International Conference on
Employability of Graduates & Higher Education Management Systems
Ljubljana, 27 - 28 September 2012

Case Study on the Influences of Economic Factors on Employment of Graduates of Japanese Engineering Programs.

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Abstract: Maximum 1500 characters (no spaces: 1103).

The employment of university graduates may be influenced by the economic situation, the composition of industry and by other conditions. Though it is recognized that Engineering graduates seek work in manufacturing and related industries, their employment is not limited to these specific industries. A case study was conducted by surveying the employment statistics of graduates from various Science and Technology departments in Bachelor's, Master's and Ph.D. courses at a Japanese national university at 5 year intervals between 1985 and 2010. The results show that new graduates continue to be employed by certain companies, but that graduates' types of preferred industries have been changing as business conditions have changed. The annual statistics for engineers graduated from university departments and the industrial sectors they entered were analysed using multiple correspondence analysis. Two dimensional scales were extracted using the industries and the graduates' academic departments. In comparing the relationships between university departments, industrial sectors, degree levels and year of graduation, these relationships have changed over the years. The factors causing these changes are discussed in context with the changes in the relationships between them.

1. Introduction

The employment of university graduates may be influenced by factors such as the economic situation, the structure of industry and the needs of companies. In Japan, manufacturing industries are major employers, although the ratio of employment of graduates of science and technology courses to the overall work force has decreased recently (Nakayama, 2011). As postgraduate courses in science and technology increase their level of expertise in Japan, many Master's students have found employment in companies in non-scientific & technological industries, such as finance and commerce. However, it is often suggested that a strong relationship still exists between specific disciplines and certain industries.

To illustrate this, a case study was conducted by surveying annual employment statistics for graduates of various Science and Technology departments at a Japanese national university, for every 5 years between 1985 and 2010, and the trends of student's employment preferences are summarized. Also, the relationships between university departments and industries are analysed across degree levels and years of graduation.

This paper will address the following topics:
(1) The number of job openings for applicants from a leading Japanese Science and Technology university are surveyed, and economic and employment trends in Japan are summarized.

(2) The relationship between the course of study and industry of employment are measured, and the matrices of the number of graduates employed in each industry are analysed, using corresponding analysis. The graduates' preferences for particular industries are also summarized.

2. Japanese labour conditions

The Japanese work environment has changed during the past quarter century. Following the "high advanced growth" of the 1970's and the "bubble economy" of the late 1980's, Japan experienced the "two lost decades". The nominal GDP increased marginally from 1985 to 2000, but decreased in the following 10 years to 2010. This suggests that there are some obstacles in the Japanese economy.

The labour force, or the number of people employed, is illustrated in Figure 1(a), according to Japanese statistics. The vertical axis shows the ratio of various industries to the overall workforce. The ratios for manufacturing industries are the highest from 1985 to 1990, while the ratio for service industries steadily increases to its highest point in 1995. The ratio of engineers employed in the construction industry also decreases after 2000, but employment in transportation and telecommunications industries increases after 2000. Business opportunities in the information technology industry peaked worldwide around 2000. This graph depicts the overall changes in the structure of Japanese industry.

Also, the activities and employment needs of industry affect the initial salary of new employees. The mean salaries for graduates with Bachelor's degree are summarized in Figure 1(b). The statistics for graduates with Master's degrees have only been surveyed since 2005, so the plots for these are limited.

Salaries jumped in 1995 due to inflation caused by the "bubble economy", and those for most industries increased slightly in the preceding years, except for finance, real estate and service industry workers. The recession in the 1990s influenced the high salaries of finance, real estate, and services industry workers, which decreased as employment grew. Salaries for graduates with Master's degrees are significantly higher than those for graduates with Bachelor's degrees, though the survey only covers two years.

As the above mentioned structural changes and salary incentives may have affected student's job selections, it is useful to analyse employment surveys at a Science and Technology university.

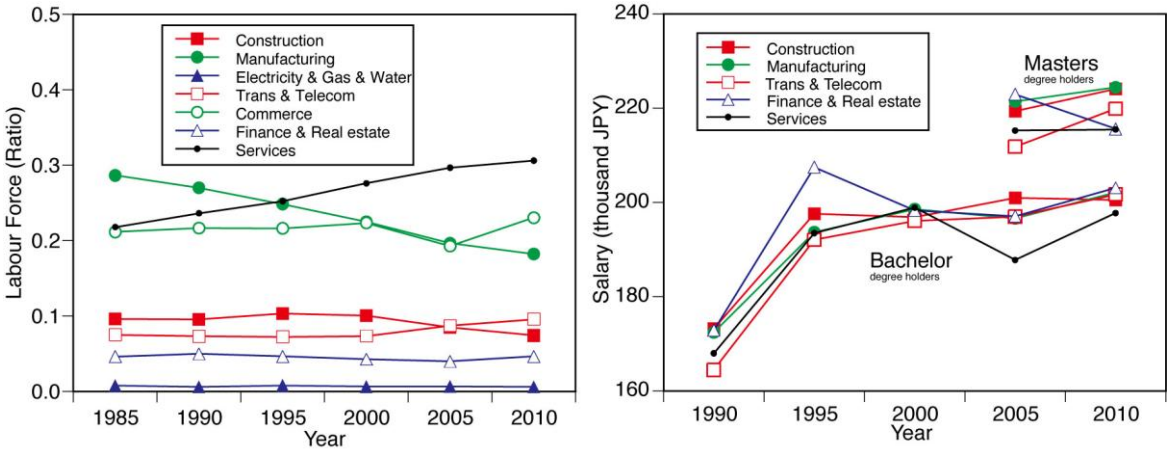

Figure 1 (a): Labour force in Japan (source: MIAC), (b): Initial salaries across industries in Japan (source: MHLW)

3. A case study of Science and Technology graduates' employment

A national science and technology university, which is one of the leading universities in Japan, was chosen as a cohort. The university has summarized graduates' employment statistics according to department and industry, on an annual basis.

In this paper, the statistics for every five years between 1985 and 2010 are compared. Some categories have changed during the years of the surveys, so some compensation is necessary. The number of graduates employed is summarized in Table 1.

Table 1. Totals of new graduates employed, by year and degree

	1985	1990	1995	2000	2005	2010
Bachelors	226	355	252	173	101	91
Masters	555	663	839	1141	1339	1308
Doctors	58	87	169	117	159	135

The table suggests that most graduates are Master's, the number of Master's graduates has increased twice during the 1990s due to the proliferation of postgraduate science and technology courses. Most Bachelor graduates currently go on to Master's courses. The number of Doctoral students has also increased, and since 2005 there have been more Doctoral graduates than Bachelor graduates.

3.1 Employment trends

To survey the demand for science and technology graduates, the number of applications by students is summarized in Figure 2(a). The ratio of job applications per student decreased once in 1995, and decreased again in 2010.

The ratios of company positions per student are generally consistent across the years. Therefore, some internal changes in company requirements vis a vis job applications may have happened around 1995, and as recently as 2010.

The number of new graduates hired per company is illustrated in Figure 2(b). As some graduates are hired by the same company, the mean number can be calculated every year. Though the mean numbers decrease slightly across the years, on average there are around 2.5 Master's graduates working together at the same company, while most Bachelor's and Doctoral graduates are working by themselves at their company of employment.

As shown in Figure 2(a), though many companies offer students employment, students choose specific companies to work at. As the author has reported, most students complete their Master's degree in science and technology, and the number of graduates with Bachelor's and Doctoral degrees is relatively small compared to those with Master's degrees (Nakayama, 2011). Therefore, the number of graduates may affect the ratios of graduate employees per company.

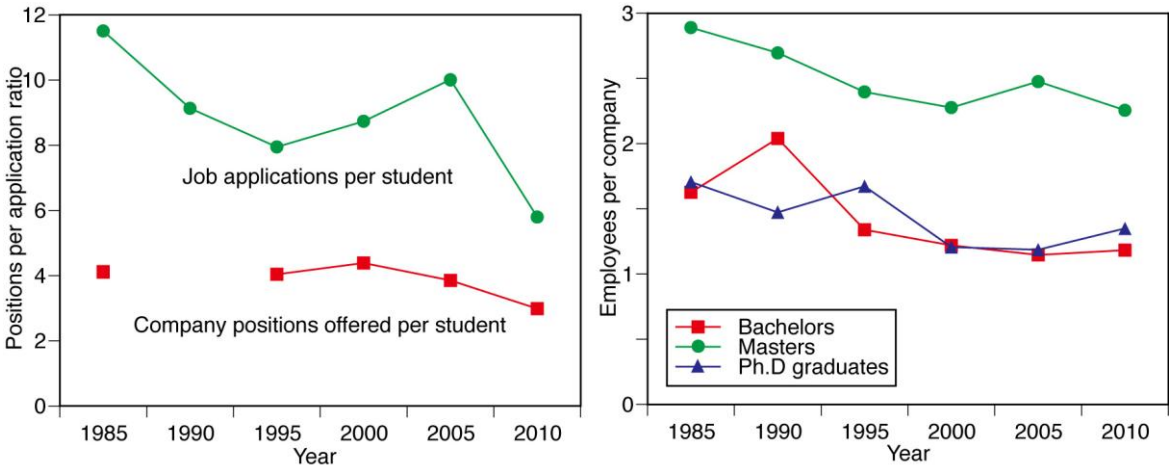

Figure 2 (a): The number of applications per student, (b): The number of graduates per company

To summarize the job selection trends of graduates, the percentages of graduates with each level of degree in each industry are summarized in Figure 3. This figure shows which industries are preferred by graduates.

Figure 3(a) shows the percentages for Construction, Chemical Engineering and Electronics. Ratios of both Bachelor's (B) and Master's graduates (M) in Electronics are the highest between 1985 and 2000, but the ratio of Bachelor's graduates decreases after 2000, and the ratio of Master's graduates remains the highest. The ratio of Doctoral graduates (D) in Electronics increases after 2000, but the ratio for Bachelor's graduates decreases.

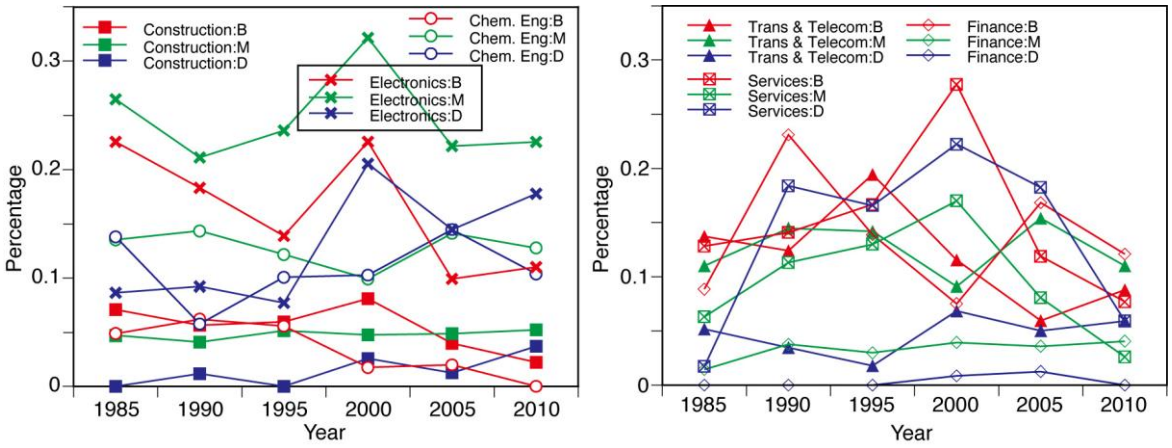

Figure 3 (a): Percentages of graduates in Construction, Chemical Engineering and Electronics, (b): Percentages of graduates in Transportation & Telecommunications, Finance and Services.

The ratios of Master's and Doctoral graduates in Chemical Engineering are almost always higher than the ratio for Bachelor's graduates, while their ratios are nearly comparable, except for 1990. The Chemical Engineering industry prefers expert engineers like Master's and Doctoral degree holders, as the results show. For Construction, the ratios are almost always low, although the ratios of Bachelor's graduates are the highest in the industry between 1985 and 2000. All of these graduates' preferences are different across each industry.

Figure 3(b) shows trends for non-manufacturing industries. All ratios for Service industries increase and decrease before and after 2000, while the ratios of Bachelor's and Doctoral graduates are the highest. Service industries include information services and academic services to industry, and there was a significant change around 2000. The Transportation and Telecommunications industries prefer Master's graduates. In additional, these industries preferred Doctoral graduates after 2000. The Finance industry always prefers Bachelor's graduates, and Master's degree holders to a lesser extent.

3.2 Relationship between departments and industries

As mentioned above, employment statistics regarding department, degree and industry of new graduates have been summarized every year. To extract the relationships, multiple correspondence analysis is applied to the survey data. The categorical variables are shown as follows: Years (1985, 1990, 1995, 2000, 2005, 2010), Degree (Bachelor's, Master's, Doctoral), Departments (Math, Physics, Chemistry, Material Engineering, Chemical Engineering, Mechanical Engineering, Electronic Engineering, Informatics, Civil Engineering and Architecture, Social Engineering, Nuclear Engineering, Bio-Engineering and Interdisciplinary studies), and Industry (Agriculture, Mining, Fisheries and Food, Construction, Publishing, Chemicals, Textiles, Metals, Machinery, Electronics, Transportation, Other manufacturing, Electricity & Gas, Telecommunications, Finance, Real Estate, Commerce, Services, Education and Public Service).

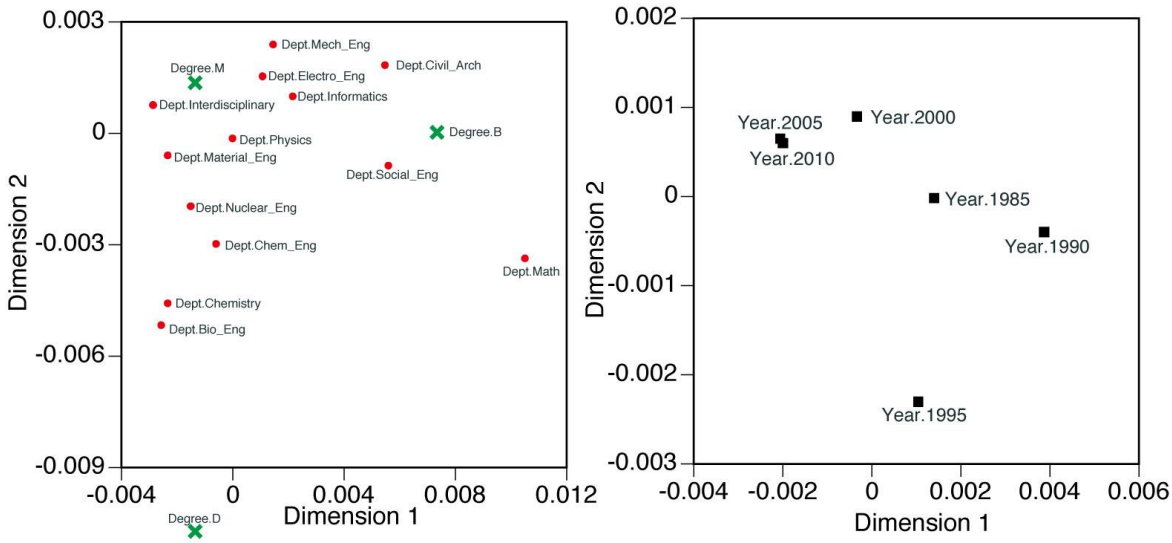

Figure 4 (a): Configuration by degree and department, (b): Configuration by year.

First, all data have been analysed, and the values for departments and degrees are illustrated using two dimensional features in Figure 4(a). The Master's degree is located near the point of origin (0,0), and Electronics Engineering, Mechanical Engineering and Interdisciplinary studies surround the Master's degree. Social Engineering is located near the Bachelor's degree. The Doctoral degree is not near the point of origin, and Bio-Engineering, Chemistry and Chemical Engineering are located between Doctoral degree and the point of origin. In these industries, graduates with Doctoral degrees are preferred over graduates with lesser degrees.

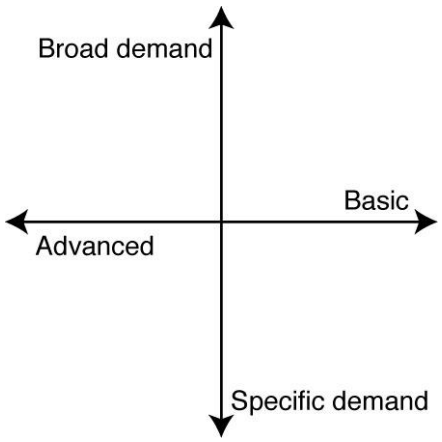

Figure 5: Suggested scales in two dimensions

To illustrate the change across the years, the values for every 5 years are mapped in Figure 4(b). In the figure, the first three years, 1985, 1990 and 1995 show significant deviations, and the rest of the years are located around the same location. Many factors have changed simultaneously during the 25 years surveyed. For the first three 5 year periods, the university increased its number of graduate courses. For the last three 5 year periods, economical conditions were unstable, resulting in a distribution without significant variation.

The features of these plots represent some tendencies in two dimensions, such as basic vs. advanced disciplines represented by the horizontal axis, and broad demand vs. specific

demand represented by the vertical axis. These axes are shown in Figure 5. A Bachelor's degree is relatively basic in comparison with postgraduate courses which deal with advanced course materials. Also, Mechanical Engineering and Electronics Engineering cover broad areas of technology, but Bio-Engineering is relatively limited in application.

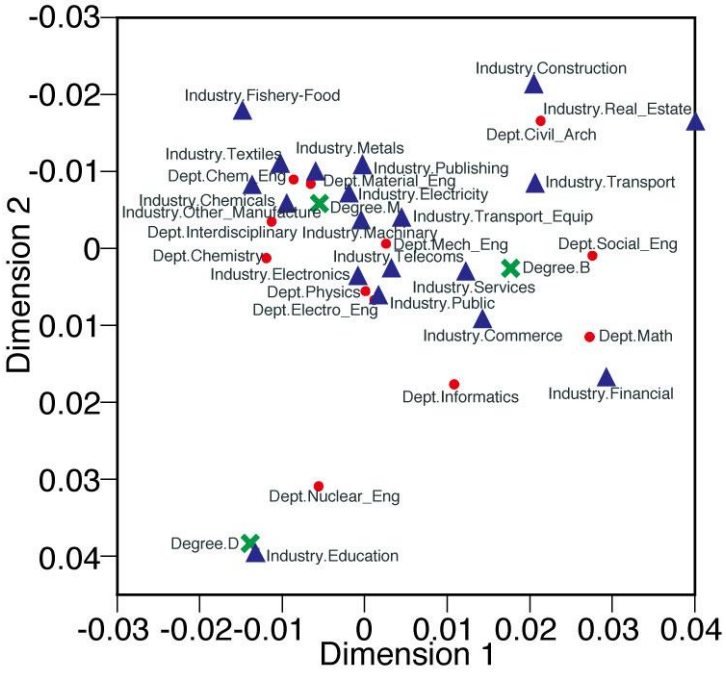

Figure 6: Configuration by degree, department and industry in 1985

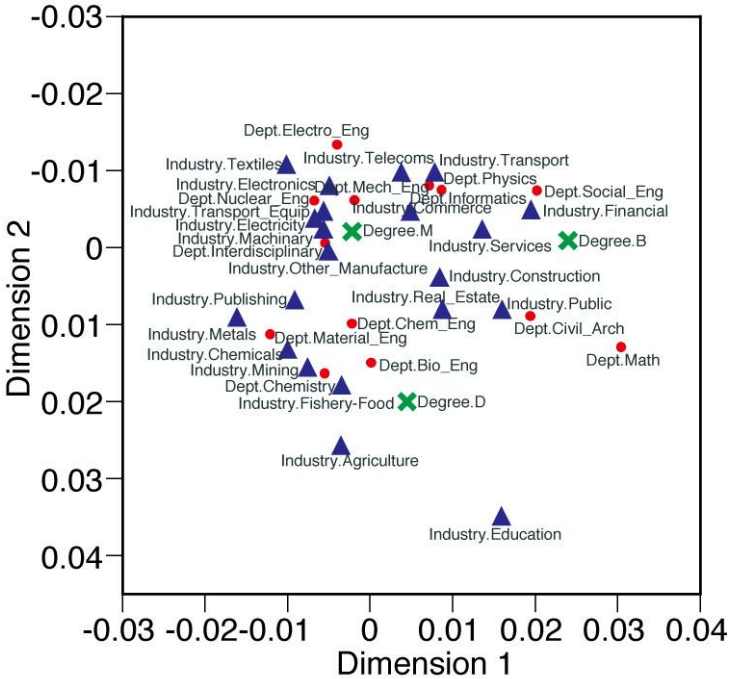

Figure 7: Configuration by degree, department and industry in 2010

The structure by degree, department and industry for 1985 is illustrated using the same features as in Figure 6. The dimensional scale in the vertical axis is converted according to Figure 5. The Doctoral degree is separate from the point of origin, and the position of Education is located near the Doctoral degree. This means that a Doctoral degree has a

high degree of expertise and most jobs for Doctoral degree holders are as teaching staff at educational institutions. In 1985, the emphasis for doctoral degree courses was on positions in research and development.

Figure 7 shows the structure in 2010. The Doctoral degree is near the point of origin, and many industries are located around the Doctoral degree. This means that some industrial sectors prefer graduates with Doctoral degrees. The typical relationships between departments and industries have disappeared, except for Social Engineering, Chemistry and Chemical Engineering, as most graduates can work in a variety of industrial sectors.

The major factors causing these structural changes and the process by which these relationships were established should be studied in more detail. Also, new educational programs should be introduced to help students recognize the changes in the labour market. These points will be subjects of our further study.

5. Summary

To measure the relationships between the employment of new graduates of university departments and the industrial sectors they entered, annual employment statistics of graduates from various Science and Technology departments at a Japanese national university for every 5 years between 1985 and 2010 were analysed as a case study.

The trends in job application statistics, and changes in employment ratios by industry for graduates across degree levels are summarized, and deviations in indices for labour economics surveys in Japan are observed. The quantitative relationships in the statistics for graduates, between their departments and the industries they entered, are extracted using multiple correspondence analysis. The relationships between dates of initial employment and degree levels are also determined.

Acknowledgement
The author would like to thank Dr. Hiromitsu Muta, Professor Emeritus of Tokyo Institute of Technology, who kindly suggested the analysis of annual institutional statistics of employment of graduates.

Literature

Japanese Ministry of Internal Affairs and Communications, Labour Force Survey, http://www.stat.go.jp/english/data/roudou/index.html

Japanese Ministry of Health, Labour and Welfare, Basic Survey on Wage Structure, http://www.mhlw.go.jp/toukei/itiran/roudou/chingin/kouzou/detail/

Economic and Social Research Institute, Cabinet Office, Government of Japan, National Accounts of Japan, http://www.esri.cao.go.jp/en/sna/menu.html

Nendadi'c, O. and Greenacre, M. (2007) Correspondence analysis in R, with Two- and Three-dimensional Graphics: The ca Package, J. of Statistical Software, Vol.20, Issue.3

Nakayama, M. (2011) A Survey of the Relationship between Quality Assurance and Employability for Graduates of Japanese Engineering Programs, Proc. of DEHEMS 2011. http://www.dehems-roject.eu/static/uploaded/files/files/contributions/Nakayama_Minoru_DEHEMS_Conference_Paper_A_Survey_of_the_Relationship_between_Quality_Assurance_and_Employability_for_Graduates_of_Japanese_Engineering_Programs.pdf