Statistical Modeling of University Ranking

------ An Interpretation of QS World University Ranking through a Statistical Approach

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INTRODUCTION

University rankings published by several institutions are receiving increasing interest. Aguillo et al. (2010) mentioned that the rankings are treated by these universities as an effective tool to promote themselves. Kehm (2009) also introduced that university ranking is a symbol of globalization, and helps the academic institutions to create their identity. These rankings are strong indicators for people to have an intuitive knowledge about the levels of the universities. Therefore, it would be important to explore the possible factors that affect the final university rankings while the competition is becoming fiercer.

University rankings announced by four institutions are the most widely recognized ones: QS, Times, U.S. News and ARWU. They collect data on different aspects and form scores for several subcategories. The final score is built by calculating the weighted sum of these subscores of each category and a rank is thereafter formed based on this final score.

There are some previous studies on the university rankings. Aguillo et al. (2010) studied the similarity of the rankings announced by different institutions, using the M-measure introduced by Bar-Ilan et al. in 2007. However, their study did not point out if there is a clear correlation between different university rankings and the meaning of the outcome is unclear. Grewal et al. (2008) developed an adjacent category logit model to show the persistence of the university ranking by studying the effect of lagged ranks and sub-ranks of the subcategories. Still, the inclusion of interaction effect between the lagged ranks and sub-ranks needs further explanation. Additionally, the accuracy of the prediction is unknown and we cannot know well about the importance of each factors. Therefore, the studies on this topic are still incomplete to some extent and further attention on this topic is necessary.

	2011	2012	2013	2014	2015	2016	2017	2018
QS	23	22	23	26	28	30	27	26
TIMES	21	34	35	43	44	44	43	40
ARWU	201-300	151-200	151-200	151-200	151-200	101-150	101-150	101-150

Fig.1 World University Rankings of HKU

Methodology and the Data Set

For rank-ordered data points, specifically the universities in this project, we assign each university an independent utility $V_1, V_2 \dots V_n$ according to the Luce Model, and the probability of observing a ranking π_n can be written as

$$P(\pi|V) = \prod_{j=1}^{k-1} \frac{V_{\pi_n^{-1}(j)}}{\sum_{i=j}^{k} V_{\pi_n^{-1}(i)}}$$

Rank-ordered logit model, which is an extended form of Luce model, incorporates covariates to determine the utility of each item. Parameters include judge-specific covariates and object-specific covariates.

$$V_{ij} = \beta_{i0} + \sum_{m=1}^{M} \beta_{IM} x_{mj} + \sum_{p=1}^{P} \gamma_p z_{pi}$$

Where $\beta_m, m = 1, 2 \dots M$ are the specific parameters to object i, and $p = 1, 2 \dots P$ are the specific parameters to all the judges.

Since university ranking in announced in yearly basis, we shall consider the time-specific factors here as the judge with regard to different time points.

University ranking tends to be "sticky", according to Grewal et al. in 2008. That is, universities tend to achieve a similar ranking as its previous one. Therefore, lag-rank tends to be an inclusive indicator. In our example, we exam several models with different covariates included. The covariates include the lag-rankings, the sub-scores of QS ranking, TIMES ranking, and ARWU ranking as the covariates. Economic factors, such as unemployment rate, GDP growth rate, etc., are also considered as time-specific judging covariates in the rank-ordered logit model.

R package *mlogit* is used to manipulate the modelling of the Rank-ordered Logit Model. To make the prediction, the estimated utility $V_1, V_2 \dots V_n$ could show the predicted ranking after descending ordering.

We use 8 years of QS ranking from 2011-2018 and include the universities that always appear in the top 60 list, in which there are 48 universities and 384 data points in total. Tied ranking, which means two or more universities share the same ranking in a specific year, are re-ordered according to alphabetical ordering. This is under the assumption that for every tied ranking, each university has the same probability to be appear first by their first letter.

RESULTS AND CONCLUSIONS

Sticking Effect:

According to Grewal et al. (2008), university rankings tend to stick to its previous ranking achieved. We used naïve model, i.e. lag ranking as the only predictor in the model. The naïve model can be written as:

$$V_{ij} = \beta_0 + \beta_1 X_{LAGRANK}$$

By using the naïve model to predict 2019 QS world university ranking, we have the following outcome:

Log-Likelihood	McFadden R^2	Kendall Rank Correlation Coefficient	Num. of Concordant Pairs
-523.84	0.58845	0.8244681	1029

Fig.2 Performance of the naïve model in prediction

Note that concordant pairs, by definition, means the number of total pairs that each of the two observations satisfy the property that

$$\text{sgn}(X_2 - X_1) = \text{sgn}(\text{Y}_2 - \text{Y}_1)$$

X and Y here relatively means the predicted ranking and the real ranking.

Determine the contribution of the parameters:

By process of variable selection, our observation is unemployment rate, by some sense, plays a more determinant role compared with the regional GDP growth rate and global GDP growth rate. Higher unemployment rate, corresponding to a positive estimated coefficient, generally contributes to a lower university ranking. TIMES rankings' sub-category scores also do not contribute to much on the overall prediction accuracy. The selected reduced model consists of following variables:

Variable Name (Interpretation)	Coefficient (standard error)	Variable Name (Interpretation)	Coefficient (standard error)
AR_SCORE (Academic Reputation)	0.498109 *** (0.075306)	IS_SCORE (International Students)	0.026877 . (0.015239)
ER_SCORE (Employer Reputation)	0.076611 *** (0.020368)	LAGRANK	0.146976 * (0.063436)
FS_SCORE (Faculty/Student Ratio)	0.183747 *** (0.032494)	alumni *(Alumni winning Nobel Prizes and Fields Medals)*	0.124445 . (0.052817)
CPF_SCORE (Citations per Faculty)	0.168928 *** (0.033733)	pub *(Papers indexed in Science Citation Index-expanded and Social Science Citation Index)*	0.124445 . (0.057640)
IF_SCORE (International Faculty Ratio)	0.050918 *** (0.010422)	Unemployment (Percentage)	21.396114 . (12.6934640

$.p < 0.1$ $*p < 0.05$ $***p < 0.001$

Fig.3 Variables in the selected model

The sub-score of "*pub*" and "*alumni*" from ARWU world university ranking, relatively stands for "Papers indexed in Science Citation Index-expanded and Social Science Citation Index" and "Alumni of an institution winning Nobel Prizes and Fields Medals". We consider these two sub scores are related with research quality, which may affect the reputation and number of citations of a university comprehensively.

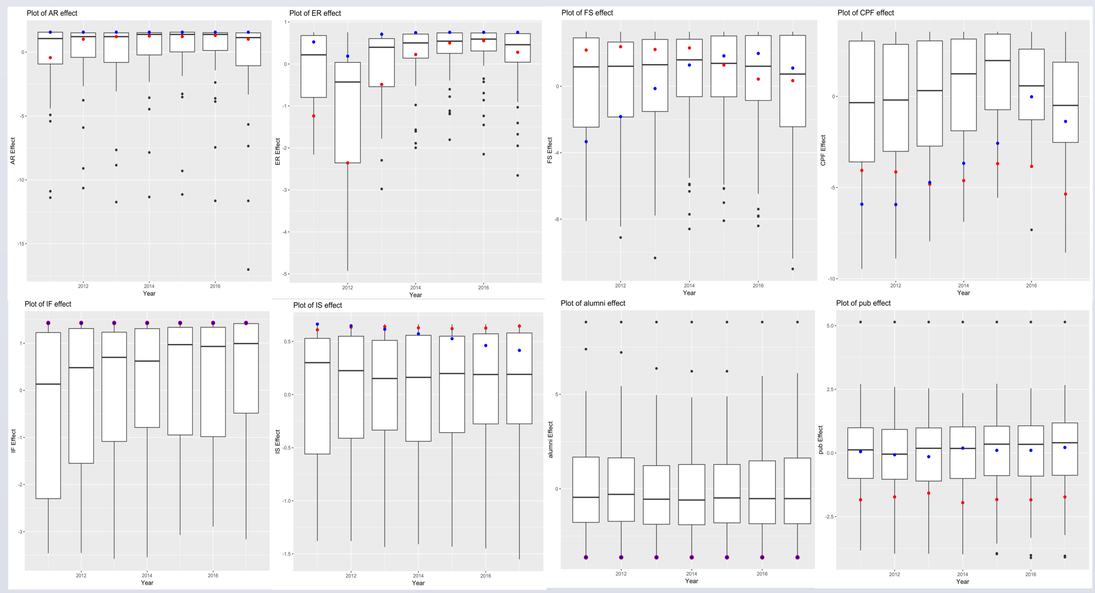
The performance of the model for prediction is shown below:

Log-Likelihood	McFadden R^2	Kendall Rank Correlation Coefficient	Num. of Concordant Pairs
-488.76	0.61601	0.8421986	1039

Fig.4 Performance of the selected model in prediction

Adverse selection:

In credit scorecard model, adverse codes are calculated to illustrate the top reasons for decline in borrowing (Siddiqi, 2012). By applying similar concept, we subtract the mean of sub-scores of each category and multiply the subtracted value with the estimation of the coefficients produced by the Rank-ordered Logit Model. The box-plots are shown below:



*Red point: the University of Hong Kong Blue Point: National University of Singapore

Fig.5 Effect of each sub-category

Overall, the impact of each category seems to be even and steady. The average impact of AR is above zero and steady so that universities may consider to put more efforts on other categories such as Citations per Faculty. We can see that HKU is doing well in its intentional outlook and diversity, but to achieve a higher university ranking especially in QS, more effort is needed in researches and outputs.

Still, it has to be pointed out that ranking is only one of the criteria to judge the level of a university. Under many circumstances, it is rather subjective and cannot be a well all-around reflection. Institutions of higher education should know what they need to provide better value to education, academic fields and the society.

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