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Research Article

Optimization for Better World University Rank

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ABSTRACT
World university rankings are very competitive among educational institutions since it is a tool to attract good resources such as staff and students to the institutions. Many institutions realize the importance and require to set up to a better rank. The aim of this paper was to find how individual institution's performance can be enhanced by finding the optimal values for each of our studied indicators: faculty student's ratio, citations per faculty, proportion of international faculty and proportion of international students, that maximizes the overall score of Quacquarelli Symonds World University Ranking and therefore will lead to a better rank. Those four indicators are commonly used in most university ranking systems and considered to be controllable. An approach of optimization using maximization of nonlinear programming problem in which the objective function was constructed from normalization and weighting was applied throughout this research. The optimal values were obtained following Prince of Songkla University context. This research has shown that the final decision for the optimal values is based on constraints setting which depends on context, ability and policy of an individual educational institution.

Keywords: Indicator, Nonlinear programming, QS ranking, THE ranking, Z-score.

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INTRODUCTION

Nowadays, there are more than 17,000 higher academic institutions that are involved in the global university ranking systems. The most famous ranking systems are US News and World Report Best Global University Ranking (USNWR), Academic Ranking of World Universities (ARWU), University Ranking by Academic Performance (URAP), Quacquarelli Symonds World University Ranking (QS), Times Higher Education World University Ranking (THE), etc. Hence, the culture of competition among institutions has been increased remarkably. Also, the world university rankings obtain more interest from many groups of people such as parents, scholars, educational institutions, government, business sector, media and so on. Therefore, most universities or institutions are discussing about how to improve their rank for being acceptable as a world class institution. The discussion is mostly concentrated on how to improve indicator scores which indicate the institution's ability in different aspects. Therefore, potential or quality as well as a reputation of educational institutions are the keys to climb for a higher rank.[1-2]

For ranking methodology, there are different weights and criteria indicators for each ranking system. The USNWR focuses on research performance and reputation scores. ARWU uses the awards to measure academic research achievement. URAP focuses on scientific research efficiency only. QS and THE emphasize on the teaching, research as well as international performance. Different systems bring in different indicators. The common indicators are divided into teaching efficiency, research ability, basis of education, financial outcome, reputation, input staff and resources as well as collaboration activities such as research collaboration and international collaboration.[1-3] However, the major criteria of famous academic ranking systems are teaching quality, research quality and internalization.[1,4-6] In order to climb in university rankings, Bougnol and Dulá[7] recommended that concentrating on raising the score of few indicators is better than more. Therefore, this research focuses on the four indicators, namely faculty student's ratio, citations per faculty, proportion of international faculty and proportion of international students. These indicators are the common ones and they are significant among most world university ranking systems.

With the main research question of how a university or an institution can improve scores for better global university rank, this study aims to find how individual organisation's performance can be enhanced by finding the optimal values for the important indicators that maximize the overall score of an institution by using an optimization technique on the normalization process since the first step of most ranking

systems is to normalize (using z-scores) the data. However, the final process which produces an exactly final score of each system can be different. Therefore, this paper does not go deeply into this detail.

MATERIALS AND METHODS

Methodology

For most of the global rankings, the weighting of each indicator which depends on the decision of each ranking agency must be decided prior to the data collection. Once data is collected, a z-score of each indicator is calculated in order to standardize the different data types to be normal scale. Then, a cumulative probability function P (Z < z) is obtained as a score of each indicator in a scale of 1-100. To our knowledge, the process of overall score is to multiply the score of each indicator with the weight and finally summing up to obtain the overall score. Therefore, the mean (μ) and the standard deviation or sd (σ) are also in our optimization process. However, these two values are not available for all ranking systems. Among those, we found that QS is the only system that provides this information. Hence, we used the QS's criteria in our analysis as a case study as shown in Table 1.

This research emphasized on four common indicators; faculty students' ratio, citations per faculty, proportion of international faculty and proportion of international students which appear among world university ranking systems and are considered to be controllable. The optimization process has been employed in this research to find the optimal values for each indicator.

The optimization consists of two main components namely, objective function and constraints. The objective function involves minimizing or maximizing problem and it is a set of decision variable values that are assumed to be optimal. The other components are the constraints or the limitations of the problem. It is a set of variables that are acceptable in this setting.[8]

The optimization problems are divided into 2 types: linear programming (LP) and nonlinear programming (NLP) which consists of constrained problems and unconstrained problems.[9]

Table 1: Indicators, weights, means and standard deviations of QS World Rankings 2016.

Indicators	Weight	Mean	Standard deviation
Academic reputation	40%	77.39	52.89
Faculty students ratio	20%	0.10	0.04
Citations per faculty	20%	37.55	29.70
Employer reputation	10%	18.20	11.11
Proportion of international faculty	5%	0.18	0.12
Proportion of international students	5%	0.16	0.10

LP is a technique of mathematical programming problem which is the simplest and most widely applied to reach the best result for minimizing or maximizing. The objective problem is to optimize a linear function of variables with subject to one or more linear constraints.

NLP technique is however a mathematical programming in which the objective function and constraints are nonlinear and solving the problem is more difficult than all linear functions.[10]

In this research sequential quadratic programming (SQP) technique which is one of nonlinear programming (NLP) techniques[3] has been used. The objective function and constraints are nonlinear as follows.

Maximize $f(x)$

where

$$f(x) = \sum_{i=1}^{4} w_i \mathrm{P}(\mathrm{z} < z_i) \quad ; \; w_i = \text{percentage weight of indicator } i$$

$$= w_1 \mathrm{P}\,(Z < \mathrm{z}_1) + w_2 \mathrm{P}(Z < z_2) + w_3 \mathrm{P}(Z < z_3) + w_4 \mathrm{P}(Z < z_4)$$

$$= 20P\left(Z < \left(\frac{M_1 - \mu_1}{\sigma_1}\right)\right) + 20P\left(Z\left(\frac{M_2 - \mu_2}{\sigma_2}\right)\right) + 5P\left(Z < \left(\frac{M_3 - \mu_3}{\sigma_3}\right)\right) + 5P\left(Z < \left(\frac{M_4 - \mu_4}{\sigma_4}\right)\right) \quad \ldots(1)$$

$$= 20P\left[Z < \left(\frac{\frac{x_1}{x_2} - 0.10}{0.04}\right)\right] + 20P\left[Z < \left(\frac{\frac{x_3}{x_1} - 37.55}{29.70}\right)\right] + 5P\left(Z < \left(\frac{\frac{x_4}{x_1} - 0.18}{0.12}\right)\right) + 5P\left(Z < \left(\frac{\frac{x_5}{x_2} - 0.16}{0.10}\right)\right)$$

Subject to

$$\frac{x_1}{x_2} \le 0.22, \frac{x_3}{x_1} \le 126.65, \frac{x_4}{x_1} \le 0.54, \frac{x_5}{x_2} \le 0.46,$$

$$x_1 \ge 2{,}000,\ x_2 \le 40{,}000,\ x_3 \ge 0,\ x_4 \ge 100,\ x_5 \ge 285$$

where x_1 is the number of faculty,

x_2 is the number of students,

x_3 is the number of citations,

x_4 is the number of the international faculty,

and x_5 is the number of international students.

Here, the objective function (1) is constructed from normalization and weighting for each indicator as shown in Table 1 to maximize the QS ranking score. In total, it consists of four terms to maximize the cumulative probability functions of faculty students ratio $\frac{x_1}{x_2}$, , citations per faculty $\frac{x_3}{x_1}$, proportion of international faculty $\frac{x_4}{x_1}$ and proportion of international students $\frac{x_5}{x_2}$, respectively. The constraint of each ratio is limited to the fact that Z-scores range from −3 standard deviations up to +3 standard deviations i.e. $Z \leq 3$. For individual x_i, the constraint follows Prince of Songkla University (PSU) context as an example.

We used the QS's criteria in our analysis as a case study since it is the only system that provides the relevant information for normalization. In this work, all results were analyzed using the software Maple 18.

RESULTS AND DISCUSSION

Based on the given objective function and constraints in which each variable follows PSU context, we found that the optimal numbers of faculty, students, citations, international faculty and international students are approximately 3754, 17064, 475440, 2027 and 7849, respectively. The results were obtained from the objective function that roughly maximizes the score of four indicators of QS ranking. These indicators are the common ones and they are significant among most world university ranking systems. The reputation indicators, however, were not included in the objective function since the scores are from the opinion surveys and therefore are uncontrollable.

The obtained results represent the optimal values for universities that have similar context with PSU. Different universities with different backgrounds can employ this method to climb up in the ranking by varying the constraints that fit universities the best. Different conditions give different outcomes for making decision. The boundaries are based on context, ability including a policy of an individual educational institution which can be different. Thus, the results depend on flexibility of boundaries setting. We cannot identify the best values for all decision variables. However, this research can give an idea of how each variable should be and this can lead to a plan making for improving the ranking of an individual educational institution.

CONCLUSION

Calculation of world university ranking score is complicated and can be different for each ranking system. Some are involved with scores of other institutions especially those who reach the top score and that information is generally not released. However, the initial process of most ranking systems is to standardize the data into z-scores. In this study, optimization was carried out to find the optimal values of variables that are in common of indicators for world university rankings namely faculty students' ratio, citations per faculty, proportion of international faculty and proportion of international students. The results showed that the optimal value of each variable was changed depending on the boundaries which were based on context, ability including the policy of an individual educational institution. Nevertheless, the rough estimation is what we obtained from this research for getting the concept of the optimal value of each variable to achieve a better world university rank.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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