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The Effects of Networks on Institution Selection by Foreign Doctoral Students in the U.S.

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THE EFFECTS OF NETWORKS ON U.S. INSTITUTION SELECTION BY FOREIGN DOCTORAL STUDENTS IN SCIENCE AND ENGINEERING

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THE EFFECTS OF NETWORKS ON U.S. INSTITUION SELECTION BY FOREIGN DOCTORAL STUDENTS IN SCIENCE AND ENGINEERING

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To my husband Omer Tanyildiz

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SUMMARY

The United States has been a very attractive destination for foreign Science and Engineering (S&E) graduate students and postdoctoral scholars for a considerable period of time. Several studies have documented significant contributions of foreign students and foreign scientists in S&E. These contributions in turn foster economic development. Recent studies suggest, however, that the U.S. is losing its dominance in attracting foreign talent. Increased competition outside the U.S. contributes to the change as do changes in visa regulations.

Despite the important role of foreign doctoral students in the U.S, relatively little is known about factors influencing their decision to attend an institution. One factor that is rarely explored is the effect of networks on institution selection. Through their networks, students learn about application procedures, studying at an institution, housing opportunities, general culture and people. In doing this, they draw both on the experience of the alumni as well as the support of current students and faculty at their target institution. Thus, networks can play an important role in where foreign doctoral students actually end up studying.

This study aims to provide both qualitative and quantitative information about the role networks play in foreign doctoral students' institution selection. This three-part study utilizes different methodologies: (1) focus group interviews conducted with Turkish doctoral students at the Georgia Institute of Technology; (2) a web study of research laboratories in science and engineering; and (3) the estimation of Random Utility Model (RUM) of institution selection. These three components build on each other, in addition

to the individual contributions that they make. Together they provide an in-depth and comprehensive analysis of the role of networks.

The results from guided focus group interviews indicate that students, alumni, faculty and local community of the same nationality influence institution choice in various ways. Such as, students provide information about the programs, and alumni introduce applicants to their former professors. Further, in the web study of research laboratories, we find strong evidence that labs that are directed by foreign-born faculty are more likely to be populated by students from the same country of origin than are labs that are directed by native faculty. These results point to the critical role foreign-born lab directors play and support the result from the focus group interviews that the presence of compatriots in their labs creates a comfortable lab environment that makes communication and information exchange easier.

The last analysis tests the effects of networks on foreign students' institution selection, using a Random Utility Model (RUM). We find a strong and significant relationship between the number of existing students from a country of origin at an institution and the probability of attending that institution for potential applicants from the same country of origin. The relationship is non linear, increasing at a decreasing rate. Also, in some of the models there is evidence that alumni and faculty from the same origin also play a role in student choice.

The results of this study have several policy implications. First, the strong network effect found raises the issue of the degree of integration of foreign doctoral students at an institution. Clearly, foreign students cluster in certain institutions. Second, this study provides insight about the possible "mismatch" between the students and institutions.

Specifically, foreign doctoral students could choose to attend institutions, not because these institutions are the best match given their qualifications, but because they provide them with the highest level of psychosocial support. Third, the findings suggest that foreign born faculty play a role in generating new enrollments from their home country as well as in staffing labs, as the web study suggests. Finally, this study draws attention to issues related to staying in the country after graduation.

CHAPTER 1

INTRODUCTION

The United States has been a very attractive destination for foreign Science and Engineering (S&E) graduate students and postdoctoral scholars for a considerable period of time. Currently, almost half a million foreign students at the graduate and undergraduate level are enrolled in US universities. In S&E fields, at the doctoral level, foreign-born students constitute nearly one-third of all graduate students enrolled at U.S. universities (The National Academies, 2005). The percentage of foreign students staying in the country after completing their studies is also increasing. For example, the proportion of foreign students staying in the U.S. for at least two years after receiving their degrees increased from 49 percent for the 1989 cohort to 71 percent for the 2001 cohort (Finn, 2003). Several studies have documented significant contributions of foreign students and foreign scientists in S&E, which in turn foster economic development. However, recent studies suggest that the U.S. is losing its dominance in attracting foreign talent. Rising competition outside the U.S. contributes to the change, as do changes in visa regulations.

Despite the important role of foreign doctoral students in the U.S, relatively little is known about the factors influencing their decision to attend an institution. Former studies addressing the issue of foreign student inflows are primarily descriptive. To date, there has not been an attempt to develop an explanatory model in this area. Moreover, issues related to foreign students are often examined from an institutional point of view rather than from an individual point of view. In most studies, student's perspectives are

not taken into account. Evidence related to why and how these students end up at their destination is only anecdotal.

One factor that is rarely explored is the effect of networks on institution selection. Because of difficulties and challenges of studying in a foreign land, students may seek to be closer to the people they know or to people with whom they can easily communicate in their own language. Through their networks, they learn about application procedures, studying in that institution, housing opportunities, general culture and people. In doing this, they draw both on the experience of the alumni and the support of current students enrolled at their target institution. Thus, networks can play an important role in where the foreign doctoral students actually end up studying.

This study provides both qualitative and quantitative information about the role networks play in foreign doctoral students' institution selection. This three-part study utilizes different methodologies: (1) focus group interviews conducted with Turkish doctoral students at the Georgia Institute of Technology (Georgia Tech); (2) a web studies of research laboratories in science and engineering; and (3) a Random Utility Model (RUM) of institution selection. These three components build on each other, in addition to the individual contributions that they make. Together they provide an in-depth and comprehensive analysis of the role of networks, presenting a clearer picture of the issue of foreign doctoral students' institution selection in the U.S.

This dissertation is organized as follows. Chapter 2 reviews relevant theories related to the foreign student movement and the network argument. The chapter begins with a summary of trends related to enrollments and stay rates after graduation, as well as a discussion of the role of foreign doctoral students in the advancement of science

and economic development in the U.S. Network and cumulative causation theories are then discussed in order to facilitate understanding foreign student trends in the U.S. The chapter concludes with the introduction of the limited literature on the institution selection of foreign doctoral students.

International migration studies and school choice studies are the two lines of research that are most relevant to our research questions. In fact, the simultaneous examination of these two bodies of research reveals the necessity of including networks in a study addressing the institution selection of foreign students. School choice studies mostly address the selection process for domestic students. Even though most of the arguments that apply to domestic students also apply to foreign students –such as financial support, quality of the institution– the case for foreign students is clearly more complicated. For foreign students, selecting an institution in a foreign country involves the issues related both to international migration (e.g. visa, work and study permits, return policies) and adaptation (e.g. language barriers, cultural differences, academic differences). In addition, the existing school choice models neglect to include the highly important role that networks play in international migration. Although the discussion in Chapter 2 constitutes the necessary background for the three studies (focus group interviews, the web study, and econometric choice models), additional theoretical discussions that are relevant to each specific study are included in the corresponding chapters.

Chapter 3 presents the results from guided focus group interviews conducted at the Georgia Institute of Technology in Atlanta, one of the top institutions in science and engineering with high concentrations of foreign-born students from top source

countries. This is the qualitative component of the study, revealing detailed information about the individual experiences of Turkish doctoral students in selecting their doctoral institution. Aside from providing real life examples, this part of the study aims to inform the research questions to be investigated. The groups in this study are selected from the population of Turkish doctoral students currently enrolled at the Georgia Institute of Technology (Georgia Tech) S&E departments. The interviews investigate the effects of networks (1) during the application process; (2) during the time between the receipt of acceptance and moving to Atlanta; (3) during their education at Georgia Tech; and (4) as graduation approaches. The results of this study point towards the strong influence of fellow Turkish students, faculty, alumni and the Turkish community living in Atlanta on student choices. More importantly, these interviews provide detailed information about the formation of social links that occur through the interactions of the applicants and fellow countrymen. Learning from the real experiences of students is an important step towards understanding why we observe a concentration of students from a country at certain institutions.

Chapter 4 examines the ethnic composition of science and engineering research laboratories in U.S. universities. In Chapter 3, the results of the focus group interviews pointed towards the role students and professors at Georgia Tech play in determining the final destination. Students, for example, identified their professors' strong ties with their undergraduate institution in their home country as one of the factors motivating students to apply and subsequently come to Georgia Tech. Also, students stated that they searched for professors from their own country who directed labs, and contacted them directly before making their formal applications. These findings led us to

investigate the extent to which foreign-born faculty staff their laboratories with students of the same nationality. We hypothesize that the percentage of foreign students from a specific country is higher in research labs directed by a faculty member who is from the same country of origin, compared to research labs directed by native (U.S. origin) faculty. To test this hypothesis, we conducted a web search of 164 science and engineering laboratory web pages. Among these 164 labs, 82 are directed by foreign-born faculty from Korea, China, India or Turkey. These 82 are matched with labs in the same department of the same university directed by a native faculty member.

Using laboratory web pages is a simple but novel methodology to study ethnic compositions. However, the identification of the nationalities of the individuals in these labs is a rather difficult task. Our methodology started with the resumes or CVs of the individuals in the research labs. In addition, foreign student assistants from each nationality were hired to identify names from their country of origin. Further, each name is cross referenced with the list of "Most Common U.S. Ethnic Surnames" provided in Kerr's (2004) study. The same methodology was used to identify the nationalities of the faculty members as the students. However, unlike the faculty members, not all students had their resumes posted on their web pages. For student nationality identification, we relied heavily on the "Most Common U.S. Ethnic Surnames" from Kerr's study, recognition by a native student, and searches in relevant web pages, such as foreign student association member lists.

This study finds strong evidence that labs that are directed by foreign-born faculty are more likely to be populated by students from the same country of origin than are labs that are directed by native faculty. This finding is consistent across discipline,

nationalities, and institutions within different ranking tiers (top, middle, and bottom). These results also support our findings from the focus group interviews. Turkish students at the Georgia Institute of Technology stated that having compatriots in their labs made communication easier and created a more comfortable environment for them.

The results of this study draw attention to the effect of affinity on the ethnic composition of research labs at the micro level that translates into the ethnic composition of the scientific community at the macro level. Further, these results emphasize the role of lab directors in creating scientific human capital, and contributing to the 'brain circulation' phenomena in the global context.

Chapter 5 presents the third component of the analysis, conducted to investigate the effects of networks on foreign student's institution selection using a Random Utility Model (RUM) and data from the Survey of Earned Doctorates (SED). The SED is administered by the National Science Foundation (NSF) and funded by four other federal agencies. It is a census of all doctoral recipients in the U.S., with a very high response rate (92-95%). The data is collected directly from individual doctoral recipients at or near the time of graduation[1].

Our empirical approach is to establish a choice set for students that is restricted to institutions to which the individual has the possibility of being selected for admission. We then assume that the individual will choose the institution that maximizes utility. Other things being equal, we assume that the greater the depth of the ethnic networks

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[1] The use of NSF data does not imply NSF endorsement of the research methods or conclusions contained in this dissertation.

available at the institution, the greater is the utility derived from attending that institution and thus the greater is the likelihood that the individual will attend that institution. We measure four dimensions of networks: (1) alumni networks; (2) current student networks; (3) faculty networks; and (4) community networks. Because of the difficulty and expense encountered in determining faculty ethnicity, the faculty network variable is tested for a limited number of institutions.

We are aware that networks also play a role in the admission decision of institutions. Here, however, we focus on student choice from a set of institutions that we assume either admitted the student or would have admitted the student had the student applied. While this is a somewhat heroic assumption, it is necessary given that we do not have access to admission data.

Our empirical analysis builds on our lab studies and our focus group study of Turkish students attending Georgia Tech. The focus group interviews pointed towards the role that fellow Turkish students, alumni, Turkish professors and Turkish residents in the local community play in the application and acceptance process. In this chapter, we examine institution selection for doctoral students not only from Turkey, but also from China, Korea, and India (the top three source counties).

The analysis in Chapter 5 also builds on and supplements the research laboratory web study presented in Chapter 4, where it was found that faculty and students from the same nationalities cluster in the same labs, suggesting that networking plays an important role in determining the composition of the research labs. Research labs, however, while being a well-defined unit for analysis, do not completely explain the foreign student allocations within the department. Nor do they allow for analysis of

clustering behavior in fields, such as mathematics, where research is not conducted in a lab setting. An advantage of the analysis of Chapter 5 is that it relaxes the 'laboratory boundaries' of the web study, analyzing the department as a unit and adding disciplines where laboratory work is less common. The comparison of the results from the web study and Chapter 5 can also clarify the role of faculty within labs as opposed to their role within the department.

In addition to the network variables, characteristics of the institution, characteristics of the geographical location, student quality and some other demographic characteristics are likely to affect students' probability selecting an institution. Therefore, these variables will be controlled for in the analyses.

The random utility models used to estimate the effects of networks have a major advantage compared to more common analysis, such as a regression analysis. While a comprehensive model that includes all the factors contributing to students' utilities is hard to achieve, in RUMs only the differences in utility between the choices matter, that enables us to evaluate the changes in utility that are attributable to the students' network ties.

In all of the models, we found a strong and significant relationship between the number of existing students from a country of origin at an institution and the probability of attending that institution for potential applicants from the same country of origin. The relationship is non linear, increasing at a decreasing rate. We also found in some of the models evidence that alumni and faculty from the same origin also play a role in student choice.

In all three analyses, different aspects of network effects on foreign students' institution selection are revealed. Our findings provide exploratory, descriptive, and explanatory information for higher education institutions and communities in crafting policies with regard to foreign students. Chapter 6 discusses the policy implications of the findings in detail as well as the limitations of the study. The chapter concludes with suggestions for future studies.

CHAPTER 2

BACKGROUND AND THEORY

This chapter provides information about foreign doctoral students in the U.S and delineates the theoretical background, motivating this study. After a brief introduction of the trends related to enrollments and staying after graduation, we discuss the role of foreign doctoral students in the advancement of science and economic development in the U.S. Next, we introduce network and cumulative causation theories that facilitate understanding foreign student movements into the U.S. Although the discussions in this chapter constitute the necessary background for the three separate studies (focus group interviews, the web study, and RUMs) presented in this dissertation, additional theoretical discussions are included in corresponding chapters that are relevant to the analyses.

Foreign Students in the U.S.

Since World War II, the United States has been a very attractive destination for foreign science and engineering (S&E) graduate students and postdoctoral scholars. The inflow of foreign students has grown since that time, and it accelerated during 1990s. Today, the total number of foreign students studying in undergraduate and graduate programs the U.S. is more than half a million. Foreign student representation is highest at the doctoral level in S&E fields. In 2004 (Table 2.1), nearly one-third of PhDs awarded in S&E at U.S. universities went to students who were non-US citizens (The National Academies, 2005)

Table 2.1: Doctorate awards, by selected characteristics of doctorate recipients: 1985, 1995 and 2004

	1985	1995	2004
Number receiving doctorates	31,296	41,750	42,115
Percentage who were Not U.S. citizen	21	32	33

SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Earned Doctorates, 2004.

Asian students have constituted the largest population of foreign students for the last three decades. The total percentage of PhD's awarded to students from China, Taiwan, India, South Korea, Japan and Pakistan rose from 6.7 percent in 1966 to 20 percent in 2003. The increase was most striking for Chinese students. In 1966 there were only 84 Chinese PhD students in the U.S., which constituted 0.7 percent of total PhD students. In 2003, the 2,559 Chinese PhDs made up 10.2 percent of all PhDs awarded, and 30.9 percent of all the students with temporary visas (Table 2.2).

TABLE 2.2: Number of US S&E PhDs Awarded by Selected Country of Citizenship, 1966, 1976, 1986, 1996, and 2003

	1966	% of Total	% of Temp. Res.	1976	% of Total	% of Temp. Res.	1986	% of Total	% of Temp. Res.	1996	% of Total	% of Temp. Res.	2003	% of Total	% of Temp. Res.
China	84	0.7	5.2	20	0.1	0.7	223	1.2	5.3	3074	11.3	38.8	2559	10.2	30.9
India	338	3	20.8	532	2.9	19.3	524	2.8	12.6	1324	4.9	16.7	801	3.2	9.7
S. Korea	73	0.6	4.5	147	0.8	5.3	417	2.2	10	987	3.6	12.4	972	3.9	11.7
Taiwan	168	1.5	10.3	544	3	19.8	809	4.4	19.4	1198	4.4	15.1	478	1.9	5.8
Japan	51	0.4	3.1	91	0.5	3.3	113	0.6	2.7	153	0.6	1.9	187	0.7	2.3
Pakistan	42	0.4	2.6	29	0.2	1.1	65	0.4	1.6	92	0.3	1.2	34	0.1	0.4
Total: Asia	756	6.7	46.5	1363	7.5	49.6	2151	11.6	51.5	6828	25	86.1	5031	20	60.8
Germany	28	0.2	1.7	36	0.2	1.3	63	0.3	1.5	171	0.6	2.2	196	0.8	2.4
United Kingdom	83	0.7	5.1	123	0.7	4.5	84	0.5	2	116	0.4	1.5	114	0.5	1.4
Italy	7	0.1	0.4	24	0.1	0.9	48	0.3	1.1	75	0.3	0.9	111	0.4	1.3
France	9	0.1	0.6	35	0.2	1.3	38	0.2	0.9	70	0.3	0.9	89	0.4	1.1
Israel	60	0.5	3.7	80	0.4	2.9	92	0.5	2.2	80	0.3	1	55	0.2	0.7
Ireland	3	0	0.2	7	0	0.3	16	0.1	0.4	29	0.1	0.4	26	0.1	0.3
Total: Europe	159	1.4	9.8	262	0.1	9.5	262	1.4	6.3	341	1.3	4.3	591	2.4	7.1
Total PhDs Awarded	11334			18250			18450			27275			25121		
Total PhDs Awarded to Temporary Residents	1627	14.3		2750	15.1		4147	22.5		7929	29.1		8276	32.9	

SOURCE: National Science Foundation. 2004. Survey of Earned Doctorates 2002

European graduate students have also been a significant part of foreign doctorate recipients in the U.S. programs. However, from 1960s to the 1990s, their representation fell from 17.5% to 12.4% of foreign students. Latin American students have composed a smaller part of the foreign student body with a nearly constant proportion (6%). Unlike some Asian and European countries, there is no constant trend for Middle Eastern countries, with a rise in PhD recipients through the 1980s, and then a fall in the 1990s (Bound *et al.*, 2004).

The foreign student population increase has been very significant in almost all of the major S&E fields. However, the citizen-non-citizen growth differential is has been highest in mathematical/computer sciences, followed by engineering and earth/environmental sciences from 1973 to 1997 (Levin *et al.*, 2004). In 2004, in physics, engineering, mathematics, and computer science, more than 50 percent of doctorate recipients were not U.S. citizens (Table 2.3).

Table 2.3 U.S. doctorate recipients who were non-U.S. citizens by field of study: 2004

Field	Percent
All fields	33.2
Science and engineering	40.7
Science	34.0
Sciences	46.0
Biological sciences	30.0
Computer sciences	56.1
Earth, atmospheric, and ocean sciences	37.4
Mathematics	56.1
Physical sciences	45.6
Astronomy	30.2
Chemistry	41.6
Physics	54.7
Other physical sciences	33.3
Psychology	8.5
Social sciences	35.1
Engineering	64.6
Non-science and engineering	20.4
Professional/other/unknown	38.0
Humanities	20.1
Health	26.8
Education	12.2

SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Earned Doctorates, 2004.

Stay Rates

Studies show that foreign students contribute to the U.S. economy while they are students (discussed in more detail in the following section), as well as when they are in the workforce. Even if they leave the U.S. after completing their studies, they create new opportunities for international collaboration, which in turn contributes to research productivity (Lee, 2004).

Two studies document foreign students' tendency to stay in the U.S. Aslanbeigui (1998) finds that 45 percent of foreign students from developing countries planned to stay for some time, 15 percent planned to stay permanently, and another 15 percent

planned to go to a third country. Finn (2003) indicates that the proportion of foreign students staying in the U.S. for at least two years after receiving their degrees increased from 49 percent for the 1989 cohort to 71 percent for the 2001 cohort. The stay rate is the highest among engineering, computer science, and physical science graduates. Stay rates differ also by country of origin. For example, among the temporary residents who received their PhD in 1996, Chinese and Indian had very high stay rates, –96 percent and 86 percent respectively. Taiwanese had 40 percent, and Koreans had 21 percent stay rates in 2001(Finn, 2003).

Contributions

Evidence suggests that foreign students contribute to the innovation process, which in turn enhances the productivity of the country. One study suggests that a 10 percent increase in the number of foreign students would raise patents granted to universities by 6 percent, and non-university patents by 4 percent (Chelleraj, 2004). In addition to their impact on scientific and technological capacity, foreign students' impacts on the host country's economy have also been documented by others. For example, Marginson (2004) estimates that the inflow from foreign students, including their fees, tuition and living expenses, constitutes the third largest in the service export industry in Australia. Similarly, the Association of International Educators (NAFSA) reports a $12.9 billion revenue in the 2003-2004 academic year in the U.S. (NAFSA, 2004).

Stephan and Levin (2001) find that foreign born and foreign educated scientists contribute disproportionately to US science using six different indicators (individuals elected to the National Academy of Sciences (NAS) and /or National Academy of

Engineering (NAE), authors of citation classics, authors of 'hot papers', authors of highly cited patents, and scientist who have played a key role in launching biotechnology firms). In a recent study, Lee (2004) provides empirical evidence that foreign born scientists are more productive (measured by both normal and fractional publication counts) than native born scientists. His findings are consistent across disciplines.

Costs

The foreign-born graduate students' and scientists' existence in the U.S. is, of course, not without costs. The idea, for example, that foreign students are 'crowding out' natives has gotten much attention. According to a report by the National Science Foundation, the number of U.S. citizen and permanent resident male graduate students decreased from 1993 to 2000, while the number of temporary foreign graduate students who are male increased (National Science Foundation, 2004). Borjas (2004a) argues that the steepest drops in white male native student enrollments are observed in institutions where foreign student enrollment increases are the largest. While this information might seem consistent with the possibility that foreign students are 'crowding out' natives, some authors point to the existence of other factors that could contribute to these results. For instance, the decrease in the number of U.S. people in the 20-24 age cohort within the last decade might contribute to the decrease in the total number of native student enrollments (Bean, 2005). In addition, the existence of more attractive job opportunities (higher-paying and with better working conditions) for native students might pull them away from pursuing academic careers (Bean, 2005; Stephan & Sharon, 2003). This effect is even stronger for male native students who are

more sensitive to U.S. labor market conditions than foreign students (Bean, 2005). Moreover, native female enrollments held steady during the 1990s even in the face of simultaneous foreign-born female enrollment increases, a pattern not consistent with the "crowding out" argument. Both foreign and native-born groups of females increased their enrollments from 2000 to 2003 (Oliver, 2005) –again a trend that does not suggest a crowding effect.

In another study, Borjas argues that foreign students lower the wages for scientific jobs. He indicates that "an immigration induced 10 percent increase in the supply of doctorates in a particular field at a particular time, reduces the earnings of that cohort of doctorates by about 3-4 percent" (Borjas, 2004b).

Rising Competition Outside of the U.S.

Because the foreign-born scientific work force is essential to U.S. dominance in science and engineering, it is important to understand the mechanisms by which foreign students come to the U.S. The need for studies in this area becomes more pressing when we consider recent reports suggesting an increase in opportunities for graduate S&E study and employment in other countries. If this trend persists, the U.S. might lose its edge as a popular destination for S&E studies. Other countries are not only strengthening their S&E education, but also producing more graduates each year. Improvements in Asia are specifically worth noting. In Asia, the percentage of students getting S&E degrees is increasing more than in the U.S. Freeman notes that at this rate China will produce more PhDs than the U.S. in 2010 (Freeman, 2005). Also, India almost doubled its S&T doctoral degree production from 1980 to 2000 (Prasad, 2004). Within the last three decades, 59 percent of Chinese students, 46 percent of South

Korean students, and 66 percent of Japanese students got their university degrees in S&E, compared to 33 percent of U.S. students, creating a larger base of students for doctoral study (National Science Board, 2004).

Foreign student compositions in Asian countries are also rapidly changing. For example, China, in 2003, received 78,000 students from 175 different countries or regions, the major ones being the Republic of Korea, Japan, the United States, Vietnam, and Indonesia (Ning, 2004).

The member nations of the European Union (EU) are investing in higher education more aggressively and increasing their public investments in R&D. The EU leaders adopted the goal of member nations' spending 3% of their GDP on R&D by 2010. Although it is exceedingly unlikely that this target can be met, the EU is experiencing growth in the number of research universities, the number of patents awarded, the number of doctoral degrees granted, and the number of citations (The National Academies, 2006). For example, since 1993, the European Union (EU) has matched the U.S. in the number of citations in many disciplines (King, 2004).

Furthermore, the EU countries have also improved their facilities to attract talented students from other countries. Some countries have established networks among students, enabling easy access to collaboration possibilities, funding sources, or job opportunities. Two such examples are the German Academic International Network (GAIN) launched by the German Academic Exchange Service, and DAVINCI, initiated by the Italian Ministry of Foreign Affairs (The National Academies, 2005). The United Kingdom has also increased the number of work permits issued to skilled workers

through the Highly Skilled Migrant Programme, which began in the mid-1990s (The National Academies, 2006).

Changes in the attractiveness of the U.S. as a leading destination for foreign talent have caught the attention of the media as well. *The New York Times* reports that, "The U.S. has started to lose its world dominance in areas of science and innovation" in reference to the declining numbers of prizes, patents, and journal papers produced (Broad, 2004). Another source reports that "U.S. loses allure in foreign students' eye", indicating that there is a decline in the number of students arriving from Europe, South Asia and the Middle East (Brumfiel, 2003).

Leadership in science and technology is essential for having a comparative advantage in the global economy. A decrease in the share of talented scientists will eventually affect the country's dominance in science and technology. Considering that foreign scientists will continue to be an integral part of the scientific workforce, there is a pressing need to formulate better policies to decrease difficulties during their initial acceptance into a PhD program, as well as after their education is complete.

Admissions of Foreign Students

Recent research on determinants of college admission primarily focuses on undergraduate admissions. Among the studies that examine graduate school admission, only a few discuss the determinants of admission to doctoral programs. Most focus primarily on the effect of one or more of the applicants' characteristics (GRE, GPA, master's degree, college quality, etc.) on the 'survival' or success of the student throughout the program. According to Grove and Wu (2006), two key measures of success are "completion of the doctorate and publishing peer reviewed articles" (p.6).

Even though the admission decisions are supposedly based on criteria for success, studies explaining the determinants of admission and the ones on the determinants of success do not have matching results. For example, math GRE scores are highly significant in determining admissions to economics doctoral programs (Attiyeh & Attiyeh, 1997; Krueger & Wu, 2000), but Ehrenberg and Mavros (1995) show that math GRE scores fail to predict time-to-degree or graduation rates.

Studies looking at the effect of college quality on the measures of success report positive results. Eide et. al. (1998) and Tuckman et.al. (1990) find that doctoral students who graduated from an elite undergraduate institution completed their program more quickly. Furthermore, Eide et. al. (1998) and Zhang (2005) report that graduates of high-quality colleges are more likely to earn degrees at research universities. Having a prior master's degree also decreases the years to completion of the doctorate (Siegfried & Stock, 2001). Grove et.al. (2005) find a greater effect when the master's degree is in the same field with the doctoral degree program.

Two studies present results showing a preference for U.S. citizens over most foreign applicants with regard to admissions (Attiyeh & Attiyeh, 1997; Krueger & Wu, 2000). The results of studies examining the completion rate for foreign students are mixed. Among economics doctoral students, Tuckman *et. al*. (1990) find that students with foreign undergraduate degrees have slower completion rates. By contrast, Ehrenberg and Mavros (1995) find that in their sample of economics doctoral students, foreign students completed the program faster. Further, Espenshade & Rodriguez (1997) show that, controlling for GRE scores, foreign students have a higher rate of graduation.

A recent study discusses faculty perceptions of foreign graduate students (Trice, 2003). Through interviews with faculty members (including deans, associate deans, department chairs, professors, departmental staff members, students leaders, and professionals across campus working with foreign students) in four departments at a Research I university in the midwestern United States, Trice presents the benefits and challenges foreign students face in departments. Among these benefits, "providing an international perspective within the department" is common for all four departments. Other benefits include filling research vacancies, representing the highest quality students, helping to establish international ties, increasing international reputation, bringing work experience, and providing American students a more realistic picture of their life circumstances (Trice, 2003).

Admitting foreign graduates to US universities might depend on all the factors listed above as well as some other institutional idiosyncrasies not discussed here. A question that remains to be investigated is how admission decisions vary according to the country of origin of the foreign student. Accumulation of foreign students with the same country of origin in specific locations might be a result of the departments' positive experiences with them from previous years. Therefore, the stock of foreign students from one origin is likely to influence the departments' decision to admit students from the same origin. Also, the previous experience of admitting students from one country makes the process of future admission less complicated. In some cases

peripheral organizations are established to help both the students and the departments when there is heavy volume of student flow from a specific country[2].

International Student Migration

International student flows between countries have unique characteristics. The most significant aspect of foreign student movement is its initially temporary status. Although later in the process foreign students might change their status and become permanent residents, the majority of the foreign students start their education on temporary visas. Thus, they are not considered as immigrants during their studies. The graduate school environment is also a unique experience compared to other forms of migration. Graduate school serves as sort of a "trial" version of permanent migration. Students face many of the challenges of migration –adaptation to a language, culture, etc.– but are somewhat protected by the benefits of being affiliated with a graduate school, such as financial assistance, university housing options and student health insurance (Szelenyi, 2003). During this period students accumulate information they needed to make a decision about staying after graduation.

The unique characteristics of foreign students explain their rare inclusion in the international migration literature. On the other hand, foreign student migration, aside from their temporary status, could be considered as similar to the migration of the highly skilled labor. As indicated in a previous section, foreign students engage in high quality research and teaching activities during their doctoral studies. Their role seems to

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[2] The graduate admission process can play a role in determining the demographic and ethnic composition of academic departments and thus presented in this section. However, in this study, the focus is the decision process of doctoral students, not the admission committees of the departments.

be crucial in programs that staff both the classroom and the laboratory with doctoral students.

Current theories do a poor job in explaining the forces that motivate foreign students to choose a specific institution. As a result of the characteristics of foreign students, there is a need for a coherent theory to incorporate a variety of perspectives and take a multifaceted approach to the phenomena. The capacity of different international migration theories to explain foreign student migration will be discussed later in this chapter.

International Migration

International migration is conceptualized at different levels –the individual, the household, the nation, the system– in different theories. However, any complex phenomenon such as international student migration requires a combination of these theories to explain the subject extensively.

In neoclassical economics, macro theory attributes international migration to geographical differences caused by differences in demand and supply of labor. Labor moves from poor countries to rich countries and investments move from rich countries to poor countries. However, the migration of highly skilled labor follows a different pattern responding to the 'rate of return' to human capital (Massey D. S., 1993). In micro theory, international migration is explained by the decision of rational actors, trying to maximize their expected net return. The introduction of collective action in migratory decisions introduced in the "new economics of migration" (Stark & Bloom, 1985). The new economics of migration suggests that international movement does not decrease if the wage differential is reduced in other markets within the sending country.

Another interesting approach, "world systems theory" tries to explain international migration as a result of global expansion influencing the economic and political organizations. According to this theory, for example, the concentration of students could be explained by the strength of the cultural, linguistic, administrative, investment, transportation, and communication links between the sending and the receiving countries.

Although wage differentials or influences created by the changing world order may initiate international movement, changing conditions during the course of migration may also become separate independent variables in an individual's migration decision (Massey *et al.*, 1993). These transformations might increase the trend of migration cumulatively. The case of foreign student migration seems to conform to some of the arguments of this approach. This process, known as "cumulative causation" and the network theory in relation to foreign students will be discussed in more detail in the following sections.

Network Theory

Considering the difficulties of studying in a foreign land, many students seek to be closer to the people they know or to people with whom they can easily communicate in their own language. Through their networks, they learn about the application procedures, studying in that institution, housing opportunities, general culture and people. They utilize both the experience of the alumni and the support of the current students in their target institution.

Massey et. al. (1993) defines migration networks as "sets of interpersonal ties that connect migrants, former migrants, and non-migrants in origin and destination areas

through ties of kinship, friendship, and shared community origin" (p. 448). Foreign students build their networks through former students as well as others living in the same location with the same country of origin.

Migrants benefit from two aspects of networks: reduced costs and risks. Initiating a migration from another country requires a great amount of information. Once social ties begin to build, information related to work and living conditions starts to accumulate, making it easier for migrants who come later. In other words, every new migrant reduces the costs for his/her friends, relatives, and compatriots who might like to migrate. Similarly, the expansion of migrant networks reduces the possible risks that emerge as a result of relocation for people who are related to the migrants.

As opposed to neoclassical theories, network theory proposes that individual or systematic characteristics are not the sole determining factors explaining the migratory flow. The costs and risks involved in the process draw migrants closer to their networks instead of considering better options.

Cumulative Causation Theory

Massey suggests that in addition to the growth of networks and creation of institutions, the migratory process itself influences possible progressive movements (D.S. Massey, 1990). That is, each additional migratory action changes the context within which the action will take place. Szelenyi explains the process as the accumulation of social and human capital that leads to further migrations (Szelenyi, 2003). Some of the propositions of 'cumulative causation theory' are highly applicable to foreign student migration. For example, when a student migrates to another country for graduate education, the skill differential between that migrant and the non-migrant

peers is likely to increase. This might later transform into a force inducing migration among non-migrants. If a student decides to migrate in order to get a more prestigious degree, the pressure on the non-migrants could increase even further if that student aims to return and work with those peers. Even if the migrant student decides to stay in the destination country, peers might still want to close that gap. A cultural gap might also emerge between the migrant and the non-migrant friends and relatives. As the number of migrants increases, the culture, language, values, and behaviors of the receiving society might become widespread, initiating a tendency for further migrations. Lastly, as implied by the theory, some jobs in the receiving countries might be labeled as "immigrant jobs." This might drive some natives away from those jobs. Although this proposition is more applicable to low-skilled labor, it is possible to observe a similar situation in graduate research assistantship positions. As these lower paying positions are more and more filled by international students, a stigma might be attached to these positions keeping natives out of university jobs.

Foreign-born professors who maintain their ties with institutions in their country of origin might also facilitate further migration. They might use these ties to recruit doctoral students from their home countries. Likewise, foreign born doctoral graduates who are employed as professors in their home country might facilitate further migration by helping students establish contact with professors at the U.S. universities where they have studied.

School Choice by Foreign Students

The majority of empirical studies on school choice focus on the selection of undergraduate institutions. The body of school choice studies on graduate school

selection, especially doctoral institutions, is relatively small. Although undergraduate school choice models could provide insights for graduate school choice, these two selection models have major distinctions. Undergraduate education is typically centralized, and the students choose institutions, rather than departments. Whereas graduate education is decentralized, and the departments within institutions make the admission decisions, or decisions related to funding opportunities (Fox, 2000). Therefore, for graduate education, the departments rather than the institutions constitute the choice set alternatives for the graduate applicants.

Among the studies addressing graduate education, only a few focus on foreign student's institution selection. In these studies, the inflow of foreign students is explained by a combination of "push" and "pull" factors. Push factors could include country-specific characteristics like limited economic wealth or adverse social and political conditions. The characteristics of the higher education institutions also 'push' students to study abroad, such as, unavailability of a particular specialty, limited access to funding –especially for junior scientists–, and poor career prospects could motivate students to seek opportunities outside of their country (Mazzarol, 1998).

Pull factors are related to the host country's capacities to attract foreign students. Better academic facilities and better financial support are two of the most important factors. Better working conditions and better job opportunities also attract students planning to stay in the country after completing their education. In addition, the prestige of a foreign degree, and living in a different culture attract students towards pursuing a foreign degree (Mazzarol & Soutar, 2001).

The decision to study abroad can be examined in three stages. At the initial stage, a student decides to study abroad, affected by one or a combination of the push factors listed above. The second stage of the decision process is to determine the country of destination. At this stage, pull factors come into play, making one country more attractive than all of the others. The third stage is the decision about selecting a particular institution within the host country. To understand the reasons why foreign students end up at one institution seems more complex than understanding why they choose a certain country. The amount of variation among the institutions within a country, especially in the U.S., is very high. The alternative combinations of location characteristics, existence of networks, and institutional characteristics create highly differentiated choice sets for the prospective students.

A small number of studies address the institutional selection mechanisms of foreign students. For example, 879 students were asked to rate the importance of a series of factors that affected the selection of a particular institution (Mazzarol & Soutar, 2001).. The most important factor for foreign students was whether their qualifications would be recognized in the host institution. Other highly rated factors included the reputation of the institution, the recognition of the institution in their own country, the quality of the institution's staff, its alumni base and its existing international student population. When student inflows are considered within the context of "international migration", the effect of networks gains more importance.

In this study, we first identify the networks of foreign students through focus group interviews. Second, we examine ethnic composition of research labs in order to test whether lab directors are more likely to populate their labs with students who share

the directors' ethnicity. Finally, we empirically test the influence of network effects on the probability of selecting an institution by estimating a Random Utility Model for students from Chin, India, Korea, and Turkey, who received PhDs from U.S. institutions during the late 1990s and early 2000s.

CHAPTER 3

FOCUS GROUP INTERVIEWS

The qualitative component of this study aims to reveal the nuances in institution selection behavior of doctoral students. A series of guided focus groups interviews were conducted for two main reasons: to provide real life examples related to this study, and to find out new research questions to be investigated in this and future studies. The plan of this chapter is as follows. In section one, we revisit some of the pertinent theories about the role of networks in foreign student movements in section one. Section two explains the focus group interviews in detail, and describes the methodology. Section three presents the results, and the conclusions are discussed in chapter five.

Background and Theory

Both migration and higher education studies provide information about the institution selection of foreign students. Some of these studies provide empirical evidence, primarily about the economic aspects of school choice. However, qualitative studies in school choice are rare, and usually explore the subject from an institutional point of view. This study seeks qualitative information about the school choice process from the students' point of view. More specifically, it identifies the steps that that bring foreign students to their destination in the U.S.

Although this section of the study is mainly exploratory, the interviews are guided by the literature discussed in Chapter 2. We aim to learn about all stages of school choice process: (1) the decision to pursue a degree; (2) the identification of institutions for application, and (3) the admissions, enrollments and actual attendance (DesJardins *et al.*, 2006). In addition to understanding the factors that were critical in

their final decision, we explore the common patterns in the earlier stages of the decision process that bring the students to this final stage.

Foreign students' decision process includes an additional in-between step; deciding whether to study abroad or to stay in the country. As we have identified earlier, finding better academic facilities, better financial support, social and personal links, better employment opportunities after graduation, and higher salaries draw students towards studying abroad (Mazzarol & Soutar, 2001). Among these factors, the role of tuition and costs has been studied more often than all the others (e.g., Ehrenberg and Sherman 1984; Dynarski 2000). Financial support is one of the most important factors effecting school choice. However, in the case of foreign students, minimizing social costs may be as important as the minimizing financial costs. Adapting to a new environment, learning about new institutional and social rules, and having to do all this in a language other than their native language requires an extra amount of time and effort. Therefore, clearly, investigating the effects of networks is essential in understanding the decision processes of foreign students.

International migration studies often focus on the importance of social and personal links in deciding to migrate and selecting a destination (Portes 1995; Brettel 2000). Tilly (1990) emphasizes the shift from 'migration of individuals' to 'migration of networks.' He suggests that migration flows become self sustaining once information and assistance accumulates between the migrants in the host country and friends and relatives in the sending country.

Methodology

Focus group interviews are particularly useful for exploring people's experiences (Kitzinger, 1994). In this research, doctoral students' experiences related to application, enrollment, and the utilization of networks throughout their education are investigated. Some other characteristics of focus groups help enhance this study. Subjects in a group are able to clarify their ideas with the help of other members of the group who have similar experiences (Berg, 2001). Also, the group dynamic helps the researcher understand the relative importance of the issues to the subjects.

In comparison with face-to-face interviews, focus group interviews provide a number of additional benefits. First, they can encourage participation from students who are reluctant to be interviewed on their own. Second, they enable the researcher to observe how students discuss the issue. In face-to-face interviews, subjects might provide a greater amount of detail, but in focus group interviews, the researcher can observe how the subjects defend their ideas within a discussion setting. This may be more important than overloading detail. However, in some cases this could be a downside to focus groups. The discussion environment could silence individuals with opposing views. The researcher needs to be alert to this and help some individuals with probing questions. Third, as Denzin (1989) suggests, meanings and answers that arise during a focus group are socially constructed rather than individual creations. This is especially important for this research, since the concept of 'network' has a collective dimension. Therefore, it might be beneficial to observe all the various nodes of the potential network at the same time. Lastly, as Berg (2001) indicated, focus groups create an environment in which the concept studied is isolated from the natural world, enabling

the researcher to examine the phenomena closely. This effect, called "bracketing," might create an environment for doctoral students to concentrate on how networks specifically play a role in their decision.

Two characteristics of focus groups also make this method more practical compared to other qualitative interviewing techniques. First, it saves time. Focus groups require less time than individual interviews do to include the same number of doctoral students. This is especially important in studies that deal with transient populations (Berg, 2001). Hence, focus groups will work better in accessing the doctoral students within one semester without risking their graduation during the course of interviews. Second, focus groups tend be less expensive compared to face-to-face interviews. The cost might increase if other researchers are hired or subjects are paid to participate, both of which do not apply to this study. The only remuneration was a set of mp3 players.

Sampling

The groups in this study were formed from the population of Turkish doctoral students enrolled at the Georgia Institute of Technology (Georgia Tech) S&E departments[3] during Spring semester, 2007. In addition to proximity, Georgia Tech provides several other benefits. First, both the university and the city in which the university is located provide a large sample population. Georgia Tech has several Turkish professors, and many Turkish students in almost every S&E department. Also, Georgia Tech has been a destination for Turkish students for a long time, which

[3] We initially intended to conduct focus group interviews both at Georgia Institute of Technology and Georgia State University (GSU). However, we were able to locate only four Turkish S&E doctoral students at Georgia State University, and only two of them had contact information.

provides a considerable number of alumni that could be a part of this potential network. Atlanta, where Georgia Tech is located, has a large Turkish population as well. Indeed, Georgia has the 6th biggest Turkish population among all states, and Atlanta has the 9th biggest Turkish population among all MSAs (Census 2000). In 2004, nearly 2,000 Turks resided in Atlanta (TACAGA, 2004).

All potential subjects who are registered in the Turkish Student Organization (TSO) were contacted through TSO's mailing list (see Appendix 3.1 for a copy of the solicitation e-mail). According to the president of Turkish Student Organization, all Turkish students are invited to join the TSO mailing list once they arrive at Georgia Tech. However, registering with this e-mail list is not obligatory and students are free to stay off this list. The International Office at Georgia Institute of Technology reported that 93 Turkish doctoral students were enrolled at Georgia Tech during Spring 2007, and the president of TSO reported that TSO mailing list includes 310 unique e-mail addresses. Although it is not certain, he thinks this number includes master's students, alumni or students who have left Georgia Tech. We assume a high percentage of doctoral students have a subscription to this mailing list. However, students might still prefer to stay off of this mailing list. These students could be the ones who value networks less than the ones who stay within this mailing list. If this is the case, the study would suffer from bias towards students who value networks.

The doctoral students were asked to respond to the solicitation e-mail in two weeks. After the first e-mail only four students responded. We sent the solicitation e-mail two more times, four and seven days after the first one. We had a total of 14 participants after these three e-mails. Then, we asked our several friends to talk about

this study in their departments and made announcements during every major Turkish community event. In addition we utilized our own networks, some of which are through individuals who are currently in Turkey. Finally 20 students agreed to participate. Among these 20 students, 18 students were actually able to participate. We formed three of six students. This falls within the recommended size. Krueger (1994), for example, suggest that for complex problems the size should be kept to no more than seven. Pramularatana (1985) suggests six to nine, and Lengua (1997) suggests not to exceed twelve.

Table 3.1 summarizes the characteristics of the participants to our focus groups. The groups included students from industrial engineering, electrical engineering, civil and environmental engineering, aerospace engineering, materials engineering, chemical engineering, computer science, biology, and chemistry departments. Seven of these participants were female, and eight did not have a master's degree. All of the students except one earned their undergraduate degree in Turkey. Among all participants only two were in their first year and only one had studied at Georgia Tech for more than five years.

Table 3.1: Characteristics of Focus Group Participants

Department	#	Master's Degree	#	Gender	#	Undergrad. Institution	#	Year in PhD	#
Electrical Engineering	1	Turkey	6	Male	11	Turkey	17	First	2
Industrial Engineering	5	US	2	Female	7	US	1	1-3	4
Materials Engineering	1	Third Country	2					3-5	11
Civil/Environmental Engineering	3	No Master's	8					5+	1
Aerospace Engineering	3								
Comp. Science	1								
Chemistry	2								
Biology	1								

All three focus group interviews took place on the Georgia Tech campus and each session lasted for about an hour. Each participant was asked to sign the consent form that had been approved by the IRB office (see Appendix 3.2 for a copy of the consent form).

Interview Format

After a brief introduction of this study and the instructions about the interview, we asked questions about four main episodes:

1 Initiation of the application process:

- Why did they consider Georgia Tech?
- Who influenced their decision in this process?
- Which institutions other than Georgia Tech were considered?

2 Process between receipt of acceptance and moving to Atlanta:

- Who did they communicate with about accommodations, immigration, registration etc.?

3 Current relations with the Turkish students, professors, residents and the Turkish Student Association:
    - How do they interact with the Turkish community? What are the benefits of having friends and/or family? What are their opinions about a doctoral experience with/without having a network?
4 Current relations with professors, students and friends back home:
    - Do they communicate with their undergraduate institutions?
    - Do they offer help to new applicants?
5 Networking prior to graduation (only for students who are at the job search stage):
    - Do they make contacts with the Turkish community for job opportunities?

The interviews were conducted in Turkish. Two major advantages led us to do the interviews in the students' native language. First, students are likely to provide more information and be more articulate in their native language. This is particularly the case considering that the subjects are S&E students, who are not required to demonstrate high verbal proficiency in English. Second, considering that the network effect has a cultural dimension, we believe cultural nuances could be captured much better in their own language. Upon consent from the students, all interviews were recorded on tape.

Results

Why Georgia Tech?

According to our sample, networks play the most effective role in identifying the list of institutions considered for application. Students explained that considering an institution is highly correlated with the amount of information about that institution. In most cases they became knowledgeable about Georgia Tech through friends studying at Georgia Tech. Students who went to Middle East Technical University and Bosphorus University added that even if they were not at the stage of applying for doctoral institutions in the US, they knew about Georgia Tech through their professors and research assistants. In both of these universities they even referred to Georgia Tech as "Georgia Turk." As a result, when they were at the stage of applying to graduate school, Georgia Tech automatically appeared in their choice sets. "We felt it could be easier to be accepted to Georgia Tech" some of the students added. Some others mentioned they "[we] wanted to go somewhere where professors already know about us and our background." Others added that they felt more comfortable knowing that they had friends that would help them with the application process and with accommodations for the first few days or weeks.

In addition to students previously admitted to Georgia Tech, professors both in the home country and the Turkish professors at Georgia Tech were influential in application decisions. Professors in the home country have connections at Georgia Tech in various forms. They might be graduates of Georgia Tech, have colleagues at Georgia Tech, or have former students who are students at Georgia Tech. They encourage their students in Turkey to apply to Georgia Tech and engage them in communication with

their contacts. One student said "When I was studying in Turkey, I told my professor that I wanted to get a PhD in the U.S. That year he introduced me to a Turkish professor who was visiting Turkey. He was a friend of my professor and he was a faculty member at Georgia Tech. I contacted him before graduating and he sent me some information about the department. I've found some Turkish students in his lab and contacted them. They answered all my questions about the application process." In some cases, Turkish applicants directly contacted Turkish professors at Georgia Tech. One participant said "I was browsing university web pages in the U.S. I found a Turkish professor at Georgia Tech and sent him an e-mail stating that I wanted to study in the U.S. I am not working with him right now but he introduced me to my current advisor." We also learned that, in rare cases, Turkish professors at Georgia Tech contacted their undergraduate institutions in Turkey for open positions in their research laboratories.

A few other reasons strengthened the students' motivation to apply to Georgia Tech. Cost of living and better weather conditions are the two factors often mentioned by the students in our sample. These reasons remained as supporting factors rather than determining their final decision. In one case, however, a student mentioned that he had been accepted to both Georgia Tech and Purdue industrial engineering doctoral programs; although he had connections at both universities, he preferred Georgia Tech because it had a larger industrial engineering department where he could have more projects to choose from and more professors to work with. In this case, size of the institution was a determining factor for him rather than being a supporting one. However, during the same interview other students pointed out that this case occurs when students do not know what they will study before starting the program. They

added that in many cases they know what they will be studying and the existence of more professors or more projects does not affect their decision.

In most of the departments represented in our sample, students from Turkey are increasing almost exponentially. Our participants stated that while there were only one or two students in each of the departments in mid-1990s, the number had increased up to 20 new Turkish students in the early-2000s. Industrial engineering also had a similar trend until 5 years ago, when a rapid decrease in the number of Turkish students began. All industrial engineering students agreed that because some Turkish students left the program after earning a master's degree, the admission committee had become more skeptical about accepting new Turkish students. According to our respondents, these students found attractive jobs in industry with their master's degree from Georgia Tech. Table 3.2 summarizes these findings.

Table 3.2: Reasons why Georgia Tech was preferred

Institutional Factors	Location Factors	Influence of Networks
High ranking (aerospace/industrial/electrical engineering)	Good weather	Friends/spouse at Georgia Tech
Large department size (industrial/electrical engineering)	Low living cost	Turkish professors at Georgia Tech
Accepts applications for Spring semester		Georgia Tech alumni in Turkey

Contacts before arriving to Georgia Tech

All but one of the students in our focus groups had contacted a Turkish student at Georgia Tech or in Atlanta before moving to the U.S. The students mentioned that they usually arrived in Atlanta before university housing is available. They need accommodations for these first few days or weeks. While students who already have

friends stay at their friends' houses, others contact the Turkish Student Organization and seek help by posting an e-mail on discussion boards. Three students mentioned that they had stayed at Turkish students' houses whom they did not know before coming.

Students in our sample inquired about the immigration, visa and registration processes through contacts with friends who moved to the U.S. earlier. Three of the students searched for Georgia Tech students in their high school and undergraduate e-mail lists, and contacted them with their questions. In some cases, Turkish professors at Georgia Tech introduced existing students to new students and initiated communication between them.

Current relations with the Turkish community in Atlanta

In our focus groups we investigated doctoral students' current relations with the Turkish community. They talked about both social and academic relations. However, for most of the students, social and academic environments overlapped. They spent their time outside the school with friends from their lab or their department.

Although students agreed that they spend a majority of their time with other Turkish friends, they had different views about this 'solidarity.' One group argued that spending their time mostly with Turkish students keeps them from being a part of the culture they moved into. They felt as though they were missing an opportunity to learn about American culture. One student stated, "I physically live in the United States, but I feel like I don't. I speak Turkish all the time, gather with friends and watch Turkish movies, and eat Turkish food." Students in aerospace engineering mentioned that because Turkish students are always together within and outside the department that

other students started calling them the "Turkish Mafia." They were discontent about this image. Overall, they were concerned about 'being stuck' in their Turkish network.

Yet, other students talked about undeniable benefits of having a Turkish student group in their departments. In addition to their help at the initial stages of their education, they constantly helped each other throughout their education. They mentioned studying together for qualifying exams, exchanging lecture notes for common courses, tutoring each other, or simply discussing questions about their field. They also mentioned that they felt more comfortable discussing their studies because Turkish students were able to ask questions and clarify ideas much easier in their own language. Even at the national conferences they attend, they communicate with Turkish participants more than other participants. One student said "I can approach someone new at a conference only if I see a Turkish last name in his/her nametag. Otherwise I feel intimidated."

Students' ideas about the social support they receive from Turkish friends are very strong. They all agreed that having friends from their country provided them with psychosocial support. One student said, "I would have gone back to my country if I did not have my Turkish friends here in Atlanta." Some others stated that they wanted to be relaxed during their leisure time. For this reason, they avoided trying to explain themselves to other people or speaking English, both of which required extra effort.

During this part of the interviews, we also found out that being Turkish was not the sole characteristic that initially brought the students together. Being from the same undergraduate institution started the initial gatherings within the departments. One student stated, "I had difficulty in becoming a part of the Turkish community at Georgia

Tech because I did not graduate from Middle East Technical University or Bosphorus University. It was hard to participate in the conversations that were mainly about their experiences at these schools."

Relations with Turkey

Our interviews indicated that doctoral students at Georgia Tech have close contacts with their undergraduate institutions in Turkey. They contact their former professors and friends in their undergraduate institutions and give updates about their studies at Georgia Tech and their life in Atlanta. Among the students who are at least in the third year in their program, forty percent said their relations were the stronger during the early years in the program while sixty percent said relation with friends and professors in Turkey remained constant.

Further, our respondents mentioned that they frequently communicate with students in Turkey planning to apply to Georgia Tech. Applicants usually find Georgia Tech students' contact information on their personal web pages. According to the students, having a personal web page increases the probability of being contacted for possible questions about Georgia Tech. In some cases, professors at Georgia Tech want Turkish students to state their opinions about a Turkish applicant. They inquire about the applicants' prior institutions, if they are unfamiliar with them. Further, they involve Turkish students in activities when a Turkish applicant makes a campus visit.

Some students also mentioned that they have been contacted by people from Turkey asking help with their research, or asking for a copy of the references that they are unable to access in Turkey.

Some of our respondents remained in close contact with former professors and friends at their undergraduate institution regarding their current work. One student said he still participates into his former professor's online course discussions. In some cases, they are invited to their home institution to give a presentation about their current studies. However, most of our participants mentioned that they study in areas that do not have any application in Turkey. Thus, their communications are limited to broader issues about the discipline, or studying in the U.S in general. Students also identified the interesting factor that knowledge exchange with the faculty at home depended on the age of the faculty. During their yearly visits to Turkey, they realized that younger faculty members were more interested in their studies than older ones. More interestingly, they were only able to discuss their studies with younger faculty who recently earned a doctorate degree in the U.S. Some students have made arrangements to collaborate with these faculty members in the near future.

Table 3.3: Students' Relations with Turkey

Form of Interaction	% of Students
Visiting Turkey at least once a year	100
Visiting their undergraduate institution during their yearly visits	77
Making Presentations in Turkey	11
Sending research material to friends in Turkey	33
Helping new applicants to Georgia Tech	27
Collaboration with someone in Turkey	11

Contacts near graduation

Only two students out of 18 were at the graduation stage. These two students identified that Turkish students continue to use their Turkish networks after 4-6 years of graduate education in the U.S. Both students made contacts with Turkish professors in

Turkey and in the U.S., just as they did during the application process, in this case inquiring about post-doc or assistant professor positions. However, unlike the application process, they do not rely heavily on these connections. They utilize their advisor's (Turkish or non-Turkish) connections and make many direct applications for job openings. One student stated that "earning a degree in the U.S. makes me feel like a global scientist. I feel I can contact anyone in my area and work in many countries."

Conclusion

The results from the focus groups interviews provide convincing evidence about the important role that networks play in doctoral institution selection. We found strong interactions among students, alumni and professors that influence where students choose to study. These established networks help students at all stages of studying abroad, decreasing the level of complications in various processes. However, this may also keep students from searching for other options that might be suitable for their doctoral studies. Students gather information mostly through their networks, and feel safer when they have connections.

On the supply side, the existence of Turkish students and experiences (positive or negative) with them seem to influence the admission decisions. Both Turkish students and Turkish professors act as intermediaries between the undergraduate institutions in Turkey and Georgia Tech. They reach out to potential applicants and provide necessary information during the application process. Negative experiences with the Turkish students influence future acceptance decisions as well. As mentioned above, Turkish doctoral students who left the program after getting their master's degrees in industrial engineering appear to have adversely affected the positive views of admission

committee towards Turkish applicants as they admitted fewer students from Turkey each year.

Our results also suggest that the effects of networks are different at each stage of doctoral education. While networks play a determining role during the application process, they provide social and academic support during students' education in the U.S. Aside from psychosocial support, Turkish student preferred to stay within their networks due to easier communication in their own language. Although most students had the necessary English skills to conduct their studies, they found it difficult to interact with non-Turkish students. Therefore, the Turkish community in Atlanta provided them with an additional level of comfort during their education.

Towards graduation, Turkish students' need for Turkish networks is diluted by the new contacts they have acquired during their studies, as well as by the confidence of having a well-accepted degree.

Although we did not systematically investigate our respondents' future plans, our conversations revealed one interesting characteristic about the Turkish doctoral students. With the exception of one student who had an obligation to go back to Turkey, none of these students had a clear idea as to whether they would stay in the U.S., go back to Turkey, or go to a third country. They talked about disadvantages related both to staying and going back to home country. Visa restrictions and negative public attitudes towards the foreign-born complicate staying in the U.S. Likewise, going back to Turkey is unattractive due to limited research funding, unfavorable economic environment, and low wages for academic positions. Thus, we predict policy changes in the U.S or in

Turkey are likely to tip this balance, and attract these students towards one country or the other.

Lastly, the results of the focus groups are essential for the other parts of this dissertation. First, they clarify our definition of foreign doctoral students' network that will make the operationalization of network variables more precise for the econometric analysis. As a result of this study, we are confident that existing students, alumni, Turkish residents and Turkish professors are very influential in Turkish students' institution selection. Second, they provide background information in interpreting the results of the web study of science and engineering research labs. Talking to Turkish students at Georgia Tech, we found out that Turkish students ended up in research laboratories in a series of ways. They directly contacted the Turkish professor at Georgia Tech and seek assistantships; Turkish professors contacted their undergraduate institutions in Turkey and made themselves available to graduating students; Turkish students told their friends in Turkey about open positions; and professors in Turkey who are Georgia Tech alumni contacted their former professors and colleagues at Georgia Tech to introduce them to the applicant. While further research might be necessary to find out additional factors, influential on foreign students movement in general, we assume some of the main characteristics of these network effects could be applicable if the focus groups were to be conducted with Chinese, Korean and Indian students.

CHAPTER 4

WEB STUDY OF RESERCH LABRATORIES

Findings from the focus group interviews suggested that students support each other within research laboratories, and foreign born faculty members play a role in finding research opportunities. In this chapter, we investigate the foreign student networks at the laboratory level. We examine the relation between foreign student networks and the ethnic composition of science and engineering research laboratories in U.S. universities. We hypothesize that the percentage of foreign students is higher in research labs that are directed by a faculty member who is from the same country of origin, compared to research labs where such an association does not exist. In order to test this hypothesis, we conduct a web search, and select 164 science and engineering laboratory web pages for analyses. Among these 164 labs, 82 are directed by foreign-born faculty (Korean, Chinese, Indian or Turkish). These 82 are matched with labs that are in the same department of the same university but directed by a native (U.S. origin) faculty member.

The results of this study draw attention to the effect of affinity on the ethnic composition of research labs at the micro level that translates into the ethnic composition of the scientific community at the macro level. Further, these results emphasize the role of lab directors in creating scientific human capital, and contributing to the 'brain circulation' phenomena in the global context.

Background and Theory

We chose to examine S&E research labs for two particular reasons. First, the research lab is a good representation of a foreign students' social environment, since

doctoral students spend a significant portion of their time at school. Many research labs are populated with foreign students and some of these labs are directed by foreign-born professors from the same country. Thus, labs present a closed environment enabling us to observe possible networks. Second, research labs have a unique independent structure within the department. They are semi-autonomous groups within the university that receive separate funding and, at times, hire separate personnel. Hence, lab directors act like entrepreneurs creating scientific human capital within these labs. Foreign-born directors often continue to be in contact with their home academic institutions and therefore provide information about open lab positions to potential students. Likewise, students from home academic institution may initiate contact with lab directors from their country of origin before formal applications. Accordingly, these two characteristics of research labs enable us to observe both the network effect in a general sense, and the effects of lab directors as 'active nodes' or initiators within those networks.

The network effect

Recent studies address high skill labor movements using a social network perspective (Khadria, 2001; Meyer, 2001; Portes & Sensenbrenner, 1993; Vertovec, 2002). However, these studies do not exclusively focus on foreign doctoral students. Foreign student movements require further attention in order to understand the internationalization of U.S. higher education. Further, since a significant number of foreign students move into the U.S. labor force at a later stage, the patterns of foreign students also have an influence on the composition of the scientific labor force in the U.S. (Hugo, 2002; Khadria, 2001; Li, 1996).

The networks that foreign students develop serve to provide opportunities for friends and colleagues in their home countries. As Meyer (2001) indicates:

> Connections with earlier migrants provide potential migrants with many resources that they use to diminish the risks and costs of migration: information about procedures (technical as well as legal), financial support, job prospects, administrative assistance, physical attendance, emotional solidarity. (p.93)

For foreign students, social networks are crucial in finding accommodations, goods and services, social and economic information, as well as emotional support. Social networks serve as a guiding source for foreign students throughout their education. Some studies also suggest that the interpersonal ties of migrants continue to be effective after graduation in finding jobs either within the U.S., or back in their home country (Poros, 2001).

Portes et al. (1993) point out the varieties of structural and relational 'embeddedness' in these networks. Meyer (2001) acknowledges this variety, however, he claims that different forms and characteristics of networks still lead to similar results where most jobs are acquired through connections. In the case of research labs, lab directors may take into account the recommendation of their existing students, especially if they are pleased with these students. Network recruitment also improves the employment relationship by endorsing a set of understandings common to the employer and the employee, thus reducing informal misunderstandings or breaking informal contracts (Waldinger, 2005). Both the student and the faculty benefit from the easy flow of information as a result of their shared culture.

Early studies regarded the foreign doctoral student flow from developing countries to developed countries as a "brain drain." Along with the recognition of networks among skilled workers, a terminology shift has occurred towards a more global concept that emphasizes benefits of both the sending and the receiving ends. Saxenian (2002a) calls this new dynamic "brain circulation," drawing attention to the role of ethnic networks in mobilizing information, know-how, skills and capital. These new transnational communities provide shared information, contacts, and trust, creating new opportunities for once peripheral regions of the world economy. Policymakers are also seeking ways to utilize a global mobile workforce and cultivate the benefits of brain exchange and brain circulation between countries (Saxenian, 2002b).

Lab directors as immigrant entrepreneurs

Viewing lab directors from an entrepreneurial perspective enables us to observe the role of foreign-born faculty in shaping the ethnic composition of their labs. Although it is clear that lab directors are not 'entrepreneurs' in a traditional sense, their roles in hiring, and in financial and structural management of the lab lead us to this analogy. Thus, the foreign-born entrepreneurship literature provides us with a good starting point of reference for this understudied group.[4]

Another parallel between the traditional entrepreneur and the lab director is that both actors play a role in bridging distinct regions. Just as traditional entrepreneurs

[4] Studies focusing on foreign-born entrepreneurs flourished after the recognition of their role in globalization. They have acted as agents between their adopted country and native country, stimulating the emergence of entrepreneurial networks (Saxenian, 2002b). In our case, the contribution to globalization comes in the form of international collaboration of research as well as access to international scientific human capital.

played an important role in building networks between Silicon Valley and Hsinchu region of Taiwan, or Bangalore, India (Saxenian, 1999), lab directors are the bridge between their academic institution in their native country and their current institution. This theory is also supported by the existence of alumni networks of most popular foreign institutions, such as the Indian Institute of Technology, in which U.S. academicians actively participate (Vertovec, 2002).

The faculty members play an important role in graduate students' lives impacting how they think and do research. Trow (1977) suggests that the influences of graduate faculty can guide students' future research and teaching during their entire careers. As for the foreign students, we found evidence from our focus group interviews that foreign students feel their background is better understood by faculty from their country of origin, and also feel more comfortable communicating with them. The relationship between the graduate faculty and the graduate student in science and engineering is perfectly described by Fox (2003):

"[In S&E fields] scientific work and training revolve strongly on faculty-student interchange. In science and engineering, faculty and students are bound together potentially in research facilities and projects, funded through faculty as principal investigators on which students largely undertake daily work." (p.92)

Recent studies build on the understanding that immigrant entrepreneurs are embedded in their social networks, by introducing the concept of 'mixed embeddedness' (Kloosterman, 2001). Mixed embeddedness aims to understand the socio-economic position of the immigrant entrepreneurs not only by their embeddedness in actual social networks, but also by their more abstract embeddedness in the social, economic and

institutional environments of their adopted countries. This approach is particularly appropriate in the analysis of lab directors because universities provide a unique environment enabling them to engage in both their ethnic networks and non-ethnic networks simultaneously.

As a result, we can confidently state that foreign-born lab directors should be considered as a distinct group of transnational scientific workers who are active in building ties in their home countries, opening new channels for collaborations, and attracting new resources for U.S. academia.

Methodology

Sampling

The sampling of this study begins with the 1993 NRC rankings of PhD granting institutions. At the initial stage, a multistage stratified random sample is constructed by drawing universities from the ranking lists of 12 S&E disciplines. The sample is stratified by discipline (biology, physics, chemistry, computer science, chemical engineering, aerospace engineering, mechanical engineering, materials engineering, electrical engineering, chemical engineering and industrial engineering) and rank (top, middle and bottom). At the first stage of the multistage sampling, we randomly selected an equal percentage of departments from each stratum. We selected 110 departments from the list of 360 departments. At the second stage, we identified research laboratories directed by native (U.S. origin) faculty[5], and then labs directed by faculty from four

[5] We refer to directors with a U.S. origin name as 'native' directors.

specific foreign nationalities: Chinese, Indian, Korean and Turkish. Departments that do not have laboratories directed by faculty from any of the four nationalities are excluded from the sample. We then randomly selected two laboratories in each department, one from the list of labs directed by a foreign-born faculty, and one from the list of labs directed by native faculty. Lab directors from a country other than China, India, Korea or Turkey[6] are not included in the sampling frame of this study. The methodology is explained in more detail later in the chapter.

Data Collection

We used a systematic approach to identifying the labs through our web search. Once we obtained the list of departments in each university, we located their web pages and made sure each was accessible. In our sample, all of the departments had a functioning web page that enabled us to proceed to the next step. In each department web page, we looked under the 'Research' tab where, in most of the cases, we found the list of research labs and the names of the directors of those labs in that department. This list constituted the sampling frame for the random selection at the next stage. An alternative approach, which was used less often than this one, was to search under the 'Faculty' tab, enabling us to identify native lab directors and directors from our four nationalities. By making a random selection from these two lists we identified one foreign director and one native director from each department. Next, we accessed each director's personal web page where we located his/her research group, with the corresponding list of group members.

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[6] All four countries are among the top ten source countries.

The majority of departments had individual web pages for each research lab. However, we had to exclude 23 pairs[7] from the sample for a variety of reasons. The most common reasons were lack of a research lab with a director from one of the four foreign nationalities; lack of a list of lab members; unidentifiable nationalities; inaccessible lab web pages; and lack of a comparable research lab with a native director.

Identification of nationalities

Chinese, Korean, Indian and Turkish doctoral students and faculty members are obvious groups to study for two reasons. First, these are among the top ten largest foreign student populations in the U.S. Second, identification of these four nationalities is relatively more straightforward compared to other nationalities. Since there are large immigrant populations from these countries in the U.S., existing ethnic name databases provide comprehensive guidance in predicting the origin of student and faculty names. Further, students of these nationalities generally form student organizations at their universities, thus providing a list of their members on their web pages that could be used as an alternative source for nationality identification. In this specific study, we benefited from the existence of large student groups from these four nationalities in an additional way; we were able to hire students from these four countries to review the student names in the sample, and identify names from their own country. This has provided us with additional certainty in nationality identification.

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[7] Out of 220 cases in 110 S&E departments.

Because identification of faculty nationality was the key step in composing our sample, we first identified the nationalities of the faculty that were listed as directors of research labs. At this stage we relied on the CVs or resumes posted on their web pages. In our sample, 97% of the faculty whom we identified as Chinese, Korean, Indian or Turkish received their undergraduate degree in the corresponding home country, therefore strengthening our certainty for country of origin[8]. In the few cases where resumes or CVs do not exist, we asked foreign student assistants to identify the nationality, and then cross referenced this identification with the list of "Most Common U.S. Ethnic Surnames" provided in Kerr's (2004) recent study. In this study, the author identifies the ethnicities of the inventor names contained in the NBER Patent Data File originally compiled by Hall, Jaffe, and Trajenberg (2001). The NBER Patent Data File provided micro records for all patents granted by USPTO from January 1975 to December 1999. Kerr maps into these inventor names an ethnic-name database, constructed by Melissa Data Corporation, originally designed for direct mail advertisements. A list of "Most Common U.S. Ethnic Surnames" is provided in the Kerr study, which we used as a reference for identifying Chinese, Korean, Indian last names[9]. Faculty members with common U.S. first and last names are selected to be coded as "native" if they received their undergraduate degree from a U.S. institution.

The same methodology was used to identify the nationalities of the students. However, unlike the faculty members, not all students had resumes posted on the web

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[8] This result makes two further suggestions: First, foreign-born lab directors might have strong network connections with their country. Second, a majority of our lab directors are first generation immigrants; second generation Korean, Chinese, Indian and Turkish directors are not represented in the sample.
[9] Turkish names are identified by the author who is a native Turkish.

pages. Consequently, for identification of the foreign students' nationality, we relied heavily on the "Most Common U.S. Ethnic Surnames" from Kerr's study (Kerr, 2004), recognition by a native student, and our searches in relevant web pages, such as foreign student association member lists.

In order to further ensure the quality of our study, we reviewed the recency of the web pages used, using the 'date of update' at the bottom of the page where possible. In other cases in which this information was missing, we looked for a recent posting or a recent publication. From the date on that post or publication, we approximated the last access date to that web page.

Analyses

The central question of this study is whether the percentage of foreign students from one specific country of origin in research labs directed by faculty with the same origin is higher than the percentage of students from that origin in research labs directed by native faculty. Our sample provided 82 matched pairs, for a total of 164 cases. We constructed the pairs by matching each lab directed by a foreign faculty with another lab directed by a native faculty within the same university and the same department. In order to answer this question, we applied a paired sample t-test that examined the significance of this difference. We tested the null hypothesis that there is no difference between the mean foreign student percentages in both labs. In addition to our main hypothesis, we also examine the relationship between nationality, institutional ranking, discipline and the ethnic composition of that research lab.

Summary of Data

The data set consists of 164 S&E research labs, 82 of which are directed by Chinese, Korean, Indian or Turkish faculty, matched with another 82 labs directed by native faculty within the same department in each university. Our intent was to include physics, chemistry, biology, mathematics, electrical engineering, mechanical engineering, chemical engineering, aerospace engineering, industrial engineering, materials engineering, civil engineering and computer science. However, we were not able to locate labs in mathematics departments. We were able to find foreign professors working on projects with doctoral students, but they were never identified as groups or research labs. In retrospect, this is not surprising given the character of mathematical research.

The 164 labs had 1074 students affiliated with them. The average number of students in each lab was 6.5 (ranging between 1 and 35) and this average was very similar for the labs directed by native faculty (6.54), and for the labs directed by foreign-born faculty (6.44). The average percentage of foreign students in each lab is 58.6 percent (ranging between 0 and 100 percent).

Among the foreign-born directors, 40 were Chinese (48.7%), 20 Korean (24.4%), 19 Indian (23.2%), and 3 Turkish (3.7%). In the dataset we also considered the year that the directors received their PhDs. Overall, the average number of years for holding a PhD degree in the dataset was 16.4, ranging from 2 years to 46 years. On average, the native directors had more years of experience than the foreign directors. Foreign directors, on average, had 13.2 years (11.9 for Korean, 12.1 for Chinese, 15.4

for Indian and 28.0 for Turkish), whereas the native directors had 19.4 years of experience on average.

Among the foreign lab directors, only two had earned their undergraduate degrees in the U.S., while the rest had earned their undergraduate degrees in their home country. Data regarding the undergraduate degrees of foreign professors revealed one interesting result. In this data set, 80% of the Korean directors graduated from Seoul National University, 57% of the Indian directors from the Indian Institute of Technology, and 21% of the Chinese directors from University of Science and Technology in China. This suggests the existence of top source institutions within these top source countries. In the case of native directors, MIT, Harvard, and Cornell were the most common undergraduate institutions.

The majority of the web pages observed in this study were updated relatively recently. Seventy five percent of all the web pages were updated within the last year, 19 percent in the year before, and 6 percent slightly more than two years before.

Results

We hypothesized that within the same university and department, the percentage of students from a specific country of origin is higher in labs with a faculty member from the same country of origin, compared with labs that are directed by native directors. In order to test this hypothesis, we applied a paired t-test to 82 pairs of science and engineering research labs. The results in Table 4.1 show that the difference of foreign student percentages between the labs directed by foreign professors and the ones directed by native directors is 33%. The mean percentage difference between the labs varies between 26% and 40%. The result is significant at the five percent level,

suggesting that lab composition in the same departments at the same institutions is related to the ethnicity of the faculty. Students from one country of origin are more likely to be in labs directed by a faculty member from their country of origin.

Table 4.1: Foreign student percentage differences between research labs (Foreign – Native directors)

	Mean Difference		**33.11**
	Std. Deviation		32.53
	Std. Error Mean		3.67
		Lower	26.02
Paired Differences	95% Confidence Interval of the Difference	Upper	40.32
T			9.22
Df			81
Sig. (2-tailed)			0.00

We also test mean differences between labs directed by native professors and labs directed by faculty from one of the four countries studied. Again, the hypothesis is that the percent of students working in a lab from a nationality is higher when the students share nativity with the director. We find the mean percentage difference to be 29%, significant at the five percent level (Table 4.2). This is slightly lower than the mean difference for foreign students between foreign-directed labs and native-directed labs of 33%. We conclude that the affinity effect is not exclusively the domain of the foreign-born.

Table 4.2 Native student percentage differences between research labs (Native – Foreign directors)

	Mean Difference		**28.92**
	Std. Deviation		44.21
	Std. Error Mean		4.92
		Lower	19.03
Paired Differences	95% Confidence Interval of the Difference	Upper	38.81
T			5.82
Df			78
Sig. (2-tailed)			0.00

As shown in Table 4.3 below, the percentage differences (the difference between the percentage of foreign students in labs directed by a faculty from the same country of origin and the percentage of foreign students in labs directed by native directors) vary slightly according to the country of origin but are still quite high[10]. In this sample, the highest mean difference is between the labs directed by Chinese faculty and native faculty. In other words, we observe the student-director affinity more in labs directed by Chinese directors.

On the other hand, the percentages of Indian students are more balanced between the native and Indian directed labs. As we can see in Table 4.3, the smallest percentage difference is between the labs directed by Indian and comparable labs directed by native faculty. The reason might be due to Indian students' better command of English compared to Chinese, Korean or Turkish students.

[10] Note that the sample includes only 3 matching pairs for Turkish nationality. The result suffers from small sample size and should be interpreted with caution.

Table 4.3: Foreign student percentage differences by director's country of origin

	N	Mean	Std. Error
China	40	37.8%	5.6
India	19	27.1%	6.4
Korea	20	29.0%	7.2
Turkey	3	36.3%	17.9
Total	82	33.1%	3.6

Table 4.4 shows that the mean percentage differences between foreign faculty directed and native faculty directed labs was much higher in lower ranked departments. This is an expected result, as the assumption that a foreign student who qualified to be accepted to a top ranked university would be less in need of the benefits of networks. Also, students that qualify for the highest ranked universities usually consider a limited number of institutions with similar ranking, regardless of the existence of students or faculty from the same origin. In the same vein, for students applying for lower ranked universities networks might play a determining role in their institution selection decision.

Table 4.4: Foreign student percentage differences by ranking of the department

	N	Mean	Std. Error
Top	45	25.9%	4.3
Middle	24	35.9%	6.8
Bottom	13	53.2%	9.8
Total	82	33.1%	3.6

The mean percentage differences are quite different among the science and engineering disciplines included in our sample (Table 4.5). The mean difference is highest among industrial engineering labs, and lowest among chemical engineering labs. In order to explain this difference, the common characteristics of projects in each

discipline should be further examined. One theory may be that ethnic networks are more visible in disciplines that require close faculty-student contact in project execution.

Table 4.5: Foreign student percentage differences by discipline

	N	Mean	Std. Error
Industrial Engineering	6	58.0%	11.1
Electrical Engineering	6	51.5%	11.7
Civil Engineering	5	40.0%	19.1
Chemistry	7	37.4%	10
Materials Engineering	12	35.4%	11
Biology	5	35.8%	16.9
Aerospace Engineering	9	35.1%	11.6
Chemical Engineering	7	31.1%	11.8
Physics	6	27.2%	13.3
Computer Science	9	23.1%	8.9
Mechanical Engineering	10	9.2%	7.2
Total	82	33.1%	3.6

Lastly, we look at 1074 students included in our sample. As shown in Table 4.6, the percentage of foreign students working with foreign faculty is higher than that of native students. Likewise, higher percentage of native students work with native faculty compared with foreign faculty. The distribution of students among labs directed by foreign and native faculty is further detailed in Table 4.7 by their origin.

Table 4.6: Origin of students by origin of lab director

			Student		
			Native	**Foreign**	**Total**
Director	**Native**	Count	319	223	542
		%	67.0	37.3	50.5
	Foreign	Count	157	375	532
		%	33.0	62.7	49.5
Total		Count	476	598	1074
		%	100.0	100.0	100.0

Table 4.7: Distribution of students in labs by faculty origin[11]

		Director's origin					
		Korea	**China**	**India**	**Turkey**	**USA**	**Total**
	Korea	43	.	.	.	8	51
	China	.	106	.	.	34	140
	India	.	.	54	.	18	72
	Turkey	.	.	.	8	0	8
Student	**USA**	49	64	35	9	319	476
	Other	56	56	46	6	163	327
Total		148	226	135	23	542	1074

In addition, we test the hypothesis that foreign students are more likely to work with a foreign director than are native students (Table 4.8). On average, in this sample, foreign student–foreign professor cases are observed 30% more often than are native student–foreign professor cases. This difference could be attributable both to student's perceptions of working with a director from their country of origin (i.e. feeling more valued and/or communicating better) and to the role that network connections between the foreign student and the foreign-born lab director play in determining students' placement.

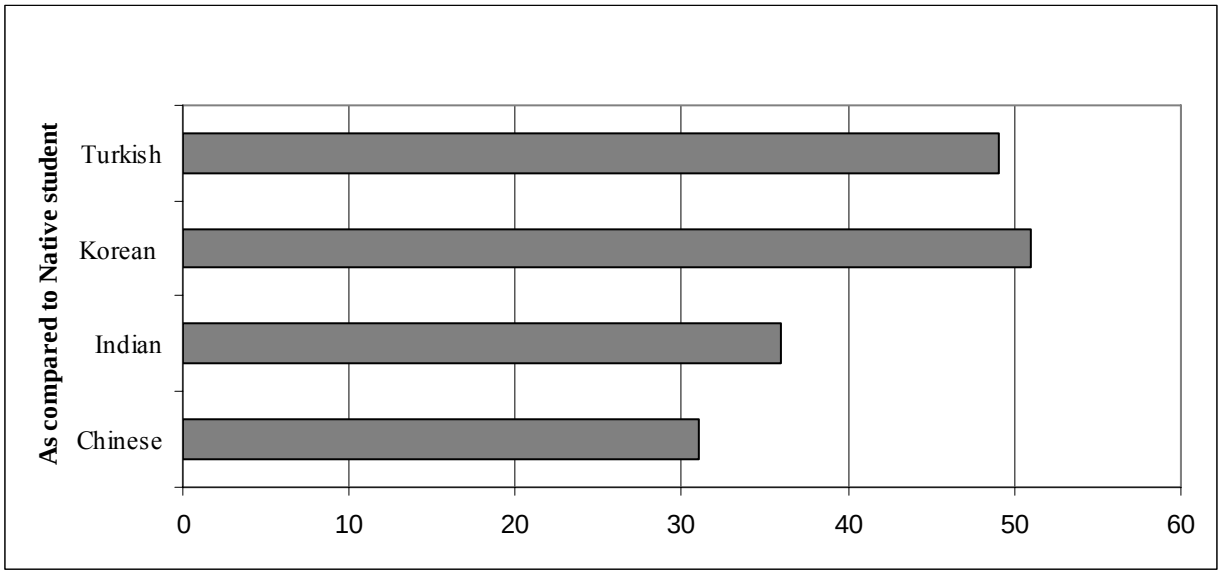
[11] This table should be interpreted with caution. In the dataset, in each lab we have only identified three groups of students: who are the same origin with the director, native students, and all others. That is we only know the nationality of the student when it is the same with the director. For example, if a Korean student is observed in a lab directed by a Chinese faculty, he or she is identified as 'other foreign' instead of Korean.

Table 4.8: Difference of mean between foreign and native students

			Director
Test for Eq. of Variances	F		8.81
	Sig.		0.00
t-test for Eq. of Means	T		10.1
	Df		1072
	Sig. (2-tailed)		0.00
	Mean Difference		**0.30**
	Std. Error Difference		0.00
	99% Confidence Interval of the Difference	Lower	0.22
		Upper	0.41

Another way of looking at the composition of S&E labs is to calculate dissimilarity indices for Chinese, Korean, Indian and Turkish Students. Figure 4.1 presents integration of foreign student groups within a research lab compared to native students. In this sample the native-Turkish dissimilarity index is 49%. This means 49% of the native students need to move to another lab to make natives and Turkish students evenly distributed across all labs. Similarly, the dissimilarity indices for Indian, Chinese, and Korean students are 36%, 31% and 51% respectively. These percentages provide an evidence of dissimilarity of foreign doctoral students among the laboratories. That is, the distribution of foreign students is not similar across laboratories.

Figure 4.1: Dissimilarity Indices for Foreign Students



Conclusion

In our analysis of science and engineering research labs in U.S. doctoral granting institutions, we find strong evidence that labs directed by foreign-born faculty are more likely to be populated by students from the same country of origin than are labs directed by native faculty. The percentage of students working in a lab from a nationality (foreign or native) is higher when they share nativity with the director.

These results support findings from the focus group interviews. Turkish students at Georgia Institute of Technology stated that having compatriots in their labs made communication easier and created a more comfortable environment for them.

In addition, these findings also build on our previous findings about the importance of foreign-born faculty. Participants in our focus group interviews expressed various ways faculty members from their country of origin helped in finding their research positions. In this study, we found evidence that similar patters might apply to Chinese, Indian and Korean students in addition to Turkish students. We suggest that

foreign-born faculty members are active nodes of ethnic networks. They play an effective role both in mobilizing foreign students from their country of origin, and in opening new channels for collaboration between their home institutions and U.S. institutions.

In this research, we tested the degree to which students in the same lab share the nativity of the lab director. While we cannot test how the matching between the student and the faculty was done, we believe that some degree of networking could well be involved given that directors play a significant role in staffing their laboratories.

CHAPTER 5

RANDOM UTILITY MODEL FOR INSTITUTION SELECTION

This chapter provides an empirical analysis of the role networks play in the institutional choice of foreign nationals. The chapter has two main purposes. First, it provides insights into factors affecting the institution foreign student choose to attend. Such insights could prove crucial in assisting higher education institutions and communities in crafting policies with regard to foreign students. Although the importance of foreign doctoral students to U.S. science and engineering is well documented, few studies examine factors affecting the institutional choice of foreign nationals. Second, the chapter tests some of the hypotheses articulated in the focus groups and suggested by the web study in the previous chapters.

Our empirical approach is to establish a choice set for students that is restricted to institutions to which the individual has the possibility of being selected for admission. We then assume that the individual will choose the institution that maximizes his/her utility. Other things being equal, we assume that the greater the depth of the ethnic networks available at the institution, the greater is the utility derived from attending that institution and thus the greater is the likelihood that the individual will attend that institution. We measure four dimensions of networks: (1) alumni networks; (2) current student networks; (3) faculty networks; and (4) community networks. Because of the difficulty and expense encountered in determining faculty ethnicity, the faculty network variable is tested for a limited number of institutions.

We are aware that networks also play a role in the admission decision of institutions. Here, however, we focus on student choice from a set of institutions that we

assume either admitted the student or would have admitted the student had the student applied. While this is a somewhat heroic assumption, it is necessary given that we do not have access to admission data. We are also aware that what we refer to as network variables may be thought of "affinity" variables to the extent that the comfort level of individuals is increased by associating with others of the same nationality.

Our empirical analysis builds on our lab studies and our focus group study of Turkish students attending Georgia Tech. The focus group interviews pointed towards the role that fellow Turkish students, alumni, Turkish professors and Turkish residents in the local community play in the application and acceptance process. In this chapter, we test the importance of these factors on a larger scale and include doctoral students from China, Korea, and India –the top three source countries sending foreign students to the U.S. –in addition to Turkish students. The analysis in this chapter also builds on and supplements the research laboratory web study presented in Chapter 4 where it was found that faculty and students from the same nationalities cluster in the same labs, suggesting that networking plays an important role in determining the composition of the research labs. Research labs, however, while being a well-defined unit for analysis, do not completely explain the foreign student allocations within the department. Nor do they allow for analysis of clustering behavior in fields, such as mathematics, where research is not conducted in a lab setting. An advantage of the current analysis is that it relaxes the 'laboratory boundaries' of the web study, analyzing the department as a unit and adding disciplines where laboratory work is less common. The comparison of the results from the web study and this chapter could also clarify the role of faculty within labs as opposed to their role within the department.

The individual level data come from Survey of Earned Doctorates (SED), 1981-2002. The SED is administered by the National Science Foundation (NSF) and funded by four other Federal agencies. It is a census of all doctoral recipients in the U.S., with a very high response rate (92-95%). The data is collected directly from individual doctoral recipients at or near the time of graduation[12].

The plan of this chapter is as follows. Section two reviews the network theory; section three sets out the model; section four describes the variables and the data used for analysis. The results are presented in section five. Conclusions are drawn in section six.

Background and Theory

In this section, after a brief review of the school choice process and how networks could enter into this process, foreign student networks are examined. Later, other factors that are also influential in the school choice process are discussed.

School choice process

Most studies on institution selection by students see the process as involving a number of stages. Some studies have detailed up to seven stages in this process; however, most empirical models of student choice define three broad stages (Hossler & Gallagher, 1987; Jackson, 1982). In the first stage, students form aspirations towards pursuing a degree. This is considered to be the longest period, going from early

[12] The use of NSF data does not imply NSF endorsement of the research methods or conclusions contained in this dissertation.

childhood through college years, and involves undertaking a number of preparations in anticipation of pursuing a doctoral degree. Informal interactions with potential institutions start at this period. For foreign students, this stage also involves the decision concerning whether to study abroad or in their home country.

The second stage involves the identification of programs for application. This is the stage where students acquire information from various sources, and where networks can begin to play an important role (Flint, 1992). Upon taking the necessary tests for application, students clarify their list of institutions. Sending application materials to one or more of these institutions finalizes the second stage and the final stage begins.

Admission decisions by institutions occur after the second stage and before the third stage. Networks can also play a role here. For example, former experiences of an institution with foreign students can influence the acceptance decisions. Given our lack of admission data, however, it is not possible to model this network effect.

From the student's point of view, the third stage involves admission, enrollment and actual attendance. This is the stage where networks can play a particularly important role for foreign students, and is therefore modeled here. During this stage, after institutions have made their choices, the students must decide whether to accept the offer for admission. As the focus group interviews revealed, networks play an important role at this stage by creating a medium for information exchange about the positions in research labs and/or financial support opportunities. Existing students at an institution could share helpful information with the applicant that could shape their decision. If a student has been accepted to more than one institution, institution-specific information

can affect his/her decision. For example, a student is more likely to attend an institution that offers greater financial support.

Most empirical studies predict the determinants of school attendance during this third, choice stage, but ignore network effects. The motivation of our study is the inclusion of network variables and the models of choice in a random utility framework.

Foreign student networks

Chapter 2 describes the significance of foreign students in the U.S., current trends in foreign student enrollment patterns, and the reasons that pull students towards studying abroad. Better academic opportunities and better financial support are the two important factors that motivate students to study in another country (Mazzarol & Soutar, 2001). While the reasons to study abroad are frequently examined, few studies address why particular institutions are selected in a foreign country. Institution selection studies mostly address the selection process for domestic students. Even though most of the arguments that apply to domestic students also apply for foreign students –such as financial support, quality of the institution– the choices made by foreign students are clearly more complicated. For foreign students, selecting an institution in a foreign country involves the issues related both to international migration (visa, work and study permits, return policies etc.) and adaptation (language barriers, cultural differences, academic differences, etc.).

This study aims to examine the role networks play in this process. When the information on institution selection is combined with international migration and network theories, it is inevitable to expect that networks are one of the primary influences in foreign students' institution selection process. Network theory suggests

that individuals stick with their networks to realize two benefits: reduced costs and reduced risks (Massey D. S., 1993). Both of these benefits are highly important for foreign students who are moving to a new country and face a series of unknowns. Therefore, the existence of networks could possibly influence the decision process.

In addition to theories in the literature, the web study and the focus groups interviews contribute to the construction of the network hypotheses tested in this chapter. The results from the focus group interviews suggest, for example, that students enrolled at Georgia Tech, professors at Georgia Tech, or professors in their own country who are the graduates of Georgia Tech, past and recent alumni from Georgia Tech and, to a lesser degree, the residents living in Atlanta, play a role in determining the final destination of Turkish applicants. Almost all of the students in the focus groups testified that one or more of these network connections played a role in their decision to attend Georgia Tech. The students acted as major sources of information about the city, the culture, the institution and the procedures. They also provided temporary solutions to the problems that arise during the initial days or months, such as accommodation.

The primary role that alumni play is in sharing information and introducing professors or colleagues to the applicants. They are also a main source of information concerning how to 'succeed' in the program. Some students identified the alumni they knew as their primary references in their applications. They also believed that their probability of acceptance was also increased if the department had positive experiences with these alumni.

The role that faculty play in the selection of a program was repeatedly stated in all of the focus groups. However, the web study (Chapter 4) brings even more striking

evidence to the apparent role played by the faculty of the same nationality. The evidence suggests that foreign students are more concentrated in labs that are directed by a faculty member from their country of origin compared to a lab directed by a native (U.S. origin) faculty in the same discipline at an institution. Focus group interviews elucidated how this situation might have occurred. Students identified their professors' strong ties with their undergraduate institution in their home country as one of the factors mobilizing students to apply to their current institutions and to select the institution. Also, students stated that they have searched for professors from their own country and contacted them directly before even making their formal applications.

Finally, the focus groups point towards the role played by residents from the home country living in the location of the university. The benefits include primarily physical support, such as housing, as well as moral support. Further, cities with an established community of compatriots offer familiar food, and venues for students to continue experiencing their culture and speaking their language.

Other factors influencing institution selection

In addition to the network variables, characteristics of the institution, characteristics of the geographical location, and some other demographic characteristics are likely to affect students' probability of selecting an institution. Therefore, these variables will be controlled for in the analyses. The role of financial support in institution selection by students is documented in several studies (Curs, 2002; Dynarski, 2003) and should be particularly important in the decision process for the foreign students from China, India, Korea and Turkey, due to the economic conditions in their home countries. The type of institution (public/private) is also related to cost

considerations, as public institutions would be more affordable than private ones. In addition to the financial support provided by the institution and the type of institution, other things being equal, higher ranked institutions are likely to be more appealing than lower rated institutions.

Another interesting characteristic would be the student's perception of the institutions 'openness' to foreign students. Foreign students could be intimidated by institutions that are highly populated with native students as they could feel more alienated in these institutions. Therefore, they could be more inclined to prefer institutions where there are higher concentrations of foreign students. Therefore, the financial support provided, type (public/private), ranking and perceived 'openness' of the institutions are the four institutions variables that are included in each model.

Among geographical characteristics, cost of living is likely to be a very important factor influencing the applicant's decision process. Given that foreign students are only allowed to work on campus, and only limited hours, other things being equal, they would prefer to keep their expenses to a minimum. The focus group interviews revealed two additional factors that could influence students' location choice: weather conditions and crime rate. For example, in addition to his friends, Atlanta's warmer climate motivated one participant to choose Georgia Tech over a northern institution. Likewise, five of the participants mentioned Atlanta's high crime rate as one of the deterrents in their decision process. In addition to these variables that originated from the focus group interviews, air quality and the proportion of foreign-born populations in MSAs are added to the choice models. Air quality could be influential factor for some students, especially ones with children. MSAs with higher foreign-born

populations could also be more attractive to foreign students, assuming that these locations are more accommodating to diverse populations. The expectations related to the effect of location characteristics on attending an institution is guided by Sumell's (2005) study of the role of amenities in the location decisions of PhD recipients in S&E. In his study, Sumell finds significant effects of crime rate, weather, foreign population percentages and air quality on the probability that a recent PhD recipient selects a specific location for work.

We hypothesize that the quality of the student's undergraduate institution could affect student's choice as well. We also assume that students with a master's degree will choose higher quality institutions, since a master's degree may provide them the skills and knowledge needed to succeed in a top program. We also test whether students with master's degrees are particularly drawn to institutions with students of their own nationality since foreign students could expand their networks during their master's studies and find new channels of information and support.

A set of demographic characteristics such as age, marital status, and having children are also included in the analyses to account for the observed heterogeneity that could affect the decision process. Since RUMs do not allow inclusion of variables invariant with regard to the choices directly into the models, a series of interaction terms will be tested. Of special importance for this study are interaction terms with network variables.

The Model

In order to study foreign student's choice behavior, we use Random Utility Models (RUMs), which are described in detail below. For the last three decades RUMs

have provided an effective means of studying choice behavior. In most basic instances, RUMs are utilized to find out what affects an individual's choice among a limited set of alternatives known as a "choice set," all of which are attainable from the individual's point of view. Initially, RUMs were commonly used in transportation studies estimating choice of transportation modes among given alternatives, such as car, bus or train, and it was originally for this purpose that McFadden (1974) developed the estimating procedure. Later, RUMs became very popular in various urban studies, especially in studying individual's recreational site choices, such as beaches or fishing lakes (Parsons, 2000). However, using RUMs to study school choice is recent and rare. Montgomery (2002) uses a nested logit model to estimate graduate business school choices, and DesJardins et.al. (2006) apply an integrated model for college choices. To date, there has not been an attempt to model doctoral institution selection utilizing a discrete choice model.

Random Utility Models

The conceptual basis for RUMs start with an agent (i.e., person, firm, etc.) facing a choice among a series of options. For example, a customer chooses which car to buy; a hospital decides which medical technology to use; a senior worker chooses to retire or continue to working; a student decides which school to attend (Train, 2003). The outcome of the decision in any given situation, the chosen option, is discrete since it takes a number of countable values. The goal in constructing a random utility model is to understand the behavioral process that leads to the agent's choice. A set of factors contribute to the behavioral process, some of which are observed and some are unobserved. The outcome, which is the choice of the agent, is a function of both the

observed and the unobserved factors. If, hypothetically, we were able to include both the observed and the unobserved factors into a function, the outcome could be easily predicted. However, due to the existence of unobserved factors, the agent's choice cannot be determined exactly. Instead, the 'probability' of a particular outcome derived from the observed factors is calculated. The unobserved component is treated as 'random' in the function –hence the name RUMs (Train, 2003).

The RUMs, thus, provide a mapping from individual's observed characteristics to their preferences. The RUM theory assumes that individuals will select the alternative that gives the highest expected utility. Individuals' preferences depend on the characteristics of the alternatives as well as personal characteristics. A key assumption is that all alternatives in the choice set are attainable. As explained above, the model separates the utility function for the individuals into two sections. A deterministic component measures the attributes of the alternatives and/or the individual; a stochastic component represents the unobserved attributes and heterogeneity of tastes, together with measurement and specification errors (Manski, 1977).

In this model, given a choice set composed of institutions where the applicant could possibly be accepted, an applicant will choose the institution that offers the highest utility. The central hypothesis of this study is that an applicant has a higher utility, therefore a higher probability of attending the institution, where the number of students, alumni, faculty and residents from their country of origin is the greatest.

The utility of individual *i* attending school *j* at time *t* can be expressed as:

$$Uij = Z_j(z_{1j....}\ z_{nj})\, X_{ij}(x_{1ij...}\ x_{nij}),\, M_i\,(m_{1i...}\ m_{nji}),\, \varepsilon_{tj} \quad j = 1,..., J,\ i=1.....n \qquad (1)$$

where Z is a vector of institutional characteristics, X is a vector of location characteristics, and M is a vector of individual characteristics.

If we observe that individual *i* chooses school *k* we infer that U_{ik} (school k) > U_{ij} (school j) and $\forall$ j≠ k. The individual-specific error terms are assumed to be random, independently-distributed variables.

The utility that the decision maker *i* obtains from alternative *j* can be decomposed into a part *Vij,* which includes the parameter that are observed by the researcher, and a random component *ei,* which is unknown (Train, 2003).

$$Ui\ (school\ j) = V\ ij\ + e\ ij \qquad (2)$$

The deterministic component of the above equation *Vij* can be expressed as follows:

$$V\ ij\ = \beta' Z_j + \Phi X_{ij} + \Omega' Mi \qquad (3)$$

Under these conditions, the probability that individual *i* chooses institution *j* at time *t* is given by the equation originally derived by McFadden (1974) :

$$\text{Prob } (i \text{ choose inst. } j) = \frac{e^{Vij}}{\sum_{j=1}^{j} e^{Vij}} = \frac{e^{\beta Zj + \Phi Xij + \Omega Mi}}{\sum_{j=1}^{j} e^{\beta Zj + \Phi Xij + \Omega Mi}} \qquad (4)$$

The three estimated parameters are: β, the effect of institution variables; Φ, the effect of location variables; and, Ω, the effect of individual characteristics interacted with one of the location or institution characteristics on the decision of which institution to attend. Individual characteristics can not enter the model directly[13]. One way to

[13] Individual characteristics do not vary across alternatives, and will be dropped out of the equation unless interacted with location or institution variables.

include these variables, as noted above, is to create interaction terms between them and location or institution variables that vary across alternatives. Inclusion of individual characteristics into the model is essential to account for the observed heterogeneity and to lend insight into individual specific preferences.

Using the conditional logit model imposes the very restrictive assumption known as the independence of irrelevant alternatives (IIA). McFadden (1974) suggests using the conditional logit model in cases where the outcome categories are distinct and can be evaluated independently in the eyes of each decision maker. Under the IIA assumption, the relative odds of choosing one alternative over the other does not change even as alternatives are added or removed from the model. In the case of institution choice of foreign students, it is reasonable to assume that students can evaluate their choices independently. For example if a student's probability of attending Emory University is 10% higher than his/her probability of attending the Georgia Institute of Technology, including a new institution into his/her choice set –say Georgia State University– should not change his/her preferential order between Emory University and Georgia Institute of Technology. In rare cases, institutions could share unobserved attributes which could lead to potential bias in parameters and violation of IIA. Further tests need to be applied to ensure this property exists. However, the results of the test do not provide guidance for better specification of the models if violation of IIA were found to occur (Train, 2003).

The variables in the equation fall into four main groups. The four *network variables*: (1) the number of foreign students from the same country of origin as the applicant in each department at each institution; (2) the number of alumni from the same

country at each department at each institution; (3) the number of faculty from the same country of origin at each institution, (4) the number of residents with the same nationality living in the Metropolitan Statistical Area (MSA) of the institution. The second group includes *institution variables*: type of the university (public or private), type of financial support that the university provides, and the ranking of the institution and the perceived 'openness' of the institution. The third group is comprised of *location variables* that account for characteristics of the MSA in which the university is located. This includes: cost of living, crime rate, air quality, weather conditions and foreign population percentages in each MSA. The *demographic variables* include individual characteristics of the students, such as the ranking of the undergraduate institution of the student, whether the student has a master's degree, age, gender, marital status and whether the student has a child. The measurement issues and data sources for all of these variables are discussed in the next section.

Determination of Choice Sets

Random Utility Models describe a decision maker's choice among alternatives. In our particular application, the assumption is that students consider a set of doctoral programs to which they were either admitted or could have been admitted had they applied in a specific field and then choose the one that maximizes their utility.

This study differs from more common studies applying RUMs. In most of these studies every individual in a model has the same choice set. However, this is not applicable to the models of school selection since each individual is in one of the ten S&E fields, and only the institutions that have a program in their discipline are relevant.

Therefore, each individual has a different choice set depending on the discipline they are in.

For our purposes we consider four possible choice sets. Choice set one, the most inclusive choice set, assumes that a student could have attended a broad range of institutions. The actual institutions in this set are restricted to 43 institutions for which we could get matching data. As a result of this, we could not include institutions that are located outside of MSAs, since the data for the location variables are available only at the MSA level.

Clearly, including all available institutions in this choice is a bold decision. However, some of the findings from our focus group interviews motivate us to start our analysis with this very broad choice set. One of the findings of the focus group interviews suggests that a possible consequence of network effects could be a 'mismatch' between the student quality and the ranking of the institution. That is, a student could value having a network more than the ranking of the institution and opt for a lower ranked institution although he/she could be eligible for a higher ranked institution. Another reason to include higher ranked institutions is that the admission decision by institutions has a random and unobserved component.

The second choice set is restricted only to the elite institutions (top ten). The assumption is made, for example that a student attending an 8^{th} ranked institution could attend any institution in the top ten. The third choice set includes only the institutions ranked between 10th and 30th, and the fourth choice set includes the institutions ranked 30^{th} and below. Similar assumptions are made with regard to these choice sets. In addition, and as noted earlier, in order to test the effects of faculty networks we have an

additional choice set restricted to institutions for which we could determine faculty ethnicity.

In order to further clarify the choice set selection, let's consider two students, one in agricultural sciences and one in civil engineering, who earned degrees from a top ranked institution. The student in agricultural sciences has 19 institutions, and the student in chemical engineering has 33 institutions in their largest choice set. The difference is because institutions do not have programs in each discipline. When the choice sets are restricted to only top institutions, the first student's choice set decreases to 4 institutions which are all top ranked in agricultural sciences; the second student's choice set decreases to 9 institutions which are all top ranked institutions in chemical engineering. Alternatively, we can consider two other students in agricultural sciences and chemical engineering who receive degrees from middle ranked institutions. The number of institutions in their broad choice set will be the same for these students as with the previous two students (19 and 33). When the choice sets are restricted by ranking, the students in agricultural sciences will have 11 institutions in his/her choice set which are all middle ranked institutions, and the chemical engineering student will have 10 institutions in his/her choice set which are also all middle ranked.

Two further assumptions are made in the formation of the choice sets. First, each choice set includes more than one institution. That is each student is assumed to be eligible for more than one institution. Therefore, choice sets that do not have at least two institutions will be excluded from the sample. Second, given that students are eligible for admission and, if everything else is equal, all institutions in the choice set have an equal probability of being selected. According to this assumption, a student is expected

to choose a particular institution because she or he receives higher utility at that institution than all others in the choice set, not because that was the only institution to which she or he could be admitted (Sumell, 2005).

Data and Descriptive Statistics

The individual level data come from Survey of Earned Doctorates (SED), 1981-2002. The SED is administered by the National Science Foundation (NSF) and funded by four other federal agencies. It is a census of all doctoral recipients in the U.S., and has a very high response rate (92-95%). The data is collected directly from individual doctoral recipients at or near the time of graduation.

Estimating the probability that foreign doctoral students attend an institution by using the SED has some limitations. Since SED data is collected at or near the time of graduation, only the students who eventually earned a degree are included in the analytical dataset. Students who dropped out, or transferred to another program, are excluded in the analyses. The latter is more problematic for this study than the former. Although dropping out at a later stage could also be explained by lack of social networks, this specific study only aims to test the effects of networks that define where students receive doctoral education. However, if the students have started their graduate degree in another institution, that is, if the institution they eventually graduated from is not their first location in the U.S, the influence of networks on the probability of attending a second institution could be less compared to students who are directly coming from their home country. This could lead to the underestimation of the total effects of networks.

On the other hand, one of the findings from the focus group interviews counters this argument. As some of the participants stated, students may start their graduate study at an institution, usually at a lower ranked institution, and then use their connections to transfer to a better institution while they are in the U.S. In cases like these, foreign students face a similar decision process as their fellow citizen students coming directly from their home country. As a matter of fact, according to this perspective, the SED provides an advantage to this study by only including individuals who actually graduated from the institution at which they are observed. That is, the dataset excludes[14] those students who are enrolled at an institution but transfer to another institution.

The analytical dataset includes individuals who received a PhD from S&E departments and are from China, Korea, India or Turkey. In the SED both the 'citizenship' and the 'place of birth' of the students is ascertained. In this study 'citizenship' rather than 'place of birth' is used, assuming citizenship to be a better measure for being 'foreign'. However, the correlations between citizenship and place of birth variables are sufficiently high[15] to conclude that virtually all students who are born in foreign countries are still citizens of those countries.

Recall that the dependent variable in this analysis is the observed choice of the foreign doctoral students. The dependent variable is observed during the 1996-1997 academic year. This is due to the fact that between 1981 and 2002, the 1996-1997 academic year is the most recent 'year of entrance' that provided a large enough sample

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[14] Note that it is also possible the dataset might be including students who wished to transfer to another institution but couldn't, and eventually graduated from their observed institution.
[15] Correlation coefficients between place of birth and citizenship for Korean, Chinese, Indian and Turkish students are 0.9874, 0.9953, 0.9967 and 0.9929 respectively.

for analysis. Basically, the dataset includes students who enrolled (first time enrollment) at an institution during the 1996-1997 academic year and graduated in or before 2002. We do not have information about the students who entered a program during the1996-1997 academic year but received their PhD after 2002. However, it is not unreasonable to expect that most students will graduate within 6 years (Hoffer & Welch Jr., 2006)

Among all doctoral students who entered a PhD program during the 1996-1997 academic year in S&E and graduated in or before 2002, 4,608 are foreign students (holding a temporary visa). The number of Chinese, Korean, Indian and Turkish students is 1,863. This constitutes our analytical set. As discussed earlier, Chinese, Korean and Indian students are the top three foreign student populations in the U.S. Turkish students are in the top ten. They are included in the analyses not only for this reason but because of the insights from the group interviews done with Turkish doctoral students.

In the analytical dataset set, 61% are Chinese, 17% are Korean, 15% are Indian, and 6% are Turkish citizens (Table5.1). Among all the students (including U.S. citizens) who entered in 1996-1997 and graduated by 2002, 12% are Chinese, 3.2% are Korean, 2.7% are Indian, and 1.1% are Turkish. These percentages are slightly lower than the composite averages of all students in the entire dataset, consisting of graduates from 1981-2002.

Table 5.1: Distribution of Chinese, Indian, Korean, and Turkish Students in the Analytical Dataset

Nationality of the student	Number	Percentage
Chinese	1,143	61.4
Indian	278	14.9
Korean	325	17.4
Turkish	117	6.3
Total	1,863	100

Originally, 13 S&E departments (biology, agricultural sciences, earth sciences, computer and information sciences, mathematics, physics, chemistry, aerospace engineering, astronomy, chemical engineering, civil engineering, electrical engineering, mechanical engineering) were included in the dataset. However, due to the very low number of foreign students in earth sciences, astronomy, and aerospace engineering, these three disciplines were excluded from the final dataset. Table 5.2 shows the distribution of Chinese, Indian, Korean and Turkish students across the remaining 10 disciplines. Percentages of students receiving doctoral degrees in electrical engineering are higher for all four nationalities. A higher percentage of Chinese and Indian students received their degrees in biology and chemistry, whereas higher percentages of Turkish and Korean students received their degrees in civil engineering. The last column in Table 3 displays the number of institutions that have programs in each of these ten S&E fields[16].

[16] Appendix 3 shows the top 10 institutions most populated by students from these four nationalities.

Table 5.2: Percentage Distribution of Chinese, Indian, Korean and Turkish in S&E Fields

	Chinese (%)	Indian (%)	Korean (%)	Turkish (%)	Number of institutions in each discipline
Agricultural Sciences	5.2	2.9	5.5	12.8	19
Biology	15.0	11.5	7.7	*[17]	36
Chemical Engineering	6.5	17.6	5.2	6.8	33
Chemistry	12.3	9.0	6.8	*	37
Civil Engineering	4.2	4.3	15.7	19.7	29
Computer Sciences	6.1	7.6	4.9	5.1	29
Electrical Engineering	22.3	31.3	25.8	22.2	37
Mathematics	7.7	4.0	6.5	10.3	34
Mechanical Engineering	15.5	9.7	17.5	11.1	36
Physics	5.2	2.2	4.3	*	26

Except for the population network variable, which was obtained from the Census 2000, the other network variables were created as a result of complex coding processes. The first network variable, the number of students at an institution from the same country of origin with the applicant, came from SED. The dependent variable is measured for foreign doctoral students who entered an institution in the U.S during 1996-1997 academic year, and who eventually earned a PhD degree. Therefore, the numbers of existing students are obtained by adding the number of students from the same country of origin who were already in the program during the 1996-1997 academic year. Obtaining these numbers included two stages. The first stage required identification of the students who were present at the institution between August 1996 and August 1997. Most of the students entered the program during Fall 1996, however

[17] Percentages which correspond to 6 or fewer students are suppressed in the table and indicated by a *.

for the students entering the program during Spring 1997, December 1996 graduates needed to be excluded. The final data set included only the students who entered the program prior to applicants' year of entry and graduated any semester after the applicant entered the program. The second stage included assigning each individual the number of existing students that are from their country of origin. That is, the variable 'same nationality student' took different values for each institution depending on the nationality of the applicant. For example if an institution has 16 Chinese and 11 Korean doctoral students in an electrical engineering department[18], the 'same nationality student' variable is coded as 16 if the applicant is Chinese and 11 if she/he is Korean. Means for the same student variable are in Table 5.4. We see that, in our sample on average students attend a program with 11.4 students from the same nationality. But there is considerable variation across nationalities. Chinese students attend a program with 13.3 other Chinese students, Koreans with 5.3 other Koreans, Indians with 4.7 other Indians, and Turkish with 1.4 other Turkish students.

The alumni variable is also obtained from the SED, and is created by adding the students from the same nationality who graduated prior to 1996 (or prior to Spring 1997 for a subset of the dataset). The 'same nationality alumni' variable is coded for each individual, according to their nationality, department, and institution, with the same methodology used to create the 'same student' variable. The mean number of same nationality alumni for our analysis is 17. It is slightly higher for Chinese (17.5) and considerably lower (2.5) for Turkish students.

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[18] Note that the 'same student' is calculated for each department in an institution, not for all the student at that institution.

Creating the 'same nationality faculty' variable was by far the most difficult task in the preparation of this dataset. It took several months to identify and verify nationalities of the faculty members. Information about the faculty in each institution came form the report "Research-Doctorate Programs in the United States: Continuity and Change" published by the National Research Council in the fall of 1995. This report contains information about 3634 research-doctorate programs in 41 fields at 274 universities. One section of this dataset has a listing of 88,208 faculty members who participate in the programs, by names, rank, institution and program codes. However, the dataset did not include the nationalities of the faculty. In order to identify Chinese, Korean, Indian and Turkish faculty members in the dataset, a methodology similar to the one used in the web study in Chapter 4 is used.

After excluding the faculty members in non-S&E fields, 59,141 names were assigned to three student assistants, one from India, one from Korea, and one from China, with the goal of identifying faculty names from their country of origin[19]. In order to do this, they drew on their knowledge of common names in their country as well as the list of "Most Common U.S. Ethnic Surnames" provided in Kerr (2004)[20]. In a majority of the cases, in addition to their own knowledge, students had to make extensive internet searches to confirm the nationality of the faculty member. However,

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[19] Turkish faculty names were identified by the author.

[20] In this study, the author identifies the ethnicities of the inventor names contained in the NBER Patent Data File originally compiled by Hall, Jaffe, and Trajenberg (2001). The NBER Patent Data File provided micro records for all patents granted by USPTO from January 1975 to December 1999. Kerr maps into these inventor names an ethnic-name database, constructed by Melissa Data Corporation, originally designed for direct mail advertisements. A list of "Most Common U.S. Ethnic Surnames" is provided in this study, which we used as a reference for identifying Chinese, Korean, and Indian last names.

some faculty names were still not identified, and had to be excluded from the final dataset. Unidentified names introduced a major limitation to obtaining a complete dataset that includes the numbers of foreign-born faculty at every institution in the analytical dataset. Because of coding problems, we limited our identification of faculty names at 24 institutions.

Another limitation resulted from the discrepancy of the time frames between the analytical dataset and this faculty dataset. The NRC data was collected four years before our analytical time frame. This could lead to the underestimation of the numbers of foreign faculty in some of the institutions given that the number of foreign faculty has grown over the years (P. E. Stephan & Sharon, 2003). Despite these limitations, we use the sub-sample of 24 institutions from the SED to examine the effect of faculty members on the probability of attending an institution. Table 3 shows the distribution of Chinese, Indian, Korean and Turkish faculty in these institutions. This dataset still provides a good range of variation in order to test the effects on students' probability of attending an institution. A comparison between the table for the top institutions with the highest Chinese, Indian, Korean and Turkish students in Appendix 2 and Table 5.3 shows considerable overlap. The institution names with the highest number of foreign faculty also appear in the top ten institutions for the corresponding nationalities.

Table 5.3: Number of Chinese, Indian and Korean Faculty Members in S&E in 1993 in Selected Departments

Institution Name	Korean	Turkish	Chinese	Indian
University of California-Davis	3	4	16	10
Univ of California-Los Angeles	7	2	12	24
Univ of California-Santa Barbara	6	1	5	7
University of Florida	4	4	5	19
Georgia Institute of Technology	3	4	12	19
Northwestern University	1	2	8	12
Iowa State University	3	2	7	20
University of Maryland	1	0	1	0
University of Michigan-Ann Arbor	1	6	18	23
University of Minnesota-Twin Cities	3	1	13	16
Rutgers University	4	3	13	21
Columbia University	5	4	5	11
Cornell University	5	2	13	19
North Carolina State University-Raleigh	3	2	11	19
Ohio State University	2	5	11	20
Carnegie Mellon University	0	2	4	5
The Pennsylvania State University	3	8	22	30
Rice University	1	0	3	7
Texas A&M University	5	3	15	24
University of Texas-Austin	5	5	28	23
Virginia Polytech Inst & State U	2	0	7	9
University of Washington	4	2	15	11
University of Wisconsin-Madison	12	6	18	41
Purdue University	3	3	9	21

The data for the final network variable, 'same nationality residents' in each MSA is obtained from the 2000 Decennial Census Data, measured in thousands. As in the case of other network variables, the 'same nationality population' variable also receives different values according to the nationality of the applicant. Appendix 4 shows the top 10 MSAs where Chinese, Indian, Korean and Turkish populations are most concentrated. As seen in Appendix B4, the locations of universities where the students from these four nationalities are most populated do not necessarily overlap with the top MSAs where residents from their countries are most concentrated.

Figures 5.1-5.4 summarize the relationship between the three network variables in the main data set. A positive relationship is observed between the number of students and the number of alumni from the same institutions for the Chinese, Indian, Korean students. That is, in the institutions where students from these countries are high, the stock of alumni is also high. This relationship is stronger for the Korean students compared to Indian and Chinese students (0.71, 0.56, and 0.51 respectively). The alumni-student relationship is weakest for Turkish students (0.37). Unlike the relationship between the student and alumni variables, the foreign populations within the MSA of the institutions are not higher where students and alumni are higher. The relationship is only positive for the Chinese students but the correlation coefficient is very low (0.02)[21]. The effects of these network variables on the probability of attending an institution are tested in the analysis section.

[21] See Appendix B5 for correlation coefficients.

Figure 5.1: Network Variables for Chinese Students

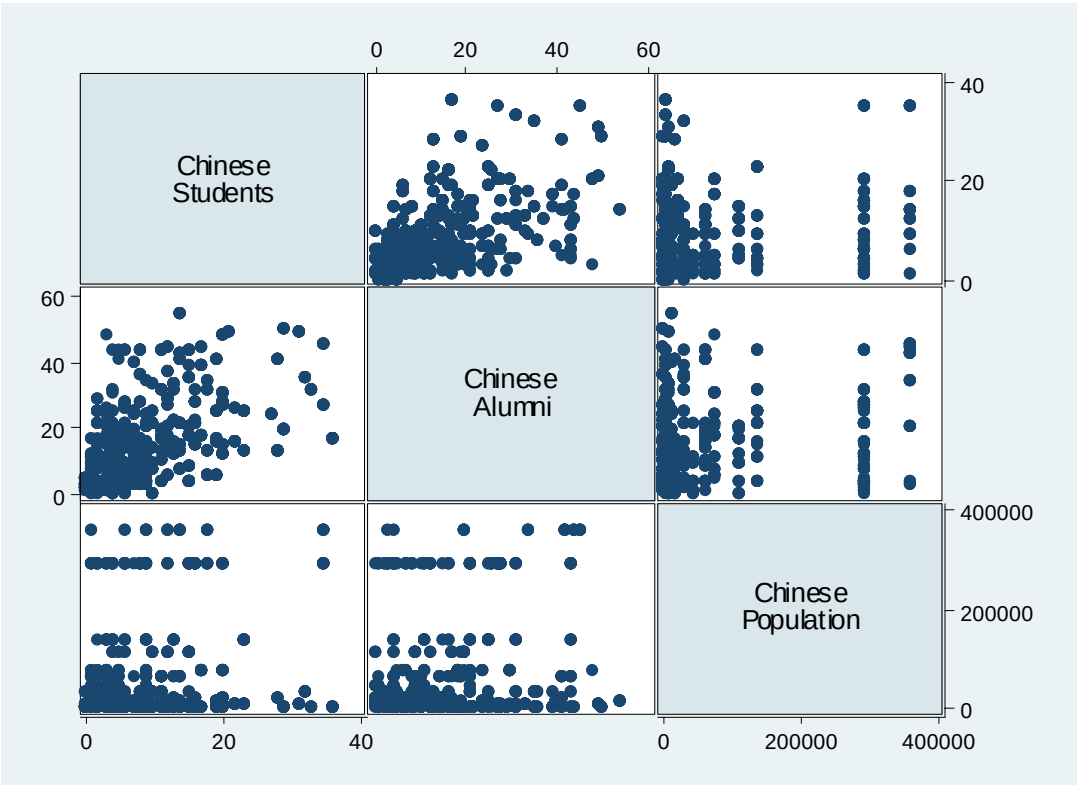


Figure 5.2: Network Variables for Indian Students

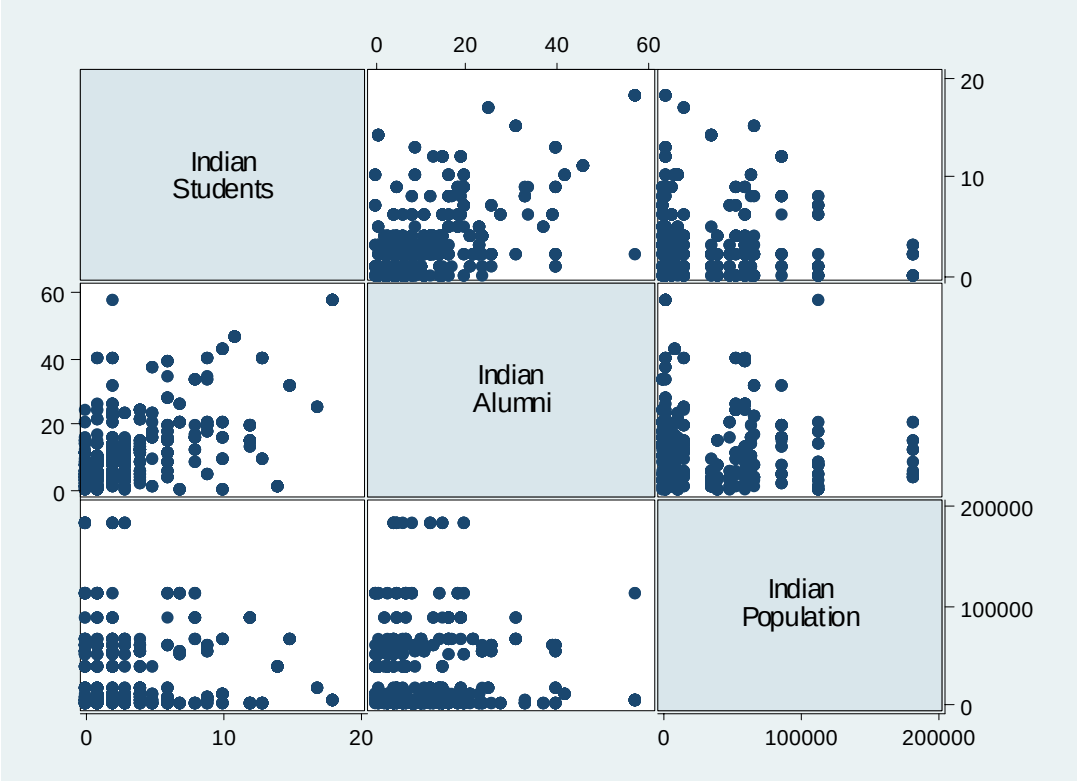


Figure 5.3: Network Variables for Korean Students

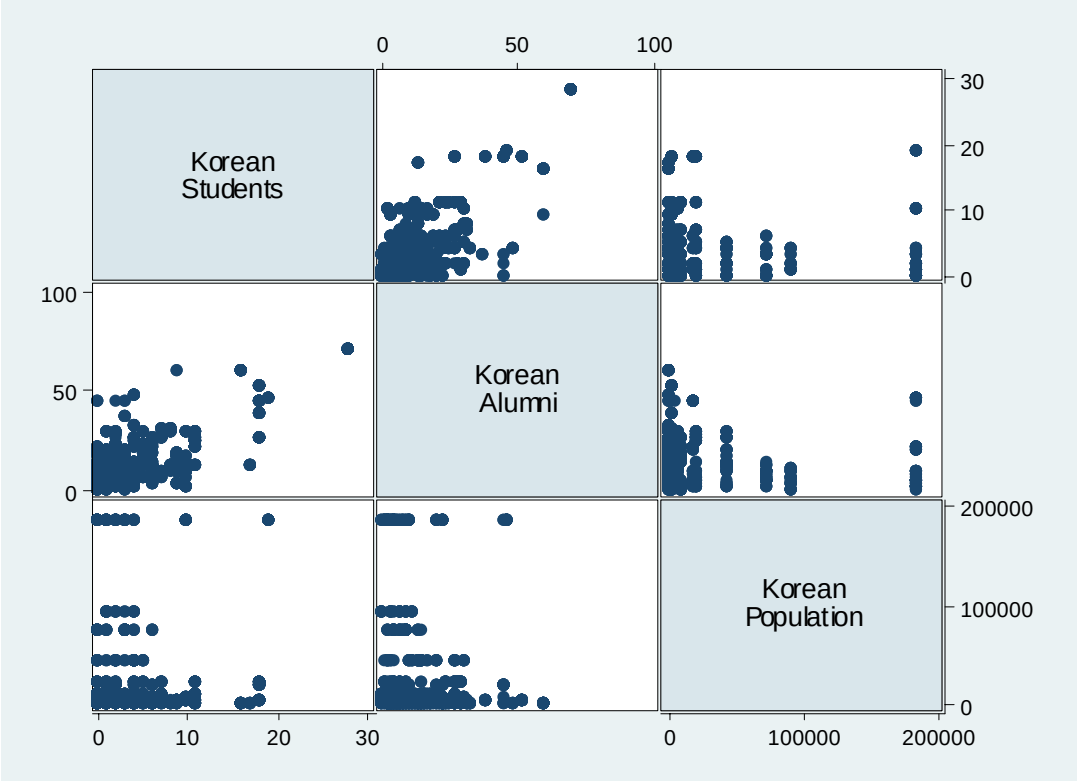
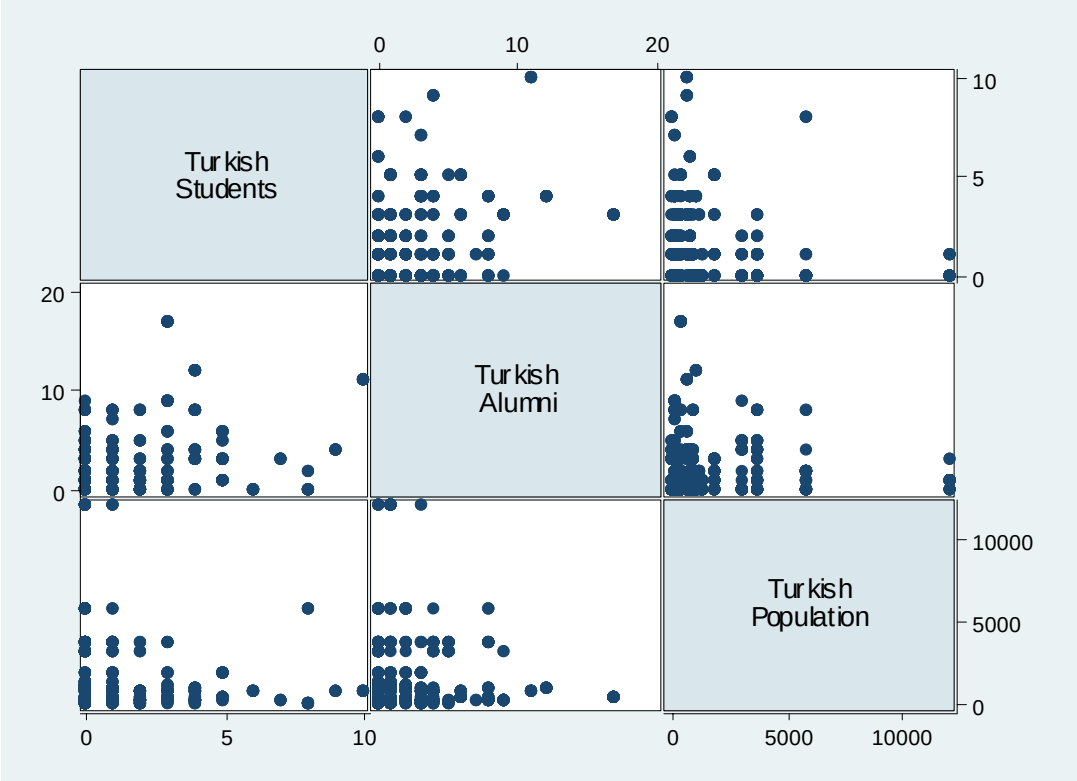


Figure 5.4: Network Variables for Turkish Students



As noted earlier, characteristics of the institution, characteristics of the geographical location, student quality, and some demographic characteristics are other factors likely to affect students' probability of attending an institution. Therefore, these variables are controlled for in the analysis. Characteristics of the institution included in this study are type of institution (public/private), financial support structure, and the department rankings. Both the rankings and the institution type information come from 1995 NRC Data. In the analytical data set, 73% of the students graduated from public institutions. The rankings of the departments[22] vary between 1 and 75, and the average rank of all is 19. The SED provides information about how students were funded during their doctoral education. The variable distinguishes between financial support provided by the institution, personal funds, grants and scholarships. With the assumption that departments that are more likely to provide internal support for students are more attractive to foreign students, we created an index which measures the percentage of cases that are supported by internal funds[23] among all the cases at that department in each institution. In this dataset the average percentage of internal support is 61.2%. The final institutional variable is the student's perception of the institution's openness to foreign students. This is measured by adding the numbers of students from each nationality in every department.

We also control for geographical characteristics, including cost of living, air quality, weather conditions, crime rate and foreign population percentages. The cost of living comparisons are obtained by using a cost of living calculator provided by

[22] Note that ranking are for each discipline.
[23] Teaching and research assistantships are coded as internal funds.

Sterling's Best Places website[24]. The index created determines how much more (or less) a person needs, to maintain the same standard of living in each MSA. In this dataset, the average cost of living is 105, indicating that students are attending institutions located in higher than average cost of living areas. This is due to the fact that the data set includes 6 institutions in California and 4 institutions in New York which are the first and second most expensive states in the U.S. Crime rates are measured by the mean number of reported violent crimes, including robberies, murders, and assaults each year per population per 100,000 residents in each MSA. Crime rate data are obtained from 1999 *Places Rated Almanac*, Savageau and D'Agostino. The average crime rate in our sample is 610. Air quality data are collected from Environmental Protection Agency (E.P.A.). The average number of days with unhealthy air quality is 11.5 in our sample. Finally, the weather related variables (the mean values for January temperatures, July relative humidity, and the percentage of area covered with water) are gathered from Economic Research Service (E.R.S.) at the U.S. Dept. of Agriculture.[25] The average July temperature in our sample is 75 degrees Fahrenheit. In comparison to the cities where most of our Chinese, Korean, Indian and Turkish students come from, this average is lower than the average July temperatures in Beijing (87 degrees), Seoul (82 degrees) and Ankara (85 degrees) and Bombay (86 degrees)[26].

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[24] www.bestplaces.net

[25] Crime rate, air quality, weather and political leaning variables are collected and used in the dissertation "The role of amenities in the location decisions of Ph.D. recipients in science and engineering" by Albert J. Sumell. The data were made available to us by the author.

[26] www.weather.com

In order to measure student quality we have included the ranking of the students' undergraduate institution and whether the student has a master's degree related to her doctoral field of study. The rankings of Korean, Indian, Chinese and Turkish universities are obtained from national websites. In all four of these countries there are one or two organizations ranking universities. In order to get a better understanding of university rankings in these countries, the research assistants, who helped to identify the origin of faculty names, were asked to research the credibility of the various ranking institutions and their methodologies through documents available on the internet that are in their own language. In order to have a comparable scale for each student included in the study, rankings of the undergraduate institutions are standardized as 'top', 'middle', and 'bottom' within each ranking list. In each case, the top 10% of all ranked institutions are coded as 'top', the bottom third of institutions are coded as 'bottom', and the remaining institutions are coded as 'middle'. Appendix B3 shows the top ten undergraduate institutions where the students in the analytical sample come from.

In addition to being a quality measure for the foreign students, a brief analysis of the students' undergraduate institutions in this dataset reveals some interesting results which could contribute to the underlying network connections between the foreign students in the U.S. and the potential applicants in the home country. For instance, in this sample, 33% of Korean students come from Seoul National University, 37% of Turkish students come from Middle East Technical University, 36% of Indian students come from the Indian Institute of Technology, and 10% of all Chinese students come from Beijing University. Recall that the focus group interviews with the Turkish students also pointed towards such a clustering. This is an interesting finding that

requires further research on the dynamics between the sending and receiving institutions.

Another variable used to measure student quality is having a master's degree. The SED includes this information for each individual. The variable 'having a master's degree' is coded 'one' if the student has a master's degree, 'zero' otherwise. In the analytical dataset, only the students who completed their master's degrees prior to year of entry in the PhD program are coded as having a master's degree. That is, the students who earned their master's degrees during (or in a few cases after) doctoral studies are excluded.

The set of demographic characteristics such as age, marital status, and having children are obtained from the SED. Age is measured at the time of admission. Marital status is 'one' for students who are married or living in a marriage-like relationship and 'zero' for single, separated, divorced or unknown. The children variable is calculated from the number of dependents coded in the original dataset. Dependents younger than 18 are considered as children.

In this sample 23% percent of the students are female and 71% are married or living in a marriage like relationship. Approximately 30% of the students have children. The age range is between 22 and 55, but 60% of all students are less than 30 years old. Compared to the entire dataset of PhD recipients, the students in this subset are slightly older; more students are married or living in a marriage like relationship and have children. However, the percent female is very similar to the average of all students who graduated between 1981 and 2002.

Table 5.4: Descriptive Statistics and Variable Definitions

Variable Label	Mean	Std. Dev.	Description of the Variable
Network Variables			
Turkish students	1.37	1.87	number of Turkish students in department a, institute j during 1996-1997
Chinese students	13.35	8.56	number of Chinese students in department a, institute j during 1996-1997
Korean students	5.34	5.98	number of Korean students in department a, institute j during 1996-1997
Indian students	4.72	4.17	number of Indian students in department a, institute j during 1996-1997
Same nationality students	11.44	8.12	number of students from the same origin with student in department a, institution j
Proportion of same nationality to total students	0.23	0.14	proportion of the number of students from the same origin to the total students
Turkish alumni	2.46	3.03	number of Turkish alumni in department a, institute j before 1996
Indian alumni	12.93	11.9	number of Indian alumni in department a, institute j before 1996
Korean alumni	16.47	15.14	number of Korean students in department a, institute j before 1996
Chinese alumni	17.51	12.37	number of Chinese alumni in department a, institute j before 1996
Same nationality alumni	17.16	14.21	number of alumni from the same origin with student i, in department a institution j
Proportion of same nationality to total alumni	0.06	0.01	proportion of the number of alumni from the same origin to the total students
Chinese population	52.90	93.42	Chinese population in MSA (in 1000s)
Indian population	29.81	39.70	Indian population in MSA (in 1000s)
Korean population	26.29	50.68	Korean population in MSA (in 1000s)
Turkish population	1.38	2.22	Turkish population in MSA (in 1000s)
Same nationality population	43.48	82.89	number of residents from the same origin with student i
Institution Characteristics			
Public Institution	0.73	0.40	dummy variable coded "1" for public "0" for private institutions
Percentage of Internal support	61.23	12.26	percentage of support provided by the institution
Program rank	19.9	15.20	ranking of the institution
Total foreign students	22.98	15.98	Total number of Korean, Chinese, Indian and Turkish students in department a institution j during 1996-1997
Location Characteristics			
January temperature	33.92	13.28	mean January temperature in degrees Fahrenheit
July humidity	61.96	8.96	mean relative humidity in July

Table 5.4 Continued

July temperature	74.91	5.17	mean July temperature in degrees Fahrenheit
Violent crime	610.09	308.06	mean number of reported murders, robberies and assaults per 100,000 residents (1997-99)
Unhealthy air	11.45	13.28	number of days that air quality index was labeled as unhealthy in 1999
Cost of living	105.38	33.63	index of cost in MSA normalized to 100
Foreign population percentage	11.98	0.35	percentage of foreign population in MSA
Demographic Variables			
Sex	0.78	0.42	dummy variable coded "1" for male "0" for female
Age	30.95	3.31	age of the individual at the time of graduation
Married	0.69	0.45	dummy variable coded "1" for married "0" for single or divorced
Children	0.3	0.45	dummy variable coded "1" for individual with children "0" for individual with no children
BA institution's ranking	1.44	0.52	ranking of the baccalaureate institution of individual i
Having master's degree	0.59	0.49	dummy variable coded "1" if the individual has a masters degree "0" if not
Turkish citizen	0.06	0.24	dummy variable coded "1" for Turkish individuals "0" for others
Indian citizen	0.17	0.36	dummy variable coded "1" for Indian individual "0" for others
Chinese citizen	0.60	0.49	dummy variable coded "1" for Chinese individuals"0" for others
Korean citizen	0.18	0.38	dummy variable coded "1" for Korean individual with children "0" for others
Interaction Terms			
hasma_phdrank	hasma*phdrank		
barank_phdrank	barank*phdrank		
samestud_phdrank	samestud*phdrank		
samestud_married	samestud*married		
children_vcrime	children*vcrime		
age_samestud	age*samestud		
children_samepop	children*samepop		
age_cost	age*cost		
children_cost	children*cost		
sex_samestud	sex*samestud		
hasma_samestud	hasma*samestud		
barank_samestud	barank*samestud		
Samestudsq	samestud*samestud		
Samepopsq	samepop*samepop		
Samelumsq	samelumsq* samelumsq		

Table 5.5: Summary of Data Sources

Variable Description	Data Source
Network Variables	
Number of students at institution j	Survey of Earned Doctorates (SED)
Number of alumni from institution j	SED
Number of residents in the MSA of the university	Census 2000
Number of foreign professors in institution j	NRC 1993 NSGF
Institution Characteristics	
Percentage of Internal support	SED
Type of the institution	NRC 1993 NSGF
Program Rank	NRC 1993 NSGF
Total number of foreign students	SED
Location Variables	
Cost of Living	Best Places
Unhealthy Air	EPA
Crime Rate	1999 Places Almanac
Weather	E.R.S. at Dept. Agriculture
Percentage of Foreign Population	Census 2000
Student Quality Variables	
Ranking of the undergraduate institution	National web pages
Having a master's degree	SED
Demographic Characteristics	
Age	SED
Married	SED
Children	SED
Sex	SED

Results

In order to test the network hypotheses, we estimated a number of conditional logit models. The results are presented in Tables 5.6-5.10. Table 5.6 includes the results from the all four nationalities and ten disciplines. The choice set in this model is the 'broad' choice set explained above, including every institution in each discipline in our initial dataset. Table 5.7 narrows the choice sets, including only the top ten institutions in the first equation, next twenty institutions in the second equation, and all other institutions in the third equation. Table 5.8 presents the coefficient estimates by discipline, and Table 5.9 by nationality. The results in Table 5.10 are for the dataset that contains faculty ethnicity.

Table 5.6 includes four different models. Model 1 presents the results from the basic model, testing the effect of networks on the probability of attending an institution. In this model –and in all others– significant coefficients are indicated showing that the variable has an effect on the probability of attending an institution at the one, five and ten percent levels. The sign of the coefficients define the direction of a relation between the variable and the probability of attending an institution. For instance, the positive (and significant) coefficient on the variable 'same nationality students' indicates that a *higher* number of same nationality students at an institution *increases* the probability of attending an institution. Further, the results imply an ordinal importance of the coefficients in the institution selection process. Z-statistics are displayed along with the coefficients. For example, in Model 1, the z-statistic for the 'same nationality student' is 10.6, while it is only 1.72 for the same alumni variable, emphasizing the larger

importance of same nationality students on the probability of attending an institution compared to same nationality alumni.

The results of Model 1 support two of the central network hypotheses of this dissertation. Both a higher number of existing students and a higher number of alumni from the same nationality increase the probability of attending an institution. However, the effect of existing students is much larger than the effect of the alumni and the variable is significant at the one percent level while the alumni variable is only significant at the ten percent level. This is consistent with our earlier observation that students who are in the program can provide the applicants a primary source of information and support, and hence increase the attractiveness of the program. Also, as one of the participants indicated in the focus group interviews, students choose institutions which are familiar with students from their country of origin. One of the participants stated that one of the reasons she considered Georgia Tech was the Georgia Tech professor's familiarity with Turkish institutions and the quality of education at these institutions. Consequently, she felt that her background could be appreciated more at Georgia Tech.

Alumni play a role in sharing information and provide a reference for the applicant. They connect applicants with the members of applied institutions and hence play a role in the application process. However, the immediate benefits –such as initial accommodation– provided by current students could be more valuable to foreign applicants than the benefits provided by alumni. Furthermore, since doctoral recipients are quite mobile (Sumell, 2005), their dispersion could provide a limited environment for the applicant-alumni interactions.

Model 1 uses the numbers of same nationality students and alumni to estimate the coefficients. Model 2 replaces student and alumni variables with the proportion of alumni and students to the total populations in each department, in order place counts in a relative framework. The effect of existing students remains unchanged and strong. However, the proportion of alumni of the same nationality to the total number of alumni does not significantly affect the probability of attending. The comparison of these two models highlights that both an increase in number of students and the concentration of these students within an institution has a similar effect on the probability of attending an institution. The total number of students rather than the proportions will be used throughout the remaining models in order to capture the possible network connections at institutions where there are only few fellow citizens.

An interesting finding in Model 2 is the negative and significant coefficient on the population variable. In assessing this result, it is important to acknowledge that the top 10 PhD institutions that receive foreign students, and the top 10 MSAs with the largest Chinese, Indian, Korean and Turkish populations (Appendix B2 and Appendix B4) do not overlap. This contributes to the discussion in Chapter 2 about the uniqueness of foreign student populations in the U.S. Although foreign student movements carry some of the characteristics of low skilled migration from their countries, they appear to be geographically detached from each other. This is not inconsistent with what we learned from focus group interviews. As the focus group interviews revealed, the students at an institution appear to have a stronger connection to the potential students than the fellow citizen residents that live within the location of that institution. The existence of residents from the same country of origin might provide cultural facilities

(e.g. restaurants, local markets, etc.); however, connections at the institution are more crucial for the doctoral applicants as their lives are mostly woven around their studies.

Model 3 adds a square term to the network variable to observe the changes in the probabilities as the student population increases. All of the models point towards an influence of existing students on attending an institution. However, the significant coefficients on the variable 'same nationality student squared' indicate that the effect of an increase in the number of same nationality students is not linear. That is, the probability of attending an institution will not uniformly increase as the numbers increase. In this model –and most other models– the signs on the coefficient for the squared term of the student variable are negative. This indicates that the effect of existing students on the probability of attending an institution increases with a decreasing rate.

Model 4 includes the interaction terms in order to account for the observed heterogeneity among individuals. For instance, the student effect is higher for students who have a master's degree. This could be due to the possibility that students could have a larger network including students they met during their master's studies.

In all four models, the total number of Chinese, Korean, Indian and Turkish student are included in the model to account for the change in probability of attending an institution as the total number of foreign students at that institution increases. We also find the probability of choosing an institution is positively and significantly related to the total umber of foreign students, other things being equal.

Among the geographical characteristics, warmer weather conditions (July temperature) increase the probability of attending a school (Model 2). However, contrary to our hypothesis, more expensive cities increase the probability of attending an institution (Model 2 and Model 4) as do higher violent crime rates. This is likely a result of the fact that the institutions included in this sample are located mostly in metropolitan areas where both crime rates and living costs are relatively high. Also, in these analyses, the cost of living indices include all types of costs, such as housing or healthcare. However, foreign students, most probably are not affected by housing costs, or not subject to private health insurance.[27] One would expect to find more consistent results if more student-specific cost measures were available.

Like the cost of living, higher violent crime rates also increase the probability of attending an institution. A possible explanation for this very odd result is that security between on-campus residences and the MSA in general is substantially higher in high crime rate cities and that doctoral students, especially single students, are likely to live on campus and thus feel safe. This is consistent with the finding that institutions in higher crime rate cities are less likely to be chosen by students who have children (Model 4) and are arguably more likely to live off-campus.

As hypothesized earlier, foreign students have a higher probability of attending public institutions than private ones. Also, as expected, higher ranked institutions are more desirable for foreign students. However, neither weather conditions not air quality

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[27] In many universities in the U.S. foreign students are required to have health insurance that is provided by the university.

seem to affect student choice. Although July temperature has the expected positive sign in all models, it is never significant. The variables July humidity and unhealthy air do not have consistent signs across models and are not significant. One possible explanation could be that weather conditions and air quality are relevant to students' choice only in comparison to where they come from. For example, air quality might influence students choice, only if the institution he/she is considering has better air quality than his/her home town. One might expect to find more significant results if geographical measures in both origin and destination cities of the students are available for analysis.

Table 5.6: Conditional Logit Model Coefficient Estimates for the Full Sample

	Model 1		Model 2		Model 3		Model 4	
	coefficient	**p>z**	**coefficient**	**p>z**	**coefficient**	**p>z**	**coefficient**	**p>z**
same nationality students.	0.084	***			0.251	***	0.313	***
	(10.6)				(16.2)		(4.06)	
same nationality student squared					-0.005	***	-0.006	***
					(-12.2)		(-10.0)	
proportion of same nationality student			3.489	***				
			(12.4)					
same nationality alumni	0.005	*			-0.005		-0.001	
	(1.72)				(-0.61)		(-0.08)	
same nationality alumni squared					0.00002		0.00007	
					(0.11)		(0.37)	
proportion of same nationality alumni			0.622					
			(0.82)					
same nationality residents	-0.001		-0.002	**	0.0003		0.001	
	(-0.80)		(-2.46)		(0.15)		(0.56)	
same nationality residents squared					0.000003		0.000007	
					(0.52)		(1.13)	
program rank	-0.004	*	-0.016	***	-0.001		-0.022	*
	(-1.76)		(-5.98)		(-0.40)		(-1.70)	
percent internal support	0.001		0.001		0.001		0.003	
	(0.19)		(0.23)		(0.40)		(0.68)	
public institution	0.174	*	0.336	***	0.111		0.215	*
	(1.73)		(3.27)		(1.12)		(1.66)	
July temperature	0.005		0.006		0.010		0.012	
			(0.75)		(1.27)		(1.06)	
violent crime	0.0001		0.0002	**	0.0003		0.0003	*
	(0.92)		(2.48)		(1.36)		(1.67)	
July humidity	0.004		0.006		0.001		-0.002	
	(1.30)		(1.63)		(0.36)		(-0.34)	
unhealthy air	0.002		0.002		-0.003		0.0005	
	(0.64)		(0.63)		(-0.93)		(0.12)	
cost of living	0.001		0.004	*	0.002		0.023	*
	(0.78)		(1.83)		(0.79)		(1.84)	
foreign population percentage	-0.006		-0.012		-0.002		0.008	
	(-0.86)		(-1.58)		(-0.21)		(0.77)	
total foreign students	0.001		0.033	***	-0.001		-0.005	
	(0.23)		(13.1)		(-0.32)		(-0.88)	
has MA_phdrank							0.004	
							(0.52)	
BA rank_phdrank							0.010	
							(1.01)	
samestud_phdrank							0.0002	
							(0.46)	
samestud_married							-0.002	
							(-0.14)	
children_v. crime							-0.001	*
							(-1.81)	
age_samestud							-0.002	
							(-0.68)	

Table 5.6 Continued

children_samepop				0.0000002	
				(0.12)	
age_cost				-0.001	*
				(1.90)	
children_cost				0.003	
				(0.90)	
has MA_samestud				0.045	**
				(2.24)	
BA rank_samestud				-0.011	
				(-0.39)	
N	29721	29721	29721	17084	
N(Groups)	1693	1693	1693	973[28]	
Pseudo R^2	0.056	0.061	0.078	0.103	
Prob.>Chi^2	0.000	0.000	0.000	0.000	
LR Chi^2	441.4	482.0	615.1	470.9	

z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

The models in Table 5.7 utilize the other more restricted choice sets. The choice sets for the previous models included all possible institutions (among the 43) in their discipline that the applicant could apply to. The primary motivation to include such a broad array of institutions that are above and below the rank of the observed institution attended is to account for possible 'mismatch' between the quality of the student and the ranking of the institution. This is in fact central to the hypotheses of this study that suggests that due to their networks connections, students might choose an institution other than that predicted by their training and ability. Although theoretical motivations suggest inclusion of a wider range of institutions, it is still essential to run the models with more restricted choice sets in order to avoid any possible bias that could result from inclusion of irrelevant alternatives, in this case institutions impossible to attend.

[28] Note that the number of alternatives varies for each individual in this model. The number of groups indicates the number of individuals, the total number indicates the total number of cases in each model.

Another motivation for using a more restricted choice set comes from the results of the web study which found that the concentration of same nationality students in top institutions was less than the concentration in middle or bottom ranked institutions.

Table 5.7 presents the coefficients for the network variables for more restricted choice sets. The results are consistent with those found for the broader choice set presented in Table 5.8. To wit, student choice is affected (at a decreasing rate) by the number of students of the same nationality. Institutional characteristics of top ranked institutions could be more influential on choice behavior than the effects of networks. Undoubtedly, receiving a degree from a top institution has large future benefits. The impact of same nationality students at bottom ranked institutions is also not as high as it is in middle ranked institutions. Clearly, more research is needed as to why the effect is strongest for middle ranked institutions.

Table 5.7: Conditional Logit Model Coefficient Estimates for Three Ranking Tiers

	Top 10		**Middle**		**Bottom**	
	coefficient	**p>z**	**coefficient**	**p>z**	**coefficient**	**p>z**
same nationality students.	0.239 (5.31)	***	0.312 (9.34)	***	0.347 (6.23)	***
same nationality student squared	-0.004 (-3.83)	***	-0.007 (-6.75)	***	-0.006 (-4.81)	***
same nationality alumni	-0.012 (-0.51)		-0.008 (-0.51)		0.028 (0.89)	
same nationality alumni squared	0.0001 (0.27)		0.0001 (0.34)		0.0002 (0.43)	
same nationality residents	-0.003 (-0.66)		0.006 (1.40)		0.001 (0.21)	
same nationality residents squared	0.000006 (0.41)		0.00002 (1.37)		0.000006 (0.27)	
N	1593		3803		1398	
N(Groups)	418		719		506	
Pseudo R^2	0.112		0.130		0.113	
Prob.>Chi^2	0.00		0.00		0.00	
LR Chi^2	99.7		210.4		74.88	

z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5.8 and Table 5.9 present the results from the models run separately for each discipline and each nationality. Although the above models showed significant results for the effects of same nationality students, it is important to examine whether the results hold for different disciplines and nationalities. We see from Table 5.8 that regardless of discipline there is a significant relationship between the probability of attending an institution and the number of students from the applicant's home country. Moreover, with the exception of the field of agriculture the effect is non-linear, as was found when all disciplines were grouped together. We find little evidence that alumni matter.

Table 5.8: Conditional Logit Model Coefficient Estimates for S&E Fields

	same nationality student		same nationality student squared		same nationality alumni		same nationality alumni squared	
	coefficient	**p>z**	**coefficient**	**p>z**	**coefficient**	**p>z**	**coefficient**	**p>z**
	0.677		-0.045		-0.328		0.007	
Agriculture	(1.96)	*	(-1.62)		(-1.77)	*	(1.10)	
	0.331		-0.005		0.047		-0.001	
Biology	(3.85)	***	(-3.08)	***	(0.92)		(-0.98)	
	0.716		-0.026		0.017		-0.0003	
Chemical Engineering	(4.54)	***	(-3.65)	***	(0.26)		(-0.18)	
	0.449		-0.011		0.053		-0.001	
Chemistry	(3.39)	***	(-2.33)	***	(0.63)		(-0.31)	
	0.783		-0.035		0.176		-0.011	
Civil Engineering	(4.38)	***	(-3.64)	***	(1.30)		(-1.49)	
	0.462		-0.024		0.007		-0.001	
Computer Science	(3.22)	***	(-2.66)	***	(0.09)		(-0.41)	
	0.247		-0.004		-0.002		-0.00002	
Electrical Engineering	(5.41	***	(-4.11)	***	(-0.11)		(-0.06)	
	0.498		-0.021		-0.021		-0.0003	
Mathematics	(3.23)	***	(-267)	***	(-0.35)		(-0.27)	
	0.379		-0.008		0.002		-0.00005	
Mechanical Engineering	(4.72)	***	(-2.96)	***	(0.05)		(-0.09)	
	1.032		-0.065		0.016		-0.0004	
Physics	(2.65)	***	(-1.82)	*	(0.19)		(-0.25)	

The results of Table 5.10 suggest that Chinese, Indian, Korean and Turkish students all have a higher probability of attending institution where they have fellow citizens. In all instances the variable measuring same nationality students is significant at the one percent level as is in the square of the variable. The alumni effect is significant in the Turkish equation, but inconsistent with what we hypothesized and what we learned from the Turkish doctoral students at Georgia Tech. Therefore, the findings about the role of alumni from Georgia Tech could neither be generalized to a larger set of institutions, nor to other nationalities in this study.

Table 5.9: Conditional Logit Model Coefficient Estimates for Four Nationalities

	Chinese		**Korean**		**Indian**		**Turkish**	
	Coeff.	**p>z**	**coeff.**	**p>z**	**Coeff.**	**p>z**	**coeff.**	**p>z**
	0.274		0.391		0.443		1.298	
same nationality student	(8.50)	***	(7.03)	***	(5.38)	***	(4.50)	***
	-0.005		-0.014		-0.015		-0.091	
same nationality student squared	(-6.41)	***	(-5.13)	***	(-3.37)	***	(-2.87)	***
	-0.002		-0.002		0.011		-0.272	
same nationality alumni	(-0.10)		(-0.13)		(0.48)		(-1.84)	*
	0.0009		0.0002		0.0003		0.017	
same nationality alum squared	(0.22)		(0.57)		(0.52)		(1.74)	*
	-0.002		0.012		0.003		0.969	
same nationality residents	(-0.46)		(1.21)		(0.31)		(1.35)	
	0.000001		0.00007		0.000009		-0.144	
same nationality residents squared	(0.14)		(1.31)		(0.19)		(-1.22)	
N	4239		1836		2403		674	
N(Groups)	623		143		117		56	
Pseudo R^2	0.075		0.146		0.107		0.253	
Prob.>Chi^2	0.00		0.00		0.00		0.00	
LR Chi^2	158		205.1		108.6		68.03	
z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1								

The final network variable, the number of faculty from the same country of origin in a department, is examined for a limited set of institutions for which we could obtain appropriate data. In Table 5.10 we see that the effect of the faculty variable varies

by nationality. It is significant for Chinese and Korean students, but insignificant for Indian and Turkish. In this sub-sample, the effect of same nationality students is only significant for the Turkish students, but not significant for other nationalities. One possible explanation could be multicollinearity, but the correlation coefficient between the same nationality faculty and same nationality students for each nationality varies only between 0.10 and 0.25. Another explanation could be inclusion of institutions that are highly populated with Chinese, Korean, and Indian students. Due to the non-linear relationship (increasing at a decreasing rate) the effect of same nationality students found in the previous models could be masked when the non-linear term is excluded from the model as it was in this estimation. This suggests that in the future we should re-estimate the model and include the squared terms.

The web study suggested there is a strong association between Turkish students and Turkish faculty members, but that result is not supported in this model. When the results from this conditional logit model and the results from the web study are examined together, one possible conclusion to draw is that foreign faculty members have a stronger influence in determining the labs that the foreign students are assigned to, than in determining the institution they are likely to attend.

Table 5.10: Conditional Logit Model Coefficient Estimates with Faculty Data by Nationality

	Chinese		Indian		Korean		Turkish	
	coefficient	**p>z**	**coefficient**	**p>z**	**coefficient**	**p>z**	**coefficient**	**p>z**
	-0.034		0.056		-0.210		0.640	
same nationality student	(-0.69)		(0.33)		(-1.53)		(2.45)	**
	0.055		-0.075		-0.052		-0.615	
same nationality alumni	(2.87)	***	(-1.38)		(-1.35)		(-1.41)	
	0.085		0.020		0.202		0.309	
Same nationality faculty	(3.63)	***	(0.63)		(3.21)	***	(1.26)	
N	4239		1836		2403		675	
N(Groups)	623		143		117		57	
Pseudo R^2	0.047		0.081		0.182		0.234	
Prob.>Chi^2	0.00		0.00		0.00		0.00	
LR Chi^2	41.54		36.55		102.70		38.55	

z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1

Conclusion

The model developed and tested here significantly contributes to studies of foreign student movements, which, to date, comprise mostly anecdotal evidence, and builds on previous studies concerning school choice and international migration. As argued earlier, neither school choice models nor international migration models are completely appropriate in explaining international doctoral student's choice of graduate institution. While school choice studies provide ample evidence concerning factors influencing school choice behavior, the effects of networks are not included in these studies since the majority of these studies model the behavior of domestic students and only a few are tailored for doctoral students. Therefore, the existing school choice models cannot be replicated for foreign students since it could lead to the omission of a highly important factor in foreign student decision process –networks.

International migration studies, on the other hand, do address the very important role of networks in location selection. However, these studies primarily model the behavior of low-skilled immigrants. There is no doubt that low-skilled immigrants and foreign doctoral students share some common motivations in choosing locations. Both groups depend on networks for physical and psychosocial support. However, the results of this study suggest that in the case of foreign students characteristics of the institution rather than the location (MSA) take a primary role.

The conditional logit model provides some important evidence regarding the role of networks. In all of the models, we find a strong and significant relationship between the number of existing students from the country of origin at an institution and the probability of attending that institution for potential applicants from the same country of origin. The relationship is non-linear, increasing at a decreasing rate. We also find in some of the models evidence that the alumni and faculty from the same country of origin also play a role in student choice.

These results advance the findings from the web study by testing some of the network hypotheses on a larger scale. The web study provided evidence for a strong relationship between the lab director's origin and the composition of that lab. Although we find evidence that faculty also play a role in foreign students' institution selection, the finding does not hold across all models. This suggests that faculty do not play as important a role at the department level in admitting PhD students as they play in staffing their labs.

These results also provide empirical support for the findings from the focus group interviews regarding the importance of students from the home country in selection. While the qualitative findings from those interviews played an important role in the formulation of network hypothesis, the interviews were limited to one institution and one nationality. This study provides convincing results that would suggest the generalizability of some of those finding.

In sum, we can confidently state that foreign doctoral student movements are not free of network influence. The 'affinity effect' plays an important role in a foreign student's institution selection. In evaluating the role of networks, it is important to note that the study suffers from being unable to include unmeasurable variables that are related to students' attitudes towards networks. Consequently, the results may be biased. For example, students who place a higher value on networks will be more likely to cluster at institutions populated by other students from their culture than do students who place a lower value on networks. Because the unobserved taste variable is correlated with the network measure the results may overstate the importance of networks.

These findings can assist policy formulations in higher education various ways. First, this study provides insight about the possible 'mismatch' effect that could occur in foreign student admission. The strong network effect found in this study suggests that support provided by compatriots is highly important for foreign doctoral students' institution choice. Therefore foreign doctoral students could be attending institutions not because these institutions perfectly match their qualifications, but because they provide them with the highest psychosocial support. Second, the strong network effect found

raises the issue of the degree of integration of foreign doctoral students at an institution. Clearly, foreign students cluster in certain institutions. How well these students are able to integrate into the academic community is yet to be determined and is a subject for further research. Finally, the findings suggest that foreign born faculty play a role in generating new enrollments from their home country as well as in staffing labs, as the web study suggests. These findings will be discussed in more detail in the final chapter.

CHAPTER 6

CONCLUSION

Purdue University is well known for its large Chinese student population; Pennsylvania State University for its Indian student population. Traditional models of student choice would predict similar patterns of foreign students at institutions that are similarly ranked, provide similar types of financial support, are located within the same region and offer similar programs of study. But these predictions can be wrong because they fail to capture the effects of networks on the clustering of foreign students in PhD programs.

The primary contribution of this study is to introduce and test the role that networks play in the selection of doctoral institutions by foreign students. Although this approach is new to scholars estimating school choice, it is well known to those studying patterns of international migration as well as to foreign students themselves. By focusing on networks, this study shifts the focus from the institution side of selection to the student side of selection. Two components of the study place the foreign students in the center of the analysis: The focus group interviews investigate the students' motivations; the random utility models test the determinants of the student's choices.

The introduction of networks to school choice models stems from international migration studies emphasizing the importance of networks in any form of migration. In addition, there is strong anecdotal evidence related to foreign student concentrations, such as research labs populated by Indian students, or large populations of Korean students at certain institutions. But this is the first study to empirically test the impact of networks on choice.

It is important to note that this study focuses exclusively on disciplines in S&E. Because of some special characteristics of S&E disciplines it is difficult to generalize to all other fields. For example, smaller research units in S&E departments, such as research laboratories or research institutes, enjoy a high degree of autonomy with separate funding and special guidelines and consequently networks could play a more important role in the staffing of labs than in the staffing of research assistantships in disciplines such as sociology or economics. Also, in most S&E disciplines faculty and students work closely together on projects making the relationship between the faculty and the students especially important. Therefore, the role affinity plays in institution selection could be different in other fields than in S&E fields.

Four network types that can serve as forces in drawing students towards institutions are discussed and investigated in this study: Students, alumni, faculty and local residents. Each is discussed below.

Students

Every participant in the focus group interviews explained particular ways that Turkish students at the Georgia Institute of Technology helped during the application process and the initial days or months after enrolling in their graduate program. In some instances, these students were the primary reason for selecting the Georgia Institute of Technology; in other instances, they played an intermediary role in providing important information, such as the availability of positions in labs, or other resources. Students from the same country of origin also mattered in many other social and economic areas. Fellow Turkish students provided the newcomers with an instant social group with which to spend time and participate in various activities, from studying together to

finding familiar food, or organizing cultural activities. Knowing that the Georgia Institute of Technology has an established community of compatriots significantly narrowed the list of institutions to be considered for the Turkish applicants.

The web study of research labs supported these findings by providing evidence that the percentage Turkish, Indian, Chinese and Korean students were more concentrated in labs directed by a faculty from their country of origin compared to labs directed by native (U.S. origin) faculty. The role faculty play in staffing labs will be further discussed below, but it is also important to emphasize the inevitable advantages of this arrangement for students –especially for S&E students. As one would expect, S&E disciplines do not rely on linguistic skills as much as do the social sciences. Therefore, especially in these areas, foreign doctoral students do not necessarily have a good command of English. Working in a research lab that is populated with compatriots can increase the comfort level of foreign students and make information exchange within the lab much easier.

The random utility models provide the strongest evidence concerning the role that students from the same country of origin play in selecting institutions. The effect of existing students is found to be consistently strong and significant across most models. The results also suggest that the effects increase at a decreasing rate, and at some critical mass, begin to dissipate.

Alumni

Participants in the focus group interviews explained the role alumni played connecting the applicant with the students and faculty at the Georgia Institute of Technology. In some cases, the alumni who returned to their country of origin became

the resource for potential applicants, and inspired them to apply to Georgia Tech. In other cases, alumni acted more directly and introduced the applicants to their former professors at Georgia Teach. In both cases, the role of alumni is limited to establishing the connection and providing a reference for the applicant. Perhaps because of this, the random utility models did not provide strong evidence that alumni from the same country of origin have a strong influence on the probability of selecting an institution.

Faculty

The idea that foreign-born faculty could play an important role in institution selection was initially explored during focus group interviews. The participants in these interviews stated unanticipated ways that the Turkish professors at Georgia Tech were influential in their decision process. Some of them were graduates of the applicant's undergraduate institution, and had close contacts with their colleagues at these institutions. They corresponded with students who were referred to them by their colleagues in Turkey; some even interviewed applicants during their yearly visits to Turkey. In some cases, Turkish applicants directly contacted Turkish professors at Georgia Tech without having any former connection. Even when the professors could not directly help the applicant, they introduced the students to other faculty members at Georgia Tech who they thought would be able to help.

In our analysis of science and engineering research labs, we find strong evidence, as noted above, that labs that are directed by foreign-born faculty are more populated by students from the same country of origin than are labs that are directed by native faculty. The results emphasize the importance of foreign-born faculty as active nodes of ethnic networks. They play an effective role in mobilizing foreign students

from their country of origin. In this study, we see lab directors as a type of immigrant entrepreneur who are active in building ties in their home countries which contribute to opening new channels for collaborations and attracting new resources for U.S. academia.

The results from the RUMs advance the findings from the web study by testing some of the network hypotheses on a larger scale. Although we find evidence that faculty also play a role in foreign students' institution selection, the finding does not hold across all ethnic groups. We suspect that this is because faculty members do not play as important a role at the department level as they play in determining the composition of their labs.

Local residents

Ethnic local communities in a foreign land provide everything familiar to immigrant populations. In fact, the largest ethnic communities in the U.S. are able to replicate home country living, creating neighborhoods where immigrants can find everything from authentic food to daycare in their native language. These established communities attract future immigrants and make moving to another country considerably easier. Although foreign graduate students could definitely benefit from these facilities, our findings suggest that for foreign doctoral students the ethnic student community in an institution has a higher impact on their decision to choose a location than does the ethnic local community. In RUMs, we did not find any evidence that larger ethnic communities influence institution choice. In fact, in one of the models we found significant evidence for just the opposite.

Policy Implications

The primary finding of this study, that networks are influential in foreign student's choice, signals a highly important issue: Networks could be a compensating mechanism for policies and programs that are not in place. Policy issues that are relevant to this idea will be discussed under the light of our findings.

Integration of foreign students

Most institutions in the U.S. have international student offices offering several orientation programs, and some even provide English-language courses or teaching assistant training. However, students cannot solely depend on these offices to 'find their way' in this new foreign land. These offices are a part of the system that is unknown to students. Hence newcomers can find established foreign students helpful in 'interpreting' the services that these offices provide. In other words, even the office that is aimed to be closest to the foreign students can be considered to be at arm's length. As a result, having students of the same nationality at an institution can be an indispensable resource for incoming students. This suggests that one possible way to improve international student offices would be to establish close relationships with each foreign student association, not only to enhance cultural dialogue, but also to learn the informal mechanisms that connect these students to their new institution.

A recent report on foreign graduate students in the U.S. suggests "the ability of the United States to continue to attract the best students will increasingly depend on its pull factors, including quality, job opportunities, convenience, and perception of being a welcoming place" (The National Academies, 2005). Policy measures to manipulate the first three pull factors –quality, job opportunities and convenience– are better known

compared to the last one –perception of becoming a welcoming place. Our results suggest that foreign students look for same nationality student 'niches' to make them feel comfortable and welcome, suggesting that there is room for improved policies to integrate foreign students into the general student body.

Institutional Mismatch

The advantages of having a social network at the institution attended are discussed throughout the chapters of this study. It is striking that our research suggests that this effect could be strong enough to attract students to institutions which are not necessarily the perfect match for them in terms of their academic abilities and experiences. This is clearly an inefficiency issue both for the institutions –receiving and sending– and the individuals. Elite institutions, for example, could be sharing their source of potential highly talented foreign students with lower ranked institutions where students find higher amounts of support.

Access to Information

Foreign student networks account for a significant amount of information exchange between U.S. and source countries related to graduate education. The reliance on social networks to gather information about U.S. institutions is well documented in this study. Our focus groups also suggest that foreign students are a source of information for faculty members at U.S. institutions who tap into the existing foreign student networks to learn about source countries and potential students. Also, the experience of faculty and administration with foreign students becomes the source of information for future applicants.

Unless new mechanisms –such as intermediary institutions between the source countries and the U.S. – become available, foreign student networks will continue to serve as an important source of information for both the potential students and the departments. Therefore, policies trying to improve information exchange between foreign academic institutions and U.S. institutions should consider the role of foreign student networks and learn from them.

Cumulative Effects of Foreign Students on Future Enrollments

As discussed in Chapter 2, there are a number of ways foreign student inflows are influenced. For example, foreign student enrollments respond to change in funding levels as well as to changes in visa regulations. Experiences post September 11 provide an example of this, with an initial decrease in foreign student enrollments after tighter visa enforcement followed by an upswing due to relaxation of some of these visa regulations.

Our research suggests that there may be other means of increasing foreign student enrollments. Although we realize our findings are only at the micro level – concerning the effect of foreign student concentrations at the institution level on student choice– the cumulative effect of these concentrations could create an effect at the macro level. That is, dramatic declines or increases in the concentration of foreign students in the U.S. could affect future enrollments. This is not only because networks play a role in attracting new students to an institution, but also in keeping students at an institution.

New Sources of Social Capital

Social network theories identify access to social capital as one of the consequences of established networks. Connections to the networks from the most critical nodes generate a flow of new social capital into the system. Our research suggests paying closer attention to foreign-born faculty members and their ability to generate new flows of students into the U.S. Today, foreign-born faculty members are as successful as their native colleagues in receiving grants and initiating research laboratories. Our research also suggests that they are also critical actors in minting talent from their home countries, as they are naturally more familiar with these countries in every aspect compared to their native colleagues. Thus, foreign-born faculty not only generate new resources, but also pave the way between their home country and the U.S. Therefore, policies affecting the ease with which foreign born faculty move between the U.S. and their home country could affect the flow of future talent.

Staying in the U.S.

The desire of foreign students to stay in the U.S. is well documented and the education and training provided by U.S. institutions enables foreign students to find high quality research opportunities and compete for these positions. However, foreign students do not easily transition into the U.S. S&E workforce, partly because they are excluded from defense related research that is only open to domestic researchers, and partly because they are discouraged by difficulties in obtaining a work permit.

What we found in this study draws attention to another condition that is related to staying in the country after graduation. As discussed earlier, the dependence on compatriots among doctoral students is found to be significant and strong in choosing

the institution to study. Other findings from the focus groups also suggest that this dependence does not cease during their education and in some cases, even at the time of graduation. Recall that, some participants stated that they sought help from Turkish faculty in different institutions, or other compatriots working in industry to find jobs. Unless programs that would reverse this dependency are in place, it is likely that foreign born students may remain contained in their ethnic niches even when they are very close to graduation. Therefore, new mechanisms to integrate foreign doctoral recipients into the S&E workforce could introduce foreign doctoral recipients to new channels of contacts other then their ethnic networks, which in turn could improve job search and increase the potential to stay in the country.

Future Studies

Revealing the effects of networks is only one of the steps taken to understand and discuss the issues related to foreign studies. The findings from this study could generate a series of new studies. Our suggestions are discussed below.

Updates and Expansion of the Data

All three studies suffered from limitations due to data availability and budget restrictions. The focus group interviews, for example, included Turkish students at the Georgia Institute of Technology. Although both the institution and the Turkish student population are appropriate for our research purposes, expanding this study to include other institutions and other nationalities would be beneficial but would require a travel budget and translation costs. Future studies with larger budgets could include interviews with students from other countries across the nation to obtain more comprehensive qualitative data on the determinants of institution selection. Also, interviews with

foreign faculty could provide very useful information in understanding ethnic networks and the role faculty play in these networks.

The web study of research labs, as discussed before, are restricted to the availability of web pages. Although it is not unreasonable to assume that most laboratories have a web page, once an official inventory of research labs becomes available the study should be replicated. In addition, the study could be expanded to include post-doctoral fellows as well as the students in these labs, as we have found indication from our focus group interviews that similar network effects could be influential in the allocation of post-doctoral fellows as well. Lastly, although we are confident that our name identification process is a strong methodology and is used in similar research, when available, data sources, including self identified nationalities of individuals, should be drawn on in replicating this analysis.

Two major updates to the data used in the RUMs would significantly improve this study: Using more recent years of the SED data and the updated roster of S&E faculty in the U.S. which should become available when the new NRC evaluation of PhD programs is released. These changes would not only provide more up-to-date results about the current situation in the U.S., but also would enable us to examine changes in network effects post September 11.

Role of Established Ethnic Networks

In addition to student networks, the U.S. is a venue for many other established ethnic networks, such as labor associations (e.g. the Association of Indian Electrical Engineers) as well as religious and ideological organizations. Although it might be difficult to obtain data from these organizations, studying the possible intermediary role

they play in the allocation of the scientific labor force would add to the network analyses performed in this study.

Relations between Institutions

Some of our findings indicate that valuable information could be obtained from studying the relationship between the institutions in sending countries and the institutions in the U.S. We found, for example, that the majority of our Korean students in the RUMs, as well as the Korean-born lab directors included in the web study, came from the Seoul National University. Further studies could examine the role 'critical' institutions play in the top sending countries.

Spatial Analysis for Foreign Student Populations

Finally, a longitudinal study could address changes in the population concentration of foreign students, utilizing Geographical Information Systems (GIS). GIS enables one to analyze changes in foreign students populations due to different factors, each presented in separate layers. Also, a similar spatial analysis could address the effects of networks on doctoral recipients' selection of location for work. The results from the two studies could be compared in order to examine how network effects differ in the two activities.

APPENDIX A.1

SOLICITATION E-MAIL

Dear Friends,
My name is Zeynep Esra Tanyildiz. I am a doctoral student at the joint Public Policy Doctoral Program at Georgia State University and Georgia Institute of Technology. Currently, I am working on my dissertation which is on the effects of networks on the institution selection of foreign doctoral students. I would like to conduct a series of focus group interviews with Turkish science and engineering doctoral students as a part of my analyses. You'll be asked to discuss how your networks (friends, family, faculty, etc.) influenced your decision to select this program. The interviews will take place on campus during Spring 2007. We'll need one hour of your time and at the end of the interviews each of you will be eligible to win a silver iPod Nano. Please let me know if you'd be interested. I'll schedule the meeting days upon your responses to this e-mail. I highly appreciate your help.
Sincerely,
Esra

APPENDIX A.2

CONSENT FORM

Georgia State University
Department of Public Administration and Urban Studies
Informed Consent

Title: The effects of networks on institution selection by foreign doctoral students in the US.

Principal Investigator: Dr. Gregory B. Lewis
Student Principal Investigator: Zeynep Esra Tanyildiz

You are invited to participate in a research study. The purpose of the study is to investigate the effects of networks on institution selection by foreign (Turkish for this section of the study) doctoral students. You are invited to participate because you are one of the Turkish doctoral students who have been admitted to Georgia Institute of Technology or Georgia State University. You will be interviewed in a group with other students. A total of 3 groups, with 16 total participants are recruited for this study. Participation will require one hour of your time.

If you decide to participate, you will discuss your application experience and the of role friends, family, professors who are also from Turkey during the application and/or institution selection process. The interviews will be take place on Georgia Tech campus.

In this study, you will not have any more risks than you would in a normal day of life.

Participation in this study may not benefit you personally. Overall, we have to gain information about network effects in institution selection. At the end of your participation, you'll be eligible to win an iPod Nano.

Participation in research is voluntary. You have the right not to be in this study. If you decide to be in the study and change your mind, you have the right to drop out at any time. You may skip questions or stop participating at any time. Whatever you decide, you will not lose any benefits to which you are otherwise entitled.

We will keep your records private to the extent allowed by law. We will use a study number rather than your name on study records. The study will be audio taped and the audiotape files will be uploaded to a computer. The data will be stored at password and firewall protected computers. The audio tapes will not be destroyed, and might be used for future studies. Only Dr. Gregory B. Lewis and Zeynep Esra Tanyildiz will have access to the information you provide. Your name and other facts that might point to you will not appear when we present this study or publish its results. The findings will be summarized and reported in group form. Members of the focus group will be reminded not to repeat anything said during the focus group session and not to identify participants. However, we cannot guarantee that any statements you make during the focus group will remain confidential.

Call Zeynep Esra Tanyildiz at 404 643 9775, esra@gsu.edu, or Dr. Gregory B. Lewis at 404 651 4443, glewis@gsu.edu, if you have questions or concerns about this study. If you have questions or concerns about your rights as a participant in this research study, you may contact Susan Vogtner in the Office of Research Integrity at 404-463-0674 or svogtner1@gsu.edu.
We will give you a copy of this consent form to keep.
If you are willing to volunteer for this research, please sign below.

_____	_____
Participant	Date
_____	_____
Principal Investigator or Researcher Obtaining Consent	Date

APPENDIX B.1

INSTIRUIONS INCLUDED IN THE CHOICE SETS

California Institute Technology
Carnegie Mellon University
Columbia University
Cornell University
Georgia Institute of Technology
Iowa State University
Massachusetts Inst of Technology
Michigan State University
North Carolina State University-Raleigh
Northwestern University
Ohio State University
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Rice University
Rutgers University
Stanford University
State University of New York-Stony Brook
State University of New York-Buffalo
Texas A&M University
The Pennsylvania State University
University of Illinois-Urbana-Champaign
University of Massachusetts-Amherst
University of California-Los Angeles
University of California-Santa Barbara
University of California-Berkeley
University of California-Davis
University of Delaware
University of Florida
University of Illinois-Chicago
University of Iowa
University of Maryland
University of Michigan-Ann Arbor
University of Minnesota-Twin Cities
University of Missouri-Columbia
University of Southern California
University of Texas-Austin
University of Washington
University of Wisconsin-Madison
Virginia Polytech Institute & State University
Wayne State University

Source: The Survey of Earned Doctorates, 1996-1997

APPENDIX B.2

TOP INSTITUIONS WITH THE LARGEST POULATIONS (6 OR MORE) OF CHINESE, INDIAN, KOREAN AND TURKISH STUDENTS

Chinese
Purdue University/IN
Iowa State University
University of Maryland
University of Minnesota-Twin Cit.
University of California-Berkeley
U of Illinois-Urbana-Champaign
University of Texas-Austin
North Carolina State U-Raleigh
Ohio State University
Texas A&M University

Indian
University of Illinois-Urbana-Champaign
Georgia Institute of Technology
University of Michigan-Ann Arbor
University of Maryland
University of Minnesota-Twin Cit.
Purdue University/IN
University of Texas-Austin
North Carolina State U-Raleigh
Texas A&M University
The Pennsylvania State University

Korean
Texas A&M University
University of Michigan-Ann Arbor
University of Texas-Austin
University of California-Berkeley
Stanford University/CA
Georgia Institute of Technology
University of Washington
Univ of California-Los Angeles
U of Illinois-Urbana-Champaign
University of Minnesota-Twin Cities

Turkish
Cornell University/NY
Purdue University/IN
Ohio State University
North Carolina State U-Raleigh
U of Massachusetts-Amherst
Texas A&M University
University of Florida

Source: The Survey of Earned Doctorates, 1996-1997

APPENDIX B.3

TOP CHINESE, INDIAN, KOREAN AND TURKISH INSTITUIONS

SENDING SIX OR MORE STUDENTS

China
Beijing University.
China University of Science and Technology
Fudan University
Zhejiang University
Nankai University
Nanjing University
Wuhan University
Beijing Medical University
Beijing Normal University

India
Indian Inst. of Technology (IIT) – Bombay
Indian Inst. of Technology (IIT) – Madras
Indian Inst. of Technology (IIT) - Kharagpur
University of Bombay
Indian Inst. of Technology (IIT) – Kanpur
Jadavpur University
Indian Inst. of Technology (IIT) - Delhi
University of Calcutta
University of Madras

Korea
Seoul National University
Yonsei University
Hanyang University
Korea University
Kyungpuk National University
Korea Adv. Inst. of S&T, KAIST
Inha University
Sung Kyun Kwan University
Ehwa Women's University
Pusan National University

Turkey
Middle East Technical University
Istanbul Technical University
Bosphorus University

Source: The Survey of Earned Doctorates, 1996-1997

APPENDIX B.4

TOP 10 MSAS FOR CHINESE, INDIAN, KOREAN AND TURKISH POPULATION

Chinese	**Indian**
New York, NY	New York, NY
San Francisco, CA	San Francisco, CA
Los Angeles, CA	Chicago, IL
San Francisco, CA	Los Angeles, CA
Oakland, CA	Washington, DC
San Jose, CA	San Jose, CA
Boston, MA	Middlesex, NJ
Washington-Baltimore, DC, MD	Oakland, CA
Honolulu, HI	Philedelphia, PA
Orange County, CA	Houston, TX

Korean	**Turkish**
Los Angeles, CA	New York, NY
New York, NY	Los Angeles, CA
Washington, DC	Washington, DC
San Francisco, CA	Nassau-Suffolk, NJ
Orange County, CA	Bergen-Passaic, NJ
Chicago, IL	San Francisco, CA
Seattle, WA	Chicago, IL
Bergen, NJ	Miami, FL
Philadelphia, PA	Boston, MA
Atlanta, GA	Philedelphia, PA

Source: U.S. Census, 2000.

APPENDIX B.5

CORRELATION COEFFICIENTS OF NETWORK VARIABLES

Korean			
	Students	**Alumni**	**Residents**
Students	1		
Alumni	0.71	1	
Residents	-0.05	-0.11	1

Chinese			
	Students	**Alumni**	**Residents**
Students	1		
Alumni	0.51	1	
Residents	0.02	0.14	1

Indian			
	Students	**Alumni**	**Residents**
Students	1		
Alumni	0.56	1	
Residents	-0.09	-0.03	1

Turkish			
	Students	**Alumni**	**Residents**
Students	1		
Alumni	0.37	1	
Residents	-0.19	-0.07	1

Source: The Survey of Earned Doctorates, 1996-1997

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