The Pennsylvania State University

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THE SCHOOLED SOCIETY IN TAIWAN:

THE RELATIONSHIP BETWEEN HIGHER EDUCATION DEVELOPMENT AND STEM+ BRAIN DRAIN OR BRAIN CIRCULATION?

A Thesis in

Educational Theory and Policy
by

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ABSTRACT

American PhD earners from American higher education institutions have contributed to a large portion of the U.S. scientific research output before 1950. However, between 1960 and 2011, the contribution to scientific output from the increasing number of international students pursuing doctoral degrees in science at universities in the U.S. was witnessed. Scientific bachelor's degree holders from Taiwan have made Taiwan one of the largest international training countries by pursuing their doctoral degrees in American institutions; however, after completing their studies, few trained Taiwanese PhD earners returned home to work. The continuous problem of student outflow has risen the Taiwanese government's awareness in terms of higher education development.

This study is to examine the relationship between higher education development and brain drain and brain circulation processes in Taiwan between 1972 and 2011. Findings show two important processes between higher education development and the student outflow: from 1972 to 1994, when higher education has not yet developed, there was an increasing number of Taiwanese STEM+ PhD from the U.S. which is the brain drain process; brain circulation happened between 1994 and 2011, when higher education became universal, more students chose to receive scientific training from Taiwanese universities.

The study is important for understanding the probable long-term future of other large scientific production contributor countries, such as India, South Korea, and China. The study also provides key information needed for sending countries to reverse brain drain

as well as develop their own systems of higher education as the world is headed into the mega-science period.

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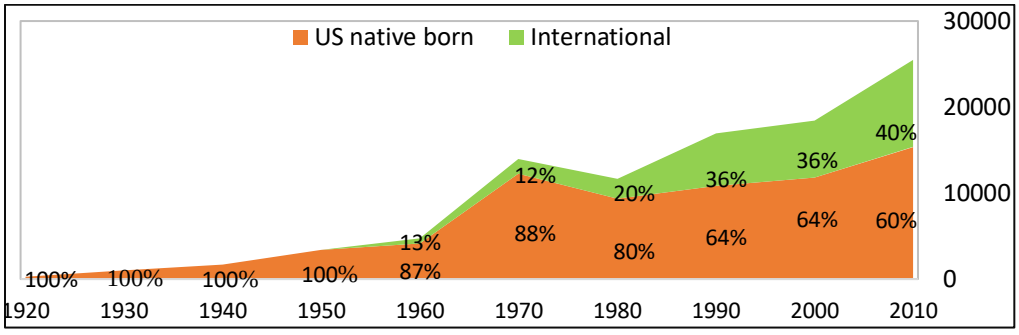
Chapter 1: Research Overview

1.1 Background of the study

American PhD earners from American higher education institutions contributed to a large portion of American scientific research output before 1950. However, the contributions to the country's scientific output international students pursuing doctoral degrees in science at American universities began to rise in 1960 (Fernandez et al., 2020). Between 1960 and 2010, the internationalization of scientific training in the United States resulted in international students earning increased from 13% to 40% of all STEM+ PhDs awarded by American universities (see Figure 1). Of these international PhD earners, the majority were from specific sending countries, including South Korea, Taiwan, China, India, and Iran, which shows that these countries started enhancing their scientific capacity in the1960s.

Figure 1

Diversification of PhD Earners in STEM+ Fields in the United States, 1920–2010 (Source: SED)



Taiwan, a relatively small country compared to South Korea, China and India, contributed 27,161 STEM+ PhDs to American scientific research output between 1972 and 2011.

Scientific bachelor's degree holders from Taiwan have made Taiwan one of the largest international training countries by pursuing doctoral degrees at American institutions; however, few trained Taiwanese graduates returned home to pursue jobs. The trained individuals who went abroad to pursue their graduate-level degrees were mostly in the STEM+ fields, which includes science, technology, engineering, mathematics, and health. Many of them were from prestigious universities, such as the National Taiwan University and National Tsing-Hua University (Chang, 1992). There were limited STEM+ PhD programs in Taiwan in the early 1970s; only a few universities offered such programs with training less than 30 PhDs in STEM+ annually. To retain domestic talent, the Taiwanese government began developing graduate programs within universities starting in 1980. The volume of PhDs from domestic higher education institutions started growing at an exponential rate between 1980 and 2011.

1.2 Purpose of the Study

The purpose of this study is to analyze the historical interaction between two processes of brain drain and brain circulation in Taiwan between 1970 and 2011. This study presents the outflow of college graduates in relation to the higher education development of the sending countries. Taiwan was ranked fourth among sending countries between 1970 and 1990, and higher education in Taiwan started to develop, which represents the prime example of the higher education expansion process.

This study relies on historical literature that describes the phenomena of "brain drain" and the development of higher education in Taiwan from 1972 to 2011. Data was constructed from the Survey of Earned Doctorates (SED) and the Department of Statistics, Ministry of Education of Taiwan, to further investigate the relationship

between the development in science and technology and the outflow of students. This data allows for assessing the development of scientific training based on the number of PhD students and higher education institutions.

1.3 Significance of the Research

The findings present a precise description of the two processes and the transition of the higher education system in Taiwan. In particular, a significant growth in the scientific training programs was found in traditional non-research institutions that were formerly expected to be less scientifically productive, such as junior colleges and associate degree institutions. The findings also show that the development of scientific training in higher education matters. Taiwanese students tended to seek doctoral degrees from American institutions when higher education in Taiwan was not fully expanded. However, as Taiwan's post-secondary education system developed, more students preferred to obtain their doctoral degrees from Taiwanese universities.

This study is important for understanding the probable long-term future of other countries, such as India, South Korea, and China. It also provides key information needed for sending countries to reverse brain drain, as well as develop their own systems of higher education, as the world heads into the mega-science period. Thus, to investigate the relationship between higher education development and brain drain in Taiwan, this study will specifically address the following research question:

What is the relationship between brain drain and education development within sending countries?

Chapter 2: Past Research

2.1 Brain Drain

In a knowledge-based economy, human capital is the key resource for shaping a country's production (Schultz, 1961). Therefore, brain drain has become an important issue and has been discussed in several studies over the years (Docquier et al., 2007). "Brain drain" is a term that describes highly skilled or educated people moving from one country to another (Kao & Lee, 1973; Nakahara, 2017), particularly those who move from developing to developed countries (Tzeng, 2006). Many phenomena can be regarded as brain drain, such as the outflow of talented workers and domestic students who study abroad and fail to return to their country after completing their studies (Kao & Lee, 1973).

Since the 1960s, some developing countries in Asia have suffered serious outflows of people to the United States, which provided advanced higher education (Tzeng, 2006).

In Taiwan, between the 1970s and the early 1990s, a growing number of Taiwanese students pursued graduate-level degrees in the United States. More than 40% of these students had studied STEM+ at top universities in Taiwan. However, a large portion of Taiwanese STEM+ PhD earners did not return to Taiwan after completing their studies at American institutions (Chang, 1992; Tzeng, 2006; Wang, 2003). During the 1970s, 31,365 Taiwanese students studied abroad (primarily in the Unite States), while only 5,028 graduates returned to Taiwan (Chang, 1992). The average American-trained Taiwanese graduate return rate was 16% in the 1970s. In particular, between 1975 and 1979, the students return rate dropped from 25% to 8%, which means that about 92% of

Taiwanese graduates failed to return home after finishing their studies at the end of the 1970s. This brain drain issue raised awareness of talent outflow in Taiwan. Therefore, the Taiwanese government started developing higher education to prevent the outflow of students.

2.2 Brain Circulation

Previous studies have proposed several push and pull factors for Taiwanese student mobility. Push factors are the reasons why students may choose to leave Taiwan to pursue graduate-level education and careers. Pull factors are the reasons why students may choose the United States for their graduation-level education and careers. From an economic perspective, the push factors include low salaries, unadvanced research facilities, and few job opportunities (Chang, 1992; Kao & Lee, 1973). From a social and political perspective, the push factors include restricted academic freedom due to the period of martial law between 1949 and 1987 and a lack of national identification with Taiwan (Chang, 1992; Kao & Lee, 1973). The pull factors include job satisfaction, higher income, and prosperous careers in the United States (Chang, 1992; Kao & Lee, 1973).

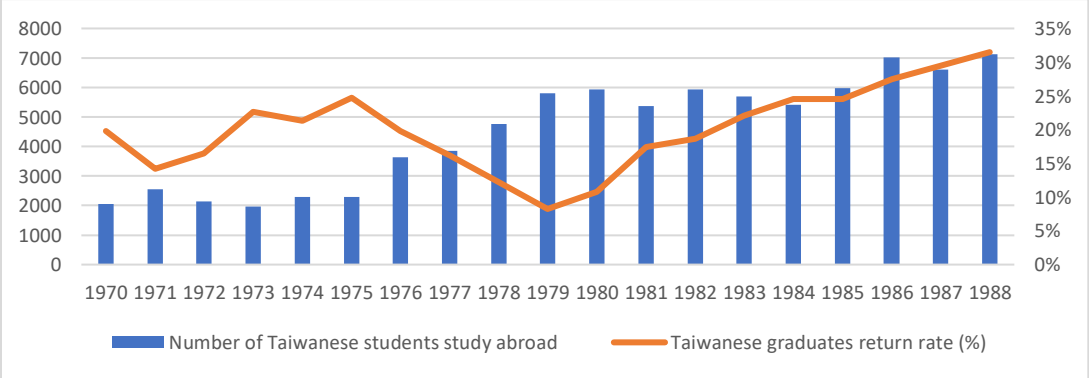
To cope with brain drain, the Taiwanese government made many efforts and implemented some measures to attract highly trained Taiwanese graduates to return to Taiwan for jobs. There were two main goals: to recruit people with STEM+ PhDs from American institutions to contribute their acquired knowledge and to develop Taiwan's higher education (Chang, 1992; Nakahara, 2017). To attract American-trained Taiwanese PhDs, the Taiwanese government implemented a series of approaches. In 1966, the National Youth Commission (NYC) was established to track returning talent. In 1980, the establishment of the Hsinchu Science Industrial Park created more job opportunities for

STEM+ PhD returnees. In the meantime, the Ministry of Education of Taiwan expanded its higher education institutions by creating graduate-level programs and recruiting domestic students to pursue their higher education in Taiwan.

A remarkable surge in the return rate of trained graduates began in 1980 (Wang, 2003); and it increased from 11% in 1980 to 31% in 1988 (Figure 2). Based on the increasing number of higher-education institutions and the gross enrollment rate for tertiary education, higher education developed in the early 1980s in Taiwan.

Figure 2

Number of Taiwanese Students at All Levels Studying Abroad in All Fields and the Postgraduate Return Rate between 1970 and 1988 (Source: the Department of Statistics, Ministry of Education of Taiwan)



Note. The second Y axis (on the right side of the figure) is used for the Taiwanese graduates return rate

2.3 Higher Education Development

In the middle of the 20th century, secondary education enrollment expanded sharply, and a decade later, tertiary education enrollment began developing in the 1970s (Baker, 2014; Schofer & Meyer, 2005; Zapp, 2017). Several studies have noted that increasing participation in higher education is an important factor in the development of the

education system (Baker, 2014; Schofer & Meyer, 2005; Yang & Chan, 2017; Zapp, 2017). In response to the diverse needs of the knowledge-based economy, higher education development has become an important issue for every government in the world (McNay, 2005). Between the 1950s and the 1970s, the higher-education enrollment rate accelerated dramatically across all countries worldwide (Meyer et al., 1977), and it has continuously increased since.

Trow (1973) defined three different processes for higher education participation to classify whether higher education is prevalent in a country: elite education, mass education, and universal education. When a country's enrollment of the relevant age-grade population in higher education is less than 15%, the higher education system is identified as a privilege for elite students. An enrollment rate of 15% to 50% is viewed as mass education, and an enrollment rate of above 51% or more considered universal education. According to the empirical data from the UNESCO Institute for Statistics (UIS), the world average gross enrollment rate for tertiary education increased from 9% in 1970 to 38% in 2018. In Asia, many countries have experienced rapid growth in tertiary education enrollment over the last forty years (OECD, 2019; UNESCO Institute for Statistics, 2014). Most of them have shifted from elite systems to mass or even universal education. According to UNESCO Institute for Statistics (2014) gross enrollment rate for tertiary education in India moved from less than 5% in 1970 to 28% in 2018. The tertiary-education gross enrollment rate in Indonesia shifted from 2.9% in 1970 to 36% in 2018. In Thailand, the tertiary-education gross enrollment rate increased from 2.8% in 1972 to 52% in 2011. Finally, the tertiary-education gross enrollment rate in China went up from less than 1% to 50% in 2018. Furthermore, some developed

countries, such as South Korea and Taiwan, have entered the universal higher education system with a tertiary education enrollment rate of more than 80% over the past few years. In 1976, both Korea and Taiwan had a higher-education gross enrollment rate of less than 15%; however, they both expanded their higher education rapidly over the last few decades and reached 100% and 84%, respectively, in 2011 (Ministry of Education, 1997; UNESCO Institute for Statistics, 2014.)

Over the past five decades, Taiwan has entered schooled society through the expansion of higher education. In 1968, the Taiwanese government extended the period of compulsory education to nine years. With a series of educational welfare programs and incentives, such as waiving tuition and granting scholarships, more students were willing to continue their secondary education when they graduated from primary school. In the late 1990s, the secondary gross enrollment rate reached 100%.

As Taiwanese secondary education expanded in the late 1990s, so did higher education. In 1972, 99 higher education institutions existed, with most of them being junior colleges (Ministry of Education, 2019). In the following four decades, the number of universities grew significantly from 9 in 1972 to 116 in 2011.

The higher-education gross enrollment rate was only 15% in 1976. For many reasons, students preferred to obtain their degrees in the United States. First, in response to scientization and internationalization (Schofer & Meyer, 2005), more and more students were officially sent from the Ministry of Education of Taiwan to the United States to pursue their graduate-level degrees in STEM+. Second, after WWII, the rise of research universities and American development assistance for Taiwan in the 1950s and 1960s helped Taiwan create a more prosperous economy. People could afford the

expense of studying abroad, which caused many individuals to seek personal development by studying abroad. Finally, the higher education system in Taiwan was not yet well developed. Few universities offered masters or doctoral programs at that time. Between 1970 and the 1990s, the number of Taiwanese students who studied abroad in the United States increased rapidly. During this period, Taiwan remained one of the top four countries with the most students studying in American institutions.

After students obtained their degrees from American institutions, most preferred to stay overseas to work (Wang, 2003). Between 1971 and 1991, only 24,981 students returned to Taiwan after they finished their studies (Chang, 1992). In 1980, the Taiwanese government established the Hsinchu Science Industrial Park, along with more job opportunities. In 1987, it abolished of martial law. These changes resulted in an increase in the number of American-trained Taiwanese doctorates with STEM+ degrees returning to Taiwan to work. Moreover, a series of policies regarding higher education were created during this period. The basic idea of these policies was to increase the proportion of college students studying in STEM+ while reducing the proportion of those in humanities and social science (Sun, 1991; Wang, 2003).

At the end of the 1990s and the beginning of the 2000s, the higher-education gross enrollment rate reached over 80% in Taiwan. Due to the rapid expansion of higher education in Taiwan, fewer students chose to study abroad to enhance their abilities and competitiveness. In 1971, there were only 23 students with domestic doctoral degrees, this number increased to 2,718 in 2011 (Ministry of Education, 2019), indicating that more Taiwanese students stayed in Taiwan to receive scientific training.

Chapter 3: Historical Framework

3.1 Growth of Mega-Science

The United States has led the world as the largest producer in STEM+ fields since the early 20th century (Fernandez & Baker, 2017). Before the 1960s, the United States contributed the largest portion of scientific output by a small core of highly productive research universities (Fernandez & Baker, 2017; Fernandez et al., 2020; Zapp, 2017). By the second half of the 20th century and into the 21st century, scientific production from the inflow of international students pursuing their graduate-level degrees in American institutions started increasing (Fernandez & Baker, 2017). Between 1960 and 2010, the number of international students who earned their PhDs in American institutions rose rapidly from 13% in 1960 to 40% in 2010, which means other countries had started their scientific training (see Figure 1). Of these international students, most were from the four largest sending countries: Taiwan, China, South Korea, and India. In the early 1960s, students from other countries started contributing science production, as the international STEM+ PhD students became an important source for scientific output (Baker & Powell, 2020). The number of students from Taiwan and India vastly rose by the 1980s, and by 2010, students from Taiwan, India, South Korea, and China had made up 40% of the trend (Baker & Powell, 2020).

In Taiwan, the growth of scientific production was mainly driven by the higher education system (Fu, 2017). Fu (2017) asserts that the growth of scientific production in the higher education system was generated by a series of higher education reforms. Some general reforms included rising participation in higher education (e.g., increased enrollment rates and the creation of more higher education institutions) and the sending

of domestic students overseas to receive scientific training. Some specific policies were also designed to focus on scientific output within higher education, such as the World Class University Project (WCUP). The WCUP was implemented in Taiwan in response to the trend of increased scientific activity around the world. Between 2006 and 2010, Taiwan's Ministry of Education started allocating resources to a small core of elite universities, aiming to spur their research capacities and, therefore, create super research universities (Fu, 2017). In the meantime, an initiative called The Teaching Excellence Project (TEP) was launched to lead some universities to teaching-oriented institutions. Two projects further facilitated the formation of the higher education system. (Fu, 2017).

3.2 STEM+ Internationalization

Baker & Powell (2020) propose three important elements of American STEM+ internationalization. First, German STEM+ students who had received scientific training pursued their PhD at American institutions in the 19th century and then continued postdoctoral positions upon completion of their PhD studies. Second, the American-trained international students contributed to a large portion of the U.S. scientific research output. The increasing research capacity in science resulted in more international students who pursued their higher education. Third, those American-trained international students fail to return home to work.

After the Chinese Civil War ended in 1950, Taiwan started having connection with the United States by sending students to pursue graduate-level scientific training at American institutions. Between 1950 and 1994, the number of Taiwanese students studying in the United States increased from 3,637 to 37,580 (Ministry of Education, 1997). In the 1980s, while the higher education has not expanded in Taiwan, there were

less than 2% of scientific publications of international collaboration (Fu, 2017). However, a vast surge occurred from the late 1990s to 2011, the international collaboration within higher education sectors rose from 5% in 1995 to 38% by 2011 (Fu, 2017). In the meantime, Taiwan started developing its scientific production within higher education institutions. Two major factors result in the growth of international collaboration: American-trained Taiwanese STEM+ PhDs and the expansion of higher education in Taiwan (Fu, 2017).

Chapter 4: Research Methodology and Design

4.1 Introduction

This chapter outlines the methodological framework and approach used to conduct the research. A descriptive historical analysis was employed for this study. The major variables were measured over time between 1972 and 2011 to observe the historical trend. The main sources of data were the Department of Statistics, Taiwan's Ministry of Education, and the Survey of Earned Doctorates (SED). Gross enrollment rates, the number of higher education institutions, the number of Taiwanese STEM+ PhD earners, and the number of Taiwanese students studying abroad and returning were collected from the Department of Statistics from the Ministry of Education. The number of Taiwanese STEM+ doctoral recipients from American institutions was collected from SED data.

4.2 Research Approach

Dataset

The SED is the National Science Foundation's annual census data of students who have obtained a doctorate from American institutions (National Science Foundation, 2019). Before 1972, Taiwan's data were included with China and Hong Kong's data; therefore, the aggregation of the number of both American-born and Taiwanese STEM+ PhD graduates from the SED data between 1972 and 2011 has been made.

The Department of Statistics is a national statistical dataset that comprises all education-related statistical data from K–12 education to higher education. However, due to the incomplete data system in Taiwan, several variables were collected for this study with different time periods based on the available year. The number of higher education

institutions, the number of Taiwanese STEM+ PhD graduates, and the number of students studying abroad between 1972 and 2011 were collected. Gross enrollment rates for both secondary and tertiary education from 1976 to 2011 were compiled. Finally, the number of trained Taiwanese students returning to Taiwan was only available between 1970 and 1988.

Measurement

Dependent Variables. The main dependent variable in this study is student outflow which was measured by determining the number of Taiwanese STEM+ PhD earners in all American institutions from 1972 to 2011, the number of Taiwanese students studying abroad between 1970 and 2011, Taiwanese post-graduates brain drain rate between 1970 and 1988, Taiwanese post-graduates return rate between 1970 and 1988, and the growth rate of Taiwanese STEM+ PhD graduates from the United States between 1972 and 2011.

The number of Taiwanese STEM+ PhD earners in all American institutions from 1972 to 2011. —The total number of Taiwanese STEM+ PhD earners in all American institutions was collected from SED data.

The number of all Taiwanese students studying abroad between 1970 and 2011. —The number of Taiwanese students at all educational levels studying abroad was collected from Department of Statistics, Ministry of Education in Taiwan.

Taiwanese post-graduates return rate between 1970 and 1988. —The number of students who returned to Taiwan was divided by the number of students studying abroad, and then the final value was multiply by 100 to find the percentage.

Taiwanese post-graduates brain drain rate between 1970 and 1988. —Brain drain rate of Taiwanese students studying abroad between 1970 and 1988 by subtracting the return rate from one and then multiplying by 100 to find the percentage.

Growth rate of Taiwanese STEM+ PhD graduates from the United States between 1972 and 2011. — growth rate was found by subtracting the previous number from the current number, dividing the answer by the previous number, and finally, multiply the result by 100 to find the percentage.

Independent Variables.

In addition to measuring the expansion of higher education in Taiwan, four main indicators were employed as independent variables in this study, including the gross secondary enrollment rate in Taiwan, the gross tertiary enrollment rate in Taiwan, the number of post-secondary education institutions in Taiwan, and the number of Taiwanese STEM+ PhD graduates from Taiwanese higher education institutions.

The gross enrollment rate for secondary education in Taiwan between 1976 and 2011. —The gross enrollment rate for secondary education in Taiwan was calculated by dividing the number of students enrolled in secondary education level (regardless of age) by the population of the corresponding age group and finally multiplying the final value by 100.

The gross enrollment rate for tertiary education in Taiwan between 1976 and 2011—The gross enrollment rate for tertiary education in Taiwan was calculated by dividing the number of students enrolled in tertiary education level (regardless of age) by the population of the corresponding age group and finally multiplying the final value by 100.

The number of post-secondary education institutions in Taiwan between 1972 and 2011. — The number of post-secondary education institutions in Taiwan was collected from the Department of Statistics, Ministry of Education.

The number of Taiwanese STEM+ PhD graduates from Taiwanese higher education institutions between 1972 and 2011. — The number of Taiwanese STEM+ PhD graduates from Taiwanese higher education institutions was collected from the Department of Statistics, Ministry of Education.

4.3 Historical Analyses

This study applied historical quantitative analyses by plotting several descriptive graphs to observe the trends. First, the historical brain drain and the circulation process in Taiwan between 1970 and 2011 is graphed in Figure 3. Second, the relationship between gross enrollment rates in both secondary and tertiary education and the number of Taiwanese STEM+ PhD graduates from American institutions between 1972 and 2011 was investigated. Figure 4 presents a clear picture of the two processes. Third, by comparing the number of Taiwanese STEM+ PhD earners from higher education institutions in Taiwan and the United States, the researcher could better examine the outflow of Taiwanese students in relation to the higher education development in Taiwan (Figure 5). Finally, a line graph was created by measuring the number of universities and colleges and the number of Taiwanese STEM+ PhD earners from Taiwanese institutions to explore how the higher education system and scientific production has been developed in Taiwan (Figure 6).

Chapter 5: Research Findings

5.1 Introduction

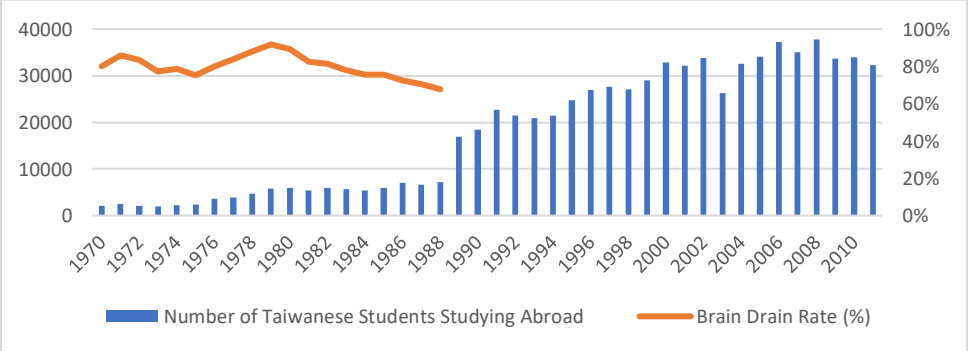
This chapter presents the research findings derived from the quantitative historical analyses. The first section explores the historical trend of brain drain from Taiwan. The second section explores the development of higher education in Taiwan and the growth of the post-graduate return rate.

5.2 Student Outflow and The Brain Drain Process

In the 1970s, the number of Taiwanese students studying abroad rose substantially from 2,056 to 5,801 in just one decade. It then increased to 8,178 by the end of the 1980s. In the meantime, the brain drain rate for these trained students rose from 85% in 1970 to a peak of 91% in 1979 and then fell to 68% by 1988, which means more Taiwanese graduates were returning from overseas by that time.

Figure 3

All Taiwanese Students at All Levels of Education Studying Abroad and the Brain Drain Rate between 1970 and 2011



Note. Data for Taiwanese brain drain rate is not available after 1988
Note. The second Y axis (on the right side of the figure) is used for the brain drain rate

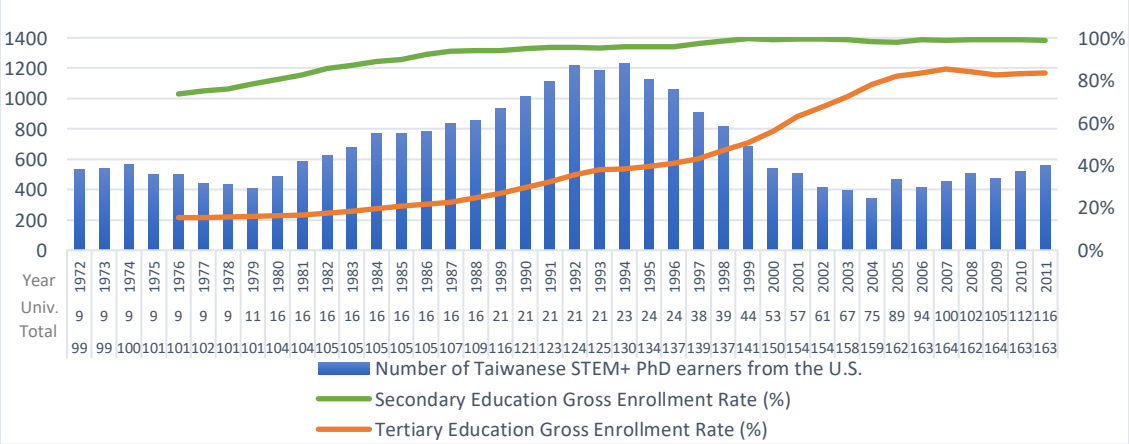
Starting in 1989, with the liberalization of the Ministry of Education of Taiwan's study abroad policy, all students were allowed to study abroad without government scholarship (Selya, 2004). Since then, there has been a growing number of Taiwanese students studying abroad annually, expanding from 16,879 in 1989 to 32,346 in 2011. Figure 3 shows the number of Taiwanese students studying abroad at all educational levels and the bran drain rate between 1970 and 2011.

5.3 Higher Education Development

The gross enrollment rate in 1976 was about 15%, and it increased to 81% over the following four decades. The trend of higher education gross enrollment rate went up continuously and has remained steady since 2005. According to Trow's (1973) three phrases of higher education development, the higher education system in Taiwan became universal in 2000 (Chan & Lin, 2015).

Figure 4

Number of Taiwanese PhDs from American Institutions and the Gross Enrollment Rates for both Secondary and Tertiary Education in Taiwan



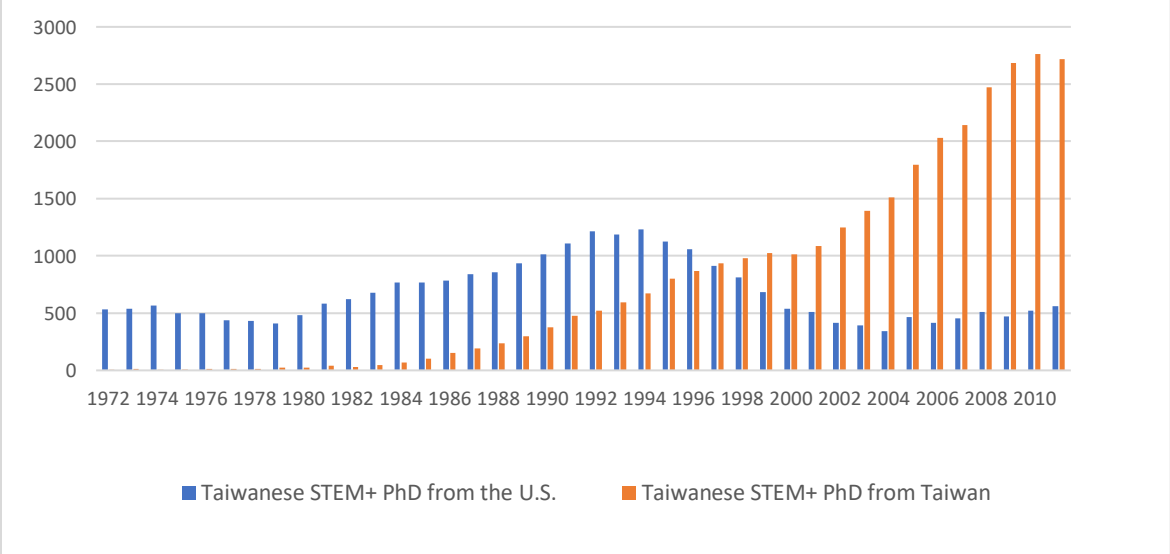
Note: The second Y axis (on the right side of the figure) is used for the gross enrollment rate for secondary and tertiary education

Additionally, the number of Taiwanese doctoral graduates increased from about 600 in 1972, growing rapidly for twenty years before finally reaching its peak in 1994 with 1,230 PhD graduates. However, the number then started declining over the following ten years, while the gross enrollment rate in higher education went up exponentially from 38% in 1994 to 78% in 2004. In 2005, the number of Taiwanese STEM+ PhDs increased again and has since remained stable. Figure 4 shows the number of Taiwanese STEM+ PhD graduates from American higher-education institutions and the gross enrollment rates for secondary and tertiary education.

Between 1972 and 1995, more Taiwanese doctoral degree holders earned their degrees from American institutions than from Taiwanese universities (Figure 5). The number of Taiwanese students who earned their doctorate from domestic institutions was less than 300 before 1990.

Figure 5

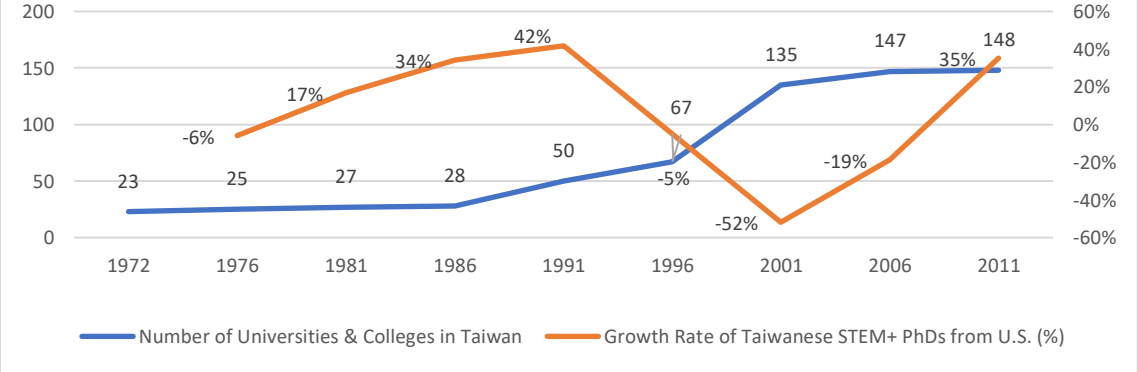
Number of Taiwanese STEM+ PhDs from American and Taiwanese Institutions



The number substantially went up thereafter and has remained constant since 2010. However, while the number of Taiwanese students who earned their doctorate from domestic institutions grew after the year 2000, the number of Taiwanese graduates who earned their doctoral degrees from American institutions remained steady for the following ten years. Even though higher education has been developed in Taiwan, some of the Taiwanese population is still pursuing degrees in the United States.

Figure 6

Number of Universities and Colleges in Taiwan and the Growth Rate of Taiwanese STEM+ PhD Earners from American Institutions



Note: The second Y axis (on the right side of the figure) is used for growth rate of Taiwanese STEM+ PhDs from the United States

Between 1972 and 2011, there was significant growth in the gross enrollment ratio and the number of higher-education institutions, especially universities. The number of universities and colleges in Taiwan was less than 30 in 1972. It then went up gradually to 148 in 2011. The growth rate of Taiwanese STEM+ PhDs from Taiwanese institutions increased as the number of Taiwanese universities and colleges increased until the 1990s. However, starting from the mid-1990s, the growth rate dropped from 42% to –52% in the following decade. Between 2001 and 2011, the higher education system in Taiwan was

well developed, with the creation of more than 130 universities and colleges. Therefore, higher education in Taiwan became universal. Almost every person had access to university education. However, credential inflation made degrees no longer valuable. Therefore, the growth rate of Taiwanese students studying at American universities started to increase again by 35% from 2006 to 2011. Some students still went abroad to pursue their graduate-level degrees to become more competitive. Figure 6 shows the number of universities and colleges in Taiwan and the growth rate of Taiwanese STEM+ PhDs from American institutions between 1972 and 2011.

Chapter 6: Conclusion and Policy Implications

6.1 Conclusion and Policy Implications

The growth of mega-science in the 20th century accelerated the development of higher education around the world. Before the 1960s, American institutions contributed the largest portion of scientific production; however, the rise of international scientific production can be witnessed between 1970 and 2011. From the 1970s to the 1980s, India and Taiwan were the top international contributors to science production. Between the 1990s and 2011, China, South Korea, India, and Taiwan contributed about 80% of the international scientific production. Taiwan, a relatively small country compared to China and India, contributed a large portion of the scientific production between 1972 and 2011.

Between 1972 and the 1990s, when higher education was not well-developed in Taiwan, an increasing number of Taiwanese students pursued graduate-level degrees at American institutions without coming back to Taiwan after obtaining their degrees. The brain drain rate between increased from 77% to 92% in the 1970s. With a serious amount of brain drain, the Taiwanese government started to implement policies to both attract American-trained graduates back to Taiwan and retain domestic students by increasing student participation in higher education.

The findings show that higher education in Taiwan expanded between 1972 and 2011. The gross enrollment rate for tertiary education rose from 15% in 1976 to 80% in 2011. At the same time, more Taiwanese students started to pursue STEM+ PhDs at Taiwanese universities. The number of Taiwanese STEM+ PhD earners from Taiwan increased from five in 1972 to 2,718 in 2011, while Taiwanese STEM+ PhD earners from

the United States fell from 1,230 in 1994 to 558 in 2011. Additionally, the number of universities and colleges dramatically increased from 23 to 148 over forty years. The brain drain rate started to fall when higher education expanded.

Taiwan has expanded its higher education and entered the universal education system, according to Trow's (1973) classification. Holding a bachelor degree is no longer an advantage in Taiwan when seeking a job. According to a survey of the relationship between educational attainment and wages in Taiwan, the wages of students who earned their graduate-level degrees in foreign countries increased by 45%, while the wages of students who obtained their PhD in Taiwanese universities rose by less than 20%. The credential inflation, therefore, resulted in an outflow of students in the 2000s. To enhance Taiwan's higher educational scientific research capacities, the Ministry of Education in Taiwan launched two projects in 2006: the World Class University Project and the Teaching Excellence Project. They aimed to further classify mass higher-education institutions as research- or teaching-oriented institutions. Further study might draw more on the long-term historical trends regarding the relationship between higher education and brain drain.

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