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Changes of Scientific Productivity in Japan from 1975 to 2010: Focusing on Second-tier Research Universities*

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Abstract: This study shows changes in scientific productivity in Japan. After Japan became the second largest country in science production in the 1990s, Japan's position declined to fifth in 2010. National universities are the core of science production, and from 1995–2000, national universities, who are not among the top 10, expanded their number of articles published as much as those among the top 10 national universities. However, under decreases in basic governmental block grants from 2005 and the expansion of competitive funds, the number of articles published by universities who were not among the top 10 stagnated, especially, the number of articles published by second-tier research universities decreased. From this result, I show the importance of second-tier research universities for science production as a country; furthermore, I demonstrate that competitive funds are not a panacea for science production.

Keywords: Scientific productivity, Japan, National university, Research university, Competitive funds, and Block grants

Özet: Bu çalışmada Japonya'daki bilimsel üretimdeki değişimi konu edinmektedir. Japonya 90'larda ikinci büyük bilimsel üretim merkezi haline gelmesinin ardından, 2010'da beşinci sıraya kadar düşmüştür. Ulusal üniversiteler, bu bilimsel üretimin ana kurumlarıdır ve 1995-2000 arasında bu kurumlar, ki hiçbirisi ilk onda değildir, ilk ondaki ulusal üniversiteler kadar bilimsel makale yayımını arttırmışlardır. Fakat, 2005 itibarıyla devlet ödeneklerinin azalması ile ilk onda yer almayan üniversitelerde yayımlanan makale sayısı sabitlenmiş, bilhassa ikinci sınıf üniversitelerce yayımlanan makale sayısı ise azalmıştır. Burada, ikinci sınıf üniversitelerin bir ülkenin bilimsel üretimi için ne denli önemli olduğunu ve rekabete dayalı fonların bilimsel üretime care olmadığını göstermekteyim.

Keywords: Bilimsel üretim, Japonya, Ulusal üniversite, araştırma üniversitesi, rekabete dayalı fonlar, Blok fonlar.

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Introduction

In his 1968 book, *The Age of Discontinuity*, Peter Drucker coined the phrase “the knowledge society.” In the globalized knowledge economy, the production of knowledge is critical for the future success of a country. In many countries, governments expect universities to play a key role in knowledge production. Japan is one such country.

The Japanese government and particularly the Ministry of Education, Culture, Sports, Science and Technology (MEXT) have recently been trying to create world-class universities. To this end, MEXT has created “The Program for Promoting the Enhancement of Research Universities.” The program was started in 2013 to create a “cluster” of world-class research universities in Japan, including 19 universities and 3 research institutions. The total budgeted amount for the program in 2013 was 6.4 billion yen, and funding is expected to continue for 10 years.

For this study, I define the production of knowledge in Japan as the number of articles published by scholars affiliated with universities, research organizations, etc. in Japan. Clarifying the number of articles published by scholars affiliated with research organizations in Japan is crucial for Japan and for the academic, social, and economic environments. Therefore, I will clarify changes in the number of articles produced in Japan from the historical and international comparative perspectives. To contextualize these changes, it is also important to understand the internal structural changes in Japan. Thus, I will also discuss internal structural changes among sources of scientific productivity in Japan, focusing on (a) types of research organizations, (b) types of national universities, and (c) individual national universities. Finally, I would like to share that the importance of second-tier research universities for science production as a country and that competitive funds are not a panacea for the science production at the certain situation. I also would like to mention the limitations of this study. In this paper, I will not address the quality of Japanese scientific publications and will not count the number of articles published in discipline. The aforementioned findings of this paper are noteworthy, even though this paper has the aforementioned limitations.

Regarding this purpose, there have been several preceding studies on Japanese higher education research¹. Saka and Kuwahara (2013) provided one of the most important and comprehensive studies of the changing trends in the number of articles published by Japan. Saka and Kuwahara are researchers of

¹ There are several preceding studies which contains Japanese data of science productivity from international perspectives, for example, schofer (2004), Adams (2009), and Meo et al (2013). However, in the following, I will focus on preceding studies on details of Japanese situation of science productivity.

the National Institute of Science and Technology Policy (NISTEP). Using the raw data of the Web of Science (WOS) purchased by NISTEP, they clarified changes in the number of articles produced in Japan and other major producers of research. Changes in the number of published articles in terms of the types of research organizations are also discussed. They found that Japan showed the lowest growth in production of papers among all countries of the G7. This was attributed to the decreases in the number of papers produced by the business enterprise sector. The decline in the role of the business sector means that the role of the university and college sector has grown proportionally as a structure of knowledge production in Japan. In recent years, however, the number of papers produced by national universities has plateaued.

The analysis of Saka and Kuwahara covered changes in the number of papers produced from 1980 to 2011. However, their analysis primarily focused on changes in three periods: the 1999–2001 average, the 2004–2006 average, and the 2009–2011 average. Thus, it is still unclear how the number of papers produced changed prior to 1999.

There have been preceding studies concerning the number of articles produced by different types of national universities and individual national universities. Kobayashi (2005) produced one of the first studies focusing on the number of articles produced by individual universities. Kobayashi showed that national universities are the main producers of articles and that former imperial universities² are the primary actors among national universities. Additionally, Shima (2011a) showed that local national universities that are less prestigious than former imperial universities created a solid base of knowledge production.

Saka and Kuwahara (2012a) showed the number of the articles produced by 158 universities in Japan, including national universities, public universities, and private universities. They gave special attention to articles produced during three periods (1999–2001, 2004–2006, and 2009–2011). Although they tried to show each university's comparative position among its peers and to capture their world-class strength in different research fields, their study was long on data but short on analysis.

Data and Methods

In this study, I use WOS data³ to analyze changes in Japanese scientific

² Those are seven highly prestigious national universities: Hokkaido University, Tohoku University, The University of Tokyo, Nagoya University, Kyoto University, Osaka University, and Kyushu University.

³ This analysis is based on Web of Science Publication Data (Science Citation Index Expanded; hereafter "SCIE") compiled by Thompson Reuters (TR) from 1900 to 2012. Data included

productivity since 1975.⁴ Regarding WOS data, I use a narrower definition of scientific articles than Saka and Kuwahara (2013) used for their analysis.⁵

I use the “Whole Count” concept to count articles in my analysis. In this manner, when one paper has two authors and both of them are affiliated with Japanese universities, I count this as one article produced in Japan. However, when one paper has two authors and one author is affiliated with a Japanese university and the other author works for an American university, I count the same article once for Japan and once for the United States. I also apply this “whole count” concept to count the number of articles produced at the individual university level.⁶

Changes of Scientific Productivity in Japan and International Comparison

In the figures that follow, I show the changes in the number of articles produced in China (CHN), France (FRA), Germany (GER), Japan (JPN), Korea (KOR), Taiwan (TWN), The United Kingdom (UK), and The United States (USA) from 1975 to 2010 at five-year intervals.

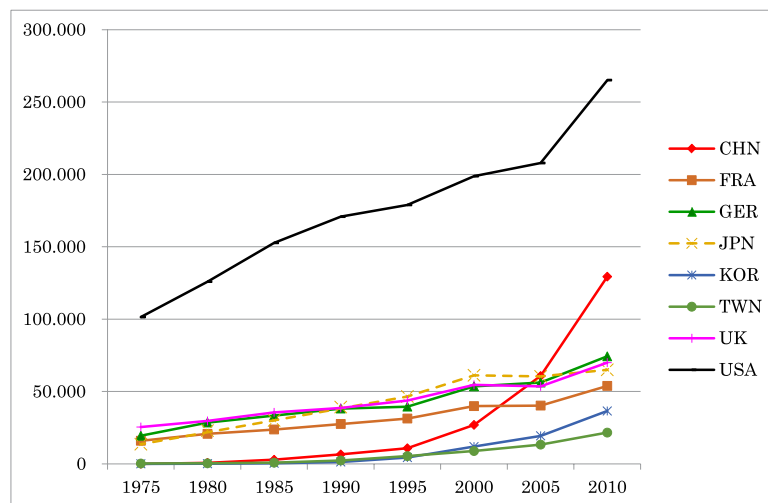


Figure 1. Changes in the numbers of articles produced by country from 1975 to 2010.

every five years from 1900 to 1980 and every year from 1980 to 2012. I only used 1975, 1980, 1985, 1990, 1995, 2000, 2005, and 2010. This SCIE collection of STEM+ journals data was bought in the fall of 2012 by SPHERE Project, which is “Science Productivity, Higher Education Development, and Knowledge Society.” The project is funded by the Qatar National Research Fund (NPRP 5-1021-159).

⁴ This period covers drastic changes of positions of Japanese science production.

⁵ I used only “Article.” However, Saka and Kuwahara (2013) used “Article,” “Article & Proceedings,” “Reviews,” and “Letter & Note.”

⁶ In more detail, refer to Baker et al (2015, pp.14-15).

The United States has been increasing its number of published articles since 1975, becoming the world center of research. The United Kingdom, Germany, France, and Japan increased their production of articles from 1975 to 2000. However, Japan increased the number of articles produced more rapidly than the United Kingdom, Germany, or France over the same period (1975–2000). Beginning in 1985 and continuing throughout the period of study, China, Korea, and Taiwan rapidly increased the number of articles produced. While the United States continued to increase its level of article production through 2010, the United Kingdom, Germany, France, and Japan stagnated from 2000 to 2005. Japan is the only country that stagnated in the number of articles it produced from 2005 to 2010. Since 1995, the number of articles produced in China increased more rapidly than that in the United Kingdom, Germany, France, and Japan, and in 2005, China became the second largest in knowledge production.

As shown in the figure above, by 1990, Japan had become the second-largest country in terms of knowledge production; however, in 2010, Japan's rank had fallen to fifth. The number of articles produced in Japan has stagnated since 2000. On the other hand, the numbers of the United States, China, Korea, and Taiwan have continued to rise, and the United Kingdom, Germany, and France have escaped their stagnations and again increased the number of articles produced. Based on this trend, there is a risk that Korea and Taiwan will surpass Japan in terms of article production.

Internal Structural Changes of Scientific Productivity in Japan Types of Research Organization

I will show the changes in the number of articles produced in Japan according to type of organization,⁷ including (a) national universities,⁸ (b) public universities,⁹ (c) private universities, (d) inter-university research institutes,¹⁰

⁷ There are three types of postsecondary institutions in the Japanese higher education system: (1) 4-year universities or colleges (2) 2-year junior colleges, and (3) 2-year colleges of technology. There are 782 universities (86 national universities, 90 public universities, and 606 private universities), 359 junior colleges, and 57 colleges of technology listed in the "School Basic Survey" (MEXT, Ministry of Education, Culture, Sports, Science and Technology) 2013. Universities enroll 2,868,872 students (including graduate students); junior colleges enroll 138,260 students; and colleges of technology enroll 58,226 students. Universities are the core of postsecondary institutions in Japan.

⁸ National universities were established by the national government. In 2004, all national universities were incorporated.

⁹ Public universities were established by local governments. Most of public universities were incorporated after 2004.

¹⁰ Inter-university research institutes are established by the national government for research. The aim of inter-university research institutes is to promote the open use of advanced facilities among researchers throughout Japan.

(e) national research institutes,¹¹ (f) incorporated administrative agencies,¹² and (g) others (including private companies).¹³

From Figures 2 and 3, it is apparent that national universities create the lion's share of knowledge production in Japan. National universities in Japan increased the number of articles they produced, although the ratio of articles they produced decreased from around 60% in 1975 to around 45% in 2010. Private universities increased the number of articles they produced from 1975, but the share of total articles produced is still less than 15%. Other producers, including business enterprises, constitute the second-largest group, but the number of articles produced decreased between 2000 and 2005. Since 1995, incorporated administrative agencies have increased the number of articles produced.

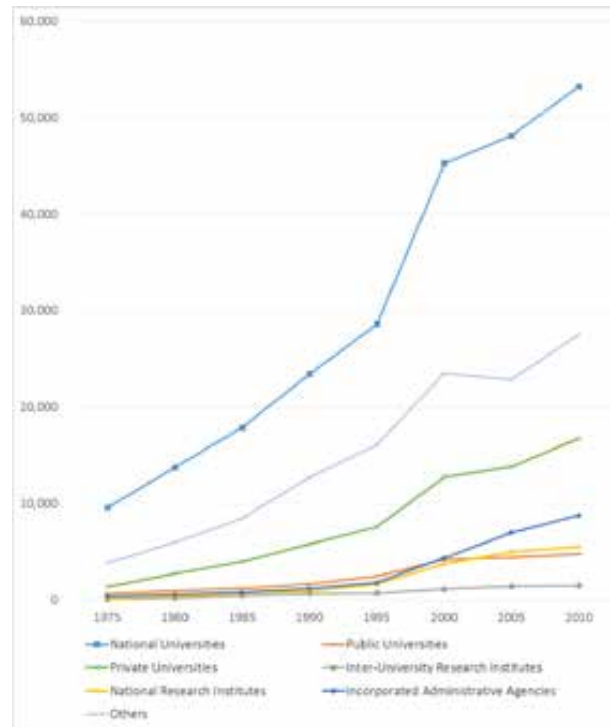


Figure 2. Changes in the number of articles produced in Japan by organization types (1975–2010).

¹¹ National research institutes were established by the national government.

¹² Incorporated administrative agencies were established by Act on General Rules for Incorporated Administrative Agency.

¹³ I used “NISTEP Dictionary of Names Universities and Public Organizations” to categorize. Retrieved April 11, 2015 from <http://www.nistep.go.jp/research/scisip/data-and-information-infrastructure>. In addition to that, in terms of national universities, I made some original arrangement to correct the data based on the information of raw data.

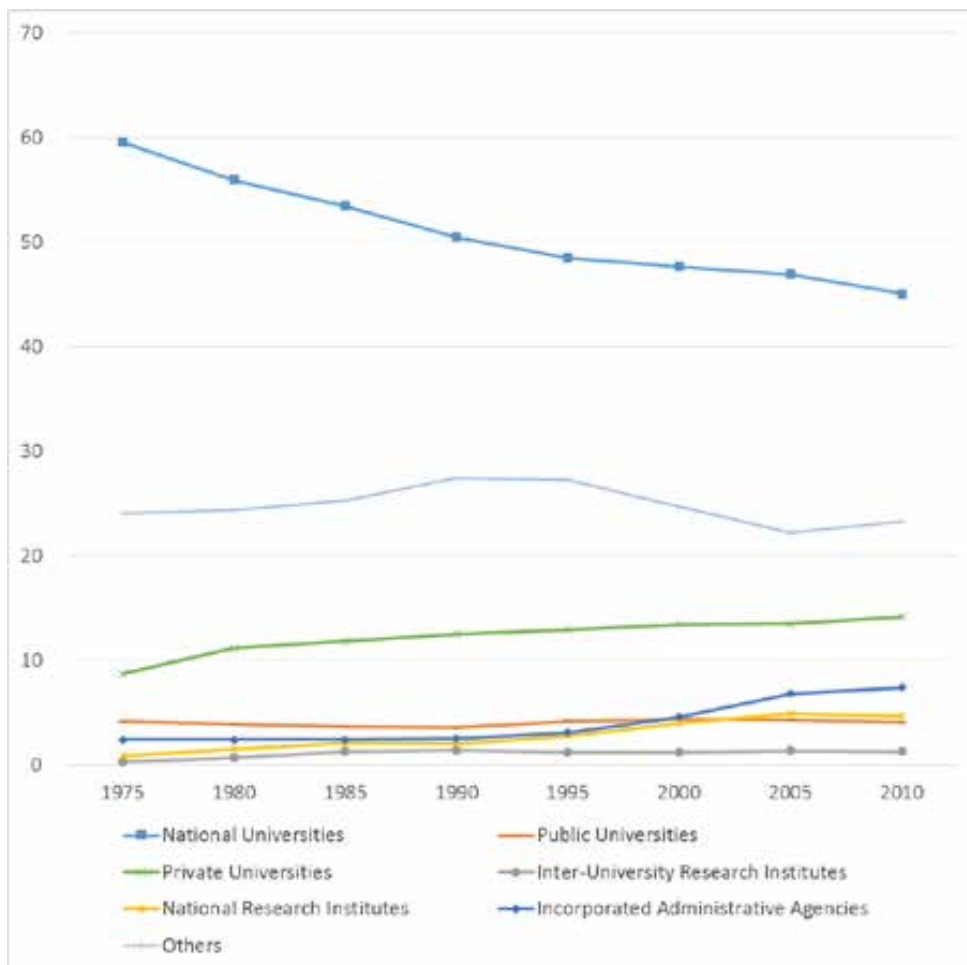


Figure 3. Changes in percent share of articles produced in Japan by organization types (1975–2010).

Types of National University

Although national universities are the largest producers of research articles, there are several types of national universities. In this section, I will explain the different types of national universities in Japan, outlining a typology of 9 national university types.

Table 1. Types of national universities

Type	Prestige	Types of National Universities	Name of National University
Type A: Universities which have multiple disciplinary schools	High	Former Imperial University	Kyushu University
	↓	Pre War University	Osaka University
	↓		Okayama University
	↓	Post War University 1	Hiroshima University
	↓		Kumamoto University
	↓	Post War University 2	Kagawa University
	↓		Ehime University
	↓	Post War University 3 (without Med School)	The University of Tokushima
	↓		Kochi University
	↓	Post War College (Humanities/Social Science)	Yokohama National University
Low	Shiga University		
Type B: Colleges which have mono disciplinary school		Post War College (Education)	Nara Women's University
		Post War College (Engineering/Agriculture)	Wakayama University
			Nara University of Education
		Post War College (Medicine)	Naruto University of Education
			The Graduate University for Advanced Studies
		Post War College (Medicine)	Nagaoka University of Technology
			The University of Electro-Communications
		Post War College (Medicine)	Osaka University of Education
			Tokyo University of Marine Technology
		Post War College (Medicine)	Kyoto University of Education
	Tokyo Institute of Technology		
	Post War College (Medicine)	Aichi University of Education	
		Tokyo University of Agriculture and Technology	
	Post War College (Medicine)	Joetsu University of Education	
		Tsukuba University of Technology	
	Post War College (Medicine)	Tokyo Gakugei University	
		Kitami Institute of Technology	
	Post War College (Medicine)	Miyagi University of Education	
		Nara Institute of Science and Technology	
	Post War College (Medicine)	Obihiro University of Agriculture and Veterinary Medicine	
		Japan Advanced Institute of Science and Technology	
	Post War College (Medicine)	Muroran Institute of Technology	
		Asahikawa Medical University	
	Post War College (Medicine)	Hokkaido University of Education	
		Shiga University of Medical Science	
	Post War College (Medicine)	Otaru University of Commerce	
		National Graduate Institute for Policy Studies	
	Post War College (Medicine)	Hokkaido University of Education	
		National Institute of Fitness and Sports in Kanoya	
	Post War College (Medicine)	Hokkaido University of Education	
		Fukuoka University of Education	
	Post War College (Medicine)	Muroran Institute of Technology	
		Toyohashi University of Technology	

Initially, I will divide all national universities into type A and B. Type A includes universities having more than three types of disciplinary schools (e.g., 1. humanities, 2. social science, 3. science and engineering, 4. medical science), and type B is composed of universities having only one type of disciplinary school. Among type A universities, all former imperial universities and pre-World War II universities were established before World War II. Most¹⁴ other university types were established after World War II. The order of the university types of type A represents a status hierarchy. As the oldest type, former imperial universities are the most prestigious universities in Japan. Regarding type B universities, each type of university has a different single disciplinary school. On average, type B universities are smaller than type A universities.

I will show changes in the number of articles produced according to the type of national universities (Figures 4 and 5). Based on Figure 4, since 1975, former imperial universities have been the source of the core of article production by national universities, and they have considerably increased the number of articles produced, although their share had been decreasing until 2000. Thereafter, imperial universities again started increasing their share. Pre-World War II universities have also increased their number of articles. They increased their share of articles produced until 1990. After that time, their share has been stable. Post-World War II universities 1 and 2 also increased their number of articles and their share of articles produced until 2000, when their shares started to decrease or stagnate. In terms of share, former imperial universities and post-World War II universities 1 and 2 have moved in different directions, and the difference between these types of university had been decreasing until 2000 but increasing after that.

Fundamentally, individual post-World War II colleges (engineering/agriculture) are much smaller institutions than individual type A universities. However, even they have increased the number of articles they have produced since 1975. Hence, post-World War II colleges (engineering/agriculture) have become one of the core producers of articles in Japan. In fact, their share of articles has been growing almost since 1975, and it has now reached more than 10%.

¹⁴ Hitotsubashi University and Tokyo Institute of Technology are exceptions.

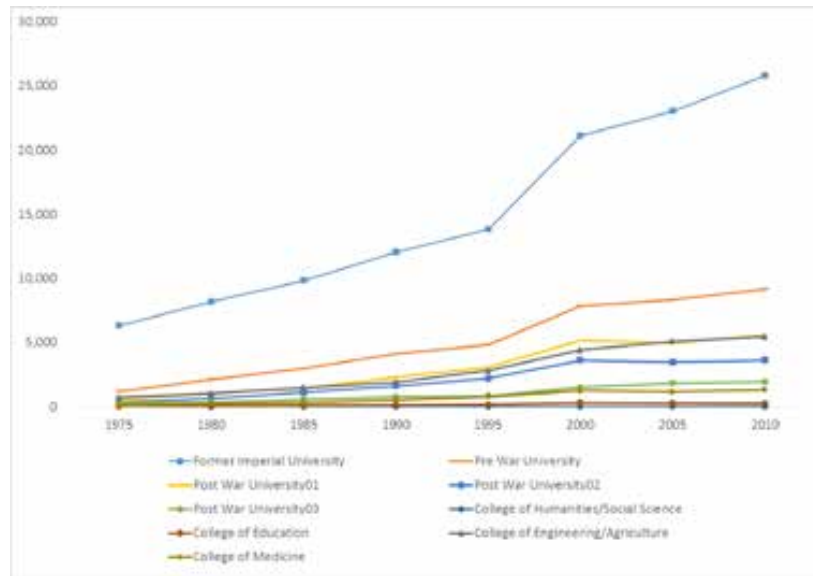


Figure 4. Changes in the number of articles produced in Japan by different types of national universities (1975–2010).

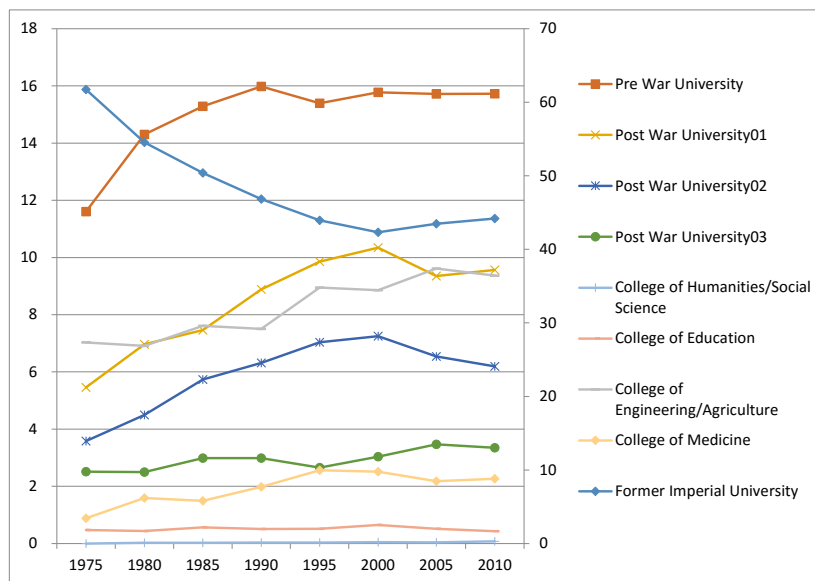


Figure 5. Changes in the percentage share of articles produced in Japan by types of national universities (1975–2010). The second Y axis is used for former imperial universities.

Article Production by Individual National Universities

In this section, I show the changes in the number of articles produced at the individual university level during three periods: from 1995 to 2000, from

2000 to 2005, and from 2005 to 2010. I focus on these three periods because they include the years when Japan was the second largest producer of scientific articles (after the United States) as well as the period that saw Japan become the fifth largest producer. First, I show the changes in the number of articles at individual university level from 1995 to 2000. In Figures 6 and 7, increases in the number of articles produced from 1995 to 2000 are plotted on the X axis. The Y axis represents increases in the ratio of articles produced from 1995 to 2000. Overall, the number of articles that each university produced increased. Among the top 10 national universities, no university reduced the number of articles it produced during this period.

Based on the data shown in Figure 7, it is clear that although several universities reduced the number of articles produced, many universities had larger increases in the ratio of articles they produced than the top 10 universities did.

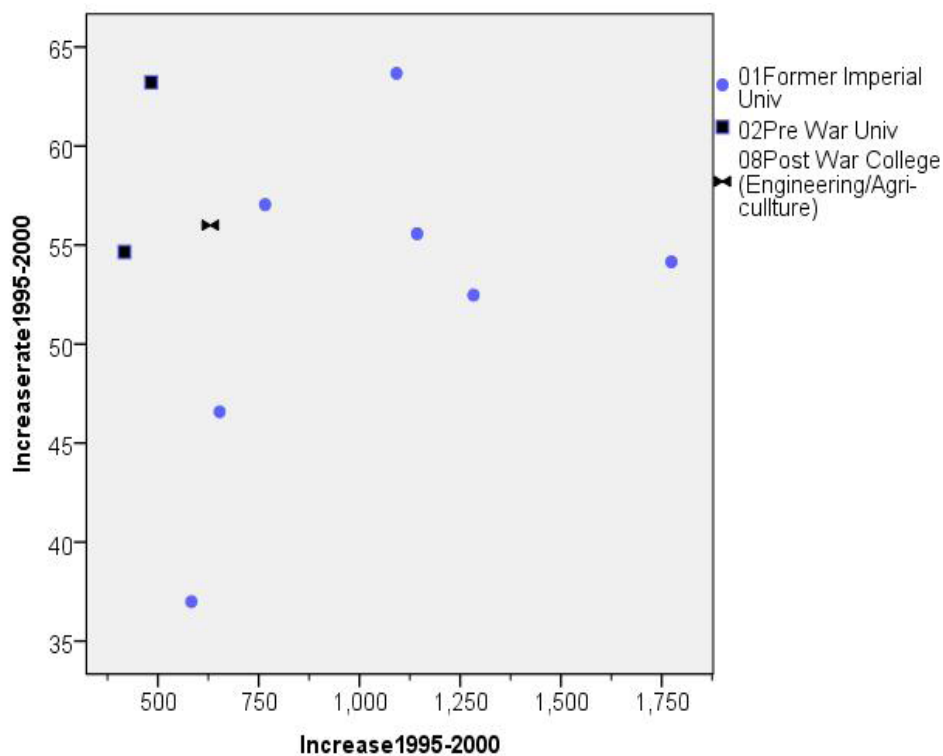


Figure 6. Increases in number \times ratio of changes in article production among the top 10 national universities (1995–2000).

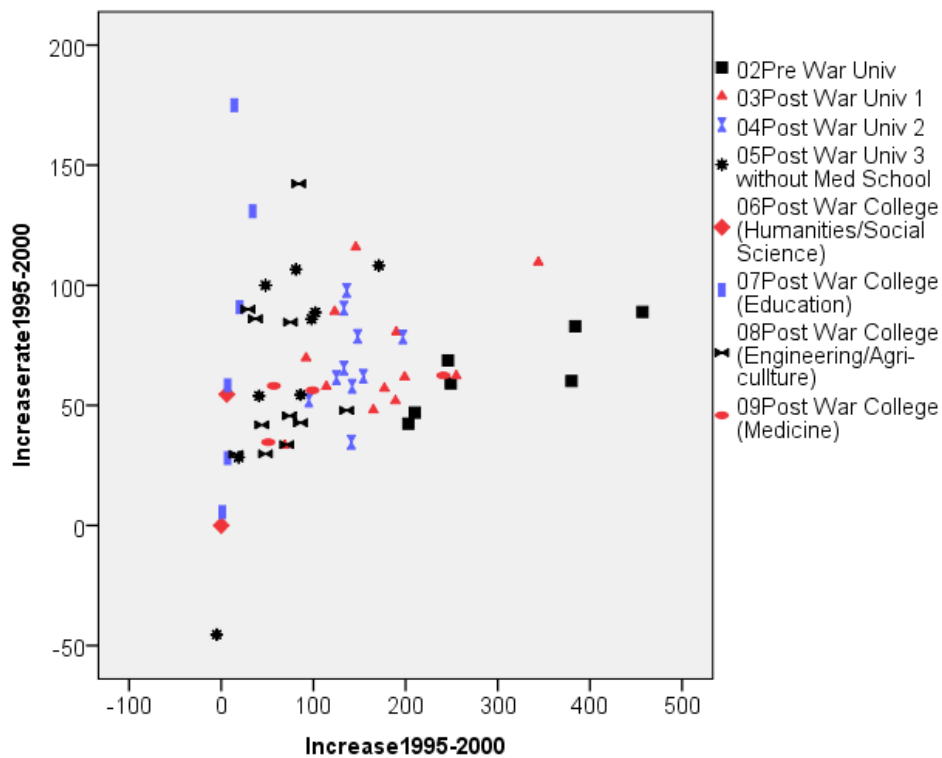


Figure 7. Increases in number \times ratio of changes in article production among national universities outside the top 10 (1995–2000). This graph excludes five outliers.

Second, I show the changes in the number of articles produced at individual university level from 2000 to 2005. The X axis represents increases in the number of articles produced from 2000 to 2005, while the Y axis represents increases in the ratio of articles produced from 2000 to 2005. Among the top 10 universities, there is no university that decreased the number of articles produced. However, increases in the ratio of articles produced from 2000 to 2005 are, on average, smaller than those from 1995 to 2000. Based on Figure 9, outside the top 10, many universities decreased the numbers of articles they produced.

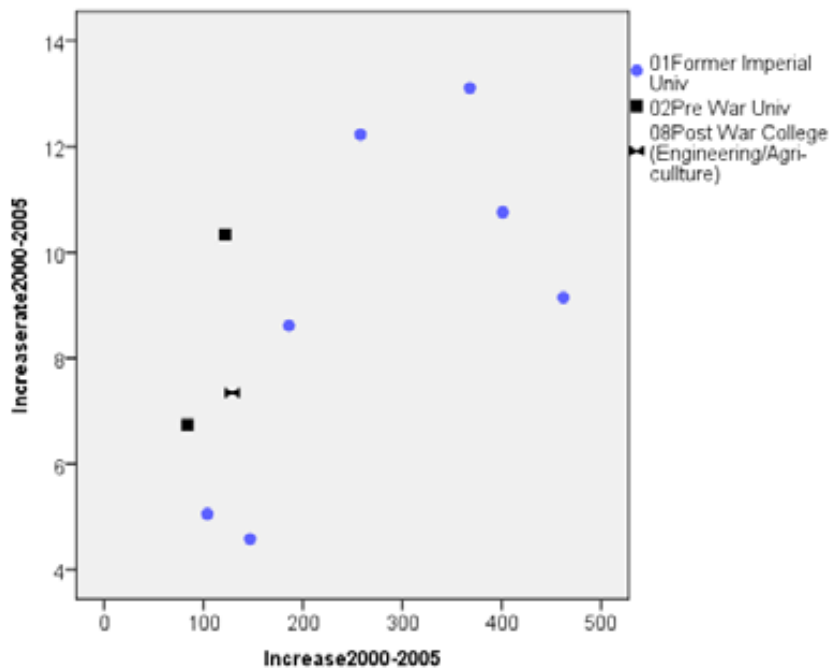


Figure 8. Increases in number \times ratio of increase in article production among the top 10 national universities (2000–2005).

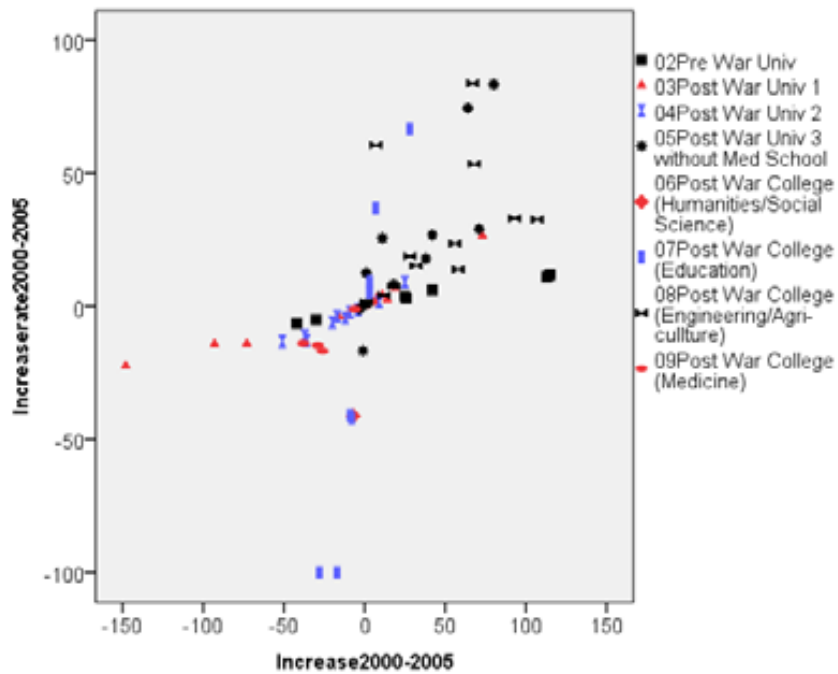


Figure 9. Increases in number \times ratio of changes in article production among national universities outside the top 10 (2000–2005). This graph excluded two outliers.

Third, I show the changes in number of articles at the individual university level from 2005 to 2010. Again, the increases in the number of articles published from 2005 to 2010 are plotted along the X axis. Increases in the ratio of articles published from 2005 to 2010 are plotted along the Y axis. Among the top 10 universities, no university decreased the number of articles produced. However, increases in the ratio of articles produced from 2005 to 2010 are smaller than those from 1995 to 2000. A different result emerged for universities who were not among the top 10. Many universities outside the top 10 decreased the number of articles they produced.

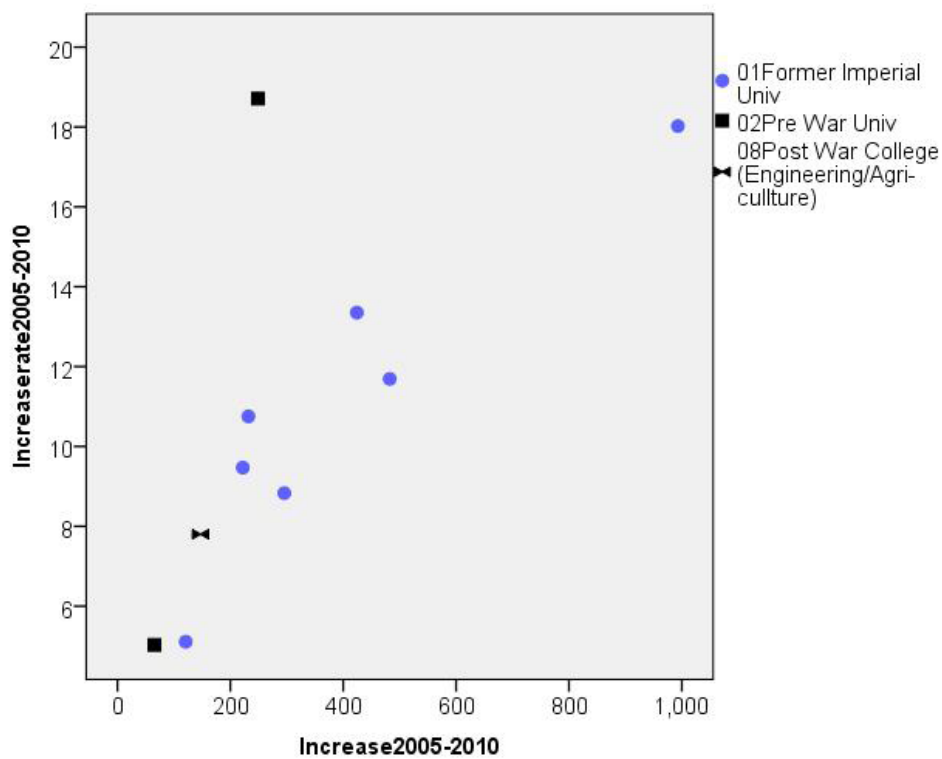


Figure 10. Increase number \times ratio of changes in article production among the top 10 national universities (2005–2010).

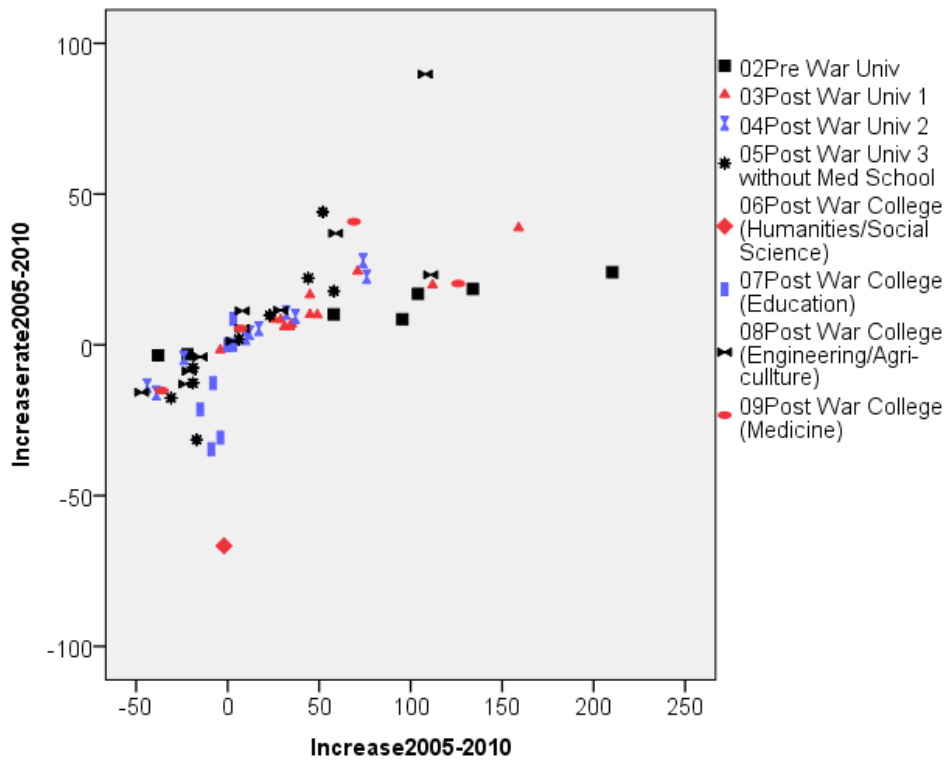


Figure 11. Increases in number \times ratio of changes in article production among national universities outside the top 10 (2005–2010). This graph excluded five outliers.

Concerning the changes between 1995 and 2000, the top 10 universities published 8,824 additional articles. However, the universities outside the top 10 increased their article publication by 7,830 articles. The difference is less than 1,000 articles. However, in the two latter time periods (from 2000 to 2005 and from 2005 to 2010), the differences in article production increased to more than 1,000. Hence, since 2000, the total number of articles produced in Japan by national universities stagnated, and the differences among national universities have been growing based on range and coefficient of variation.

		Increase 1995-2000	Increase 2000-2005	Increase 2005-2010
TOP10	Total	8824	2261	3232
	Average	882	226	323
	Number of Case	10	10	10
Non TOP 10	Total	7830	632	1816
	Average	113	9	26
	Number of Case	69	69	69

Table 2. Average and total increases in number of articles published by top 10 and universities outside the top 10

Type A	Post War Univ 1①	Post War Univ 1②	Post War Univ 1③	Post War Univ 1④	Post War Univ 1⑤	Post War Univ 2①	Post War Univ 2②	Post War Univ 2③	Post War Univ 2④
	-148.00	-93.00	-11.00	-73.00	-16.00	-36.00	-9.00	-12.00	-4.00
	Post War Univ 2⑤	Post War Univ 2⑥	Post War Univ 2⑦	Post War Univ 2⑧	Post War Univ 3 without Med School①	Post War Univ 3 without Med School②	Pre War Univ①	Pre War Univ②	
	-17.00	-51.00	-20.00	-37.00	-3.00	-1.00	-42.00	-30.00	
Type B	Post War College (Medicine)①	Post War College (Medicine)②	Post War College (Medicine)③	Post War College (Medicine)④	Post War College (Education)①	Post War College (Education)②	Post War College (Education)③	Post War College (Education)④	
	-26.00	-38.00	-29.00	-6.00	-28.00	-9.00	-17.00	-8.00	
	Post War College (Humanities/Social Science)①	Post War College (Humanities/Social Science)②	Post War College (Engineering/Agriculture)①						
	-7.00	-1.00	-4.00						

Table 3. List of universities that decreased numbers of articles published from 2000 to 2005

Most universities that decreased the numbers of published articles from 2000 to 2005 are post-World War II universities 1 and post-World War II universities 2. Furthermore, all colleges of medicine decreased the number of articles they produced from 2000 to 2005. A reason for these changes may be that all national universities were incorporated in 2004. After being incorporated, block grants were decreased by 1% for national universities and by 2% for university hospitals. This reduction in block grants pushed national universities, especially university hospitals to raise money from private sources. However, based on Shima (2012), unfortunately, not all universities have been able to succeed in this aspect. In fact, 51.8% of national universities decreased their income levels after incorporatization, excluding their hospital incomes. On the other hand, university hospitals have been able to succeed,

but faculty of medical schools became very busy for earning payments for medical service.

Findings and Implications

Japan's position as a leading producer of science publication (the second largest in 2000) in the global knowledge society declined during the period of study (the fifth in 2010) and is severely at risk moving forward. Universities are at the core of science productivity in Japan. Although the share of science publications of national universities has been decreasing, national universities are still the primary actors within this core. Internal structural changes affecting science productivity is that from 2000 to 2005, second-tier national universities that are not prestigious but had nevertheless strengthened and underpinned scientific productivity decreased the number of articles they produced. These situations were not well recognized, but very crucial for the future of science productivity in Japan. Conversely, the excellence policy for research universities was initiated in 2002 as COE (Center for Excellence) program by MEXT.¹⁵ Recently, in this context, MEXT created "The Program for Promoting the Enhancement of Research Universities." The program was started in 2013 to create a "cluster" of world-class research universities in Japan, led by 19 universities and 3 research institutions. Most of the universities that were selected for this program were former imperial universities and pre-World War II universities.¹⁶

The result of "The Program for Promoting the Enhancement of Research Universities." seems to mean that post-World War II universities 1 and 2, which had strengthened and sustained the position of Japan in science productivity, were ignored by the government as research universities. In addition, in 2015, MEXT categorized all national universities into three categories (1. world class research universities, 2. world and national level research universities of specific areas, and 3. universities which primarily serve for local community). As a result, all post-World War II universities 1 and 2 were categorized into category 3 (universities which primarily serve for local com-

¹⁵ Ida and Fukuzawa (2013) showed that COE research grants had positive impacts on science productivity, but unfortunately they did not pay attention to the decrease of block grants and the effects of incorporatization of national universities in 2004.

¹⁶ These universities include Hokkaido University, Tohoku University, University of Tsukuba, The University of Tokyo, Tokyo Medical and Dental University, Tokyo Institute of Technology, The University of Electro-Communications, Nagoya University, Toyohashi University of Technology, Kyoto University, Osaka University, Kobe University, Okayama University, Hiroshima University, Kyushu University, Kumamoto University, and Nara Institute of Science and Technology.

munity), even though three of them were ranked in world top 550¹⁷ of 2010 QS World University Ranking 500 and eleven of them were ranked in Asian top 200 of 2010 QS Asian University Rankings 200 (Shima, 2011b).

MEXT also started decreasing their governmental block grants to national universities from 2005, just one year after incorporatization of all national universities. Under this financial trend, Shima (2012) showed that the difference in total income of national universities was increased, and more than half (51.8%) of national universities have decreased their total income, excluding university hospital income. From these results, I wonder if investing large amounts of money into prestigious universities (either competitively or selectively) is the only panacea for improving scientific productivity. Building world-class research universities is certainly crucial; however, building thick clusters that sustain science productivity with stable block grants should also be considered¹⁸.

Limitations and Future Challenges

In this study, I did not address the quality of Japanese scientific publications. Additionally, I did not count the number of articles published according to discipline. These issues present opportunities for future research.

¹⁷ In that ranking, there were data of ranking 501-550, 550-600, and 601+.

¹⁸ In this paper, I did not do statistical analysis to examine the relationship between the research funds, including block grants, and number of articles. This also presents opportunity for future research.

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