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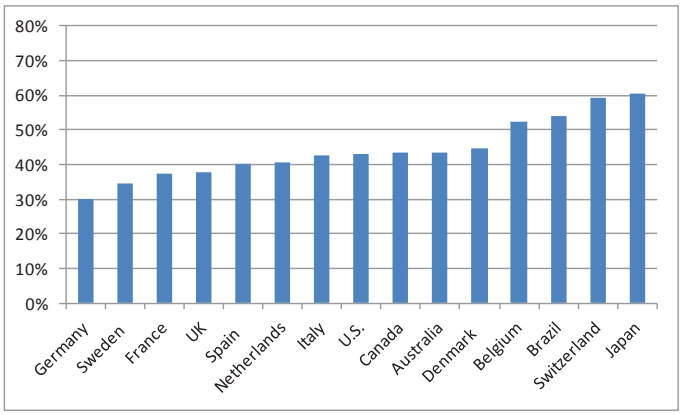
国際的な研究交流における多様性
Diversity in mobility patterns of researchers

依田達郎，大竹裕之（公益財団法人未来工学研究所）
Tatsuro Yoda and Hiroyuki Ohtake (Institute for Future Engineering)

1. Introduction

The result of the GlobSci survey on international mobility patterns of scientists (Franzoni et al 2012) shows that the combined share of the top 4 countries of foreign researchers coming to Japan or of Japanese researchers going abroad from Japan is higher than top 4 countries' share of other major countries (Figure 1). In other words, the composition of the countries from which foreign researchers come to Japan or the composition of the countries to which Japanese researchers go working are less diversified.

In this paper, we look at the trend of diversity in terms of the composition of countries of incoming and outgoing researchers drawing on the data on annual survey on international exchange of researchers in Japan since 2002, and discuss the meaning of such diversity in international exchange of researchers. The goal of the study, although the results of this article is still preliminary, is to answer the following research questions: 1) why diversity in international cooperation in terms of composition of cooperating countries is so low in Japan, and 2) whether it should increase diversity in order to increase the efficiency and effectiveness of its international cooperation.

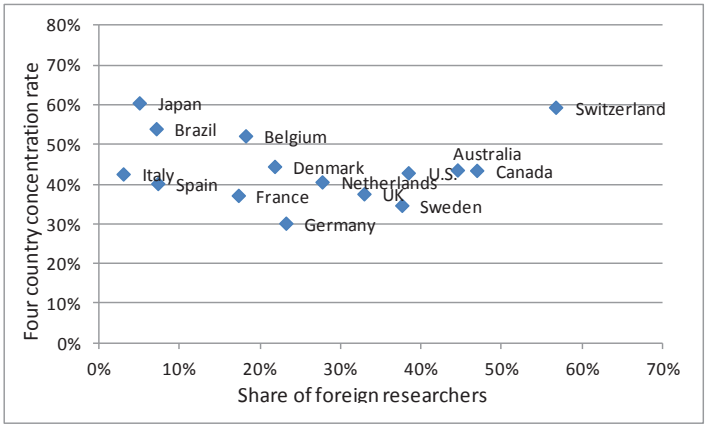


Source: Data is from G. Scellato et al (2012).
Figure 1: Four country concentration rate

2. Previous literature

Franzoni, et al (2012) sent questionnaires to 47,304 corresponding authors of journal articles in 4 scientific areas (biology, chemistry, earth and environmental sciences, and materials) published in 2009. The countries covered were 16 countries (Australia, Belgium, Brazil, Canada, Denmark, France, Germany, India, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, UK, and US). The number of articles written by authors in those 16 countries accounts for more than 70 percent of articles in journals in those 4 scientific areas. The response rate was 35.6 percent.

They showed that, in Switzerland and Japan, over 60 percent of foreign researchers come from the top 4 countries of largest share (Figure 1). In Japan, 60.5 percent of foreign researchers come from the top 4 countries, and the diversity of foreign researchers measured by Herfindahl index



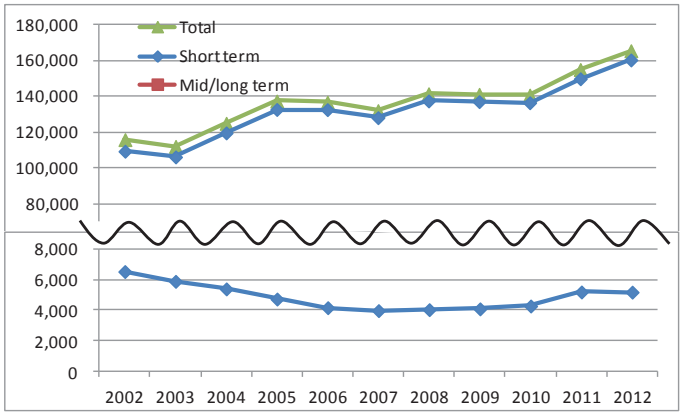
Source: Data is from G. Scellato et al (2012).
Figure 2: Relationship between share of foreign researchers and four country concentration rate

(see section 3) is the smallest.[1] The proportions of foreign researchers from the top 4 countries were small in Germany (30 percent) and Sweden (35 percent), meaning that the compositions of the countries from which foreign researchers originally come in those countries are more diversified. Figure 2 is a scatter plot showing the relationship between four country concentration rates and shares of foreign researchers of the countries. Although four country concentration rate is high in Switzerland as is seen in Figure 1, the share of foreign researchers is also high (59.4 percent), different from the pattern in Japan. The share of foreign researchers in Japan is only 5.0 percent. In Figure 2, there is a weak correlation between concentration rates and shares of foreign researchers, if the data for Switzerland is excluded (correlation coefficient=0.40 (significant level=0.15)). This correlation would partly explain why diversity of international exchange of researchers in Japan is smaller, although there may be other reasons such as its geographical location or language barrier.

3. Data and method

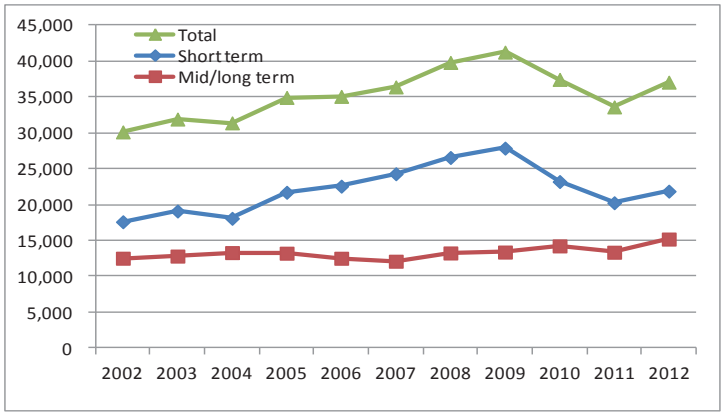
Science and Technology Agency before 2001 and Ministry of Education, Culture, Sports, Science and Technology in Japan (MEXT) after 2002 have been conducting annual survey on international research exchanges since 1989 ("Survey on International Research Exchanges"). In the survey, a questionnaire is sent to all the universities and national research institutions in Japan.[2] The data obtained from those institutions are the number of incoming foreign researchers to the institution and outgoing Japanese researchers from the institution classified by duration of stay (less than 30 days (short-term stay), between 31 days and 1 year (mid-term stay), and more than 1 year (long-term stay), countries (countries from which incoming foreign researchers come from, and countries to which Japanese researchers go), and so on.

Figure 3 shows that the number of researchers going abroad from Japan for short-term stay has been increasing and is about 160,400 in FY2012. The number of researchers going abroad for mid/long-term stay[3] is about 5,200 and has been stagnating in the past ten years. Figure 4 shows that the number of researchers coming to Japan for short-term stay has increased in FY2012 to about 21,800 after 2 consecutive years of rapid decline after the Great East Japan



Source: MEXT (various years)

Figure 3: The number of researchers going abroad from Japan (2002-2012)



Source: MEXT (various years)

Figure 4: The number of foreign researchers coming to Japan (2002-2012)

[1] The data on India is excluded since the number of samples is small. In the data on India, 4 country concentration rate is 100 percent and the number of foreign researchers is 4 out of 254 corresponding authors.

[2] In the survey conducted in FY2013, questionnaires were sent to 836 universities (86 national universities, 82 public universities, 607 private universities, 4 inter-university research institute corporations and 57 colleges of technology) and 62 national research institutions (46 incorporated administrative agencies and 16 national research laboratories). The responses were obtained from 788 universities and 52 national research institutions and the response rate was 93.5 percent.

[3] This includes the number of researchers who go abroad before FY2012 and continue their stay in FY2012. But it does not include the number of researchers who quit their job in Japan, since questionnaire is sent only to research institutions in Japan and they do not have information about researchers employed by foreign research institutions.

Earthquake and the disaster at the nuclear plant in Fukushima in March 2011 (FY2010). The number of researchers coming to Japan for mid- to long-term stay had been relatively stable between 12,000 and 14,000, and slightly increased to more than 15,000 in FY2012.
In order to examine the trend of concentration or diversity of composition of countries of incoming researchers to Japan or outgoing researchers from Japan, first, we look at the trend of 4 country concentration rate, which is defined as the share of researchers coming from or going to the top 4 countries whose share are the highest in a given fiscal year, using the survey data.
Second, we look at the trend of Herfindahl index (H index), which is defined when calculating it for incoming foreign researchers as follows:

$$\text{Hindex} = \sum_{i=1}^{R} P_i^2$$

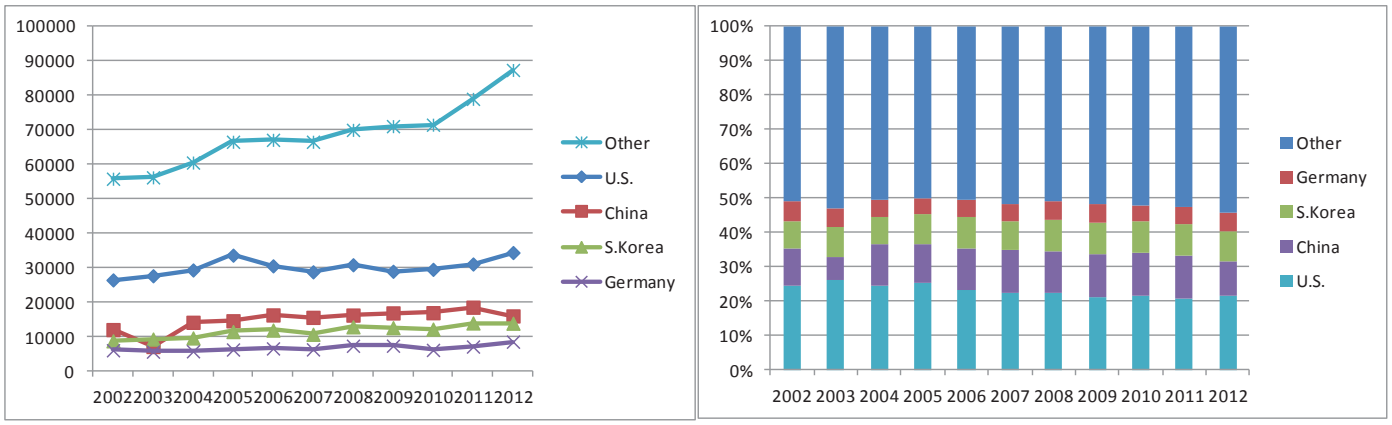
where Pi is a share of the researchers who come from country i (percent) and R is the number of countries.
In FY2012, the number of the countries which Japanese researchers visited for short-term stay and for mid to long-term stay was 181 and 112 respectively, and the number of the countries from which foreign researchers in Japan come for short-term stay and for mid/long-term stay was 139 and 142 respectively. By using H index, it would be possible to examine the state of diversity more in detail than the 4 country concentration rate, taking into account the shares of all the countries.

4. Preliminary results

Figure 5 to 12 show the change in the number of researchers who go to or who come from top 4 countries for short-term stay or for mid/long-term stay, and the change in its share, between 2002 and 2012. France was the 4th instead of Germany in 2004 and 2011 for outgoing researchers (short term) (Figure 5 and 6), and India was the 4th instead of UK between 2002 and 2007 for incoming researchers (mid/long term) (Figure 11 and 12). Except for those, between 2002 and 2012, the lists of the top 4 countries have been the same for incoming or outgoing researchers in each duration.
The relatively large changes observed in those figures are as follows:

- The number and the share of the category “other” have been increasing in Figure 5 and 6, which is caused by the fact that the increase of the number of researchers who visit Asian and European countries other than the 4 top countries for less than 1 month increased.
- The number and the share of the researchers who stay in the U.S. for more than 1 month decreased rapidly during the 2000s but they have been increasing again in recent years in Figure 7 and 8. The number and the share of the UK have decreased slightly, and those for the “other” category increased because of the increase of European countries other than France, Germany and the UK.
- The number and the share of incoming researchers (short term) from China decreased in FY2012 although the total number of incoming researchers increased in the year in Figure 9 and 10. The number of the “other” category, mainly Asian countries, had been increasing before the Great East Japan Earthquake and the nuclear plant disaster in FY2010, but its share was stable because the total number increased as well.
- The share of incoming researchers (mid/long term) from China has been decreasing since its number is almost the same when the total number has been increasing in Figure 11 and 12. The share of the US has been increasing slightly.

Figure 1, based on the number of corresponding authors of journal articles, shows that 4 country concentration rate for most of the major countries is around 30 to 40 percent. Although the data in Figure 6, 8, and 10 are based on actual flow of researchers and different from Figure 1, they would be correlated. In order to reduce 4 country concentrations in Japan, it would be necessary to reduce the share of the 1st or 2nd country in the number of incoming or outgoing researchers. The share of the U.S. for outgoing researchers or China for incoming researchers (mind/long term) seem to be too large in order to reduce the concentration rate to the level of 30 to 40 percent. Of course, whether it is desirable to reduce the concentration rate or not is another complex problem.



Source: MEXT, "Survey on International Research Exchanges" (various years)

Figure 5 and 6: The number and proportion of researchers going abroad from Japan, by country (2002-2012, short term)

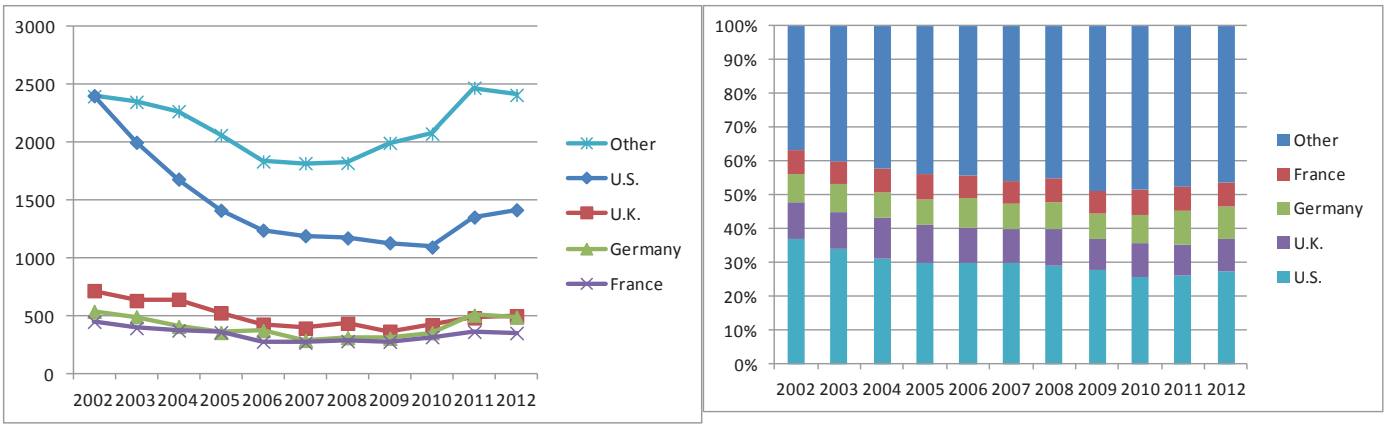


Figure 7 and 8: The number and proportion of researchers going abroad from Japan, by country (2002-2012, mid/long term)

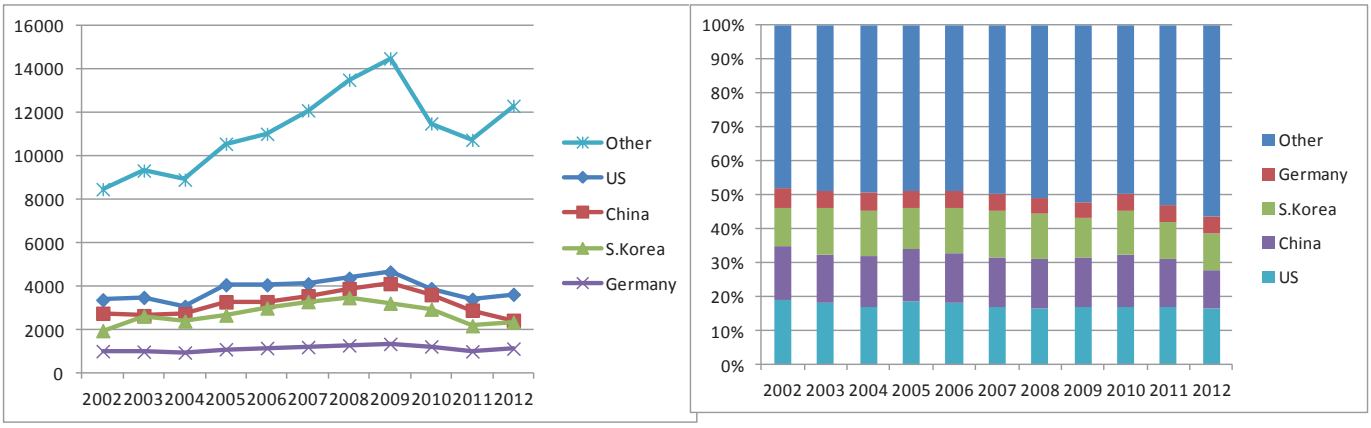
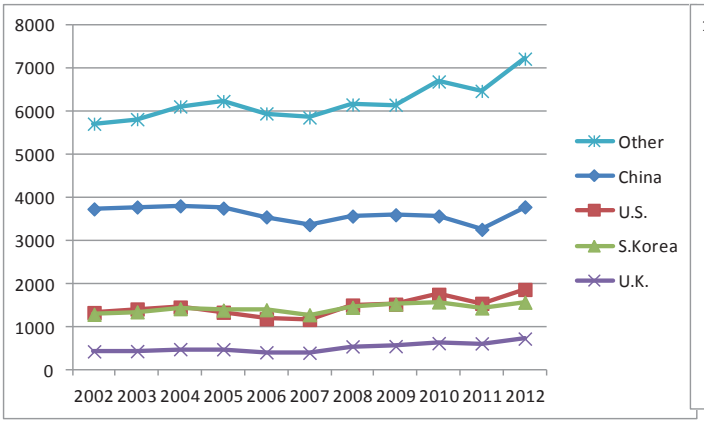


Figure 9 and 10: The number and proportion of of foreign researchers coming to Japan, by country (2002-2012, short term)



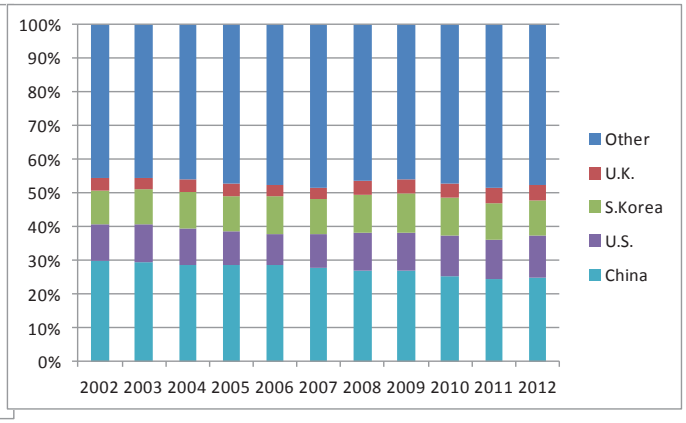


Figure 11 and 12: The number and proportion of foreign researchers coming to Japan, by country (2002-2012, mid/long term)

Figure 13 shows the trend of 4 country concentration rate of incoming and outgoing researchers for short-term and mid/long-term duration of stay in Japan between 2002 and 2012. Concentration rates for mid/long-term stay are larger than those for short-term stay. As is explained above, the concentration rate of outgoing researchers for mid/long term has been decreasing, because of the decrease in the share of the U.S. Other concentration rates are almost the same or slightly decreased since 2002. But compared to other countries (Figure 1), these are still high.

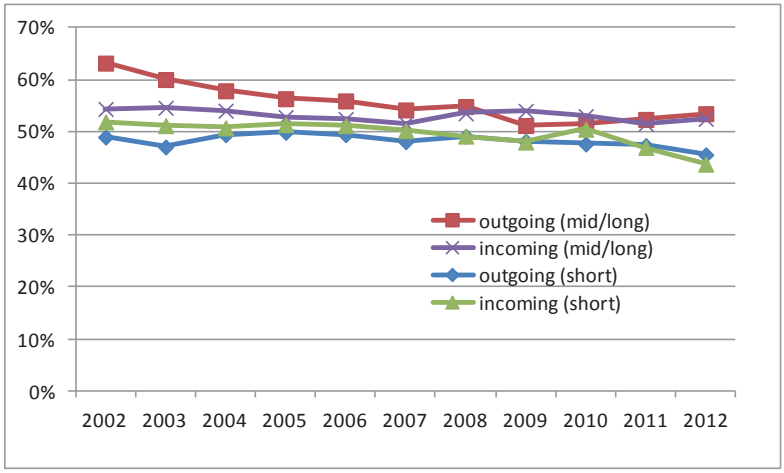


Figure 13: 4 country concentration rate of incoming and outgoing researchers in Japan (2002-2012)

Figure 14 shows the trend of H index. The pattern seen in Figure 14 is about the same as Figure 13, but the difference among lines and change are much clearer. The H index for outgoing researchers (mid/long term) has decreased. In other words, the composition of countries for outgoing Japanese researchers has become more diversified. Other H indexes have been decreasing, but the change is very slow. As in Figure 13, H indices for mid/long term are higher than H indices for short term.

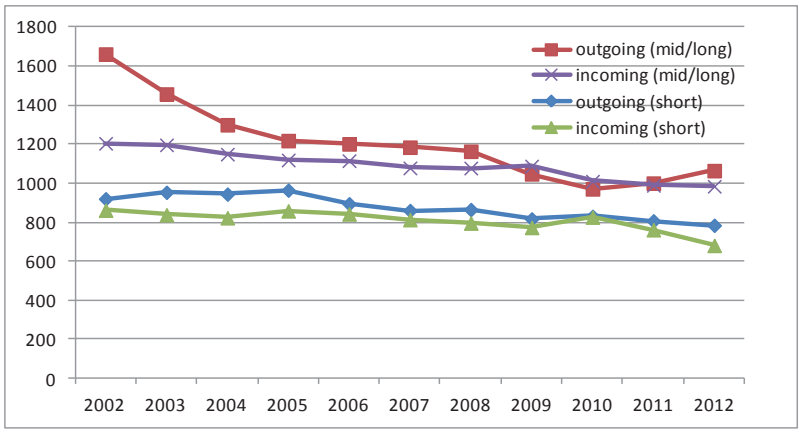


Figure 14: Herfindahl index for composition of countries of incoming and outgoing researchers

5. Discussion

White Paper on Science and Technology 2013 of the Japanese government explains about various kinds of activities for promoting international cooperation of science and technology as follows:

> In accordance with the 4th Science and Technology Basic Plan, the government is making efforts to contribute to the solution of global-scale issues, to promote strategic international

cooperation in advanced S&T fields, to enhance international networks of human resources and research, and to promote the improvement of environment in order to support these efforts, all of which strengthen international activities. (p.128)

The white paper goes on to explain about the purpose of the first kind of activity (solution of global-scale issues) that "particularly in Asian countries, there are many issues that Japan can tackle by using its S&T capabilities, such as issues regarding the environment, energy, food, water, disasters, and infectious diseases" (p.129). As to the purpose of the second kind of activity (cooperation in advanced S&T fields), it explains that "Japan needs to improve international research networks in various areas with countries that have the world's highest levels of S&T and while also promoting international cooperation concerning advanced S&T that utilizes quality research resources overseas" (p.130).

What is the value of diversity in the relationship with foreign countries in S&T cooperation? It certainly would depend on how we define the word and the type of activities as described above. For solving global problems, it would be necessary to strengthen the relationship with countries that face the problems. If the problem is global in nature, the relationship should be diversified. On the other hand, in order to improve S&T capability by cooperating with advanced countries, it may lead the decrease of diversity by strengthening with a few strategically important countries. As the same time, as diversity in investment is desirable in order to reduce risks and cope with uncertainty, diversity in the relationship with advanced countries in S&T would be still desirable, when R&D investment becomes larger in scale and riskier. As we see in Figure 1, the more it may become necessary to concentrate in strengthening a relationship with a few important countries, the lower the share of foreign researchers becomes. However, it would become more important to increase diversity when the volume of international cooperation becomes larger, and it would be possible as Figure 2 suggests.

6. Conclusion and future direction

In this paper, we looked at the trend of diversity of the composition of incoming and outgoing researchers in Japan during the past 10 years, and found that diversity is still lower when compared to other countries but it has been increasing very slowly, especially for outgoing researchers of mid to long-term stay. The reason behind the low level of diversity would be that the shares of the 1st or 2nd country such as the U.S. and China for outgoing researchers and the US, China and South Korea for incoming researchers are high. In addition, the low proportion of foreign researchers in Japan itself may be part of the reasons for low level of diversity as suggested by data of the GlobSci survey (Figure 2).

Of course, diversity in international cooperation is not only about the composition of countries of incoming and outgoing researchers, but also it would relate to composition of academic disciplines, balance of male and female researchers among incoming and outgoing researchers, composition of research institutions accepting foreign researchers, and so on. It would be interesting to examine diversity on those aspects using the results of the MEXT survey.

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