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Size, Internationalization, and University Rankings: Evaluating and Predicting Times Higher Education (THE) Data for Japan

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Abstract: International and domestic rankings of academics, academic departments, faculties, schools and colleges, institutions of higher learning, states, regions, and countries are of academic and practical interest and importance to students, parents, academics, and private and public institutions. International and domestic rankings are typically based on arbitrary methodologies and criteria. Evaluating how the rankings might be sensitive to different factors, as well as forecasting how they might change over time, requires a statistical analysis of the factors that affect the rankings. Accurate data on rankings and the associated factors are essential for a valid statistical analysis. In this respect, the Times Higher Education (THE) World University Rankings represent one of the three leading and most influential annual sources of international university rankings. Using recently released data for a single country, namely Japan, the paper evaluates the effects of size (specifically, the number of full-time-equivalent (FTE) students, or FTE (Size)) and internationalization (specifically, the percentage of international students, or IntStud) on academic rankings using THE data for 2017 and 2018 on 258 national, public (that is, prefectural or city), and private universities. The results show that both size and internationalization are statistically significant in explaining rankings for all universities, as well as separately for private and non-private (that is, national and public) universities, in Japan for 2017 and 2018.

1. Introduction

It is well known that a broad range of higher-education rankings of academics, academic departments, faculties/schools/colleges, institutions of higher learning, states, regions, and countries are of academic and practical interest and importance to students, parents, academics, and private and public institutions. The international and domestic rankings are typically based on a variety of arbitrary methodologies and criteria, which means they are not optimal from a statistical perspective. Moreover, evaluating how the rankings might be sensitive to different factors, as well as forecasting

how they might change over time, requires a statistical analysis of the wide variety of factors that affect the rankings.

The primary purpose of this paper was to evaluate and predict the relationships over time among rankings and two crucial factors. The three leading and most influential annual sources of international and domestic university rankings are as follows:

(1) Shanghai Ranking Consultancy Academic Ranking of World Universities (ARWU) (originally compiled and issued by Shanghai Jiao Tong University), founded in 2003;

(2) Times Higher Education (THE) World University Rankings, founded in 2010 (*THE–QS World University Ranking*, in partnership with QS, 2004–2009);

(3) Quacquarelli Symonds (QS) World University Rankings, founded in 2010 (*THE–QS World University Ranking*, in partnership with THE, 2004–2009).

ARWU was the first agency to rank world universities, and was followed closely by THE–QS, which used a different methodology. Since 2010, ARWU, THE, and QS used different methodologies, with each having their supporters and critics.

As stated succinctly by THE (2018) [1]:

"The Times Higher Education World University Rankings, founded in 2004, provide the definitive list of the world's best universities, evaluated across teaching, research, international outlook, reputation, and more. THE's data are trusted by governments and universities and are a vital resource for students, helping them choose where to study."

THE (2018) [1] recently provided the Young Universities Rankings, World Reputation Rankings, Emerging Economy Rankings, Japan University Rankings, Asia University Rankings, World University Rankings, United States (US) College Rankings, and, most recently, Latin America Rankings and Europe Teaching Rankings. These separate rankings provide a rich source of data for two countries, namely the USA and Japan (see THE (2018) [2] and THE (2018) [3], respectively, for further details), and alternative groupings of countries and regions (for Asia, see THE (2018) [4]) (https://www.timeshighereducation.com/world-university-rankings/2018/regional-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats).

Institutions of higher learning in the US were analyzed extensively and comprehensively over an extended period. However, this was not the case in Japan, as data on a wide range of national, public, and private universities were not readily available. Recently, THE (2018) [5] provided data for Japan on numerical rankings for 258 national, public (that is, prefectural or city), and private universities.

THE (2018) [5] gives the following explanation of the dataset:

"The Times Higher Education Japan University Rankings 2018, based on 13 individual performance metrics, are designed to answer the questions that matter most to students and their families when making one of the most important decisions of their lives—who to trust with their education.

This year's methodology includes the same 11 indicators as last year, as well as two additional internationalization measures: the number of students in international exchange programs, and the number of courses taught in a language other than Japanese.

The rankings include the top-ranked 150 universities by overall score, as well as any other university that is in the top 150 for any of the four performance pillars (resources, engagement, outcomes, and environment). Scores in each pillar are provided when the university is in the top 150, while a dash ("−") indicates that the institution is not ranked in the top 150 for that pillar.

Institutions outside the top 150 are shown with a banded rank ("151+") and a banded score ("9.4–38.2": these two numbers represent the lowest and highest scores of all universities ranked outside the top 150), and are displayed in alphabetical order."

The dataset includes a number of factors that are used in defining the ranking, but they cannot be used to predict the rankings. For purposes of predicting rankings in advance of obtaining the data

that are used to construct them, two factors that should have a significant effect on rankings will be used to evaluate and predict the effects of **size** (specifically, the number of full-time-equivalent (FTE) students, or **FTE (Size)**)) and **internationalization** (specifically, the percentage of international students, or **IntStud**) on academic rankings of the private and non-private (that is, national and public) universities in Japan. Sources of whether universities are national, public, or private are given at the following websites, as well as on the respective university websites:

National:
http://www.mext.go.jp/en/about/relatedsites/title01/detail01/sdetail01/1375122.htm;
Public:
http://www.mext.go.jp/en/about/relatedsites/title01/detail01/sdetail01/1375124.htm;
Private:
http://www.mext.go.jp/en/about/relatedsites/title01/detail01/sdetail01/sdetail01/1375152.htm.

The analysis of the data on these three key variables will enable a statistical analysis of, and response to the following issues relating size and internationalization of non-private and private universities to their respective rankings over time:

(i).　Are private or non-private universities more highly ranked?
(ii).　Are private or non-private universities larger in terms of size?
(iii).　Do private or non-private universities have a higher degree of internationalization?
(iv).　Do the size, internationalization, and rankings of private and non-private universities change over time?
(v).　Are there differences in the effects of size and internationalization on the rankings of private universities?
(vi).　Are there differences in the effects of size and internationalization on the rankings of non-private universities?
(vii).　Do the effects of size and internationalization change over time for private and non-private universities?

There is extensive literature on university rankings and, more generally, on methodologies used to generate such rankings. There are numerous studies relative to a number of industries that compared results from different methods, and approaches that emphasize the differences and similarities related to rankings, as highlighted below.

Carrico et al. (1997) [6] considered data envelope analysis and university selection. Hu et al. (2017) [7] analyzed a hybrid fuzzy DEA/AHP methodology for ranking units in a fuzzy environment. Dale and Krueger (2002) [8] estimated the payoff to attending a more selective college through an application of selection on observables and unobservables. Eccles (2002) [9] evaluated the use of university rankings in the United Kingdom. Federkeil (2002) [10] examined some aspects of ranking methodology of German universities. Kallio (1995) [11] considered the factors influencing the college choice decisions of graduate students. Liu et al. (2005) [12] commented on the "fatal attraction" of academic ranking of world universities using scientometrics. lo Storto (2016) [13] analyzed the ecological efficiency-based ranking of cities based on a combined DEA cross-efficiency and Shannon's entropy method. McDonough et al. (1998) [14] evaluated college rankings based on democratized college knowledge. Meredith (2004) [15] analyzed why universities compete in the ratings game with an empirical analysis of the effects of the US News and World Report College Rankings. Merisotis (2002) [16] examined the ranking of higher-education institutions. Pavan et al. (2006) [17] evaluated data mining by total ranking methods based on a case study on optimization of the "pulp and bleaching" process in the paper industry. Lastly, van Raan (2005) [18] examined the fatal attraction ranking of universities by bibliometric methods.

Additional research papers that examined international and domestic university rankings can be found in a wide range of international journals. Some recent papers based on scientific publishing,

country-specific and industrial linkage factors, and the associated policy implications include Tijssen et al. (2016) [19], Piro and Sivertsen (2016) [20], Shehatta and Mahmood (2016) [21], Moed (2017) [22], Kivinenet al. (2017) [23], Pietrucha (2018) [24], and Johnes (2018) [25].

The remainder of the paper is organized as follows: Section 2 discusses the data and descriptive statistics, while the empirical analysis is presented in Section 3, and some concluding remarks are given in Section 4.

2. Data and Descriptive Statistics

As discussed in Section 1, in the dataset released in THE (2018d), cardinal rankings are given for the leading 100 and 101 universities in 2017 and 2018, respectively, with 50 universities listed in intervals from 101–110, 111–120, 121–130, 131–140, and 141–150. The remaining 108 universities are listed equally as 151+.

Table 1a,b show the universities that have more than 20% internationalization, where IntStud denotes the percentage of international students, in 2017 and 2018, respectively. The universities are essentially all private, with seven of seven and six of seven in Table 1a,b, respectively. The sole exception is Akita International University (AIU), a public (specifically, prefectural) university, in Table 1b. Ritsumeikan Asia Pacific University has the highest IntStud scores in both years, with 46.5% and 53.4%, in 2017 and 2018, respectively, as well as being ranked 24th and 21st in Japan in these two years. At 12, AIU has the highest ranking of the universities in the two tables, with all the other private universities being ranked in the range 151+.

Table 1. (**a**) More than 20% IntStud 2017. (**b**) More than 20% IntStud 2018.

University	Rank	Type	Prefecture	IntStud
(**a**)				
Ritsumeikan Asia Pacific University (APU)	24	Private	Oita	46.50
Digital Hollywood University	151+	Private	Tokyo	35.10
Kobe International University	151+	Private	Hyogo	31.00
Tokyo Fuji University	151+	Private	Tokyo	30.60
Okayama Shoka University	151+	Private	Okayama	22.90
Tokuyama University	151+	Private	Yamaguchi	21.00
Hokuriku University	151+	Private	Ishikawa	20.40
(**b**)				
Ritsumeikan Asia Pacific University (APU)	21	Private	Oita	53.40
Osaka University of Tourism	151+	Private	Osaka	38.90
Kobe International University	151+	Private	Hyogo	24.10
Hokuriku University	151+	Private	Ishikawa	20.90
Kanagawa Dental University	151+	Private	Kanagawa	20.50
Akita International University	12	Public	Akita	20.40
Osaka University of Economics and Law	151+	Private	Osaka	20.10

Note: IntStud denotes the percentage of international students.

Of the seven universities in Table 1a, four universities do not appear in Table 1b. In fact, apart from Digital Hollywood University, which drops from 35.1% in Table 1a to 5.7% in Table 3b, Tokyo Fuji University, Okayama Shoka University, and Tokuyama University seem to have disappeared altogether in terms of IntStud after 2017. Of the seven universities in Table 1b, Osaka University of Tourism, Kanagawa Dental University, AIU, and Osaka University of Economics and Law are new entrants, although, as discussed previously, only AIU has a cardinal ranking, with the others being ranked above 151.

Table 2a,b show the universities with IntStud scores in the range of 10–20% for 2017 and 2018, respectively, with 14 of 16 and 14 of 21 being private universities in the two years. However, the two national universities, Tokyo Institute of Technology and Nagaoka University of Technology, are ranked at fourth and 17th, and fourth and 21st in Table 2a,b, respectively, while the remaining 14

universities are ranked outside the top 100. The seven national universities are ranked in the top 21 in Table 2b, with only Waseda University, Sophia University, and International Christian University, all of which are located in Tokyo, as the only private universities in the top 100. It is clear that the national universities dominate the rankings in the IntStud range 10–20%.

Table 2. (**a**) 10–20% IntStud 2017. (**b**) 10–20% IntStud 2018.

University	Rank	Type	Prefecture	IntStud
(a)				
Osaka University of Economics and Law	151+	Private	Osaka	16.70
Hagoromo University of International Studies	151+	Private	Osaka	15.50
Meikai University	141–150	Private	Chiba	14.90
Sanyo Gakuen University	151+	Private	Okayama	14.80
Nagoya Keizai University	151+	Private	Aichi	14.40
Takaoka University of Law	151+	Private	Toyama	12.70
Osaka Sangyo University	151+	Private	Osaka	12.50
Kanto Gakuen University	151+	Private	Gunma	11.70
Nagaoka University of Technology	17	National	Niigata	11.50
Ashikaga Institute of Technology	151+	Private	Tochigi	11.10
Seigakuin University	151+	Private	Saitama	11.00
Kibi International University	151+	Private	Okayama	10.70
Tokyo Institute of Technology	4	National	Tokyo	10.70
Tokyo International University	141–150	Private	Saitama	10.40
Nagasaki International University	151+	Private	Nagasaki	10.30
Reitaku University	101–110	Private	Chiba	10.30
(b)				
Nagoya Keizai University	151+	Private	Aichi	18.50
Josai International University	151+	Private	Chiba	17.40
Meikai University	151+	Private	Chiba	16.40
Tokyo International University	151+	Private	Saitama	16.00
Nagoya University of Commerce & Business	111–120	Private	Aichi	15.90
Hagoromo University of International Studies	151+	Private	Osaka	15.60
Shizuoka Eiwa Gakuin University	151+	Private	Shizuoka	15.60
Seigakuin University	151+	Private	Saitama	14.10
Osaka Sangyo University	151+	Private	Osaka	13.30
The University of Tokyo	1	National	Tokyo	12.40
Reitaku University	121–130	Private	Chiba	12.20
Tohoku University	3	National	Miyagi	11.60
Hitotsubashi University	14	National	Tokyo	11.50
Nagaoka University of Technology	21	National	Niigata	11.50
University of Tsukuba	9	National	Ibaraki	11.50
Tokyo Institute of Technology	4	National	Tokyo	10.90
Kyushu University	5	National	Fukuoka	10.60
Waseda University	11	Private	Tokyo	10.60
Nagasaki International University	151+	Private	Nagasaki	10.40
Sophia University	15	Private	Tokyo	10.40
International Christian University	16	Private	Tokyo	10.00

Note: IntStud denotes the percentage of international students.

Universities with IntStud scores in the range 5–10% for 2017 and 2018 are shown in Table 3a,b, respectively. Of the 35 universities in Table 3a, 18 are private, while 11 of 29 universities in Table 3b are private. These are much higher percentages than those in Tables 1 and 2. However, in Table 3a, 11 of the 17 non-private universities are ranked in the top 20, while only three private universities, namely Waseda University, International Christian University, and Sophia University, with rankings of 10th, 15th, and 18th, respectively, are listed in the top 100 universities.

Table 3. (**a**) 5–10% IntStud 2017. (**b**) 5–10% IntStud 2018.

| University	Rank	Type	Prefecture	IntStud
(**a**)				
Hitotsubashi University	14	National	Tokyo	9.80
Nagoya University	4	National	Aichi	9.80
University of Tsukuba	9	National	Ibaraki	9.50
Sophia University	18	Private	Tokyo	9.40
Takushoku University	151+	Private	Tokyo	9.40
The University of Tokyo	1	National	Tokyo	9.20
Osaka University	6	National	Osaka	8.40
Tokyo University of Foreign Studies	27	National	Tokyo	8.00
Kyushu University	7	National	Fukuoka	7.90
Fukuoka Women's University	48	Public	Fukuoka	7.80
Tohoku University	2	National	Miyagi	7.50
Kyoto Gakuen University	151+	Private	Kyoto	7.40
Tokyo Medical and Dental University (TMDU)	38	National	Tokyo	7.20
Toyohashi University of Technology (TUT)	37	National	Aichi	7.20
Tokyo University and Graduate School of Social Welfare	151+	Private	Gunma	7.10
Waseda University	10	Private	Tokyo	7.10
Ashiya University	151+	Private	Hyogo	6.80
Hokkaido University	8	National	Hokkaido	6.70
Yamanashi Gakuin University	151+	Private	Yamanashi	6.70
Kyoto University	3	National	Kyoto	6.60
Utsunomiya Kyowa University	151+	Private	Tochigi	6.60
Tokyo University of Marine Science and Technology	36	National	Tokyo	6.50
Yokohama National University	33	National	Kanagawa	6.50
Toyama University of International Studies	151+	Private	Toyama	6.40
Baiko Gakuin University	151+	Private	Yamaguchi	6.10
Gifu Keizai University	151+	Private	Gifu	6.10
Hiroshima University	12	National	Hiroshima	5.80
International Christian University	15	Private	Tokyo	5.70
Musashino University	151+	Private	Tokyo	5.60
Musashino Art University	151+	Private	Tokyo	5.50
Ryutsu Keizai University	141–150	Private	Ibaraki	5.50
Kobe University	13	National	Hyogo	5.40
Tokyo Polytechnic University	151+	Private	Kanagawa	5.30
Sapporo University Women's Junior College	151+	Private	Hokkaido	5.20
Kyushu Sangyo University	121–130	Private	Fukuoka	5.10
(**b**)				
Fukuoka Women's University	62	Public	Fukuoka	9.00
Nagoya University	7	National	Aichi	8.70
Tokyo University of Foreign Studies	17	National	Tokyo	8.50
Tokyo Medical and Dental University (TMDU)	39	National	Tokyo	8.40
Yokohama College of Commerce	151+	Private	Kanagawa	8.20
Kyoto University	1	National	Kyoto	8.00
Yokohama National University	25	National	Kanagawa	7.80
Tokyo University of Marine Science and Technology	41	National	Tokyo	7.60
Hokkaido University	6	National	Hokkaido	7.50
Keio University	10	Private	Tokyo	7.30
Osaka University	8	National	Osaka	6.70
Hiroshima University	13	National	Hiroshima	6.60
Toyohashi University of Technology (TUT)	38	National	Aichi	6.60
Baiko Gakuin University	151+	Private	Yamaguchi	6.40
Musashino Art University	151+	Private	Tokyo	6.40
Tama Art University	151+	Private	Tokyo	6.30

Table 3. *Cont.*

University	Rank	Type	Prefecture	IntStud
Musashino University	151+	Private	Tokyo	6.20
Yamanashi Gakuin University	151+	Private	Yamanashi	6.10
The University of Electro-Communications	55	National	Tokyo	6.00
Kanazawa University	20	National	Ishikawa	5.90
Ritsumeikan University	23	Private	Kyoto	5.90
Kobe University	18	National	Hyogo	5.80
Digital Hollywood University	151+	Private	Tokyo	5.70
Kyoto University of Foreign Studies	92	Private	Kyoto	5.70
Tokyo University of the Arts	151+	National	Tokyo	5.60
Asia University	151+	Private	Tokyo	5.30
Saitama University	70	National	Saitama	5.20
Kyoto Institute of Technology	42	National	Kyoto	5.10
Ochanomizu University	32	National	Tokyo	5.10

Note: IntStud denotes the percentage of international students.

In Table 3b, eight of the 18 non-private universities are in the top 20, while 17 of 18 are in the top 100; the sole exception is Tokyo University of the Arts, having a ranking in the 151+ group. On the contrary, only three private universities of 11, namely Keio University, Ritsumeikan University, and Kyoto University of Foreign Studies, with rankings of 10th, 23rd, and 92nd, respectively, are listed in the top 100 in Table 3. As in Tables 1 and 2, national universities tend to dominate the rankings in terms of IntStud scores.
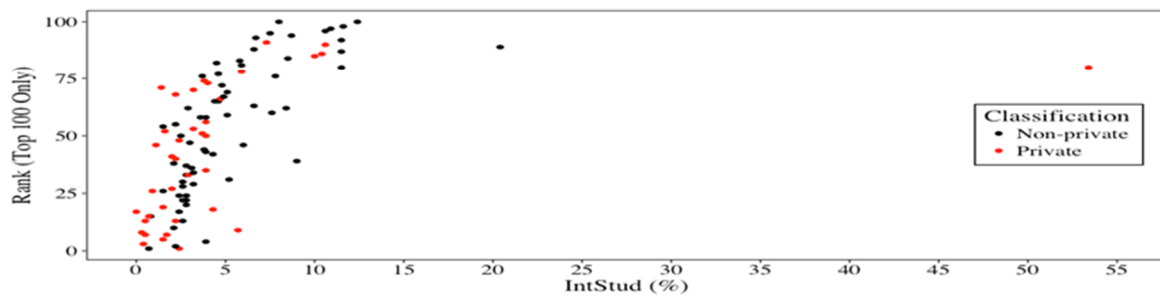
The plots between Rank and IntStud, and between Rank and FTE (Size), are shown in Figure 1a,b and Figure 2a,b, for 2017 and 2018, respectively. It is clear that there are positive linear relationships for Rank with IntStud and FTE (Size) in both years, especially if a single outlier was deleted in 2017 in Figure 1a, and two outliers were deleted in Figure 1b.
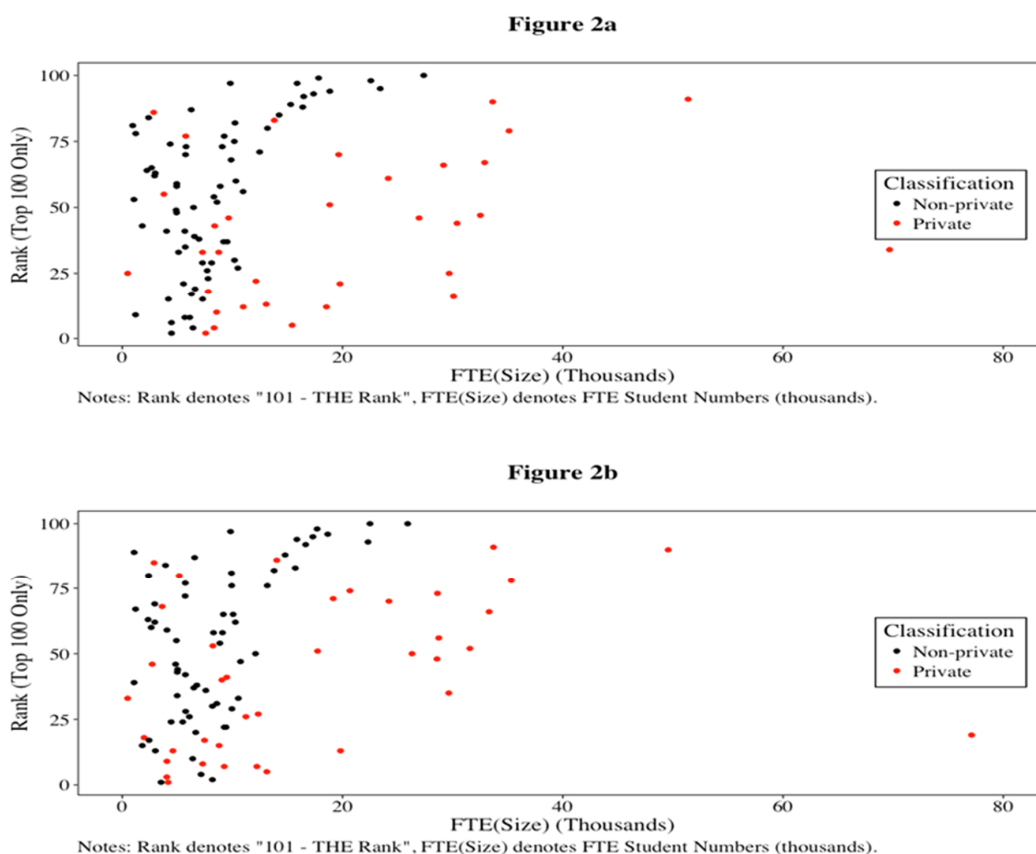

Figure 1a
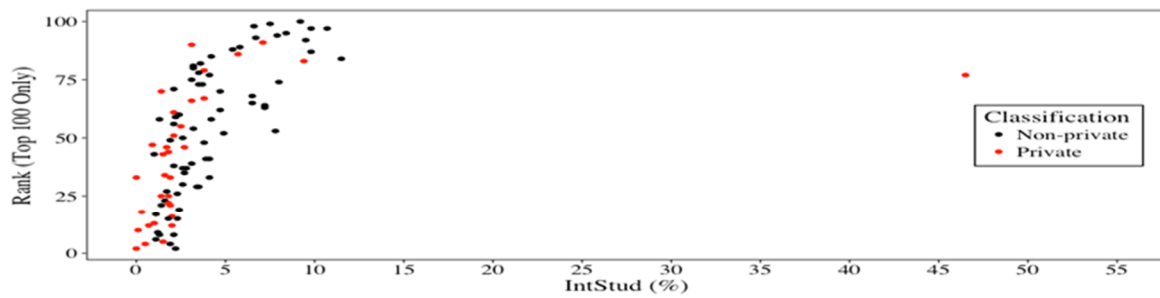
Notes: Rank denotes "101 - THE Rank", IntStud denotes % of International Students.

Figure 1b

Notes: Rank denotes "101 - THE Rank", IntStud denotes % of International Students.

Figure 1. (**a**) Rank and Intstud, 2017; (**b**) Rank and Intstud, 2018.

Figure 2a

Notes: Rank denotes "101 - THE Rank", FTE(Size) denotes FTE Student Numbers (thousands).

Figure 2b

Notes: Rank denotes "101 - THE Rank", FTE(Size) denotes FTE Student Numbers (thousands).

Figure 2. (**a**) Rank and FTE (Size), 2017; (**b**) Rank and FTE (Size), 2018.

The pairwise linear relationship between Rank and IntStud was steeper for private than for non-private universities in both 2017 and 2018, but there seems to be little difference from one year to the next. Unlike Figure 1a,b, the pairwise linear relationship between Rank and FTE (Size) was steeper for non-private than for private universities in Figure 2a,b in 2017 and 2018, respectively, with little apparent difference in the relationship between the two variables from one year to the next.

3. Empirical Analysis

As mentioned in Section 2, there are only 100 universities that are given cardinal rankings for 2017 and 2018. For this reason, only the first 100 leading universities in Japan were used for estimating and testing the effects of size and internationalization on the rankings of non-private (that is, national and public) and private universities.

The linear regression models to be estimated were variations of the following:

$$Rank = intercept + a* \ IntStud + b* \ FTE \ (size) + error,$$

where Rank denotes "101—THE rank", IntStud denotes "% of international students", FTE (size) denotes "FTE student numbers (Thousands)", and the random error is presumed to satisfy the classical assumptions, which can be tested using the Breausch–Pagan test of homoskedasticity, the RESET test of no functional form misspecification, and the Jarque–Bera test of normality.

The estimates of the linear regression models, with the rankings being explained by IntStud and FTE (size), are based on 100 and 101 universities in 2017 and 2018, respectively, with 33 and 38 private universities, respectively, and 67 and 63 non-private universities, respectively, in 2017 and 2018. As the numbers of observations across the three tables, as well as for the two years, are different, the *R*-squared values cannot be compared.

The estimates of the linear regression models of Rank on IntStud and FTE (size) for all (that is, private and non-private) universities, private universities, and non-private universities in the top 100 universities, are given in Table 4a,c, respectively. The results for both years are presented in each table. "Rank" is defined as "101—THE rank", such that universities with a higher ranking are given a lower cardinal number.

Table 4. (**a**) Regressions of Rank on IntStud and number of full-time-equivalent students (FTE (size)) for the top 100 universities. (**b**) Regressions of Rank on IntStud and FTE (size) for private universities (from top 100). (**c**) Regressions of Rank on IntStud and FTE (size) for non-private universities (from top 100).

	2017	2018
(a)		
Intercept	32.62 ***	30.08 ***
	(4.78)	(5.07)
IntStud	2.732 ***	2.479 ***
	(0.493)	(0.319)
FTE (size)	0.584 **	0.650 *
	(0.250)	(0.357)
Breusch–Pagan	48.23 ***	42.55 ***
Jarque–Bera	3.92	7.27 **
RESET	43.72 ***	45.44 ***
Wald Test	16.82 ***	33.49 ***
Observations	100	101
Adjusted R^2	0.254	0.301
Residual Standard Error	24.98 (df = 97)	24.43 (df = 98)
(b)		
Intercept	24.43 ***	25.35 ***
	(6.70)	(7.86)
IntStud	1.509 ***	1.454 ***
	(0.138)	(0.214)
FTE (size)	0.623 *	0.623
	(0.309)	(0.383)
Breusch–Pagan	0.83	5.00 *
Jarque–Bera	1.80	1.13
RESET	14.02 ***	14.41 ***
Wald Test	60.62 ***	23.97 ***
Observations	33	38
Adjusted R^2	0.223	0.247
Residual Standard Error	24.42 (df = 30)	25.00 (df = 35)
(c)		
Intercept	13.21 **	11.00 **
	(5.57)	(4.76)
IntStud	6.560 ***	5.067 ***
	(0.568)	(0.437)
FTE (size)	1.646 ***	1.985 ***
	(0.414)	(0.311)
Breusch–Pagan	9.05 **	1.09
Jarque–Bera	1.95	1.43
RESET	3.24 **	7.11 ***
Wald Test	68.49 ***	92.47 ***
Observations	67	63
Adjusted R^2	0.615	0.659
Residual Standard Error	17.84 (df = 64)	16.79 (df = 60)

Dependent Variable: Rank. **Notes:** Rank denotes "101—THE rank", IntStud denotes "% of international students", FTE (size) denotes "FTE student numbers (thousands)"; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

When the data for private and non-private universities from the top 100 universities were combined in Table 4a, both IntStud and FTE (size) were positive and statistically significant in both years. This is consistent with the pairwise findings in Figure 1a,b and Figure 2a,b that were discussed above. The estimated coefficients of IntStud and FTE (size) were separately similar for each of the two years.

The Lagrange multiplier tests for heteroscedasticity (Breusch–Pagan) were significant, but did not affect the validity of statistical inference as the standard errors were based on the Newey–West HAC consistent covariance matrix estimator. The Lagrange multiplier tests for non-normality (Jarque–Bera) were significant, which means that the errors were not normally distributed. Ramsey's RESET test for functional form suggests there may be some model misspecification, especially regarding the non-linearity of the relationship among Rank, IntStud, and FTE (size).

The regression estimates for private universities selected from the top 100 universities are given for the two years in Table 4b. Overall, the results are quantitatively similar to those in Table 4a, with the estimates being positive and statistically significant. In particular, the estimated coefficients of IntStud and FTE (size) were separately similar, not only for each of the two years, but also with the estimates for all universities in Table 4a, especially the estimated effects of FTE (size).

The Lagrange multiplier test for heteroscedasticity (Breusch–Pagan) was significant, but did not affect the validity of statistical inferences as the standard errors were based on the Newey–West HAC consistent covariance matrix estimator. The Lagrange multiplier test for non-normality (Jarque–Bera) was significant, which means that the errors were not normally distributed, Ramsey's RESET test for functional form suggests there may be some model misspecification, especially regarding the non-linearity of the relationship among Rank, IntStud, and FTE (size). The Lagrange multiplier tests for heteroscedasticity were either insignificant or marginally significant, while the Lagrange multiplier tests for non-normality were insignificant. The RESET functional form tests suggest there may be a non-linear relationship among Rank, IntStud, and FTE (size).

Table 4c presents the regression estimates for non-private universities selected from the top 100 universities for the two years. As compared with the estimates shown in Table 4a,b, the results are quantitatively dissimilar. Although the estimated coefficients of IntStud and FTE (size) were separately similar for each of the two years, with the estimates being positive and statistically significant in all cases, the estimates of the coefficients for both IntStud and FTE (size) were considerably larger than their counterparts in Table 4a,c for both 2017 and 2018.

The Lagrange multiplier test for heteroscedasticity (Breusch–Pagan) was significant for 2017 but not for 2018, while the Lagrange multiplier tests for non-normality (Jarque–Bera) were insignificant, which means that the errors were normally distributed for each of the two years. As in the case of Table 4a,b, Ramsey's RESET test for functional form suggests there may be some model misspecification, especially regarding the non-linearity of the relationship among Rank, IntStud, and FTE (size).

Overall, there seemed to be strong positive and statistically significant effects of both IntStud and FTE (size) on Rank in 2017 and 2018, regardless of whether the data for the top 100 private and non-private universities were combined, as in Table 4a, or examined separately, as in Table 4b,c.

4. Concluding Remarks

As international and domestic rankings are typically based on arbitrary methodologies and criteria, evaluating how the rankings might be sensitive to different factors, as well as forecasting how they might change over time, requires a statistical analysis of the factors that affect the rankings. The Times Higher Education (THE) World University Rankings represent a leading and influential annual source of international university rankings.

Using recently released data for Japan, the paper evaluated the effects of size (specifically, the number of full-time-equivalent (FTE) students, or FTE (size)) and internationalization (specifically, the percentage of international students, or IntStud) on academic rankings using THE data for 2017 and 2018 on national, public (that is, prefectural or city), and private universities. The results showed that

both FTE (size) and IntStud were statistically significant in explaining rankings for all universities, as well as separately for private and non-private (that is, national and public) universities, in Japan for 2017 and 2018.

As discussed in Section 1, the purpose of the paper was to answer the following questions (the answers are given in **bold**):

(i). Are private or non-private universities more highly ranked? (**Non-private**)
(ii). Are private or non-private universities larger in terms of size? (**Private**)
(iii). Do private or non-private universities have a higher degree of internationalization? (**In general, private**)
(iv). Do the size, internationalization, and rankings of private and non-private universities change over time? (**Slightly**)
(v). Are there differences in the effects of size and internationalization on the rankings of private universities? (**Yes**)
(vi). Are there differences in the effects of size and internationalization on the rankings of non-private universities? (**Yes**)
(vii). Do the effects of size and internationalization change over time for private and non-private universities? (**Not between 2017 and 2018**)

Further empirical analysis could be undertaken for private and non-private universities in Japan, as well as for the US, Europe, Asia, and Latin America; however, the distinction between private and non-private universities is prevalent primarily for the US.

A deeper analysis of the issue requires much richer data, which might be forthcoming in the foreseeable future. Limitations of the analysis include the late arrival of some data series, which can make the prediction of rankings problematic.

The paper is intended for the Special Issue of the journal on "Sustainability of the Theories Developed by Mathematical Finance and Mathematical Economics with Applications". In this sense, the paper is an application of applied econometrics to evaluate and predict university rankings using size and internationalization from the Times Higher Education (THE) data for Japan.

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