What Predicts Whether Foreign Doctorate Recipients from U.S. Institutions

Stay in the United States:

Foreign Doctorate Recipients in Science and Engineering Fields from 2000 to 2010

By

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Abstract

This study examines the trend of foreign doctorate recipients from U.S. higher education institutions who decided to stay in the United States after their degree completion, and it explores individual, institutional, and country factors predicting whether the foreign doctorate recipients stay in the United States or return home. Analyzing data from the Survey of Earned Doctorates by the National Science Foundation, this study focuses on foreign doctorate recipients in science and engineering fields from 20 sending countries during 2000 to 2010. Whether or not a foreign doctorate recipient in science and engineering fields decides to stay in the United State significantly affects the economic performance, knowledge flow, and innovation of both the United States and sending countries. This study uses the push-pull theory of international migration with an economic perspective as a lens to understand individuals' decisions to stay in the United States.

Approximately 81% of the study sample decided to stay in the United States after they earned their PhD degrees. Chinese doctorate recipients were most likely to stay; however, a slowdown of Chinese doctorate recipients' staying was detected in recent years. A series of logistic regressions show that while individual characteristics and their home country variables greatly predict foreign doctorate recipients' decisions to stay in the United States, where they earned their doctoral degrees does not significantly influence their decisions to stay in the United States, except in the most prestigious institutions. Foreign doctorate recipients who planned to work in industry were more likely to stay in the United States, while those who graduated from the most prestigious doctoral programs were more likely to leave the United States. The home country's high unemployment rate tended to increase the foreign doctorate recipients' odds of staying in the United States. The country of origin was an important predictor of the stay pattern.

These findings suggest important implications for the U.S. visa policies regarding recruiting foreign-born highly skilled workers and international students. For sending countries, the findings imply that improving their higher education sector and creating R&D employment in their home countries would decrease the brain drain of their students over the long term.

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Chapter I
Introduction

In this chapter, I introduce the importance of examining factors predicting foreign doctorate recipients' decisions to stay in the United States after they complete their degrees. First, I present the background of this study. Then, I discuss the purpose, research questions, and hypotheses of the study. I also briefly introduce theories used for this study. Finally, I suggest the importance of this study.

Background

International migration of students in higher education has increased rapidly in the past decades. According to the United Nations Educational, Scientific, and Cultural Organization Institute for Statistics (2011), the number of international students tripled between 1980 and 2009, from 1.1 million to 3.4 million. The students tend to migrate from developing countries to the more developed countries and from Europe and Asia to the United States (Altbach, 2004b). Some students migrate temporarily for education, while others remain permanently (Hazen & Alberts, 2006). The United States remains the destination of the largest number of international students for both undergraduate and graduate programs, followed by the United Kingdom, Germany, France, and China (UNESCO, 2011).

After World War II, U.S. universities emerged as world leaders in higher education (Clotfelter, 2010). The world-class universities in the United States have an international reputation unmatched by universities in any other country (Altbach & Balán, 2007). As the internationalization of higher education has increased, doctoral education at U.S. universities has drawn an increasing number of students from around the world (Bound & Turner, 2010). The share of doctoral degrees earned in the United States by foreign-born students has increased,

especially in science and engineering fields (Ehrenberg & Kuh, 2009). In 2009, international students with temporary visas earned half or more of all doctoral degrees in engineering, physics, computer science, and economics (National Science Board, 2012). The expansion of science and engineering PhD programs in the United States resulted from the influx of international doctoral students in their programs (Black & Stephan, 2007; Bound & Turner, 2010). During 1981-1999, the enrollment size of science and engineering PhD programs increased by 61.7% (Black & Stephan, 2007). Without the international doctoral students in the program, the enrollment size of science and engineering PhD program would have increased only by 26% (Black & Stephan, 2007). Since many doctoral students have come from other countries, the undergraduate institutions providing the largest number of U.S. doctorates are no longer U.S. institutions. In analyzing the undergraduate institutions of recipients of U.S. PhDs in 2006, the top undergraduate institution feeder school was Tsinghua University in China, followed by Peking University in China (Mervis, 2008). From 1997 to 2004, the University of California, Berkeley was the top undergraduate institution on the list for producing their graduates to U.S. PhD programs (Mervis, 2008).

Purpose of the Study

The purpose of this study is to examine the trend of foreign doctorate recipients who decide to stay in the United States after their degree is completed and to analyze individual, institutional, and country-specific factors affecting their decisions to stay in the United States. More specifically, this study focuses on foreign doctorate recipients in science and engineering fields from 2000 to 2010. During 2000 to 2010, globalization and knowledge economies have intensified (Organization for Economic Cooperation and Development, 2009), and higher education institutions worldwide have become more important than ever as the medium for the

global exchange of people, knowledge, and capital (Marginson & Van Der Wende, 2009). Foreign doctorate recipients in science and engineering fields have become increasingly well-qualified in the course of their studies, and their migration patterns have created a form of highly skilled migration as they participate in the global labor market (Tremblay, 2005). In a global knowledge economy, the U.S. educated foreign doctorate recipients are the talent pool that many countries need in order to attain economic development (OECD, 2008). Historically, these foreign doctorate recipients have been an important source of immigrant scientists and engineers for the United States (Freeman, 2010). Thus, analyzing these various factors provides enhanced understanding of foreign doctorate recipients' decisions to stay in the United States and helps policymakers identify rationales for effective policy interventions. According to OECD (2008), the mobility of these highly skilled workers has become a central aspect of globalization and has a significant impact on a nation's economic performance.

Theoretical Framework

This study uses the push-pull theory of international migration as a lens to understand individuals' decisions to stay in the United States (Altbach, 2004b; de Haas, 2008; Mazzarol & Soutar, 2002; National Academy of Sciences, 2005; Yang, 2010), focusing on economic perspectives (Borjas & Bratsberg, 1996; Bratsberg, Ragan Jr, & Nasir, 2002; Grossmann & Stadelmann, 2008; Kim, Bankart, & Isdell, 2011; Mattoo, Neagu, & Özden, 2008; Song, 1997; Sumell, Stephan, & Adams, 2009). The previous literature suggests that higher wages and better job opportunities in the United States pull foreign doctorate recipients to stay in the United States (Finn, 2010; Hazen & Albert, 2006; Kim, Bankart, et al., 2011). On the other hand, personal ties and cultural values pull the foreign doctorate recipients to return their home countries (Gupta, Nerad, & Cerny, 2003; Hazen & Alberts, 2006; Lee & Kim, 2010). The foreign doctorate

recipients' decisions are made by a combination of push-pull factors, and the wage differences between countries are one particularly strong country push-pull factor (Borjas & Bratsberg, 1996; Bratsberg et al., 2002; Grossmann & Stadelmann, 2008; Song, 1997). Equilibrium theory suggests that people tend to move from lower wage countries to higher wage countries (Yang, 2010), and the individuals' variations in human capital such as education and skills play an important role in this migration process that may lead to the different outcomes (de Haas, 2008, 2010; Regets, 2001, 2007; Sumell et al., 2009; Yang, 2010). Thus, according to the human capital theory, a doctoral degree from a U.S. institution increases the probability of migration (Tremblay, 2005), and if the degree were from a prestigious institution, the odds of staying in the United States may increase due to the higher level of human capital (Black & Stephan, 2007).

Research Questions

Given the importance of foreign doctorate recipients to maintaining the excellence of the research and development enterprise in the United States and the increasing competition among nations for the most talented scientists and engineers worldwide including the newly emergent power of China and India (National Academy of Sciences, 2007), this study investigates the following research questions:

1. What are the descriptive trends of foreign doctorate recipients who earned U.S. doctoral degrees in science and engineering fields in 2000-2010?
2. What individual factors (i.e., gender, marital status, having children, age, parental education, BA, funding source, and career plans) predict foreign doctorate recipients' decisions to stay in the United States?
3. What institutional factors (i.e., institutional type, institutional research expenditure, and program ranking) predict foreign doctorate recipients' decisions to stay in the

United States?

4. What country-specific factors (i.e., GDP, unemployment rate, R&D expenditure, education expenditure, and the number of world-class universities) predict foreign doctorate recipients' decisions to stay in the United States?

5. How do individual, institutional and country factors influence foreign doctorate recipients' decision to stay in the United States? After controlling for individual and institutional variables, do country variables have a unique contribution to their decisions to stay in the United States?

To address these research questions, this study employs a series of logistic regression analyses to understand how foreign doctorate recipients' decisions are affected by their individual characteristics, their doctoral institutions, and their home countries. First, this study examines individual factors that predict the stay of a foreign doctorate recipient in the United States. Previous research found female international students were more likely to stay in the United States than males, while age, marital status, and presence of children had mixed results on explaining decisions to stay in the United States (Gupta et al., 2003; Jin, Lee, Yoon, Kim, & Oh, 2006; Kim, Bankart, et al., 2011; Musumba, Jin, & Mjelde, 2011). This study expands the previous studies by exploring if the gender effect varies by country. In addition, this study examines how one's educational background predicts the odds of staying. Previous studies suggest that having a U.S. bachelor's degree increased the odds of staying in the United States (Black & Stephan, 2007; Freeman, 2010; Kim, Bankart, et al., 2011). This study further examines if having a selective bachelor's degree from one's home country influences a foreign doctorate recipient's decision to stay in the United States. The selectivity effect of bachelor's degree has been largely discussed; however, no research has examined the effect of selective

foreign bachelor's degree on one's migration decision (Black & Smith, 2006; Brewer, Eide, & Ehrenberg, 1999; Hoekstra, 2009; Thomas & Zhang, 2005).

Next, this study examines institutional factors that predict the stay of a foreign doctorate recipient in the United States. In this study, the term institution refers to one's doctoral institution. This study examines if the prestige of a doctoral institution has a positive effect on students' decisions to stay in the United States. According to human capital theory, a higher quality doctoral education enhances one's human capital (Thomas & Zhang, 2005), which may lead to higher probability of employment in the United States. That is, foreign doctorate recipients from prestigious programs are expected to have better job opportunities than foreign doctorate recipients from less prestigious programs (Black & Stephan, 2007; Finn, 2010). Mixed results have been found regarding whether or not the foreign doctorate recipients who graduated from the most prestigious programs are more likely to stay in the United States (Black & Stephan, 2007; Bound & Turner, 2010; Finn, 2010). This study reveals how the quality of higher education influences the migration decision for the graduates from 2000 to 2010.

Finally, this study provides an enhanced explanation of the country of origin on decisions to stay in the United States by examining the change in economic conditions of the students' home countries from 2000 to 2010. Country factors create the macro economic and social contexts that vary by the country of origins (OECD, 2008). Previous research suggests that relative economic conditions in the United States and home countries significantly affect decisions to stay (Bratsberg et al., 2002; Johnson, 2001; Song, 1997). The trend of stay rate among East Asian countries, for example, shows that students from China and India have the highest stay rates, while students from Japan and South Korea have lower stay rates (Kim, Bankart, et al., 2011). By looking at the top 20 sending countries' economic capacity data, this

study investigates how the economic opportunities in a student's home country predict that person's decision to stay in the United States. The current high stay rates of doctorate recipients from China and India may not continue if economic and career opportunities in those countries improve in the future (Clotfelter, 2010).

Hypotheses of the Study

This study hypothesizes that individual, institutional, and country variables affect foreign doctorate recipients' decisions to stay in the United States. Individual variables include demographic factors such as gender, age, marital status, having children, and parent's education. Students' educational experiences are also included, such as if the bachelor's degree is foreign, if the foreign bachelor's degree is selective, the year the PhD was earned, time to doctoral degree, and the primary funding source for their doctoral study. Moreover, this study examines if future career plans such as whether a foreign doctoral recipient wants to work in industry or academia influence the decision to stay in the United States. Push-pull theory suggests that the migration process becomes selective due to the variations of human capital such as demographic and educational background among individuals. Thus, foreign doctorate recipients may respond to the general push-pull factors differently depending on their demographic and educational background. The present study hypothesizes that those who have selective, foreign BA degrees are more likely to stay in the United States because their ability to overcome obstacles on migration is greater than those who have less selective, foreign BA degrees. In addition, this study also hypothesizes that those who plan to go to industry after graduation are more likely to stay in the United States because industry wages in the United States are much higher compared to those from their home countries.

Individuals' decisions to stay in the United States may be subject to the institutional influence. Institutional variables include institutional type of their doctoral institutions, doctoral program ranking, and institutional research expenditure. Astin (1985) suggested that the resources and reputation of an institution constitute the excellence of higher education (Sweitzer & Volkwein, 2009). Financial resources, faculty composition, and external funding are viewed as the resources of an institution (Sweitzer & Volkwein, 2009). Moreover, institutional and program reputation ratings by peers are generally accepted as "legitimate reflections" about institutions and their programs (Sweitzer &Volkwein, 2009, p.815). Thus, using institutional variables, this study examines how a doctoral institution can add value to their students' current human capital. This study hypothesizes that attending a prestigious doctoral institution increases the odds of staying in the United States.

This study broadens the analysis to the country level and hypothesizes that the foreign doctorate recipients' decisions to stay in the United States are affected by the economic conditions of their home countries. This study hypothesizes that the economic conditions of a country are negatively associated with the odds of staying. Thus, as the economic conditions of a country improve, the odds of staying are more likely to decrease. For country variables, this study includes GDP per capita centered on U.S. GDP per capita, unemployment rate, R&D expenditure, public education expenditures, and the number of world-class universities in their home countries.

Hypotheses. The main hypotheses this study test are summed up as follows:

1. Foreign doctorate recipients who have selective, foreign BA degrees are more likely to stay in the United States compared to those who had less-selective, foreign BA degrees.

2. Foreign doctorate recipients who plan to work in industry after graduation are more likely to stay in the United States.

3. Foreign doctorate recipients who attended a prestigious doctoral institution are more likely to stay in the United States.

4. A high level of GDP of one's home country decreases the odds of staying in the United States. Foreign doctorate recipients are less likely to stay in the United States as the economic conditions of the home country improve.

5. After controlling for individual and institutional variables, country variables have a unique contribution to the decision to stay in the United States.

Importance of the Study

Given the increasing number of international students in the United States, a large body of research has focused on analyzing the trend of international graduate students coming to study in the United States (Altbach, 2004b; Blanchard, Bound, & Turner, 2009; Borjas, 2007; Bound & Turner, 2010; Bound, Turner, & Walsh, 2009; Freeman, Jin, & Shen, 2007; Institute of International Education, 2011; National Academy of Sciences, 2005; National Science Foundation, 2010; Zhang, 2009). Despite the large body of existing literature on the international mobility of students in higher education, researchers have paid limited attention to international students' decisions to stay or not in the country where they have received their doctoral degrees after graduation (Kim, Bankart, et al., 2011). Understanding foreign doctorate recipients' decisions to stay in the United States is important for both the United States and the students' home countries.

For the United States, given the decreasing number of U.S. native scientists and engineers between 1970 and 2005 and the increasing number of foreign doctorate recipients in science and

engineering fields, the number of foreign doctorate recipients who stay in the United States and the changes in these numbers and their patterns are important to the U.S. higher education system and labor market (Bettinger, 2010; Black & Stephan, 2007; Freeman, 2010). It affects the composition of the U.S. workforce, and it can affect the flow of knowledge from the United States to other countries (Black & Stephan, 2007). For example, in STEM (science, technology, engineering, and mathematics) fields, international faculty make up to one-third of all new faculty hires (Kim, Wolf-Wendel, & Twombly, 2011). In Silicon Valley, 52% of technology and engineering companies that started from 1995 to 2005 had immigrant CEOs or lead technologists with Masters or PhD degrees (Wadhwa, Saxenian, Freeman, & Gereffi, 2009). While the numbers of U.S. native students who earned PhDs in science and engineering fields decreased between 1970 and 2005, the United States has led the world in science and technology by attracting exceptional foreign-born scientists (Bettinger, 2010; National Academy of Sciences, 2007; Stephan & Levin, 2001). One study suggested that foreign-born engineers generated economic gains by contributing to industrial and business innovation, resulting in a net increase in wages for both U.S. citizen and immigrants (Chellaraj, Maskus, & Mattoo, 2008). If the number of foreign doctorate recipients who stay in the United States drastically decreases due to an incident like September 11, the U.S. higher education institutions and U.S. labor markets could face a painful adjustment (Clotfelter, 2010).

On the other hand, the countries that are sending their students to the United States for advanced studies are concerned about their students not coming back to their home countries, leading them to suffer from the brain drain phenomenon (Blanchard et al., 2009). The term "brain drain" refers to the transfer of highly skilled people from one country to another (OECD, 2008, p.43). Specifically, brain drains happen when people with a high level of skills,

qualifications, and competence leave their countries and migrate to another country (Baruch, Budhwar, & Khatri, 2007). The brain drain phenomenon causes the decline of potential positive externalities that highly educated people can generate in a society, a lower return from public investment in education, and reduced future tax revenues (Gribble, 2008; Grossmann & Stadelmann, 2008; Mattoo et al., 2008; Regets, 2007). For example, since many doctoral students from China stayed in the United States after their degree completion, the brain drain has resulted in the loss of productive labor within China's research community (Zweig, Fung, & Han, 2008). Analyzing 1995-2000 publication data, research found that many Chinese scientists between the age 28 and 36 who published did not physically reside in China but were abroad (Jin, Li, & Rousseau, 2004). Recently, the concept of "brain circulation" has been discussed to rethink the concerns about brain drain (Gribble, 2008, p.27). In this concept, the stocks of migrants are viewed as a "precious resource" rather than a brain drain (OECD, 2008, p.47). The professional and social networks maintained by returners with their former host countries help continue the flow of knowledge associated with brain circulation (OECD, 2008). In sum, for sending countries, understanding their students' stay patterns and factors affecting the students' decisions to stay in the United States is important in order to develop appropriate policies to reverse the pattern or to facilitate brain circulation of their people.

In addition, this study contributes to existing research on factors affecting the mobility of highly skilled by bridging the individual level studies and country level studies and providing a more comprehensive picture that is useful for predicting their migration decisions. Foreign doctorate recipients' decisions to stay in the United States are influenced not only by individual characteristics but also by country-specific push-pull factors. While previous studies analyzed how the variations in individuals' characteristics influenced the foreign doctorate recipients'

decisions to stay in the United States, they failed to consider the broader contexts that the foreign doctorate recipients face, such as the economic state and the labor demand of the home countries and the labor demand in the United States (Black & Stephan, 2007). While the economic conditions of the United States are applied to the same degree among the foreign doctorate recipients, their home countries' economic conditions vary greatly. Thus, this study focuses on their home countries' economic states on a yearly basis in order to reveal how the differences between the United States and home countries influence the migration decision (Bratsberg et al., 2002; Finn, 2010; Grossmann & Stadelmann, 2008; Johnson, 2001). This study also expands the existing literature on human capital theory on migration decision by investigating how higher education quality influences the migration decision. This study examines the effect of selectivity of bachelor's degree among foreign degree holders and the effect of doctoral degree prestige on foreign doctorate recipients' decisions to stay in the United States. By examining the impact of higher education quality on an individual's decision to stay in the United States, this study offers empirical evidence regarding how an individual's unique combination of human capital formed by higher education plays a role on migration decisions.

Organization of the Dissertation

Chapter 1 introduced the importance of examining foreign doctorate recipients from U.S. higher education institutions and their decision to stay in the United States after their degree completion. This study investigates what individual, institutional, and country factors influence the foreign doctorate recipients' decisions to stay in the United States. Chapter 2 reviews concepts, theories, and empirical research on factors that may affect foreign doctorate recipients' decisions to stay in the United States. Chapter 3 discusses research methodology that is used to explore research questions. This includes data sources, research variables, analytic methods, and

model specifications. Chapter 4 reveals findings from the data analysis. Chapter 5 discusses findings, policy implications, and suggestions for future research.

Chapter II
Literature Review

In this section, I review the theoretical and empirical literature regarding foreign doctorate recipients' decisions to stay in the United States. First, I discuss the trend of foreign students coming to the United States and the trend of foreign doctorate recipients' staying after they complete their degrees. Then, I review the theories and previous research that provide an understanding of why foreign doctorate recipients decide to stay in the United States. This helps to identify the gap in the literature and suggest the significance of this study.

The Trend of Foreign Doctorate Recipients in Science and Engineering Fields

This section provides an overview of the trend of coming and staying of foreign doctorate recipients in the United States. I review why this trend took place and what the consequences have been to the U.S. science and engineering fields. This analysis suggests the importance of studying this population, who are the foreign doctorate recipients from U.S. institutions.

Foreign students coming to the United States. After World War II, the United States and the Soviet Union competed for international education exchange in order to expand their political influence on rest of the world (Knight & De Wit, 1995). In the United States, an important drive to attract foreign students was the Hart-Cellar Immigration Act of 1965, which removed the national origin quotas established by the Johnson-Reid Immigration Act of 1924 (Chellaraj et al., 2008). The 1965 Act resulted in a greater influx of foreign students and highly skilled immigrants to the United States, and the trend was accelerated after passage of the Kennedy-Rodino Immigration Act of 1990 (Chellaraj et al., 2008). A large increase in federal research funding for science and direct public support for graduate education also provides more

opportunities for foreign students in science and engineering fields (Bound et al., 2009; Zhang, 2009). Comparing the United States native proportion of PhDs in science and engineering fields between 1966 and 2000, Freeman et al. (2007) found a decline in the U.S. native-born male share of PhDs in science and engineering fields. In 1966, U.S. native males dominated the science and engineering fields: 71% of PhDs were U.S. native males, 6% were U.S. native females, and 23% were foreign-born (Freeman et al., 2007). However, in 2000, the proportion of foreign-born PhDs in science and engineering exceeded U.S. native males. The number of U.S. native males shrank to 36% , while the number of U.S. native female increased to 25%, and the foreign-born PhDs increased to 39% (Freeman et al., 2007).

Data suggest that graduate student enrollments in science and engineering fields have been relatively stable since 1993, remaining at about 22-26% of the total enrollment of graduate students (National Academy of Sciences, 2007). However, the number of doctoral degrees awarded in science and engineering was mainly driven by the increasing number of foreign-born students (National Academy of Sciences, 2007). In 2009, temporary residents earned 13,400 U.S. doctoral degrees in science and engineering fields (National Science Board, 2012). Most of the degrees were awarded in computer sciences, engineering, physical sciences, and economics (National Science Board, 2012). The top 10 sending countries accounted for 67% of all foreign doctorate recipients from 1989 to 2009 (National Science Board, 2012). During 1989-2009, students from China earned the largest number of U.S. doctorates in science and engineering fields (57,700), followed by those from India (24,800), South Korea (21,800), and Taiwan (17,800) (National Science Board, 2012). Interestingly, in 1989, students from Taiwan earned more U.S. degrees than students from China, India, and South Korea (National Science Board, 2012). However, as higher education institutions in Taiwan increased their capacity for advanced

science and engineering education and research, the number of students from Taiwan declined (Johnson, 2002).

The trend of increasing international doctoral students can be viewed in the context of the globalization of the U.S. economy and internalization of U.S. higher education (Altbach, 2004b; Clotfelter, 2010). Blanchard et al. (2009) argued that an expansion of full trade and diplomatic relationships yields a sharp increase in study in the United State. The establishment of diplomatic relations in 1979 between the United States and China opened a new pathway to U.S. graduate education that had been largely closed in the 1960s and 1970s (Blanchard et al., 2009). According to Golash-Boza (2012), foreign direct investment (FDI) also affected migration flow. The closer economic ties between the two countries in the 1990s accelerated the increasing number of Chinese students in the United States (Golash-Boza, 2012). The increasing interaction of U.S. corporations in South Korea's economy also motivated the migration flow of its students to the United States (Golash-Boza, 2012). In addition to economic influences, America's leadership in higher education attracted the best and the brightest students worldwide, especially at the most advanced graduate levels (Clotfelter, 2010). Most of the world's leading research universities are located in the United States (Altbach, 2004a; Altbach & Balán, 2007). According to the *Academic Ranking of World Universities* (2011) published by Shanghai Jiao Tong University, seventeen out of its twenty top-ranked universities in 2011 were American. Clotfelter (2010) argued that "first-mover advantages" of American universities and the language, English, help them remain at the top for decades (p.10). He suggested that by establishing a position of leadership worldwide, the United States has effectively "set barriers to entry into the top rugs" of higher education (p.10). When higher education institutions around the world seek to improve themselves, they refer to American higher education, especially in the research university

domain (Marginson & Van Der Wende, 2009). The use of English also helps them remain competitive because English became the dominant language in science, engineering, and other fields in twentieth century (Clotfelter, 2010).

The nature of science and engineering disciplines also affected the representation of doctoral students in U.S. programs (Bound et al., 2009). Science and engineering doctoral education has a unique hierarchical nature that requires academic preparation for advanced study beginning in early school days (National Academy of Sciences, 2007). Students who choose not to finish the first level of algebra before 9th grade will probably not major in sciences and engineering fields when they go to college (National Academy of Sciences, 2007). Among U. S. students who start college in a STEM major, about one-third switch majors before graduating (National Academy of Sciences, 2007). In contrast to the United States experience, Bound et al. (2009) found that a rapidly increasing number of undergraduate degree attainment in sciences and engineering in many countries outside of the United States had a direct effect on the demand for doctoral education in the United States. In South Korea, 38% of all undergraduates received their bachelor's degree in natural science and engineering in 2004. In China, the corresponding number was 50%, while in the United States, it was only 15% (National Academy of Sciences, 2007). Countries without strong graduate systems but with recent expansion in undergraduate degree attainment had the greatest representation of doctorate students at U.S. institutions (Bound et al., 2009).

In sum, the expansion of foreign doctoral students in U.S. institutions and the diminishing numbers of U.S. native students who study in advanced STEM fields imply a new demography of U.S. educated scientists and engineers in the U.S. labor market. The trend suggests that the dependency on foreign students in U.S. science and engineering fields will

continue (Black & Stephan, 2007). Thus, it becomes crucial to examine who stays and who returns as well as to explore what factors may influence students' decisions to stay in the United States.

Foreign doctorate recipients staying in the United States. Temporary student visa holders are increasingly likely to stay in the United States after earning the doctoral degree, a measure referred to as the "stay rate" (National Science Foundation, 2010, p.13). Data suggest that foreign doctoral students who decide to remain in the United States after their graduation are more likely to set themselves toward long-term residency (National Science Board, 2012). In the 1980s, about half of foreign doctorate recipients stayed in the United States after graduation (Kim, Bankart, et al., 2011). In the 2000s, the percentage increased, and the stay rate rose to 66% (Kim, Bankart, et al., 2011), although the recession and the September 11 terrorist attack both negatively affected the stay rate (Finn, 2010). Stay rates are highest in fields where temporary visas holders are most prevalent: engineering, physical sciences, and life sciences (NSF, 2010). Increasing demand for postdoctoral study is one main reason for the higher stay rates for some fields (Johnson & Regets, 1998). Foreign doctorate recipients in the biological sciences had a significantly higher stay rate due to their postdoctoral study when compared to engineering and agriculture majors (Kim, Bankart, et al., 2011).

Estimating the 5-year stay rate among foreign doctorate recipients who received their degrees in 2002, Finn (2010) found that the highest stay rate was among Chinese doctorates, 92%, followed by Yugoslavian doctorates, 88%. During the time periods examined from 1995 to 2007, China dominated the highest 5-year stay rate, while Japan, South Korea, and Brazil had the lowest 5-year stay rates; each of three countries had the 5-year lowest stay rate at least once during 1995 to 2007 (Finn, 2010). Finn (2010) argued that the country of origin predicted the

stay rate of foreign doctorate recipients, and the different stay rates among countries persisted during the time examined. A few countries had stay rates that are above the average were China, India, Iran, and Yugoslavia.

Previous research on stay rate trend of foreign doctorate recipients from U.S. institutions suggests that the country of origin plays a significant role on the stay patterns (Black & Stephan, 2007; Finn, 2010; Kim, Bankart, et al., 2011). This study expands the previous studies by examining how the stay rates and stay patterns of foreign doctorate recipients respond to the economic conditions of their home countries. This provides an enhanced explanation of country factors associated with the foreign doctorate recipients' decisions to stay in the United States.

Impact of foreign doctorate recipients on U.S. science and engineering fields. The presence of foreign doctorate recipients who stayed in the United States changed the landscape of U.S. science and engineering fields. Borjas (2007) analyzed the enrollment trends in graduate programs from 1978 to 1998 using the Higher Education General Information System (HEGIS) and Integrated Postsecondary Education Data System (IPEDS) data. He discovered that while the increasing enrollment of foreign-born graduate students had little effect on the probability of U.S. native student enrolled in a PhD program, the increase of foreign-born PhDs had adverse effects on the enrollment of white male U.S. citizens in PhD programs. The effect was the strongest at the most prestigious institutions (Borjas, 2007). One study argued that the influx of foreign students in science and engineering fields has lowered the average wage of the field, and this moved U.S. native students to other fields because U.S. students are more sensitive to lowered wages (Borjas, 2005). Borjas (2005) calculated that a 10% increase of foreign doctorate recipients in science and engineering fields lowered the wage of competing workers by about 3%

during 1968-2000. On the other hand, Regets (2001) found that the proportion of foreign-born PhDs were positively associated with the median salary of fields (r=0.75). Analyzing the median salary of PhDs, he argued that in the life sciences, biological scientists were paid more than agricultural scientists. In the physical sciences, physicists were paid more than geologists. He suggested that the higher the proportion of foreign doctorate recipients in that field, the higher the salary in that field (Regets, 2001).

While many U.S. native doctorate recipients in science and engineering fields are discouraged by the lower life time earnings compared to law and medical school graduates, foreign doctorate recipients are still attracted to the U.S. science and engineering fields (Freeman, 2006). Freeman (2006) argued that foreign students have "lower opportunity costs" than U.S. native students because most of them are from lower income countries compared to the United States, which means that their future earnings in the United States will be higher compared to the earnings of their home countries (p.138). He also suggested that science and engineering careers may be the "only way" for many talented foreign-born to obtain a good job, a green card, or a citizenship in the United States (p.138). Analysis of the correspondence between level of education and job qualifications of immigrants to OECD countries also found that immigrants are more likely to be overqualified for their jobs than those native born (OECD, 2007).

Research suggests that foreign doctorate recipients contribute to the advancement of U.S. science and engineering fields (Chellaraj et al., 2008; Stephan & Levin, 2007). One study found that a 10% increase in the number of foreign graduate students raised the university patent grants by 6%, while the enrollment of U.S. native graduate students had no detectable effect (Chellaraj et al., 2008). Stephan and Levin (2007) found that individuals who made

"exceptional"[1] contributions to U.S. science and engineering fields during the early 1990s were "disproportionately" foreign-born or foreign-educated (p.170). They also found that foreign-born PhDs substituted for U.S. native counterparts with less compensation within academia, especially in mathematics and computer science fields.

In sum, historically, many immigrant scientists and engineers have come to the United States first as students (Freeman, 2010). This increasing number of foreign students coming and staying in the United States suggests that they will greatly affect the supply of highly skilled immigrants to the United States (Black & Stephan, 2007; Freeman, 2010). In fact, they have become so integral to the U.S. science and engineering fields to the point that if the flow of these students were sharply reduced, research and academic work in the United States would suffer until an alternative source could be found (Clotfelter, 2010; National Academy of Sciences, 2005). However, from the point of view of most sending countries, the potential gains related to sending their native students to the United States may be limited if they decide to stay in the United States and subsequently immigrate to the United States (Tremblay, 2005). Thus, it becomes important to examine the factors associated with their decisions to stay in the United States and draw out policy implications.

[1] .The authors defined "exceptional" work as individuals elected to the National Academy of Sciences (NAS) or the National Academy of Engineering (NAE), authors of citation classics, authors of hot papers 250 most cited authors, authors of highly cited patents, and founders of biotech firms (p. 155).

Theoretical Background for Foreign Doctorate Recipients' Decisions to Stay in the United States

In this section, I review the key concepts and theories related to foreign doctorate recipients' decisions to stay. I review the brain drain concepts and theories on international migration. This supports the theoretical background of this study.

Brain drain, brain gain, and brain circulation. The concept "brain drain" implies the emigration of highly skilled people from developing countries to advanced countries, particularly to the United States (Miyagiwa, 1991, p. 743). According to the brain drain concept, foreign doctorate recipients' decisions to stay in the United States negatively affect the sending country's economy because it reduces the supply of highly skilled workers in that country (Regets, 2007). From a sending country's perspective, loss of their U.S. educated PhDs suggests a decline in positive spillover effects that the highly educated may produce within the economy, a loss of potential higher tax revenue, and lower returns from public investment in K-12 education of one's country (Gribble, 2008; Mattoo et al., 2008; Regets, 2007). With brain drain, the level of human capital, particularly in the higher skill levels in the sending country, will not grow because its highly skilled workers migrate out to the United States. One study analyzed the migration flow of highly skilled workers in 77 countries and found that a higher emigration rate was associated with downward adjustment of public R&D investments (Grossmann & Stadelmann, 2008). That is, when the brain drain increased, public R&D investments decreased in the sending countries (Grossmann & Stadelmann, 2008). Thus, many countries are concerned about the high stay rate of their students who attend other countries for advanced studies (Regets, 2007).

The contrasting concept to brain drain is "brain gain" (Baruch et al., 2007, p. 99). For host countries like the United States, when foreign doctorate recipients decide to stay in the United States, the United States gains “brains,” which increases its stock of human capital (Regets, 2007). Additional highly skilled workers such as foreign doctorate recipients will increase research and development capacity and economic activities in the United States (Regets, 2007). A larger number of highly skilled workers in a country leads to increased productivity due to the scale effect of advanced education and research (Miyagiwa, 1991). Stephan and Levin (2007) found that individuals who contributed to the progress of U.S. science and engineering were disproportionately drawn from the foreign-born. With brain gain, the United States also benefits from increasing collaborations with sending countries because many of its global connections come from immigrant scientists and engineers who remain in the United States (Regets, 2007).

Though many studies argue that the effect of highly skilled migration on the sending countries is negative, a growing body of research proposes that sending countries can also benefit from educating their nationals abroad. The term “brain circulation” is used to describe the increasingly circular nature of migration (Gribble, 2008, p.27). One concept is return migration, which occurs when a student returns to his or her home country after a certain period of study or work in a host country, and another concept is the networks maintained by returners with their former host country (Gribble, 2008). Saxenian (2002) found a strong connection between Silicon Valley in California and the Hsinchu-Taipie region of Taiwan. They argued that the links have been built by U.S. educated Chinese engineers who not only transferred new knowledge and skills on their return to Taiwan but also created social and professional links with Silicon Valley’s Chinese network (Saxenian, 2002). Kapur (2001) documented the brain circulation of

Indian engineers and scientists. The Indian engineers in Silicon Valley helped the potential high quality contenders in India overcome the initial hurdle and enhanced knowledge and information flow to India (Kapur, 2001). Brain circulation suggests that many immigrant scientists and engineers in the United States maintain financial, cultural, and sometimes political links with their home country, an exchange that can be a benefit to the sending countries (Gribble, 2008).

In sum, brain drain explains the effects of foreign doctorate recipients' decisions to stay in the United States from a sending country's perspective, while brain gain explains the positive effect on United States. Brain circulation suggests that these mobile effects are not zero-sum games. That is, the United States' gains do not necessarily lead to China's losses. Regets (2007) suggested that beyond the sum of effects on individual's countries, the global net effect of high-skill migration is likely to be positive for knowledge flow and innovation, which are essential to the growth of global economy.

Theories on international migration. To better understand the foreign doctorate recipients' decisions to stay in the United States, it is necessary to look at the theories explaining why the international migration takes place. No single theory can provide a comprehensive explanation for the international migration (Massey et al., 1998). I review the push-pull theory as a basic model to explain an individual's decision to stay in the United States, and then I expand the push-pull theory, emphasizing an economic perspective and a sociological perspective (Yang, 2010).

Push-pull theory. Push-pull theory was suggested by Lee's (1966) work on revising Ravenstein's *Laws on Migration* (1889), and it became a popular model in migration literature because of its explanation of why people move (de Haas, 2008; Yang, 2010). This theory is also widely used in explaining the migration of students in secondary and higher education (de Haas,

2008). Individuals decide to move from one place to another when they are pushed or pulled out by various environmental, demographic, and economic factors (de Haas, 2008). According to the push-pull theory, unfavorable conditions within the area of origin "push" people out, while the favorable conditions in the area of destination "pull" them in (Lee, 1966). Some factors affect most people in much the same way, while others affect different people in different ways (Lee, 1966). For example, a good climate in the area of destination can be a pull factor for most people. Another pull factor is a good school system in the area of destination, but this is more important for a parent with young children than it might be for a single person (Lee, 1966). In addition, Lee (1966) suggested the impact of "intervening obstacles" on the migration process, which may affect people's decisions to migrate (p.50). He argued that variables such as physical and psychological distance, physical barriers, political barriers, and having children can prevent a decision to migrate (Lee, 1966). He also argued that migration process is "selective" because age, gender, social status, and education level affect how people differently respond to the same push-pull factors, as these conditions shape their ability to overcome these intervening obstacles (p.56). For example, a 28-year-old male foreign doctorate recipient without a child whose major is computer science will show a higher migration propensity because he does not have many intervening obstacles; if there should be any, he can easily overcome them.

Previous literature on the flow of international students used the push-pull theory to explain the factors related to the students' decisions on migration. Research found that the foreign doctorate recipients' decisions to stay in the United States result from a combination of push and pull factors (Altbach, 2004b; Gupta et al., 2003; Lee & Kim, 2010; National Academy of Sciences, 2005). Research consistently found that the low level of economic and political development in one's home country push the scholars out, while the resources and benefits of the

United States pull them in (Altbach, 2004b; de Wit, 2010; Gupta et al., 2003; Lee & Kim, 2010; Mazzarol & Soutar, 2002; McMahon, 1992). Studies suggest that the push factors for foreign doctorate recipients' decisions to stay in the United States are unfavorable conditions within their home country such as lower salaries, few world-class universities, no availability of a particular specialty, limited research funding, poor career prospects, and adverse social or political conditions (Altbach, 2004b; Finn, 2010; Mazzarol & Soutar, 2002; National Academy of Sciences, 2005). On the other hand, the pull factors can be favorable conditions of the United States for the foreign doctorate recipients, such as better academic facilities, better financial support, academic prestige of institutions, better working conditions that includes academic freedom, better opportunities for employment, openness to hiring well-qualified foreigners, and higher salaries, including academic salaries (Altbach, 2004b; de Wit, 2010; Gupta et al., 2003; Lee & Kim, 2010; National Academy of Sciences, 2005). Altbach (2004b) pointed out that many international students go abroad to study with the intention to stay in the host country; thus, employability becomes the key pull factor. Altbach (2004b) suggested that the high stay rates of students from India or China result from this employability pull factor.

This present study uses the push-pull theory to examine the factors affecting the foreign doctorate recipients' decisions to stay in the United States, and it tests new variables that may influence their decisions to stay by looking at the factors at individual, institutional, and country level. The advantage of the push-pull theory is that it can incorporate all the factors that influence the outcome and suggest a general view of migration (de Haas, 2008). However, some criticize the simplicity of this theory since it only lists push and pull factors (de Haas, 2008; Yang, 2010). For example, this theory does not take into account the role of specific development in particular countries that this theory cannot explain why with similar push and

pull conditions, as some countries have large international migration flows while other countries do not (Portes & Bach, 1985). Beyond push and pull factors, other conditions such as cross-national connections, individual's human capital and social networks, and immigration policies should be considered when explaining the international migration (Yang, 2010). Thus, in the following section, I review an economic perspective and a sociological perspective on international migration that mitigate the criticism of simplicity that has been aimed at the push-pull theory.

Economic perspective: Equilibrium theory and human capital theory. Economists have proposed many theories to explain the international labor migration in the process of economic development and brain drain issue (de Haas, 2010; Yang, 2010). Previous studies on the international migration of highly skilled workers utilized equilibrium theory and human capital theory to explain the migration (Borjas & Bratsberg, 1996; Bratsberg, 1995; Bratsberg et al., 2002; Grossmann & Stadelmann, 2008; Kim, Bankart, et al., 2011; Mattoo et al., 2008; Regets, 2001; Song, 1997; Sumell et al., 2009). Equilibrium theory (Yang, 2010), also called neoclassical economic macro theory (de Haas, 2010; Massey et al., 1998), was initially developed to explain the rural-urban migration within a country from rural and agricultural to urban and industrial areas due to the disequilibrium of labor supply and demand with wages (Todaro, 1969, cited in Yang, 2010). This concept was extended to international migration research (de Haas, 2010). This theory suggests that "labor markets" are the primary mechanism that causes international migration (Massey et al., 1993, p. 434). People move because of the differences in wage rates between countries (Yang, 2010). That is, people tend to move from lower wage countries to higher wage countries. This theory suggests that the international flow of highly skilled workers has a distinct pattern of migration that differs from that of unskilled

workers because the labor markets between two groups are "segmented" (Yang, 2010, p.6). Thus, this theory predicts that international migration ceases when the wage level at the sending country and the receiving country converge (Massey et al., 1993). Research suggests that the decision of a foreign student to stay in the United States is significantly influenced by the comparison of economic conditions between the sending country and the host country (Borjas & Bratsberg, 1996; Bratsberg, 1995; Bratsberg et al., 2002; Grossmann & Stadelmann, 2008; Johnson, 2001; Rosenzweig, 2010; Song, 1997). Previous studies found that the higher wage gap between the sending country and the receiving country led to the higher stay rate in the receiving country (Borjas & Bratsberg, 1996; Bratsberg et al., 2002; Grossmann & Stadelmann, 2008). The limitation of this theory is that it only explains international migration at the national level (Yang, 2010). On the other hand, human capital theory for migration emphasizes the choice of individuals in the migration process, which is called neoclassical economic micro theory (de Haas, 2010).

Sjaastad (1962) was the first to suggest human capital theory as an explanation of migration (Massey et al., 1993; Yang, 2010). Human capital theory assumes that personal assets such as skills, education, and physical abilities are fundamental capitals that increase one's productivity (Becker, 1993; Kim, Bankart, et al., 2011). Human capital theory on migration views "migration as an investment increasing the productivity of human resources" (Sjaastad, 1962, p. 83). This theory assumes that this investment has both costs and benefits, and rational individuals decide to move from one place to another when they expect a positive net return from the migration after a cost-benefit calculation (Sjaastad, 1962). Assuming free choice and full access to information, "utility maximizing" individuals are expected to move where they can be the most productive and earn the highest return such as higher wages, better jobs, and a more

satisfying lifestyle (de Haas, 2010, p. 231; Regets, 2001; Sumell et al., 2009; Yang, 2010). Before individuals decide to move, they consider the "migration cost" (Massey et al., 1993, p. 435), including the monetary costs of moving and looking for a job, the effort to learn a new language and culture, the difficulty in adapting to a new labor market, and the psychological costs of cutting old ties (Baruch et al., 2007; Chellaraj et al., 2008; Sumell et al., 2009; Tremblay, 2005). Since each individual has a unique blend of human capital such as education, social and cultural experiences, and language skills, the expected return on one's migration will vary (de Haas, 2008). This theory argues that due to the different levels of human capital, individuals from the same country of origin can display different propensities to international migration (Massey et al., 1993). Previous literature on the mobility of highly skilled individuals suggests that the most qualified are more easily and rapidly absorbed to the new labor market because they have greater ability to adjust with a higher level of education, the mastery of foreign language, and the country-specific knowledge (Mattoo et al., 2008; Tremblay, 2005). Both the quantity and quality of education experiences improve one's stock of human capital (Becker, 1993), and the possession of a doctoral degree from the host country removes the entry barriers related to the recognition of their diplomas, which accelerates the migration (Tremblay, 2005). Thus, individual's human capital that increases the probability of employment in the destination compared to the sending country will also increase the likelihood of international migration (Massey et al, 1993). The high stay rate of foreign doctorate recipients in science and engineering fields compared to that of non-science and engineering fields indicates that they have much higher returns if they stay in the United States (Kim, Bankart, et al., 2011).

This study utilizes the economic perspective on international migration to examine push-pull factors affecting the foreign doctorate recipients' decisions to stay in the United States.

While previous country-level studies focused on the wage differences among countries, they had limited interest in individual variations. This study fills the gap in the previous economic approach in two ways. First, this study simultaneously takes into account the individuals' human capital assets and the country-specific economic conditions, and it examines the influence of each factor on the migration decision. This analysis provides a unique contribution of the understanding of the factors explaining the migration of highly skilled. Second, this study focuses on the impact of the quality of higher education on one's human capital and examines how the individual's human capital variations due to higher education quality affect the migration decision. The theory suggests that the labor market for the highly skilled is segmented. Thus, the impact of higher education quality on the highly skilled is important to examine because the impact may be different from what it would be on the general population. The main data in this study, the Survey of Earned Doctorates (SED: 2010), provides the detailed information related to the foreign doctorate recipients' educational background, such as their undergraduate institutions, including foreign institutions, and doctoral institutions. This information allows us to explore how human capital variations formed by higher education experiences influence the foreign doctorate recipients' decisions to stay in the United States.

Sociological perspective: world system theory and social network theory. While neo-classical economy theories focuses on economic factors to explain the international migration using costs and benefits and supply and demand concepts, sociologists emphasized the importance of social factors on international migration. World system theory and social network theory are two theories that reflect a sociological perspective (Massey et al., 1998; Massey et al., 1993; Yang, 2010).

World system theory seeks to analyze the social changes by combining the study of inter-societal relationships and the economic and political relations within one global system (Chen & Barnett, 2000). World system theory argues that international migration is a byproduct of global capitalism (Sassen, 1988). According to the theory, the global structure consists of "core," "semi-peripheral," and "peripheral" areas (de Haas, 2008, p.7). The core countries produce "capital-intensive" and "high technology" goods, while the peripheral countries produce "labor-intensive" and "low technology" goods (Chen & Barnett, 2000, p.437). People move from the peripheral to the core countries because factors associated with industrial development in the core countries generate structural economy problems and thus push factors in the peripheral countries (Yang, 2010). Analyzing the trend of foreign student flow, research has found that an academic hegemony was consistent with world economic development and political structure (McMahon, 1992; Chen & Barnett, 2000). That is, the core countries such as the United States and Western European countries were receiving foreign students, while the countries in the periphery were exporting their students to the core (Chen & Barnett, 2000). In addition, world system theory suggests that military interventions and political and ideological linkages between the peripheral countries and the core countries influence the international migration pattern (Golash-Boza, 2012; Massey et al., 1993; McMahon, 1992; Sassen, 1988). For example, Golash-Boza (2012) suggested that the U.S. military interventions in the Vietnam War and Korean War established inter-country connections and facilitated migration to the United States. Sassen (1988) and Golash-Boza (2012) viewed the foreign direct investment (FDI) as an important migration push factor. The number of Mexican students at U.S. institutions increased as the trade between Mexico and the United States increased (Massey et al., 1993; Golash-Boza, 2012).

The implication of world system theory on the present study is that countries that dominate resources, knowledge, and technology stay at the core of the system (Chen & Barnett, 2000; Clotfelter, 2010). Countries with limited educational capabilities and lack of high-tech skills stay at the periphery, and they send their students and scholars to the core countries with the hope that they will return with the knowledge and expertise to improve their home countries' conditions (Chen & Barnett, 2000). This theory can explain the historical change of numbers of Chinese students in the U.S. institutions and why the number of Western-European students (core countries) is smaller in the U.S. institutions than that of Asian students (peripheral countries). This theory can be used to explain migration between countries that are geographically far apart (Yang, 2010).

Another important sociological theory is social network theory (Massey et al., 1993). The social network theory argues that migrants' social networks play a crucial role in international migration (Yang, 2010). It argues that international migration depends not only on individuals' motivation but also on resources, particularly social resources such as the existence of social networks (Yang, 2010). Migrants' social network refers to migrants' interpersonal relationships in origin and destination areas through the connections of their relatives, friends, ethnic communities, and institutions (Massey et al., 1993). Massey et al. (1993) argued that migrant social networks are a form of "social capital," which can be converted into financial capital through higher wages in employment (p.448). Social networks increase the likelihood of migration because they lower the costs and risks of migration and increase the expected return in migration by facilitating flows of information, capital, and job opportunities among those in the network (Massey et al., 1993). This theory can explain the migration processes that are not revealed by quantitative studies alone (Yang, 2010).

In sum, several international migration theories can be applied to explain why foreign doctorate recipients decide to stay in the United States or not. This study utilizes a push-pull framework to explore the factors associated with the foreign doctorate recipients' decisions to stay in the United States at individual, institutional, and country level. Explaining the push-pull factors, this study incorporates the economic perspective to analyze the effect of individual's human capital accumulation and the economic state of home countries on decisions to stay. However, this study has limitations when trying to examine the sociological perspective on foreign doctorate recipients' decisions to stay. This study has no variable to measure the individual's social network, inter-country connections, or political circumstances of the home country in the model. Thus, this study cannot explain the effect of social factors on an individual's migration decision. The sociological perspective may be used as a tool to fill out the caveat that the economic perspective cannot explain at the interpretation stage.

Theoretical rationale for the effect of attending a prestigious higher education institution. To measure adequate brain drain impact, previous literature suggests that the quality of human capital should be considered in the analysis (Mattoo et al., 2008). One of this study's goals is to examine the effect of the quality of human capital on foreign doctorate recipients' migration decision; thus, it is helpful to discuss the theories explaining the effect of attending a prestigious higher education institution in the United States.

The U.S. doctoral education is differentiated and highly stratified (Altbach, 2004a; Bound & Turner, 2010). Among more than 3,000 four-year higher education institutions, only 413 institutions awarded doctorates in 2002, with the median number granting 38 degrees (Bound & Turner, 2010). Prestigious graduate institutions tend to attract above average college graduates, while the less prestigious institutions admit the below average college graduates

(Lang, 1987). Attending a prestigious doctoral program for a foreign student can be viewed as enhancing one's human capital and social capital (Gerber & Cheung, 2008; Krieg, 1991; Zhang, 2005).

According to the human capital theory, education and training are the most important investments in human capital (Becker, 1993). More schooling raises earnings and productivity by providing knowledge and skills (Becker, 1993). Thus, graduate education is an integral part of human capital accumulation (Zhang, 2005). Prestigious programs provide high quality education, and high quality institutions provide better resources for their students' human capital improvement than low quality institutions (Thomas & Zhang, 2005). Inputs such as higher quality of academic faculty (which includes their scholarly output and leadership in professional organizations), a broader range of research opportunities, higher investment per student, a bigger pool of role models, and peer effects by higher ability students can greatly enhance a student's human capital at a faster rate (Bedeian, Cavazos, Hunt, & Jauch, 2010; Thomas & Zhang, 2005). On the other hand, signaling theory argues that schooling does not improve productivity much (Becker, 1993). Rather, a degree from a prestigious institution just sends a "signal" to future employers about a graduate's capabilities (Spence, 1973, p. 358). Signaling theory stresses "credentialism" in that degrees and education signal information about the abilities, persistence, and other traits of graduates (Becker, 1993, p.19).The foreign doctorate recipients in science and engineering fields tend to be educated at the best institutions in their home countries, and they have intensely competed for the limited slots available for their doctoral education in the United States (Stephan & Levin, 2007). Thus, human capital theory implies that foreign doctorate recipients who graduated from prestigious doctoral programs will have significant gains in their

human capital that enhances their employability, which may increase their likelihood of staying in the United States.

In addition, studies of educational outcomes suggest that social capital plays a significant role in the job search process or occupational attainment (Martin, 2009). Social capital is defined as the various "resources embedded in social networks" that can be accessed by social actors (Lin, 2001, p. 25). From the social capital perspective, prestigious higher education institutions serve as important links between the educational system and elite labor market (Useem & Karabel, 1990, cited in Martin, 2009). This suggests that those who attend high quality institutions have a better opportunity to accumulate more valuable social capital in the form of network connections than those who attend low quality institutions (Gerber & Cheng, 2008). Research found that the effect of attending a prestigious undergraduate was larger for black and Hispanic students compared to white students because minority students earned new networking opportunities through college experiences (Dale & Krueger, 2011). In applying social capital theory to the foreign doctorate recipients, attending prestigious institutions may provide informal social ties with highly established faculty and higher ability peer students and influential alumni networks among graduates, which they could not have obtained if they did not attend a prestigious institution. Thus, attending a prestigious program may expand their social networks in the United States, which will increase their employability in the United States.

In sum, both the human capital theory and social capital theory imply that the probability of foreign doctorate recipients' decisions to stay in the United States will be higher for those who attend prestigious institutions. High quality doctoral programs not only enhance their skills, knowledge, and credentials but also provide the doctoral students with social network

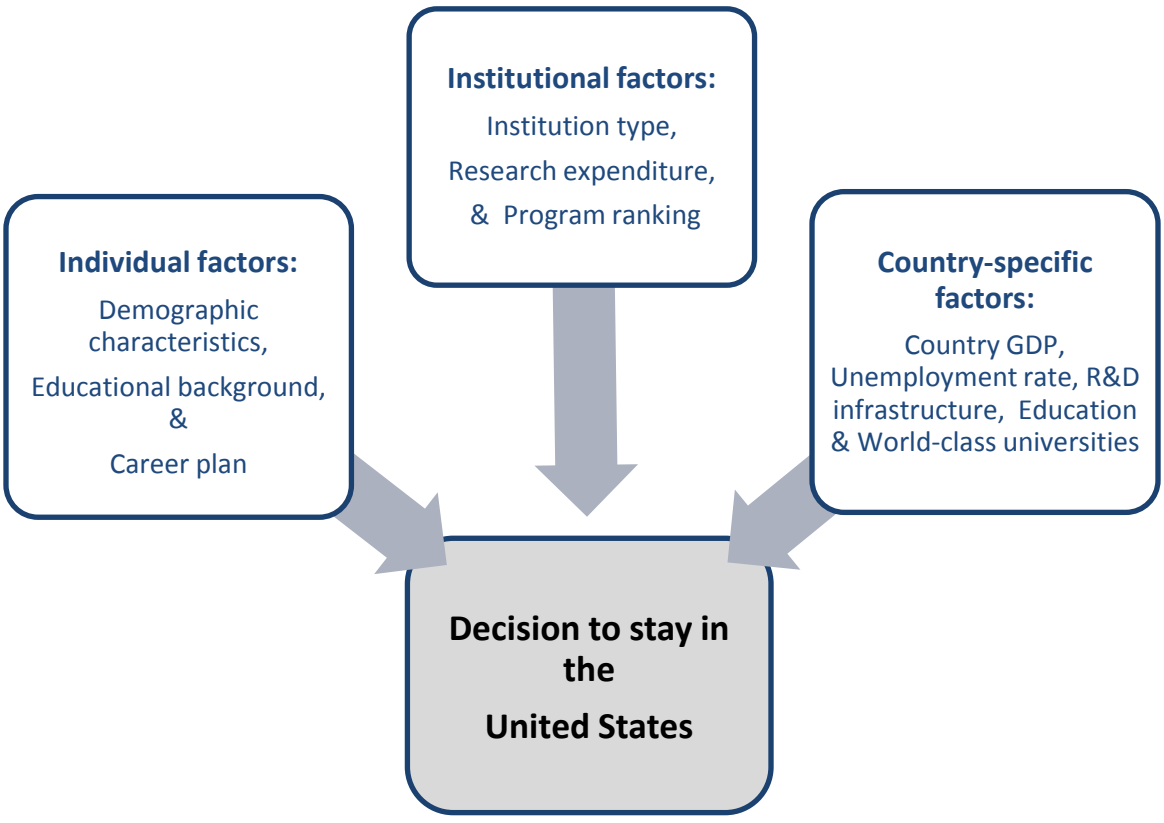
connections that might help them to navigate the U.S. job market, and this positively affects the foreign doctorate recipients' decisions to stay in the United States.

A Conceptual Framework for the Study

This section proposes a conceptual framework used for examining what individual, institutional, and country factors influence the foreign doctorate recipients' decisions to stay in the United States based on an understanding of the theories and previous research.

Figure 1

A Conceptual Framework for Factors Affecting a Foreign Doctorate Recipient's Decision to Stay in the United States



Factors Affecting Foreign Doctorate Recipients' Decisions to Stay in the United States

In this section, I review previous research on factors affecting foreign doctorate recipients' decisions to stay in the United States. The previous studies suggest caveats in the literature and support a need for this study. I categorize previous literature into individual factors, institutional factors, and country factors.

Individual factors. The individual factors include demographic background, educational background, career opportunities, and personal ties. Previous literature shows that individual factors greatly affect the odds that foreign students and scholars will stay.

Demographic factors. Female foreign students tend to have higher odds of staying than male foreign students (Gupta et al., 2003; Kim, Bankart, et al., 2011; Musumba et al., 2011). According to the survey of 493 international graduate students at Texas A&M University (TAMU), female students had a 15% higher odds of preferring to start their career in the United States than males (Musumba et al., 2011). Females found that the level of gender equality is better in the United States than their home countries because of more opportunities for careers, freedom, and technology advancement (Musumba et al., 2011). Marital status has mixed results on the decisions to stay in the United States. One study found that foreign doctorate recipients that stayed in the United States after ten years tended to be younger and were less likely to be married when they completed their PhDs (Gupta et al., 2003). On the other hand, the TAMU survey results showed that married students preferred to stay in the United States more than single students did (Musumba et al., 2011). A survey of 454 U.S. educated doctorates from South Korea revealed that among those who stayed, one-fifth of them chose to stay in the United States because of their children's educational opportunities in the United States (Jin et al., 2006). The age of a foreign doctorate recipient did not significantly predict the decision to stay for in the

2000s, while the odds of staying decreased with age in the 1990s (Black & Stephan, 2007; Kim, Bankart, et al., 2011). This study expands previous studies by examining if the gender effect varies by country of origins.

Educational background factors. Educational background includes undergraduate experiences and doctoral education experiences, such as one's field of study and the funding sources (i.e., TA, RA, scholarship, fellowship, or own). Analyzing the share of U.S. degrees to non-citizen residents from 1985 to 2005, Freeman (2010) suggested that foreign students who had U.S. bachelor's degrees were more likely to continue to study in the United States and eventually remain in the United States to work. However, the author indicated that the data did not confirm whether the relation is causal. He argued that the foreign-born undergraduates could be selectively drawn from a group who would end up working in the United States regardless of where they were educated. Kim et al. (2011) examined the historical trend of stay rates of foreign doctorate recipients in 1980s, 1990s, and 2000s using the SED data. They found that foreign doctorate recipients who attained their bachelor's degrees in the United States were about two times more likely to stay in the United States than those who had foreign bachelor's degrees. The effects of U.S. bachelor's degree on stay rate decreased over time.

Previous research suggests that the field of study affects the variation of stay rate among foreign students. Kim et al. (2011) study reveals the lower stay rates of foreign doctorate recipients in social sciences, agriculture, and education majors compared to science and engineering majors. Results from a Texas A&M University survey also suggest that students in science and engineering majors had a higher odds of preferring to stay in the United States than those in other majors (Musumba et al., 2011). The authors argued that the higher stay propensity of science and engineering majors is attributed to the knowledge of fields. The authors suggested

knowledge can be categorized into "global" knowledge and "local" knowledge (p.513). Global knowledge is associated with newer high–technology production methods, and the return of utilizing global knowledge is much greater in a developed country than a less-developed country (Musumba et al., 2011). Thus, foreign students in science and engineering, which fall into the global knowledge category, are more likely to stay in the United States because the return of their investment is greater in the United States compared to the return in their home countries (Musumba et al., 2011). On the other hand, students with an education major or agriculture major are more likely to return home because the knowledge in these fields is more local than global.

Research found that how foreign doctorate recipients were financially supported during their study significantly affected their decisions to stay in the United States (Gupta et al., 2003; Kim, Bankart, et al., 2011; Musumba et al., 2011). Studies found that those who did not stay in the United States tend to be funded by their home countries such as their national governments, their employers, their families, or self-supported (Gupta et al., 2003; Musumba et al., 2011). Those who stayed in the United States had financed their doctoral education primarily by teaching assistantships and research assistantships. Kim et al. (2011) suggested that research assistantship experience may enhance foreign doctorate recipients' research capabilities and increase their opportunities to stay in the United States.

Recognizing the importance of educational experiences on forming one's human capital, this study further examines the effect of bachelor's degree on the foreign doctorate recipients' decision to stay in the United States. Among foreign bachelor's degree holders, this study examines if and how the selectivity of bachelor's degree in their home countries affects the migration decision.

Career factors. Career factors include job opportunities after graduation, future career plans whether working in academia or in industry, and working at postdoctoral positions. Previous literature indicates that career factors related to their job opportunities can be both push and pull factors for foreign doctorate recipients to stay in the United States (Franzoni, Scellato, & Stephan, 2012; Gupta et al., 2003). Survey results from 185 international graduate students at the University of Minnesota found that career-related factors affect strong pull and pull factors for international students regarding their decisions to stay in the United States (Hazen & Alberts, 2006). According to the survey, the most important reasons to stay in the United States were "better career opportunities" (64%), and "greater academic freedom" (29%) (Hazen & Alberts, 2006, p.207). On the other hand, the home country's career perspectives pushed them to stay in the United States. Students were concerned about "poor job opportunities" (50%) and "restricted career structures" (30%) on returning to their home countries (Hazen & Alberts, 2006, p.205). A study of the mobility of foreign born scientists from 16 countries revealed that the most likely reason to come to a foreign country for study or work was professional (Franzoni et al., 2012). Researchers surveyed 17,192 scientists working abroad in 16 countries. They found no variation across country in response. The "opportunity to improve my future career prospects" and the presence of "outstanding research team" proved the most important reasons for immigration (Franzoni et al., 2012, p. 9). "Prestige of the foreign institutions" and "extension of my network of international relationships" were in third place. They also reported that whether or not they returned in the future would depend in part on job market conditions of their home countries (Franzoni et al., 2012).

Recent surveys on U.S. doctoral recipients showed that new doctoral recipients with temporary visas were more likely to report having a position in industry than in academia

compared to U.S. native doctoral recipients when they stayed in the United States (Wendler et al., 2010). In 2006, only 17% of U.S. native doctorates across all fields reported their job commitment to be in industry, while among those with temporary visas, this number was 55% (Wendler et al., 2010). Gupta et al. (2003) found that when comparing the career paths between returners and stayers of U.S. foreign doctorate recipients in biochemistry, computer science, and electrical engineering majors, returners were much more likely to be in academia than those who stayed in the United States. They found that returners were less likely to consider higher salary or career ambitions compared to those who stayed in the United States.

Increasing postdoctoral positions in the United States also affects the odds of staying of foreign doctorate recipients (Kim, Bankart, et al., 2011). Postdoctoral positions have been a common career path for the doctorate recipients who are in life sciences and physical sciences (NSF, 2010). Many students take postdoctoral positions immediately after graduation (NSF, 2010). Finn (2010) suggested that increasing postdoctoral positions explains why the number of foreign doctorate recipients in science and engineering fields who had spent at least one year after graduation is about three times as large as the number who spent at least five years in the United States.

In sum, previous research indicates that those who highly value better job opportunities, including high salaries, tend to stay in the United States. This study further examines whether the foreign doctorate recipients' future career plans influence their decisions to stay in the United States. In particular, this study examines those who plan to work in industry versus academia.

Personal factors. Personal factors include family and friend ties and cultural values draw foreign doctorate recipients back to their home countries. A study called "PhDs – 10 Years Later" funded by Mellon Foundation surveyed 6,000 international PhD recipients who completed

their doctoral degrees between 1982 and 1985 in six fields: biochemistry, computer sciences, electrical engineering, English, mathematics, and political science (Gupta et al., 2003). In the sample, four-fifths of Japanese and two-thirds of South Koreans left the United States for their first post PhD jobs. Analyzing the returners, the authors concluded that those who returned home countries were pulled by their strong ties to cultural values, preferences, friends, families, or personal values such as the desire to contribute to their nation (Gupta et al., 2003). Research on U.S doctorate recipients who returned to South Korea showed similar findings. After in-depth interviews with 12 faculty members, Lee and Kim (2010) found that while the political economy might help predicting why they study in the United States, it did not fully explain why they returned home countries. Cultural familiarity and reuniting with family members were important reasons for the returners, despite not securing immediate employment (Lee & Kim, 2010). Moreover, survey results from 185 international graduate students at the University of Minnesota also suggested that the most popular reason to return home countries was "friends and family ties" (78%), followed by "feeling comfortable" (44%) (Hazen & Alberts, 2006, p.212).

Though previous research indicates that personal values such as family, friends, and home country pull the foreign doctorate recipients' decision to return home countries, this study cannot control for these personal factors associated with their migration decision. This study does not have adequate data available to measure and control for the personal factors, which indicates a limitation for this study.

Institutional factors. In this study, the institutional factors are defined as the effect of one's doctoral institutions on foreign doctorate recipients' decisions to stay in the United States. In particular, this study is interested in whether attending a prestigious doctoral institution influences foreign doctorate recipients' decisions to stay in the United States. In 2010, the

National Research Council's *A Data-Based Assessment of Research Doctorate Programs in the United States* (NRC 2010) measured the quality of U.S. doctoral education. The study collected the data during 2005-2006 academic year from 5,000 programs at 212 institutions. MIT, Harvard, Stanford, and University of California Berkeley tend to have top ranked programs over the years (Jaschik, 2010). Some argued that graduates from prestigious institutions were less likely to stay in the United States, while others revealed the reverse direction (Black & Stephan, 2007; Bound & Turner, 2010; Finn, 2010).

Institutional quality on decision to stay in the United States. Finn (2010) defined the doctoral program quality in terms of the research reputation of the faculty: he found lower stay rates of foreign doctorate recipients from higher quality institutions in 2007. He assumed that graduating from a highly ranked program increases the likelihood of receiving attractive job offers. He found that foreign doctorate recipients from the top twenty to twenty-five rated graduate programs have a lower stay rate in the United States compared to those from other programs. According to his calculation, the 5-year stay rate among top-rated program graduates was 58%, while that of all other programs was 63%. He used the top fifteen ranked programs so labeled by the 1993 National Research Council study and the top twenty ranked programs labeled by the *2008 U.S. News and World Report*. He suggested that the lower stay rate for graduates from highly ranked programs is attributed to the countries of origin (Finn, 2010). That is, international students from lower stay rate countries graduated from the top-rated programs. Bound and Turner's (2010) analysis supported Finn's (2010) argument. They analyzed the PhD recipient data from four fields, chemistry, biochemistry, physics, and engineering, during 1955 to 2005. They found that the number of PhD recipients from higher stay rate countries, China, South Korea, and Taiwan, is underrepresented in the top five programs. According to Bound and

Turner's (2010) analysis, East Asian students who tend to stay in the United States after graduation are much less likely to receive their doctoral degrees from the top five programs than PhD recipients from the United States in these fields.

A study on U.S. science and engineering PhDs who earned their degrees during 1997 to 1999 and were employed in industry suggested a similar finding. Sumell, Stephan, and Adams (2009) suggested that top quality U.S. PhD programs produce graduates who will leave the local area. They found that graduates from top-rated doctoral programs are more likely to move out of the state where the doctoral institution is located. They found that graduates from engineering, biology, chemistry, math, and medicine at a program rated in the top ten by the 1993 National Research Council study are significantly more likely to leave those states than those who were not at a top program. They also found that graduates who were supported on a fellowship or dissertation grants are more likely to leave the state. Sumell et al. (2009) suggested that job placement outside of the local area is an indication of the success of a program, signaling that the institution has the connections and a reputation to support more distance job placement.

On the other hand, Black and Stephan (2007) found that if the foreign doctorate recipients studied at top ten PhD programs, they are more likely to intend to stay in the United States after graduation. They analyzed the intentions to stay in the United States among PhD recipients holding temporary residents during 1981 to 1999 in science and engineering fields from SED data. They defined the top ten programs according to the rankings from 1993 National Research Council study. They found that the number of temporary residents in top programs remained constant for most of the 1990s despite the fact the overall number of foreign doctorate recipients increased. They also revealed that foreign doctorate recipients from top engineering program and top biology programs are more likely to intend to stay than those from non-top ten

programs in these fields. They suggested that a foreign-born person who works in the United States represents a highly selective group because the U.S. market demand is higher for PhDs from higher quality programs; however, they also suggested that a student from a country with a strong scientific infrastructure would be less likely to stay in the United States given the likelihood of adequate opportunities in that student's home country. They suggested that changes in demand for PhDs in the United States as well as in the home county need to be included in future studies.

In sum, previous literature shows that attending a prestigious doctoral institution has a significant impact on one's decision to stay in the United States; however, the directions of impacts were inconsistent. This study uses yearly ranking of *U.S. News and World Report* instead of the 1993 National Research Council study to reflect the changes of doctoral program quality that may have occurred during the study period that previous research did not take into account. By using yearly ranking data, this study can match the doctoral institution quality to their graduates more accurately. Moreover, this study examines the foreign doctorate recipients from 2000 to 2010; thus, this reveals the prestigious degree effect on most recent doctorate recipients' decisions to stay in the United States.

Prestigious degree effect on labor market. The relationship between the doctoral institution quality and the decision to stay in the United States should be understood in the context of the effect of prestigious degree on labor market. The foreign doctorate recipients' decisions to stay is affected by their employability in the United States and the home countries (Black & Stephan, 2007), and the prestige of a doctoral degree can affect the employability in the United States and the home countries.

Previous research has examined the prestige effect of undergraduate education and found that college quality can have effects on graduates' lives in many ways, including on their educational attainment, earnings, family formation, and basic life satisfaction (Black & Smith, 2006; Brewer et al., 1999; Long, 2008). For example, attending a selective undergraduate institution is strongly correlated to attending a prestigious graduate and professional school (Lang, 1987; Zhang, 2005). On the other hand, prior research on the effects of a prestigious degree on earnings shows mixed results. Previous literature suggests that students who graduated from a highly prestigious college generally have higher earnings (Black & Smith, 2006; Hoekstra, 2009; Long, 2008; Thomas & Zhang, 2005). Using the National Longitudinal Study of the High School Class of 1972 data, Eide et al. (1998) estimated the effects of college quality on earnings and found that a larger premium occurred from attending an elite private college, and the premium increased over time. However, they found a weaker return effect from attending an elite public university. Thomas and Zhang (2005) also found that the effect of college quality increased the graduates' earnings in their early period of career. The return was greater for engineering and mathematics majors compared to education majors. Hoeskstra (2009) suggested that attending a flagship state university resulted in 20% higher earnings five to ten years after graduation; however, the higher earning effect was significant only for white males. Analyzing the earning gains from the graduates of MBA (Masters of Business Administration) programs between 1990 and 1998, Grove and Hussey (2011) found that attending a top ten business school meant higher earnings, but the premium disappeared when a student attended a lower ranked program. They suggested that individuals with higher ability tended to attend the most elite programs (Grove & Hussey, 2011).

On the other hand, one study found that there was no statistically significant relationship between attending a college ranked in the top tier by *U.S. News and World Report* and the wage earned (Owings-Edwards, 2011). Dale and Krueger (2011) also argued that the prestige of a college was not significant in predicting the higher earnings after adjusting observable (i.e., GPA and SAT scores) and unobservable (i.e., motivation and ambition) characteristics. However, the return of attending a prestigious college was significantly large for black and Hispanic students who came from low SES families due to the enhanced networking opportunities (Dale & Krueger, 2011). One study found that institutional variables such as college selectivity or institutional type had an insignificant effect on higher earnings, while college major was a strong predictor on higher earnings (Wolniak, Seifert, Reed, & Pascarella, 2008). College majors such as engineering, mathematics, and computer sciences had a strong impact on higher earnings (Wolniak et al., 2008).

Studies of the effects of prestige of doctoral programs examined the job placement of their graduates. Fogarty and Saftner (1993) defined the academic prestige as "the academic department's ability to place its doctoral recipients" (p.427). An empirical analysis of faculty placements showed that departments recruit graduates from the most prestigious programs (i.e., top twenty programs) while the prestige of candidates moved downward on the faculty market (Fogarty & Saftner, 1993; Fogarty, Saftner, & Hasselback, 2012). They found that the better research environment provided by the institutions is differentially valued by the other programs (Fogarty & Saftner, 1993; Fogarty et al., 2012). Bedeian et al. (2010) also analyzed 171 PhD holders in management and confirmed the link between the department prestige and graduate student placement. They found that those who graduated from highly ranked doctoral programs obtained more prestigious initial academic appointments. Highly ranked doctoral programs are

known for the quality of their faculty members' scholarly work and their leadership in professional organizations (Bedeian et al., 2010). They suggested that individuals who obtained more prestigious initial academic appointments hold more prestigious academic appointment later in their later career.

In sum, although no research focused on the effect of prestige of a doctoral degree among foreign doctorate recipients on labor market, previous research on U.S. students suggests that the prestige of a doctoral degree has a significant effect on foreign doctorate recipients' employability, which may affect their decisions to stay in the United States.

Country-specific factors. Country-specific factors include wage differences among countries, research infrastructure of home countries, and visa and immigration policies of the United States. Previous research suggests that the country of origin plays a significant role predicting foreign doctorate recipients' decisions to stay in the United States (Black & Stephan, 2007; Finn, 2010; Kim, Bankart, et al., 2011). Finn (2010) found that the different stay rates among countries continued for a long time. Students from China, India, Russia, Iran, and Yugoslavia had higher stay rates (Finn, 2010). Kim et al. (2011) revealed that stay rates of students from China, South Korea, and Canada significantly increased from 1980s to 2000s. Among the top 10 sending countries, students from China and India were the most likely to stay in the United States after they graduated, while those from Taiwan and South Korea had significantly lower stay rates (Kim, Bankart, et al., 2011). The stay rates were lowest for students from Brazil and Mexico among the top ten sending countries (Kim, Bankart, et al., 2011).

Economic factors. Foreign doctorate recipients have a high propensity to remain in the United States, at least for the early stage of their careers, because most of them can earn higher wages compared to their home countries (Bratsberg et al., 2002). According to the equilibrium

theory, wage differences among countries trigger international migration (de Haas, 2010). Many studies used GDP (gross domestic product) as a proxy for the income differences among countries (Bratsberg, 1995; Bratsberg et al., 2002; Grossmann & Stadelmann, 2008; Johnson, 2001; Mattoo et al., 2008; Song, 1997). GDP is the market value of goods and services produced within a country (National Science Board, 2012). It is one of the main measures in the national income and product accounts (NSB, 2012, p.4-56). An empirical analysis of 69 countries showed that the variation in stay rates of foreign students in the United States is explained by differences in economic and political conditions of their home countries (Bratsberg, 1995). He found that students tend to return to rich and close countries and to countries that value their investment in education highly (Bratsberg, 1995). Finn's (2010) findings on the lower stay rates of students from high income countries also confirms that economic factors are crucial in whether or not foreign doctorate recipients decide to stay in the United States. Finn (2010) suggested that high income countries have well-established research universities as well as extensive research and development employment in industry in their home countries, and these jobs can pay high salaries. Thus, the lower stay rate indicates that students from high income countries have less economic incentives to stay in the United States. Analyzing the migration flow of highly skilled workers in 77 countries, researchers found that a higher income difference between host countries and sending countries accelerated a "higher emigration rate" (Grossmann & Stadelmann, 2008, p.18). Researchers compared the median of log GDP per capita of 1990 and 2000 among countries and found that when the income gap is higher between the host country and the sending country, the domestic economy of the sending country accelerated the emigration of highly skilled worker (Grossmann & Stadelmann, 2008).

Examining the flow of U.S. educated scientists and engineers from South Korea and Taiwan, Johnson (2002) argued that South Korea and Taiwan were successful in reversing the flow of brain drain due to new economic opportunities in their home countries. Johnson (2002) pointed out that both countries were able to create high-paying jobs in high-tech industry for expatriate scientists and engineers. Analyzing the historical trend of return rate of U.S. educated South Korean scientists and engineers, Song (1997) also found that an improving South Korean economy prompted its scientists and engineers to return there. He found that while the background of South Korean scientists and engineers who received their U.S. doctoral degrees in the 1960s was similar to that of the 1980s cohort, the return rate to South Korea changed. Apart from personal reasons, the most important factor that affected the choice was the difference in economic conditions between the United States and South Korea at the time when the person made the decision (Song, 1997). Song (1997) suggested that GDP per capita, the entry level income ratio between South Korea and the United States, and the number of R&D personnel per 1,000 South Koreans was associated with the decision of doctoral students to return to South Korea. For example, in his sample, he found that the return probability of South Korean science and engineers to South Korea was 1% among 1963 PhD graduates, while the number increased to 19% among 1983 PhD graduates. In 1960, the United States income was ten times higher than income in South Korea, while in 1988, the income gap narrowed to two times. He suggested that GDP, R&D share of GDP, and total amount of R&D investment might indicate the economic situation for science and technology activities, too (Song, 1997, p.297). Johnson (2001) also confirmed that foreign doctorate recipients' decisions to stay in the United States appears to be strongly affected by conditions in the students' home countries, primarily the unemployment rates, the percentage of the labor force that works in agriculture, and the GDP per capita

(Johnson, 2001). However, Regets (2001) pointed out that the unemployment rate can be a poor measure of labor market conditions for foreign doctorate recipients because highly-skilled workers are usually more employable than average workers.

This study examines how the foreign doctorate recipients' decisions to stay in the United States respond to the economic conditions of home countries. Previous research implies that economic factors play a significant role in the foreign doctorate recipients' decisions to stay in the United States. Most doctorate recipients from South Korea stayed in the United States after their graduation when South Korea was a low-income country (Kim, 2010). However, when South Korea began to recruit the talented expatriates to promote economic growth during 1970s and the development of higher education sector and the career prospects of the returnees improved, the return rate of South Korean doctorates increased (Song, 1997). This indicates that foreign doctorate recipients from China and India might start to return to their home countries on a larger scale when the economic conditions of their home countries become more amenable to them (Kim, 2010). Bratsberg (1995) argued that foreign students tend to go home countries when their investment in higher education (in this case, a prestigious doctoral degree from a U.S. institution) is highly valued in their home countries.

Non-economic factors. Research found that the physical distance between the United States and the home countries affected the migration pattern, but the effect was not large (Bratsberg, 1995). Distance represented both monetary and psychological migration costs (Bratsberg, 1995). The restricted visas or the change of immigrant policy affected the composition of students coming to the United States (Chellaraj et al., 2008; Musumba et al., 2011). For example, the Chinese Student Protection Act of 1992 made thousands of Chinese students enrolled in U.S. higher education institutions eligible for permanent residence on July 1,

1993 in response to the Tiananmen Square uprising in 1989 (National Academy of Sciences, 2005). Analyzing the visa classes issued among foreign students in 2003, a clear regional difference is found (National Academy of Sciences, 2005), which can affect the stay rate that occurred after they graduated. European countries send more J-class (exchange visitors) while Asian countries send more F-class (student visitors) (National Academy of Sciences, 2005). For J visas, a consular official determines the person's eligibility for a 2-year foreign residence requirement (National Academy of Sciences, 2005). F-class visas include high school students, college students, and graduate school students. J-class visas include graduate students, postdoctoral scholars, and short-term faculty visitors (National Academy of Sciences, 2005). The changes in visa and immigration policies since the September 11 terrorist attacks have negatively affected the visa application process for international graduate students (National Academy of Sciences, 2005). A steep decline in visa issuances began in 2001, and it negatively affected the number of students from China, Pakistan, and Saudi Arabia in 2003 according to the Institute of International Education (Institute of International Education, 2011).

While previous research suggests that the change of U.S. visa and immigration policies significantly affects the stay rate and pattern of foreign doctorate recipients, this study does not have variables accounting for the impact of immigration policies on foreign doctorate recipients' decisions to stay in the United States. After the September 11 attacks in 2001, U.S. visa and immigration policies toward foreign students changed in many ways, emphasizing the national security issues (Black & Stephan, 2007). Since the time period of this study includes the time after September 11 attacks, the results should be interpreted with this limitation.

In sum, this chapter has provided a review of literature with regard to foreign doctorate recipients' decisions to stay in the United States. I also presented a conceptual framework upon

which this study is based. This conceptual framework involves individual, institutional, and country factors found to be related with foreign doctorate recipients' decisions to stay in the United States. Based on the conceptual framework, the next chapter discusses the data and variables as well as statistical methods used for this study.

Chapter III

Research Methodology

In this chapter, I present research methodology that was conducted to examine the factors predicting foreign doctorate recipients' staying in the United States during 2000 to 2010. First, I present data sources and sample of this study. Then, I discuss the dependent variable and independent variables that were used to explore the research questions. The independent variables include individual, institutional, and country variables. Last, I present the analytic methods including model specifications, data analysis process, and limitations of this study.

Data Sources and Sample

This study primarily used data from the Survey of Earned Doctorates (SED: 2010) administered by the National Center for Science and Engineering Statistics (NCSES), formerly the Science Resources Statistics (SRS) Division of the National Science Foundation (NSF) (National Science Foundation, 2011). This annual survey collects information on an individual's education, characteristics, and post-graduation plans, and it is widely used to assess trends in U.S. doctoral education and degrees (NSF, 2011). The SED is a census of all individuals receiving a research doctorate from accredited U.S. academic institutions (NSF, 2011). According to the NSF (2011), a research doctorate is defined as a degree that requires the completion of an original intellectual contribution in the form of a dissertation or an equivalent project of work and is not intended as a degree for the practice of a profession (NSF, 2011). Thus, the most common research doctorate degree in the SED is the PhD because the survey does not include the recipients of professional doctoral degree such as MD, DDS, JD, and DPharm (NSF, 2011). In the 2010 SED dataset, the most recent doctorate recipients included in the dataset were all individuals receiving a research doctorate from a U.S. academic institution in the 12 month

period ending June 30, 2010 (NSF, 2011). This study focused on the doctorate recipients who earned their doctoral degrees in the time period from 2000 to 2010. This study used restricted individual data made available through a license with the NCSES, NSF. This study sample was restricted to doctorate recipients who reported a non-U.S. temporary resident status (CITIZ=3) when they earned their doctoral degrees during 2000 to 2010. The total number of doctorate recipients with a temporary visa status in SED was 131,950 during the years 2000 to 2010 (N=131,950).

This study used additional datasets to construct the institutional variables. First, institutional data from the Integrated Postsecondary Education Data System (IPEDS) were incorporated to the SED dataset. IPEDS is a system of surveys conducted annually by the U.S. Department of Education's National Center for Education Statistics (National Center for Education Statistics, 2012). IPEDS gathers institutional information from higher education institutions that participate in any federal student financial aid program authorized by Title IV of the Higher Education Act of 1965 (NCES, 2012). More than 7,500 institutions complete IPEDS surveys every year (NCES, 2012). I obtained the dataset from IPEDS Data Center that is open to the public. The doctorate granting institutions in SED data use the same institution identification numbers as used in the IPEDS data; thus, I merged two datasets based on the institution identification numbers. I used institutional data from IPEDS, such as the type of institution and total research expenditure variables. The total research expenditure was drawn from 1993 to 2007 to represent the first-year effect in a doctoral institution. The time period 1993 to 2007 was the entry year of the PhD program among this study sample for those students who earned their degrees from 2000 to 2010.

In addition to this data, the institutional variable that indicated the quality of a doctoral program was added to the SED dataset. I used the annual rankings of *America's Best Graduate Schools* published by the *U.S. News and World Report* (USNWR) from 2000 to 2010. I linked the doctoral institution variable in the SED data to the USNWR ranking of institution by academic programs. The ranking year represented the time when the data were released by the *U.S. News and World Report*, and the ranking year was matched to the graduation year of the PhD, because this indicates the terminal degree institution of a doctoral recipient. USNWR published the annual ranking of academic programs; however, USNWR does not rank them annually except for engineering programs. While engineering programs were ranked yearly with a combination of statistical measures regarding the quality of school's students and faculty and the peer assessment scores from 2000 to 2010, other PhD programs in this study sample were ranked solely on the peer assessment scores for 4 times during 2000 to 2010 (USNWR, 2012). For example, biological science was ranked in 2002, 2006, 2007 and 2010 during 2000 to 2010 time period. Thus, I used 1999 values for 2000 and 2001 rankings; 2002 values for 2002, 2003, 2004 and 2005 rankings; 2006 values for 2006 rankings; 2007 values for 2007, 2008 and 2009 rankings; and 2010 values for 2010 ranking of biological science PhD program. As for the peer assessment, deans, program directors, and senior faculty were asked to judge the quality of schools in their field on a 1 (marginal) to 5 (outstanding) scales (USNWR, 2012). Ehrenberg (2003) argued that some administrators in higher education institutions chose not to participate in USNWR survey because they questioned the value of this survey, while other administrators participated in order to rate their peer schools lower than their reputation would deserve. Despite the criticism on rater bias and halo effect, school reputation and prestige do affect defining the quality in graduate education (Astin, 1985; Morphew & Swanson, 2011), and the USNWR

rankings have persisted in quantifying such reputation and prestige (Sweitzer & Volkwein, 2009).

In order to investigate the home country's push and pull factors on foreign doctorate recipients, country-specific variables from 2000 to 2010 were added to the SED dataset. The country variables were matched to the graduation year of PhDs because this was the time when they decided whether or not to stay in the United States. I chose 20 countries that sent their doctoral students to the United States from 2000 to 2010. The 20 countries included were China, India, South Korea, Taiwan, Canada, Turkey, Thailand, Japan, Mexico, Germany, Russia, Brazil, Romania, Italy, Greece, Egypt, Argentina, Spain, Iran, and the United Kingdom. These top 20 sending countries consisted of 79% of the total number of foreign doctorate recipients during 2000 to 2010. Thus, the sample size decreased from 131,950 to 104,537 cases. The top 10 sending countries remained constant during 2000 to 2010. Particularly, the top 4 sending countries, which were China, India, South Korea, and Taiwan, constituted more than half (54%) of the total number of foreign doctorate recipients during the study period. I used publicly available databases from the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics, International Labor Organization (ILO), World Bank, and the Academic Ranking of World Universities (ARWU). Since Taiwan was not a member of the United Nation in 1971, Taiwan data were not found in the databases from the United Nations. Thus, Taiwan data were derived from the IMD (International Institute for Management Development) World Competitiveness Yearbook Online. The country variables included GDP (gross domestic product) per capita centered on U.S.'s GDP per capita, unemployment rate, the percentage of total expenditures for research and development by the GDP per capita, the public

expenditure on education per capita, and the number of research universities in one's home country per capita.

The final sample size decreased to 69,593 cases when eight academic fields were selected from doctorate recipients in the top 20 sending countries during 2000 to 2010 period. The academic fields were agricultural sciences, biological/biomedical sciences, computer and information sciences, engineering, mathematics, chemistry, physics and economics. Engineering had the largest number of foreign doctorate recipients (n=29,352), followed by biological/biomedical sciences (n=13,460).

Research Variables

Dependent variable. The dependent variable was a dichotomous variable indicating whether or not the foreign doctorate recipients intended to stay in the United States after receiving their doctoral degree. This study used variable PDUSFOR in the SED dataset, which indicated the post-graduation location (1 = U.S. location, 0 = non-U.S. location).The data were collected from two SED questionnaires: 1) In what country or state do you intend to live after graduation within the next year? and 2) Please name the organization and geographic location where you will work or study (NSF, 2011). If the value was missing from the first question, the value was taken from the second question (NSF, 2011). This variable represented the first-year stay after graduation including the postdoctoral training in the United States (NSF, 2011). According to the study sample, 53% of foreign doctorate recipients intended to take postdoctoral training, and among them, 86% received appointments in the United States. Thus, due to the foreign doctorate recipients who took postdoctoral positions in the United States, the number of foreign doctorate recipients who stayed in the United States is overestimated because those who took postdoctoral positions might go back to their home countries after the training. Finn (2010)

found that among science and engineering majors, the first-year stay rate was three times higher than the fifth-year stay rate.

Independent variables. This study included a comprehensive set of independent variables that might explain foreign doctorate recipients' decisions to stay in the United States. The independent variables in the model consisted of individual, institutional, and country variables that might influence an individual's decision. In addition, this study included a series of dummy variables for each year of the PhDs awarded from 2000 to 2010, every PhD institution that produced foreign doctorate recipients, and the 20 countries of origin in this study sample in order to control for fixed effects that might influence foreign doctorate recipients' decisions to stay in the United States.

Individual independent variables. The individual variables were drawn from the SED data. Individual's demographic variables included gender, age, marital status, presence of children, and parental education. Previous studies revealed that females were consistently more likely to stay in the United States (Gupta et al., 2003; Kim, Bankart, et al., 2011; Musumba et al., 2011), while the effect of age, marital status, and presence of children had inconsistent results depending on the study of samples on foreign doctorate recipients' decisions to stay in the United States (Black & Stephan, 2007; Gupta et al, 2003; Jin et al., 2006; Kim, Bankart, et al., 2011; Musumba et al., 2011). Parental education was positively associated with the likelihood of foreign doctorate recipients staying in the United States (Kim, Bankart, et al., 2011). This study explored whether the gender effect varied by the country of origins.

An individual's educational experiences were essential to form one's human capital (Becker, 1993), and the individual's variation in human capital might influence decisions to stay in the United States (de Haas, 2008). A group of variables included in individuals' educational

background category were whether or not a foreign doctorate recipient earned a bachelor's degree from a U.S. institution, if one's undergraduate institution was selective in their home country among foreign bachelor's degree holders, the broad field of doctoral study program, the time to degree for their doctoral degree, and the primary funding source for their doctoral degree (i.e., teaching assistantship, research assistantship, scholarship, fellowship, grant, foreign government, own, or loan). Research found that having earned one's bachelor's degree from a U.S. institution increased the likelihood of staying in the United States after earning a doctoral degree compared to those who had a foreign bachelor's degree (Black & Stephan, 2007; Freeman, 2010; Kim, Bankart, et al., 2011). Among the foreign bachelor's degree holders, the selectivity of a bachelor's degree in their home country is related to human capital and may influence decisions to stay in the United States. A high level of human capital might increase an employment opportunity in the United States. In this study, the selectivity of an undergraduate institution was defined as a top 5 ranked higher education institution in one's home country as Bound and Turner (2010) defined highly selective doctoral programs as top 5 ranked programs by National Research Council 1995. This study used the data from the Academic Ranking of World Universities 2012 (ARWU) published by Shanghai Jiao Tong University, China. ARWU is the oldest and most frequently cited ranking of world's leading universities (Clotfelter, 2010). For example, the foreign doctorate recipients from the United Kingdom who received a bachelor's degree from University of Cambridge; University of Oxford; University College London; the Imperial College of Science, Technology, and Medicine; and the University of Manchester were categorized as having received selective bachelor's degree from their home country. If a country did not have top 5 ranked institution on the top 500 list from ARWU, the

list of 200 foreign undergraduate institutions that produced most of the U.S. doctoral degrees was used as an alternative.

Previous research found that field of study and the primary source of funding for doctoral study significantly affected the foreign doctorate recipient's decision to stay in the United States (Black & Stephan, 2007; Gupta et al., 2003; Kim, Bankart, et al., 2011; Musumba et al., 2011; NSF, 2010). NSF (2010) suggested that the stay rates of foreign doctorate recipients greatly varied by the field of study. The fact that those who majored science and engineering fields had a higher probability of staying in the United State than those who majored in non-science and engineering fields (Kim, Bankart, et al., 2011) suggests that work permits for temporary visa holders are more easily obtained for science and engineering fields than in other fields (Black & Stephan, 2007). This study examined the fields where foreign doctorate recipients received the most degrees: agricultural sciences, biological and biomedical sciences, computer and information sciences, mathematics, physics, chemistry, engineering, and economics. In addition, support from a research assistantship during the study increased their likelihood of staying in the United States (Kim, Bankart, et al., 2011), while support from their home countries decreased their likelihood of staying in the United States (Gupta et al., 2003; Musumba et al., 2011).

The career plan after graduation variable was also included in the model because whether a doctorate recipient was employed in academia or industry might influence the foreign doctorate recipient's decision to stay in the United States. I used variable PDEMPLOY in the SED dataset. The variable was measured by a principal employment type (including postdoctoral training) in the next year; thus, there were some logical skips for those students who did not have employment plans yet at the time of the survey (NSF, 2011). Previous research found that returners were more likely to work in academia than those who stayed in the United States

(Gupta et al., 2003). Thus, this study tested whether the foreign doctorate recipients who began working in industry were more likely to stay in the United States. In addition, in order to capture the effect of time, a series of year dummy variables for each year when the degree was awarded from 2000 to 2010 was included in the model (Reference:2000). Each year dummy indicated changes in foreign doctorate recipients' decisions to stay over time, and this model showed how odds of staying in each year differed from that of the reference year, 2000.

Institutional independent variables. In this study, institutional variables were related to the quality of the doctoral education that the foreign doctorate recipients have received in the United States, which might affect the level of one's human capital. The different level of human capital might influence the foreign doctorate recipients' decisions to stay in the United States (de Haas, 2008). Previous research suggests that foreign doctorate recipients from prestigious programs were less likely to stay in the United States (Bound & Turner, 2010; Finn, 2010), while other research revealed that foreign doctorate recipients from prestigious programs tended to be more likely to stay in the United States (Black & Stephan, 2007).

The variables included the characteristics of doctoral institutions such as institutional control (public versus private), the 2010 Basic Carnegie Classification of the doctorate-granting institutions (i.e., very high research activity, high research activity, doctoral, and others), institutional research expenditures, and the rankings of graduate programs by academic fields. The National Research Council (1995) suggests that "talented faculty," "well-prepared graduate students," and "sufficient institutional resources" construct the prestige of a doctoral program (p.2). The research expenditure variable was defined as the "total expenses associated with activities producing research outcomes, and this includes institutes and research centers and individual and project research" (IPEDS Data Center, 2012). The data were drawn from IPEDS

variables: B023 (1993-1996, Public 1997- 2003), F1C021 (Public, 2004-2007), F2B02_1 (Private, 1997-2002), and F2E021 (Private 2003-2007). The institutional categories in the 2010 Basic Carnegie Classification were determined by levels of doctoral degrees awarded, fields in which degrees were conferred, enrollment, and level of research activity including R&D expenditures (Carnegie Foundation, 2012; National Science Foundation, 2011).

The doctoral program ranking variable was also drawn from the graduate school and program rankings by academic fields. The data were published by the *U.S. News and World Report* (USNWR) from 2000 to 2010. The ranking variable indicated the prestige of a doctoral degree. For example, the ranking of engineering program was calculated based on the indicators of peer assessment score (survey), student selectivity (mean GRE scores and acceptance rate), faculty resources (student to faculty ratio, percent of faculty in the National Academy of Sciences, and the number of PhDs awarded), and research activity (total research expenditure) (USNWR, 2012). However, other programs in this study sample were ranked only by the reputation of PhD program. USNWR used the peer assessment scores of survey to rank the science PhD programs and social science PhD programs (USNWR, 2012).

Research suggests reputation of an organization is considered a "soft" criterion, but it is actually a "hard" asset that does not change over time (Morphew & Swanson, 2011, p.192). Analyzing the USNWR ranking, only 29 institutions appeared in the top 25 lists between 1988 and 1998, and 20 institutions were on the top 25 lists during 10 years (Morphew & Swanson, 2011). This result indicates that it is hard for an institution outside the top 25 to join the "elite group" (Morphew & Swanson, 2011, p.190). This study defined a prestigious doctoral program as an institution ranked on the top 25 lists by USNWR, as Morphew and Swanson (2011) referred to them as an "elite group" in academic fields (p.190). This study examined whether or

not graduating from a prestigious doctoral institution influenced the foreign doctorate recipients' decisions to stay in the United States. To control for any unobserved institutional fixed effects that might influence an individual's decision, 319 institutional dummy variables that represented each doctoral institution were added in the model. The reference institution was Alabama A&M University.

Country independent variables. Previous research suggests that the country of origin significantly predicts the likelihood of a foreign doctorate recipient's staying in the United States (Black & Stephan, 2007; Finn, 2010; Johnson, 2001; Kim, Bankart, et al., 2011; OECD, 2008). This study included variables related to the economic conditions and R&D infrastructure of the student's home country from 2000 to 2010 in order to examine how the changes of economic and career opportunities in that home country might influence the foreign doctorate recipients' decisions to stay in the United States. The country variables had annual values from 2000 to 2010, with the exception of the number of research universities in one's home country. The values were included in the form of per capita to control for the size of a country. For instance, GDP per capita is gross domestic product divided by midyear population (World Bank, 2012). GDP was defined as "the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products" (World Bank, 2012, the World Development Indicators). The variables related to the economic condition of one's home country included GDP per capita centered on the U.S. GDP per capita as well as the unemployment rate of one's home country. Each year's GDP per capita for the 20 countries in the study was centered on the U.S. GDP per capita of that particular year in order to compare the home country's economy to the U.S. economy. This centering on the U.S. GDP took into account both the push and pull factors between the U.S. economy and their home country's

economy when the foreign doctorate recipients made their decisions on migration. For instance, the GDP per capita of Japan in 2000 was 37,126 USD, while the GDP per capita of the United States in 2000 was 34,775 USD (World Bank, 2012). Thus, the value for Japan's GDP per capita centered on U.S. GDP per capita in 2000 was 2,351 USD, and this value was entered into the dataset. The positive value suggested that Japan's economy performed better compared to that of the United States in 2000. On the other hand, in 2010, the GDP per capita of Japan increased to 43,141 USD; however, the GDP per capita of the United States in 2010 increased more, to 46,900 USD (World Bank, 2012). Accordingly, the value for Japan's GDP per capita centered on the U.S. GDP per capita decreased to - 3,759 USD in 2010. Thus, even though Japan's net GDP increased from 2000 to 2010, Japan's economic condition in 2010 might not be as appealing to Japanese graduates in 2010 in comparison to those in 2000 and when considered against the U.S. economy.

Previous research uses the GDP variable to compare the different income levels and economic conditions among countries, and it has found that students from lower income countries are more likely to stay in the host country than those from higher income countries (Bratsberg, 1995; Bratsberg et al., 2002; Finn, 2010; Grossmann & Stadelmann, 2008; Johnson, 2001; Song, 1997). In this study, GDP data were drawn from World Bank National Accounts database and OECD National Accounts database, and the values were adjusted in 2012 U.S. dollars. The unemployment rate variable was also included to indicate the job market condition of the doctoral student's home country (Johnson, 2001; Regets, 2007). Unemployment rate refers to the share of the labor force that is without work but available for and seeking employment; however, definitions of labor force and unemployment differ by countries (World Bank, 2012).

This study used the unemployment rate data from the Labor Market database presented by the International Labor Organization.

Studies have demonstrated that high-income countries tend to have high quality R&D infrastructure such as well-established research universities and extensive R&D employment opportunities outside academia, which would lower the stay rate of their doctorate recipients in the United States (Altbach, 2004b; Finn, 2010; Johnson, 2002; Mattoo et al., 2008; OECD, 2008; Song, 1997). This study examined if the R&D environment of one's home country influenced the foreign doctorate recipient's decision to stay in the United States. The variables that suggested the level of R&D infrastructure of a nation were included in the model: this included the percentage of total expenditure of R&D on GDP per capita, total public expenditure on education per capita, and the number of world-class universities in one's home country per capita. The number of R&D personnel (FTE: full-time equivalent) employed nationwide per capita variable was included in the initial model, but it was excluded in the final model because the R&D personnel variable and the R&D expenditure variable correlated at a high level (r=0.81). Thus, to prevent multicollinearity issues, I excluded the R&D personnel variable and kept the R&D expenditure variable in the final model. R&D related data were drawn from United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics from 2000 to 2010. UNESCO (2012) defines expenditures for R&D as both public and private expenditures on "creative work undertaken systematically to increase knowledge, and the use of knowledge for new applications." Public education expenditures included government spending on educational institutions (both public and private), education administration, and subsidies for private entities (students/households and other private entities) (UNESCO, 2012). Data on the number of research universities in one's home country were drawn from Academic Ranking of

World Universities (ARWU, 2012) published by Shanghai Jiao Tong University, China (Shanghai Ranking Consultancy, 2012). Top 500 world universities were defined as world-class research universities in this study. Among 20 countries in this study, Germany had 39 research universities, followed by the United Kingdom with 37 institutions. Romania and Thailand did not have any world leading university according to the ARWU 2012. Moreover, to control for any unobservable country fixed effects that might influence an individual's decision, 19 country dummy variables that represented each home country were added in the model (Reference: Argentina). The country dummy variables might help investigate the effect of country variables suggested in the model by controlling for unobserved country variables that were common to individuals from the same country (Wooldridge, 2009).

Statistical Method: Logistic Regression Analyses

This study used a logistic regression analysis because the outcome variable (Y) was binary (Y =1 if a foreign doctorate recipient stayed in the United States; Y = 0 if a foreign doctorate recipient did not stay in the United States). The logistic regression analysis takes into account the non-normal distribution of the binary outcome variable, its restricted range, and the dependent relation between mean and variance (Raudenbush & Bryk, 2002; Snijders & Bosker, 1999). This binary regression model allows a researcher to explore how each predictor affects the probability of the event occurring (Hosmer & Lemeshow, 2000).

Since the data in this study were grouped by year, PhD institution, and country, it is important to note that individuals were nested within year, institution, and country layers. A foreign doctorate recipient's decision to stay in the United States might result from a combination of individual and those group characteristics. If foreign doctorate recipients from the same country were correlated within the country cluster and one country cluster differed from

the other, the homoscedasticity and independence assumptions would be violated (Arceneaux & Nickerson, 2009; Snijders & Bosker, 1999). Ignoring this clustered nature of data would mislead the group-level effects and overstate standard errors (Raudenbush & Bryk, 2002; Snijders & Bosker, 1999). Thus, to take into account the nested structure of this data, commonly used methods to adjust for clustering were conducted: fixed effects model, random effects model, and hierarchical linear modeling (HLM)[2] (Arceneaux & Nickerson, 2009).

First, I estimated the variances explained by clustered variable, and I found that the country variable explained 15% of the variance in a foreign doctorate recipient's decision to stay, while the year variable explained 1%, and the PhD institution variable explained 2% of the variance. Since the country variable explained the most variance, I decided to deal with the dependency of individuals nested in the same country for this study. The ordinary least squares (OLS) regressions were used to estimate coefficients and standard errors with and without adjustment for country-level clustering. Comparing the results, OLS without any adjustment and random effects model regression had similar findings, while fixed effects model with country dummies and HLM (level 2: country) had similar results. Most country effects were significant in the OLS without any adjustment and random effects model, while they became insignificant except for the unemployment rate predictor in the fixed effects model and HLM. When there is a choice between two nested models, fixed effects model and random effects model, a trade-off occurs between bias and the efficiency issue (Allison, 2009). The random effects model leads to more efficient estimates, but those estimates might be biased if the assumptions of the model were wrong (Allison, 2009). On the other hand, the fixed effects model controls for all time-invariant characteristics (i.e., culture, religion, and climate) that estimates of the fixed effects

[2] The results of various models are reported in Appendix III.

model are less likely to be biased but at the expense of greater sampling variability (Allison, 2009). The fixed effects model assumes that the unobserved variables are correlated with observed variables, while the random effects model assumes no correlation between the unobserved variables and observed variables (Allison, 2009). To test whether the biases behind the random effects methods were small enough to ignore for this study, the Hausman (1978) test of the null hypothesis was conducted (Allison, 2009; Wooldridge, 2009). A researcher can use the random effects model unless the Hausman test rejects the null hypothesis (Wooldridge, 2009). The Hausman test on this study sample suggested the evidence against the random effects model that there were correlations between the unobserved variables and the observed variables in the dataset ($\chi^2(263) = 1395.73,\ p < 0.01$). Therefore, I decided to use the fixed effects model for the final model.

Theoretically, when the purpose of the study is to generalize the findings on the population of cluster and the study sample is randomly sampled from the population, the random effect approach is appropriate (Rabe-Hesketh & Skrondal, 2008; Wooldridge, 2009). On the other hand, when the study is interested in the effects of the cluster on the particular dataset and the unit of analysis is taken as sampled, the fixed effects model is used (Rabe-Hesketh & Skrondal, 2008; Wooldridge, 2009). Since this study focuses on a particular sample, the foreign doctorate recipients from 20 countries during 2000 to 2010 whose majors were mostly STEM areas, the fixed effects approach is appropriate according to the theory. Wooldridge (2009) also suggested that the fixed effects model is much more convincing than the random effects model for policy analysis using a large dataset.

The primary goal of this study was to examine what individual, institutional, and country related factors influenced the probability of a foreign doctorate recipient's decision to stay in the United States. The basic structure of final model was formally specified as using logit link,

$$\log\left(\frac{p\,(Y=1)}{1-p\,(Y=0)}\right) = \alpha + \boldsymbol{\beta} * \boldsymbol{IND} + \boldsymbol{\gamma} * \boldsymbol{INSTI} + \boldsymbol{\delta} * \boldsymbol{CNTRY} + \sum_{t=2}^{11} \varepsilon_t TIME_{ti} + \sum_{k=2}^{320} \zeta_k INSTI_{ki} + \sum_{j=2}^{20} \eta_j CNTRY_{ji}$$

where α was an intercept, indicating the average probability of the staying of an individual *i* from Argentina (*j*=1) who earned the doctoral degree from Alabama A&M University (*k*=1) in 2000 (*t*=1) after controlling for all covariates. The equation represented the log odds that $Y = 1$ as a function of the values of the predictors. Specifically, the vector $\boldsymbol{\beta} * \boldsymbol{IND}$ represented the individual predictors associated with the foreign doctorate recipients' decisions to stay in the United States such as demographic characteristics, educational background, and career plan. The vector $\boldsymbol{\gamma} * \boldsymbol{INSTI}$ represented the institutional predictors associated with the foreign doctorate recipients' decisions to stay in the United States including doctoral institution type, institutional research expenditure, and PhD program rankings by academic fields. Last, $\boldsymbol{\delta} * \boldsymbol{CNTRY}$ was a vector of home country predictors such as GDP per capita centered on the U.S. GDP per capita, unemployment rate, total R&D expenditure, total public expenditure on education, and the number of world-class universities. The variable $TIME_{ti}$ denoted a vector of time dummy indicators that control for the fixed effect of time. The year 2000 (*t*=1) was the reference category. The variable $INSTI_{ki}$ denoted a vector of doctoral institution dummy

indicators that controlled for institutional fixed effects. The variable $CNTRY_{ji}$ denotes a vector of country fixed effects. By adding these 3 sets of dummy variables, this model controlled for time-invariant effects of time, doctoral institution, and country that might affect foreign doctorate recipients' decisions to stay, and it was able to estimate the pure effect of predictors (Wooldridge, 2009). These dummies also adjusted estimators for the clustering of foreign doctorate recipients by year, institution, and country (Wooldridge, 2009).

Data Analysis Process

First, I analyzed the descriptive statistics to explore the trends of foreign doctorate recipients who earned U.S. doctoral degrees in science and engineering fields in 2000-2010 (Research Question 1). In this process, I detected some outliers among continuous independent variables; thus, I excluded them from the sample. For example, the mean age when the PhD was awarded was 32.5, and the age variable ranged from age 22 to age 73. I excluded 1% of observations that ranged from age 51 to age 73 because they would not show the general pattern of migration decision. As a result, 1908 cases were deleted, and the mean age of PhD awarded in the sample decreased to age 31.6. In addition, the years spent in PhD program (from entry year to graduation year) ranged from 2 year to 47 years. Again, I excluded 1% of observations that ranged from 15 years to 47 years in the PhD program because they would hardly represent the general pattern of migration decision. Accordingly, 6711 cases were deleted, and the mean year in the PhD program decreased from 7.2 years to 6.9 years. I did not treat an institution that had $0.00 for research expenditure as an outlier because the IPEDS data center (2012) reported that the minimum amount of research expenditure of an institution was $0.00. After deleting outliers, the final sample reduced from 77,720 to 69,593 cases.

Next, I examined the correlations among independent variables to screen a potential problem of multicollinearity. This occurs when several independent variables correlate at an excessively high level with one another, and this would mislead the results (Keith, 2006). First, I examined the correlation between the selectivity of foreign BA variable and PhD program ranking variable, because those who graduated from selective BA institutions were assumed to go to high ranked PhD programs, which might lead to the multicollinearity in the model. The result showed that those who graduated from selective foreign BA institutions went to higher ranked PhD programs in the United States, but the two variables did not correlate highly (r = 0.17, $p < 0.01$). Second, I examined the correlations among institutional variables that contained the research fund component in their variables. The Carnegie Classification variable, PhD program ranking variable, and the total research expenditure variable were examined. The relation suggested that institutions where larger amounts of research expenditures were spent were more likely to be in the very high research active institution category (r = - 0.35, $p < 0.01$) and placed higher on the PhD ranking charts (r = 0.5, $p < 0.01$), but the correlations indicated that multicollinearity was not an issue among three variables. However, among country variables, multicollinearity was detected; thus, some variables have been changed. Initially, the R&D expenditure variable was defined as the total expenditure of R&D per capita in USD. But the correlation between GDP variable and R&D expenditure variable was too high (r = 0.82, p <0.01), and therefore I could not use the R&D expenditure variable as defined. Thus, I changed the R&D expenditure data as the percentage of total expenditure of R&D on GDP, and the multicollinearity issue between GDP variable and R&D expenditure variable disappeared (r=0.51, p <0.01). Moreover, the number of R&D personnel employed nationwide variable was included in the model to show the R&D environment of one's home country, but this variable

was excluded because the correlation suggested that the R&D personnel variable and the R&D expenditure almost overlapped ($r = 0.81$, $p < 0.01$).

In order to determine which independent variables were significant predictors on foreign doctorate recipients' decisions to stay or not, logistic regressions were conducted due to the binary nature of the outcome. Independent variables were categorized into individual variables, PhD institutional variables, and the home country variables, and were tested separately to identify which factors predicted the foreign doctorate recipients' decisions to stay in the United States (Research Question 2, Research Question 3 & Research Question 4). To explore whether gender effect varied by the country of origin, 20 logistic regression analyses on individual variables by country were conducted (Research Question 2). To control for institutional fixed effects, 319 PhD institutions that produced the foreign doctorate recipients were initially entered as dummy variables; however, 45 institutions were omitted in the regression analysis including the reference institution, Alabama A&M University[3]. This suggests that after controlling for institutional predictors such as R&D expenditure, PhD program ranking, and the institution type, this group of institutions became so similar to each other that they showed collinearity.

Finally, a full model with all the variables in the model was tested to compare the changes of effects of predictors after controlling for the other covariates and to determine the relative influence of each of the variables studied (Research Question 5). The full model was tested with and without 19 country dummy variables to identify the country fixed effects. While the year variable and institution variables explained only 1% and 2% of the variances, respectively, the country variables explained the most of the variances, at 15%. Thus, this study focused on exploring the country factors, including the country fixed effects such as culture, in

[3] Appendix IV shows the list of 45 institutions

order to identify significant country factors in explaining the variances in a foreign doctorate recipient's decision to stay. In the final model, the sample size was reduced to 25,943, as all cases with missing data were removed from the analysis. In addition, to explore if predictors explained by the full model varied by countries, four countries(China, India, South Korea and Taiwan) that had the largest numbers of stayers were examined. China consisted of approximately 40% of this study sample. China, India, South Korea and Taiwan together made up 73% of the study sample, which indicated that it was worthwhile to examine significant factors further for each country.

Table 1

Summary of Data Analyses.

Research Question	Data Analysis
1. What are the descriptive trends of foreign doctorate recipients who earned U.S. doctoral degrees in science and engineering fields in 2000-2010?	Descriptive statistics: Distribution of frequency, percentage, mean, standard deviation, minimum maximum & correlations of variables
2. What individual factors predict foreign doctorate recipients' decisions to stay in the United States?	Model 1: Logistic regression analysis on individual factors Model 1-1: Twenty logistic regression analyses on individual factors by countries (whether gender effect varied by country)
3. What institutional factors predict foreign doctorate recipients' decisions to stay in the United States?	Model 2: Logistic regression analysis on institutional factors
4. What country-specific factors predict foreign doctorate recipients' decisions to stay in the United States?	Model 3: Logistic regression analysis on country factors

Research Question	Data Analysis
5. How do individual, institutional and country factors influence foreign doctorate recipients' decision to stay in the United States? After controlling for individual and institutional variables, do country variables have a unique contribution to their decisions to stay in the United States?	Model 4: Logistic regression analysis of full model without country fixed effects Model 5: Logistic regression analysis of full model with country fixed effects Model 6: Four logistic regression analyses by China, India, S. Korea and Taiwan

Limitations

This study has several limitations. First, the dependent variable, the decision to stay or not in the United States, was defined as the first-year stay rate after graduation, which also included the post-doctoral positions employed in the United States (NSF, 2010). Thus, this study predicted the migration patterns of foreign doctorate recipients including the number of post-doctoral study for their career. Some academic fields like biological sciences or physical sciences required post-doctoral study after their degree completions (Johnson & Regets, 1998; Kim, Bankart, et al., 2011), and thus many foreign doctorate recipients were employed in postdoctoral positions in the United States. In this study sample, while 72% of computer science PhDs did not take a post-doctoral position, 84% of biological science PhDs took a post-doctoral position. Among those who took a post-doctoral position, 86% were employed in the United States. Therefore, they were counted as the stayers in the United States. This number made the stay rate estimate high because those who were employed in the postdoctoral positions would make their decisions on migration after their training was completed. Despite the overestimated number, the first-year stay rate is still meaningful because it is the very first indicator of actual behavior in the future (Finn, 2010). The changing trends such as decreased stay rates of certain groups or characteristics could be detected from the changes of first-year stay rates (Finn, 2010). Second, this study did not control for social and personal factors such as connections with ethnic communities in the United States, family and friends ties, and personal values due to the limited data availability. Previous literature suggests that family and friends ties, personal values, and cultural distance between their home countries and the United States greatly influenced decisions to stay or not (Barush et al., 2007; Gupta et al., 2003; Hazen & Alberts, 2006; Lee & Kim, 2010; Massey et al., 1993). This study controlled for country-specific fixed effects such as culture or

values shared by the same country of origins by including country dummy variables in the analysis, but this did not capture the individual variations regarding social and personal factors.

In this study sample, the individuals were nested within their home countries and PhD institutions from which they graduated; however, the data did not have a linear hierarchical structure. That is, the foreign doctorate recipients came from a country outside of the United States while graduating from a PhD institution located in the United States. The institutions were not nested in the home country. A cross-classification arises when the lower-level unit, foreign doctorate recipients, share memberships in a unit of one factor, PhD institution, and belong to different units of a second factor, the home country (Raudenbush & Bryk, 2002). The foreign doctorate recipients were nested within "cells" defined by the cross-classification of two higher level factors, PhD institutions and countries (Raudenbush & Bryk, 2002, p. 375). Although this study utilized fixed effects model to adjust for clustering by PhD institution and country, this model had a limitation on identifying the variances in outcome that were cross-classified by PhD institutions and countries. In future studies, a cross-classified random-effects model can be conducted to examine the variance in outcomes that lie between PhD institutions, between countries, and within cells (PhD institution by country cells) (Raudenbush & Bryk, 2002).

Summary

This chapter presented research methodology regarding factors used to predict foreign doctorate recipients' odds of staying in the United States. This study mainly used individual data from 2000 to 2010 found in the Survey of Earned Doctorates (SED: 2010) by the NSF. The dependent variable was whether or not a foreign doctorate recipient stayed in the United States after his or her degree completion. To predict the outcome, individual, institutional, and country independent variables were suggested. A series of logistic regression analyses were conducted to

explore research questions. The next chapter presents results from these descriptive statistics and logistic regression analyses.

Chapter IV

Results

In this chapter, I present the results of analyses to answer the research questions. First, I report on the descriptive statistics of study sample in order to explore who foreign doctorate recipients are in U.S. higher education institutions from 2000 to 2010. The descriptive analyses include individual, institutional, and country variables. Then, I report the results from a series of logistic regression analyses that predict the factors on foreign doctorate recipients' decisions to stay in the United States.

Descriptive Results

Table 2 and Table 3 present the descriptive statistics of the study sample, the foreign doctorate recipients who earned their PhD degrees in U.S. higher education institutions during 2000 to 2010. This study focused on the academic fields where foreign doctorate recipients received a large number of degrees: agriculture, biological and biomedical sciences, engineering, computer and information sciences, mathematics, chemistry, physics, and economics. The male foreign doctorate recipients outnumbered the female foreign doctorate recipients. Males were 73% of the sample, while females were 26%. The average age when they received their PhD degrees was 31 years old, and the average years in the PhD program (from graduate entry year to graduation year) was 6.93 years. Among the study sample, 60% of the doctorate recipients were married when they earned their PhD degrees, but only 28% of them had children. Many of them came from highly educated families; that is, approximately 60% of the sample had a parent who had a bachelor's degree or beyond. Examining the origins of bachelor degrees of the sample, 3% of them graduated from U.S. undergraduate institutions, 35% of them graduated from selective (top 5) foreign undergraduate institutions, and 60% graduated from non-selective foreign

undergraduate institutions. During their PhD studies, about 60% of them reported a research assistantship as their primary funding source, followed by a teaching assistantship (17%), and then scholarship, fellowship, or grant (15%). A small number of foreign doctorate recipients were funded from their home countries: foreign government, 3%; and self, family or loan, 2.7%. For their career plan, about 40% of the sample expected to be employed in industry, while 59% were employed in academia after graduation.

In regards to their PhD institutions, the majority of the foreign doctorate recipients (82%) earned their doctoral degrees from research universities classified as being "very high research activity" institutions according to the Carnegie Foundation's classification of institutions of higher education (Carnegie Foundation, 2012). About 71% of the sample attended public institutions, and the mean of annual research expenditures of an institution was $185,000,000. Annual research expenditure of an institution ranged from $0 to $995,000,000. MIT had the maximum research expenditure value. Approximately 35% of foreign doctorate recipients earned their doctoral degrees from prestigious PhD programs in their academic fields, which were defined as the top 25 ranked PhD programs.

Table 2

Descriptive Statatistics of the Study Sample (N=69,593)

Category	Variable		Percentage (%)	Frequency (N)
Demographic Characteristics	Gender	Female	26.58 %	18,496
		Male	73.42 %	51,096
	Marital status	Married	57.94 %	40,140
		Not-married	42.06 %	29,121
	Having Children	No child	71.58 %	44,772
		Children under 6	21.85 %	13,674
		Children aged 6-18	6.57 %	4,116
	First generation	A parent with a bachelor's degree or beyond	61.01 %	42,460
		No parent with a bachelor's degree	38.99 %	27,133
Educational Background	Bachelor's Degree	U.S. bachelor's degree	3.49 %	2,429
		Selective foreign BA	35.70 %	25,808
		Non-selective foreign BA	59.83 %	41,356
	Primary funding source for PhD studies	Research assistantship	59.99 %	41,754
		Teaching assistantship	17.72 %	12,338
		Scholarship, fellowship & grant	15.77 %	10,977
		Foreign government	3.00 %	2,638
		Self, family or loan	2.71 %	1,886
	PhD field	Agriculture	4.46 %	3,106
		Biological/biomedical sci	19.34 %	13,460
		Engineering	42.18 %	29,352
		Computer/information sci	7.13 %	4,965
		Mathematics	6.07 %	4,223
		Chemistry	8.50 %	5,918
		Physics	6.80 %	4,731
		Economics	5.51 %	3,838

Category	Variable		Percentage (%)	Frequency (N)
Career Plan	Employed	Academia	59.61 %	22,138
		Industry	40.39 %	14,998
Institution	Carnegie classification	Very high research active inst	82.05 %	56,736
		High research active inst	13.04 %	9,569
		Doctoral granting inst	1.08 %	749
		Others	3.03 %	2,093
	Public	Public	71.54 %	49,677
		Private	28.46 %	19,762
	Prestige	Top 25 ranked PhD program	34.94 %	23,678
		Outside top 25 ranked PhD program	65.06 %	44,086

The results in Table 3 also presents the descriptive statistics of the foreign doctorate recipients' home country variables that were tested in the analyses. Among 20 countries, the average GDP per capita of a foreign doctorate recipient's home country centered on U.S. GDP per capita was $-34,734.37, and the average unemployment rate was 5.69% during the study period 2000-2010. The countries in the sample spent 1.42% of their GDP on R&D sector on average. The average of total public expenditures on education per capita was $239.83, which ranged from $16.45 to $2,822.93. The average number of world-class universities per one million people was 0.09, which ranged from 0 to 0.64.

Table 3

Descriptive Statistics of Continuous Variables (N= 69,593)

Variable	Mean (Standard deviation)	Min	Max
Individual variables:			
Age when the PhD was awarded	31.65 years old (3.62)	22 years old	50 years old
Years in PhD program	6.93 years (1.45)	2 years	14 years
Institutional variables:			
Research expenditure	$185,000,000 (155,000,000)	0	$995,000,000
Country variables:			
GDP per capita centered on US[4] GDP per capita	$-34,734.37 (10,508.82)	$-45,822.91	$2,350.45
Unemployment rate	5.69 % (2.67)	1.04 %	20.07 %
% of R&D expenditure on GDP	1.42 % (0.83)	0.19 %	3.73 %
Public expenditure on education per capita	$239.83 (452.90)	$16.45	$2,822.93
Number of world-class universities per capita[5]	0.09 (0.15)	0	0.64

The distribution of 20 countries of origins of the study sample is shown in Table 4. The largest number of foreign doctorate recipients came from China. Approximately 40% of the study sample was from China. The four countries that sent the largest number of students were all Asian: China (39.66%), India (16.26%), South Korea (11.73%), and Taiwan (5.34%). They

[4] All dollar amounts are adjusted to 2012 U.S. dollars.
[5] The population unit is in millions

consisted of 73% of the study sample. In addition, eight European countries made up 13% of the sample.

Table 4
Distribution of Country of Origin

	Country	Percentage (%)	Frequency (N)
1	China	39.66 %	27,600
2	India	16.26 %	11,313
3	S.Korea	11.73 %	8,165
4	Taiwan	5.34 %	3,716
5	Turkey	4.30 %	2,991
6	Canada	2.90 %	2,016
7	Thailand	2.89 %	2,010
8	Russia	2.00 %	1,394
9	Mexico	1.99 %	1,384
10	Germany	1.64 %	1,141
11	Romania	1.56 %	1,084
12	Japan	1.52 %	1,055
13	Brazil	1.41 %	981
14	Iran	1.21 %	843
15	Italy	1.20 %	834
16	Greece	1.11 %	770
17	Egypt	1.08 %	751
18	Argentina	0.92 %	642
19	United Kingdom	0.66 %	458
20	Spain	0.64 %	445
		100 %	69,593

Table 5 compares the mean of country variables from 2000 to 2010, except for the number of world-class universities. Every country variable except the number of world-class university had yearly values by 20 countries from 2000 to 2010. Comparing the mean GDP by each country during the study period, 2000-2010, Japan ($36,392), Canada ($35,697), United Kingdom ($34,915), and Germany ($32,545) had the highest mean GDP per capita, while India ($928), Egypt ($1,542), China ($2,441), and Thailand ($2,874) had the lowest mean GDP per capita. The richest country among the 20 countries, Japan, had almost a 40 times higher GDP per capita compared to India, one of the lowest GDP countries. However, among 20 countries of the study sample, no country had a higher mean GDP per capita than that of the United States, $41,783. Thus, when every country's GDP per capita was centered on the U.S.'s GDP per capita, the averages of values became all negative. The negative values suggest that the economic condition of the United States was better than any other country in the world on average during the study period. While the average unemployment rate was 5.69% during 2000 to 2010, the unemployment rate varied by countries. Spain (11.9%), Argentina (11.4%), Turkey (10.5%), and Greece (9.8%) had the highest unemployment rate, while Thailand (2.0%), South Korea (3.5%), Mexico (3.6%), and China (4.0%) had the lowest unemployment rate on average.

In this study, the conditions of R&D infrastructure of one's home country were measured by the country's total expenditure on R&D sector, total public expenditure on education, and the number of world-class research universities. Japan had the leading R&D environment among 20 countries. Japan spent the largest portion of GDP on R&D sector (2.9%) and the second highest public expenditure on education ($1,381). South Korea (2.9%), Germany (2.5%), and Taiwan (2.4%) spent high portions on R&D sector of their GDP; the United Kingdom ($1,768) had the highest spending on education followed by Japan ($1,381) and Germany ($1,378). The number

of world-class research universities per capita suggested that Canada had the most world-class universities, followed by the United Kingdom and Germany among the 20 countries.

Table 5

Descriptive Statistics of the Country Variables: The Mean by Countries from 2000 to 2010

	GDP per capita[6]	GDP per capita centered on US's GDP	Unemploy-ment rate	% of R&D expenditure on GDP	Public expenditure on education per capita	Number of World-Class University (500 lists)	Number of WCU per capita [7]
U.S.	$41,783.01	$0.00	5.91%	2.70%	$2,718.57	150	0.47
Argentina	$6,308.93	$- 36,389.51	11.4%	0.46%	$84.63	1	0.02
Brazil	$5,752.35	$-36,349.08	8.7%	1.03%	$271.50	6	0.03
Canada	$35,697.91	$-6,841.99	7.05%	1.96%	$1,119.35	22	0.64
China	$2,441.64	$-40,542.65	4.05%	1.35%	$67.04	28	0.02
Egypt	$1,542.06	$-40,426.94	9.8%	0.18%	$20.87	1	0.01
Germany	$32,545.21	$-8,811.35	8.3%	2.57%	$1,378.80	39	0.45
Greece	$21,941.75	$-20,436.25	9.8%	0.47%	$841.52	2	0.18
India	$928.02	$-42,784.20	8.7%	0.80%	$28.60	1	0.0008
Iran	$3,820.89	$-39,901.04	6.4%	0.38%	$22.22	1	0.01
Italy	$29,967.10	$-12,425.77	7.8%	1.14%	$1,270.07	20	0.33
Japan	$36,392.31	$-6,084.06	4.6%	2.90%	$1,381.59	21	0.16
Mexico	$7,890.88	$-33,800.53	3.6%	0.28%	$319.52	1	0.008
S. Korea	$17,217.77	$-25,338.89	3.5%	2.90%	$659.22	10	0.20
Romania	$5,023.87	$-37,037.52	7.5%	0.43%	$123.79	0	0

[6] All dollar amounts are adjusted to 2012 US dollars.

[7] The population unit is in millions.

	GDP per capita[6]	GDP per capita centered on US's GDP	Unemploy-ment rate	% of R&D expenditure on GDP	Public expenditure on education per capita	Number of World-Class University (500 lists)	Number of WCU per capita [7]
Russia	$5,715.72	$-35,929.27	7.9%	1.13%	$217.13	2	0.01
Spain	$25,530.03	$-16,462.35	11.9%	1.14%	$1,140.13	11	0.23
Taiwan	$15,598.83	$-26,032.15	4.4%	2.42%	$601.73	9	0.39
Thailand	$2,874.84	$-38,844.57	2.0%	0.22%	$88.45	0	0
Turkey	$7,101.71	$-35,340.22	10.5%	0.63%	$218.50	1	0.01
United Kingdom	$34,915.07	$-6,865.21	5.5%	1.76%	$1,768.73	37	0.61

The stay rate of this study sample is presented in Table 6. This study followed the definition of stay rate according to NSF (2010), who defined the stay rate as "the proportion of doctorate recipients with temporary visas who have definite commitments for employment or a postdoctoral position in the coming year and who indicated the location of their commitment is in the United States" (p.13). Approximately 81% of the study sample decided to stay in the United States after they earned their PhD degrees. Figure 2 shows the percentage of stayers and non-stayers among the sample from 2000 to 2010, and Figure 3 illustrates the frequency of stayers and non-stayers by year. The stay rates by year ranged from 77% to 84% during the study. The year 2007 had the highest stay rate, 84%, and the year 2003 had the lowest stay rate, 77%. After the stay rate marked its highest point in 2007, the stay rate declined every year. The frequency of stayers and non-stayers in Figure 3 shows that the trends of stayers reflected the trends of number of doctorate recipient produced. From 2000 to 2002, the number of stayers decreased every year, and the year 2002 hit the lowest number of stayers (3,637 stayers); however, starting in 2003, the flow of stayers reversed, and the number of stayers increased every year until 2007. The year 2007 reached a peak, with the highest number stayers (6,829 stayers) during the study period. In 2008, the number of stayers started to decrease, while the number of non-stayers continued to increase. From 2008 to 2010, the number of stayers decreased every year, and the number of stayers in 2010 went back to the number of stayers in 2005. On the other hand, in general, the number of non-stayers increased every year, from 824 doctorates in the year 2001 to 1480 doctorates in the year 2010. The year 2010 reached the highest number of non-stayers during the study period.

Figure 4 and Figure 5 demonstrate the percentage of stayers and non-stayers by doctoral institutions. The stay rate was the lowest among foreign doctorate recipients who graduated from

the very high research active institutions, according to the Carnegie Classification. The stay rate of very high research active institutions was 81%. The stay rates of doctoral-granting institutions and other institutions were 82% and 89%, respectively. In addition, through analyzing the PhD program rankings, the stay rate of the top 10 rated institutions was the lowest, 79%. The stay rate of institutions that ranked from 11 to 25 was 80%. The stay rate was the highest for those who graduated from institutions that ranked 26 to 50, 84%. Figure 6 demonstrates the percentage of stayers and non-stayers by their fields of study. Foreign doctorate recipients who majored in chemistry had the highest stay rate, 87.62%, followed by those in biological/biomedical sciences, 87.42%. The stay rate of computer sciences was 83%, and that of engineering was 82%. The stay rates of agriculture and economics were lower, 63%, and 54%, respectively.

Figure 7 illustrates the distribution of coming and staying of foreign doctorate recipients by countries during the study period. Figure 7 suggests that countries that sent the most number of doctoral students also had the higher number of stayers: China, India, and South Korea. In Figure 7, the size of circle represented the number of coming and staying foreign doctorate recipients from a country during the study period. China had the largest circle, followed by India. The dark area represented the number of coming doctoral students, and the white area represented the number of foreign doctorate recipients who stayed in the United States. If every doctoral student from a country stayed in the United States after their degree was completed, the proportion of the dark area and the white area of the circle would be the same. The highest stay rate country, China, had an almost even proportion of the dark area and the white area.

Figure 8 shows the percentage of stayers and non-stayers by countries. China had the highest stay rate, 93%, followed by Iran, 91.9% and India, 91.1%. The lowest stay rate countries

were Thailand (26%), Brazil (43%), and Mexico (49%). Figure 9 presents the number of stayers and non-stayers by countries. China had the highest number of stayers, 25,500 doctorate recipients, followed by India (10,225), and South Korea (5,863). Brazil, Mexico, and Thailand had a lower number of stayers than non-stayers. Figure 10 compares the frequency of stayers among four countries that had the highest number of stayers from 2000 to 2010: China, India, South Korea, and Taiwan. From 2000 to 2007, the number of stayers from China increased every year. The year 2007 reached the highest number of stayers (3,286), and the number of stayers started to decline from 2007 to 2010. The stay pattern of India was similar to that of China. From 2000 to 2008, the number of stayers from India increased, and the year 2008 reached the peak point. However, from 2008 to 2010, the annual number of stayers from India decreased. The number of stayers from South Korea and Taiwan in 2000 had similar numbers, over 300 doctorates. However, while the number of stayers from South Korea increased, the number of stayers from Taiwan decreased during the study period. In 2010, South Korea had two times more stayers compared to that of Taiwan.

Table 6

Distribution of Decision to Stay in the United States

	Percentage (%)	Frequency (N)
Stay in the U.S.	81.36 %	56,094
Non-stay in the U.S.	18.64 %	12,852

Figure 2

Percentage of Stayers and Non-Stayers by Year

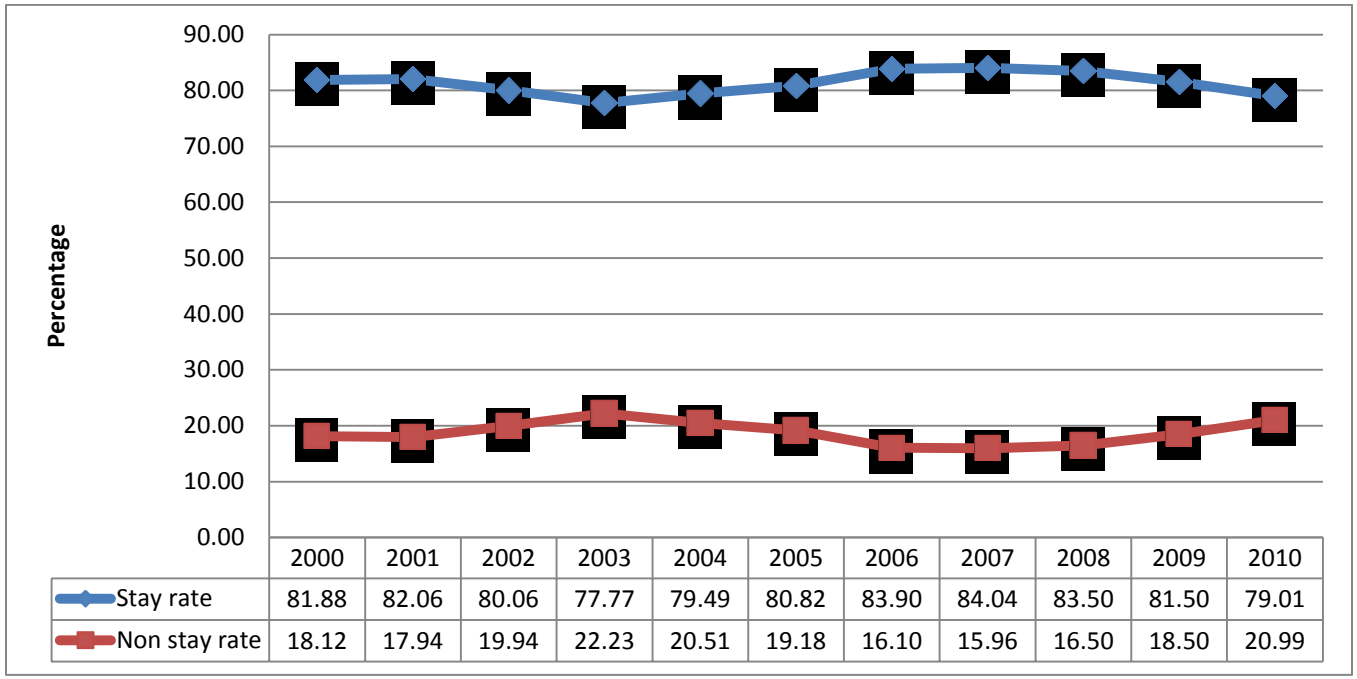
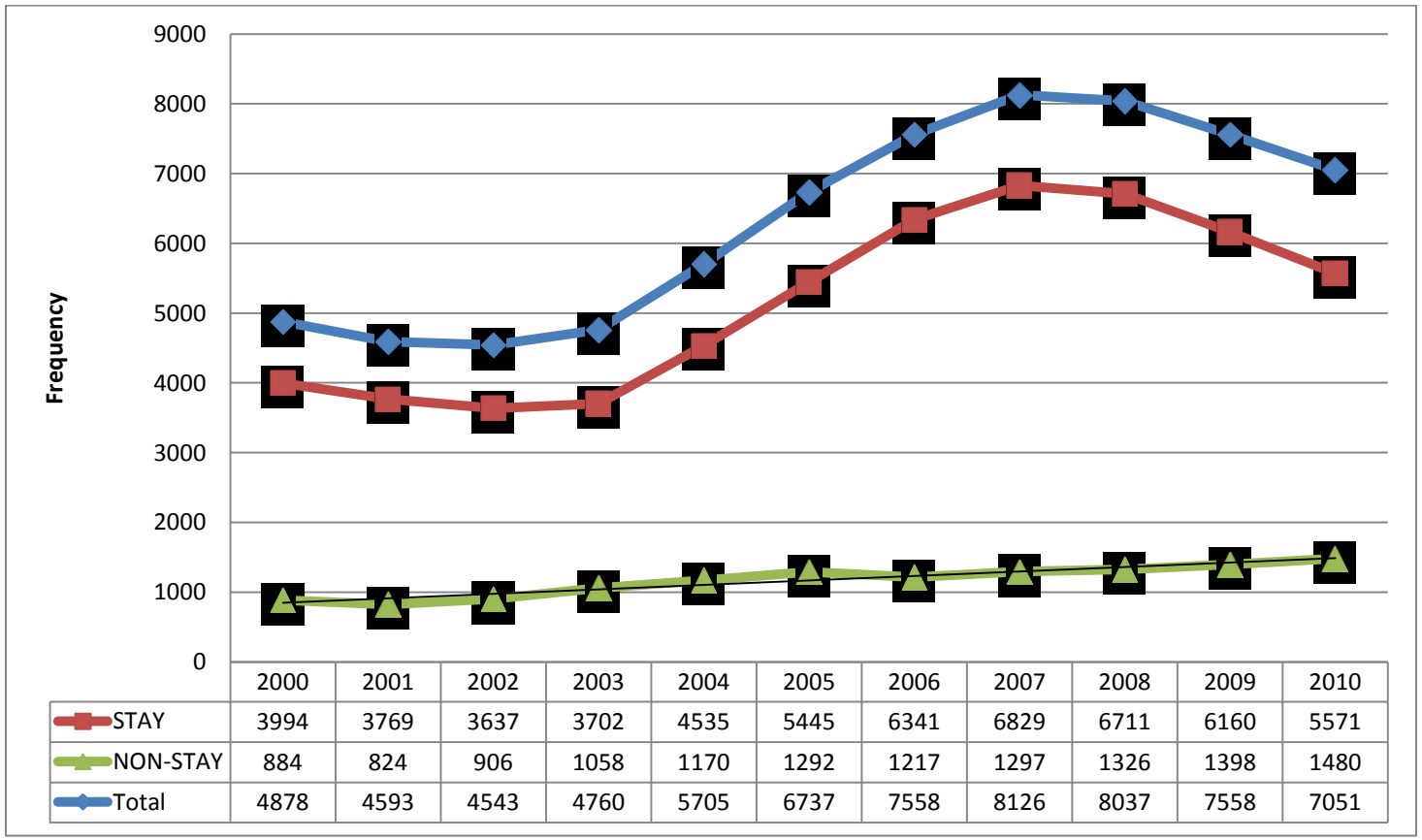


Figure 3

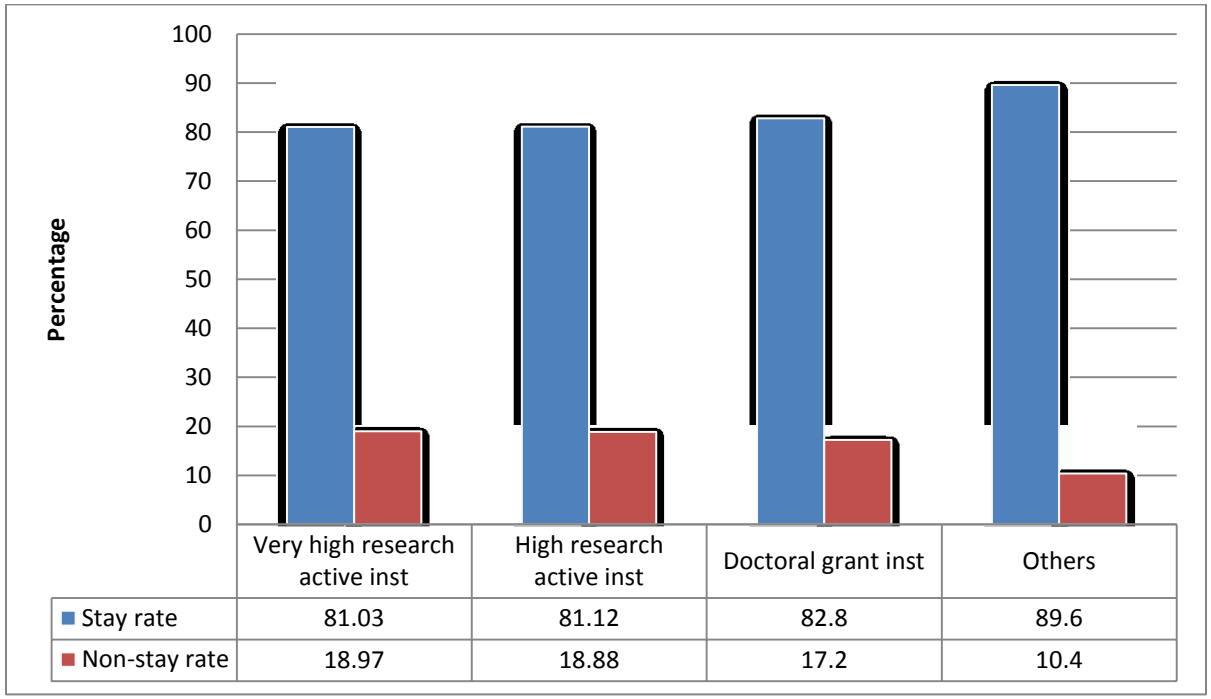
Number of Stayers and Non-Stayers by Year



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
STAY	3994	3769	3637	3702	4535	5445	6341	6829	6711	6160	5571
NON-STAY	884	824	906	1058	1170	1292	1217	1297	1326	1398	1480
Total	4878	4593	4543	4760	5705	6737	7558	8126	8037	7558	7051

Figure 4

Percentage of Stayers and Non-Stayers by Institution (Carnegie Classification)



	Very high research active inst	High research active inst	Doctoral grant inst	Others
Stay rate	81.03	81.12	82.8	89.6
Non-stay rate	18.97	18.88	17.2	10.4

Figure 5

Percentage of Stayers and Non-Stayers by Institution (PhD program ranking)

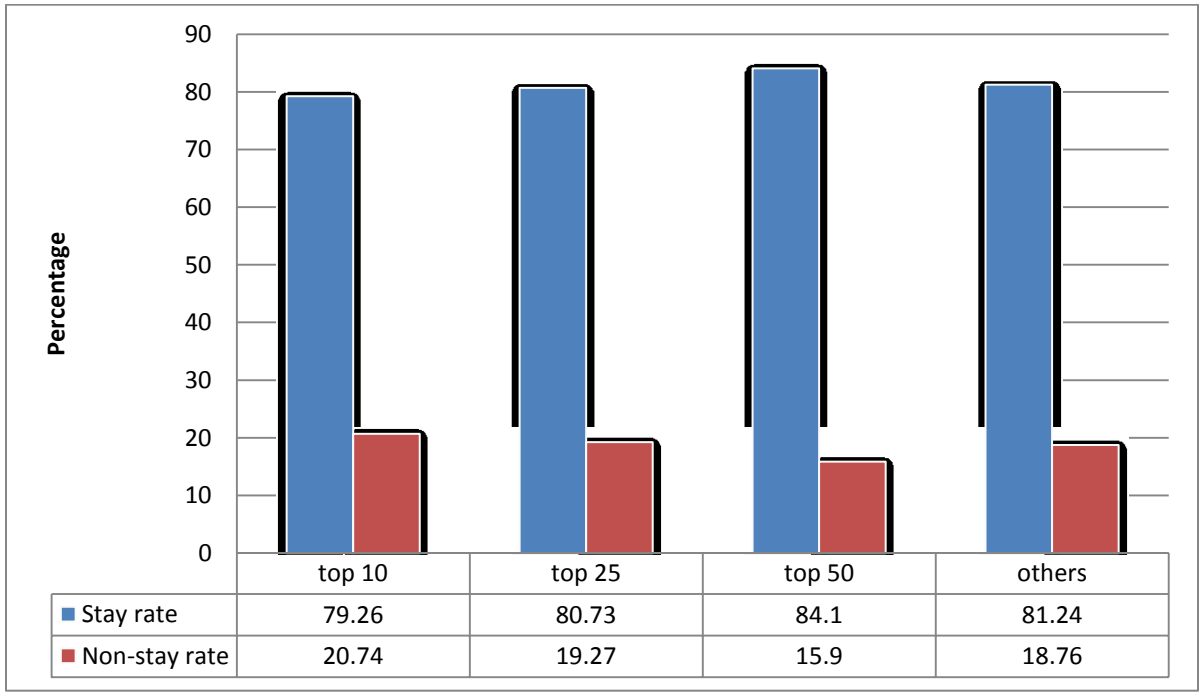
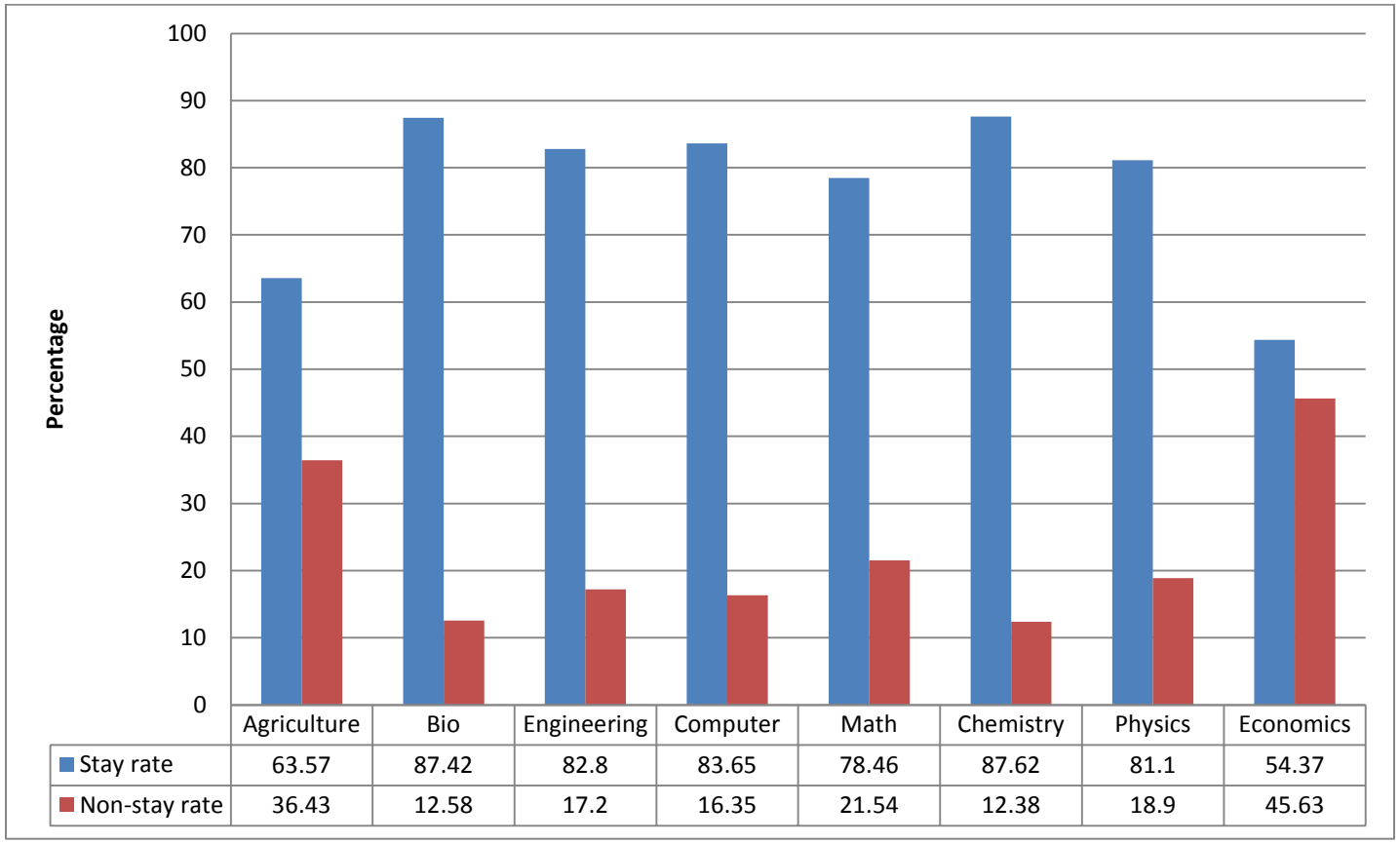


Figure 6

Percentage of Stayers and Non-Stayers by Field of Study



	Agriculture	Bio	Engineering	Computer	Math	Chemistry	Physics	Economics
Stay rate	63.57	87.42	82.8	83.65	78.46	87.62	81.1	54.37
Non-stay rate	36.43	12.58	17.2	16.35	21.54	12.38	18.9	45.63

Figure 7
Distribution of Coming and Staying by Countries

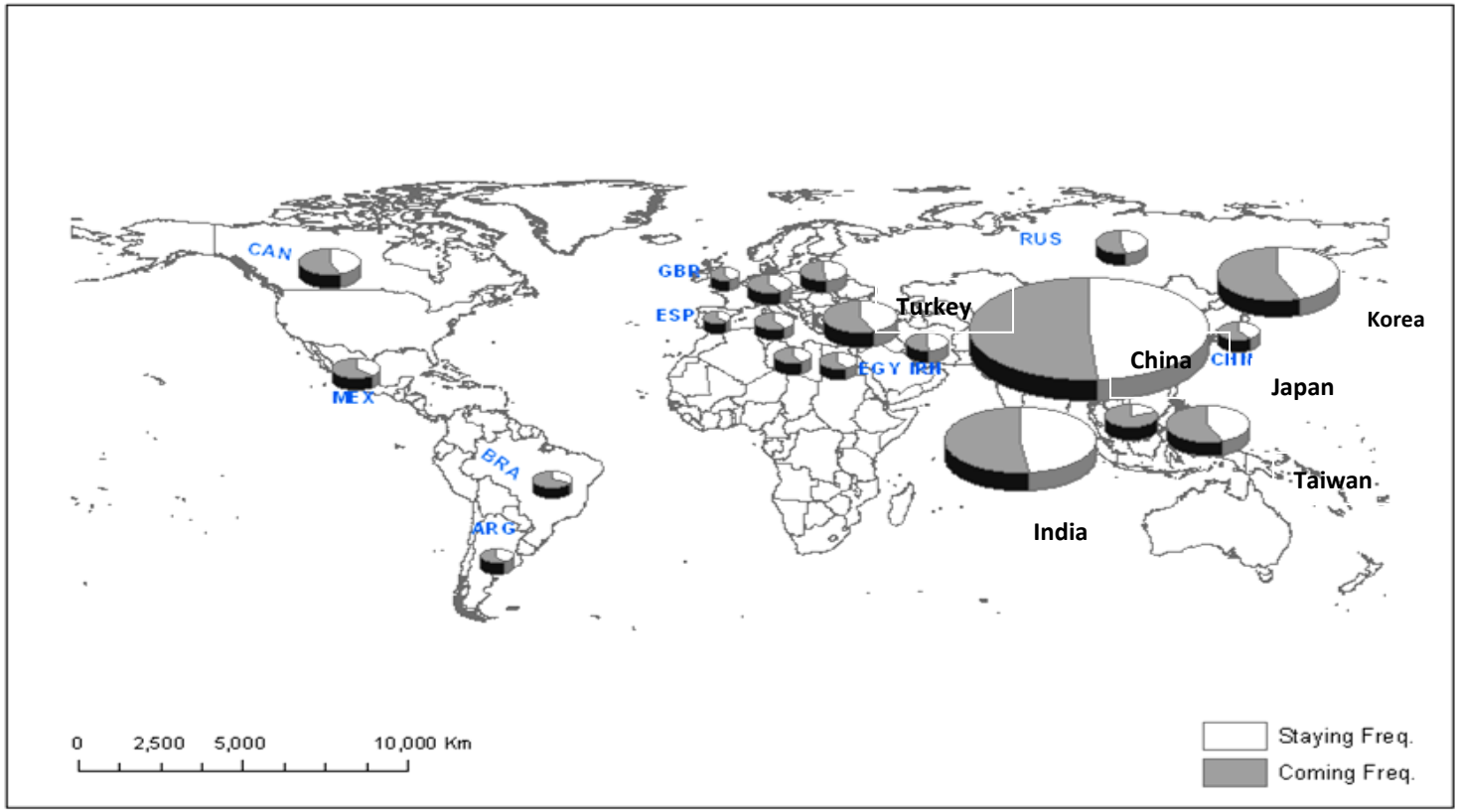
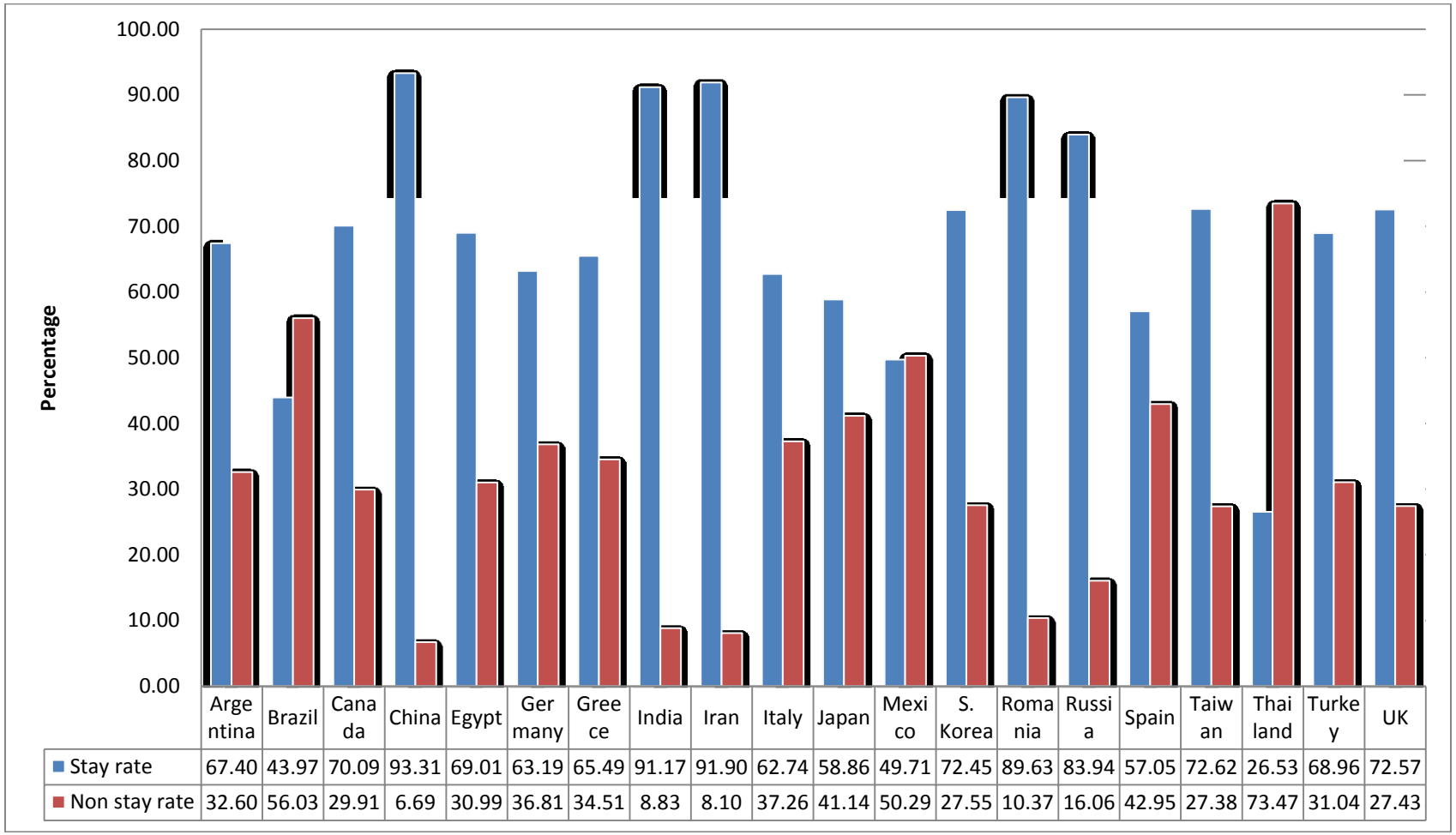


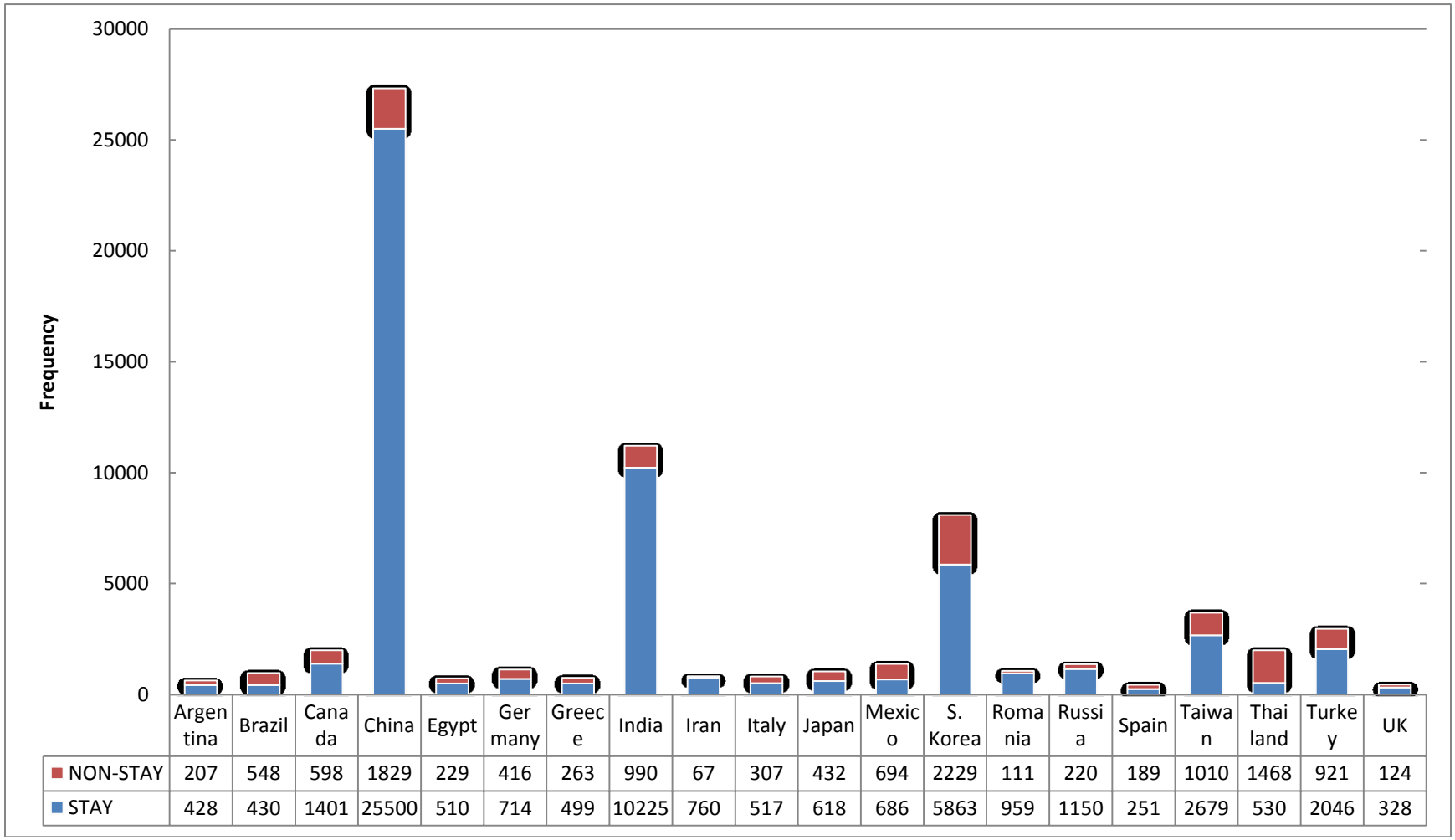
Figure 8
Percentage of Stayers and Non-stayers by Country



	Argentina	Brazil	Canada	China	Egypt	Germany	Greece	India	Iran	Italy	Japan	Mexico	S. Korea	Romania	Russia	Spain	Taiwan	Thailand	Turkey	UK
Stay rate	67.40	43.97	70.09	93.31	69.01	63.19	65.49	91.17	91.90	62.74	58.86	49.71	72.45	89.63	83.94	57.05	72.62	26.53	68.96	72.57
Non stay rate	32.60	56.03	29.91	6.69	30.99	36.81	34.51	8.83	8.10	37.26	41.14	50.29	27.55	10.37	16.06	42.95	27.38	73.47	31.04	27.43

Figure 9

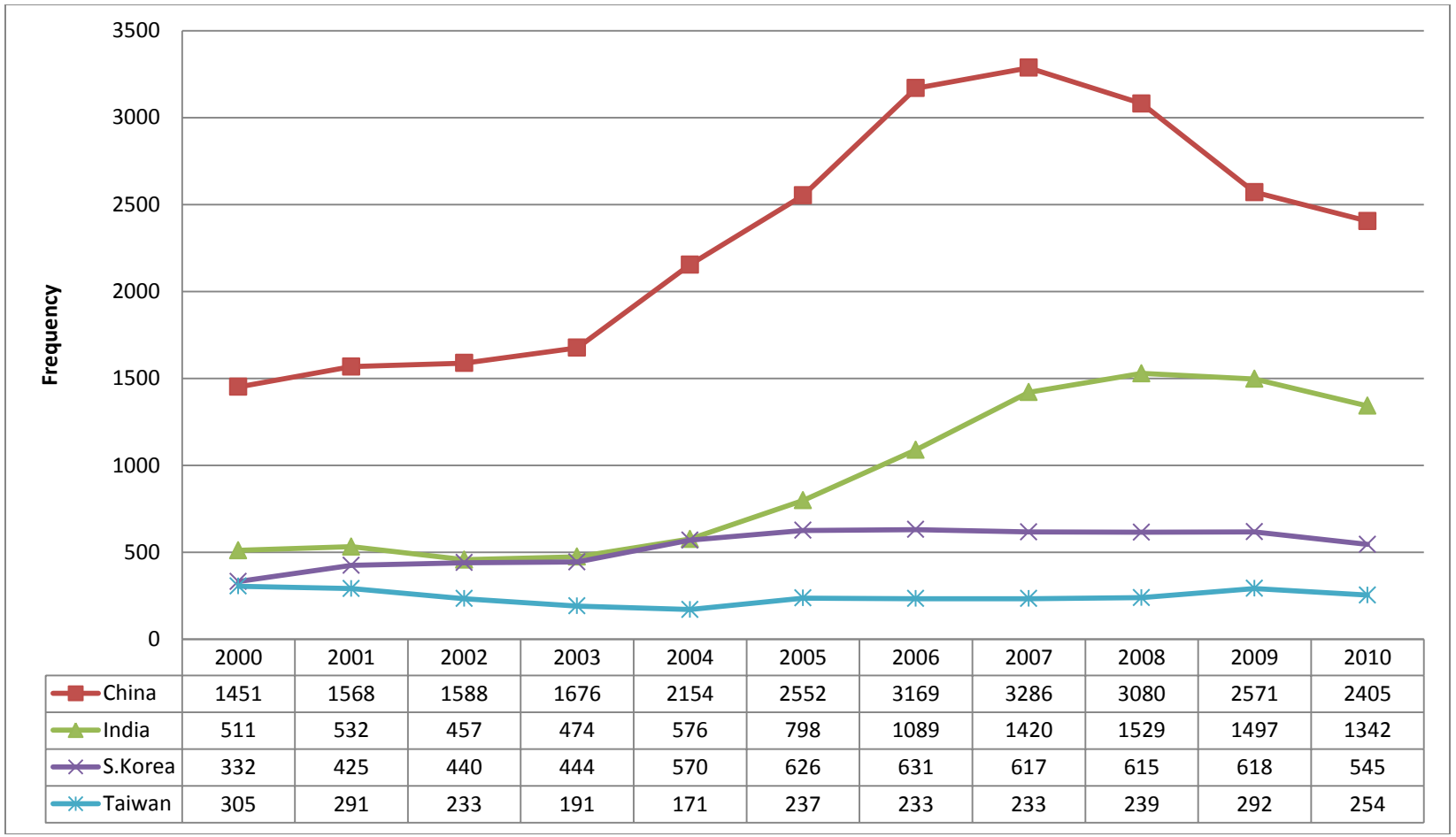
Number of Stayers and Non-stayers by Country



	Argentina	Brazil	Canada	China	Egypt	Germany	Greece	India	Iran	Italy	Japan	Mexico	S. Korea	Romania	Russia	Spain	Taiwan	Thailand	Turkey	UK
NON-STAY	207	548	598	1829	229	416	263	990	67	307	432	694	2229	111	220	189	1010	1468	921	124
STAY	428	430	1401	25500	510	714	499	10225	760	517	618	686	5863	959	1150	251	2679	530	2046	328

Figure 10

Number of Stayers by Year from China, India, South Korea, and Taiwan



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
China	1451	1568	1588	1676	2154	2552	3169	3286	3080	2571	2405
India	511	532	457	474	576	798	1089	1420	1529	1497	1342
S.Korea	332	425	440	444	570	626	631	617	615	618	545
Taiwan	305	291	233	191	171	237	233	233	239	292	254

Since the decision to stay in the United States included the postdoctoral appointments, (generally known as *postdocs*) in this study, Table 6 and Table 7 present the findings of the frequency of postdoc positions of this study sample. Table 6 presents the distribution of postdoc positions across the academic fields. Among the study sample, 53% of foreign doctorate recipients took a postdoc position, while 46% did not take a postdoc position. Approximately 84% of the foreign doctorate recipients in biological/biomedical sciences chose postdoc positions, while only 28% of the foreign doctorate recipients in computer and information sciences had postdoc positions. Physical sciences such as chemistry and physics also had a higher rate of postdoc position, 73%, and 74% respectively, while it was rare to have a postdoc position for a PhD in economics (12%). Table 7 presents the distribution of postdoc position and the stay pattern. Among those who took a postdoc position, 86% of them stayed in the United States, while 13% of them did not stay in the United States. On the other hand, the stay rate was lower for those who did not take a postdoc position compared to that of those who took a postdoc position. Among those who did not take a postdoc position, 77% of them stayed in the United States, and 23% of them did not stay in the United States. Thus, the findings suggest that there is about 9% difference of stay rate between those who took a postdoc position and those who did not take a postdoc position. Thus, the stay rate for this sample which included both those who took a postdoc position and those who did not, 81%, is lower than the stay rate among those who took a postdoc position (86%), but higher than the stay rate among those who did not take a postdoc position (77%).

Table 7

Percentage Distribution of Postdoc Positions within PhD Fields

	Agriculture	Bio sci	Engineering	Computer	Math	Chemistry	Physics	Economics	Total
Postdoc	63.30 %	84.08 %	42.25 %	28.06 %	51.33 %	73.32 %	74.47 %	12.34 %	53.75 %
No Postdoc	36.70 %	15.92 %	57.75 %	71.94 %	48.67 %	26.68 %	25.53 %	87.66 %	46.25 %

Table 8

Distribution of Postdoc Positions and Stay Pattern

	Stay in the U.S.	Non-stay in the U.S.	Total
Postdoc (frequency)	23,009	3,670	26,679
Row %	86.24 %	13.76 %	100.00 %
Column %	56.54 %	41.05 %	53.75 %
No postdoc (frequency)	17,688	5,270	22,958
Row %	77.05 %	22.95 %	100.00 %
Column %	43.46 %	58.95 %	46.25 %
Total (frequency)	40,697	8,940	49,637
Row %	81.99 %	18.01 %	100.00 %
Column %	100.00 %	100.00 %	100.00 %

Note: $\chi^2(1) = 707.08$ ($p < 0.01$)

Factors Predicting the Foreign Doctorate Recipients' Decisions to Stay in the United States

This section presents the results of logistic regression analyses to predict what factors influenced the foreign doctorate recipients' decisions to stay in the United States. The results are reported in odds ratio (the exponent of the log odds) rather than the log odds because they are easier to interpret and understand (Jaccard, 2001; Long & Freese, 2006). This section begins by reporting the results of individual factors that predicted their decisions to stay in the United States. Then, I present the results of institutional factors and country factors that predicted their decisions to stay, respectively. Last, I present the results of the final model with all the factors in the full model with and without country fixed effects.

Individual factors. Table 9 presents the results of logistic regression analysis on individual factors that predicted the foreign doctorate recipients' decisions to stay in the United States (Model 1). The pseudo-R^2 of Model 1 is 0.15[8]. The results suggest that individual variables significantly predict their decisions to stay in the United States. The odds of staying in the United States were 16% greater for female foreign doctorate recipients than male foreign doctorate recipients (odds ratio=1.16, p <0.01). Furthermore, to explore whether female effect varied by country of origins, 20 separate logistic regression analyses on individual factors by country were conducted to compare effects between male and female from each country (Table 10: Model 1-1). Examining the female effect by countries, some Asian countries had significant female effects. For example, the odds of staying were 45% greater for female doctorate recipients from India (odds ratio=1.45, $p < 0.05$), 50% greater for female doctorate recipients from Taiwan (odds ratio=1.5, $p < 0.05$), and 40% greater for female doctorate recipients from China (odds ratio=1.4, $p < 0.05$) than male counterparts from each country (Table 10). The

[8] To report the goodness of fit, the pseudo-R^2 used is McFadden's R^2 that is defined as 1- L_1/L_0. It compares a model with just intercept to a model with all explanatory variables (Long & Freese, 2006).

direction of female effect was reversed for the doctorate recipients from Thailand. The odds of staying were 52% less for female doctorate recipients from Thailand compared to male doctorate recipients from Thailand (odds ratio=0.48, $p < 0.05$). Although Japan and South Korea are Asian countries, no gender difference was found on odds of staying in the United States. There was no gender difference on odds of staying among doctorate recipients from Argentina, Brazil, Canada, Egypt, Germany, Greece, Iran, Italy, Mexico, South Korea, Romania, Russia, Spain, Turkey, Japan, and the United Kingdom ($p > 0.05$).

The age when the PhD degree was awarded was another significant predictor of the foreign doctorate recipients' staying in the United States. The age was negatively associated with the odds of staying in the United States (odds ratio=0.92, $p < 0.01$). When the age of a foreign doctorate recipient increased one year, the odds of staying in the United States decreased by 8%. Married foreign doctorate recipients were two times more likely to stay in the United States than non-married foreign doctorate recipients (odds ratio=2.00, $p < 0.01$). However, having a child under age 6 reduced the odds of staying in the United States by 18% compared to those who did not have a child (odds ratio=0.82, $p < 0.01$). Meanwhile, whether a parent had a bachelor's degree or not did not predict the foreign doctorate recipients' decisions to stay in the United States ($p > 0.05$).

Educational background played a significant role predicting the odds of staying in the United States. When a foreign doctorate recipient had a selective bachelor's degree from his or her home country, the odds of staying in the United States decreased by 16% compared to those who did not have a selective bachelor's degree from their home country (odds ratio=0.84, $p < 0.01$). The foreign doctorate recipients' educational experiences in the United States also predicted the odds of staying. More years in a PhD program increased the odds of staying in the

United States (odds ratio=1.03, $p < 0.01$). One more year in the PhD program increased the odds of staying in the United States by 3%. The primary funding source for PhD studies influenced the odds of staying, too. When a foreign doctorate recipient was primarily funded by a research assistantship rather than self, family, or a loan during the PhD studies, he or she had a 3.3 times higher odds of staying in the United States (odds ratio=3.33, $p < 0.01$). When a foreign doctorate recipient was primarily funded by a teaching assistantship rather than self, family, or a loan, the odds of staying was 2.5 times higher (odds ratio=2.54, $p < 0.01$). On the other hand, when a foreign doctorate recipient was funded by his or her own government, the odds of staying in the United States was 79% less than those who were funded by self, family or a loan (odds ratio=0.21, $p < 0.01$). Last, the academic fields greatly predicted the odds of staying in the United States. The foreign doctorate recipients in biological/biomedical sciences had a 3.8 times higher odds of staying in the United States compared to the foreign doctorate recipients in agriculture (odds ratio=3.87, $p < 0.01$). The foreign doctorate recipients in chemistry also showed a 2.6 times higher odds of staying than foreign doctorate recipients in agriculture (odds ratio=2.68, $p < 0.01$). Those who majored in engineering (42% of the study sample) had 88% higher odds of staying in the United States relative to those who majored in agriculture. On the other hand, the odds of staying of foreign doctorate recipients in economics were 30% less than the foreign doctorate recipients in agriculture (odds ratio=0.70, $p < 0.01$).

Whether the foreign doctorate recipients planned to work in industry or academia predicted the odds of staying in United States. The foreign doctorate recipients whose career plans were in industry were more likely to stay in the United States compared to those whose career plans were in academia (odds ratio=1.80, $p < 0.01$). Those whose career plans were in industry had 80% higher odds of staying in the United States compared to those in academia.

Examining the relationship between the PhD awarded year dummies and the decision to stay in the United States, there was no difference of odds of staying in the United States among foreign doctorate recipients who graduated in 2000, 2001, 2002, and 2010 ($p > 0.05$). However, the odds of staying of the foreign doctorate recipients who graduated in 2003 declined by 32% compared to the foreign doctorate recipients in 2000 (odds ratio=0.68, $p < 0.01$). There was a statistically significant increase of odds of staying from 2004 to 2009 compared to those of 2000. In particular, the foreign doctorate recipients who earned their doctoral degrees in 2006 had the highest odds of staying during the study period, with a 58% higher odds of staying than those who graduated in 2000 (odds ratio=1.58, $p < 0.01$).

Institutional factors. Table 11 presents the results of logistic regression analysis on institutional factors that predicted the foreign doctorate recipients' decisions to stay in the United States (Model 2). The pseudo-R^2 of Model 2 is 0.02, indicating that Model 1 (pseudo-R^2 =0.15) better predicts the outcome compared to Model 2. The institutional factors used in this study were related to the student's doctoral institution in the United States. The results suggest that overall, the variations of PhD institutions did not influence the odds of a foreign doctorate recipient's staying in the United States. The majority of foreign doctorate recipients (82%) in this study earned their doctoral degrees from very high research active institutions according to Carnegie Classifications (Table 1). Graduating from a very high research active institution decreased the odds of staying in the United States by 75% compared to graduating from the smaller institutions, which granted less than 20 research doctoral degrees annually (odds ratio=0.25, $p < 0.05$). Graduating from high research active institutions and doctoral granting institutions did not have any different odds of staying relative to graduating from the smaller institutions that had less than 20 research doctoral degrees granting annually ($p > 0.05$).

Whether a foreign doctorate recipient attended a public institution or a private did not predict the odds of staying in the United States, either ($p > 0.05$). In addition, the level of institutional research expenditure had no effect on predicting the odds of staying in the United States ($p > 0.05$). While the selectivity of one's bachelor's degree was a significant predictor on foreign doctorate recipient's staying in the United States., whether a foreign doctorate recipient graduated from the most prestigious PhD program or not did not predict the odds of staying in the United States ($p > 0.05$).

Country factors. Table 12 presents the results of logistic regression analysis on home country factors that predicted the foreign doctorate recipients' decisions to stay in the United States (Model 3). The pseudo-R^2 of Model 3 is 0.15, indicating that Model 3 better predicts the outcome compared to Model 2 (pseudo-R^2= 0.02). The results suggest that some home country factors significantly influenced the foreign doctorate recipients' decisions to stay in the United States. While a country's GDP per capita centered on the U.S.'s GDP per capita was not a significant predictor on estimating the foreign doctorate recipients' odds of staying in the United States, the unemployment rate of one's home country significantly predicted their decisions to stay in the United States. There was a positive relationship between the unemployment rate of one's home country and the odds of staying in the United States (odds ratio=1.01, $p < 0.05$). When the unemployment rate of one's home country increased 1%, the foreign doctorate recipients' odds of staying in the United States increased 1%. The R&D expenditure of one's home country also affected the foreign doctorate recipients' decisions to stay in the United States. While the public expenditure on education and the number of world-class universities had no significant effect on predicting the odds of staying in the United States, the level of expenditure on R&D sector of one's country was negatively associated with the foreign doctorate recipient's

odds of staying in the United States (odds ratio=0.78, $p < 0.01$). As 1% of R&D expenditure on country's GDP increased, the foreign doctorate recipients' odds of staying in the United States decreased 22%. The more investment in R&D, the more their doctorate recipients returned to their country.

Country of origins significantly predicted the foreign doctorate recipients' odds of staying in the United States. The foreign doctorate recipients from China, India, Iran, and Romania had higher odds of staying, while those from Brazil, Mexico, Spain, and Thailand had lower odds of staying in the United States compared to the reference group, those from Argentina. The foreign doctorate recipients from China had a nine times higher odds of staying in the United States compared to the foreign doctorate recipients from Argentina (odds ratio=9.65, $p < 0.01$). Those who were from Iran and India had about a six times higher odds of staying in the United States compared to those from Argentina (odds ratio=6.02, $p < 0.01$ for Iran; odds ratio= 5.87, $p < 0.01$ for India). The foreign doctorate recipients from Romania also had higher odds of staying, which was four times higher odds of staying in the United States compared to those from Argentina (odds ratio=4.57, $p < 0.01$). The foreign doctorate recipients from Canada, Egypt, Germany, Italy, Turkey, and the United Kingdom had the same odds of staying in the United States compared to those from Argentina. On the other hand, the foreign doctorate recipients from Thailand had 80% lower odds of staying in the United States relative to those from Argentina (odds ratio=0.20, $p < 0.01$). The foreign doctorate recipients from Brazil also had 55% lower odds of staying relative to those from Argentina (odds ratio=0.45, $p < 0.01$). The foreign doctorate recipients from Mexico, Spain, Japan, and Greece had lower odds of staying in the United States compared to counterparts from Argentina.

Table 9
Estimating the Odds of Foreign Doctorate Recipients' Staying in the United States: Results of Logistic Regression Analysis on Individual Factors (Model 1)

Variables	Odds Ratio	S. E.
Demographic Characteristics		
Female	1.16**	0.04
Age	0.92**	0.005
Marital status	2.00**	0.07
Having children under 6	0.82**	0.03
Having children aged 6-18	0.85*	0.05
A parent with a bachelor's degree	1.02	0.03
Educational Background		
Having a selective foreign BA	0.84**	0.02
Time in PhD Program	1.03**	0.01
Primary funding source for PhD study		
RA as primary funding source	3.33**	0.31
TA as primary funding source	2.54**	0.25
Scholarship, fellowship & grant	1.83**	0.18
Foreign government	0.21**	0.02
Self, family or loan (Reference)		
PhD field		
Biological/biomedical sci	3.87**	0.33
Engineering	1.88**	0.14
Computer & information sci	2.00**	0.18
Mathematics	1.72**	0.16
Chemistry	2.68**	0.26
Physics	1.55**	0.14
Economics	0.70**	0.06
Agriculture (Reference)		
Career plan (0:academia,1:industry)	1.80**	0.06

Variables	Odds Ratio	S. E.
Year PhD awarded		
2000 (Reference)		
2001	1.15	0.09
2002	0.93	0.07
2003	0.68**	0.05
2004	1.39**	0.09
2005	1.48**	0.09
2006	1.58**	0.10
2007	1.56**	0.10
2008	1.43**	0.09
2009	1.30**	0.08
2010	Omitted	
Log likelihood	- 12389.20	
Pseudo R^2	0.15	
N	32,840	

* $p < 0.05$, ** $p < 0.01$.

Table 10

Estimating Female Effect on the Odds of Staying in the United States by Country: Results of 20 Logistic Regression Analyses on Individual Factors by Countries (Model 1-1)

Significant* (Odds ratio)	Non-significant
India (1.45), Taiwan (1.50), China (1.40), & Thailand (0.48)	Argentina, Brazil, Canada, Egypt, Germany, Greece, Iran, Italy, Mexico, South Korea, Romania, Russia, Spain, Turkey, Japan, & United Kingdom

* $p < 0.05$.

Table 11
Estimating the Odds of Foreign Doctorate Recipients' Staying in the United States: Results of Logistic Regression Analysis on Institutional Factors (Model 2)

Variables	Odds Ratio	S. E.
Carnegie Classification		
Very high research active institution	0.25*	0.15
High research active institution	0.46	0.32
Doctoral granting institution	0.32	0.32
Others (Reference)		
Institutional control (Public)	1.04	0.13
Research expenditure	1.00	0.000000167
Prestigious PhD program	0.98	0.03
Log likelihood	- 26411.45	
Pseudo R^2	0.02	
N	55,385	

Note: 319 PhD institution fixed-effect dummy variables (Reference: Alabama A&M University) are controlled in the model.
* $p < 0.05$, ** $p < 0.01$.

Table 12
Estimating the Odds of Foreign Doctorate Recipients' Staying in the United States: Results of Logistic Regression Analysis on Country Factors (Model 3)

Variables	Odds Ratio	S. E.
GDP per capita centered on the US GDP	1.00	0.000402
Unemployment rate	1.01*	0.009
% of R&D expenditure on GDP	0.78**	0.03
Public expenditure on education per capita	1.00	0.00003
Number of world-class university per capita	1.80	0.98
Country of origins		
Argentina (Reference)		
Brazil	0.45**	0.04
Canada	0.87	0.11
China	9.65**	1.15
Egypt	1.05	0.12
Germany	0.88	0.10
Greece	0.78*	0.08
India	5.87**	0.59
Iran	6.02**	0.98
Italy	1.17	0.07
Japan	0.71*	0.21
Mexico	0.53**	0.06
S. Korea	2.16**	0.26
Romania	4.57**	0.63
Russia	3.12**	0.38
Spain	0.57**	0.07
Taiwan	1.56**	0.15
Thailand	0.20**	0.02
Turkey	1.14	0.11
United Kingdom	Omitted	
Log likelihood	- 27911.91	
Pseudo R^2	0.15	
N	68,946	

* $p < 0.05$, ** $p < 0.01$.

Factors predicting the foreign doctorate recipients' decisions to stay in the United States by the full model. Table 13 presents the results of logistic regression analysis of the full model. The full model includes individual factors, institutional factors, and country factors to determine which factors predicted the foreign doctorate recipients' decisions to stay in the United States after controlling for covariates. Model 4 is a full model without country fixed effects, while Model 5 is a full model with country fixed effects. By comparing two models, this study found significant changes among country-related estimators due to the country fixed effects. The pseudo-R^2 of Model 4 is 0.19, and the pseudo-R^2 of Model 5 is 0.24. The increases of pseudo-R^2 values suggest that the fit of the model improved from Model 4 to Model 5.

First, the results of full model with country fixed effects (Model 5) suggest that in general, the odds ratio of individual variables slightly decreased as institutional variables and country variables were controlled. For example, married foreign doctorate recipients were 200% more likely to stay in the United States compared to non-married counterparts in Model 1 (odds ratio=2.00, $p < 0.01$). However, in Model 5, the odds ratio of staying declined to 1.38, which indicated that married foreign doctorate recipients were only 38% more likely to stay in the United States than non-married after controlling for institutional and country variables (odds ratio=1.38, $p < 0.01$). The level of parent's education was not a significant factor predicting the odds of staying in Model 1 ($p > 0.05$), but it became a significant predictor as institutional variables and country variables were controlled in Model 5. The foreign doctorate recipients whose parent had a bachelor's degree or beyond were 9% more likely to stay in the United States compared to those whose parent did not have a bachelor's degree (odds ratio=1.09, $p < 0.05$).

The effect of one's selective foreign bachelor's degree changed as institutional variables and country variables were controlled in Model 5. Before controlling for institutional variables

and country variables, the foreign doctorate recipient who had a selective bachelor's degree from one's home country were 16% less likely to stay in the United States (odds ratio=0.84, $p < 0.01$). However, after controlling for institutional variables and country variables, the direction of having a selective foreign bachelor's degree effect changed (Model 5). In Model 5, those who had selective foreign bachelor's degrees were 9% more likely to stay in the United States compared to those who did not have selective foreign bachelor's degrees (odds ratio=1.09, $p < 0.05$). This change results from the country fixed effects that were taken into account in Model 5. Model 4, which included institutional variables and country variables without country dummies, had the similar results to Model 1 (Model 4: odds ratio=0.87, $p < 0.05$; Model 1: odds ratio=0.84, $p < 0.01$). In sum, the results after controlling for the unobserved effects of home countries suggest that the effect of selective foreign bachelor's degree was positively associated with the foreign doctorate recipients' decisions to stay in the United States.

The time effect also changed as institutional variables and country variables were controlled in Model 5. Before controlling for institutional variables and country variables, the year 2001 was not different from the reference, year 2000 ($p > 0.05$). However, the year 2001 became a significant predictor after controlling for institutional factors and country factors (Model 5). That is, the odds of staying of foreign doctorate recipients who graduated in 2001 were 56% greater compared to those who graduated in 2000 (odds ratio=1.56, $p < 0.01$). While the odds of staying of the foreign doctorate recipients who graduated in 2003 decreased by 32% compared to the foreign doctorate recipients in 2000 (odds ratio=0.68, $p < 0.01$) before controlling for institutional variables and country variables, the time effect in 2003 became non-significant after controlling for institutional factors and country factors. In other words, though

the odds of staying in the United States decreased in 2003 compared to the year 2000, the smaller odds ratio of 2003 was not a statistically significant decrease from 2000 ($p > 0.05$).

Next, all institutional variables became non-significant predictors except the prestige of PhD institution variable as individual variables and country variables were controlled in Model 5. Before controlling for individual variables and country variables, the very high research active institution according to Carnegie Classifications was a significant predictor on estimating the odds of staying in the United States in Model 2 (odds ratio=0.25, $p < 0.01$). However, after controlling for individual variables and country variables, there was no difference between the very high research active institutions and other institutions in Model 5 ($p > 0.05$). This finding suggests that the effect of very high research active institutions in Model 2 was due to the differences of individuals who attended the very high research active institutions or their home country variables rather than the institutional variances. On the other hand, the prestige of a PhD program was not a significant predictor in Model 2, but after controlling for individual variables and country variables, the effect of a prestigious PhD program became significant in Model 4 (without country fixed effects) and Model 5 (with country fixed effects). Those who graduated from the most prestigious PhD programs had 15% lower odds of staying in the United States compared to those who did not graduate from the most prestigious PhD programs (odds ratio=0.85, $p < 0.05$).

In addition, the effects of some country predictors changed as individual variables and institutional variables were controlled in Model 5. Again, a country's GDP per capita centered on the U.S.'s GDP per capita was not a significant predictor on estimating the foreign doctorate recipients' odds of staying in the United States, while the unemployment rate of one's home country significantly predicted their decisions to stay in the United States after controlling for

individual variables and institutional variables. When the unemployment rates were high in their home countries, the foreign doctorate recipients were more likely to stay in the United States. The foreign doctorate recipients' odds of staying in the United States increased 5% when the unemployment rate of one's home country increased 1% (odds ratio=1.05, $p < 0.01$). The R&D expenditure of one's home country became a non-significant predictor as individual variables and institutional variables were controlled in Model 5 ($p > 0.05$). On the other hand, the public expenditure on education became a significant predictor as individual variables and institutional variables were controlled in Model 5. The level of public expenditure on education of one's country was negatively associated with the foreign doctorate recipient's odds of staying in the United States (odds ratio=0.99, $p < 0.05$). As $1.00 of public expenditure on education per capita increased, the foreign doctorate recipients' odds of staying in the United States decreased 1%. The more investment in education of one's home country, the more that country's doctorate recipients returned home.

The odds ratio of country fixed effects also changed as individual variables and institutional variables were controlled in Model 5. The number of countries that had significant differences from the reference country, Argentina, decreased in Model 5. In Model 3, the foreign doctorate recipients from Canada, Egypt, Germany, Italy, Turkey, and the United Kingdom had the same odds of staying in the United States compared to those from Argentina ($p > 0.05$). As individual variables and institutional variables were controlled in Model 5, Greece, Japan, Mexico, Spain, and Taiwan were newly added to the countries that had no different odds of staying relative to Argentina ($p > 0.05$). This suggests that the significant differences between the foreign doctorate recipients from the reference country, Argentina, and counterparts from Greece, Japan, Mexico, Spain, and Taiwan before controlling for covariates resulted from the individual

variations from those countries rather than country variances. Thus, after controlling for individual variables and institutional variables, no difference was found between the foreign doctorate recipients from the reference country, Argentina, and counterparts from Greece, Japan, Mexico, Spain, and Taiwan in Model 5 ($p > 0.05$). While China, India, Iran, Romania, and Russia had higher odds of staying, only two countries, Brazil and Thailand, had lower odds of staying in the United States relative to Argentina after controlling for individual variables and institutional variables. Before controlling for individual variables and institutional variables, the foreign doctorate recipients from China had a nine times higher odds of staying in the United States relative to those from Argentina (odds ratio=9.65, $p < 0.01$). However, the odds ratio of China declined after controlling for individual variables and institutional variables.

In Model 5, the foreign doctorate recipients from China had five times higher odds of staying in the United States compared to those from Argentina (odds ratio=5.76, $p < 0.01$). The foreign doctorate recipients who were from Iran had six times higher odds of staying in the United States relative to those from Argentina (odds ratio=6.35, $p < 0.01$), and those from India had three times greater odds of staying (odds ratio=3.17, $p < 0.01$). On the other hand, the foreign doctorate recipients from Thailand had 80% lower odds of staying in the United States compared to those from Argentina (odds ratio=0.20, $p < 0.01$). This odds ratio was the same before and after controlling for individual variables and institutional variables. The foreign doctorate recipients from Brazil had 43% lower odds of staying relative to those from Argentina after controlling for individual variables and institutional variables (odds ratio=0.57, $p < 0.01$).

Last, to examine the country fixed effects, I compared the full model with and without country fixed effects. Model 4 is a full model without country fixed effects, and Model 5 is a full model with country fixed effects. The results show that while most of individual variables and

institutional variables had no major differences between with and without country fixed effects, all country variables showed significant differences between Model 4 and Model 5. All country variables were significant predictors without country fixed effects in Model 4. Both a country's GDP per capita centered on the U.S.'s GDP per capita and the public expenditure on education were negatively associated with the foreign doctorate recipients' odds of staying in the United States (GDP odds ratio=0.99, $p < 0.01$; Education odds ratio=0.99, $p < 0.01$). A country's unemployment rate, the percentage of R&D expenditure on GDP, and the number of world-class universities per capita in their countries were positively associated with the foreign doctorate recipients' odds of staying in the United States (Unemployment rate odds ratio=1.03, $p < 0.01$; R&D odds ratio=1.26, $p < 0.01$; WCU odds ratio=1.84, $p < 0.01$). However, after country fixed effects were added in Model 5, only two variables, the unemployment rate and the public expenditure on education per capita, remained significant predictors, and the other predictors became non-significant.

Each country dummy variable in Model 5 absorbed the effects particular to each country (Allison, 2009). For example, there was a negative relationship between a country's GDP per capita centered on the U.S.'s GDP per capita and the foreign doctorate recipient's odds of staying in the United States without country fixed effects in Model 4 (odds ratio=0.99, $p < 0.01$). As $1.00 of a country's GDP per capita centered on the U.S.'s GDP per capita increased, the foreign doctorate recipients' odds of staying in the United States decreased 1%. However, after controlling for country fixed effects in Model 5, the GDP effect on predicting the foreign doctorate recipients' odds of staying in the United States disappeared ($p > 0.05$). This suggests that the significant GDP effect in Model 4 was mediated by the unobserved variances across

countries. Thus, after controlling for unobserved country characteristics such as culture and lifestyle, the GDP was not significant predicting the odds of staying in Model 5.

Table 13
Estimating the Odds of Foreign Doctorate Recipients' Staying in the United States: Results of Logistic Regression Analyses of Full Model

	Full Model without Country Fixed Effects (Model 4)		Full Model with Country Fixed Effects (Model 5)	
Variables	Odds Ratio	S.E.	Odds Ratio	S. E.
Demographic Characteristics				
Female	1.14**	0.05	1.16**	0.05
Age	0.94**	0.006	0.95**	0.006
Marital Status	1.68**	0.07	1.38**	0.06
Having children under 6	0.82**	0.04	0.86**	0.04
Having children aged 6-18	0.81**	0.06	0.78**	0.06
A parent with a bachelor's degree	1.05	0.04	1.09*	0.04
Educational Background				
Having a selective foreign BA	0.87*	0.03	1.09*	0.04
Years in PhD Program	1.02	0.01	1.05**	0.01
Primary funding source for PhD				
RA as primary funding source	3.04**	0.32	2.16**	0.23
TA as primary funding source	2.17**	0.24	1.60**	0.18
Scholarship, fellowship & Grant	1.68**	0.19	1.50**	0.17
Foreign Government	0.20**	0.02	0.40**	0.05
Self, family or loan(Reference)				
PhD field				
Biological/biomedical sci	3.63**	0.38	2.97**	0.32
Engineering	1.85**	0.18	1.71**	0.17
Computer & information sci	2.15**	0.25	1.80**	0.21
Mathematics	1.80**	0.21	1.38**	0.16
Chemistry	2.69**	0.32	2.23**	0.27
Physics	1.64**	0.19	1.29*	0.15
Economics	0.82	0.09	0.73**	0.08

Variables	Full Model without Country Fixed Effects (Model 4) Odds Ratio	S.E.	Full Model with Country Fixed Effects (Model 5) Odds Ratio	S. E.
Agriculture (Reference)				
Career plan	1.67**	0.07	1.39**	0.06
(0:academia,1:industry)				
Year PhD awarded				
2000 (Reference)				
2001	1.78**	0.19	1.56**	0.18
2002	1.36**	0.14	1.22	0.14
2003	0.94	0.09	0.84	0.09
2004	1.91**	0.17	1.70**	0.16
2005	1.77**	0.16	1.71**	0.17
2006	1.84**	0.14	1.84**	0.15
2007	1.81**	0.15	1.85**	0.16
2008	1.65**	0.13	1.72**	0.14
2009	1.43**	0.11	1.44**	0.11
2010	Omitted		Omitted	
Institutional characteristics				
Carnegie Classification				
Very high research active Institution	0.47	0.39	0.51	0.47
High research active Institution	1.39	1.61	1.10	1.33
Doctoral granting institution	0.51	0.59	0.46	0.57
Others (Reference)				
Institutional control (Public)	0.73	0.18	0.80	0.20
Research expenditure	1.00	0.000000039	1.00	0.0000000398
Prestige of PhD program	0.85*	0.05	0.85*	0.05

Variables	Full Model without Country Fixed Effects (Model 4)		Full Model with Country Fixed Effects (Model 5)	
	Odds Ratio	S.E.	Odds Ratio	S. E.
Country Characteristics				
GDP per capita centered on US GDP	0.99**	0.000423	1.00	0.00097
Unemployment rate	1.03**	0.008	1.05**	0.02
% of R&D expenditure on GDP	1.26**	0.38	0.96	0.07
Public expenditure on education per capita	0.99**	0.00006	0.99*	0.00006
Number of world-class University	1.84**	0.42	1.61	1.17
Country of origin				
Argentina (Reference)				
Brazil			0.57**	0.12
Canada			0.77	0.17
China			5.76**	1.34
Egypt			0.74	0.16
Germany			0.91	0.20
Greece			0.85	0.17
India			3.17**	0.61
Iran			6.35**	1.96
Italy			1.14	0.22
Japan			0.74	0.27
Mexico			0.89	0.21
S. Korea			1.69*	0.42
Romania			3.36**	0.85
Russia			2.14**	0.49
Spain			0.68	0.17
Taiwan			1.15	0.24

	Full Model without Country Fixed Effects (Model 4)		Full Model with Country Fixed Effects (Model 5)	
Variables	Odds Ratio	S.E.	Odds Ratio	S. E.
Thailand			0.20**	0.05
Turkey			0.94	0.17
United Kingdom			Omitted	
Log likelihood	- 9456.79		-8922.51	
Pseudo R^2	0.19		0.24	
N	25,756		25,756	

Note: 319 PhD institution fixed-effect dummy variables (Reference: Alabama A&M University) are controlled in the model.
* $p < 0.05$, ** $p < 0.01$.

Factors predicting the foreign doctorate recipients' staying in the United States by countries. Table 14 presents the results of logistic regression analyses of four countries that had the largest numbers of stayers in the United States: China, India, South Korea, and Taiwan. Four countries made up 73% of the foreign doctorate recipients in this study. In particular, China had the largest number of the foreign doctorate recipients in this study, as approximately 40% of the study sample came from China. Thus, it is important to examine further whether significant predictors explained by the full model varied by countries. The results by countries suggest that the factors predicting one's staying in the United States varied by countries, indicating that the country of origin had a unique contribution explaining the variances.

China. Among Chinese doctorate recipients, female doctorate recipients were more likely to stay in the United States relative to male doctorate recipients. The odds of staying were 47% greater for Chinese female doctorate recipients relative to Chinese male doctorate recipients (odds ratio=1.47, $p < 0.01$). The younger doctorate recipients tended to stay more in the United

States (odds ratio=0.95, $p < 0.01$), and married doctorate recipients were more likely to stay in the United States (odds ratio=1.49, $p < 0.01$). However, having children and having a parent who had a bachelor's degree or beyond did not significantly predict the odds of staying in the United States ($p > 0.05$). For Chinese doctorate recipients, educational background did not significantly predict their odds of staying, either. That is, having a selective bachelor's degree from China and years in PhD programs did not predict the odds of staying in the United States ($p > 0.05$). The primary funding source for their PhD studies did not predict their decisions to stay in the United States, except for the foreign government source. When Chinese doctorate recipients were funded by Chinese government rather their family, own, or a loan, the odds of staying in the United States decreased 96% (odds ratio=0.04, $p < 0.05$). The field of study significantly predicted the odds of staying in the United States. Chinese doctorate recipients who majored in biological/biomedical sciences had four times higher odds of staying in the United States compared to Chinese doctorate recipients who majored in agriculture (odds ratio=4.08, $p < 0.01$). Those who majored in computer/information sciences had a 3.6 times higher odds of staying in the United States compared to those who majored in agriculture (odds ratio=3.68, $p < 0.01$). Chinese doctorate recipients in engineering showed a 2.7 times higher odds of staying than Chinese doctorate recipients in agriculture (odds ratio=2.71, $p < 0.01$). On the other hand, the odds of staying for Chinese doctorate recipients in economics were 53% less than those in agriculture (odds ratio=0.47, $p < 0.01$). Chinese doctorate recipients who planned to work in industry had 76% higher odds of staying in the United States relative to Chinese doctorate recipients whose career plans were in academia (odds ratio=1.76, $p < 0.01$). Among Chinese doctorate recipients, the institutional factors and country factors did not significantly predict the odds of staying in the United States at all ($p > 0.05$).

India. The female doctorate recipients from India were more likely to stay in the United States relative to male counterparts. The odds of staying were 50% greater for Indian female doctorate recipients relative to Indian male doctorate recipients (odds ratio=1.50, $p < 0.05$). Married Indian doctorate recipients had 71% greater odds of staying in the United States compared to non-married counterparts (odds ratio=1.71, $p < 0.01$). Having children reduced the odds of staying in the United States by 44% (odds ratio=0.56, $p < 0.05$). Whether a parent had a bachelor's degree or beyond was not a significant predictor affecting the odds of staying in the United States ($p > 0.05$). Like Chinese doctorate recipients, the primary funding source for the PhD studies did not predict Indian doctorate recipients' decisions to stay in the United States, except for the foreign government source. For Indian doctorate recipients who were funded by their government rather than their family, own, or a loan, the odds of staying in the United States decreased 98% (odds ratio=0.02, $p < 0.05$). Among doctorate recipients from India, only those who majored in physics and economics had significantly different odds of staying from those who majored in agriculture (odds ratio=0.26, $p < 0.01$ for physics; odds ratio=0.13, $p < 0.01$ for economics). Indian doctorate recipients whose career plans were in industry had two times higher odds of staying relative to counterparts whose career plans were in academia (odds ratio=2.32, $p < 0.01$). Among Indian doctorate recipients, the institutional factors and country factors did not predict the odds of staying, with the exception of the prestige of PhD program variable. The doctorate recipients from India who graduated from the most prestigious PhD programs were less likely to stay in the United States. The odds of staying in the United States declined 26% when doctorate recipients from India graduated from the most prestigious PhD programs relative to doctorate recipients from India who did not graduate from the most prestigious PhD programs (odds ratio=0.74, $p < 0.05$).

South Korea. Unlike China, India, and Taiwan, female South Korean doctorate recipients had no different odds of staying compared to male counterparts ($p > 0.05$). There was no gender difference of odds of staying in the United States. Age was not a significant predictor for the doctorate recipients from South Korea, either ($p > 0.05$). However, married doctorate recipients were more likely to stay more in the United States (odds ratio=1.94, $p < 0.01$). Although if a having a selective foreign bachelor's degree did not predict one's staying in the United States among Chinese, Indian, and Taiwanese students, having a selective bachelor's degree from South Korea was a significant predictor for South Korean doctorate recipients regarding their decisions to stay in the United States. South Korean doctorate recipients who graduated from Seoul National University, Yonsei University, Korea University, KAIST, and Sungkyunkwan University had 42% higher odds of staying in the United States relative to South Korean doctorate recipients who did not graduate from those institutions (odds ratio=1.42, $p < 0.01$). Being funded with a research assistantship was significant in predicting the odds of staying in the United States for South Koreans. South Korean doctorate recipients who were funded by research assistantships rather than their family, own, or a loan had about two times higher odds of staying in the United States (odds ratio=2.19, $p < 0.01$). The fields of study significantly predicted the odds of staying in the United States for South Koreans. Those who majored in biological/biomedical sciences and economics had significantly different odds of staying as opposed to those who majored in agriculture (odds ratio=3.43, $p < 0.01$ for biological/biomedical sciences; odds ratio=0.29, $p < 0.01$ for economics). South Korean doctorate recipients who majored in biological/biomedical sciences had three times higher odds of staying in the United States relative to those who majored in agriculture. Unlike China, India, and Taiwan, a career plan in industry was negatively associated with the odds of staying in the United States for South

Korean doctorate recipients. Among South Korean doctorate recipients, those who planned to work in industry had 84% less odds of staying in the United States compared to those who planned to work in academia (odds ratio=0.16, $p < 0.01$). Among South Korean doctorate recipients, some institutional factors and country factors were significant predictors on their decisions to stay in the United States. For example, when South Korean doctorate recipients graduated from high research active institutions or doctoral granting institutions according to Carnegie classifications, they were less likely to stay in the United States relative to South Korean doctorate recipients who graduated from the smaller institutions that granted less than 20 research doctoral degrees annually (odds ratio=0.11, $p < 0.05$ for high research active institution; odds ratio=0.07, $p < 0.05$ for doctoral granting institution). In addition, South Korea's GDP per capita centered on the U.S.'s GDP per capita was a significant predictor on estimating the odds of staying for South Korean doctorate recipients. As $1.00 of South Korea's GDP per capita centered on the U.S.'s GDP per capita increased, the odds of staying in the United States among doctorate recipients from South Korea decreased 1% (odds ratio=0.99, $p < 0.05$). South Korea's expenditure on the R&D sector was also a significant predictor on estimating the odds of staying of South Korean doctorate recipients, too. As 1% of R&D expenditure on South Korea's GDP increased, the odds of staying in the United States among South Korean doctorate recipients decreased 38% (odds ratio=0.62, $p < 0.01$).

Taiwan. The female foreign doctorate recipients from Taiwan were more likely to stay in the United States compared to male counterparts. The odds of staying were 61% greater for Taiwanese female doctorate recipients relative to male doctorate recipients (odds ratio=1.61, $p < 0.05$). Among the Taiwanese students, age, marital status, having children, having a parent with a bachelor's degree or beyond, and having a selective bachelor's degree from Taiwan did not

significantly predict their staying in the United States ($p > 0.05$). Like South Korean doctorate recipients, a research assistantship significantly predicted the odds of staying in the United States among Taiwanese doctorate recipients. Taiwanese doctorate recipients who were funded by research assistantships rather than their family, own, or a loan had about two times higher odds of staying in the United States (odds ratio=2.15, $p < 0.01$). Among Taiwanese doctorate recipients, those who majored in biological/biomedical sciences, chemistry, and economics had significantly different odds of staying from those who majored in agriculture (odds ratio=3.30, $p < 0.01$ for biological/biomedical sciences; odds ratio=5.22, $p < 0.01$ for chemistry; odds ratio=0.20, $p < 0.01$ for economics). Taiwanese doctorate recipients who planned to work in industry had seven times higher odds of staying in the United States relative to Taiwanese doctorate recipients who planned to work in academia (odds ratio=7.20, $p < 0.01$). All institutional factors and country factors did not significantly predict the odds of staying of Taiwanese doctorate recipients in the United States ($p > 0.05$).

Table 14
Estimating the Odds of Foreign Doctorate Recipients' Staying in the United States: Results of Logistic Regression Analyses by China, India, S. Korea & Taiwan (Model 6)

Variables	China Odds Ratio (S.E.)	India Odds Ratio (S.E.)	S. Korea Odds Ratio (S.E.)	Taiwan Odds Ratio (S.E.)
Demographic characteristics				
Female	1.47**	1.50*	1.24	1.61*
	(0.15)	(0.26)	(0.22)	(0.38)
Age	0.95**	1.00	0.96	0.96
	(0.01)	(0.02)	(0.02)	(0.03)
Marital status	1.49**	1.71**	1.94**	1.00
	(0.14)	(0.23)	(0.28)	(0.19)
Having children under 6	1.19	0.56*	0.81	1.03
	(0.13)	(0.15)	(0.10)	(0.22)
Having children aged 6-18	0.78	2.00	0.71*	0.57
	(0.16)	(0.34)	(0.10)	(0.20)
A parent with a bachelor's	1.04	1.07	1.09	1.15
degree	(0.09)	(0.19)	(0.11)	(0.18)
Educational background				
Having a selective foreign BA	0.94	1.07	1.42**	0.78
	(0.09)	(0.15)	(0.15)	(0.13)
Years in PhD Program	1.04	1.10*	1.03	1.11*
	(0.03)	(0.05)	(0.03)	(0.5)
Primary funding source for PhD				
RA as primary funding source	1.69	0.54	2.19**	2.15**
	(0.98)	(0.57)	(0.41)	(0.61)
TA as primary funding source	1.13	0.37	1.50	1.66
	(0.66)	(0.39)	(0.35)	(0.53)
Scholarship, fellowship &	1.48	0.49	1.55	1.52
Grant	(0.87)	(0.52)	(0.36)	(0.50)
Foreign Government	0.04*	0.02*	0.81	0.15**
	(0.06)	(0.04)	(0.28)	(0.09)
Self, family or loan(Reference)				
PhD field				
Biological/biomedical sci	4.08**	1.25	3.43**	3.30**
	(0.97)	(0.70)	(1.29)	(1.37)
Engineering	2.71**	0.59	1.49	0.91

Variables	China Odds Ratio (S.E.)	India Odds Ratio (S.E.)	S. Korea Odds Ratio (S.E.)	Taiwan Odds Ratio (S.E.)
	(0.59)	(0.31)	(0.48)	(0.35)
Computer & information sci	3.68**	0.42	1.92	1.39
	(1.00)	(0.23)	(0.74)	(0.66)
Mathematics	2.51**	0.28	1.81	0.86
	(0.65)	(0.16)	(0.72)	(0.39)
Chemistry	3.51**	0.83	1.61	5.22**
	(0.88)	(0.48)	(0.59)	(3.30)
Physics	2.09**	0.26*	1.30	0.87
	(0.53)	(0.14)	(0.49)	(0.40)
Economics	0.47**	0.13**	0.29**	0.20**
	(0.12)	(0.75)	(0.10)	(0.09)
Agriculture (Reference)				
Career plan	1.76**	2.32**	0.16**	7.20**
(0:academia,1:industry)	(0.17)	(0.31)	(0.01)	(1.61)
Institutional characteristics				
Carnegie classification				
Very high research active	1.02	0.90	0.14	0.84
Institution	(0.31)	(0.44)	(0.14)	(0.44)
High research active	0.84	1.28	0.11*	0.82
Institution	(0.26)	(0.66)	(0.12)	(0.48)
Doctoral granting institution	0.46	0.61	0.07*	0.57
	(0.20)	(0.44)	(0.08)	(0.60)
Others (Reference)				
Institutional control (Public)	1.12	0.92	1.21	0.79
	(0.10)	(0.12)	(0.15)	(0.14)
Research expenditure	1.00	1.00	1.00	1.00
	(3.22e-10)	(4.37e-10)	(3.76e-10)	(6.17e-10)
Prestige of PhD program	0.86	0.74*	0.82	1.21
	(0.09)	(0.10)	(0.09)	(0.23)
Country characteristics				
GDP per capita centered on				
US GDP	0.99	0.99	0.99*	1.00
	(0.00002)	(0.00005)	(0.00006)	(0.0002)
Unemployment rate	0.75	0.73	0.75	0.48
	(0.28)	(0.35)	(0.21)	(0.18)

Variables	China Odds Ratio (S.E.)	India Odds Ratio (S.E.)	S. Korea Odds Ratio (S.E.)	Taiwan Odds Ratio (S.E.)
% of R&D expenditure on GDP	1.03	0.05	0.62**	16.01
	(0.74)	(0.19)	(0.11)	(31.34)
Public expenditure on education per capita	0.98	0.98	1.00	1.00
	(0.003)	(0.019)	(0.0002)	(0.0005)
Number of world-class university	omitted	omitted	omitted	omitted
Log likelihood	- 2153.03	-1089.41	-1228.56	-516.96
Pseudo R^2	0.10	0.10	0.18	0.23
N	10,614	4,375	2,745	1,143

Note: 319 PhD institution fixed-effect dummy variables (Reference: Alabama A&M University) are controlled in the model.
* $p < 0.05$, ** $p < 0.01$.

Summary of Results

In sum, this chapter discussed the results from data analyses. The descriptive analyses revealed that the foreign doctorate recipients in the U.S. higher education institutions from 2000 to 2010 were mostly young males from Asian countries who majored in engineering. China had the largest number of the foreign doctorate recipients in this study sample, followed by India and South Korea. This study found that the foreign doctorate recipients tended to study at very high research active public institutions and tended to be supported by the research assistantships during their studies. The foreign doctorate recipients in this sample had high propensities to stay in the United States after their degree completions, and the stay rates varied by the country of origins. China and India had the highest numbers of stayers in the United States from 2000 to 2010. However, the number of Chinese doctorate recipients who stayed in the United States declined every year from 2007 to 2010. Analyzing the factors predicting the foreign doctorate recipients' staying in the United States, this study found that while individual factors and country

factors significantly predicted whether the foreign doctorate recipients stayed in the United States, institutional factors did not played a significant role on their decisions to stay in the United States, except for the most prestigious PhD programs. This study found that the high propensity to stay in the United States among female doctorate recipients was only for some Asian countries. Having a selective bachelor's degree from home countries increased the odds of staying in the United States after controlling for institutional and country factors. The foreign doctorate recipients who planned to work in industry were more likely to stay in the United States. While the institutions where the foreign doctorate recipients graduated did not predict their decisions to stay in the United States, this study found that those who graduated from the most prestigious PhD programs were more likely to go back to their countries. The home country's high unemployment rate tended to increase the odds of foreign doctorate recipients' staying in the United States, while increasing public investment on education tended to decrease the odds of their staying in the United States. The country of origins also greatly predicted the foreign doctorate recipients' stay patterns. The foreign doctorate recipients from China, Iran, India, Russia, and Romania were more likely to stay in the United States. In the next chapter, I provide a discussion of these findings and their implications for policy and future research.

Chapter V

Conclusions

In this chapter, I discuss the results of the research conducted and the implications for policy and future research. First, I interpret the findings from the data analyses that were relevant to the research questions. By analyzing the data of the most recent foreign doctorate recipients from U.S. higher institutions in STEM fields, this study found that while individuals' human capital greatly predicted whether or not the foreign doctorate recipients stayed in the United States, the country factors also played a significant role on their decisions to stay. China had the largest number of stayers in the United States from 2000 to 2010, but the descriptive trends revealed that the number of Chinese doctorate recipients who stayed in the United States declined every year from 2007 to 2010. I suggest the implications of my findings for policy and future research and reach a conclusion for this study.

Discussion

Using the data of foreign doctorate recipients from U.S. higher education institutions from 20 countries, this study mainly focused on investigating the following research questions:

1. What are the descriptive trends of foreign doctorate recipients who earned a U.S. doctoral degree in science and engineering fields in 2000 to 2010?
2. What individual factors (i.e., gender, age, marital status, having children, parental education, selectivity of foreign bachelor's degree, and future career plan) predict foreign doctorate recipients' decisions to stay in the United States?
3. What institutional factors (i.e., institutional type, institutional research expenditure, and program ranking) predict foreign doctorate recipients' decisions to stay in the United States?

4. What country factors (i.e., GDP, unemployment rate, R&D expenditure, education expenditure, and the number of world-class universities) predict foreign doctorate recipients' decisions to stay in the United States?

5. How do individual, institutional and country factors influence foreign doctorate recipients' decisions to stay in the United States?

The results of this study confirm and expand the findings of previous studies on factors affecting the international mobility of highly skilled workers. This study adds new contributions to literature by exploring individual factors, institutional factors, and country factors on foreign doctorate recipients' decisions to stay in the United States; it then suggests a more comprehensive model to predict their migration decisions. Bridging the individual level studies and country level studies of the international migration of highly skilled workers, this study offers empirical evidence on how a foreign doctorate recipient's decision to stay in the United States was influenced by both individual characteristics and larger economic and social contexts that varied by their home countries from 2000 to 2010. The notable findings of this study include the following:

- Approximately 81% of the study sample decided to stay in the United States after they earned their PhD degrees. Chinese doctorate recipients stayed the most; however, a slowdown of Chinese doctorate recipients' staying was detected in recent years.
- The effect of being a female on the decision to stay in the United States varied by country. Female doctorate recipients from China, India, and Taiwan were more likely to stay in the United States.

- Foreign doctorate recipients who had selective foreign BA degrees were more likely to stay in the United States relative to those who had less-selective, foreign BA degrees after controlling for the home country fixed effects. (supports hypothesis 1)
- Foreign doctorate recipients who planned to work in industry after graduation were more likely to stay in the United States relative to those who planned to work in academia. (supports hypothesis 2)
- Foreign doctorate recipients who graduated from the most prestigious doctoral programs were more likely to leave the United States after controlling for individual and country variables. (rejects hypothesis 3)
- The GDP of home country effect on the decision to stay in the United States disappeared after controlling for the home country fixed effects. The foreign doctorate recipients were responsive to the unemployment rate of their home countries. (rejects hypothesis 4)
- While individual characteristics and country factors greatly predicted the foreign doctorate recipients' decisions to stay in the United States, where they earned their doctoral degrees did not affect their decisions, except in the most prestigious institutions in the full model. (support hypothesis 5)

Descriptive trends. The descriptive results of this study sample, the foreign doctorate recipients from 2000 to 2010, reflected the general characteristics of STEM fields' doctorate recipients (Table 2). They were young males who had relatively shorter time to degrees. Male foreign doctorate recipients were 73% of the study sample, and the average age when the foreign doctorate recipients received their PhD degree was 31 years old. The average time to degree among the study sample was 6.93 years. This finding is consistent with NSF's (2006) analysis

that U.S. doctorate recipients in science and engineering fields were much younger (31.9 years old) than those who received doctorates in non-science and engineering fields (39.5 years old) at the time when they received their PhD degrees. The NSF study (2006) also suggested that international students tended to have a shorter time to degree compared to U.S. citizens and permanent residents due to their heavy concentration in science and engineering fields. This study also found that research assistantships (59%), teaching assistantships (17%), and fellowships and grants (15%) were common sources of financial support for this study sample.

This study found that 61% of the study sample had a parent who had a bachelor's degree or beyond (Table 2). The advanced level of educational attainment of the foreign doctorate recipients' parents suggests that the foreign doctorate recipients come from families of upper levels of social and cultural capital in their home countries (Perna, 2000). In fact, this number is extremely high, considering the average higher education achievement level within most countries. For example, China reported that the percentage of population that had attained at least post-secondary education for age from 25 to 34 was 24% in 2009 (World Bank, 2012), and the percentage of the population that had attained at least post-secondary education should be smaller for those who were 55 or older. Among U.S. doctorate recipients, the level of educational attainment for parents of doctorate recipients was above the national average, too (NSF, 2006). Nearly 50% of U.S. doctorate recipients in 2000 had a parent who held a bachelor's degree or beyond (NSF, 2006). This number is also high because among those 55 or older in the U.S. population, those who had a bachelor's degree were less than 20% of the population (NSF, 2006).

By examining the country of origin of the study sample, this study discovered that China produced the largest number of foreign doctorate recipients from U.S. institutions between

2000 and 2010 (Table 4). China dominated the study sample by 40%, followed by India (16%), South Korea (12%), and Taiwan (5%). These four countries constituted 73% of the study sample. Since China had the largest number in this study sample, some Chinese factors were influential in the findings. For example, this study found a decreasing trend of foreign doctorate recipients' staying in the United States in recent years, while the number of leavers steadily increased. The year 2007 saw the highest number of foreign doctorate recipients' staying, and this number declined every year from 2007 to 2010. The number of temporary visa (H-1B) issued to the foreign-born scientists and engineers supported this finding. In 2009, the number of temporary visa issued dropped to 72% of the number issued in 2007 (National Science Board, 2012). This study found that the stay trend of Chinese doctorate recipients was similar to the general stay trend of the study sample. In 2007, the number of Chinese doctorate recipients who stayed in the United States reached its highest number; following that, this number dropped every year from 2007 to 2010. The stay rate patterns of Chinese were similar, too. Among Chinese, the stay rate reached its highest point in 2006, 94%, and it declined every year from 2006 to 2010. In 2010, the stay rate among Chinese dropped to 87%. On the other hand, the number of stayers among South Korean doctorate recipients steadily increased during the study period. The results suggest that the recent decreasing trend of foreign doctorate recipients' staying in the United States was reflected by the declining number of stayers among Chinese doctorate recipients during 2007 to 2010. Meanwhile, the large number of Chinese doctorate recipients in STEM fields also implies the increasing importance of Chinese doctorate recipients on the U.S. higher education and science and engineering enterprise (Black & Stephan, 2007; Li, 2010).

This study found that about 81% of the study sample decided to stay in the United States after they earned their PhD degrees (Table 6). Among those who decided to stay in the

United States in this sample, the largest number was employed at U.S. four year institutions (25%), followed by U.S. industry (24%) within the next year. The increasing demand for post-doctoral training in science and engineering fields led many foreign doctorate recipients to be employed at U.S. four year institutions. Increases in competition for tenure-track faculty jobs, collaborative research in large teams, and needs for specialized training explained the growth of these post-doctoral positions at the U.S. higher education institutions (NSB, 2012). Approximately 53% of foreign doctorate recipients in this study sample intended to take post-doctoral training, and among those, 86% received postdoctoral training appointments in the United States (Table 8). In the study sample, those who majored in biological/biomedical sciences had the highest post-doctoral training rate, 84%. The stay rate of this study sample, 81%, is higher than Kim et al.'s (2011) finding. Analyzing the historical trends of stay rate of foreign doctorate recipients, Kim et al. (2011) found the stay rate was 66% in the 2000s. Kim et al.'s (2011) stay rate measured not only STEM fields but also included the social sciences, humanities, education, and business. Among international students in the United States, doctorate recipients in science and engineering fields tended to have a higher stay rate compared to those in humanities and education fields; this is due to the increasing demand for post-doctoral training in science and engineering fields in the United States (Kim, Bankart, et al., 2011; NSF, 2010).

Individual factors predicting the decision to stay. This study confirmed the previous literature that individual variables significantly predicted the foreign doctorate recipients' decisions to stay in the United States. First, this study discovered that the female foreign doctorate recipients had 16% higher odds of staying in the United States compared to their male counterparts (Model 1). This result is consistent with the previous research that indicated female

foreign students are more likely to stay in the United States relative to their male counterparts (Gupta et al., 2003; Kim, Bankart, et al., 2011; Musumba et al., 2011). Research suggests that female foreign students might find more career opportunities and social freedom in the United States compared to their home countries (Gupta et al., 2003; Hazen & Alberts, 2006; Kim, Bankart, et al., 2011; Musumba et al., 2011). In addition, this study discovered that the effect of being female on the decision to stay in the United States varied by country. In this study sample, only female doctorate recipients from China, India, and Taiwan were more likely to stay in the United States, while 16 countries had no difference between male and female doctorate recipients on their decisions to stay in the United States (Model 1-1). The findings indicate that the female doctorate recipients from Asian countries were more likely to stay in the United States, perhaps due to their lack of career opportunities or gender discrimination in their home countries. This is reiterated in *The Global Gender Gap Report 2012* published by the World Economic Forum (2012), which measured the gender gap by countries based on economic participation opportunity, educational attainment, and political empowerment of women in one's country (Hausmann, Tyson & Zahidi, 2012). According to *The Global Gender Gap Report 2012*, Iceland ranked first place, which indicates that Iceland had the least gender gap in the world (Hausmann et al., 2012). Among 20 countries of this study sample, Germany ranked 13th, the United Kingdom ranked 18th, and the United States ranked 22nd, while China ranked 69th and India ranked 105th (Hausmann et al., 2012). For example, data show that the female to male ratio of estimated earned income was 0.93 for the United States, while the same number was 0.65 for China and 0.27 for India (Hausmann et al., 2012). More specifically, when a U.S. male earned $40,000 a year on average, a U.S. female earned $37,376 (Hausmann et al., 2012). When a Chinese male earned $10,156 a year, a Chinese female made $6,592 a year (Hausmann et al.,

2012). Among Indians, when a male earned $5,635 a year, a female earned $1,530 a year (Hausmann et al., 2012). The lower rankings of China and India imply that female doctorate recipients from countries that have a larger gender gap in their home countries were pushed away by their home countries' unfavorable conditions to women. Unless the gender gaps of China and India narrow, the high propensity to stay in the United States among Chinese and Indian female doctorate recipients would be expected to continue, and China and India could lose their talented female scientists and engineers.

In addition, perhaps the lower odds of staying among Chinese male doctorate recipients are also related to China's one-child policy. While taking care of elderly parents is a culture of tradition in many East Asian countries, this obligation is mainly given to sons (Lee & Kim, 2010; Song, 1997). Since China introduced its one-child policy in 1979, the Chinese doctorate recipients in this study sample are more likely to face the high possibility that they do not have any siblings. Thus, a Chinese male doctorate recipient might have a higher odd of returning compared to a female counterpart because he is more likely to be the only son in the family and thus has to take care of his parents. This could reflect the lower odds of staying for Chinese male doctorate recipients in the United States relative to Chinese female doctorate recipients.

Next, this study examined whether undergraduate experiences predicted the foreign doctorate recipients' stay in the United States; it found a foreign doctorate recipient’s graduation from a selective undergraduate institution in their home country increased the likelihood of staying in the United States after controlling for the home country fixed effects such as culture (Model 5). Previous studies consistently found that foreign doctorate recipients who attained their bachelor's degrees in the United States are more likely to stay compared to those who had foreign bachelor's degrees (Black & Stephan, 2007; Freeman, 2010; Kim, Bankart, et al., 2011).

The foreign doctorate recipients who earned their bachelor's degrees from U.S. undergraduate institutions might be more familiar with U.S. academic and social cultures relative to those who have foreign bachelor's degrees, which in turn led to their higher probability of staying in the United States (Kim, Bankart, et al., 2011). In this study sample, 95% of the participants had a foreign bachelor's degree. Among these foreign BA holders, about 37% of them graduated from top five selective institutions in their home countries. This study found a significant effect of the selectivity of foreign bachelor's degree in predicting the foreign doctorate recipients' decisions to stay in the United States. This study found that the foreign doctorate recipients who had selective bachelor's degrees from their home countries were more likely to return to their home countries when the home countries' fixed effects were not controlled in the model (Model 4). On the other hand, after controlling for the home country fixed effects such as culture, this study found that the foreign doctorate recipients who had selective bachelor's degrees from their home countries were 9% more likely to stay in the United States relative to those who did not have selective bachelor's degrees from their home countries (Model 5). This result confirms the human capital theory for migration that a higher level of human capital increases mobility (de Haas, 2008; Tremblay, 2005). The high level of human capital increases the employment opportunities in the destination country (Massey et al., 1993; Tremblay, 2005) as well as the capability to overcome obstacles on migration more easily (de Haas, 2008; Mattoo et al., 2008). From the sending countries' perspectives, these results can be viewed as a brain drain because the sending countries invested and educated their best students and therefore were expecting high returns in the future (Mattoo et al., 2008), but instead they lost their students from the best undergraduate institutions to the United States. The results suggest that the United States benefits from the investments in education made by the sending countries (Stephan & Levin, 2007).

This study explored whether planning to work in academia or industry predicted the foreign doctorate recipients' decisions to stay in the United States, and it found that those who planned to work in industry tended to be more likely to stay in the United States relative to those whose career plans were in academia (Model 1). The results reflect the characteristics of the U.S. science and engineering workforce. According to the National Science Board (2012), in 2008, the U.S. science and engineering workforce broadly consisted of 70% of the industry sector, 12% of the government sector, and 18% of the education sector. Thus, if a STEM foreign doctorate recipient were to stay in the United States after degree completion, the probability of working in industry might be higher compared to working in education sector (academia), since literally more science and engineering related jobs are available in the industry sector. Previous research also found that foreign doctorate recipients stayed were more likely to work in industry (Gupta et al., 2003; Wendler et al., 2010). Many U.S. doctorate recipients aspire to tenure-track academic appointments after they complete their doctoral degrees; however, only a small number of doctorate recipients worked in tenured or tenure-track academic appointments (Nerad, 2009; NSB, 2012). Data showed that in 2008, 16% of all U.S. doctorate recipients who had earned their doctoral degrees in science, engineering, and health related fields within the previous three years had tenure or tenure-track faculty appointments at four year institutions (NSB, 2012).

The high salary in industry might influence foreign doctorate recipients to stay in the United States, too. According to NSB (2012), the median annual salary of science and engineering doctorate recipients employed in industry was $85,000, while that of those employed in the tenure-track position at 4-year institution was $65,000 in 2008 (NSB, 2012). Although both monthly salaries of industry and academia were about the same, approximately over $7,000 per month because the tenure-track position at four year institution is a nine month contract, the

annual salary is higher for those who were employed in industry. This higher annual salary in industry suggests that the larger wage differences in industry between their home countries and the United States might contribute to the higher odds of staying for those who planned to work in industry compared to those in academia. One study suggested that the foreign doctorate recipients who stayed in the United States highly valued the larger salaries in the United States compared to those who returned their home countries (Gupta et al., 2003).

Institutional factors predicting the decision to stay. This study revealed that in general, institutional variables did not significantly predict the foreign doctorate recipients' decisions to stay in the United States (Model 2). Whether or not a foreign doctorate recipient graduated from a high research active institution or a doctoral granting institution did not predict his or her decision to stay in the United States. Whether or not an institution had a large amount of research expenditure did not affect the foreign doctorate recipients' staying in the United States, either. However, after controlling for individual variables and country variables, this study found that the prestige of PhD institutions significantly predicted the foreign doctorate recipients' decisions to stay in the United States. The results suggest that foreign doctorate recipients who graduated from the most prestigious PhD programs were more likely to leave the United States compared to those who did not graduate from the most prestigious PhD programs as individual variables and country variables were controlled. This finding is consistent with Finn's (2010) findings of the five year stay rate of the foreign doctorate recipients. He found that foreign doctorate recipients who graduated from highly ranked programs in 2002 were less likely to stay in 2007 relative to those who did not graduate from highly ranked programs (Finn, 2010). On the other hand, Black and Stephan (2007) found the opposite effect when analyzing the foreign doctorate recipients from 1981 to 1999. They found that those who graduated from

highly ranked programs were more likely to stay in the United States (Black & Stephan, 2007). According to human capital theory, the foreign doctorate recipients who graduated from the most prestigious PhD programs would increase their human capital and have higher employability (Black & Stephan, 2007). While both the United States and their home countries may be interested in retaining this highly talented population, the results suggest that their home countries might have pulled them harder to return home in the 2000s compared to in the 1990s. If the United States and their home countries pulled this group with the same working conditions, personal factors such as family and friend ties and cultural familiarity would influence the decision making process related to their migration (Franzoni et al., 2012; Hazen & Alberts, 2006; Lee & Kim, 2010). At Caltech, officials witnessed that an increasing number of their Chinese graduates returned to China and were employed in attractive jobs in recent years, which the Caltech staff never imagined 20 years ago (Partnership for a New American Economy, 2012). Unless the United States could offer more incentives to this high demand group, the foreign doctorate recipients from the most prestigious programs would decide to return to their home countries when they were offered excellent career opportunities there. Freeman (2006) argued that the current flow of foreign-born scientists and engineers would transit in the United States from "being a superpower" in science and engineering to "being one of the many centers of excellence" in the world (p.124).

Country factors predicting the decision to stay. This study found that country variables significantly predicted foreign doctorate recipients' staying in the United States, and the country of origin was very important predicting their decisions. While the home country's unemployment rate and the level of education expenditure significantly predicted a foreign doctorate recipient's decision to stay in the United States, the home country's GDP per capita

centered on the U.S.'s GDP per capita was not significant after controlling for the home country fixed effects such as culture (Model 5). The previous literature used GDP per capita as a proxy of income differences among countries (Bratsberg, 1995; Bratsberg et al., 2002; Grossmann & Stadelmann, 2008). The previous research found that the GDP per capita was negatively associated with the international migration of people: students from lower-income countries tended to stay more in the United States or other host countries relative to those from high-income countries (Bratsberg, 1995; Bratsberg et al., 2002; Finn, 2010; Grossmann & Stadelmann, 2008; Song, 1997). This study also confirmed the significant negative relationship between a country's GDP per capita centered on the U.S.'s GDP per capita and the odds of staying in the study sample when the model did not control for the country fixed effects (Model 4). However, unlike the previous literature, this study discovered that the GDP effects on predicting the odds of staying disappeared after controlling for the home country fixed effects (Model 5). The results suggest that the significant negative relationship between the GDP and the odds of staying might be mediated by the unobserved variances across countries. After controlling for these home country fixed effects, this study found that the GDP effect did not significantly predict the foreign doctorate recipients' decision to stay in the United States.

This study confirmed the previous literature that the unemployment rate of one's home country significantly predicted the odds of staying (Franzoni et al., 2012; Johnson, 2001). The unemployment rate of one's home country indicates the job market conditions (Johnson, 2001), although the unemployment rate for the STEM doctorate recipients is considerably lower than that of the general labor force (NSB, 2012). Still, this study found that when the unemployment rate of one's home country was high, those foreign doctorate recipients tended to be more likely to stay in the United States. This study also found that when the unemployment rate increased

1%, the foreign doctorate recipients' odds of staying in the United States increased 5% in the full model with country fixed effects (Model 5). Though the foreign doctorate recipients' staying in the United States would be affected by both the state of the U.S. economy and that of the home country according to Black and Stephan (2007), this study showed that the foreign doctorate recipients were responsive to the economic conditions of their home countries when they made their decisions to stay in the United States.

In addition, this study found that public expenditure on education in their home country was negatively associated with the foreign doctorate recipients' decisions to stay in the United States as individual variables and institutional variables were controlled (Model 4 & Model 5). The public expenditure on education indicates the educational quality of the home country (Mattoo et al., 2008), and the results suggest that when the home country invested more in education, their doctorate recipients were less likely to stay in the United States. One study found similar results, noting that when the return of education was high in their home countries, students were less likely to stay in the United States (Bratsberg, 1995). Previous research suggests that the education variable might affect the odds of staying of foreign doctorate recipients who have young children (Jin et al., 2006; Song, 1997). Jin et al.'s (2006) analysis of the U.S. educated South Korean scientists and engineers discovered that their children's educational opportunities in the United States were one pull factor for their staying in the United States. Thus, these results imply that improving educational infrastructure for the future generation at home countries could decrease the likelihood of the foreign doctorate recipients' staying in the United States.

When conducting additional analysis of the foreign doctorate recipients from four countries who were planning to work in academia or industry, this study discovered an

interesting variation (Model 6). While the foreign doctorate recipients from China, India, and Taiwan who planned to work in industry were more likely to stay in the United States, those from South Korea who planned to work in industry were more likely to return to South Korea. In the 1990s, the returning South Korean doctorate recipients from U.S. institutions contributed to the development of the South Korean semiconductor industry such as Samsung (Johnson, 2002); with an increasing number of multinational corporations located in Korea in the 2000s, more career opportunities in industry might pull those doctorate recipients to return to South Korea (Lazonick, 2007). Among 20 countries in this study sample, Japan, Germany, and South Korea were the top three countries that invested heavily in R&D sector at the country level. Examining Japanese and German doctorate recipients of this study sample showed similar results to those found for South Korean doctorate recipients. Among Japanese doctorate recipients, those who planned to work in industry had an 81% less odds of staying in the United States compared to those who planned to work in academia (the odds ratio=0.19, $p < 0.01$). For German doctorate recipients, those who planned to work in industry had 41% lower odds of staying in the United States compared to those who planned to work in academia (the odds ratio=0.59, $p < 0.05$).

In sum, since the number of academic positions in the United States is limited and competitive, many foreign doctorate recipients sought their career opportunities in U.S. science and engineering industry and thus contributed to America's economic leadership in the world (National Academy of Sciences, 2007; Nerad, 2009). However, the results of South Korean, Japanese, and German doctorate recipients' stay patterns suggest that if the home country could offer good career opportunities for these new doctorate recipients, the probability of their doctorate recipients' staying in the United States would decrease. This study found that the foreign doctorate recipients from China and India had the highest stay rates for the last decade,

but this current trend could change if their economies grew fast and if both countries created extensive R&D employment outside of academia that would pull their doctorate recipients from the United States (Clotfelter, 2010; Freeman, 2006; Wadhwa, Saxenian, Freeman & Salkever, 2009).

This study also confirmed the previous research that foreign doctorate recipient's nationality predicted the odds of staying in the United States (Black & Stephan, 2007; Finn, 2010; Gupta et al., 2003; Kim, Bankart, et al., 2011). This study found that the foreign doctorate recipients from China, India, Iran, Romania, and Russia had high propensities to stay in the United States, while those from Brazil and Thailand were less likely to stay in the United States after controlling for individual variables and institutional variables (Model 5). Foreign doctorate recipients who were mostly likely to stay in the United States tend to be from countries that have limited political freedom and limited transparency, and these characteristics might influence the higher odds of these students staying in the United States. On the other hand, the lower odds of staying for Brazilians show that Brazil has become "a regional hub" for higher education in Latin America (Gribble, 2008, p.31). Brazil has implemented national programs (i.e., ProDoc and tax exemptions on R&D) with the aim to foster R&D in industry and higher education (Gribble, 2008).

The findings that China and India accounted for two largest groups of foreign doctorate recipients and both countries had high propensities to stay in the United States suggest that they are important sources for the doctoral-trained science and engineering workforce in the United States. The United States is projected to have 230,000 jobs in STEM fields that will not be filled with U.S. native-born workers by 2018, and foreign STEM doctorate recipients are expected to fill the gaps (Carnevale, Smith & Strohl, 2010). On the other hand, some studies showed an

increasing number of U.S. educated students from China and India returned to their home countries (Partnership for a New American Economy, 2012; Wadhwa, Saxenian, Freeman & Salkever, 2009; Zweig, Chung & Vanhonaker, 2007). Wadhwa et al. (2009) surveyed 878 students from India and 229 students from China who were studying in the U.S. higher education institutions and found that these students were optimistic about the economies of their home countries. In particular, Chinese students responded that the best job opportunities were in their home countries, not in the United States. Wadhwa et al.'s (2009) results were in conflict with this study's findings; however, they suggest that the current high stay rates of China and India might change in the future if more students from China and India perceived better economic opportunities in their home countries.

In sum, this study discovered that the decision of foreign doctorate recipients to stay in the United States was influenced by various factors including individual factors, institutional factors, and country factors. This study found that while individual characteristics and country-specific variables greatly predicted the foreign doctorate recipients' decisions to stay in the United States, where they earned their doctoral degrees did not affect their decisions to stay in the United States, except in the most prestigious institutions in the full model. While the wealth of a country did not significantly predict the foreign doctorate recipients' staying in the United States, the foreign doctorate recipients were responsive to the job market conditions of their home countries after controlling for country fixed effects. Despite an incident like September 11, the number of stayers in this study sample did not drastically decrease after 2001, suggesting that they are in high demand in U.S. science and engineering industry. China and India had the largest numbers of doctorate recipients staying in the United States, but the trend revealed that the number of Chinese and Indian doctorate recipients who stayed in the United States declined

in recent years. Implications for policy and future research on these findings are discussed in the following section.

Implications for Policy

The findings of this study suggest several important implications for policymakers for both the United States and the home countries of foreign doctorate recipients. However, the implications for policies might be different between the United States and other countries. First, I discuss the implications for the United States including the U.S. federal government and U.S. higher education institutions. Then, I discuss the implications for sending countries.

The findings suggest that the United States needs new recruiting and retaining policies for international students including reforming visa policies to maintain research excellence in the U.S. sciences. To retain those who came to the United States, it could specifically target the foreign doctorate recipients in STEM fields and offer a more clear and viable path for this group to remain in the United States after they completed their degrees. Though a graduate with a temporary visa can stay and work between 12 to 29 months in areas related to his or her studies (USCIS, 2012), the U.S. science and engineering industry still argues that unlike the United Kingdom or Canada, the U.S. government lacks dedicated visa programs that would help highly talented foreign students smooth transition to the U.S. workforce (Partnership for a New American Economy, 2012). Decreasing an uncertainty of status by removing the caps on H-1B visas or providing job opportunities before they completed their degrees would help encourage the foreign doctorate recipients to stay in the United States. For example, Canada allows PhD students in STEM fields to become permanent residents while they are still in school (Payton, 2011). This study found that in the 2000s, the foreign doctorate recipients who graduated from the most prestigious PhD programs were more likely to leave the United States. This finding

implies a brain gain of sending countries for some degrees. To reduce the possibility that foreign doctorate recipients might go back their home countries and develop industrial activities that could compete with those in the United States, it should provide more favorable conditions for this group to obtain permanent residency and citizenship or at least removing or raising the caps on H-1B work visas (Freeman, 2006; National Academy of Sciences, 2007; Partnership for a New American Economy, 2012). The Mayor of New York City, Michael Bloomberg, has argued that "Every day we let our antiquated immigration policies stand is a day we send new innovators, new companies and new jobs abroad" (Partnership for a New American Economy, 2012, p.21).

The large number and high stay rate of Chinese doctorate recipients in this study sample suggest that the U.S. science and engineering enterprise is increasingly dependent on them to maintain its excellence and leadership. Clotfelter (2010) argued that this growing dependence on foreign students is one "sign of vulnerability of the American hegemony" and raised concerns about the slowdown of foreign students flowing to the United States (p.14). This study detected a slowdown of stayers among Chinese doctorate recipients from 2007 to 2010 as the returners increased. India followed a similar stay pattern as of China from 2008 to 2010. If this trend continued in the future, research and academic work in the United States would need to adjust to decreasing supply of new doctorate recipients in STEM fields until an alternative source could be found (Clotfelter, 2010).

To decrease the high dependence of the U.S. science and engineering enterprise on graduates from a particular country such as China and India, the U.S. higher education institutions could strive to diversify the country of origins of their students at the stage of recruiting international graduate students. This study found that China had the largest number of

foreign doctorate recipients from U.S. institutions. China dominated the study sample by 40%, followed by India (16%). If China continued to dominate the population of foreign doctorate recipients in U.S. higher education institutions, the impact of China could become critical to the U.S. higher education and the U.S. labor market. After 20 years, the high stay rate of Chinese doctorate recipients could decline. Thus, the U.S. higher education institutions need to recruit graduate students from more diverse countries to decrease the dependency of a particular country. More importantly, the United States should closely look at the pipeline that produces Americans with PhDs in STEM fields (Bettinger, 2010) and seek to improve the pipeline in order to increase domestic students in STEM fields (Freeman, 2006). Moreover, giving more research fellowships to American students at the graduate school level and providing opportunities to do independent research early in career could increase the U.S. supplies to the STEM fields (National Academy of Sciences, 2005).

For the sending countries, this study suggests some policy implications, too. The results of this study suggest that sending countries should make every effort to improve their higher education sector and create R&D employment in industry in order to decrease the brain drain of their doctorate recipients in STEM fields in the long-term. The findings of this study that the foreign doctorate recipients from China, India, and Taiwan who planned to work in industry were more likely to stay in the United States while those from South Korea, Japan, and Germany who planned to work in industry were less likely to stay in the United States indicate the importance of creating career opportunities at home countries by fostering strong R&D industries. After all, the higher odds of staying among Chinese and Indian doctorate recipients were related to their high tendency to work in industry, and the United States offers much better R&D job opportunities compared to their home countries. Johnson (2002) argued that investing

heavily in both higher education and R&D infrastructure would influence the flow of a country's highly skilled workers and eventually reverse that pattern. That is, to attract these highly skilled workers, a country needs to be able to offer good employment opportunities for their doctorate recipients and returning scientists and engineers, such as higher salaries, high-quality research facilities and infrastructure, a research environment that values collaboration between academia and industry, and promising career prospective (Finn, 2010; Gribble, 2008; Johnson, 2002; OECD, 2008). For example, domestic investment by industry and government in South Korea drove that country's development of high-technology capabilities (Lazonick, 2007). When the South Korean government created a major research institution in 1966, the Korea Institute of Science and Technology (KIST) that was funded by the U.S. Johnson Administration paid high salaries and offered incentives such as relocation expenses, free housing, and education expenses for children in order to attract South Korean researchers to the United States (Kim, 2010; Lazonick, 2007). In the 2000s, multinational corporations increasingly opened R&D facilities in South Korea to access highly skilled labor (Lazonick, 2007). By developing a strong R&D sector and providing favorable working conditions and incentives that would encourage transnational investment and entrepreneurship, the sending countries could facilitate the return migration of their natives (Gribble, 2008).

The high stay rate, 81% of this study sample, suggests that it is difficult for the sending countries to reverse the flow of their doctorate recipients immediately. The brain circulation concept offers a short-term policy option for the sending countries. According to the brain circulation, the sending countries can still benefit from the immigrant scientists and engineers in the United States by maintaining social and professional networks and facilitating exchanges of knowledge, experts, and capital (Gribble, 2008). The sending countries should view those who

stayed in the United States as a "precious resource" who can contribute to the social and economic development of their home countries (OECD, 2008, p.47). Therefore, establishing and maintaining wide networks for communication between the sending countries and the migrants can be a policy tool to activate the flow of highly skilled workers. Strong networks provide a chance to exchange information about opportunities for employment, collaborate with research projects, and establish business partnerships in the home countries (Gribble, 2008; OECD, 2008; Zweig et al., 2008). For example, Saxenian (2002) established strong networks between the Silicon Valley in the United States and the Hsinchu-Taipei in Taiwan that benefited both sides. Thus, the sending countries could benefit from their doctorate recipients in the United States by establishing strong and wide networks. Moreover, these networks could serve as channels to offer opportunities for their migrants to return home as the social, economic, and political conditions of their home countries change in the future.

Implications for Future Research

The findings of this study also suggest some implications for researchers for future research. First, the results of this study showed that the foreign doctorate recipients from the most prestigious PhD programs were less likely to stay in the United States. Despite higher demand for individuals from strong STEM programs in the U.S. labor market and generally better initial academic appointments for the graduates from the prestigious programs (Bedeian et al., 2010; Black & Stephan, 2007), the foreign doctorate recipients from the most prestigious programs were more likely to return. Further research could explore who graduated from the most prestigious programs in U.S. higher education institutions, why they tend to go back, and the impact of their migration on sending countries and the United States. Previous research

argues a brain drain phenomenon from a sending country's perspective because of the high number of stayers in the United States (Grossmann & Stadelmann, 2008; Mattoo et al., 2008). However, the findings imply the brain drain phenomenon might not be so harsh since the most talented scholars were more likely to return home. This finding backs what the U.S. science and engineering industry has repeatedly insisted: U.S. research universities have trained the top "brains" in the world, only to send them back to "compete against" the United States (National Academy of Sciences, 2005; Partnership for a New American Economy, 2012, p.5). Further research could scrutinize the characteristics of graduates from the most prestigious programs, their motivations, and the future careers in their home countries.

Second, future research can explore whether or not having world-class universities in a country could affect the number of their students coming to the United States for advanced degrees. This study examined if having world-class research universities in the home country would predict the foreign doctorate recipients' decisions to stay in the United States; it found that there was no relationship between the number of the world-class universities in a country and the foreign doctorate recipients' staying in the United States (Model 5). While the high level of research capacities of a country could pull the foreign doctorate recipients, the number of world-class universities did not significantly influence the foreign doctorate recipients' stay patterns. The results suggest that since only a small number of doctorate recipients could be employed in tenured or tenure-track academic appointments at research universities, the number of world-class universities did not predict the foreign doctorate recipients' staying or leaving. However, it is plausible that the number of world-class universities in a country could still be related to the flow of international students to the United States. Previous research found that the countries without strong graduate programs but with recent expansion in undergraduate STEM programs

sent large numbers of students to the United States for advanced studies (Bound et al., 2009). On the other hand, in the last 20 years, the Chinese government implemented a number of major educational reforms to foster world-class universities and establish strong research teams in China (Li, 2010). Future research could evaluate the direct effects those policies on the flow of international students and scholars. If the talented students had new options to pursue their advanced degrees in the home countries, some countries' flow of students coming to the United States for the doctoral degrees could be affected (Byun, Jon & Kim, 2012).

Third, this study used the first-year stay of foreign doctorate recipients after they earned their PhDs as an outcome variable based on data available from the SED data. Future study can expand the predicting time to the return of foreign doctorate recipients beyond the first year by merging the Survey of Doctorate Recipients (SDR) data from the NSF and the SED data. The SDR is a longitudinal panel study of individuals who received PhDs from U.S. institutions in science, engineering, and health fields (NSF, 2013). The survey has been conducted every two to three years since 1973, and it follows a sample of individuals with doctorates throughout their careers until age 75 (NSF, 2013). For foreign doctorate recipients, the SDR sample includes those who indicated in the SED that they had planned to stay in the United States after their degree was awarded (NSF, 2013). Thus, by using the SDR data, future studies can predict the odds of returning and factors affecting the event happening over time by employing an event history model. This analysis examines the time to return of foreign doctorate recipients over time.

Fourth, although this study attempted to explore general stay factors predicting foreign doctorate recipients, the fact that Chinese students constituted approximately 40% of the study sample and their extremely high stay rate (93%) influenced the findings on predicting the stay factors. When a variable was positively associated with predicting the stay decision of Chinese

doctorate recipients, the variable was more likely to be positively significant in the study sample. Thus, future research could be conducted separately by countries or focus on one particular country to understand some important stay factors further. For example, this study and previous studies consistently found that the female effects on decisions to stay in the United States were significant in that females were more likely to stay in the United States. In addition, when analyzing the female effects by countries, this study discovered that the female effects on stay pattern were significant only for China, Taiwan, and India, countries where women face more social, cultural, and practical obstacles regarding career opportunities. On the other hand, female effects on stay pattern were insignificant among other countries, which imply that gender was not an issue for this highly skilled group. Further analyses by countries could offer more insights on understanding factors affecting foreign doctorate recipients' decisions to stay in the United States.

Conclusion

This study investigated the most recent trends of foreign doctorate recipients from U.S. higher education institutions who decided to stay in the United States after their degree completion and analyzed individual, institutional, and country factors predicting the foreign doctorate recipients' staying in the United States. As the foreign students complete their doctoral degrees, they become highly skilled workers that many countries need for their economic development and innovation. Because of the issues of globalization, stay patterns and factors affecting the foreign doctorate recipients' decisions become important issues for both sending countries and the United States. Their migrations predict knowledge flow and innovation patterns all around the world. Historically, foreign doctorate recipients have been an important source of immigrant scientists and engineers for the United States. The findings of this study

confirm previous studies that indicate U.S. science and engineering was increasingly populated by the foreign doctorate recipients, especially from China and India. This study found that while the foreign doctorate recipients' individual human capital predicted their staying in the United States, the foreign doctorate recipients' decisions to stay in the United States were also influenced by the conditions of the home countries. While the United States navigates to find an appropriate balance between meeting concerns regarding its domestic economy and national security and reforming visa and immigration policies to maintain the excellence of U.S. science and engineering enterprises, the global competition for these highly talented graduates continues to increase. This study reveals that the United States has been the absolute winner on attracting and retaining highly talented people all around the world. Given the major differences of R&D capacities among China, India, and the United States for now, the high propensity to stay in the United States among Chinese and Indian doctorate recipients is not going to change in the foreseeable future. However, by learning from the economic development in South Korea and Taiwan, as economic conditions and higher education in China and India improve so that good career opportunities are available for their graduates, the stay patterns of China and India have possibilities to change in the long-term. If the high stay rates of China and India were to decline, the impact could disrupt the U.S. economy and innovation, because of the U.S science and engineering enterprises' dependency on foreign doctorate recipients. This study also found that those who graduated from the most prestigious doctoral programs are more likely to leave the United States in the 2000s, while they were more likely to stay in the United States in the 1990s. Is this one example of rapid changes in the global job markets for these highly talented workers?

While sending countries strived to attract their best students to come home, the United States have not taken an active position in retaining these international talents that it has

educated. During the presidential race in 2012, both President Obama and Republican candidate Mitt Romney called attention to the fact that many foreign students go to graduate school in STEM fields in the United States and would like to stay after graduation, but they return home or go to other countries because not enough visas are available. If the U.S. institutions trained the top minds in the world only to send them abroad to be competitors, it is important to address the shortcomings of policies that might prevent the United States from retaining these doctoral recipients. Otherwise, as Freeman (2006) warned, the U.S. leadership in science and engineering enterprises could be threatened sooner than expected. As competition for highly skilled workers has increased internationally, it appears that now is the right time for the United States to create policies that encourage retaining these talented doctoral recipients that the country needs to prosper. Without more proactive policies to retain foreign doctorate recipients in the United States, it could lose its dominant position in the world as other countries aggressively strive after the same pool of talent.

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Appendix I

A List of Independent Variables

Category	Variable	Description of Coding	Data Source
Demographic characteristics	FEMALE	1 if female	SED 2010
	MARRIED	1 if married	SED 2010
	CHILD5	1 if having a child under 6	SED 2010
	SCHCHILD	1 if having a child from 6-18	SED 2010
	AGE	Age when the phd degree was awarded	SED 2010
	CONTI	1 if a parent's highest educational level is four-year college graduation or beyond	SED 2010
Educational Background	USBA	1 if US bachelor's degree	SED 2010
	FORBASE	1 if foreign BA is selective	ARWU 2012 & SED 2010
	TTD	Years in phd program (entry to exit year)	SED 2010
	RA	1 if the primary source for funding is RA	SED 2010
	TA	1 if the primary source for funding is TA	SED 2010
	SF	1 if funding is scholarship or fellowship	SED 2010
	FORG	1 if funding is foreign government	SED 2010
	OWN	1 if funding is self, family, or loan (Reference)	SED 2010
	PHDFD1	1 if phd field is agriculture (Reference)	SED 2010
	PHDFD2	1 if phd field is biological/biomedical sci	SED 2010
	PHDFD3	1 if phd field is engineering	SED 2010
	PHDFD4	1 if phd field is computer & inform sci	SED 2010
	PHDFD5	1 if phd field is mathematics	SED 2010
	PHDFD6	1 if phd field is chemistry	SED 2010
	PHDFD7	1 if phd field is physics	SED 2010
	PHDFD8	1 if phd field is economics	SED 2010
Career plan	CP	1 if career plan is in industry 0 if career plan is in academia	SED 2010

Category	Variable	Description of Coding	Data Source
Institutional characteristics	RI	1 if very high research active institution	IPEDS 2012
	RII	1 if high research active institution	IPEDS 2012
	DOC	1 if doctoral granting institution	IPEDS 2012
	OTHERS	1 if other institution (Reference)	IPEDS 2012
	PUB	1 if public institution	IPEDS 2012
	RESE	Annual research expenditure total	IPEDS 1993-2007
	PRESTIGE	1 if phd program ranked top 25 0 if phd program ranked outside top 25	USNWR 2000-2010
Country	GDPC	GDP per capita centered on U.S.'s GDP per capita	World Bank National Account database & OECD National Accounts database 2000-2010
	UNEMP	Annual unemployment rate	Labor Market database, International Labor Organization 2000-2010
	RDG	% of total expenditure of R&D on GDP	UNESCO Institute for Statistics 2000-2010
	PEP	Total public expenditure on education per capita	UNESCO Institute for Statistics 2000-2010
	WCUP	Number of world-class universities per capita	ARWU 2012

Appendix II

A List of Selective Foreign BA Institutions in the Model: 83 Institutions

Country	Institution	Institution ID by NSF
Argentina	University of Buenos Aires	AR0002
Brazil	University of Sao Paulo	BR0036
	State University of Campinas	BR0043
	Federal University of Minas Gerais	BR0010
	Federal University of Rio de Janeiro	BR0033
	Federal University of Rio Grande do Sul	BR0030
Canada	University of Toronto	CA0055
	University of British Columbia	CA0006
	McGill University	CA0023
	McMaster University	CA0024
	University of Alberta	CA0002
China	Beijing University	CN0026
	Tsinghua University	CN0054
	Shanghai Jiao Tong University	CN0006
	Zhejiang University	CN0005
	University of Sci & Tech of China	CN1132
Egypt	University of Cairo	EG0006
	Ain Shams University	EG0001
	American U of Cairo	EG0004
Germany	Technical University Munich	DE0047
	University of Munich	DE0048
	University of Heidelberg	DE0038
	University of Freiburg	DE0064
	University of Frankfurt	DE0029
Greece	Aristotle University of Thessaloniki	GR0007
	National and Kapodistrian University of Athens	GR0004
India	Indian Institute of Science	IN0023

Country	Institution	Institution ID by NSF
	University of Delhi	IN0017
	University of Calcutta	IN0015
	University of Mumbai	IN0013
	Indian Institute of Technology, Bombay	IN0024
Iran	University of Tehran	IR0005
	Amirkabir U of Technology	IR0008
	Sharif U. of Technology	IR0002
Italy	University of Milan	IT0035
	University of Padua	IT0039
	University of Pisa	IT0044
	University of Roma-La Sapienza	IT0047
	Polytechnic Institute of Milan	IT0045
Japan	University of Tokyo	JP1248
	Kyoto University	JP0021
	Osaka University	JP0030
	Nagoya University	JP0024
	Tokyo Institute of Technology	JP0065
Mexico	National Autonomous University of Mexico	MX0013
	Monterrey Institute of Technology	MX0020
South Korea	Seoul National University	KR0011
	Yonsei University	KR0015
	Korea University	KR0007
	Korea Advanced Inst of Sci and Tech	KR0008
	Sungkyunkwan University	KR0013
Romania	University of Bucharest	RO0005
	University of Babes-Bolyai	RO0003
	“AI.I. Cuza” University of Iasi	RO0002
Russia	Moscow State University	RU0013

Country	Institution	Institution ID by NSF
	St. Petersburg State University	RU0011
	Moscow Institute of Physics and Technology	RU1323
	Novosibirsk State University	RU0021
Spain	Autonomous University of Madrid	ES0001
	Complutense University of Madrid	ES0007
	University of Barcelona	ES0002
	University of Valencia	ES0015
	University of Granada	ES0004
Taiwan	National Taiwan University	TW0012
	National Cheng Kung University	TW0009
	National Tsing Hua University	TW0014
	National Chiao Tung University	TW0016
	National Yang Ming University	TW0023
Thailand	Chulalongkorn University	TH0003
	Kasetsart University	TH0004
	Thammasat University	TH0008
	Chiang Mai University	TH0002
	Mahidol University	TH0006
Turkey	Istanbul University	TR0009
	Middle East Technical University	TR0010
	Bilkent University	TR1036
	Istanbul Technical University	TR1098
	Bogazici University	TR1040
UK	University of Cambridge	GB0008
	University of Oxford	GB0030
	University College London	GB0009
	Imperial College of Sci, Tech and Medicine	GB0009
	University of Manchester	GB0025

Source: The institutions are derived from the top 500 lists from Academic Ranking of World Universities (ARWU, 2012) and most common 200 foreign BA institutions of US doctorate recipients in 2010 (NSF, 2011).

Appendix III

Comparing Methods: Models on Adjustments for Clustering

DV: Stay 1=US, 0=non US	OLS without any adjustment	OLS with country dummies (Fixed Effects)	Random Effects (clustered by country)	HLM (level 2: country)
Female	0.01 (0.005)**	0.01 (0.004)**	0.01 (0.005)**	0.01 (0.004)**
Married	0.05 (0.004)**	0.02 (0.004)**	0.05 (0.004)**	0.02 (0.004)**
Child under 5	-0.01 (0.005)*	-0.01 (0.005)*	- 0.01 (0.005)*	-0.01 (0.005)*
School aged child	-0.02 (0.009)*	-0.03 (0.009)**	- 0.02 (0.009)**	-0.03 (0.009)**
Age	-0.007(0.0007)**	-0.004(0.009)**	-0.007 (0.0007)**	-0.004 (0.0007)**
Conti Generation	0.005 (0.004)	0.008 (0.004)	0.005 (0.004)	0.008 (0.004)
Select foreign BA	-0.01(0.004)**	0.01 (0.004)*	-0.01 (0.004)**	0.01 (0.004)*
Time to degree	0.002 (0.001)	0.006 (0.001)**	0.002 (0.001)	0.006 (0.001)**
RA	0.19 (0.01)**	0.14 (0.01)**	0.19 (0.01)**	0.14 (0.01)**
TA	0.15 (0.01)**	0.11 (0.01)**	0.15 (0.01)**	0.11 (0.01)**
Scholarship	0.12 (0.01)**	0.09 (0.01)**	0.12 (0.01)**	0.09 (0.01)**
Foreign Govtment	-0.32 (0.01)**	-0.18 (0.01)**	-0.32 (0.01)**	-0.18 (0.01)**
Career in Industry	0.05 (0.004)**	0.03 (0.004)**	0.05 (0.004)**	0.03 (0.004)**
RI	-0.217 (0.35)	-0.05 (0.34)	-0.13 (0.23)	-0.11 (0.23)
RII	-0.12 (0.47)	-0.35 (0.46)	0.05 (0.30)	0.10 (0.29)
Doctoral	0.14 (0.47)	0.11 (0.46)	-0.12 (0.26)	-0.12 (0.25)
Public	-0.10 (0.47)	-0.41(0.46)	-0.04 (0.02)	-0.03 (0.02)
Research Fund	- 3.87e-11 (4.58e-11)	-3.88e-11 (4.46e-11)	-3.87e-11 (4.58e-11)	-3.80e-11 (4.44e-11)
Prestige	-0.01 (0.007)*	-0.01 (0.007)*	-0.01 (0.007)*	-0.01 (0.007)*
GDPC	-7.63e-06 (5.81e-07)**	9.303-07 (1.22e-06)	-7.63e-06 (5.81e-07)**	4.51e-07 (1.17e-06)
Unemp rate	0.005 (0.009)**	0.005 (0.002)*	0.005 (0.009)**	0.005 (0.002)*
R&D expenditure	0.04 (0.004)**	0.001(0.01)	0.04 (0.004)**	0.001 (0.01)

	OLS without any adjustment	OLS with country dummies (Fixed effects)	Random Effects (clustered by country)	HLM (level 2: country)
Education expense	-0.00001 (8.77e-06)*	-7.38e-06 (8.99e-06)	- 0.00001 (8.77e-06)*	-8.13e -06 (8.91e-06)
WCU	0.10 (0.03)**	Omitted	0.10 (0.03)**	-0.70 (0.15)
Biological Sci	0.17 (0.01)**	0.13 (0.01)**	0.17 (0.01)**	0.13 (0.01)**
Engineering	0.10 (0.01)**	0.08 (0.01)**	0.10 (0.01)**	0.08 (0.01)**
Computer Sci	0.11 (0.01)**	0.08 (0.01)**	0.11 (0.01)**	0.08 (0.01)**
Mathematics	0.09 (0.01)**	0.05 (0.01)**	0.09 (0.01)**	0.05 (0.01)**
Chemistry	0.14 (0.01)**	0.11 (0.01)**	0.14 (0.01)**	0.11 (0.01)**
Physics	0.09 (0.01)**	0.05 (0.01)**	0.09 (0.01)**	0.05 (0.01)**
Economics	-0.04 (0.01)**	-0.06 (0.01)**	-0.04 (0.01)**	-0.06 (0.01)**
Constant	0.69 (0.33)*	1.14 (0.33)**	0.47 (0.24)	0.69 (0.24)**
N	25,943	25,943	25,943	25,943
R^2	0.20	0.24	0.20	N/A

* $p < 0.05$, ** $p < 0.01$

Note: The dependent variable is whether one stayed in the U.S. or not (US=1, non US=0).

Standard errors are given in parentheses.

Appendix IV

A List of PhD institution dummy variables omitted in the regression analysis: 45 units

Institution	ID by IPEDS
Alabama A&M University (Reference)	100654
Arkansas State University	106458
California School of Professional Psych-San Diego	110468
Naval Postgraduate School	119678
Rand Graduate School of Policy Studies	121628
Santa Clara University	122931
University of Colorado Health Sciences Center	126571
University of Colorado at Colorado Springs	126580
Delaware State University	130934
Florida Agricultural and Mechanical University	133650
Nova Southeastern University	136215
Mercer University	140447
Boise State University	142115
University of Northern Iowa	154095
Louisiana State University-Shreveport	159416
Northeast Louisiana University	159993
University of Maryland Eastern Shore	163338
Towson State University	164076
Uniformed Services University of the Health Sci	164137
University of Massachusetts Dartmouth	167987
Suffolk University	168005
University of Detroit Mercy	169716
Eastern Michigan University	169798
Montana State University	180461
Creighton University	181002
Rutgers University Newark	186399
Seton Hall University	186584

Institution	ID by IPEDS
New Mexico Institute of Mining and Technology	187967
Alfred University	188641
Rochester Institute of Technology	195003
SUNY College of Environmental Science and Forestry	196103
SUNY College of Optometry	196228
Medical College of Ohio	203951
Oregon Graduate Institute of Science and Technology	209472
Hahnemann University	212841
Indiana University of Pennsylvania	213020
Villanova University	216597
University of Tennessee Memphis	221704
University of Tennessee Chattanooga	221740
Tennessee Technological University	221847
Stephen F Austin State University	228431
Southwest Texas State University	228459
Hampton University	232265
Marshall University	237525
Toyota Technological Institute Chicago	445054