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Bipartite Networks of Universities and Companies: Recruiting New Graduates in Japan

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We investigated the bipartite Universities-Companies Network in Japan in terms of companies' recruitment of new graduates. In Japan, graduates of universities are typically hired by companies upon their graduation. To examine socially accepted ideas about this recruiting system, we combined different types of data on education, recruitment and corporate finance. The hypothesis that graduates from prestigious universities have the advantage of entering excellent companies was verified by examining the determinants of ratio of graduates entering top-ranked companies. Through hierarchical clustering, we obtained classification trees and observed the stability of their structure, as well as interesting changes corresponding to the business climate. We also calculated weighted HITS hub and authority values for each university and company and identified the links between the results of this analysis and those above. Finally, analysis of all the data indicated that excellent companies recruiting many graduates from prestigious universities do not necessarily show superb performance in profit-making and growth.

KEYWORDS: bipartite network, university, simultaneous recruiting system, hierarchical clustering, dendrogram, weighted HITS, hub and authority

1. Introduction

The objective of this paper is to elucidate the structure of the bipartite network composed of universities and companies. For this purpose, we combined different types of data on recruitment, education, and corporate finance in order to evaluate socially accepted ideas; for example, that of graduates from prestigious universities having the advantage of entering excellent companies. We compared the results from the same sample in different years to examine the robustness of the structure.

Universities have been one of the biggest providers of human capital to the business world in modern society. In Japan, universities make every effort to send their graduates into excellent companies and, at the same time, companies struggle to recruit promising graduates within their limited hiring budget [1]. The patterns of recruitment of new graduates—which university sends how many to whom—have always been of interest to the public. So far, however, there has been little quantitative research on these recruitment patterns. We present the first empirical characterizations of the recruitment web, a bipartite network [2] built between universities and companies.

Although methods such as co-citation analysis [3] and graph clustering [4] have been proposed for bipartite networks, they are designed mainly for the study of networks whose nodes do not have any attributes. In our case, universities and companies are not homogeneous: scholastic scores, specialties and campus locations characterize universities, while companies have their own attributes of performance. To fully utilize such data, we did not confine ourselves to methodologies exemplified above.

In §2, we briefly describe the common hiring practices in Japan to acquaint the readers with the topic, and then explain the data we used in §3. We show our quantitative analyses to clarify the topology of the Universities-Companies Network (UCN) in §4, followed by the conclusion in §5.

2. Hiring Practices in Japan

The Economist magazine portrays the uniqueness of recruitment practice in Japan as follows [5]: “New university graduates across Japan start work on April 1st—in a job that some presume they will hold for life. It is almost impossible to get hired for an executive-track position at any other time of year, or any later in life.”

Immediate employment upon graduation offers practically the only method to become a regular employee of a big company, not a temporary worker. The prevalent hiring practice in Japan has been the annual simultaneous hiring of new graduates, specifically young people fresh out of universities with no career experience having been recruited while they are students. Japanese companies have a strong preference for hiring new graduates as opposed to looking for mid-career recruits [6].

In general, graduating students of universities strongly prefer working for government or branded companies, rather than starting their own business. The widespread perception is that the hiring company is more important than what kind of work the student might do [7].

As huge numbers of students rush to the limited number of large companies, the resulting competition is especially stiff. The schedules are also hectic because of the time constraints. The final decision of whether to hire or not is done during the summer in the student’s final academic year [8].

Traditionally, Japanese companies have tried to avoid large-scale lay-offs of full-time career employees to maintain cooperative labor-management relations, resulting in the so-called “permanent employment system” [9]. Although this practice has been gradually changing, the system’s influence still remains strong in the business world. Therefore, hiring new graduates from universities continues to play a critical role in recruitment practice. In this context, which companies employ how many graduates, and from which universities, is also a big concern for universities. The reputation of a university still largely depends on the number of students who are successfully hired by big-name companies.

3. Dataset

We compiled different types of data on education, recruitment and corporate finance from various sources. The main data used in our study, namely the recruitment data, were compiled for both 2011 and 2015 from *Sunday Mainichi* [10,11], a weekly magazine, to examine the influence of economic fluctuations on the recruitment. The macro economy was stagnant in 2011 but it was on a track to recovery in 2015. In fact, the ratio of job offers to job hunters across the nation was 0.68 in 2011 and 1.23 in 2015 [12].

The data is originally constructed as a form of matrix of 77×325 [10,11]. The matrix shows which universities sent how many new graduates into the top-ranking companies. However, the selected universities and companies on the matrix were not exactly the same in 2011 and 2015, because the notoriety and popularity change over time. Thus, we use the common sample appearing in both years in order to make a rigorous comparison. As a result, we use the matrix of 71 universities by 222 companies.

We also obtained the data indicating the difficulty of entrance examination of each university from the website of Obunsha, an educational publishing company [13]. The difficulty is measured by modified standard deviation (MSD) value which is popular in Japan. The higher the score, the harder to enter the university. The value of 50 corresponds to the mean value of the sample, and 10 deviation from 50 indicates one standard deviation. The score is calculated from the preliminary tests that prep schools give to high school students. The score which we used is the average score of several departments in each university, excluding the medical department. The MSD values are assumed to be constant over the years. Additionally, data on the specialties and locations were gathered. Abbreviations are used hereafter for some universities, whose formal names are given in Table II. Lastly, corporate finance data were collected from Osiris [14], a corporate finance database provided by Bureau Van Dijk.

4. Results

4.1 Attributes of Universities and Their Overall Employment Performance

In this subsection, we will follow a statistical approach in an attempt to examine the socially accepted idea that graduates from prestigious universities have the advantage of entering excellent companies. We defined r_{top} to be the ratio of graduating students entering the top-ranked companies from a university. The value of r_{top} varied widely by universities. Among the top-ranked universities (Hitotsubashi, Tokyo Tech, and Keio), it exceeds 50%, while it did not reach 10% for some universities.

We applied the logit model, which was chosen against ordinary linear regression by AIC using 2015 data and the full variety of variables. The variables were MSD, TECH, WOMAN, TOKYO and NATIONAL (defined below). Then the variables used for regression were reduced to 4 (listed in Table I) by AIC, again using 2015 data. The same model with the same variables was applied for 2011 data. TECH, WOMEN, TOKYO and NATIONAL are dummy variables [15] that represent the attributes of a university. For example, the value of TECH is set to be 1 if a university specializes in science and technology and 0 otherwise. The value of WOMEN, TOKYO or NATIONAL is respectively set to be 1 if a university is a women’s university, if its main campus is located in Tokyo or if it was established or primarily funded by government.

Table I. Estimated effects, *t*-value and *P*-value of variables resulting from the statistical fitting of the 2011 and 2015 data to the logit model.

	2011			2015		
	Est. Effect ± SD	***t***	***P***	**Est. Value ± SD**	***t***	***P***
MSD	0.1155±0.0085	13.5308	0.0000	0.1090±0.0071	15.3138	0.0000
TECH	0.6233±0.1694	3.6804	0.0005	0.4045±0.1412	2.8640	0.0056
WOMEN	0.2335±0.1922	1.2151	0.2287	0.5444±0.1602	3.3977	0.0012
TOKYO	0.2118±0.1234	1.7163	0.0908	0.2208±0.1029	2.1462	0.0355
Intercept	–8.7234±0.4758	–18.3343	0.0000	–8.2131±0.3968	–20.7004	0.0000

First of all, it is reasonable that companies prefer to hire new graduates with sound scholastic ability. Figure 1 clearly shows the positive correlation between r_{top} and MSD for both years and it was confirmed by regressions (Table I). It indicates that academic competency is always an important factor regardless of economic fluctuation.

The variable TECH was also statistically significant in both years. The coefficient of TECH is higher in 2011 than in 2015, indicating the advantage of technological institutes in the period of recession.

The variable WOMEN was not statistically significant in 2011, although it was statistically significant in 2015 with large coefficient with high *t*-value. It means that companies hired women in bulk in a good economic condition but severely refrained from hiring them in the recession period (also see Fig. 1). It is suggested that companies use the female workforce as an adjustment valve.

TOKYO is a proxy variable for locational advantage since more than half of the headquarters of big companies are located in Tokyo and students in Tokyo can easily access the big companies. The effect of TOKYO was not statistically significant in 2011(at the 5% level), but it actually was significant in 2015. Students in Tokyo apparently enjoyed the advantage of the geography only in a recovering economy.

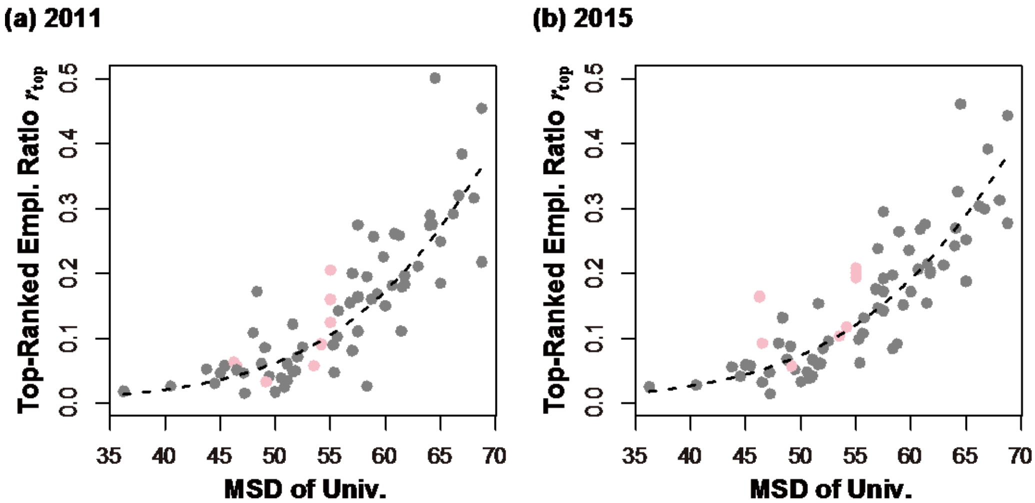

Fig. 1. The ratio of entering 222 top-ranked companies (r_{top}) is plotted against the academic competence of universities indicated by MSD for 2011 (a) and for 2015 (b). Pink dots correspond to women's universities. Dashed lines are expected r_{top} for universities of average TECH, WOMEN and TOKYO value.

4.2 Hierarchical Clustering

So far, we have investigated the effect that the attributes of universities had on their overall employment performance. While the results verified several socially-accepted ideas, a significant portion of information in the original data has not been utilized.

To conduct a deeper analysis, Ward's method [16], which exploits all the matrix data, was applied here. It was originally designed to find a classification tree or a grouping of the sample individuals (here, universities). Its "objective function" was here set to be squared sums of Euclidian distances of all the samples from the average of each cluster, summed over all the clusters.

The resulting tree (Fig. 2) indicates both the degree of uniqueness of a sample and the degree of difference between samples. If a single university is directly rooted at the center, this indicates that it occupies a very unique position among the whole sample set. On the other hand, two universities can be seen to be occupying very different positions if the path in the tree passes the center on the way from one to the other. In addition, if we set the number of clusters, we can obtain mutually exclusive clusters or grouping of universities. It is here set to be 2 and 10 arbitrarily. Note that the results for smaller universities should be subject to random fluctuation by year, since minor universities have entries typically less than 10. The order of university in the figures is manually reordered so that the major clusters occupy the same position in both Figs. 2(a) and 2(b).

The resulting dendrogram or classification tree is shown in Fig. 2. Remarkably, the two dendrograms were still similar in comparison as a whole, with only several changes in major groups in spite of the drastic change in the labor market between 2011 and 2015.

While the whole structure of the dendrogram was stable, there were two major changes. First, in 2011, Keio and Waseda (lime green in Fig. 2(a)) were in a very unique position, as the whole tree was partitioned into these two with the others at the central root of the tree. This was in contrast with 2015, in which, when the whole is classified into two, Keio and Waseda were located among the other private universities (lime green, bottom right in Fig. 2(b)). Second, Utokyo was more unique in 2011 than in 2015, relative to the Kobe-Kyoto-Osaka cluster and the Tohoku-Hokkaido-TokyoTech-TUS-Nagoya cluster (at the bottom of Fig. 2). When the economy is in recession, companies are forced to reduce hiring and employment, and they seek to employ only graduates with high competency, because the wage for new employees of the same expected career in the same company is usually homogeneous [17]. Moreover, the companies would look for employees only from "core" universities with which they have to sustain some relationship. In either case, only the most prominent universities could send graduates to

Table II. Abbreviations of universities used in the text, in the figures or in the tables.

AGU	Aoyama Gakuin University	**TCU**	Tokyo City University
CIT	Chiba Institute of Technology	**TDU**	Tokyo Denki University
JWU	Japan Women's University	**TMU**	Tokyo Metropolitan University
KIT	Kanazawa Institute of Technology	**TUFS**	Tokyo University of Foreign Studies
OCU	Osaka City University	**TUS**	Tokyo University of Science
OIT	Osaka Institute of Technology	**TWCU**	Tokyo Woman's Christian University
OPU	Osaka Prefecture University	**UTokyo**	The University of Tokyo
SIT	Shibaura Institute of Technology	**YNU**	Yokohama National University

D.W.C.L.A. Doshisha Women's College of Liberal Arts; **TUAT** Tokyo University of Agriculture and Technology; **UEC** The University of Electro-Communications

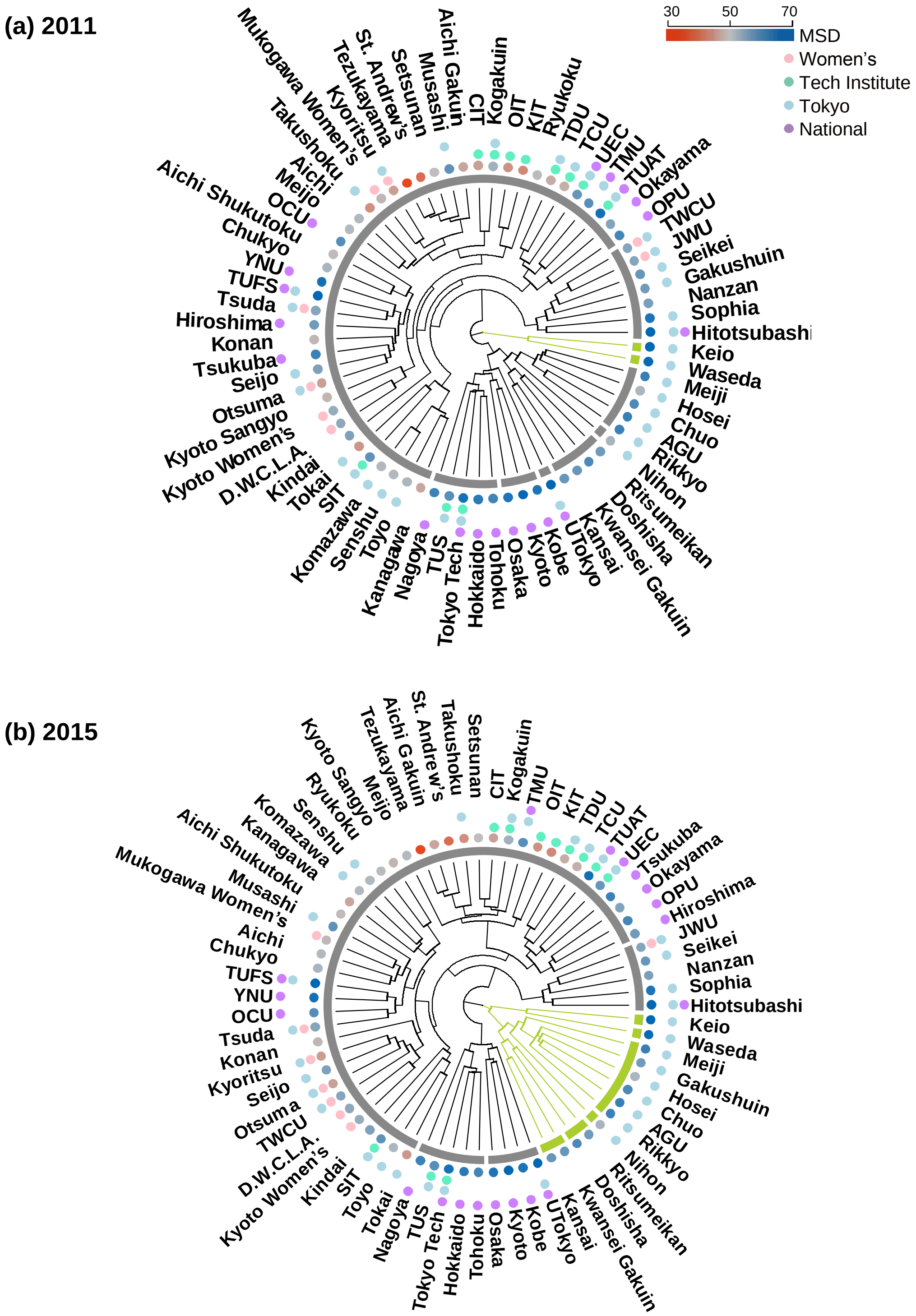

Fig. 2. The resulting clustering tree of universities from the (a) 2011 and (b) 2015 data. Grey and lime green bands indicate the classification into 10 groups, while the lime green edges marks the classification into 2. Colored circles indicate the MSD (red, grey and blue is <50, =50 and >50 respectively), features (blue-green for TECH and pink for WOMENS), locations (light blue for TOKYO) and the government involvement in establishing or funding (purple for NATIONAL).

top-ranked companies in economic recession, thus located at more unique positions.

Interestingly, although NATIONAL did not significantly affect the overall performance of universities, their position in the trees were clearly concentrated, indicating that some companies are relatively easier to enter from national universities.

4.3 Hubs and Authorities in the UCN

In the previous section, we scrutinized the matrix data using the hierarchical clustering, but the method did not quantify the “prestige” of universities and companies. The HITS algorithm [2,18], giving each node in a network an authority/hub centrality, can be implemented to calculate such indices. The definition of the centrality is recursive: a node with high authority centrality is pointed to by many other nodes with high hub centrality, and vice versa [2]. In the Universities-Companies Network (UCN), we regard universities and companies as nodes, and the flow of graduates from universities into companies as links. The weight of a link is defined as the number of graduates. In order to apply Kleinberg’s original approach [18] to our data, we modified the algorithm by weighting the authority/hub values of nodes with weights of their incoming links.

Table III summarizes the ranking of companies with high authority value in 2011 and 2015. Evidently, big banks took the dominant position. Each of these banks hires more than 1000 graduates a year. Security houses and an insurance company ranked in the top ten in both years. In addition, big manufactures like Fujitsu appeared on the list. By definition, these companies accepted large numbers of graduates from hub universities.

The universities with high hub value are shown in Table IV. Waseda and Keio were continuously the largest hubs in both years, presumably sending a large number of graduates into the companies of high authority mentioned above. In contrast, there were three national universities (UTokyo, Osaka and Kyoto) in the top 10 in 2011 but only UTokyo remained in 2015. It seems from this fact that hub values of big private universities increase during good macroeconomic conditions.

The fluctuation of hub values in the 2011–15 period might be related to the change of relative positions taken by universities. In §4.2, it was shown with hierarchical clustering that the performance of the Waseda-Keio cluster was quite different from other’s (especially middle-ranked private universities’) in the recession of 2011. The unique position of these two seems consistent with their exceptionally high hub values, and the eclipse of their uniqueness in 2015 actually coincided with the hub value increase of other private universities. Similarly, UTokyo constituted a single cluster in 2011 but was absorbed into the cluster with other national universities in 2015. This could be linked

Table III. The 10 companies with the highest authority values in 2011 and in 2015.

2011		2015	
Mizuho Bank	0.360	**Sumitomo Mitsui Banking**	0.406
Bank of Tokyo-Mitsubishi UFJ	0.341	**Bank of Tokyo-Mitsubishi UFJ**	0.394
Sumitomo Mitsui Banking	0.220	**Mizuho Bank**	0.378
Hitachi	0.204	**Resona Bank**	0.236
Fujitsu	0.202	**Tokio Marine & Nichido Fire Insurance**	0.195
Nomura Securities	0.189	**Daiwa Securities**	0.176
NTT DATA	0.185	**Fujitsu**	0.160
Daiwa Securities	0.180	**SoftBank**	0.157
East Japan Railway	0.171	**Mitsubishi Electric**	0.154
Rakuten	0.163	**Nomura Securities**	0.134

Table IV. The 10 universities with the highest hub values in 2011 and in 2015.

2011		2015	
Waseda	0.520	**Waseda**	0.502
Keio	0.508	**Keio**	0.456
UTokyo	0.242	**Kwansei Gakuin**	0.235
Doshisha	0.200	**Doshisha**	0.231
Meiji	0.188	**Meiji**	0.226
Osaka	0.173	**Rikkyo**	0.185
Kyoto	0.171	**Kansai**	0.181
Ritsumeikan	0.164	**UTokyo**	0.170
Chuo	0.148	**Ritsumeikan**	0.169
Kwansei Gakuin	0.142	**AGU**	0.167

with the fall in the rank of its hub values. These results also support the socially widespread idea that UTokyo is dominant especially in recessionary periods, because some companies which definitely require graduates from the most prestigious university to maintain their brand.

4.4 Matchings between Companies and Universities and their Consequences

We have shown that there are hiring relationships among the graduates of different universities and various companies, and that they depend on the business climate. Nevertheless, the question of what companies are favored by graduates of what universities is not yet clarified. We address this by combining the 71×222 matrices with scholastic scores of universities and market capitalization or net profit of companies. In this way, we can evaluate whether employing graduates from top-ranked universities is profitable to companies.

It is worth noting here that there is a certain bias inherent in the data. As has shown, companies which employed over 90% students of universities with MSD less than 50 are excluded from the data (Fig. 1).

The first hypothesis to be tested is whether the net profit per employee had a positive correlation to their employee's scholastic scores. Figure 3(a) shows the net profit per capita of each employee's companies versus MSD of universities that the employee had belonged to in both years. Correlations are only barely evident in the plot. This would be because of the bias of the data: the correlation could have been more apparent if the data of non-top-ranked companies with poor performance had been added.

To test the hypothesis more precisely, we reordered the columns (companies) and rows (universities) of the matrix according to their net profit per capita and MSD. Some companies were excluded, as their net profit per capita was unknown. Then the reordered matrix was divided into 2×2 at the median of the column and row, and Fisher's exact test was applied to the 2×2 matrix whose respective components are the total sum of entries corresponding to division of the reordered matrix. Significant positive correlations were found for 2011 data ($P < 8.7\times10^{-4}$; 95% confidence interval of odds ratio (OR) is $1.047 \leq \mathrm{OR} \leq 1.194$). Surprisingly, a negative correlation was detected for 2015 data ($P < 3.4\times10^{-9}$; 95% confidence interval $0.793 \leq \mathrm{OR} \leq 0.890$), however. From Fig. 3(a), the increase of net profit per employee was higher for companies that hired students of mid-ranked universities, compared to those companies that the top-ranked students entered. These results seem to support the idea that middle-ranked universities are better

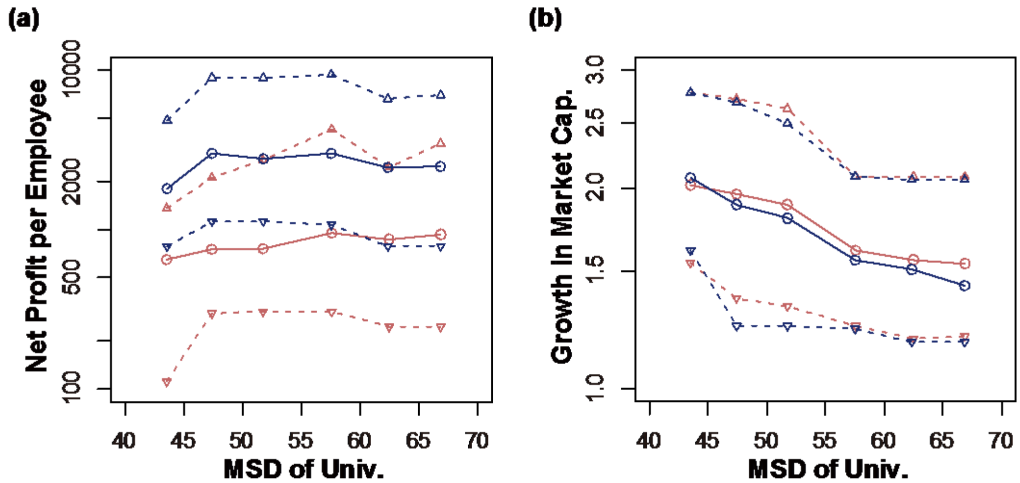

Fig. 3. Percentiles of (a) net profit per employee and (b) growth in market capitalization in 2011–15 of companies that each employee entered, plotted against scholastic scores of universities to which the employee had belonged, based on 2011 data (pale red) and on 2015 data (navy blue). All the plot was generated by binning the scholastic scores with the interval of 5, excluding bins whose sample sizes were smaller than 1000. The coordinates of x-axis indicate the average MSD in each bin and those of y-axis represent 25% (△), 50% (○) and 75% (▽) percentiles of indices for performance of companies. The sample size is 24,578 for 2011 and 30,190 for 2015 (i.e. sum of all the matrix entries).

at sending students into top-ranked companies only during an economic boom.

We also tested whether the growth of companies in market capitalization correlated with their employees' academic competence. Applying the same statistical method as above, the data exhibited striking negative correlations (Fig. 3(b)). Companies hiring with low-scoring universities in 2011 tended to grow faster in the 2011–15 period in average ($P < 2.2\times10^{-16}$; 95% confidence interval $0.566 \leq OR \leq 0.647$), while graduates from high-scored universities in 2015 were still being hired at slowly growing companies ($P < 2.2\times10^{-16}$; 95% confidence interval $0.574 \leq OR \leq 0.644$). The result might imply that the Japanese labor market is inefficient in that assumed high-quality employees are not good at making their own companies grow. On the contrary, this might be a reflection of the fact that graduates with high scholastic ability avoid companies whose performance is more prone to economic recession. Such companies would experience higher growth only with an economic uptrend during the focal period of this study. Longer-term data, covering at least one business cycle, are thus needed to make a conclusive remark.

5. Conclusion

In this paper, we investigated the Universities-Companies Network (UCN) regarding the recruitment of new graduates. Combining different types of data, we quantitatively examined socially accepted ideas. We found that companies put emphasis on the academic ability on recruitment, and some other attributes of universities also affected the fraction of graduates entering famous companies, with the effects varying with business climate. Using hierarchical clustering, we found that universities clustered based on the performance of their students' employment. The result was mostly robust, while some structural features of the clustering tree also changed according to the economic trend. We calculated the weighted HITS hub/authority values for each university and company, and found that the change of hub values coincided with the structural change of the clustering tree. Finally, we examined whether companies which recruited graduates with better academic competence had higher performance. Counterintuitive results were obtained, though they are far from conclusive due to the lack of appropriate data.

The analytical framework we have developed here can be applied to any matrix-formed data to whose rows and columns some features are attributed. For example, financing by banks of companies, the scientific publication by researchers at different universities in journals, and voting by people in different areas for candidates are all possible prospective topics for using our methodology.

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