role in a country's development, particularly in the socio-economic advancement of developing nations, beyond its function of generating and disseminating knowledge in specific fields. Across the globe, research universities are recognized as the primary drivers of scientific and technological progress and the cultivation of a knowledge-based economy. Consequently, nations worldwide are giving particular attention to fostering research universities as hubs for innovation and new knowledge production. This article investigates the evolution of research universities and draws from countries' experiences in establishing and nurturing them. Additionally, it compares the performance metrics of some leading Mongolian universities with those of globally renowned institutions and discusses the challenges anticipated in establishing a research university in Mongolia. The establishment and growth of a research university are imperative for our nation, not only for enhancing the higher education sector but also for fostering scientific and innovative endeavors within the country.

Keywords: innovation management, research and development, entrepreneurship, cooperation and partnership, world-class university.

HISTORICAL DEVELOPMENT OF RESEARCH UNIVERSITIES

In fact, the contemporary research university dates back only to the beginning of the 19th century-specifically to Wilhelm von Humboldt’s reformed University of Berlin. Before that, universities were largely devoted to teaching and to the preparation of professionals in fields such as law, medicine, and theology. Although the Humboldtian model brilliantly focused on research, it stressed research for national development and applied work as much as, if not more than, basic research. From this research model, the disciplinary structures emerged–with the development of fields such as chemistry and physics, as well as the social sciences, including economics and sociology [1].

In the case of the United States, it was in 1862 that the federal government granted land to each state to support universities. Morrill's law provided significant momentum to universities in agriculture and mechanization, enabling them to educate specialists and conduct experimental research. Consequently, these supported universities have made a valuable contribution to the leading position of U.S. agriculture globally [6]. These were semi-research universities, marking the beginnings of research universities in the United States. By the middle of the 20th century, US research universities had become the world's foremost models of higher education. Through substantial government funding for research, a shift in educational emphasis towards research, and the integration of a robust, non-profit research and teaching sector, US universities have attained international recognition as the "standard of excellence" [1]. After World War II, or after 1950, the period spanning from 1950 to 1975 and beyond 1975 can be divided into two stages based on the role of research universities in the science, technology, and society of the United States. In the first stage, research universities emerged as the nucleus of the science and technology systems of developed nations. Subsequently, in the second stage, the proportion of funding from government and industry for research and development continued to rise, leading US research universities to evolve into a global model. For instance, since 1975, the number of Nobel Prize-winning scientists from US research universities has far surpassed the combined count from scientists in the rest of the world [4].

Research-based learning was regarded as the ideal approach for the modern university. This concept started being discussed in many countries worldwide in the 1970s and gained momentum in the 1990s. Consequently, numerous institutions shifted their development focus from teaching-based to research-based activities. By the early 2000s, the establishment of research universities was realized.

II. DEVELOPMENT OF RESEARCH UNIVERSITIES

In order to achieve the Millennium Development Goals, the utilization of new advanced knowledge and the training of competent specialists will hold a crucial position. The role of the higher education system, particularly research universities, is paramount in this endeavor. According to J. Salmi (2009), three main conditions influence any university's journey towards achieving world-class status. These include:

1. Attracting talented researchers.
2. Ensuring adequate financial resources, training, and research environments.
3. Establishing an effective management system.

In his book “The Challenge of Establishing World-Class Universities" J. Salmi presents three main ideas for constructing a world-class university:

- Improving the operations of select existing universities (through selection).
- Consolidating certain institutions and elevating them into a new model university (Hybrid formula).
- Establishing entirely new universities through government intervention (new advanced method).

Countries around the globe are implementing these methods when establishing research universities, with the first two approaches being commonly favored.

Countries experiencing rapid economic development have actively enhanced their universities in the era of globalization. Many examples demonstrate that it is possible to ascend to the ranks of top universities worldwide within a relatively short period, despite taking several centuries. Consequently, as nations reinforce and enhance the academic and research capabilities of their leading national universities, they have also initiated the establishment of new research universities.

The establishment of research universities within Korea's national research system has seen significant progress, particularly since the launch of the Brain Korea 21 project in 1999, leading to the emergence of seven selective Korean universities characterized by notable growth in research publications, citations, and patent registrations, as well as high rankings in global systems, yet Korea's achievement of fully competitive research universities remains premature, with challenges persisting in Ph.D. training programs and a predominant emphasis on quantity rather than quality of research accomplishments [11].

China stands out as the most successful country in establishing world-class universities. The endeavor to establish such universities commenced with the implementation of the "211 projects" and "985 projects" by China's Ministry of Education.Top of Form

Established in 1995, the "211 project" aimed to develop 100 internationally competitive universities, prioritizing key areas in the country's economy and social life by the first half of the 21st century. This national initiative emphasized four primary domains: interdisciplinary programs, digital campuses, workforce development, and university infrastructure. Subsequently, in 1998, the "21st Century Education Reform Program" was sanctioned and incorporated into the "985 Project" with the objective of establishing premier universities and research centers (totaling 39 universities). The project involved phased investments to support these 39 universities, fostering gradual improvements in university leadership, management, and human resource capacity. Through the implementation of these initiatives, Peking University and Tsinghua University each received 1.8 billion RMB ($225 million), while other universities were allocated between 400 million RMB and 1.4 billion RMB respectively [5]. For instance, Shanghai Jiaotong University's total budget has quadrupled over the past 10 years. Of Shanghai Jiao Tong University's income, 20% originates from regular government funding, 20% from government-initiated special funding such as the "985 Project" and "211 Project," 30% from research income, 20% from tuition fees, and the remaining 10% from various other sources, including donations and income from university-affiliated enterprises [1].

China's 985 Project, one of the earliest national initiatives to concentrate research funding to build world-class universities, has, over its ten-year span, empowered selected institutions to enhance their research capabilities and competitiveness, thereby reducing the disparity between them and their global counterparts [14].

Through the implementation of "Project 211" and "Project 985," the number of schools listed among the world's best universities by the Times Higher Education organization has increased. Additionally, the aim of doubling the number of universities recognized as the world's best within the next 30 years has been established [10].

Examining world-class universities solely through technical benchmarks or as part of a nation-state strategy to address global competition underestimates their significance in reshaping human life, as illustrated by the Chinese experience, which prompts reflection on the limitations of Chinese world-class university policy instrumentality and the interplay between states and universities [7].

Let's compare the methodologies of three organizations (QS World University Rankings, Times Higher Education, Academic Ranking of World Universities) that determine the rankings of globally recognized universities [16].

The QS World University Rankings are based on six indicators: research, teaching staff, teaching, and globalization. A university is required to offer advanced and post-graduate studies and operate in at least two of the five fields (including humanities and arts, engineering and technology, social sciences and management, natural sciences, agriculture, and medicine). These indicators include:

- Academic reputation (40% of the total score): Global academic research reputation.
- Employer reputation (10%): Reputation of graduates who are leaders in their field.
- Student-to-faculty ratio (20%): High-quality training and counseling.
- Research citations per faculty member (20%): Extent of institutional research.
- Proportion of international faculty (5%): Employment of foreign teachers.
- Proportion of international students ((5%): Status of foreign students.

Times Higher Education evaluates 13 criteria across 5 categories, including:

- Teaching (30%): Prestigious research (15%), faculty-student ratio (4.5%), bachelor and doctoral student ratio (2.25%), doctoral graduate ratio (6%), institutional revenue (2.25%).
- Research (30%): Reputation research (18%), research income/teacher-to-purchasing power parity ratio (6%), number of articles published in highly rated journals per teacher (6%).
- Research citations (30%).
- International outlook (7.5%): Foreign student ratio (2.5%), foreign faculty ratio (2.5%), international collaborative research (2.5%).
- Industry income (2.5%): Balance ratio between industry income and the teacher-to-purchasing power parity ratio.

The Academic Ranking of World Universities (ARWU) published by Shanghai Jiao Tong University relies on six indicators, prioritizing research:

- Alumni (10%): Graduates who have received Nobel Prizes and Fields Medals for breakthroughs in their field.
- Awards (20%): Graduates who have won Nobel Prizes, Fields Medals for breakthroughs in their field, and highly cited research in 21 disciplines.
- Highly cited studies (20%): Thomson Reuters index of indexed works.
- Papers in Nature and Science (20%): Articles published in Nature and Science journals during four years.
- Indexed articles (20%): Articles published in the previous year in the Science Citation Index and Social Science Index.
- Per capita performance (10%): The sum of the above five criteria divided by the number of teachers and researchers at the school.

As of 2023, schools ranked in the top 1000 worldwide by these institutions' rankings can be considered research universities, as 60 to 100 percent of their indicators are recognized globally as research indicators. Considering countries with the highest number of highly ranked universities:

- According to Times Higher Education, the countries with the most schools in the top 1000 are the USA (160), England (92), China (65), Italy (59), Germany (49), India (37), France (31), Australia (31), Canada (30), Spain (27), Japan (22), South Korea (18), Russia (18), and the Netherlands (13).
- According to QS World University Rankings, the countries with the most schools in the top 1000 are the USA (160), England (81), China (59), Germany (44), Japan (38), Italy (33), Russia (32), South Korea (31), Australia (36), France (24), India (28), Canada (27), Spain (24), and the Netherlands (13).
- According to the Academic Ranking of World Universities, the countries with the most schools in the top 1000 are the USA (196), China (186), England (63), Germany (47), Italy (46), Australia (33), Japan (32), Spain (40), South Korea (30), France (28), Canada (26), India (14), the Netherlands (13), and Russia (10).

According to this data, universities in developed countries dominate the world rankings, while universities in China, Japan, South Korea, and India have gained significant global positions, not only in Asia but also worldwide.

Salmi (2009) made the case that the superior results of these institutions–highly sought graduates, leading-edge research, and dynamic knowledge and technology transfer–could essentially be attributed to three complementary sets of factors at play in top research universities: (a) a high concentration of talent (faculty members and students); (b) abundant resources to offer a rich learning environment and to conduct advanced research; and (c) favorable governance features that encourage leadership, strategic vision, innovation, and flexibility and that enable institutions to make decisions and manage resources without being encumbered by bureaucracy.

Adequate facilities for academic work are essential– the most advanced and creative research and the most innovative teaching must have access to appropriate libraries and laboratories, as well as to the Internet and other electronic resources [2]

III. RESULTS COMPARING SOME UNIVERSITIES OF MONGOLIA WITH WORLD LEVEL UNIVERSITIES

Table 1 displays various indicators of Mongolia's two largest universities, NUM and MUST, compared to representative research universities from each continent.

According to the comparison, while the number of students per teacher at MUST and NUM is similar to that of foreign research universities, their budgets are considerably lower. For instance, the cost per student at foreign research universities exceeds $4,000 (excluding Russian universities), whereas the operational expenses of our country's universities, NUM and MUST, range from 50.5 to 55 billion MNT. When converted to the exchange rate of US dollars (in 2021, the official exchange rate was 2,849 MNT per US dollar), this amounts to $820 to $1,420, or 2 to 80 times lower than the figures for foreign universities.

Table 1

Comparison of the main indicators of universities

Universities, year of establishment	Number of students	Student to-faculty ratio	Endowment /USD/	Annual budget /USD/	Per student expenditure /USD/
University of Ibadan (1962)	19521	16:1	0,2 million	43 million	46700
Shanghai Jiao Tong University (1896)	14000	15:1	120 million	700 million	16300
Pohang University	3100	6:1	2 billion	220 million	70000

of Science and Technology (1987)					
University of Chile (1842)	30702	15:1		520 million	17000
Catholic University of Chile (1888)	22035	8:1		453 million	20500
Indian Institutes of Technology 1950)	28000	8:1		123 million	4400
Hong Kong University of Science and Technology (1991)	9271	19:1	0.25 million	267 million	28850
University of Malaya (1949)	26963	12:1		271 million	14000
National University of Singapore (1980)	27396	14:1	1 billion	1.37 billion	39000
Monterrey Institute of Technology (1943)	25705	12:1	1 billion	1.15 billion	10200
Higher School of Economics (1992), Russia	16000			45.5 сая	2843
National University of Mongolia (NUM) (1942)*	21285	29:1		73.9 billion MNT or approximately 23.52 million USD	1105
Mongolian University of Science and Technology (MUST) (1959)*	16327	18:1		62.34 billion approximately $19.8 million	1214

Source: Altbach P. and J. Salmi. (2011). (Ed.). The Road to Academic Excellence: The Making of World-Class Research Universities,

*2022 financial and key operational indicators of MUST and NUM

Table 2

Main Funding Sources of Each Institution, %

Universities	Government budget	Tuition fees	Endowment income, donations, lottery, and corporate support	Competitive research funding	Consultancies, training, and contract research
Shanghai Jiao Tong University	40	10	5	15	30
Pohang University of Science and Technology	6	7	34	45	6
University of Malaya	73	11	10		6
University of Ibadan	85	1	1	2	10

University of Chile	11	23	1	20	45
Catholic University of Chile	11	30	7	4	48
Indian Institutes of Technology	70	5	5	5	10
Hong Kong University of Science and Technology	63	18	6	10	3
Monterrey Institute of Technology		77	13	3	7
Higher School of Economics	52	25	3	10	10
National University of Mongolia (NUM)*	2.5	84.3	0.1	6.5	
Mongolian University of Science and Technology*	5	68.1	2.7	6.9	

Source: – Altbach P. and J. Salmi. (2011). (Ed.). The Road to Academic Excellence: The Making of World-Class Research Universities,

*2022 financial indicators of MUST and NUM

The share of student tuition fees in the budgets of MUST and NUM is much higher than that of world-class universities, while the share of indicators such as competitive research funding and contract research is a small percentage (Table 1,2). Also, it can be seen that the share of government funding in the budget of our country's universities is quite low. In the case of our public universities, the strict regulation of student tuition fees every year without increasing them (student tuition fees of state-owned universities are on average 3-4 million dong) is a limitation of financial resources in the current situation where tuition fees account for more than 66% of the total income. For example, it is worth noting that universities are not provided with sufficient funds to acquire modern teaching equipment or to support training and research activities.

In 2023, for the first time in Mongolia, the international ranking organization "Times Higher Education" established the national rankings and university rankings based on their methodology, and the NUM took the top spot.

An important indicator of university research is the number of articles published in journals with a high Impact Factor. In 2016, Chinese researchers published 426,000 research papers, accounting for 18.6% of the total number of papers registered in Scopus, while US researchers published 409,000 papers. India has overtaken Japan in this indicator, and the trend is increasing in developing countries [12].

Publication output reached 2.9 million articles in 2020 with over 90% of the total from countries with high-income and upper middle-income economies. Considering the average annual growth since 2002, high-income economies have experienced a 3% growth rate, upper-middle-income economies have experienced an 8.6% growth rate, and lower-middle-income economies have experienced a 10% growth rate (Figure 1).

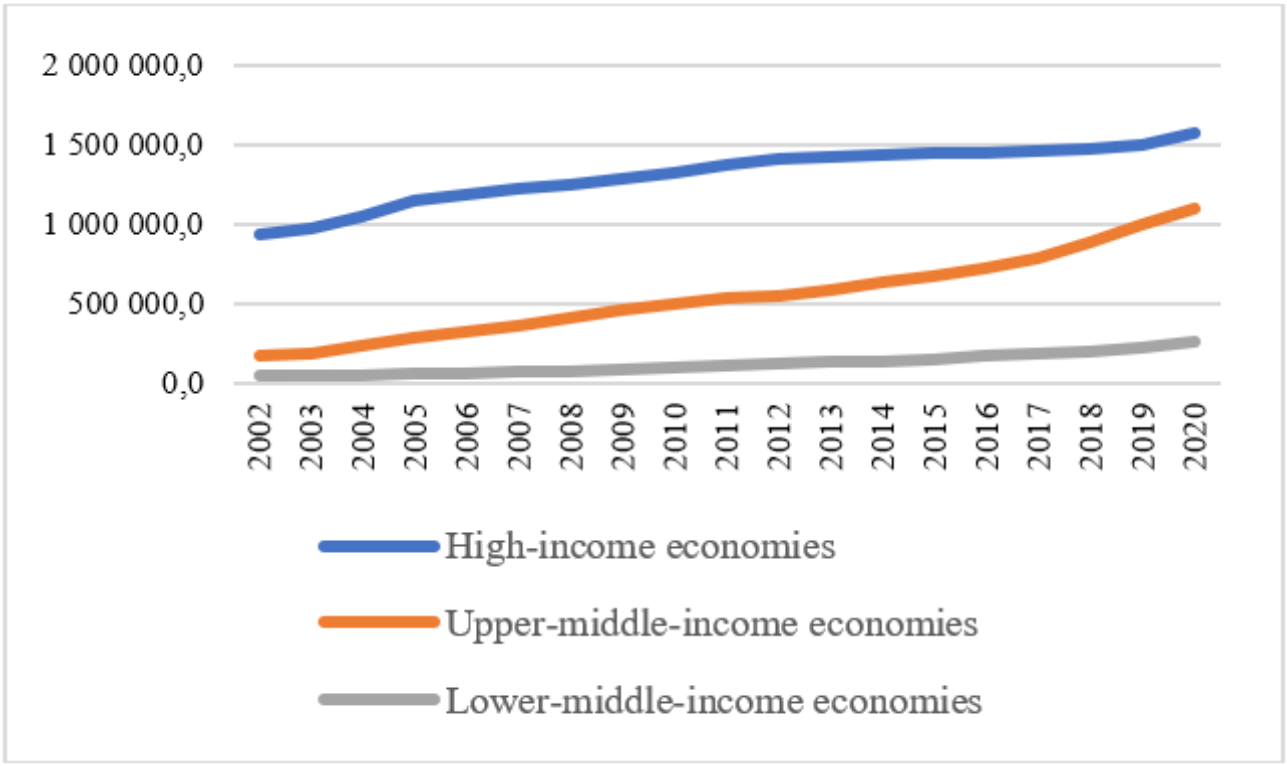

Figure 1. Economy and Scientific articles, by income group: 1996–2020
Source: U.S. National Science Foundation. Science & engineering indicators

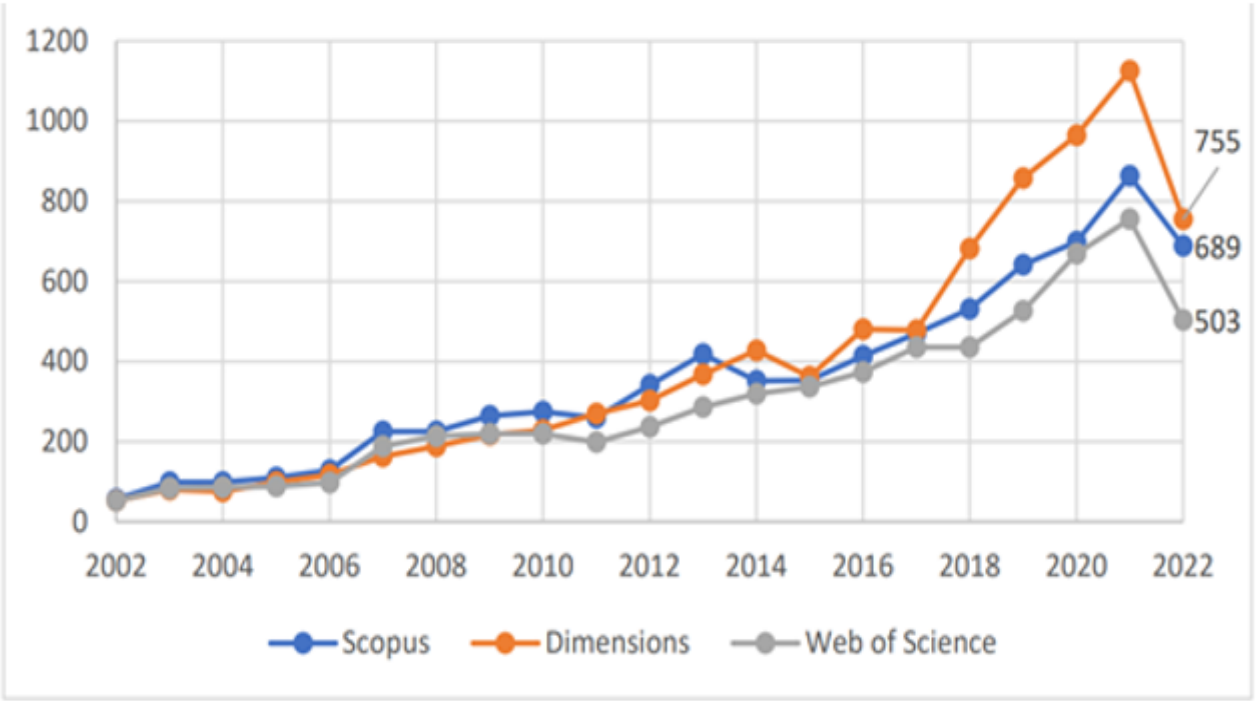

Figure 2. Mongolian publications for Web of Science, Scopus and Dimensions
Source: Mongolian Academy of Sciences. 2022 Research activity reports

The number of works published by Mongolian scientists in academic journals registered in the WoS, Scopus, and Dimensions databases has increased dramatically since 2002. In 2002, fewer than 100 articles were published, but in 2022, 503 were published in WoS, 689 in Scopus, and 755 in Dimensions (Figure 2). If we calculate the average growth of works published abroad by our country's scientists over the last 20 years, the average annual growth rate is approximately 9 percent. This rate closely aligns with the growth rate of low-income economies worldwide, as depicted in Figure 1.

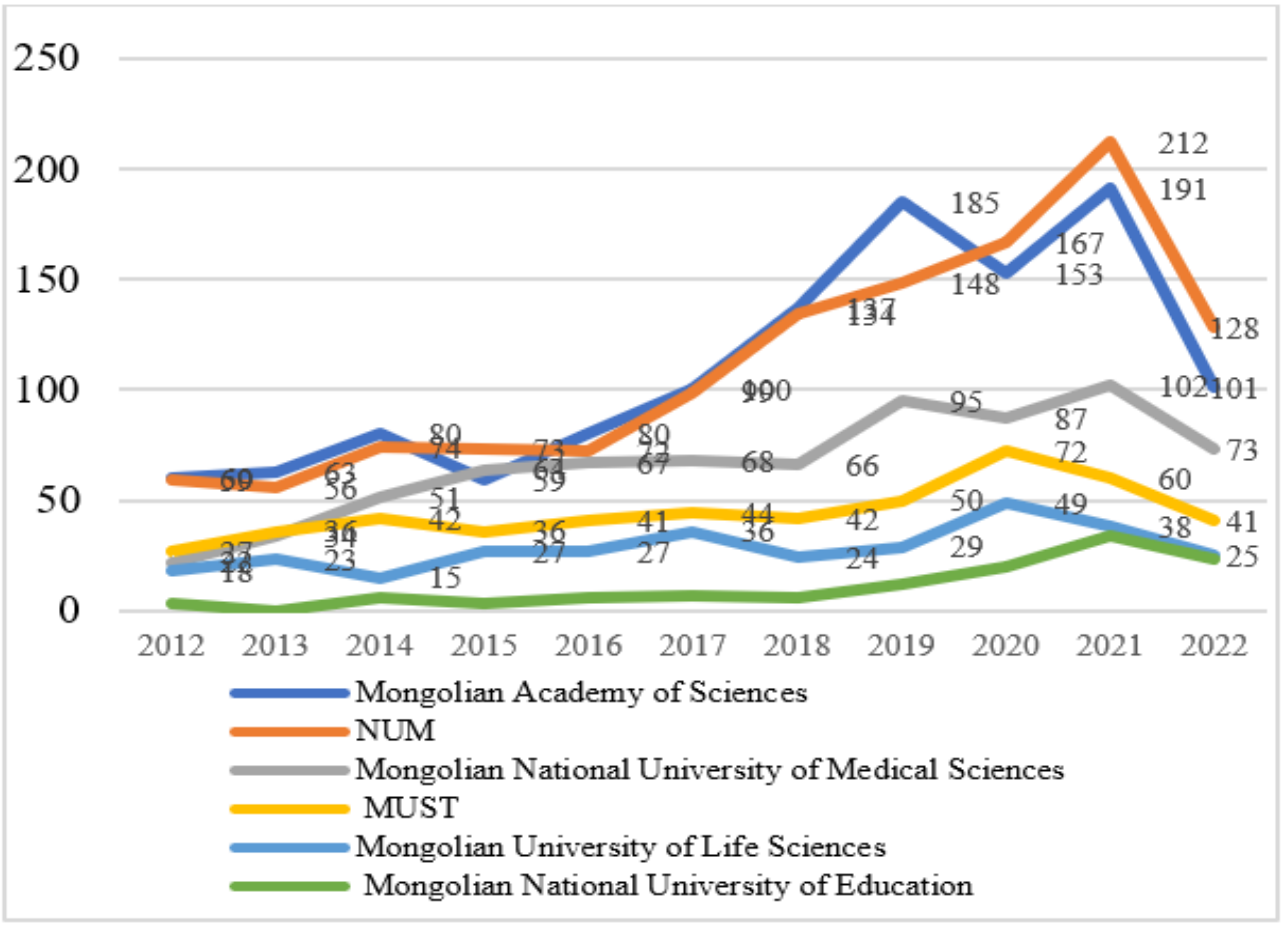

Figure 3. The number of works published in journals registered in the Web of Science group database (Leading universities and the Mongolian Academy of Sciences)
Source: Mongolian Academy of Sciences. 2022 Research activity reports

In 2022, Mongolian researchers published 483 articles in the journals registered in Web of Science, the most prestigious international scientific database, and scientists and researchers from the following organizations published the most articles. Among them, NUM 128, Mongolian Academy of Sciences 101, Mongolian National University of Medical Sciences 73, MUST 41, Mongolian University of Life Sciences 25, Mongolian National University of Education 23 (Figure 3). Let's compare this indicator with examples from universities in other countries. On average, within one year (1999-2009), the University of Malaya published 340 papers, Hong Kong University of Science and Technology 1040, the National University of Singapore 1870, and Seoul National University 3377, respectively. This comparison illustrates the ranking of academic output at research universities.

The percentage of GDP spent on Research and Development indicates the level of importance a country assigns to scientific development. As of 2020, countries with the highest rates were Israel at 5.4%, South Korea at 4.8%, Sweden at 3.53%, and the United States at 3.5%, while the member countries of the Organization for Economic Co-Operation and Development averaged 2.96%. The global average was 2.6%, with China at 2.4%, Russia at 1.1%, and Mongolia at 0.13% [15]. According to this, Mongolia's indicator is 20 times lower than the world average.

Mongolia ranked 68th out of 132 countries in the Global Innovation Index 2023 rankings and 97th in Research and Development (R&D). Additionally, according to the QS university ranking, it placed 71st among the top 3 universities and 114th in University-industry R&D collaboration [17]. From this, it can be seen that the research and development work related to universities is insufficient.

In recent years, the government has deliberated on establishing a research university in Mongolia at an appropriate level and has made certain decisions. The government has approved the following legal documents related to the establishment of a research university:

1. The "Sustainable Development Concept of Mongolia," adopted in 2016, includes the goal of having at least 4 universities ranked among the best in Asia by 2025. Note: This goal was unachievable without a specific detailed program plan.

2. In 2017, the Government's Science and Technology Policy stated that funding and investment support would be provided for the development of research-based universities.

3. In 2018, National program for the development of Mongolian studies was approved [9].

The following objectives have been proposed within the framework of the national program for the development of research-based universities for the period of 4 years from 2019 to 2023. These objectives include:

- Creating a system for evaluating research results.
- Improving the governance, management, organization, and operation of the University.
- Establishing optimal funding sources and implementing competitive scholarship forms.
- Developing advanced training and research in modern leading areas of science, technology, and innovation development.
- Enhancing the innovation ecosystem by expanding research and development, innovation cooperation and partnerships, and improving infrastructure.

It can be concluded that this program aims to lay the foundation for the development of research-based universities. However, the resources of universities are very limited to finance the many important goals included in the program, and financial support from the government is essential.

Research universities face a number of challenges, mainly the pressures towards privatization and that of maintaining their autonomy and controlling essential academic decision-making. Central to the success of a research university is adequate and stable funding Top of Form [3].

CONCLUSION

Research universities are at the pinnacle of the education systems of countries worldwide, generating new knowledge, nurturing highly skilled professionals, and leading the way in innovation. Many countries globally are swiftly establishing institutions that rank among the world's best universities through specialized policies and initiatives. China's example vividly illustrates this trend.

When examining the methodologies of three organizations (QS World University Ranking, Times Higher Education, Academic Ranking of World Universities) responsible for ranking globally renowned universities, it becomes evident that over 60% of the total points (out of 100) are allocated solely based on world-class research.

However, for Mongolia's universities, several challenges persist. The cost per student remains low, and metrics such as the number of articles published in high Impact Factor (IF) journals, the presence of foreign professors and students, and the funding for competitive research contracts are notably lower compared to those of top-tier universities worldwide.

In 2023, the Education Law underwent revision, officially incorporating the status of Research University into the Higher Education Law. Currently, there is a pressing need for comprehensive reforms aimed at elevating university funding to adequate levels. This endeavor is crucial for training experts aligned with global standards and conducting research in line with international benchmarks.

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