Vol. 3, 2022
Journal of Medical Library and Information Science

doi.org/10.22037/jmlis.v3i.38107

Citation: Sani'ee N, Nemati-Anaraki L, Sedghi S, Noroozi Chakoli A, Goharinezhad S. Comparative study of research performance and innovation-industry indicators in national and international university ranking systems. J Med Libr Inf Sci. 2022; 3: e30.

CrossMark

Original article

Comparative Study of Research Performance and Innovation Industry Indicators in National and International University Ranking Systems

Nadia Sani'ee[1], Leila Nemati-Anaraki*[2], Shahram Sedghi[3], Abdolreza Noroozi Chakoli[4], Salime Goharinezhad[5]

[1] Department of Medical Library and Information Science, School of Health Management and Information Sciences, Iran University of Medical Sciences, Tehran, Iran.

[2] Department of Medical Library and Information Science, Iran University of Medical Sciences, Tehran, Iran.

[3] Health Management and Economics Research Center, Iran University of Medical Sciences, Tehran, Iran.

[4] Department of Information Science and Knowledge Studies, Shahed University, Tehran, Iran.

[5] Preventive Medicine and Public Health Research Center, Psychosocial Health Research Institute, Iran University of Medical Sciences, Tehran, Iran.

Recieved: 11 Apr 2022
Accepted: 7 Jun 2022

Keywords:
Research performance
Innovation
Industry
Indicator
University rankings

*** Corresponding author**
Leila Nemati-Anaraki
nematianaraki.l@iums.ac.ir

Abstract

Introduction: There are different national and international university ranking systems in the world which rank universities in numerous metrics. Previous studies have investigated some educational and research indicators, but research and innovation metrics have not yet been compared. The present study aimed to compare research performance and innovation-industry indicators in the national and international university ranking systems based on measured dimensions and data extraction sources, and find the highest innovational and research-oriented ranking systems.

Methods: This cross-sectional study covered the 2020 edition of each ranking, and the data were collected in January 2021. According to the inclusion criteria, 20 national and international university rankings were selected among 75 ranking systems. This study used a thematic method for data analysis.

Results: Among 20 included university rankings in the study, 17 were international, and three national university rankings all have research performance indicators, and seven of them applied innovation-industry indicators. The highest research-oriented rankings were CWTS, NTU, U.S. News, URAP, and Research Excellence Framework. The highest innovative-industrial-oriented rankings were U-Multilink and SciVision. The U-Multilink and the SciVision were the most research and innovative-industry-oriented rankings, among others.

Conclusion: The international university rankings are more innovational and research-oriented than national rankings. Accordingly, the national university rankings must introduce new national research and innovation-industry indicators for their universities' performance evaluation.

Introduction

The university rankings have become very popular in recent years. They conform to different methodologies to evaluate educational and research performance (1). Several studies explain the shortcomings of international university rankings, such as:

- A focus on the size of the university (including the number of faculty members and academic fields);
- English language;
- Bias in the hard sciences;
- Age (of university);
- Scope;
- Research focus;
- Spurious precision (these rankings overestimate slight differences in the total score);
- Weight discrepancies;
- Assumed mutual compensation;
- Indicator redundancy;
- An inter-system discrepancy;

• Negligence of indicator scores;
• An inconsistency between changes in ranking and overall scores;
• Excessive emphasis on country and university reputation (2-5).

These methodical weaknesses limit the reliability of the world university rankings. Another study showed a relationship between a university's score in the international university rankings, its expenditure per student, and other factors, such as the university mission, size, and productive inefficiency (6). Other challenges about the international university rankings are the relatively small coverage of universities, more focus on standard outputs in citation databases for some fields and languages (e.g., peer-reviewed publications and citations), lack of transparency of ranking methodology, and indefinite weightings (4, 7, 8).

Besides global ranking systems, the national university rankings have been developed by local institutions. Most national rankings are not equally known as the international rankings, but they provide access to in-depth knowledge about local institutions. They include more comprehensive indicators that are often excluded by the international rankings due to the challenges such as data collection on a global scale. In contrast, the international ranking systems rely on accessible bibliometric or webometric data and reputation surveys. The emphasis on bibliometric indicators in the international rankings has been criticized because such indicators favor large research universities without focusing on other important missions of a university, including education and service to the public. Thus, the national rankings aim to provide better access to the national data sources (9).

Also, searching the university rankings' websites show that innovation-industry indicators alongside other metrics are provided by some national and international rankings recently due to the increased importance of university and industry relationships and creating income from technological and innovational actions. One of these university rankings is the Ranking of Innovative Universities (RIU), provided by Thomson Reuters (10). Sometimes, these rankings are overestimated in public debate as a mirror reflection of the efficiency of research and the higher education system and are used to reform university management (4). Thus, these rankings use different indicators explicitly to evaluate universities' research and innovative performance. The backbone of many ranking systems is citation databases such as Clarivate Analytics' Web of Science, Elsevier's Scopus, and Google Scholar, which have facilitated access to bibliometric data on academic output. Some studies have shown that most national rankings emphasize educational indicators rather than research performance evaluation (11, 12). Although focusing on innovational indicators besides research and educational ones will be necessary for more effective university ranking changes in technology, the application of science and research in industry, knowledge and technology transfer by collaboration between university and industry, creating income, and attracting research grants from leading industries in the world. Some educational and research indicators had been investigated in previous studies, but research and innovation metrics were not compared in different university ranking systems.

In this regard, Taylor and Braddock looked at some of the theoretical and methodological issues underlying international university ranking systems, particularly their conceptual connections with the idea of excellence. They examined the Times Higher Education World University Rankings and the Shanghai Jiao Tong Academic Ranking of World Universities. They argued that the Jiao Tong system, although far from perfect, is a better indicator of university excellence (13). Moed compared five university rankings in another study, including ARWU, Leiden, THE, Q.S., and U-Multirank. He pointed out that current systems are still non-perfect in providing finalized, seemingly, unrelated indicators rather than offering a dataset and tools to observe patterns in multi-faceted data (3). Kiraka et al. also said that using indicators in the international university rankings means that universities in developed countries compete for high positions in these rankings as "world-class universities." In contrast, universities in developing countries may mainly build institutional competence to become research-intensive universities (14).

Osareh et al. compared national university ranking systems worldwide regarding their indicators. The main metrics in these rankings were education, students, financial factors, alumni, research, and faculty members. Among the main functions of universities, two factors of education and research are more salient (15). Another study compared the national and the international university rankings in terms of their indicators, coverage, and ranking results. They concluded that the national rankings include a more significant number of educational and institutional indicators, whereas the international rankings tend to have fewer indicators mainly focusing on research performance. Generally, literature shows that the national university rankings and their indicators have been studied less than international university rankings.

On the other hand, the previous studies have not investigated innovation-industry indicators in university ranking systems. Most researchers focused on university-industry relationships and innovational studies conducted by universities (16-19). Overall, the literature review reveals that the national and international university rankings in research and innovation-industry indicators have not been investigated. The previous studies compared these rankings for educational objectives and fewer research ones. Besides, the university-industry relationship's importance to improving an innovational aspect of universities and making income must not be ignored by university evaluation managers and research policymakers. Nowadays, the university rankings also pay attention to this dimension and include its metrics.

The present study can clarify and explain the different evaluation methods regarding research and innovation-industry indicators by comparing the national and international university rankings that have not been investigated before. In addition, identifying these research and innovation-industry indicators is essential in two ways: first, recognizing existing and trying to introduce more efficient indicators. Second, helping universities to find their proper place in these rankings and strive to improve in the future. Thus, the current study compares the national and the international ranking systems to answer the following questions:

1. What are the leading research indicators, their sources of data extraction, and measured dimensions in the studied university ranking systems?
2. What are the leading innovation-industry indicators, their sources of data extraction, and measured dimensions in the studied university ranking systems?
3. Which system is a more innovational and research-oriented ranking system than others?

Methods

In this qualitative cross-sectional study, we included the latest edition of ranking schemes. The primary data were collected from their methodology section in January 2021. Inclusion criteria were being a national or an international university ranking in English methodological details regarding research performance and innovation-industry indicators, the sustainability of these rankings in the last two years, and being a university ranking rather than benchmarking. Exclusion criteria were subject-based, only educational university ranking, and in other languages. For collecting data, the national and the international ranking systems were investigated in published articles indexed in Web of Science and Scopus databases and related journals such as Scientometrics, Research Evaluation, Journal of Informetrics, and Higher Education. Also, keywords like research performance ranking and university ranking were searched on Google. If there is more than one national ranking system in a particular country, the sustainability of the ranking is considered an essential factor—finally, 20 national and international university rankings among 75 ones in terms of inclusion criteria. The methodology section on the website of the included university rankings was investigated, and the primary data was extracted. For this reason, a data collection form was used to organize extracted data, including the name and type of university ranking, country origin, research and innovation-industry indicators, measured dimension, and the source of data extraction for these indicators. The data were synthesized and interpreted by thematic content analysis to find the highest innovational and research-oriented ranking systems than others.

Results

The national and the international university ranking systems have been compared in Tab 1 in terms of their research and innovation-industry indicators, the source of data extraction for these indicators, measured dimension by each indicator, and the highest innovational and research-oriented ranking systems than others. A comparison of included national and international university rankings based on research performance indicators is presented in Table 1.

In the other part of the study, innovation and industry indicators were extracted from the included rankings. Among these university rankings, a few introduce innovation-industry indicators that presented in Table 2.

Table 1. Research performance indicators in the university rankings

University ranking (last edition)	National/international (country origin, % research-oriented ranking)	indicators	Measured dimension by research indicators	Source of data collection	Time period of data collection
Academic Ranking of World Universities (ARWU)-2020	International (China-60%)	Papers published in Nature and Science-N&S (20%), Papers indexed in SCIE and SSCI-PUB (20%), Highly cited researchers-HICI (20%)	Papers, research impact	Web of science	2015-2019 (N&S articles) 2019 (HICI, PUB)
The world university rankings-2021	International (United Kingdem-62.5%)	Reputation survey (18%), research income (6%), research productivity (6%), citations (research influence-30%), international collaboration (2.5%)	Research income, outputs (papers, books), citation, international collaboration, research reputation	Scopous	2015-2020 (citation and international collaboration) 2020 (research productivity)
QS world university rankings-2021	International (United Kingdem-20%)	Citations per faculty (20%)	Citation	Scopus	2014-2019
Performance Ranking of Scientific Papers for World Universities (NTU ranking)-2020	International (Tiwan-100%)	Research productivity (25%), Research impact (35%), research excellence (40%)	Papers, citation, research impact, research excellence	Web of Science (ESI)	2009-2019 (last 11 years, last 2 years, current years)
Webometrics ranking of world universities-2020	International (Spain-55%)	Transparency (number of citations from top 210 authors- 10%), ranking highly cited researchers in ESI, excellence or scholar (10% most cited papers- 35%)	Papers, citation, researchers, research excellence	Google Scholar profiles (citation)	2014-2018 (highly cited papers)

Continue of Table 1. Research performance indicators in the university rankings

University ranking (last edition)	National/international (country origin, % research-oriented ranking)	indicators	Measured dimension by research indicators	Source of data collection	Time period of data collection
CWTS Leiden ranking-2020	International (Netherlands-100%)	Scientific impact, collaboration, open access, gender diversity	Papers and citation, open access, gender diversity, collaboration	Web of Science	Papers (2015-2018) Citation (2019)
The Center for World University Rankings (CWUR)-2020	International (Saudi Arabia- 40%)	Research output (10%), high-quality publications (10%), influence (10%), and citations (10%)	Paper, citation, research influence	Web of Science	10 years (high quality publication)
Scimago Institutions Ranking-2020	International (Spain-50%)	Normalized impact (13%), excellence with leadership (8%), output (8%), scientific leadership (5%), not own journals outputs (3%), own journals (3%), excellence (2%), high quality publications (2%), international collaboration (2%), open access (2%), scientific talent pool (2%)	Outputs, impact, excellence, leadership, publishing services, research quality, international collaboration, open access, number of researchers	Scopus	2014-2018
U-Multirank-2020	International (Germany-not mentioned on the website)	External research income, doctorate productivity, research publications, citation rate, top-cited papers, interdisciplinary publications, research orientation of teaching, research publications (size-normalized), post-doc positions, art-related output, professional publications, strategic research partnerships, open access publication, international research grants, International joint publications, regional joint publications, income from regional sources	Research income, doctoral and post-doc students, papers, citation, education, research collaboration, research grant, open access	Web of Science	Not mentioned
U.S. News & world report's best global universities ranking-2021	International (United States-100%)	Global research reputation (12.5%), regional research reputation (12.5%), publications (10%), books (2.5%), conferences (2.5%), normalized citation impact (10%), total citations (7.5%), number and percent of 10% most cited papers (22.5%), international collaboration relative to country (5%), international collaboration (5%), number and percent of 1% most cited papers in their respective field (10%)	Research reputation, outputs (book, papers, conference), impact, citation, scientific excellence, international collaboration	Web of Science	Five years for bibliometric indicators (2014-2018) Five years for research reputation survey (2016-2020)

Continue of Table 1. Research performance indicators in the university rankings

University ranking (last edition)	National/international (country origin, % research-oriented ranking)	indicators	Measured dimension by research indicators	Source of data collection	Time period of data collection
Round university ranking-2020	International (Russia-40%)	Citations per academic and research staff (8%), doctoral degrees per admitted Ph.D. (8%), normalized citation impact (8%), papers per academic and research staff (8%), world research reputation (8%)	Papers, citation impact, citation, doctoral researchers, research reputation	Web of Science	publications: 2013-2017 Citations: 2013-2018
Universitas Indonesia GreenMetric world university ranking-2020	International (Indonesia-18%)	The ratio of sustainability research funding towards total research funding, number of scholarly publications on environment and sustainability, number of scholarly events related to environment and sustainability (18%)	Papers, research funding, research events	-	-
ITU Quality Research Rankings (ITU-QRR)-2019	International-Muslim countries (Pakistan-not mentioned in the website)	The highest quality publications, high quality publications, medium quality publications, multi-institutional collaborations, international collaborations	Papers, collaboration	Scopus	2010-2015
Nature Index-2020	International (Germany-not mentioned)	Count and share of high-quality articles	Papers	Nature index	Annually
SciVision university ranking-2020	International (not mentioned-52%)	Scientific reputation (4%), scientific productivity (10%), research performance (15%), average research performance (6%), top 10% highly-cited papers (1%), top 11-20% highly-cited papers (3%), high-impact researchers (0.5%), international researchers (0.5%), international collaboration (2%), the size of inter-organizational teams (4%), the scientific impact of teams (4%), international researchers, researchers employed by high-impact universities (2%)	Scientific reputation, papers, research performance (citation), research quality, research impact, international collaboration, organizational collaboration, citation, researchers	Web of Science	2013-2016
University ranking by academic performance (URAP)-2021	International (Turkey-100%)	Article (21%), citation (21%), total document (10%), article impact total (18%), citation impact total (15%), international collaboration (15%)	Papers, citation, scientific impact, international collaboration	Web of Science	2015-2019

Continue of Table 1. Research performance indicators in the university rankings

University ranking (last edition)	National/international (country origin, % research-oriented ranking)	indicators	Measured dimension by research indicators	Source of data collection	Time period of data collection
ISC world university ranking, ISC Islamic world university ranking-2020	International (Iran-80%)	Research volume (25%), time cited (15%), number of articles in a top journal (Q1, Nature, Science, Nature Index) (15%), impact relative to the world (4%), category normalized citation impact (1%), an international collaboration (10%), number of collaborating countries in joint publication (4%), international reputation (1%), negative international reputation, highly cited faculty members (5%)	Papers, citation, citation impact, international collaboration, international reputation, negative international reputation, high-impact researchers	Web of Science	3 years
Chinese universities ranking, Chinese medical universities ranking	National (China-40%)	Number of papers in Scopus (10%), Field Weighted Citation Impact (FWCI=Quality of Research, 10%), world top 1% most cited paper (10%), Chinese most cited researchers (10%)	Papers, other academic documents (like proceedings), impact, researchers	Scopus	2013-2017
Greater china ranking	National (China-45%)	Annual research income (5%), Nature & Science papers (10%), SCIE & SSCI papers (10%), international patents (10%), highly cited researchers (10%)	Papers, research income, patent, high-impact researchers	Nature, Science, Web of Science, Derwent	Past year and five years
Research Excellence Framework	National (United Kingdom-100)	quality of outputs (e.g., publications, performances, and exhibitions), their impact beyond academia (on the economy, society, culture, public policy and services, health, environment, and quality of life within the UK and internationally), and the environment that supports research	Output, impact, environment	Web of Science, survey	2014

Table 2. Innovation-industry indicators used in the university rankings

University ranking	indicators	Measured dimension by innovation-industry indicators	Data source
Chinese university ranking, Chinese medical universities ranking	Technology service (research income from industry), technology transfer (income from technology transfer)	Technology transfer and income from technology and industry	-
The World University Rankings	Knowledge transfer	Industry income	-
CWTS Leiden ranking	Industry publication	University-industry relationship	-
U-Multirank	Income from private sources, co-publications with industrial partners, patents awarded, co-patents with industry, publications cited in patents, B.A. theses with regional organizations, M.A. theses with regional organizations, patents awarded (size-normalized), industry co-patents, spin-offs, income from continuous professional development (CPD), graduate companies	Knowledge transfer	PATSTAT database
Scimago institutions rank	Innovative knowledge, technological impact, patents	Innovation and technology impact	PATSTAT database
SciVision university ranking	Science-technology linkage, university-industry collaboration, industrial impact, funded researchers, industrial researchers, technological reputation	Technological impact, technological reputation	USPTO
ISC world university ranking	Patents, industry collaboration	Innovation and technology impact	USPTO

Based on Table 1 and the percentage of each research indicator on the studied university rankings' website, the highest research-oriented university rankings were CWTS, NTU, U.S News, URAP, and Research Excellence Framework. As Table 2 shows, the U-Multilink and the SciVision provide more significant innovation-industry indicators. Overall, the U-Multilink and the SciVision are the most research and innovative-industry- oriented rankings among others.

Discussion

This study aimed to compare research performance and innovation-industry indicators in the national and the international university rankings (3 the national and 17 the international university rankings). The results show that European countries such as the United Kingdom, Germany, and Spain have introduced more university rankings, followed by Asian countries such as China, Saudi Arabia, and Turkey. For this study, most of these rankings are based on research performance indicators that are extracted from citation databases (Web of Science, Scopus, Google Scholar), and a few use the information submitted by universities (survey), which provide reputation indicators regarding education and research like THE, Round, and QS. While, U-Multirank is a combination of educational, research, and innovational indicators. Thus, the international ranking system indicators are largely research-oriented (9).

Among 20 included university rankings, 17 and 3 were the international and national rankings, respectively. There are many similarities between these rankings. Most of them focused on research outputs or productivity (papers) and citations show that these indicators are the main research metrics in university rankings. These metrics indicate the research quantity and quality, respectively. Regarding research output or productivity,

Academic Ranking of World Universities (ARWU), Nature index (considering only 12 high-quality journals on its website), Greater china ranking, and ISC consider research papers published in Nature and Sciences as the highest quality journals. ARWU and Greater china ranking alongside Nature & Science papers assign a weight for SCIE and SSCI articles, which may imply research impact or influence. Some of these rankings considered other productivity indicators such as books (THE world university); doctoral and art-related publication, research income and grant, interdisciplinary and professional publication (U-Multilink); books and conference papers (U.S. News); events and research funding (GreenMetric); international patents and research income (Greater china ranking); not own journals outputs and own journals (Scimago); performances and exhibitions (Research Excellence Framework). Also, the primary resource for extracting citation (research influence or impact) in most cases has been Web of Science core collection then Scopus. Only Webometrics ranking extracted citations from Google Scholar. The GreenMetric world university ranking has not been implying the source of data extraction and considers all outputs and events regarding environment and sustainability. On the other hand, one of the leading indicators is reputation. Among these rankings, THE world university rankings, U.S. News, Round, SciVision, and ISC world university rankings consider the positive research reputation of universities as the primary research indicator for rating them. Only ISC world university ranking from Iran introduced a new indicator regarding reputation from 2020 named negative international reputation that implies universities with the highest number of retracted articles. Other rankings did not use this indicator worldwide as a negative research performance of universities. Also, most studied rankings consider research influence and impact based on different indicators like highly cited papers, top papers, citations, and highly cited researchers. In this regard, there are different indicators such as highly cited researchers (ARWU), citation (THE), citation for 2 and 11 years (NTU), highly cited articles (Webometrics), 1%, 5%, 10%, 50% top papers, total and average citation, and normalized total and average citation (CWTS); high quality papers in top and high influential journals, and highly cited papers (CWUR); citation and top cited papers (U-Multilink); high-quality papers (Scimago); normalized citation impact, total citation, 1%, 10% highly cited papers (U.S News); citation, normalized citation impact (Round); highest, high, and medium quality papers (ITU); 10% and 11-20% highly cited papers, high impact researchers (SciVision); citation, normalized citation impact, impact relative to the world, high quality papers in Q1 journals, Nature, Science, Nature index, highly cited researchers (ISC); article impact total and citation impact total (URAP); citation impact, 1% top papers, highly cited researcher (Chinese ranking); highly cited researchers (Greater china ranking). Research Excellence Framework introduces impact beyond academia on the economy, society, culture, public policy and services, health, environment, and quality of life within the UK that other ranking has not considered. In this regard, contrary to the present study, Taylor and Braddock, examined only Times Higher Education World University Rankings and the Shanghai Jiao Tong Academic Ranking of World Universities. They assessed the various metrics used by these systems and argued that the Jiao Tong system, although far from perfect, is a better indicator of university excellence (13).

CWTS, U-Multilink, Scimago, U.S. News, Round, ITU, SciVision, ISC, and URAP introduced impact, influence, excellence, and normalized citation based on field or field and year. The NTU included Excellence indicators in terms of two-year h-index, highly cited papers, and articles in high-impact journals. Other rankings applied 10% of most cited papers (Webometrics), excellence with leadership, and 10% of the most cited papers (Scimago). The excellence with leadership is the number of documents in which an institution is the main contributor. In line with the results of this study, Wang stated that the increase in the number of citations could vary depending on the subject area, type of document, total citations, and months of publication, and normalizations in this regard give a clear picture of research performance (20).

Another critical research indicator is collaboration, which has not been applied directly as a research indicator. THE is one of these rankings that separates collaboration indicators from research indicators, while most included rankings use this metric in the research evaluation of universities. THE defined this indicator as the international collaboration with a weight of 2.5%. Also, the CWTS are using organizational (100 km or 5000 km), international, and industrial (100 km or 5000 km) collaborations. Other related collaboration indicators include interdisciplinary publications, strategic research partnerships, international joint publications, and regional joint publications in the U-Multilink. The Scimago, U.S. News, URAP, and ISC used international collaboration metrics, but the ITU and the SciVision used both institutional and international collaborations. In this regard, several studies have pointed to the role of research collaborations in improving the Scientometric indicators of researchers (21, 22). However, these collaborations can vary based on factors such as gender. In one study, the results showed that men have more research collaboration than women, which should be considered in evaluating the performance of researchers (23).

Among studied rankings, CWTS has emphasized more open access articles and report numbers, and a portion of gold (journals that only publish open access), green (including published versions or manuscripts accepted for publication and available at repository), and bronze (re-published versions of record or manuscripts accepted for publication. The publisher has chosen to provide temporary or permanent free access) and hybrid articles (documents are in journals which provide authors the choice of publishing open access) (24). Other rankings such as U-Multilink and Scimago imply the number of open access publications and have not separated their types.

The CWTS is the only ranking that includes gender diversity in research performance evaluation. The Scimago has applied the scientific leadership as the number of papers in which a corresponding author belongs to an institution and the scientific talent pool as the total authors in an institution that contributed to the total publication outputs of that institution during a particular time. Other rankings have not applied this indicator. The GreenMetrics and Research Excellence Framework are the only rankings considering environmental factors such as environmental and sustainability publications, events and supporting environmental research. The environmental indicator implies having a suitable environment for research. The Stockholm Declaration of 1972 addressed the Sustainability in Higher Education (SHE) for academic institutions. The declaration focused on finding ways in which universities, their leaders, lecturers, researchers, and students can use their resources to respond to the challenges of balancing between

the human quest for economic and technological development with environmental preservation (25). Speake et al. also pointed out that students perceived green spaces as an important factor for the university's image and as an essential component of the campus environment (26).

Overall, the research indicators divide into six main dimensions: scientific or non-scientific outputs; research quality or impact; research excellence; national, international, or organizational collaboration; open science and open access; reputation. Besides, other indicators like scientific leadership, gender diversity, scientific talent pool, own or not-own journal articles, environmental factors, and sustainability have been less applied by the university rankings that can be considered more by others.

Besides, only seven university rankings introduced the innovation-industry metrics. Each of these rankings has a different definition from these indicators. In this regard, the leading innovation-industry indicators divide into knowledge transfer, technology impact, and technological reputation. Knowledge transfer can be defined in industry publication (university-industry relationship), and income from private sources, patents awarded, co-patents with industry, publications cited in patents, spin-offs, income from continuous professional development (CPD). Technological and industrial impact implies several universities papers cited by innovational or industrial publications. The technological reputation is number of university innovational and industrial papers cited by other countries' innovational and industrial publications. SciVision only uses this indicator. The science-related non-patent literature references (NPLRs) in patents are generally seen as a proxy for science-technology linkages. Highly-cited patents are often international breakthrough technologies. Successful transfer of knowledge from universities to the industry is shaped by geography, and small distances tend to have positive effects on a firm's innovation performance. Geographical proximity is an essential factor in university-industry R&D linkages, where the distance from the university decreases the likelihood that a firm would collaborate with the university. The five main categories of proximity are geographical, cognitive, organizational, social, and institutional (10). The results of one study showed that the three factors of management mechanism, innovation climate, and reward system affect the collaboration between university and industry and promote the innovative performance of the university (27). However, the factors presented in this study are different from the indicators obtained from the present comparative study.

Overall, the international university rankings are more innovational and research-oriented than national ones. According to the above mentioned, there are some challenges concerning the research performance and innovation-industry indicators in the national and the international university rankings that can be addressed in future studies, or these rankings will eliminate them in their rating systems. These challenges include modifying the indicators' weight (28); considering a new research performance indicator for research in the arts, humanities, and social sciences; using composite indicators for university ranking (consisting of educational, research, innovational, environmental, ethical) (29); taking into account the scientific outputs of other non-English speaking countries and a new indicator for this; also including an indicator that defines the national and regional industry-based publications. Besides, it requires defining precisely indicators in a related dimension of the university rankings' website. The most important limitation of this study was the constant updating of university rankings that until the writing and submission of the article, the latest version of each ranking system was checked.

Conclusion

The international university rankings are more innovative and research-oriented ranking systems than national ones. So, the national university rankings must introduce new national research and innovation-industry indicators for their universities' performance evaluation. Concludingly, various ranking methodologies measure different aspects, and no single, final, or perfect operationalization of academic excellence exists. It might be possible to reduce numerous indicators to a manageable number of dimensions even with an appropriate weighting system for use in scientific, research, and financial policymaking. Managers and research policymakers can use the indicators presented in this study to assess the status of their universities and research institutes and take steps to improve their position. Also, according to the specific conditions of each country, it is suggested to create and introduce a comprehensive national university ranking in terms of educational, research, innovational, and industry dimensions.

Declarations

Acknowledgement
Not applicable.

Conflicts of Interests
None declared.

Ethical statement
This study is the result of the first phase of a doctoral thesis entitled "Futures study of the research performance evaluation using the scenario approach" and Code of Ethics IR.IUMS.REC.1398.229 at Iran University of Medical Sciences, Tehran, Iran.

Funding and support
This study was funded by Vice Chancellor for Research & Technology at Iran University of Medical Sciences, Tehran, Iran.

Authors' contributions
The research ideation was done by Nadia Sani'ee and Leila Nemati-Anaraki. The data were collected by Nadia Sani'ee and analyzed by all the authors. The manuscript was written and approved by all the authors.

References

1. Rauhvargers A. Global university rankings and their impact. Brussels: European University Association [Book on the Internet]; 2011 [cited 2021 Feb 20]. Available from: http://www.ehea.info/media.ehea.info/file/EUA_seminar_June_2011/76/5/Rankings_Seminar_Rauhvargers_Presentation_of_Report_607765.pdf

2. Safón V. What do global university rankings really measure? The search for the X factor and the X entity. Scientometrics. 2013 March;97(2):223-244. doi: 10.1007/s11192-013-0986-8

3. Moed HF. A critical comparative analysis of five world university rankings. Scientometrics. 2016 December;110(2):967-990. doi: 10.1007/s11192-016-2212-y

4. Saisana M, d'Hombres B, Saltelli A. Rickety numbers: Volatility of university rankings and policy implications. Res Policy. 2011 February;40(1):165-177. doi: 10.1016/j.respol.2010.09.003

5. Soh K. The seven deadly sins of world university ranking: A summary from several papers. J Higher Educ Pol Manage. 2017 November;39(1):104-115. doi: 10.1080/1360080x.2016.1254431

6. Marconi G, Ritzen J. Determinants of international university rankings scores. Appl Econ. 2015August;47(57):6211-6227. doi: 10.1080/00036846.2015.1068921

7. Van Raan AF. Fatal attraction: Conceptual and methodological problems in the ranking of universities by bibliometric methods. Scientometrics. 2005 January;62(1):133-143. doi: 10.1007/s11192-005-0008-6

8. Soh KC, Ho KK. A tale of two cities' university rankings: Comparing Hong Kong and Singapore. High Educ. 2014 March;68(5):773-787. doi: 10.1007/s10734-014-9743-z

9. Çakır MP, Acartürk C, Alaşehir O, Çilingir C. A comparative analysis of global and national university ranking systems. Scientometrics. 2015 April;103(3):813-848. doi: 10.1007/s11192-015-1586-6

10. Tijssen RJ, Yegros-Yegros A, Winnink JJ. University–industry R&D linkage metrics: Validity and applicability in world university rankings. Scientometrics. 2016 August;109(2):677-696. doi: 10.1007/s11192-016-2098-8

11. Dill DD, Soo M. Academic quality, league tables, and public policy: A cross-national analysis of university ranking systems. High Educ. 2005 June;49(4):495-533. doi: 10.1007/s10734-004-1746-8

12. Usher A, Savino M. A global survey of rankings and league tables. College and university ranking systems. Global perspectives and American challenges. 2007. P. 1-18. doi: 10.1163/9789087908164_002

13. Taylor P, Braddock R. International university ranking systems and the idea of university excellence. J Higher Educ Pol Manage. 2008 Jun;29(3):245-60. doi: 10.1080/13600800701457855

14. Kiraka R, Maringe F, Kanyutu W, Mogaji E. University league tables and ranking systems in Africa: Emerging prospects, challenges and opportunities. 2020. doi: 10.4324/9780429325816-15

15. Osareh F, Farajpahlou A, Rahimi F, ParsaeiMohammadi P. A study of the criteria and indicators of the National University Ranking Systems. Sci Res J [Internet]. 2019 [cited 2021 Feb 20]; 5(10):1-22. [In Persian]. Available from: http://rsci.shahed.ac.ir/article_874_a0cb19de652ff7d37a2f63f73e1fd317.pdf?lang=en

16. Fernandes G, O'Sullivan D. Benefits management in university-industry collaboration programs. Int J Project Manage. 2021 January;39(1):71-84. doi: 10.1016/j.ijproman.2020.10.002

17. Steinmo M, Rasmussen E. The interplay of cognitive and relational social capital dimensions in university-industry collaboration: Overcoming the experience barrier. Res Policy. 2018 December;47(10):1964-74. doi: 10.1016/j.respol.2018.07.004

18. Tseng F-C, Huang M-H, Chen D-Z. Factors of university–industry collaboration affecting university innovation performance. J Technol Transf. 2018 February;45(2):560-577. doi: 10.1007/s10961-018-9656-6

19. Fischer BB, Schaeffer PR, Vonortas NS. Evolution of university-industry collaboration in Brazil from a technology upgrading perspective. Technol Forecast Soc Change. 2019 August ;145:330-340. doi: 10.1016/j.techfore.2018.05.001

20. Wang J. Citation time window choice for research impact evaluation. Scientometrics. 2012 May;94(3):851-872. doi: 10.1007/s11192-012-0775-9

21. Chen K, Zhang Y, Fu X. International research collaboration: An emerging domain of innovation studies? Res Policy. 2019 February;48(1):149-168. doi: 10.1016/j.respol.2018.08.005

22. Abramo G, D'Angelo CA, Di Costa F. Research collaboration and productivity: Is there correlation? High Educ. 2008 April;57(2):155-171. doi: 10.1007/s10734-008-9139-z

23. Kwiek M, Roszka W. Gender disparities in international research collaboration: A study of 25,000 university professors. J Econ Surv. 2021 December;35(5):1344-1380. doi: 10.1111/joes.12395

24. Open Access Australia. What are the different types of open access? [Internet]. 2022 [cited 2021 Feb 20]. Available from: https://oaaustralasia.org/2021/05/25/what-are-the-different-types-of-open-access/

25. Lozano R, Lukman R, Lozano FJ, Huisingh D, Lambrechts W. Declarations for sustainability in higher education: Becoming better leaders, through addressing the university system. J Clean Prod. 2013;48:10-19. doi: 10.1016/j.jclepro.2011.10.006

26. Speake J, Edmondson S, Nawaz H. Everyday encounters with nature: Students perceptions and use of university campus green spaces. J Stud Res Hum Geogr. 2013;7(1):21-31. doi: 10.5719/hgeo.2013.71.21

27. Tseng F-C, Huang M-H, Chen D-Z. Factors of university–industry collaboration affecting university innovation performance. J Technol Transf. 2020;45(2):560-577. doi: 10.1007/s10961-018-9656-6

28. Docampo D, Cram L. On the effects of institutional size in university classifications: The case of the Shanghai ranking. Scientometrics. 2015;102(2):1325-1346. doi: 10.1007/s11192-014-1488-z

29. Waltman L, van Eck NJ. Field normalization of scientometric indicators. Springer handbook of science and technology indicators: Springer; 2019. p. 281-300. doi: 10.48550/arXiv.1801.09985