

The comparison of innovation capabilities in Japan, Korea, China and Taiwan

Wen-Cen Wan^{1 +}

¹ 14-16F, No. 106, Heping E. Rd., Sec. 2, Taipei 10636, Taiwan

Abstract. This paper compares the input of the expenditure and researchers on R&D and the output of the scientific articles and invention patents among Japan, Korea, China and Taiwan. The conclusions can be drawn from this paper that first, Japan outperformed others in its output because of its input on researchers in business enterprise and their targets of long-term research performance. Second, China is an emerging economy. Most of its input and output were increased before 2009. However, although China had outstanding performance on scientific articles, its number of invention patents still far behind of other three countries. Third, the innovation capabilities of Korea and Taiwan were highly similar on both input and output, but Korea invested more, so its outcome was better than Taiwan. Finally, Taiwan's patents were less credited to its academic research, so Taiwan should enforce the relationship between academic research and the need in industry.

Keywords: Innovation capabilities, Invention patent, scientific articles

1. Introduction

Innovation capabilities represent competition ability of the country. Good innovated capabilities help develop industries and countries to grow. Innovation capabilities can be separate into two parts: input of the expenditure and researchers on R&D, and output of the scientific articles and invention patents. This paper selected the leading competitive countries in east of Asia, Japan, China, Korea, and Taiwan, analyzes their input, output and performance.

2. Methodology

This paper attempts to combine and compare the different data between the input of the expenditure and researchers on R&D, and the output of the scientific articles and invention patents. The data sources of this analysis derived from four parts: First, from the book "Main Science and Technology Indicators", released by OECD in 2011. Second, from the book "2011 White Paper on Taiwan Industrial Technology", released by Ministry of Economic Affairs in 2011. Third, from the database which constructed by Science and Technology Policy Research and Information Center (STPI) based on the Thomson Reuters' data sources. Finally, from the data release by USPTO. Please note that in this paper, to represent the invention appropriately, the patents refers to the utility or invention patents granted by the United States Patent and Trademark Office (USPTO), and the scientific articles refer to those compiled by Science Citation Index (SCI), which document types are "Articles, Letters and Reviews" in the database.

3. The Input of the Expenditure and Researchers on R&D

The figure 1 and 2 show that both of the gross domestic expenditure on R&D (GERD) and the business enterprise expenditure on R&D (BERD), Korea, China and Taiwan were increased from 2005 to 2009. Japan

⁺ Corresponding author
E-mail address: lbgats@gmail.com

was a little different from others: the GERD and BERD was increased from 2005 to 2007 but decreased after 2008. Besides, the ranking of GERD and BERD of these four countries before 2008 were Japan, China, Korea and Taiwan. In 2009, China was getting ahead of Japan in the first time, ranked in the number one.

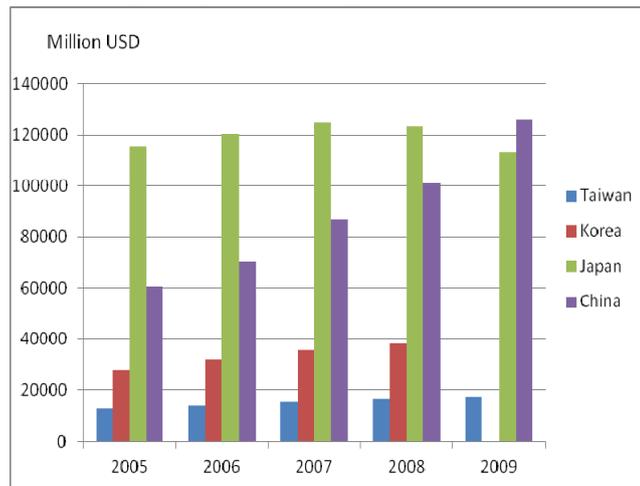


Fig.1 Gross domestic expenditure on R&D (GERD) at current prices

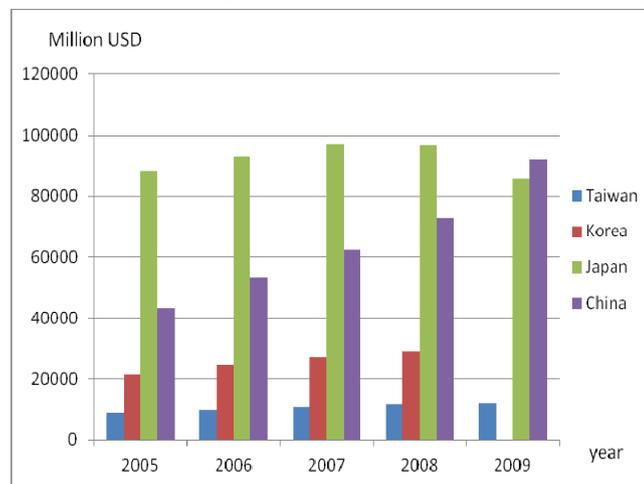


Fig.2 Business enterprise expenditure on R&D (BERD) at current prices

Data source: OECD (2011), Main Science and Technology Indicators, OECD

Ministry of Economic Affairs (2011), 2011 White Paper on Taiwan Industrial Technology, Ministry of Economic Affairs

Notes: The data of Korea includes only the expenditure in scientific fields, the fields of social science were ruled out. Besides, the data of 2009 was insufficient in Korea.

The figure.3 displays the gross domestic expenditure on R&D as a percentage of GDP. It shows that in Korea, China and Taiwan, GERD were slightly increased after 2005, and Japan was slightly decreased after 2008. Besides, the GERD in Korea was approaching Japan in 2008.

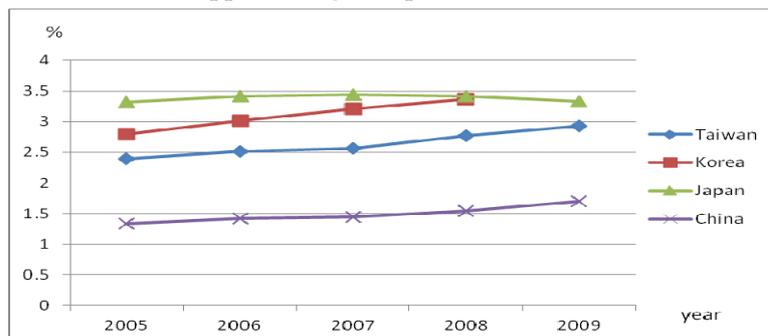


Fig.3 Gross domestic expenditure on R&D (GERD) as a percentage of GDP

Data source: OECD (2011), Main Science and Technology Indicators, OECD

Note: The data of 2009 was insufficient in Korea.

The figure 4 and 5 demonstrate that both of the total researchers and the business enterprise researchers in full-time equivalent. Observed from the figures, the researchers in Korea and Taiwan were increased from 2005-2008/2009. However, China and Japan told the different stories. In China, as show on the figures, from 2005-2008, the number of total researchers and researchers in the business enterprises were increased from about 0.7 million to 1.1 million, and from about 0.7 million to 1.1 million, respectively. But in 2009, the numbers were sharply decreased in both of them, from 1.6 to 1.16 million, and from 1.1 to 0.71 million respectively, almost went back to the level of 2005. This sharply decrease might be caused by the global financial crisis. Japan's total researchers were also sharply decreased after 2007, but different from China, Japan's researchers in the business enterprises maintained almost in the same level from 2005 to 2009.

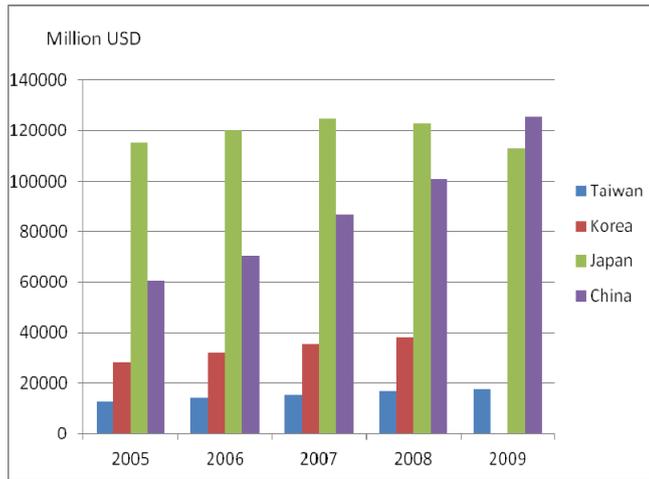


Fig.4 Total researchers in full-time equivalent (FTE)

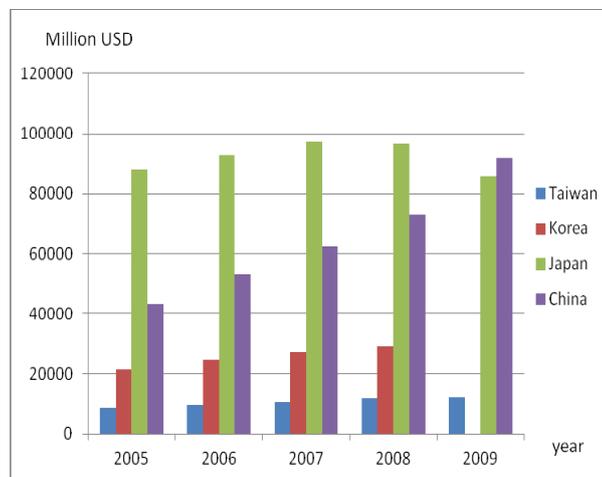


Fig.5 Business enterprise researchers in full-time equivalent (FTE)

Data source: OECD (2011), Main Science and Technology Indicators, OECD

Ministry of Economic Affairs (2011), 2011 White Paper on Taiwan Industrial Technology, Ministry of Economic Affairs

Note: The data of 2009 was insufficient in Korea.

4. The Output of the Scientific Articles and Invention Patents

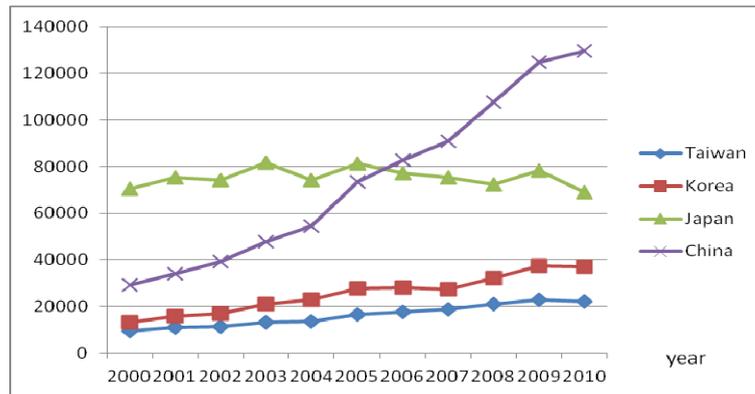


Fig.6 Number of scientific articles

Data Source: the database constructed by STPI

The figure 6 uncovers the number of scientific articles. Observed from the figure, the number of scientific articles of Korea, Taiwan, and China were increased but Japan’s was wavy. Besides, Japan, China, Korea and Taiwan ranked orderly in the quantity of scientific articles before 2006; however, China surpassed Japan and became number one in 2007 and thereafter.

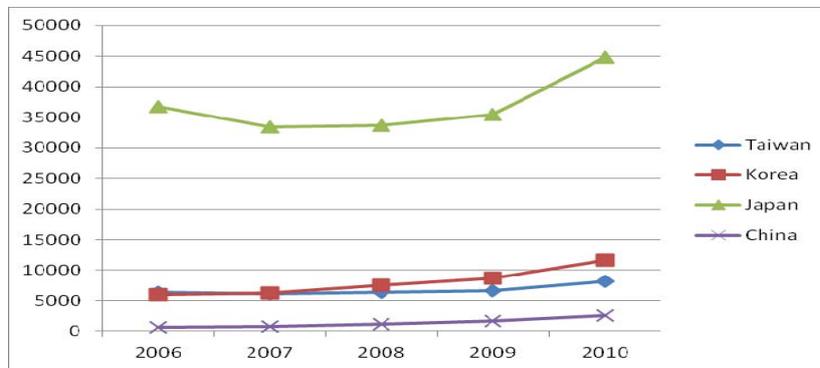


Fig.7 Number of invention patent in USPTO

Data Source: the data released by USPTO

The figure 7 uncovers the number of invention patents. As figure shows, the number of invention patents in Korea, Japan and China were increased gradually; Taiwan was almost the same from 2006 to 2008 but started to increase in 2009. Figure 7 also shows that Japan’s invention patents outperformed others in number, followed by Korea and Taiwan. In 2006, the invention patents of Korea and Taiwan were almost in the same level, but after 2008, Korea was getting beyond Taiwan slightly.

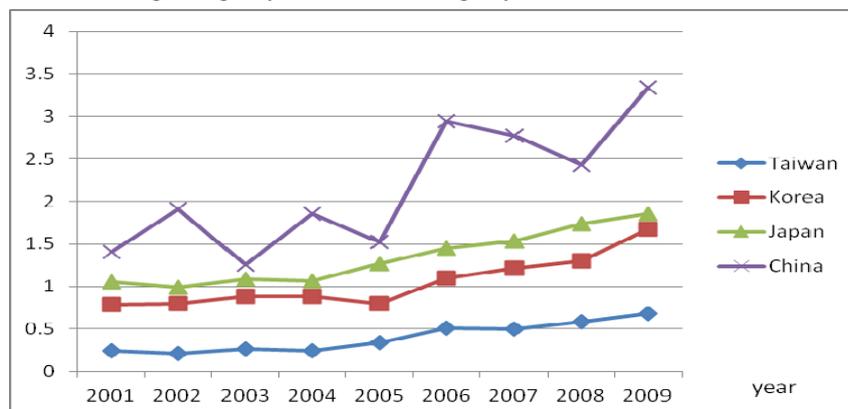


Fig.8 Average citation numbers of non-patent references on invention patents

Data Source: Ministry of Economic Affairs (2011), 2011 White Paper on Taiwan Industrial Technology, Ministry of Economic Affairs

The non-patent references - most of them are academic research - cited by patents display the value of academic research to help invent the patents. Observed on Figure 8, Korea and Taiwan’s average citation

numbers of non-patent references on invention patents were slightly increased from 2005 to 2009, Japan's was increased from 2004 to 2009, and China's was continuously unstable. Besides, in 2009, the numbers of citation in Japan and Korea were almost in the same level, but Taiwan was far behind China, Japan and Korea. Fortunately, no evidence shows that there was a linear relationship between the citation of academic research and invention patents; it only revealed that Taiwan's patents were less credited to its academic research.

5. Summary

In Japan, the GERD, BERD and total researchers were decreased after 2008 because of the global financial crisis, but researchers in business enterprise almost maintained in the same level from 2005 to 2009. Fortunately, although it was deeply struck by the financial crisis, the number of its invention patents was increased from about 34 thousands in 2008 to about 45 thousands in 2010, far beyond Korea, China, and Taiwan. Besides, its number of scientific articles was still in front of Korea's and Taiwan's, too.¹ The key point of Japan's successful performance in patents and articles should be credited to their business enterprise maintained the same level of researchers and targeted in the long-term research performance, though they cut the expenditure on R&D by the lack of money.

China is an emerging economy. GERD, BERD, the number of scientific articles, and the number of invention patents were all increased before 2009, although its total researchers were sharply decreased from 2008 to 2009. Besides, the number of scientific articles and invention patents were increased from 2009 to 2010, too. It seems like there were no linear relationships among the number of scientific articles, invention patents and the decrease of the total researchers. In addition, although China surpassed other three countries in the number of scientific articles, its number of invention patents still far behind of Japan's, Korea's and Taiwan's.

The innovation capabilities of Korea and Taiwan were highly similar on both input and output, but Korea invested more, so its outcome was better than Taiwan. Besides, although Korea and Taiwan were also struck by the financial crisis, they still decided to gain their expenditure on R&D and the number of researchers in order to strengthen their innovation capabilities and have advanced technology.

Finally, the average citation numbers of non-patent references on invention patents in Korea and Japan seemed to be increased gradually and evidently than Taiwan. It referred that in Korea and Japan, scientific articles had more contributions to help inventing patents, but Taiwan was on the contrary. It referred that Taiwan should enforce the relationship between academic research and the need in industry.

6. References

- [1] OECD (2011), Main Science and Technology Indicators, OECD
- [2] Ministry of Economic Affairs (2011), 2011 White Paper on Taiwan Industrial Technology, Ministry of Economic Affairs
- [3] OECD (2009), Science, Technology and Industry Scoreboard 2009, OECD
- [4] OECD (2010), OECD Science, Technology and Industry Outlook, OECD
- [5] USPTO, information on: <http://www.uspto.gov/>

¹ No evidence proved the impact of GERD, BERD and business enterprise researchers on scientific articles.