

ENVIRONMENTAL AND INSTITUTIONAL FACTORS AND STRATEGIES OF RESPONSE
IN ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENTS AT RESEARCH
AND DOCTORATE UNIVERSITIES IN THE U.S. AND THEIR ASSOCIATION TO
INTERNATIONAL GRADUATE ENROLLMENT

By

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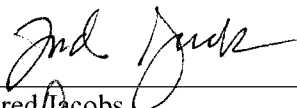
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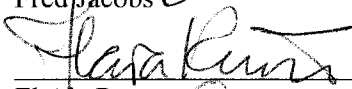
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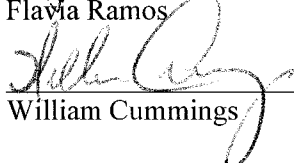
In

Educational Leadership

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ENVIRONMENTAL AND INSTITUTIONAL FACTORS AND STRATEGIES OF
RESPONSE IN ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENTS
AT RESEARCH AND DOCTORATE UNIVERSITIES IN THE U.S. AND THEIR
ASSOCIATION TO FOREIGN GRADUATE ENROLLMENT

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ABSTRACT

The electrical and computer engineering (ECE) academic field is among the top fields in the U.S. that can claim predominance in international graduate student participation. This study hypothesizes that academic ECE departments in the U.S. depend on international graduate enrollment for their operation, and that such departments and their parent institutions have strategies in place to manage the uncertainties of changing enrollment. Thus, it is the percent of international graduate enrollment that is considered as the dependent variable, while environmental factors, institutional characteristics, and response strategies followed by individual institutions and ECE academic programs play the role of independent variables. The objectives are: (1) to explore categories of environmental characteristics related to international graduate enrollment fluctuations in electrical and computer engineering departments from 1982 through 2003; (2) to explore whether and to what extent, institutional characteristics influence the departmental strategies to manage international graduate enrollment. Following regression analysis of

survey results and follow-up phone interviews with administrators and ECE department chairs from selected research universities, some of the findings of the study are:

(1) Growth of graduate enrollment has slowed and the change of the *niche* in the environment of the ECE field-caused by developments in Asian higher education, paradigm shifts in the electrical engineering field, and uncertain future employment estimates-has alarmed ECE chairs and administrators responsible for international student issues in the institutions examined in the study; (2) response to changing enrollment is subject to departmental discretion and is not the outcome of a concerted action among administrative units; (3) the most popular strategies for controlling international graduate ECE enrollment is the collaboration of U.S. ECE departments with specific “feeder” institutions in developing countries.

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CHAPTER 1

INTRODUCTION

They say that if you throw a frog into boiling water, it will jump out. But if you put a frog in cool water and heat it slowly, the frog won't jump out, and you'll get a boiled frog.....Our creeping crisis is not a slow, one-dimensional change like the frog's water temperature... We are facing a number of problems-not just outsourcing/off-shoring-each one like a tile in a mosaic. No problem by itself creates the sort of crisis that provokes action. But if you stand back and look at the whole collection of problems, a disturbing picture emerges-a pattern for preserving the status quo rather than reaching for the best big goal.

Wm Wulf, President of the National Academy of Engineering.
In "A Disturbing Mosaic" *The Bridge Vol. 35 no. 3 (Fall, 2005)*.

In the last three decades, different academic fields and levels of study have experienced "conditions of decline" that required responses from various levels of administrative units (Cameron, 1983). Studies on conditions of decline in higher education have involved domestic traditional groups of students and mostly undergraduate enrollments, but graduate units and non-traditional groups such as international students have been given less attention.

Historically, international graduate participation has dominated research universities in science and engineering disciplines (Altbach, 1998; 2004). Research universities interact with a complex environment that involves changes in state and federal policies, demographics, changes in market demands for individual sectors and in relations with international higher education (Prisco et al., 2002). In most cases of profound social and economic changes at a national and international level, American research universities have shown resilience and adaptability. The element of diversity, the highly decentralized mechanisms of decision-making and the loosely coupled

administrative structure are key features that differentiate the research universities at both institutional and programmatic level in their responses to a changing environment (Schmidtlein & Taylor, 1996; Whetten, 1988; Bess, 1984). In view of the globalization process, values and mechanisms of research universities are challenged, as policy issues related to international relations and commitments gain priority (Vaira, 2004). After World War II, international student enrollment in American research and doctoral universities has been a phenomenon with steady growth (Altbach, 1998).

Students on temporary visa status have contributed substantially to the growth of doctoral programs in the fields of science and engineering. In 1983 the participation of temporary residents was 18 percent and rose to 32 percent in 2003. From 1983 through 2003 the field with the largest participation of international students in doctoral programs was engineering, where temporary residents earned 55 percent of doctorates, particularly in the sub-field of electrical and computer engineering. International enrollment in this field declined by 12 percent in the early 2000s (U.S. Department of Education, 2006; Matthews, 2006).

Kenneth Connor, President in 2006 of the Electrical and Computer Engineering Department Heads Association, highlights the heart of the problem as follows:

We grew with the fortunes of IT ...[and]... now our student numbers are falling. IT jobs are outsourced... [and] ...the media focus on IT outsourcing....[there is] perception among prospective students that IT related jobs are risky.... Our graduates are facing a new workplace (Connor, 2006).

First-time, full-time graduate enrollment in electrical and computer engineering (ECE) dropped from 71 percent to 52 percent between 2000 and 2003, a decline that

started gradually since the late 1990s (U.S. Department of Education, 2006). According to *Engineering Trends*, computer and electrical engineering first-year, full-time enrollments have experienced substantial declines since fall 2001 and 2002, respectively, and full-time enrollment declines are expected to continue. In addition, master's and doctoral full-time enrollments experienced significant decline in the fall 2004 (Engineering Trends, 2006).

Looking back at the overall trends in the international graduate student participation in engineering, since the late 1970s, there is a steady increase that peaked in the late 1970s and 1980s, while it slowed in the mid-1990s. For the sub-field of electrical engineering, the number of earned bachelor's, master's, and doctoral degrees increased between 1983 and 1986. The number of undergraduate degrees fell almost 50 percent between 1987 (n=24,547) and 1999 (n=12,531). In contrast, the number of earned doctorates nearly doubled from 724 in the year 1987 to 1,591 in the year 1996, before falling to 1,303 in year 1999. Master's level earned degrees over this same period remained relatively stable. These trends reversed in the 1999-2000 school year; when by 2002 an approximate 1 percent increase in bachelor degrees occurred along with a 5 percent decrease in master degrees and an 11 percent decline in doctorates (U.S. Department of Education, 2003). During the 1990s, international students earned more than half of the doctorates conferred in mathematics and engineering (NCES, 1997). According to the National Science Foundation, the number of first-time graduates on temporary visas in science and engineering fields dropped by 8 percent for men and 1 percent for women in 2002 (COSEPUP, 2005). In 2003, there were over 383,000 students

in U.S. undergraduate engineering programs, but only 41,009 were awarded graduate degrees, and from those only 5,870 held doctorates (AAES, 2005). For some engineering programs, where 80 percent of the student body consists of Chinese and Indian graduates, first-year graduate student enrollments for the year 2004 were down by 25 percent (Wilson, 2004).

Policy makers and academic leadership in the engineering discipline have underscored that the U.S. needs to maintain a competitive research environment in order to maintain its leading status in technology related fields. Science and technology fields require special preparation that begins at the early middle school years, but a large pool of perspective science and engineering graduates do not receive adequate preparation in math and science while in secondary education. In addition, efforts to instill aspirations for advanced studies or research-oriented careers in technology among minority students are undermined by the nexus of difficulties to reassure equal education opportunities from K-12 (Maddox & Maddox, 1990). The ideological imperatives of multiculturalism drove several policy implementations in research universities favoring the recruitment of minority students in graduate programs of science and engineering fields during the 1990s. However, these policies “had been frustrated to some extent by limited pools of qualified applicants” (Geiger, 1993, p. 328). Given the conditions of decline in U.S. enrollment at the graduate and especially doctoral ECE programs, the support of international students is deemed compelling for the maintenance of a competitive research environment. Many factors in the environment of graduate programs have affected the flow of international graduates in numbers and percentages. National policies related to visa restrictions have discouraged many international graduates from applying

in U.S. research institutions. Delays involving certain types of visas requested for certain nationalities and for certain fields of study also affect graduate international enrollments. Improvements in the higher education of developing countries have also contributed to decrease in the number and percentages of international students from selected countries for technology and science fields (COSEPUP, 2005; Holden, 1993).

Administrators and academics do not address changes in the international student enrollments with equal interest. In a broader sense, there is reason for a deeper examination of international participation in graduate programs, given the strong element of diversity that characterizes American higher education. For instance, selected departments in the engineering discipline allegedly admit students from abroad “only to maintain a rationale for the continued existence of a department, and to provide a basis for seeking research funds to keep the faculty of that department engaged in funded research ” (Skolnikoff, 1993, p. 247; Deutch, 1991). Some have the quality ranking and reputation that allow them to be more selective, whereas others cannot afford to support international graduates, who normally enjoy full financial support through teaching and research assistantships, as is the case in science and engineering disciplines (Choy & Geis, 2003). Christopher Connell (2006) at NAFSA emphasizes that cases of successful international graduate enrollment management in engineering disciplines among American institutions are the outcome of multiple factors, and, in particular, the product of cooperation among administrators and faculty within an institution. Individual departments enjoy a supportive environment, where the state enhances international commercial activity, encourages student participation in foreign exchange programs, and welcomes international students to complete internships with the local corporate

environment. One of these cases is Purdue University, ranked at the 3rd place among public universities for international enrollment in 2005. Distinct features of the success story of Purdue and its relations with international graduate enrollments include professors with international reputation, generous funding of recruiting activities, top-down leadership activities and concerted actions among administrative units in support of international presence (Connell, 2006).

In general, colleges and universities in the U.S. have strategies for monitoring and controlling undergraduate student enrollment, but less is known about the mechanisms of response to changes in graduate student enrollment (Hossler, 1987). Recruitment is a strategy particularly popular among institutions interested in maintaining graduate enrollments. Some departments have more sophisticated recruiting programs than others. This can be attributed to lack of money or knowledge, but also to the culture of the department that may dislike methods related to marketing and recruitment or to reluctance to establish any concrete set of strategies related to international students (Malaney, 1987).

Recent restrictions due to security issues are allegedly associated with the drop in the number of student visas from 560,000 in 2001 to 474,000 in 2003 (Fortescue & Newland, 2004). In the meantime, other countries, competitors to the U.S., experience increases in international enrollments. A recent study of the American Council on Education shows that from 1999-2000 to 2004-2005 the U.S. experienced only a 17 percent increase of international student enrollment, as opposed to Britain with 29 percent, Australia with 42 percent, Germany 46 percent, France 81 percent, and Japan 108 percent (Woo, 2006). It is not known, however, the percentage of graduate

enrollments that accounts for these numbers, in order to conclude on the actual losses of the U.S. in graduate students.

In response to the negative implications that recent government policies have had on the pool of applicants and subsequently on enrollment, graduate schools have followed various strategies. In 2004 the Council of Graduate Schools (CGS) conducted a three-part study of international graduate admissions. Seventy-five percent of responding graduate schools reported that some steps they have taken included establishing call centers, improving on-line information and web-based applications, and issuing notifications of admissions decisions more quickly. Over 60 percent also reported having international exchange partnerships (Brown, 2005). As these strategies are not universal among graduate academic programs, it is difficult to identify their effectiveness on international graduate enrollment. This information, although offering a significant basis for further research, does not provide information on the specific conditions individual academic fields and departments encounter that may determine their willingness and ability to respond to international enrollment changes.

Organization of the study

Chapter 1 introduces the topic, presents the statement of the problem, the research questions, the hypotheses, the significance of the study, the limitations and the definition of key terms. Chapter 2 provides the theoretical basis of the study, what we know about the mechanisms that support international study in the U.S. the last 25 years, and the most related studies on enrollment decline determined by the environment of the academic organizations. The chapter includes sections pertinent to the environment of the field of

electrical and computer engineering, such as its evolution, the funding, and information on the international engineering education in two developing countries that have historically sent the largest numbers of graduates into the ECE departments, China and India. Chapter 3 outlines the methodology and variables. Chapter 4 presents the results and analysis of quantitative and qualitative data, as well as the results of follow-up telephone interviews. Chapter 5 discusses the main findings, concluding with recommendations for further study.

Statement of the problem

During the last twenty-two year period from 1982 to 2003, three out of four international graduate electrical engineering students on temporary visa status were concentrated in 62 Research I and II, Doctorate I and II institutions; 16 private and 46 public. Graduate enrollment in electrical engineering presented an upward trend from 1982 through 1993, followed by a steep decline up to 1999, and has leveled off since (NSF, 1999, 2005). Whereas the majority of the institutions experienced stable or steadily increasing international enrollment trends, some institutions presented distinct periods of international enrollment fluctuations, primarily during the 1990s and beginning of 2000s. It is not clear whether and how these enrollment fluctuations have affected individual academic programs. There is also limited information on the approaches ECE graduate programs followed, in anticipation of these changes.

This study intends to clarify and better understand the type of approaches taken by ECE academic programs in response to declines in their international student enrollment.

Hypotheses

The central hypothesis of this study is that graduate electrical and computer engineering departments depend on international enrollments for continuation of their funding and research. Thus, the dependent variable considered for this study is the percent of international graduate enrollment, whereas various strategies followed by individual institutions and ECE academic programs constitute the set of independent variables. Taking into consideration the compelling diversity of American higher education, it is hypothesized that the institutional and departmental response strategies are determined by: (1) perceptions of administrators and ECE department chairs as to what the environmental and demographic changes in the field are; (2) factors in the environment of the ECE programs; (3) selected institutional characteristics such as the program quality ranking, the total of R&D expenditures per ECE program, and the size of the department measured by the total of graduate enrollment for a 22-year period (1982-2003).

Research Questions

- What policies and circumstances are associated with changes in international ECE graduate enrollment in selected public and private institutions?
- What national and state factors have affected institutional responses regarding international students and subsequently international graduate ECE enrollment decreases?
- What institutional factors are associated with changes in international graduate enrollment in ECE programs?

- What academic department characteristics influence strategies of response to international graduate enrollment decreases in ECE programs?

Significance of the study

There is a compelling need for the maintenance of a competitive engineering graduate student population in the U.S., in response to more rigorous research environments emerging in engineering graduate programs in developing countries. There is limited knowledge of the impact that decreasing international enrollment may have on graduate ECE programs, since, for most of the ECE graduate programs the last two decades, international presence has been considerably larger than native student presence. While literature on enrollment management focuses heavily on domestic undergraduate and graduate student retention and recruitment, it is not sufficiently known how selected academic programs address the international graduate enrollment management. A number of factors may be associated with the changes in international graduate enrollment in the electrical and computer engineering field.

For instance, the improvement of higher education in developing countries may affect the decision-making of potential recruits from overseas, who choose to stay home for graduate study. For the first time in history, the U.S. presents a high-tech trade deficit reported in 2003, which still persists today. Studies have attributed this phenomenon to the high numbers of returnees and the number of highly educated persons in developing countries such as India, China, Israel, South Korea, Taiwan, who remain home to pursue advanced academic work. These observations can be alarming when coupled with the

limited growth of international student population and projections for serious shortage of highly trained U.S. labor in the coming decades (Heenan, 2005).

It is of foremost significance, therefore, to explore the extent that these demographic and economic factors affect graduate enrollments within departments that are particularly tied to the presence of international students, and their subsequent actions taken, if any. Related information is useful to policy makers, who oversee the phenomenon in order to coordinate efforts of support to these institutions, to distinguish factors inherent in individual academic programs that may be related to international enrollment decreases and reconsider policies that may have affected international graduate enrollment. In terms of contribution to theory and practice, this study intends to contribute to the literature on: (1) environment effects on academic programs that experience changes in resources related to their human activity; (2) the institutional response to graduate enrollment fluctuations associated with a changing environment that is subject to major U.S. legislations, changing demographics in S&E graduate education, and dramatic improvements in international graduate education.

Definition of Terms

Response Strategies: The term is used interchangeably with the term *organizational response* and is referred to “any action (whether planned or spontaneous) taken to maintain, improve or rectify a given problem. Refusal to act is also an organizational response” (Shopshire, 1980, p.39). The following conditions underline the survey statements related to strategies that also constitute part of the group of independent variables: (1) flexibility in admissions standards; (2) state policies favoring

international student enrollment; (3) teaching and research assistantships for the completion of academic work; (4) collaboration with currently enrolled international graduates in support of future graduate enrollment; (5) collaboration of ECE departments in the U.S. with departments in other countries with the purpose to recruit new graduates; (6) faculty visits to international countries with the purpose to recruit new graduates; (7) contact with international students who have expressed prior interest in the department; and (8) international graduate participation in publicly or privately funded research.

Environmental Factors : The following statements illustrate conditions that draw upon the literature and constitute the environment directly affecting ECE academic programs in the U.S.; they are the constructs of the survey statements and they operate as independent variables in this study: (1) changes in political systems of sending countries and ethnic composition of international graduates; (2) visa restrictions; (3) other governmental regulations; (4) changes in the curriculum of ECE; (5) employment conditions in technology related fields; (6) funding fluctuations; (7) improvements of higher education in developing countries and international enrollments in the U.S.

Enrollment Decrease: As there are large differences in enrollment among institutions, the percent of decrease is- chosen as a uniform measure of enrollment decrease for the 22-year period (1983-2003). Also, selected institutions do not present steady declines over the 22-year period, but rather show sharp “peaks” and “valleys” in the graphic representation of international graduate enrollments. To account for the non-linear patterns of international enrollment, the criteria for identifying decline are defined by a greater than 20 percent decrease over a minimum of a consecutive three-year period. Studies have operationalized enrollment decline in undergraduate programs as a greater

than 5 percent decrease (Zammuto et al., 1983). In this study, student percentage decline rather than actual number provides a better estimation of impact, as the numbers of international graduates are typically far smaller than the student groups in undergraduate programs. Some institutions in the sample present enrollment decreases during the mid-1990s and beginning of the 2000s.

ECE Academic Programs/Academic Departments: The term defines an administrative unit of the college with a community of scholars; it has relative autonomy and responsibility for instruction and research within a specialized field of knowledge (McHenry, 1977).

Electrical and Computer Engineering (ECE)¹ The field that deals with (1) *solid state electronics* such as silicon semiconductors, which is the basis of most integrated circuits; (2) *electromagnetics*, the foundational science for the cell phones, cable TV, and high speed internet; (3) *Communication and signal processing* that involves the operation of cellular phones, radio and television satellite, the transfer of music and image in digital form; (4) *control systems* such as robots, navigation and landing aircraft systems rely on real-time processing to gather critical information in conditions of “uncertainty”; and (4) *Power engineering*, the domain of power system operation, distribution lines, power generation and transmission (Arizona State University, 2005).

Research I and II and Doctoral I and II institutions: The level of federal funding is the main distinction among 1994 Carnegie Research classification codes. In 1994, the Carnegie Foundation defined Research I and II institutions as being committed to

¹ The guide was obtained from *EE Connections*, (Spring 2005), 2 (3). Electrical Engineering Alumni Newsletter The Arizona State University.

graduate education through the doctorate level, placing high priority on research, and awarding 50 or more doctoral degrees each year. However, Research I institutions receive annually \$40 million or more in federal support, and Research II Institutions receive lesser amounts of annual support between 15.5 and 40 million. As in the case of Research I and II, Carnegie also defined Doctoral I and II institutions as being committed to graduate education through the doctorate. However, the additional stipulation was that Doctoral I institutions award at least 40 doctoral degrees annually in five or more disciplines, and Doctoral II institutions award at least 10 doctoral degrees annually (in three or more disciplines), or 20 or more doctoral degrees in one or more disciplines.

International Graduates: The term defines the group of students who enter the U.S. on temporary-resident status under the F-1 visa category. These students are not eligible for federal loans but they obtain research and teaching assistantships provided to the ECE programs they attend through federal and state funding. This group of students includes masters and doctorates at a full-time status. The majority of international graduate students are registered in full-time status, and they may receive credit towards full-time enrollment status by involvement in teaching and research assistantships. Although the institutions require that international students on temporary visa be enrolled on full-time status, data indicate that the number of part-time international graduate students vary by institution, from very few to as much as one-half in some years. The IPEDS enrollment survey that supports the data used for this study does not differentiate international graduate students by degree level (master or doctoral).

Quality Ranking: The quality ranking is tabulated from the ratings for electrical engineering departments scored by faculty, students and doctorate recipients for all

academic programs in research I and II, doctorate I and II institutions in a large study that evaluated all research-doctorate programs in the U.S. and was conducted by the National Research Council in 1993 (NCR, 1995).

Limitations of the study

As the study will explore only one sub-field of engineering, the findings will have relatively limited applicability beyond electrical engineering. As institutions and graduate programs in the U.S. have different agendas regarding admissions and need of international students, the findings may not be applicable to the broader group of academic ECE programs in the US. Therefore, the findings will improve internal rather than external validity. The study examines only the top quartile of ECE graduate programs in international student concentration, and, consequently, it does not address issues of programs with smaller number of international graduates.

In addition, department reluctance to discuss internal policies for international graduate admissions or recruitment poses a serious obstacle and limitation to data gathering procedures.

Summary

Projections for graduate enrollment in ECE field do not present an upward trend for the U.S. student population, and eventual decreases of graduate enrollment from international student groups may require institutional initiative for the maintenance of robust graduate participation in selected academic programs. Limited information exists on: (a) the reasons selected academic programs and specific fields experience decreases in international graduate enrollment; (b) what strategies, if any, follow in response.

CHAPTER 2

LITERATURE REVIEW

There are few studies examining the issues of the changing environment of higher education and the subsequent institutional responses to current challenges (Schmidtlein & Taylor, 1996). Educational researchers have established that declining enrollment is a major indicator of organizational decline (Kraatz & Zajac, 1996). Based on international enrollment data, there are large differences among academic programs not only in their graduate enrollments, but also in their interaction with their environment. The field of electrical and computer engineering was selected to illustrate how graduate programs interact within their own environment to manage or maintain international enrollment. The present study suggests that there are selected factors that contribute to changes and observed declines in international graduate enrollment in research and doctorate universities in the U.S. These factors are identified, described and elaborated through political, economic and academic aspects pertinent to the ECE field, and they constitute the first set of independent variables of the study. The period addressed includes the years from 1982 through 2003. Strategies followed in higher education in response to international enrollment changes are also discussed, and they are the second set of independent variables. Institutional attributes such as quality ranking, R&D Expenditures for ECE programs and type of governance are also considered for their influence on international graduate enrollment, and they constitute the third set of independent variables. International graduate enrollment, the dependent variable, is a dynamic and

evolving external resource to graduate programs of demographic character (Cameron & Whetten, 1984).

Environment and Organizational Decline

This study draws upon the theories that consider the environment as controller of the resources provided for the growth and survival of an organization, and presents the key aspects of literature that address approaches of management of decline in higher education. Human activity as a resource for an organization is mainly considered through the organizational bargaining power to attract people to the service of the organization (Aldrich, 1979). The theoretical approach that focuses on strategies that organizations follow to manage relations and interdependencies, and the environment, as a provider of resources for which organizations compete, is the basis of the *resource dependence theory* (Aldrich, 1999). Resource dependence theory views the various fluctuations in the factors related to the academic organization environment and the changes in demographics, as conditions that require the organizational response for adaptability and survival (Thompson, 1967, 2003). Thompson (1967), the father of resource dependence approach, differentiates specific task environments as environmental subsets that influence an institution. The major task environments that Thompson distinguishes are *customers* (various groups of students both domestic and international), *suppliers* (undergraduate institutions both international and American), *competitors* (other institutions outside the U.S. competing for graduates and funding), and *regulators* (immigration agencies, public policy makers, state boards of higher education) (Thompson, 1967).

Organizations seek “trained personnel, strategic geographical locations, favorable government regulations and, of course, money” (Aldrich, 1979, p.62). By the same token, ECE graduate units seek highly skilled individuals to undertake graduate study, to support the research operations of the programs, and eventually be employed in the related industries. They would presumably proceed to a range of activities to maintain the flow of these individuals, should declines of enrollment arise.

The *resource* concept entails both the resources in the form of “human activity”(changing) and the resources in the form of money, credits and facilities (stable). The norm is that stable resources would provide a flexibility and security to the organizations against fluctuations in the participation of human activity. Certain types of resources, however, are not transferable to “other tasks or functions” (Hannan & Freeman, 1977, p. 929). It is not clear, therefore, how organizations respond, when decline of human activity hinders capitalization of certain stable resources for the continuation of vital services, e.g. research activity in academic programs. The resource dependence approach emphasizes the option and need of organizations to change and control the environment (Aldrich, 1999).

A distinct component of the resource dependence theory makes reference to the web of relations that the organization develops with other agencies that share the same vested interests, and the strategies the organization adopts for the survival and maintenance of its resources. The model is illustrated in a variety of applications in the corporate sector, and dependence on agents external to the organization is associated with inter-organizational activities such as mergers and joint ventures. Researchers assert that interdependence of agencies--in the present case, institutions, academic programs, federal

agencies, and industrial support sources--is inevitable, given the nature of the capitalist economy (Aldrich, 1999). As dependence between organizations and specific sources of support continues, corresponding administrative positions associated with the management of this dependency grow as well (Tolbert, 1985). Thus, if an institution has academic departments particularly dependent on international students for graduate education, it will presumably establish administrative support to monitor and manage this dependency. Research suggests, however, that academic departments are proponents of autonomy, and they place emphasis on minimum coordination; "they are not usually inclined to seek advice in matters regarding their specific programs," including coordination of efforts in response to graduate enrollment declines (Malaney, 1985, p.384).

Dependency on other sources also increases in order to maintain the flow of graduate students, however contingent upon the type of governance (Tolbert, 1985). Considering the dependence on international graduates and subsequent response strategies in cases of enrollment decreases, academic organizations differ in how they perceive their need and dependency on international student enrollment, because they differ in terms of agendas, material resources, prestige, and consideration of constituencies. Thus, "decision makers' perceptions of dependence may still play a part in determining an organization's response to a situation of dependence (Aldrich, 1979, p. 120).

In their pursuit of interests and resources, academic programs are bound by a distinct loosely coupled structure; as components of a complex system they respond at a different pace to the environmental changes that have an effect on their individual

operations. Some distinct characteristics of a loosely coupled organization provide the grounds for distinct patterns of interactions of the sub-units (academic programs) with environmental sectors with which they are tightly coupled, and ultimately “a feedback loop connects environmental conditions with organizational responses” (Aldrich, 1979, p. 84).

In general, the loosely coupled structure of institutions of higher education makes academic organizations more capable than other organizations of surviving environmental disruptions (Cameron & Whetten, 1984); and it is associated with conditions of decentralization that determine the formulation of objectives by interested units and strategies used for their implementation (Whetten, 1988). Caution is recommended when studying loosely coupled systems, where “important events occur infrequently,” and “observers must be careful not to fall into the trap of taking participants’ justifications for their behavior at face value” (Aldrich, 1979 p. 86). Infrequent enrollment declines, therefore, may not necessarily imply disruptions of the academic units with a sector of their immediate environment or steady enrollments may obscure upcoming changes in that environment that may affect unit operations.

The topic of *organizational decline* emerged in scholarship during the late 1970s and 1980s due to declines in the various disciplines of business, administration and higher education domains. Literature has indicated contradictions among disciplines, and the inferences on related factors and strategies addressing declines are difficult to generalize across domains (Zammuto & Cameron, 1985). Observations, documented in related research, report that characteristics of the external to the organization environment are determinant of the success or failure or simply selection of the organizational

strategies in response to conditions of decline. Public organizations such as colleges and universities follow cutbacks and consolidation strategies (Cameron & Zammuto, 1988).

The conceptual definition of decline determines the “substantial decrease in an organization’s resource base, over a specified period of time,” and is contingent upon the type of organization (Cameron & Zammuto, 1988, p. 118). Therefore, it is a phenomenon different in nature and character among organizations in different industries (Cameron & Zammuto, 1988). The concept of environment means a totality of *niches*, i.e. “a segment of the larger environment that is bounded by such factors as the availability of resources to support the organization’s activities, constraints such as technology and culture, and the presence of consumer demand for organization outputs” (Zammuto, 1986, p. 43).

Meyer (1988) argues that there are

fields of clustered resources confronting the organizations, inhabiting them with varying levels of munificence, competition, and interconnectedness. These models emphasized the multidimensional nature of environments, suggested new operationalizations, and alerted us to the possibility that certain organizational forms are better equipped with the demands of a given environmental niche than others (p. 412).

For colleges and universities, changes of a *niche* can occur because of fewer student enrollments (size of a niche). For an academic program, a shrinking niche can also result from the reduction of resources from federal, state government and industry, from changing institutional policies and decreased demand of graduate education, or distortions in the labor force that result in shift of student interests (shape of a niche) (Zammuto et al. 1983). As a result, graduate enrollment decline can be attributed to decline of various types of resources that sustain a graduate program, but there is not

always a clear causal inference of specific enrollment decline and a specific type of resource. In short, enrollment decline is a phenomenon with multiple dimensions and the strategies followed should be carefully tailored to respond to the environmental factors associated to the change (Zammuto et al, 1983).

Literature is extensive on the organizational performance and environmental effects on organizational decline, but it focuses mostly on the business sector. In the business sector, the response of the organizations to changes considers the environment as critical contingency variable for the relationship between the strategies of organizations responding to changes, and the subsequent performance of the organization (Prescott, 1990).

Zammuto and Cameron (1988) suggest that certain environmental characteristics produce different types of decline; therefore there are different types of responses depending on the type of decline. Higher education, for instance, does not follow the same patterns of strategic response to decline as other industries, because enrollment declines in different levels (undergraduate or graduate) and for different groups of students (domestic, international or minority) are an outcome of different factors (Cameron & Zammuto, 1988).

In higher education, for instance, the environment of academic fields differentiate the responses to changes in international student participation, since international graduate enrollments are considered as a resource for certain programs depending on the nature and subject matter of the field. This reflects on the variety of initiatives institutions take to enhance international presence. Hence, the rationale of this study is driven by the following premises: (1) the environment is a variable that determines strategies and

enrollment changes; (2) international graduate enrollment is an outcome of the environment within which academic programs manifest different range of dependency; (3) perceptions of administrators and academics determine response strategies.

Studies on Environment and Organizational Decline

In studies conducted during the mid-1990s, senior university administrators, in particular, address issues involving research universities. Most of the issues identified are related to the potential of shrinking funding, the federal science policy, changing demographics and the increase of international institutional competition. The changing environment of research universities and the changing expectations are considered to be the biggest challenge for U.S. higher education (Schmidlein & Taylor, 1996).

Most of the studies examining actions taken by institutions of higher education in response to environmental conditions that affect enrollment, focus on specific types of institutions. In two comprehensive elaborations of the phenomenon of decline as a product of the environment, Zammuto et al., (1983, 1985) explain why different organizations in the same population of organizations experience different types of decline, and how this affects their strategies of response. What is confirmed in this study is the variety of prescriptions for the management of decline, and, for that reason, emphasis is advised on individual study of different types of organizations for better understanding of practices of institutional response (Zammuto & Cameron, 1985).

Hence, enrollment decline is a multidimensional phenomenon and retrenchment strategies have to be carefully tailored to match the characteristics of environmental change causing it" (Zammuto et al. 1983, p. 106). The types of responses, therefore,

followed by an institution or academic program are dependent upon the causes of the decline (Zammuto et al. 1983). Not all causes are easy to identify. Declines involving international students may be the result of different factors from those related to domestic students. Public colleges may have different factors associated with declines from private; for instance, decreasing state funding can be an easily identified factor of decline concerning both groups of students. Other reasons may include changes in demographics of the student body, or changes in the interests of students while making career choices at the senior high school or undergraduate years (Zammuto et al. 1983).

Through an exploratory study, Mikolusky (1983) examined the management of decline during the 1980s in university departments. That research followed qualitative methods, and department chairs from four growth and four decline departments were interviewed. A sample of faculty was also used from each group of department types. Decline chairs expressed more concerns for pressures coming from the environment, they were more tolerant of ambiguity, they used more strategies related to students, and they expressed more limitations on decision-making. Both groups reported similar management styles and some chairs had less difficulty than others maintaining resources. The results of the study were inconclusive regarding any general lines of management of decline (Mikolusky, 1985).

Drawing on the theories of organizational response to environmental change in view of enrollment declines of traditional groups, Shopshire (1980) shows that academic organizations and individuals within the organizations react with rigidity and resistance upon experiencing a decrease in enrollments, and if these cause further “turbulence and

uncertainty,” leadership proceeds to responses that “ensure quality and viability” (Shopshire, 1980).

Following a similar theoretical context twenty years later, a study of women’s colleges in Massachusetts showed that institutions rebounded from their declines, after acknowledging and carefully identifying the causes of those declines, collecting data, and after engaging in strategic planning in response to their external environment, with the collaboration and communication of all stakeholders within the institutions. Pivotal was the role of the leaders in inspiring endorsement of actions by trustees, faculty and other administrators (Gueverra, 2001).

Milliken (1990) explored the relationships between organizational characteristics, resource dependencies, and administrators’ responses to environmental changes; she concluded that the administrators’ perceptions of their institutions and the characteristics of the institution interfered with their interpretation of the environment (Milliken, 1990).

A chief academic officer conducted a study on environmental and institutional characteristics and academic strategic action variables in small private colleges and their relation to enrollment change during 1980s. One of the key findings of that study is that the application of specific strategies “ must be viewed carefully in the context of the environmental and institutional attributes of that institution” (Driessner, 1993).

Useful information is provided by studies that have considered factors that influence international graduate student decision to apply to graduate schools. A study conducted also in the 1980s, using data from 393 international graduate students in education in 19 campuses of 11 U.S. universities, found that international graduates apply to graduate schools following the availability of advanced educational resources,

instructional technology materials and equipment, and with major incentive “the opportunity to increase professional and academic growth.” Highest ratings were given to items of the survey that addressed “letters, brochures from the university regarding specific programs” and “catalogue or university bulletin or publication.” Institutional characteristics counted considerably and included the quality of the curriculum in most educational areas (Bornstzein, 1987). The same year Malaney (1987) conducted an analysis of departmental recruiting practices for domestic graduates in 114 graduate academic units, and concluded that the number of recruiting practices that departments adopt is to some extent dependent on the field of study. The study researched the number of recruiting practices, and pointed to the need for further study in order to identify relations between the quality and quantity of the students and the number of recruiting practices (Malaney, 1987).

About what concerns the departmental characteristics and organizational response to international student enrollments, Trice (2000) found that “ Departments response to these [international] students varied based on the nature of the discipline, the physical structure of the department, the unit’s leadership, and its size and ranking” (p. 3). Considering the case of a prestigious program, she found that faculty considers students as a whole that will contribute to the overall improvement of the department and research outcomes regardless of nationality and origin, regardless even of language deficiencies. The study does not consider that, although the criteria of selection and admission may be the same for both domestic and international student groups, policy and environment imperatives are such that they entail special approaches for the maintenance of the smooth flow of international graduates into a program.

A study involving public universities at one state in the Midwest revealed that not all institutions are systematically involved in recruiting international students. Most universities do not have a strategic plan supported by a designated budget in order to promote their services in the international market and recruit students. After September 11, recruitment efforts were particularly hindered by new policies on visa restrictions targeting particularly students from Middle Eastern countries (Magaya, 2004).

Bain and Cummings (2005) present an analysis of the academic organization and environment relations, focusing on factors and institutional strategies that may advance or hinder enrollments of international students. The study shows that many institutions changed their position in relation to international student enrollments between 1994 and 2001. At the same time, changes in student mobility due to shifts in higher education infrastructure in developing economies have decreased immigration for study to more advanced countries. The study has distinguished two basic institutional objectives: improvement of quality and improvement of quantity. These objectives are served by four general types of institutional strategies, each with unique implications for international student participation. Thus, there are: (1) institutions that experience financial constraints but they are too large to afford expansions that would include more international students; (2) institutions that increase tuition with the objective to attract new types of students, which has a negative association with both numbers and percentages on international students; and (3) institutions that do not increase tuition so that they do not lose traditional clientele. Finally, there are already quality institutions with the objective to attract international students that would upgrade this quality.

Most studies highlight the importance of environment in shaping the actions of response to enrollment decline and the importance of the perception of the administrators and academic leaders for necessary actions to be taken. The majority of studies select a specific type of institution and most researchers consider the diversity and uniqueness as a determinant factor to the conditions of decline and response by the institutions. It is also underscored that strategies of response are dependent on the type of the academic field, a finding that supports the rationale of the study for the examination of units in an individual academic field. However, what has not been sufficiently addressed is this: how do the distinct character and *niche* of an academic field determine the way a specific environment interacts with its institutional attributes and influence the strategies followed by academic stakeholders.

Institutional Strategies for International Graduate Enrollment Management

A report of the Carnegie Council on Policy Studies published in the early 1980s had predicted that international students and older adults would fill gaps in graduate education programs following the 1970s (Jenkins, 1980). In fact, international students have played that role for most graduate programs in science and engineering fields, and particularly for engineering fields. After more than twenty years, projections on international student growth have been proven far from accurate, and selected fields, especially at the graduate level, are found in great need of international enrollment.

Although projections of international student enrollment for the 1990s and 2000s were pointing to approximately 1,000,000 based on the impetus of international student

flows during the 1970s and 1980s, the total number of international students currently is not more than 565,039 at all levels of American higher education (IIE, 2005).

Landmark studies during the 1980s underscored the need for a comprehensive institutional policy on international students in light of growing enrollment, trends by nationality, discipline and levels of study (ACE, 1982). Administrators identified institutional policy governing international students as a cause of confusion, albeit agencies and organizations involved in issues related to international students claimed that the international student enrollment was not working properly and that there was need for “a conscious and intelligent intervention” (Kaplan, 1987; Barber, 1985; Barber, 1984; Goodwin, 1983; Jenkins, 1983; NSF, 1981). This is perhaps the reason why information on how academic programs deal with changes in international student enrollment is scarce.

As is the case with domestic graduate enrollment declines, responses to international graduate enrollment declines cannot be managed in a centralized manner, given the “discipline-specific nature of graduate education” (Malaney, 1987, p. 126).

Differences among academic disciplines are profound in terms of structure, relation with the institution they are part of, scholarship communication patterns, as well as teaching and research standards in a globally comparative perspective (Braxton & Hargens, 1996).

Studies addressing enrollment management at the undergraduate or graduate level concur that there is a variety of factors that determine enrollment, and those factors constitute the environment that an institution or academic unit interacts with and draws upon for survival and growth (Brinkman & McIntyre, 1997). Concerns for graduate

enrollment do not necessarily involve maintenance of sufficient student numbers as much as student quality; nonetheless, strategies for maintaining the quality of students do not differ from strategies related to maintaining quantity (Malaney, 1985). Most research universities adopt a centralized enrollment management system for undergraduate enrollment, but graduate enrollment is mostly under the realm of individual departments that make decisions for marketing and recruitment (Hossler, 1990).

Faculty has oversight of graduate enrollment, but they can change quite often and many lack a tradition of being systematic about graduate admissions. For international graduate enrollment, there are external structural issues that take place outside the control of enrollment planning. For instance, support of international students incurs expenses to the programs, which may ultimately discourage recruitment operations. In addition, as universities in Asia and Central Europe improve, there are fewer reasons for students to study abroad and recruitment practices may become more problematic (Hossler, 2005. Electronic Interview, October 20).

A recent press release from the Council of Graduate Schools reports that seventy-nine percent of graduate schools have adopted strategies to increase the enrollment of international applicants. These strategies may include collaborations such as agreements with international agencies, recruitment trips, and additional staff designated to support international student admissions and other related matters (Brown, 2006).

Recruitment is a common strategy followed by institutions to increase or maintain international graduate enrollment. Officials at Columbia University have recently attributed a 5.6 percent increase of international students to better outreach. The university was committed to “a concerted effort, from the president on down” to recruit

overseas, stated Ellen Cohen, associate director at the office of international students' and scholars at Columbia ((Bollag, 2006; Levinson, 1998; Lewington, 1997). Careful study of the decision process of international students while in selection of a field and an institution maximizes the effectiveness of recruitment strategies (Olsen, 1987).

Certain universities have gained the assistance of state governmental agencies in creating incentives for international graduates to choose their programs over other destinations. Indiana University has joined a concerted effort of the National Association of International Educators (NAFSA) and the Committee on Institutional Cooperation for the development of endowments for the support of international student study in the U.S.

Duke University reserves private sources with the purpose of assisting financially international students (Anderson, 2005). Some institutions do not hesitate to restrict, even with written policies, international student enrollment. Certain public universities are very careful with the ways they allocate taxpayers' money, and faculty is forced to consider not only the quality of the students but also the nationality. The University of Tennessee in Knoxville is a case in point (Wilson, 1999).

Collaborations with other institutions have gained ground as a strategy of response of research universities to declining graduate enrollments during the past decade. Approximately 15 research universities have established graduate programs in developing and developed countries around the world. Carnegie Mellon has established degree programs in Greece, South Korea, Qatar and Japan. The ECE department in the same institution has recently established research and educational outreach programs with Taiwan and the Industrial Technology Research Institute (ITRI), which is sponsored by the government. Research focuses on circuit design and applications in communication,

information technology, computer and consumer electronics, and multimedia (Dpt. of ECE, Carnegie Mellon, 2007).

Georgia Institute of Technology associate vice provost for international programs acknowledges the sharp decrease in enrollment of international graduates in his institution, and reveals that in order to maintain ties with outstanding prospective graduates, GIT has opened degree programs in France, Singapore, and in fall 2006, in China. In 2003, the State University of New York in Buffalo opened master's programs in business and communication in Singapore, and it signed an agreement to run two master's programs in information technology in Bangalore, beginning in 2006 (Bollag, 2006).

Electrical and computer engineering programs present a strategic plan underlined by their mission and scope of research objectives. For many ECE departments, international presence and collaboration with institutions abroad are considered very important to their research objectives (Gamal et al. 2006). Information on strategies ECE graduate programs follow to attract or maintain prospective graduates, however, is not well documented. During the last decade, in view of the irreversible decreases of international graduate enrollment, related agencies have increased efforts to improve recruitment of graduates from underrepresented minority groups. Some programs have followed strategies with the purpose to eliminate "perceived barriers to graduate school entry" (NSF & ECEDHA, 2003). One of them is waving the GRE exam that is considered a repellent to prospective graduates and an unreliable predictor of performance, and, according to faculty experience, waving GRE does not compromise the quality of the program. Providing supportive atmosphere among members of the

graduate student cohorts is another recommended strategy to maintain graduates but with no reported results. Financial assistance is one of the most critical incentives provided to prospective students among minority groups who, in most cases, have accumulated debts from undergraduate study where in many cities the cost of living is very high (NSF & ECEDHA, 2003).

Although mechanisms of support and management of international enrollment by research universities are present, they are rather marginal to “their real activities,” presumably because the very role of the research university is to serve national social goals, before serving the global. Experts argue that, despite this feature, American institutions of higher education “are more globally networked” than any others and they go as far as to suggest that globalization itself has “Americanized nature” and that it will eventually switch priorities and operations of the American universities to more international levels (Tierney, 2004).

Environment of Electrical and Computer Engineering Programs. Funding and Evolution of the ECE Field

High funding levels of graduate programs create a sense of trust by students towards graduate education. Trends in funds particularly originated in federal sources affect graduate enrollment in engineering fields (Merrill, 2001). The federal government has been the largest funding source of graduate programs and, in the last forty years, science and engineering disciplines have enjoyed the lion’s share in funding from the federal government. The departments of defense and energy have provided the majority of funding for academic research and training in electrical engineering, but there were major cuts in funding by these two sources during 1992 and 1996 (Merrill, 2001).

Researchers have pointed out that, although fluctuations in resources are potential measures of organizational health, they may not be predictors of organizational decline (Cameron & Zammuto, 1988). Institutional resources that are associated with academic programs and educational levels (graduate and undergraduate) comprise the environments that interact with structures or academic programs within the organizations (Cameron & Zammuto, 1988). Organizational research indicates that multiple factors probably contribute to decline with some of its antecedents being centralization, conflict, and rigidity in addition to funding (Zammuto, 1986). Furthermore, when considering funding as a source of organizational decline, environmental and organizational resources must be examined separately (Cameron, et al. 1987).

Engineering fields present differences in funding for university research. Data on engineering international graduate enrollments and funding reveal that funding is not necessarily a determinant factor to enrollment trends. The National Research Council (1999) reports that there is a high but not necessarily perfect correlation between the decrease in funding observed in the mid-1990s and the decrease in graduate enrollment in 1999. Confirming the literature on funding and enrollment association, the same study emphasizes that the funding and enrollment relation should be considered with caution, because increasing federal funding is not necessarily associated with declining graduate enrollment (Merrill, 2001). Following decreases in funding from 1993 through 1999, there is an overall downward trend in graduate enrollment in the field of engineering.

There is also a decrease in the doctorate production (Merrill, 2001, p. 86). The field with the smallest decline in graduate enrollment was electrical engineering with 0.6 percent and with a decrease of 12 percent in federal funding. Nonetheless, the full-time

graduates with federal support increased by 12.3 percent due to an increase by 15.1 percent in the number of graduate electrical engineers supported by NSF (Merrill, 2001).

Funding trends have influenced the research paradigm of electrical and computer engineering. Engineering education during the period pre-and post World War II had a strong focus on design with limited application of mathematics. Most engineering faculty had experience and connections with the industry, and design was the primary focus of curriculum. Three landmark events in the environment of engineering field changed the academic focus of the field, and led to a dramatic paradigm shift in the curricula and research foci: the launch of Sputnik in 1957, the National Defense Act, and the establishment of the Advanced Research Projects Agency (ARPA) and the National Science Foundation in 1958. A significant outcome of the events was the generation of generous funding for science and engineering, and, hence, the beginning of international student inflow into the U.S. with the purpose to complete advanced degrees in related fields. ARPA, the first governmental agency set up to prevent events such as Sputnik, reported directly to the Secretary of Defense. It could afford the support of large team projects, and for that reason, was critical to Ph.D students who relied on its funds for the completion of their work. On the other hand, the National Science Foundation was more focused on supporting basic research in computer science and furthering computing infrastructure in education (NSF, 1999).

Electrical engineering and computer science departments were separate academic units until the mid-1990s. Computer science has attracted large numbers of international graduates. It was not, however, established as science until the first departments of computer science were founded in 1970s in Stanford, MIT and Carnegie Mellon (NSF,

1999). Funding for science and engineering fields has been one of the determinant factors in the evolution and emancipation of both fields. In the 1970s and the 1980s, the political atmosphere after the Vietnam War did not favor funding of defense related research, and universities had to change their research agendas. The Nixon administration controlled the research directions of the academic community and Congress followed the same position. NSF activities supporting computing research were dramatically curtailed. Three key industries, the microelectronics, computer, and automobile were seriously challenged by Japanese technology. Alarming was also the declining market share of the U.S. in the semi-conductors industry, which fell from 75 percent to 40 percent during 1980s (NSF, 1999).

Once more, support of graduate education in engineering became subject to international evolutions. Japanese dominance in the industry brought together joint ventures, cooperative agreements and university industry collaborations with the purpose to face “the Japanese threat” (NSF, 1999 p. 17). NSF regained its role in funding computer science through the Computer Sciences Section, and, by 1977, it was the largest federal supporter of basic research in computer science. In the report to Congress in the 1979 budget, NSF provided almost all of the support for software engineering, 60 percent of the support for computer systems design, and 50 percent of the support for software systems science (NSF, 1999, p. 110). This funding was conducted under the direction of the Computer and Information Sciences and Engineering Directorate under the direction of Gordon Bell, firm supporter of funding to computing research (CISE). Major concern at the time was that graduate programs in engineering departments did not produce enough PhDs, and the increasing funding intended to remedy that problem (NSF, 1999, p.

24). During that time, in combination with significant increases in defense expenditures that followed during the Reagan administration, graduate enrollment presented a dramatic increase in both electrical and computer engineering departments, and international enrollments reached an unprecedented level (NSF, WebCaspar, 2006).

In the mid-1990s, graduate education experienced the outcomes of changes in the political climate internationally with the end of the Cold War and the decrease of the defense budget for research. After the end of the Cold War, growing federal deficit created an unstable environment for higher education and slow-moving national and state economies during the mid-1990s resulted in the reduction of federal and state funding to higher education (Smidlein & Taylor, 1996). Enrollment in graduate programs in some universities was affected dramatically, and this was the case for many electrical engineering programs during that period, although it is not documented whether there is an association between decreasing international enrollment and funding. Federal research funding stagnated from 1993 through 1998, when there was an increase of 4.5 percent over the 1993 level (Merrill, 2001, p.2). It was not until 2001 that federal R&D funding surpassed the levels observed in 1992. Although the fields that experienced most of the reductions in federal funding were electrical, mechanical engineering and physical sciences, the majority of the graduate electrical engineering programs did not show changes in international graduate enrollment trends (Merrill, 2001, p. 2). The current administration had pledged a small increase for NSF in FY 2005; however, Congress finally cut the NSF budget by 1.9 percent, the first cut since 1996. A bipartisan group of senators acknowledged that for an innovative policy and strengthening of the competitive position of the U.S. in the world, there was need to make the U.S. more attractive to

international students and scientists to work in the U.S., while improving the U.S. educational system and the participation of minority students in science and engineering related subjects (Aspray et al. 2006).

State funding of domestic and international student enrollment varies, and influences significantly the decisions of academic departments. For instance, out-of state tuition fee is considered a burden to many departments in research universities that are responsible for the entire financing of their international graduates. This policy is highly dependent on higher education finance mechanisms across states. In general, most analysts agree that the "golden age" of expansion of public higher education has ended, and public institutions have to fight over limited resources. During the 1990s, state appropriations for academic research declined dramatically. State support for public higher education fell from 14% of total state budgets to 12.5% during the first half of the 1990s, citing "prisons, elementary and secondary education, Medicaid, and welfare" as some of the programs receiving higher funding priority (Heller, 1999, p.67).

In addition to funding, the changing environment of the field is also driven heavily by commercial competition and the impetus of advancements in information technology and biology (Prados, 1998). ECE has expanded increasingly into new, yet nameless branches that range from design and distribution to sales, engineering, teaching or testing. In such an increasingly changing environment, if someone were to seek a common activity that binds students of electrical engineering, that would have to be circuit design and all its products. Nevertheless, the contemporary ECE student should not only be able to design but must be capable of a lot more; According to Wallich (2004) the imperatives of today's market are such that

if the chip doesn't do what it was designed to do, a project will lose months getting to market while waiting for a new fabrication cycle. So design now means endless rounds of simulation and modeling. And design engineers effectively become programmers, as they type the "source code" representing their circuits into the tools that will ultimately generate a layout (p. 1).

In today's EE design, large numbers of transistors can be assembled without the designer ever needing to see a physical circuit, because the circuit board is a number of files stored on a desktop. This activity entails enhancing project management skills, something that perhaps is not a qualification many engineers have. According to the president of the National Academy of Engineering, Wm Wulf, regardless of how many disciplines may be involved in the making of contemporary electrical engineering subject matter, the use of technology to make new things will be the distinct qualification someone will need to be an engineering type (Wallich, 2004). As a result, many departments have embraced the imperatives of the contemporary trends in the field of engineering and have altered curricula with a range of subjects addressing the demands of the contemporary market, research and development demands (Williams, 2002; Pong, 2005).

The paradigm shift and changes in the identity of ECE may also be attributed to the background and preparation of graduate students. International graduates differ from their American counterparts in preparation and training. For instance, entrance to college in certain developing countries in Asia and Europe is a daunting experience that rewards the few that prove their abilities at competitive exams (Epstein & Kuo, 1991). Given the need for rigorous training before the college entrance exams, those who can afford cramming (preparatory) schools come usually from affluent families (Epstein & Kuo,

1991). The undergraduate schooling in science and engineering programs in many developing countries places greater emphasis on theoretical learning. On the other hand, undergraduate engineering programs in the U.S. are known to accommodate both theory and practical education. American graduate programs continue to emphasize both academic and practical skills through state-of-the-art technology and well-funded research. These were the foundations set by the first engineering programs in land-grant institutions in the middle of 19th century. The students of engineering at the time were off-springs of farmers and lower classes of manufacturers, and emphasis was placed on research that would promote industry and agriculture (Altbach, 1998).

According to studies conducted in the 1990s based on faculty interviews, the ECE graduates in the U.S. who originate in Asian countries, have strong technical skills, and are immersed in curricula with strong emphasis on math and science theory. It is also stressed by experts in the field that international engineering graduates may have strong technical skills but have limited understanding of manufacturing processes. They have weak design capability or creativity, limited experience working with teams, and deficient communications skills not necessarily related to language difficulties (North, 1995, p. 74). Qualitative data produced during the 1980s and 1990s from interviews with chairs and deans of engineering programs reveal that international graduates are more successful as research assistants rather than teaching assistants and they are industrious and hard working (AAU, 1998; Barber & Morgan, 1987). Other studies reveal that in many cases international graduates are reluctant to challenge their professors because they are used to doing so in their home educational environments, which are more teacher-centered rather than learner-centered environments that encourage

experimentation and creativity. Some international graduate engineers often expect to be told what to do in the labs, and, in general, they avoid taking initiatives mainly because they are not familiar with manual work and machinery (North, 1995, p. 74).

Preferences for types of research may also vary. For instance, Asian faculty when compared to white or minority is said to conduct more basic research, more theoretical versus experimental, more analysis versus synthesis, more funding agency driven rather than principal investigator driven. Asian faculty is also reported to give greater importance to hardware, computer programs, algorithms, commercial and military products (Kannankutty, 1996).

Electrical Engineering and International Graduate Programs

Changes in international education may have an impact on the U.S. graduate enrollment trends. European and Asian countries that have historically sent graduate students to the U.S. continue to improve their capacity for graduate education in S&E fields (Hsiung, 2005; Gilman & Schultz, 2004). As a result, many prospective international candidates for U.S. academic programs opt to stay home. For instance, graduate enrollment from Taiwan, a country that was ranked first among the top sender countries during the 1980s and beginning of the 1990s, has dropped dramatically; the reason being that Taiwanese economy and higher education have advanced significantly and provide strong incentives for prospective researchers to stay home (Cameron et al. 1988). China and India remain leading sender countries of graduates to engineering programs in the U.S.

China has followed an aggressive policy to support the engineering education through generous funding, flexible curriculum and limitation of competing programs. These initiatives, supported by the historical shift from the centrally planned to a more free-market economy and opening to international investment have brought engineering enrollments from 1.8 million in 1995 to 5.8 million in 2003 (U.S. Department of Education, 2006).

Since the 1980s, in the context of government's efforts to speed up improvement of research and innovation, a range of incentives was offered to Chinese software workers and specialists in the form of housing, cars and promotions upon their return to China from studies abroad (Aspray et al. 2006). A network of websites, TV stations and job fairs contributes systematically to that objective. Beijing maintains an office in Silicon Valley from where up to 4000 Chinese engineers- most former graduates of electrical engineering schools- are recruited with the promise of a rewarding life back home, while working to boost China's high technology industry. Yet, this "rewarding" life is known to present returnees with a 30 to 50 percent salary cut. China is producing three times the number of PhDs produced by the U.S. and four times more engineers than the U.S. (Heenan, 2005).

The Chinese government has focused particularly on supporting of research and development related to software industry in universities, research institutes and industry. It also increased the number of software engineers from 250,000 in 2002 to 800,000 by the end of 2005. The Chinese Ministry of Education urged all institutions of higher education to establish programs in computer science or software engineering. Thus, by 2005 ninety percent of Chinese universities had created programs in computer science

and software engineering. Fields attracting the interest of government include satellite launching, superconductivity, biotechnology, nano-technology and optics. American companies invest large amounts especially in the coastal areas of China, among them are Motorola, Intel, General Motors, and McDonald's (Heenan, 2005).

Some key facts for the electrical engineering field and China's technology growth are: (1) the Chinese government focuses on developing Shanghai as the 21st century's center of electronics industry; and (2) The Chinese labor ministry estimates that by 2010 there will be a need for 300,00 integrated circuit designers, and more than 1000 senior technical managers by 2010 (Heenan, 2005). Chinese higher education lags behind in terms of autonomy and academic freedom of faculty, and an institutional environment that still has not resolved the dilemmas between the values of research for professional and commercial purposes (Mooney, 2006; Cao & Suttmeier, 2001; Heenan, 2005).

In India, after the independence, Prime Minister Nehru emphasized technical education, and put the foundation of the first elite academic institutions in the country; the Indian Institute of Technology. The intensity of training in math and science that Indian children receive from the elementary school level may be a good reason for the production of approximately 300,000 engineering graduates a year, which is expected to grow 50 percent the next ten years (Heenan, 2005, p. 97) .

India, ranked first among country-senders of students to the U.S. has sent its brightest and most competitive students to American universities. During the 1980s and 1990s, Indian entrepreneurs, graduates of electrical engineering and science from U.S. schools, populated Silicon Valley and other technology-driven cities in the U.S. After the collapse of several "dot.com" companies, Indian professionals have returned home,

including people with working visas and U.S. citizenship (Heenan, 2005). As infrastructure disparities in strategic research fields between the U.S. and India gradually decrease, the U.S. becomes “India’s gateway to advanced technology” (Heenan, 2005, p. 90-91). In 2004 India exported \$17.3 billion in technology services mainly to the U.S., with an anticipated growth of exports up to 30 percent (Heenan, 2005, p.97). While the U.S. Bureau of Labor statistics reports that 234,000 American IT professionals are unemployed, thousands of Indian engineers will be working for American companies in India, such as Intel, Oracle, Hewlett-Packard, IBM, Accenture and others (Heenan, 2005).

The growing number of engineers who graduate in China and India is often presented as a threat to the leading role of the U.S. in technological research and innovation, mainly because the U.S. produces 5 times fewer graduates in engineering than India does, and approximately 9 times fewer engineers than China. Scientists from both countries rebut these fears, and point to the quality issues that higher education in both countries experience. There are few institutions that can compete with the U.S. academic programs of the same quality, and those are usually the feeders of graduates for the U.S. ECE programs (Mooney & Neelakantan, 2006).

The issue of quantity versus quality of the ECE graduates from China and India is subject to debate for various reasons. Large proportion of India’s higher education is still short in quality research and qualified faculty. The culture and meritocracy necessary for the establishment of research universities are not present yet in India, although the Information Technology (IT) sector and high-tech industries are growing (Altbach, 2005). Following a study from Duke University, the reported numbers of engineers

graduating in India every year refer also to the 3-year degree holders. Similarly, the numbers of Chinese engineering graduates include some of those specialized as auto-mechanics (Wadhwa et al., 2006).

American companies involved in off-shoring/outsourcing operations experience difficulties in finding candidates with desired qualifications, as some engineering applicants, especially from China, although they are degree holders, they do not have competitive technology related academic qualifications, knowledge of English, business management and teamwork skills (Mooney & Neelakantan, 2006). In addition, the engineering curriculum and financing of higher education in China fall short, and many stakeholders in the engineering education industry have underscored the need for improvement of the curriculum and graduation standards (Farrell & Grant, 2006). It is not clear to what extent the quality of ECE graduates in both countries is equivalent to that of American graduates. In that regard, those who advocate that the fast growing numbers of ECE graduates in both countries can pose a threat to the competitiveness of the U.S. seem to rely on the assumption that quality is proportional to quantity.

Changes are also underway in the European higher education system. Major legislation is currently implemented for the harmonization of the higher education systems of the country-members, and for the facilitation of the transfer of credits among institutions (NCES, 2006). Some projections consider this legislation a buffer for international student flow from Asia into the U.S.

Electrical engineering Labor Market and International Enrollments

Technology related fields have a disproportionately large participation of international graduates in the U.S. There is ample evidence in the corporate U.S. regarding the professional advancement of foreign-born graduates in the high-tech industry. The sectors with high concentration of international professionals are related to personal computers, telecommunications and medical instruments. The citizenship status of these professionals is said to be an obstacle for access to more employment opportunities in the defense-related contracts, and, hence, the subsequent concentration particularly in the aforementioned sectors (Endelman & Loughran, 1993).

More than 50 percent of the international students who earn a doctorate and have temporary visa status remain in the U.S. after graduation, and become citizens either by marriage or through the process of sponsoring by an employer. Despite the alarming projections about losing international talent to their home countries, the stay rates for international doctorates has increased. Seventy-one percent of international students who completed a doctorate in 1999 were still in the United States two years later, an increase of 49 percent since 1987 (Greenberg, 2004). International doctorates in the fields of computer sciences and mathematics present a stay rate after graduation of up to 63 and 53 percent, respectively (Matthews, 2006).

Analysts have agreed that standard projection models cannot provide reliable information regarding changes in the S&E workforce (Kelly et al., 2004). It becomes increasingly apparent, however, that factors affecting changes in international graduate ECE engineering enrollment may be a result of changing demands for the science and engineering workforce. The employment opportunities for graduates of electrical

engineering are considerably favorable. The U.S. Bureau of Labor Statistics addresses employment conditions and perspectives for electrical engineers and computer engineers separately. Based on the 2002 occupational data, electrical engineering was the largest engineering sub-field with approximately 292,000 jobs. Among the top 20 occupations projected to grow fastest during the 2002-2012 period is the network systems and data communications analysts (2nd place), computer software engineers applications (8th position), and computer software engineers systems software (9th position), all occupations requiring strong background in ECE engineering (U.S. Department of Labor Statistics, 2005). However, international competition and engineering services outsourcing is limiting employment growth for electrical engineers in rates faster than the average rate for the rest of occupations (U.S. Department of Labor Statistics, 2005). One reason is that ECE graduates from U.S. programs have to compete in the job market with low-wage engineers in India and China. Another reason is that the demand for PhD holders is very limited, following information on highest degree required in job descriptions from five multinational corporations that operate in India and China: CISCO, INTEL, HP, MICROSOFT, ORACLE (Kenney & Dossani, 2005). This subsequently may affect the number of students who would otherwise seek to complete a Ph.D. in the U.S.

As the Chair of the R&D Policy Committee of IEEE-USA states it, “there has been a dangerous trend for industry to view engineers as merely another commodity that they can import when times are good and dispose of when times are tight” (Hira, 2003, p.5).

Developments in other disciplines have changed the funding priorities of industry and government sources. Shift of scientific and engineering activity from university to

business, decreased spending on the space program, the doubling of National Institutes of Health (NIH) spending, the national nano-technology initiative, the bio-shield initiative, the outsourcing of several S&E operations conducted at a lower cost are some of the key reasons for changes in the demand for engineering population in selected fields; lastly, increasing spending does not necessarily conform to increase in career opportunities in the academic sector, because faculty researchers receive appropriations which support the hiring of young scientists, but not necessarily the creation of new tenure track academic positions (Aspray et al., 2006) .

Alleged decrease in demand of highly skilled IT workers may have a negative impact on international graduate enrollment but creates serious skepticism, on behalf of key stakeholders in the field, for policies that would favor international graduate employment rates. According to the Information Technology Association of America in 2004, the IT industry filled 270,000 fewer jobs than in 2003. Conversely, stakeholders in the electrical engineering industry advocate that policies limit international professional employment. The president of the Institute of Electrical and Electronics Engineering (IEEE), Dr. John Steadman, testifying in Congress, emphasized that by raising the H1-B visa cap and creating special visa exemptions for highly skilled international graduates, it may result in decrease of U.S. enrollments.² The U.S. Chamber of Commerce has opposed this IEEE view and along with the *Compete America Coalition*, a coalition of

² H 1-B visa program was created in 1952 and offer international nationals with even a bachelor's or equivalent knowledge to work in the United States for three years with the potential of a three-year extension. Many of the H 1-B visa candidates are students in U.S. universities and most of the times they apply for permanent residence after the expiration of the H 1-B-visa; see also IEEE-USA (News Release) "Unemployment rate for electrical engineers skyrockets to record level" (Washington April 28, 2003) Available at <http://ieeeca.org/communications/releases/2003/042803pr.html> Retrieved on November 24, 2005.

more than 200 corporations, universities, research institutes and trade associations concerned about legal immigration and emigration, has fought to adjust the H1-B visa cap and to maintain the L-1 visa category for international intra-company transfers (U.S. Chamber of Commerce, 2006).

Restrictions on visas intended to provide employment to international graduate engineers produced strongly negative effects on international graduate enrollments among the dominant group of international engineering students in the U.S., the Indians. H1-B visa restrictions generated reverse immigration; the U.S. Indian Political Action Committee (USINPAC) executive director asserts: “What you’re starting to see now is reverse immigration, noting job fairs in Silicon Valley and New York promoting jobs in India for Indian graduates of U.S. universities”(Lochhead, 2003). Thus, there were 22,000 pending petitions for H 1-B in 2003. Similarly, visa holders employed by the tech–industry dropped by 60 percent from 2001 to 2002, that is, from 180,286 visas to 70,067, whereas computer occupation visas decreased from 84,853 to 16,174. While approximately 560,000 visas were issued, they were only 474,000 in 2003 (Lochhead, 2003).

Summary

International graduate enrollment in the ECE field is subject to changes in funding trends from federal agencies and other sources, changes in the curriculum of the field, the labor market imperatives, and the research trends globally.

This review has presented the theoretical framework that, supports the assumption that just as with other science and engineering graduate programs, international students in ECE departments constitute a significant resource. For this reason, strategies for

international enrollment management may be of critical importance to these departments. The premise that environmental factors are associated with the strategies that academic programs follow to safeguard against unwanted international enrollment declines is enhanced by reference to these factors and their potential effects on international enrollment. Landmark events that have changed the international graduate enrollments in ECE departments are related to challenges to American competitiveness in the domain of science and technology. In response to these challenges governmental agencies generated funding for research in these critical domains. Level of funding in itself has been a strong predictor of international graduate enrollment in ECE programs. China's shift to market economy is another landmark event that opened opportunities to thousand of graduates for study in the U.S. Industry also regulates the number of ECE graduate enrollment because prospective international graduates pursue advanced studies when their potential for employment is high upon the completion of their study. A great number of U.S. companies operate the last few years in the home countries of these graduates, thus influencing their decision to come to the U.S. for graduate study.

Studies on the environmental factors of ECE field show that international graduate enrollment is also affected by the political and economic situation and employment and training opportunities in the field of electrical engineering at the home country of prospective graduates. Part of the literature that addresses the strategies of response to environmental factors considers the perceptions of administrators, academic leaders and other stakeholders of the environment of an institution and academic field.

Policies concerning international student participation in the American higher education have encouraged and at the same time restricted academics and policy makers,

creating a conundrum in the response operations of academic programs that has not been unraveled yet by sufficient research. An additional set of assumptions addresses the role of the highly decentralized structure of decision making within institutions and the highly diverse character of research and doctoral universities.

The literature and the theoretical frameworks on management of decline and resource dependence approach emphasize the importance of considering the unique characteristics of an organization when studying the responses to its changing environment. It confirms the shortage of information on how institutional and programmatic uniqueness is manifested in decision-making for international student enrollment. Therefore, the rationale of the study to address international graduate enrollment in research I and II, doctorate I and II universities through the dynamics of a single academic field may provide the optimal route for clarifications of and contributions to existing important descriptive data provided by related agencies.

CHAPTER 3

METHODOLOGY

The purpose of this study is to research institutional responses to declining international graduate enrollment in ECE, and to identify strategies for bolstering and increasing international participation. One of the reasons this study concerns the graduate levels is because academic departments are mainly responsible for the admissions and the financial support of graduate students but not for undergraduates. Another reason is that the international enrollment is mostly observed in graduate programs (Trice, 2000). Following the theoretical premises elaborated in the literature review, the dependence of the ECE programs on international graduates is measured by aggregate data on international student participation in the ECE programs examined and by survey participant categories of response to related survey items. The literature review showed that both quantitative and qualitative approaches are followed to highlight the factors and imperatives that determine international student participation in individual academic fields and the strategies that departments adopt to manage it. Patton (2002) reminds that quantitative approaches facilitate the measurement of beliefs and reactions of a large number of people and the comparison of aggregate data. On the other hand, given the scarcity of information on how academic programs manage international graduate enrollments and what factors determine the management of these enrollments, the present study has an exploratory objective that can be enhanced by qualitative methods (Creswell, 2003). A survey proposed to obtain descriptive information is shown to be effective

for acquiring better insight about response phenomena in educational and other organizational settings from people who are directly associated with these settings, participate in and influence their operations (Graziano & Raulin, 2000; Best, 2000).

While quantitative measures based on scales are “systematic and standardized”, open-ended questionnaires help the researcher to create a framework where people “can respond in a way that represents accurately and thoroughly their points of view about the world-or that part of the world about which they are talking” (Patton, 2002, p. 20).

In developing the survey, steps were taken to ensure the survey items or questions are valid. The content validity was measured by how well the survey questions reflected the overall research objectives of the study (DeVellis, 2003; Litwin, 1995). Subject matter experts (e.g., faculty) in graduate ECE programs reviewed the survey items for relevance to the study.

Data Gathering

The first consideration of the study design was to locate and review existing data relevant to the status of international ECE graduate enrollment. Through an Internet search of national databases, National Science Foundation (NSF) provided a comprehensive collection of data for international first-time graduate students.

Three of the principal sources on engineering enrollment are the American Society for Engineering Education (ASEE), the Engineering Workforce Commission (EWC) and the National Science Foundation (NSF).

The search in the NSF databases identified two surveys containing cross-sectional multi-year data specific to electrical engineering international graduate students i.e.,

Survey of Earned Doctorates (SED) and Enrollment Survey. Enrollment Survey data were drawn from the Higher Education General Information Survey (HEGIS) and the Integrated Postsecondary Education Data System (IPEDS), which were conducted by the National Center for Education Statistics (NCES).

The Survey of Earned Doctorates is administered annually by the University of Chicago National Opinion Research Center (NORC) for the following federal sponsors: the National Science Foundation (NSF), the National Institutes of Health (NIH), the U.S. Department of Education (USED), the National Endowment for the Humanities (NEH), the U.S. Department of Agriculture (USDA), and the National Aeronautic and Space Administration (NASA). Information collected from Survey of Earned Doctorates also becomes part of the Doctorate Records File (DRF), which maintains data on doctorates earned in the U.S. from 1920 to the present.

The WebCaspar database also provides information on R&D expenditures (federal, state, and industry), and institutional control (private or public) by academic institution for a range of years. For instance, international undergraduate and graduate enrollments in electrical and computer engineering (ECE) and R&D expenditures per institution were reported by surveys administered annually from 1982 onwards. The period examined for this study reflects the availability of information between the years of 1982 and 2003.

Institutional trends showed that while overall rates of international ECE graduate students were growing rapidly from the 1970s through the 2000s, some institutions experienced significant multi-year declines in their international graduate student enrollments, namely during the 1990s and beginning 2000s. According to the theoretical

framework of the study and literature review, a *niche* was realized by upward trends in international enrollment and steady increase of resources in the form of federal, state and industry funding during the 1980s and partly during the 1990s. However, institutions had to struggle with constantly changing environmental factors, such as growing competition from developing economies for graduate students, shifting technological emphasis, and local or/and national employment conditions. This line of reasoning is taken into consideration in the identification of independent variables for the study of institutional response strategies to declines in international ECE graduate enrollment.

For most institutions, enrollment management concerns the undergraduate levels, while graduate enrollment falls in the jurisdiction of the graduate schools. International student enrollment is subject to the jurisdiction of the academic department, the graduate school, and the international student office and outreach program. It cannot be assumed that every graduate school has a designated division managing international graduate enrollment. This constitutes the rationale for investigating the role that chief academic officers play in the formulation of policies related to international graduate enrollment.

During the selection of participants, identifying the Dean of the Graduate School was problematic, as some institutions have associate deans with designated responsibilities listed on the web page of the school. Very few institutions have designated an associate dean in charge of the enrollment management and retention. This officer was perceived as the most relevant to participate in the survey. Another institution listed on the web page of the graduate school an “associate dean” under the title “dean of international enrollments.” In that case that person was also perceived as the most appropriate to be addressed for this survey.

Sample

There are 169 Doctoral I and II, and Research I and II, institutions identified with electrical and computer engineering programs, where data for R&D are also available in the WebCaspar database services (NSF, WebCaspar, 2006). Of these 169 institutions, 62 represent three quarters of the international graduate enrollment in ECE programs, and 41 of those belong to the top quartile and comprise the sample of this study. Among these academic programs, many institutions experienced fluctuations in international enrollment of more than 20 percent in international graduate enrollment, as defined by a minimum of a three consecutive year period sometime during the years from 1982 to 2003.

For example, the University of Illinois, Chicago (UIC) experienced multi-year declines in international ECE graduate students between 1984-1987, 1992-1995, and 2000-2003. Between the years 2000-2003, international ECE graduate enrollment at UIC declined from approximately 300 to 100 students. Between 1992 and 1996, the University of Arizona experienced decline from approximately 150 to 50 international ECE graduate students. The University of Massachusetts at Lowell experienced similar patterns of international graduate student declines in ECE programs between the years 1991-1996. The University of Missouri, Columbia sustained 69 percent decline from 1991 to 1996, followed by an over 100 percent increase from 1996 to 2001.

Survey Instrument

The main objective of the survey questionnaire was to gather responses pertaining to strategies and factors affecting international graduate enrollment trends in the

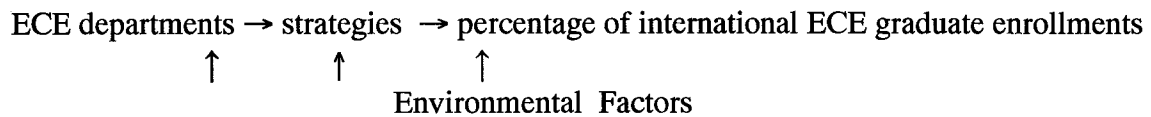
programs. The questionnaire contained 23-Likert style items (statements) and coded 1-5, where 1=low and 5=high. Two items that inquired the type of participating institution and the position of the participant introduced the survey. The survey was administered through *Survey Monkey*, an on-line survey program provided by the institution the researcher attends, the School of Education at American University, Washington D.C. The estimated completion time for the survey was about 5 to 7 minutes.

The participants of the survey included the Dean or Director of the Graduate School of the institution, the Director of the International Student and Scholar Services, and the Chair/Head of the department of electrical engineering. An email was sent to a total of 123 persons with the embedded link that prompted the survey setup through the *SurveyMonkey* software.

Following the literature review, administrators in educational organizations vary in terms of their knowledge and opinion on issues related to enrollment changes. In addition, survey items concerning departmental issues could only be addressed by ECE department chairs. Thus, the participant groups answered the survey items, as follows: Directors of graduate programs and international student office directors answered only ten (10) statements that address both environmental and strategy statements, they are of general interest and they appear in Fig.1. ECE department chairs answered all twenty-three (23) statements. When the participant indicated his/her position, the system prompted him/her to the corresponding group of survey statements.

The Variables

The following diagram shows how the variables in the study are related:



This diagram takes into consideration that every ECE department responds to environmental factors based on its attributes. These attributes include quality ranking, amount of funding, location and prestige of parent institution. The diagram also expresses the assumption that the degree of dependence the ECE departments manifest on international enrollment, ultimately determines the type of strategies they follow to manage this enrollment. Strategies adopted by ECE departments follow the events and evolutions in the environment of the department at a national and international level. For instance, the international graduate recruitment operations may be limited, if the U.S. government drops the H1B visa cap for an individual year. At an international level, off-shoring and out-sourcing of American corporate operations in Asian countries along with the growing graduate education in ECE in the same region, create conditions of keen competition for ECE departments in the U.S.

Dependent Variable

For the purpose of this analysis, the 22-year aggregate enrollment represents the dependent variable. The reason for the choice of an aggregate variable rather than, say, a yearly variable is because annual ECE enrollment for some institutions presents large variations (double or half in any given year), without being the result of a particular strategy.

Moreover, the dependent variable taken as the percent of international ECE enrollment rather than absolute number presents a more normalized description of the enrollment variability. It was downloaded from the NSF WebCaspar database into an Excel spreadsheet. The percent of international ECE graduate student enrollment from 1982 to 2003 was computed from the Excel spreadsheet by dividing the total number of first-time ECE international graduate students by the total number of first-time, full-time, ECE graduates for every academic program of the sample and then multiplying the result by one hundred (100).

Independent Variables

The selection of independent variables for the analysis draws upon the literature review. The variables are grouped according to their relation to the environment of the ECE academic field, the strategies known to be adopted by institutions for international enrollment management, and the different characteristics of ECE departments. The survey statements state actual conditions and are based on demonstrated association with the ECE field and impact on graduate enrollment. As independent variables will be examined for their unique impact on enrollment changes, response categories are coded as N/A, 1-strongly disagree, 2- disagree, 3-neutral, 4-agree, 5-strongly agree

Environmental Factors (1) changes in political systems of sending countries and ethnic composition of international graduates (CHPOLS); (2) visa restrictions (VISAS); (3) other governmental regulations (GOVREG); (4) changes in the curriculum of ECE (CURRCH); (5) employment conditions in technology related fields (EMPL); (6) funding

fluctuations (FUND); (7) improvements of higher education in developing countries and international enrollments in the U.S. (IMPINTED).

Strategies of response: (1) Flexibility in admissions standards (FLEXADM); (2) State policies favoring international student enrollments (STATPOL); (3) Teaching and research assistantships for the completion of academic work (TEACHREASASSIST); (4) Collaboration with currently enrolled international graduates in support of future graduate enrollment (COLLABGRADS); (5) Collaboration of ECE departments with departments in international countries with the purpose to recruit new graduates (COLLABDEPTS); (6) Faculty visits to international ECE departments with the purpose to recruit new graduates (FACVISITS); (7) Contact with international students who have expressed prior interest in the department (CONTSTUD); (8) International graduate participation in privately funded research (PRIVFUNDREAS); (9) participation in publicly funded extracurricular activities (PUBFUNDREAS); (10) Periods of declines in international graduate enrollments at your institution are associated with changes in the admission standards of your graduate programs (DECLADMST).

Departmental Characteristics: (1) The number of applications that your department has received from foreign students in recent years has declined (APPLDECL); (2) Declines in foreign enrollment has been a major concern for your department (DECLCONCERN); (3) ECE curriculum has become more interdisciplinary and as a result there is a growing competition with other academic fields for graduate enrollment (INTERDCURRIC); (4) ECE department faculty has greater authority over foreign graduate admissions than graduate school admission officers (ECEFACAUTH); (5) Responses to declines in foreign graduate enrollment cannot be managed in a

centralized manner given the “discipline-specific nature of graduate education” (WAYOFRESP); (6) Foreign graduate engineering enrollment is associated with the academic quality of the departments in your institution (ENROLQUAL).

The profile of ECE programs of the sample is as follows: ECE graduate enrollments range from 54 to 453 over the 22-year period. The total number of international first-time ECE graduate students ranges from 48 to 712 for the period 1982-2003. The average annual number of first-time international graduate ECE students for the same period ranges from approximately 3 to 32. The mean of academic quality ranking of ECE programs ranges from 1.66 to 4.83. The R&D expenditures aggregated over the 1982-2003 period reported by NSF range from \$30,733 to \$1,407,019. Complete information for all institutional characteristics was not available; the analysis included institutions presenting complete information on all variables (see APPENDIX). There are thirty-eight (38) ECE programs found with complete data that were used in the data analysis.

Job Title of Respondent – The variable representing job title is coded as 1-Director of Graduate School, 2-ECE chair, and 3-Director of International Student Office

The total number of years, for which increases occurred between 1982 and 2003 for international graduate ECE enrollments, will be tabulated for each institution. The institutions will be ranked by the top, middle and lower quartiles based on total number of years of increase in international ECE graduate students. The statements related to enrollment strategies will be compared by quartile to determine whether there is an association between upper and lower quartile rank in years of enrollment increase and strategies followed. More independent variables include:

Institutional Control : Universities are coded dichotomously, where 0=private and 1=public.

Funding is coded as 1=lowest quartile, 2=inter-quartile, and 3=upper quartile for the following independent measures: Federal, State and Industry funding for R&D expenditures of ECE departments also from the WebCaspar database.

Data Analysis

The measurement of any sort of organizational change is a complex undertaking; even organizations with the same characteristics, can become very different over time, as they can react in a different way to the same phenomenon. Theorists of organizational change, while trying to underline the rationale in the changes within an organization, have underscored that it is “irrational” to consider any rationality in organizational change. What is more effective is to consider whether the change is “episodic or continuous,” a situation that reflects the type of change observed currently in the international graduate enrollments in the ECE field (Warner, 2002, p. 142).

In its quantitative component this study seeks to point to the predictor variables in the form of environmental variables, institutional attributes and subsequent preferred strategies that participants have reported most agreement with, and which show association with percent international enrollment changes in the academic programs of the sample. Through the literature review a number of factors were established as influential on international enrollment for ECE graduate programs. Yet, it is not known which of those factors may have the greatest impact on international ECE enrollment. Furthermore, if two or more of the independent variables were highly correlated to one

another, their unique contribution to enrollment change may have been difficult to distinguish. Regression analysis assists with distinguishing the variables that have the most impact on international enrollment change. The appropriateness of this approach to circumstances similar with this study has been discussed widely in the literature (Prescott, 1998). The outcome of the regression assists with the identification of the relative importance on ECE international graduate enrollment by comparing the standardized regression coefficients or beta values. The use of the B coefficients in the regressions for those variables that show significance assists with the creation of a model of prediction of the enrollment outcome (SPSS, 2003). It is important, therefore, that the analysis includes variables that have practical and demonstrated relation with the enrollment outcome. The survey results were analyzed with the SPSS software package for windows version 11.0, which supported the regression analysis, the analysis of variance in the response of the three groups of participants (ANOVA), and the t-tests.

Descriptive Statistical Measures

The analysis begins with a summary of the means (symbolized by X) of responses to the survey statements; that is, the central tendency (average) of responses for each statement of the survey, as measured by the level of agreement, where 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5= strongly agree.³

Bivariate Statistical Measures

Opinions and levels of agreement of participants in any kind of research design present variations. To clarify eventual differences in responses among the three

³ The mean is calculated through the corresponding command in the SPSS programs and is the sum of all of the scores divided by the number of the responses.

participant groups in this study, an ANOVA statistic was used to measure the variance of agreement between the groups and the variance of agreement within the groups (Stangor, 1998). If opinion variations are greater between groups rather than within groups, then there is a group effect which can be determined by a follow up post hoc t-test.

Sample and Interview Procedures

To enhance and verify survey results, follow-up telephone interviews were scheduled with survey participants. Telephone interviews as a qualitative means of gathering information is practical because it requires less cost and time. It also provides more confidentiality because the interviewer knows less about the respondent. Telephone interviews are believed to have fewer negative effects than the in-person interviews because visual cues from the interviewer cannot affect the respondent (Frey & Oishi, 1995).

The following pairs of institutions were selected controlling for R&D expenditures, type, and quality ranking from the sample of the study (Table 9). Two institutions in the low quartile for percentage of ECE international graduate enrollment and high quartile for both quality ranking and R&D; two institutions from the high quartile for percentage ECE graduate enrollment and low quartile for both quality ranking and R&D and two from middle quartiles for percentage enrollment and quality ranking and R&D expenditures. Quartiles were calculated with the assistance of the Excel program in the spreadsheet that includes all related data on the ECE programs of the sample.

A letter was sent to the participants explaining the rationale of the study and the requested follow-up phone interview, including the interview questions for their review and the estimated time for the telephone interview completion of 15 to 20 minutes. The interview questionnaire included 3 questions common for all participants and questions that address the individual domain of every group of participants (see Appendix). Interviews took place on different days during December 2006 and January 2007. Out of 36 candidates contacted, only 8 agreed to participate in the interviews.

CHAPTER 4

ANALYSIS OF DATA RESULTS

This study used quantitative and qualitative methods to obtain information on the strategies, environmental factors and selected departmental characteristics that are associated with graduate ECE international enrollment. The relation of variables is illustrated by the statistical analysis of survey responses. Follow-up interviews intend to clarify aspects of survey results and highlight the principal causes of declines in graduate international enrollment in the institutions of the participants.

At the end of July 2006, the survey participants received an electronic letter explaining the scope and objectives of the study and reassured confidentiality; the letter had a link embedded that prompted to the survey. The survey participation window closed on August 25, 2006. A reminder electronic letter was sent eight weeks after the first deadline to those survey recipients who had not responded initially.

The analysis of the final survey results found **39** out of the **41** institutions with valid responses and a total of **62** respondents out of **123** survey recipients. Validity of a survey response was considered compromised when no survey questions were completed, although the administrator/academic head might have visited the survey site and when an entire section of the survey was not completed. Nineteen survey participants identified themselves as belonging to the job category “other”. Before the analysis of the survey results, they were recoded in one of the three administrative categories provided in the survey depending on the administrative office that they indicated. For instance, if they

were from the Graduate School of their institution, they were merged in the group of “graduate admissions officers.” Participants acknowledged the significance of the topic and the issues it addressed. Some survey participants followed-up with encouraging emails and requested the study results. Some others commented on the need for clarification of the term “graduate students” which was meant to include masters and doctorates. However, master students, do not receive teaching or research assistantships and financial aid is awarded when their doctoral research proposals are approved. National databases do not address this logistical quandary, because departments do not report when their students move to the doctoral status. This discrepancy is acknowledged, and is due to the fact that many master students may defend research proposals for their doctorates, while finishing their masters, in order to qualify for financial aid.

Only one participant made a negative comment about the name of the survey browser (survey monkey), as well as the server used (aol), and that created concerns to the recipient about the seriousness of the project.

Description of Survey Results

Survey results revealed the existence of differences among administrative units on knowledge and perception of issues related to international ECE graduate enrollment. They also revealed associations among short-term periods of decline with the overall international ECE enrollment over the 22-year period.

Responses to statements related to environment of ECE departments

Over half of the responding ECE department chairs agreed ($X=3.5$) that the increasing

interdisciplinary character of the electrical engineering field curriculum resulted in growing competition among other fields for international graduates.

Interestingly, ECE department chairs presented divided opinions on the effects of federal funding changes on the international graduate enrollments; one-third of the respondents agreed that decreases of federal funding is followed by decreases in international graduate enrollments, one-third were neutral and the others held opposite opinion. More than 70 percent of the respondents agreed ($X=4.06$) that visa restrictions decreased the number of applicants to their departments. Equally divided were the opinions on the effects of labor market fluctuations in the technology fields and the effects on international enrollments in ECE programs. Fifty percent (50%) of the respondents agreed that there are enrollment decreases followed by unemployment periods, whereas 11% disagree and 39% express neutrality on the statement. Less than one-fourth (15 of 54) of those surveyed agreed ($X=2.76$) that improvements in the higher education of developing countries resulted in decreasing enrollments in ECE graduate programs in the U.S. (Fig. 3).

Responses to Statements Related to Institutional Characteristics

There are four statements that concentrated the highest agreement among ECE chairs and administrators. Thirteen (72%) ECE department chairs surveyed agreed ($X=3.8$) that *the number of applications from international students has declined in recent years and more than two-thirds agree that these declines have been a major concern for their departments.*

In addition, over three-quarters of the chairs of ECE departments surveyed

agreed ($X=3.94$) with the statement *faculty has greater authority over international graduate admission than graduate admission officers* and with the statement that associates international enrollment with the quality of ECE department ($X=4.10$).

Responses to Strategy Statements

More than 60 percent of the ECE chairs surveyed agreed ($X=3.39$) that in their departments international ECE graduate students are encouraged to participate in privately funded extracurricular research, over three-quarters agreed ($X=4$) that their graduate ECE students are encouraged to participate in publicly funded departmental research and 50% of ECE chairs surveyed agreed that cooperating with ECE departments outside the U.S. is an effective strategy for the increase of ECE international graduate enrollment. Thirteen of eighteen ECE chairs surveyed agreed ($X=3.7$) that contacting international students who have expressed interest in their program has increased the number of international graduate enrollment in the department (Fig. 3).

Fifty-seven of sixty survey respondents (92%) agreed ($X=4.28$) that enrolled international graduates can be considered as a resource for the recruitment of new graduates. Fifty-five percent of the ECE department chair respondents agreed that increasing faculty visits to international countries has been an effective strategy for attracting international graduate engineers to their department.

Nearly 60 percent or specifically 33 of 56 of the survey respondents agreed ($X=3.68$) that state policies should be formulated with the purpose of attracting international graduate students into the state where their institution is located and less

than a third percent (31%) agreed ($X=2.87$) that flexibility in admission standards can be an effective strategy for the increase of international graduate enrollments.

Over seventy percent (44 of 60) of the respondents agreed ($X=3.8$) that the majority of their international graduates receive teaching and research assistantships.

In the statements addressed only by the ECE department chairs agreement was concentrated on the statement *International graduate students in your department are encouraged to take part in publicly funded departmental research* and contrary to the literature they expressed disagreement with the statement *Decreases of federal funding to your department have been followed by decreases in international graduate enrollments* (Fig. 3).

Data Analysis

Of the 23 survey questions that represented the independent variables, only ten (10) were addressed by all participants and all 23 by the ECE chairs. Therefore, for the other 13 statements, it was not possible to perform analysis of variance (ANOVA) for variances in agreement among ECE chairs, Graduate School Directors and International Student Office Directors.

ANOVA, t-tests, and multiple regressions were performed using the SPSS program. The ANOVA was performed to determine variance attributed to the job title of participants in the survey. For this sample, the multiple regression method may pose some difficulties, when there are more than five independent variables in the equation.

The reason is related to the relatively small sample size of approximately 60 survey responses that limits the total number of variables that can be incorporated in a regression equation (e.g. minimum of about 10 responses per variable). Taking this into

account, the regressions were performed on categorically logical groups of independent variables that ranged from 5 to 8.

The five strategy statements answered by all participants were selected for the first regression. To control for the effects that the variance of the quality ranking of the programs may have on the participant responses to strategy statements, the mean of quality ranking variable was introduced in the regression (Table 5).

Since there were distinct fluctuations in international ECE enrollments during the 1990s, the second regression examined association of past period enrollment with the overall enrollment during 1982-2003. For instance, the period 1990-1994 presented decline and the period 1995-1999 presented decrease (Table 6).

The third regression was performed on the five remaining non-strategy statements that did not pertain to enrollment strategies to examine the institutional effects on enrolment. Two of the statements addressed environmental factors and three addressed departmental factors including type of institution, ECE expenditures for 1982-2003 and ECE quality ranking (Table 7).

Initially an ANOVA statistic was calculated to compare agreement among the three groups of participants to the commonly addressed statements of the survey (Fig. 1) and to determine whether the differences between groups for each statement were statistically significant. ANOVA showed that the following statements have statistically significant group difference:

- *International graduate engineering enrollments have decreased in your institution, as a result of improvements in the graduate engineering programs in developing countries ($f=14.1, p<.001$).*

- *Periods of declines in international graduate enrollments at your institution are associated with changes in the admission standards of your graduate programs* ($f=3.62$ $p<.05$).
- *State policies should be formulated with the purpose of attracting international graduate students into your state* ($f=3.23$, $p<.05$) (Table 1).

If the (F) statistic that is computed to determine whether group differences exist in an ANOVA is significant, then follow-up t-test analyses are required to identify which pairs of group participants differ significantly. For the three strategy statements that the ANOVA showed significant group differences, a post-hoc analysis of mean comparisons (T-tests) for all common statements was generated to test which group of survey participants differs significantly from the other two in relation to the statements presenting statistical significance (Table 3) (Stangor, 1998, p. 174; Graziano & Raulin, 2000, p. 429).

Agreement to the ten statements answered by all participants varies as shown in Fig. 1. The least agreement was to the statement related to the declines as outcome of admission standards. The highest level of agreement was observed for the statement that considers currently enrolled international students as a means of recruiting future graduates. Several statements presented significant differences among groups of participants, as explained in Table 3.

The statement *State policies should be formulated with the purpose of attracting international graduate students into your state* presented significant difference between the international program directors ($X=4.14$) and the ECE ($X=3.3$) department chairs/heads ($t= -2.61$, $p=.01$, $df=37$) (Figure 1). The statement *Changes in the ethnic*

composition of international engineering graduates at your institution are associated with changes in the political system of sending countries was also included in the post hoc analysis results, because the ANOVA showed potential group differences with a probability $p < .08$.

The responses to the statement *international graduate engineering enrollments have decreased in your institution, as a result of improvements in the graduate engineering programs in developing countries* reveals that a statistical significant difference occurs ($t=5.26$ and $p < .001$ $df=37$) in agreement levels between ECE department heads/chairs ($X=3.6$) and directors of international student office ($X=2.2$). For the same statement there is also a significant difference ($t=-2.94$ and $p < .01$ $df=30$) between the graduate school directors ($X=2.7$) and the ECE department chairs/heads ($X=3.6$) (see Tables 2 and 3).

This finding addresses the first hypothesis of the study, according to which environmental and demographic changes associated with ECE graduate enrollments are subject to different perceptions among stakeholders, different levels of knowledge and interpretation. The statement *periods of declines in international graduate enrollments at your institution are associated with changes in the admission standards of your graduate programs* showed significant difference between the graduate school directors ($X=2$) and the ECE ($X=2.8$) department chairs/heads ($t= -2.34$ $p=.03$, $df=32$). There is also significant difference in the level of agreement between international program directors ($X=2.2$) and ECE chairs ($t= 1.99$ $p=.05$, $df=37$).

Fig. 1 Statements administered to all participants

1=strongly disagree, 5=strongly agree (*p<.05; **p<.001; n=63)

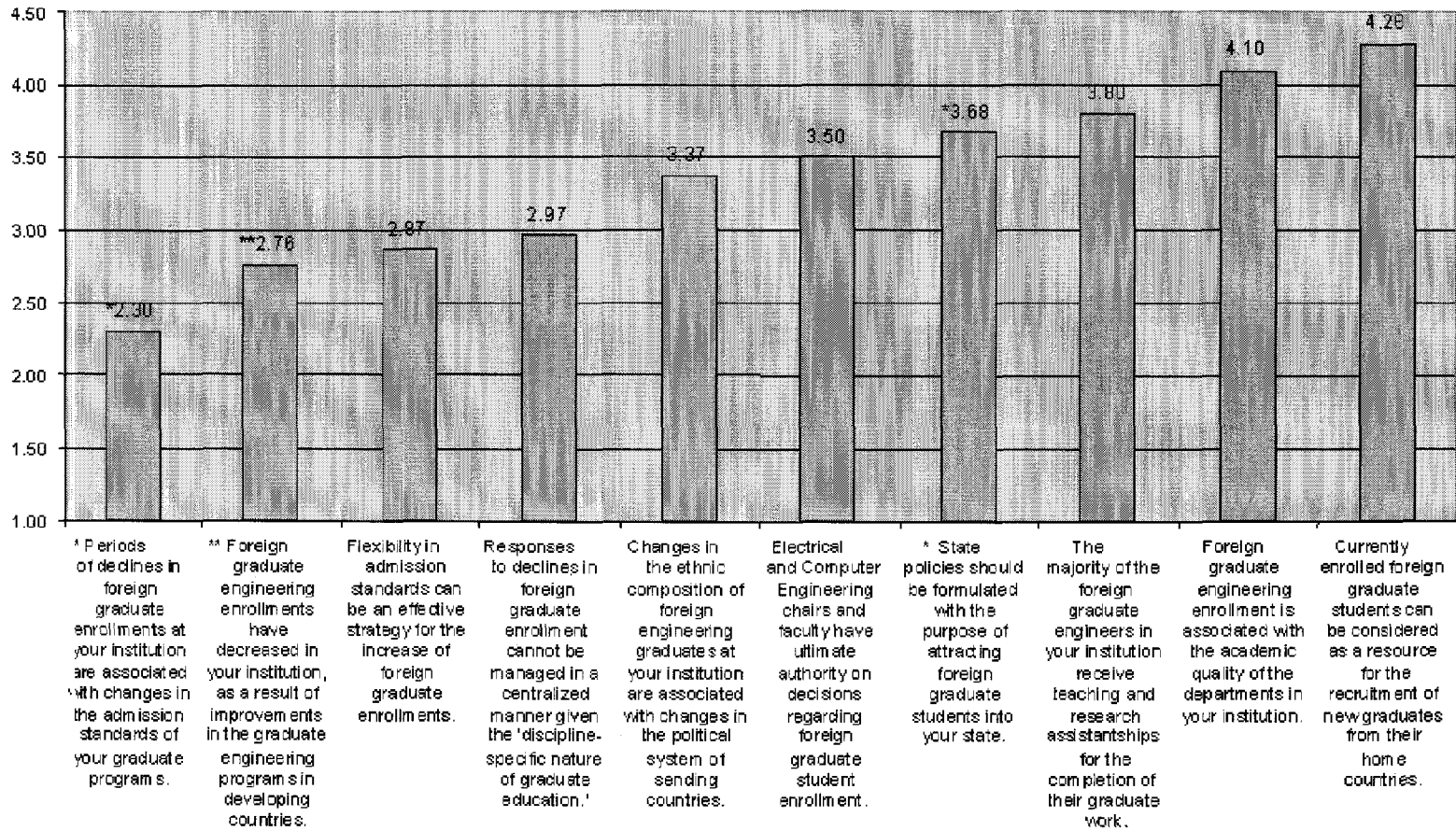


Fig. 2 ECE Chair Responses to Strategy Statements

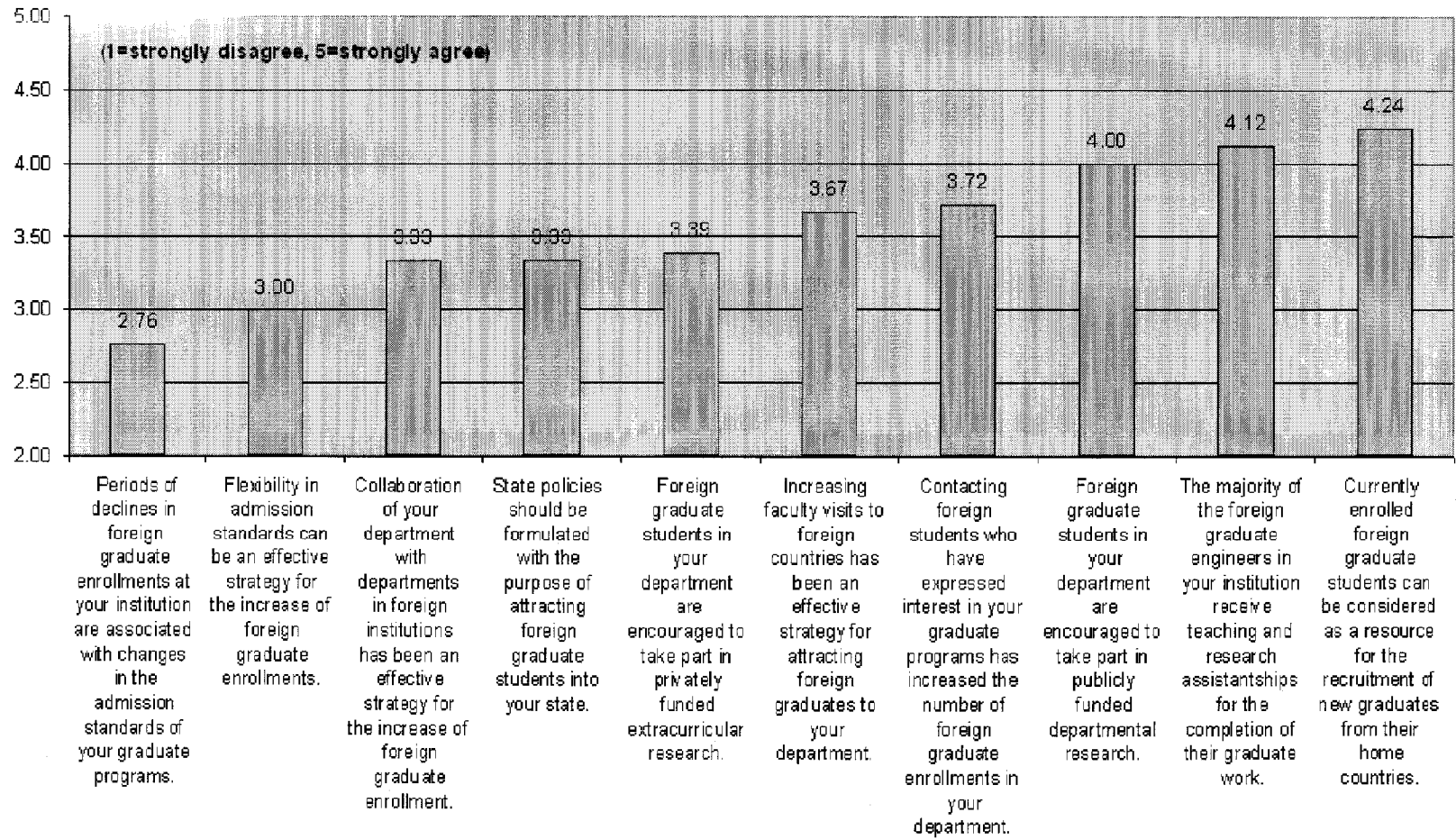


Fig. 3 Statements Completed by ECE Chairs

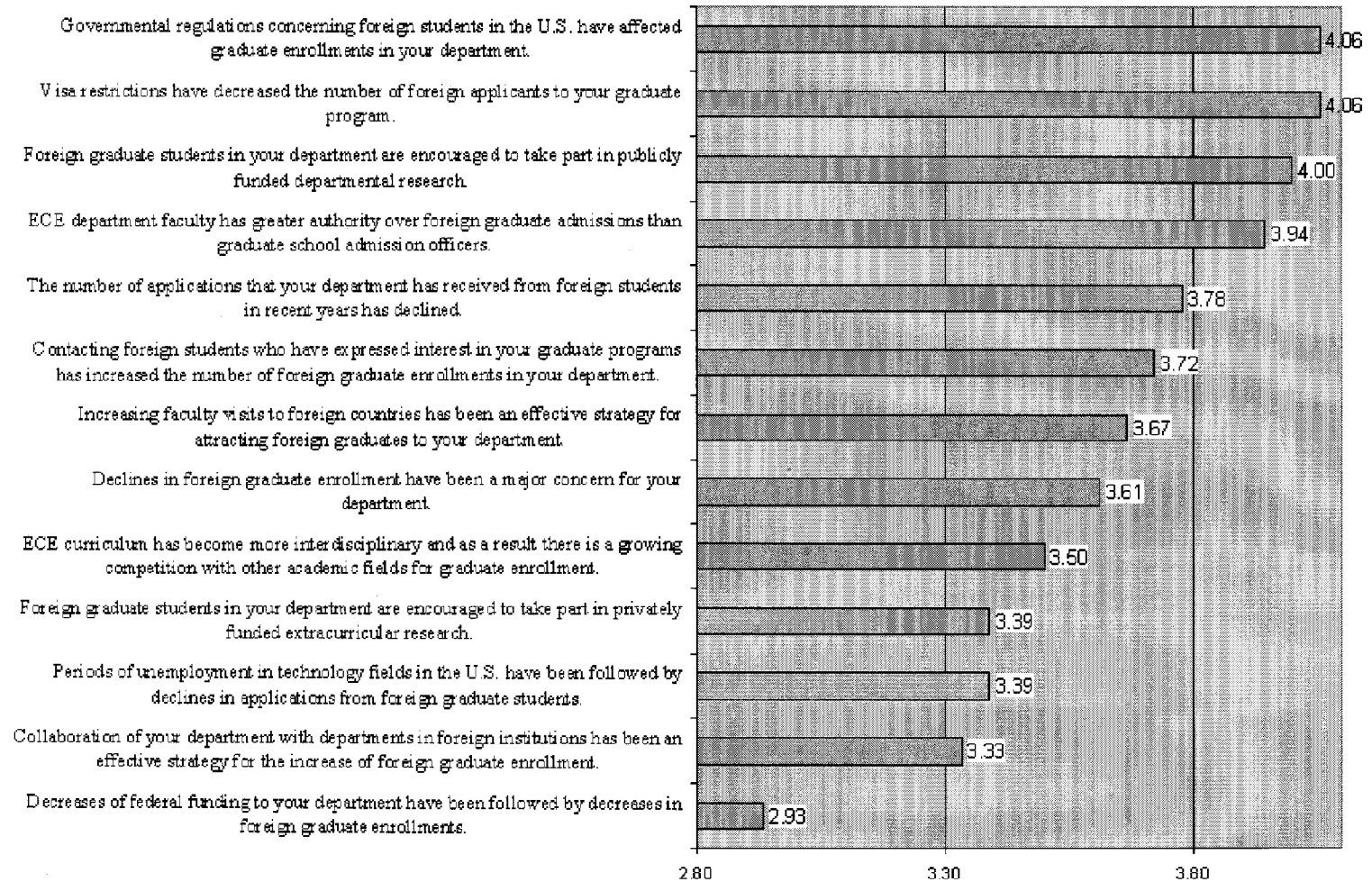


Table 1. ANOVA for ECE Chairs, Directors of International Student Offices and Directors of Graduate Schools

		Sum of Squares	df	Mean Square	F	Sig.
STATEPOL	Between Groups	7.40	2	3.70	3.228	.048
	Within Groups	60.80	53	1.14		
	Total	68.21	55			
DECLADMSD	Between Groups	5.50	2	2.75	3.619	.034
	Within Groups	40.33	53	.76		
	Total	45.83	55			
IMPINTED	Between Groups	19.14	2	9.57	14.06	.000
	Within Groups	34.72	51	.68		
	Total	53.87	53			

Table 2. Post hoc Analysis of Group Mean Comparisons for Levels of Agreement Among ECE Chairs, International Student Office Directors and Directors of Graduate Schools

		N	Mean	Std. Dev	Std. Err	Min	Max
STATEPOL	Director of Graduate School	17	3.47	1.28	.311	2	5
	Chair/Head of ECE	18	3.33	1.13	.268	1	5
	Director of International Office	21	4.14	.793	.173	2	5
	Total	56	3.68	1.11	.149	1	5
CHPOLS	Director of Graduate School	19	3.21	.855	.196	2	5
	Chair/Head of ECE	17	3.76	1.03	.250	2	5
	Director of International Office	23	3.22	.902	.188	1	5
	Total	59	3.37	.945	.123	1	5
DECLADMST	Director of Graduate School	17	2.00	.791	.192	1	4
	Chair/Head of ECE	17	2.76	1.09	.265	1	5
	Director of International Office	22	2.18	.733	.156	1	4
	Total	56	2.30	.913	.122	1	5
IMPINTED	Director of Graduate School	15	2.67	.816	.211	2	4
	Chair/Head of ECE	17	3.59	.939	.228	2	5
	Director of International Office	22	2.18	.733	.156	1	4
	Total	54	2.76	1.00	.137	1	5

Table 3. T-test for Equality of Means for Independent Samples Test

Director of Graduate Schools compared to ECE Department Chairs				
	t	df	Sig. (2-tailed)	Mean Diff.
CHPOLS	-1.761	34	.08	-.554
DECLADMST	-2.340	32	.02	-.765
IMPINTED	-2.942	30	.006	-.922
ECE Department Chairs compared to International Office Directors				
	t	df	Sig. (2-tailed)	Mean Diff
STATPOL	-2.607	37	.01	-.810
CHPOLS	1.784	38	.08	.547
DECLADMST	1.994	37	.05	.583
IMPINTED	5.258	37	.00	1.406

An independent t-test was performed to examine the differences in agreement between respondents from public and private institutions. Differences were found in the following statements (Table 4):

- *International graduate engineering enrollment is associated with the academic quality of the departments in your institution (t=2.013, p=.05, df=30) with greater agreement from respondents from private (X=3.4) than public institutions (X=3.0).*
- *The number of applications that your department has received from international students in recent years has declined (t= -3.94, p=.04 df=16) with greater agreement among respondents from public (X=4.13) than private (X=2) institutions.*

- *Declines in international graduate enrollment have been a major concern for your department* ($t = -1.98$, $p = .06$ $df = 16$) with greater agreement among respondents from public ($X = 3.8$) than private ($X = 2.67$) institutions (Table 4).

Table 4. Public and Private Institutions Independent Samples T-Test

	T	df	Sig. (2-tailed)	Mean Difference
INTENRQUAL	2.013	30	.05	0.397
APPLDECL	-3.939	16	.00	-2.133
DECLCONCERN	-1.983	16	.06	-1.133

In order to examine the predicting power that the quality ranking variable and strategy statements—that stood out for agreement by all participants—have on the enrollment changes, enrollment variable is regressed against the six independent variables. The regression equation presented a significant proportion of variance in the dependent variable explained by the five strategy statements and the mean of quality ranking for ECE programs (Table 5).

Table 5. Multiple Regression with Number of International ECE First Time Graduate Students 1982-2003 Regressed on Strategy Statements and Quality of ECE Program

Model Summary (a)						
R	R-Square	Adjusted R-Square	F	df 1	df 2	Significance F
.66	.437	.334	4.266	6	33	.003
a. Dependent Variable: International first-time ECE graduate students 1982-2003						
Predictors	Unstandardized B	Standardized Beta	T	p-value		
(Constant)	130.471		.727	.473		
TEACHREASASSIST	-86.245	-.512	-3.709	.001		
COLLABGRADS	87.567	.331	2.236	.032		
DECLADMST	52.251	.328	2.170	.037		
FLEXADM	16.188	.119	.830	.413		
STATEPOL	-46.998	-.328	-2.209	.034		
QUALITY	30.908	.162	1.166	.252		

For each independent variable, i.e. for each statement addressing preferred strategy of response, along with the measure of quality for every ECE program in the sample, as shown in Table 5, a unit change in the agreement scale will result in change in the number of international ECE, first-time graduates, indicated by the B value. For example, holding all independent variables constant, except state policies in the regression, there is a drop of 47 students (Table 5).

An unexpected finding concerns a unit increase in the scale of agreement to the statement *the majority of the international graduate engineers in your institution receive teaching and research assistantships for the completion of their graduate work that*

corresponds to a drop of 86 students in the ECE international graduate enrollment. The statement intended to address the doctoral students but as indicated by certain participants of the survey, it was unclear because the term “graduates” includes also masters who are not eligible for financial aid. Therefore, the respondents’ confusion has certainly compromise the validity of responses.

Approximately 33 percent of the variance in the percent of first time, international graduates-adjusted R Squared- is explained by $F=4.266$, $p=.003$, i.e. the significance of the actual regression model as a whole by the following strategy statements (Table 5):

- *the majority of the international graduate engineers in your institution receive teaching and research assistantships for the completion of their graduate work (t=-3.7 i.e. the indication of the significance of change that the independent variable effects on the dependent $p<=.001$).*
- *currently enrolled international graduate students can be considered as a resource for the recruitment of new graduates from their home countries (t=2.24; $p=.032$).*
- *periods of declines in international graduate enrollments at your institution are associated with changes in the admission standards of your graduate programs (t=2.17; $p=.037$).*
- *state policies should be formulated with the purpose of attracting international graduate students into your state (t= -2.21; $p=.034$).*

Table 6. Multiple Regression with Percent of International ECE Graduate Students and ECE R&D Expenditures, Institution Type, Quality Ranking and Recent Enrollment Trends.

Model Summary (a)						
R	R Square	Adjusted R Square	F	df1	df2	Sig. F
.682(a)	.466	.405	7.66	5	44	.00
a. Dependent Variable: Percent international ECE graduate students 1982-2003						
Predictors	Unstandardized Coefficients B	Standardized Coefficients Beta	t	Significance		
(Constant)	1.353		7.341	.000		
Percent international ECE graduate 1995-1999	-1.123	-.278	-2.330	.024		
Percent international ECE graduate 1990-1994	-.104	-.028	-.238	.813		
Type 0=private 1=public	-5.388E-02	-.135	-1.070	.290		
ECE expenditures 1982-2003	-1.006E-07	-.153	-1.080	.286		
ECE quality ranking	-9.835E-02	-.506	-3.220	.002		

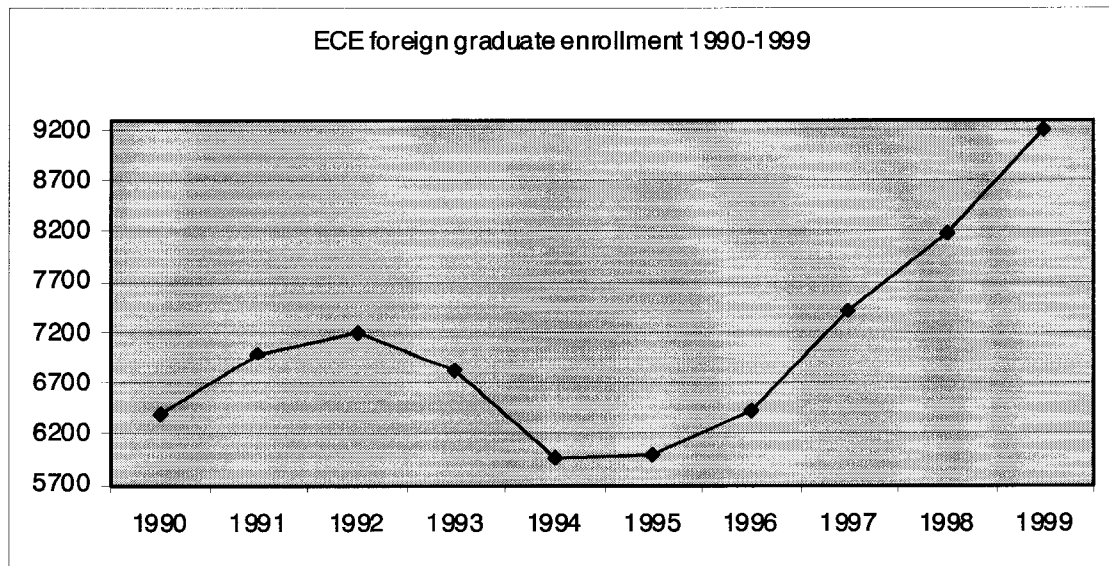
The effect of two 5-year periods 1995-1999 and 1990-1994, when most of the international enrollment declines were observed in ECE programs, was examined for association with the overall enrollment changes at the programs. The results show that over 40 percent (i.e. Adjusted R-square) of the variance in percent ECE international graduate enrollment is explained by quality ranking and the 5-year period percent in international graduate enrollment 1995-1999 (Figure 4).

In order to explore the extent that expenditures and quality have influenced international graduate enrollment changes, a third multiple regression was performed with percentage of international ECE graduate students regressed on R&D expenditures, institutional type, department prestige and the five survey statements administered to all participants not identified, as being associated with department strategies.

Over 30 percent (adjusted R-square) of the variance in the percent of international ECE graduate enrollment over the last 20 years was attributed to R&D expenditures, and the statements,

- *electrical and computer engineering chairs and faculty have ultimate authority on decisions regarding international graduate student enrollment, and*
- international graduate engineering enrollment is associated with the academic quality of the departments in your institution (Table 7).

Figure 4. Percent of First-Time International ECE Graduate Enrollment
1990-1999



R&D expenditures were negatively associated with enrollment growth. A unit move towards more positive agreement with the statement associating international graduate enrollment with academic quality is associated with over 7 percent increase in international graduate enrollment for the period from 1982 through 2003 (Table 7). This is confirmed by the examination of the percentage of international participation in ECE programs in relation to the mean of quality ranking of the institution.

As R&D expenditures for ECE programs of the sample increased, percent of international ECE enrollment decreased (Table 7). For instance, ECE in Stanford is among the programs with the highest amount in R&D expenditures for a 22-year period but it is not among the highest for percent international enrollment for the same period.

As the broad range of years 1982-2003 encompassed a variety of events with uncertain impact on ECE enrollment, another regression was performed to examine a

narrower period covering the most recent 5-year period (1999-2003) of ECE graduate enrollment. The 5-year ECE international graduate enrollment percent was regressed on all statements (strategy, institutional, and environmental) with predictive importance in explaining ECE graduate international enrollment in the prior regressions (Tables 5-7).

The regression revealed that ECE international graduate enrollment was negatively related to quality ranking and positively related to the statement, *Periods of declines in foreign graduate enrollments at your institution are associated with changes in the admission standards of your graduate programs.*

Table 7. Multiple Regression, with Percent of International ECE graduate students and ECE R&D Expenditures, Institutional Type, Program Quality Ranking and Departmental Characteristics

Model Summary (a)						
R	R Square	Adjusted R Square	F	df1	df2	Significance F
.662(a)	.438	.306	3.311	8	34	.007
a Dependent Variable: Percent international ECE graduates 1982-2003						
Predictors	Unstandardized B	Standard Beta	t	Sig.		
(Constant)	.284		1.912	.064		
ECEFACAUTH	-.08	-.592	-3.807	.001		
IMPINTED	2.41E-02	.165	1.209	.235		
CHPOLS	-8.89E-03	-.061	-.441	.662		
INTENRQUAL	.072	.382	2.673	.01		
WAYOFRESP	3.12E-02	.242	1.642	.110		
Type 0=private 1=public	7.48E-02	.225	1.480	.148		
ECE expenditures 1982-2003	-3.06E-07	-.425	-2.037	.049		
ECE academic quality	.0596	.354	1.594	.120		

For each unit increase in department quality ranking mean, there was nearly 8 percent decrease in international ECE graduate students and for each step in agreement with the statement concerning periods of declines associated with changes in admissions standards there was over a 6 percent increase in ECE international enrollment. Thus, the statement that associates declines in foreign enrollments to changes in admission standards was paired with

mean of quality ranking, as predictive of percent of ECE international enrollment for the years 1999-2003. Departments with higher quality ranking had lower percent international graduate students and declines in the percentage of ECE international graduate students may be attributed to the changes into more rigid admission standards.

Table 8. Multiple Regression with Percent of International ECE Graduate Students 1999-2003 and Environmental, Institutional, and Strategy Predictive Statements.

Model Summary						
R	R Square	Adjusted R Square	F	df1	df2	Significance F
.683(a)	.466	.356	4.243	7	34	.002
Predictors		Unstandardized Coefficients B	Standardized Coefficients Beta	t		Sig.
(Constant)		.804		5.005		.000
QUALITY		-7.778E-02	-.456	-3.374		.002
STATPOL		-3.373E-02	-.267	-1.773		.085
TEACHREASASSIST		-1.430E-02	-.097	-.735		.468
ECEFACAUTH		4.568E-04	.003	.023		.982
COLLABGRADS		4.016E-02	.172	1.193		.241
INTENRQUAL		1.649E-02	.093	.653		.518
DECLADMST		6.274E-02	.427	2.929		.006
a Dependent Variable: 1999-2003 percent ECE graduate enrollment						

Further analysis and categorization was conducted considering selected institutional characteristics of the programs. Through the excel program ECE departments of the sample were categorized in top and bottom quartiles based on the following characteristics: size of the institution (number of total graduate enrollments), total international graduate enrollments in the ECE programs for a 22-year period (1982-2003) percent of international ECE graduates in the program, quality ranking and total R&D expenditures of the ECE programs for the 22-year period (1982-2003). The categorization confirmed the regression finding that ECE programs that belong to institutions included in the top quartile for R&D expenditures belong to the bottom quartile for percent of international participation (Table 9).

Table 9. Institutions Ranked by Size, Total International ECE Graduate Enrollment, Percent of International Graduate ECE Enrollment, Quality of ECE Academic Program and R&D Expenditures.

	<u>TOP QUARTILE</u>	<u>LOW QUARTILE</u>
Size of the Graduate Program	Ohio State Rutgers State U. of Texas Arizona State U. U. of Florida Penn State U. of Wisconsin-Madison University of Illinois at Urbana U. of Michigan U. of Washington	Georgia Institute U. of Notre Dame SUNY at Buffalo MIT North Carolina Carnegie Mellon New Jersey Polytechnic Rensselaer Polytechnic Texas A&M Mississippi State U.
Total International ECE graduate enrollment	U. of S. California Stanford Michigan State U. U. of Texas-Austin Arizona State U. Georgia Institute of Technology U. of Wisconsin-Madison Virginia Polytechnic U. of Texas-Arlington University of Illinois at Urbana	SUNY at Buffalo Clemson U. Oregon State U. Mississippi State U. SUNY at Stonybrook U. of Missouri at Columbia Rutgers The State U. of NJ U. of Oklahoma U. of New Mexico U. of Notre Dame
Percentage of ECE graduate enrollment	Rutgers The State U. of NJ U. of Texas-Arlington U. of Missouri-Columbia SUNY at Stonybrook Louisiana State U. Mississippi State U. Arizona State U. U. of Oklahoma New Jersey Institute of Tech. Texas A&M University U. of Wisconsin-Madison U. of Southern California	U. of New Mexico Georgia Institute Carnegie Mellon U. of California-S.Barbara U. of Michigan Cornell University U. of California-Berkeley University of Illinois at Urbana U. of Washington -Seattle MIT
Quality Ranking	Stanford MIT University of Illinois at Urbana U. of California-Berkeley Michigan State U. Cornell U. U. of Southern California Carnegie Mellon	SUNY at Stonybrook SUNY at Buffalo U. of Texas-Arlington Clemson University Ohio State U. Louisiana State U. Mississippi State U. New Jersey Institute of Tech.
ECE Departments R&D Expenditures	Georgia Institute of Technology MIT U. of California-Berkeley Stanford U. of Michigan Pennsylvania State U. of Illinois at Urbana U. of Southern California U. of Texas-Austin U. of California-S.Barbara	SUNU at Buffalo U. of Texas-Arlington New Jersey Institute of Tech. U. of Notre Dame Mississippi State U. U. of Oklahoma U. of Missouri-Columbia Oregon State U. SUNY at Stonybrook Louisiana State U.

Interview Results

Approximately one month and a half after the survey completion, phone interviews were scheduled with selected participants from institutions in the sample, as discussed in Chapter 3. The main objectives of the interviews were to clarify aspects of survey responses on what administrators and ECE chairs considered as main causes of international enrollment decline in their institutions and departments, and how the decisions are made for international enrollment management. First, all participants were asked to indicate any landmarks events that would consider influential for international graduate enrollments during their career in higher education. The rationale for this question was to explore whether there are any events that have an impact on international enrollment, other than issues related to visa restrictions that have been already highlighted by the media and articles related to international students. Second, participants were asked to indicate the uniqueness of their position in the decision making on international enrollments.

As shown in the literature review factors outside the U.S. influence international graduate enrollments in ECE departments. Systematic initiatives from international governments encourage their students to pursue advanced studies in the U.S. Singapore is one of those cases (Int'l. Student Office Director Dec. 4, 2006). Other countries such as Iran and Taiwan, that during the 1980s were top on the list of senders, do not send as many students any more (ECE Chair Dec.15, 2006). Technological growth, advancements in higher education and government incentives for students to remain home for graduate study have decreased significantly the enrollments of Taiwanese students in the U.S. (ECE Chair Dec.21, 2006).

However, not all academic leaders in ECE programs perceive the evolutions in higher education in Asia, and especially in China, as a threat.

Chinese students will eventually stop coming but this will not pose any threat to us. The U.S offers the integrated education. We are not only for the circuit design but also for the application and advanced building of a system. This is not so much the case in higher education of Asia. We are always entrepreneurial and we are pushed by the changes in Asia to stay on our toes (ECE Chair Dec.21, 2006).

U.S. institutions sign agreements with institutions overseas that they share a *niche* especially supported by the state economy.

We have many faculty members who go abroad and work out agreements between our university and universities in other countries. For instance, we are very much focused on agricultural studies and we have students from Thailand, who are interested in agricultural engineering studies. Our international students bring a lot on the table and this helps us make better programs (Dean of the Graduate School Dec. 14, 2006).

In many regions of the world, financial difficulties prevent students from pursuing advanced studies in the U.S.

Although African students do not present dramatic declines in raw numbers, they have declined dramatically in percentages. Economic and political events internationally clearly determine who comes and who does not. The school had no Chinese undergraduates during the past decades. The last few years, Chinese undergraduates have increased, because the economy in China has undergone significant development and students can finance themselves (Int'l Student Office Director Dec. 4, 2006).

State policies, that impose the out-of-state fee international graduates, affect colleges of engineering, and subsequently ECE departments that support financially the majority of their graduates.

One factor that creates obstacles to recruitment operations is the imposition of the out-of state tuition fee. I can understand this policy for the undergraduate level but for graduate students is incomprehensible; it affects the college of engineering, because we bear the cost of subsidizing all our graduates (ECE Chair Dec. 13, 2006).

The main departmental and institutional factors that have an impact on international enrollment concern the availability of financial aid, the reputation of faculty and their connections with institutions overseas.

Financial aid is a big issue. If the institution has no money to support coming students, then this will affect graduate enrollments. The economy at the home country has also an impact on the overall international student enrollment (International Student Office Director Dec. 4, 2006).

The issue of quality boils down to faculty (ECE Chair Dec. 15, 2006).

International-born faculty in the graduate programs brings graduates from their native countries. Example was a Nobel Prize winner in physics faculty, who was bringing Chinese students in the science and engineering departments before even Tiananmen Square (Dean of International Enrollment Dec. 12, 2006).

Foreign-born faculty members assist in encouraging the arrival of more students to other disciplines, other than science and technology. Sometimes, it is hard for this faculty to be as effective because, they do not have direct relation with the disciplines the institution is targeting (Int'l Student Office Director Dec. 11, 2006).

Regional and ethnic discrepancies in the participation of international graduates in the U.S. institutions are strongly felt in some institutions in the south.

Discrepancies in the preference that foreign graduates have for certain institutions should alleviate and a better job should be done to reassure that, for instance, the East Coast is not the only place worth going for study. We also need to broaden and even out the interest of students for more disciplines and from more countries. For that reason we established two years ago the "ambassadors program" and through this program our current graduates visit their home countries with the purpose to hold meetings and recruit new graduates (Int'l Student Office Director Dec. 11, 2006).

With the exception of one public institution in the sample, participants emphasized the independence of the individual colleges and departments in decision

making on international graduate enrollment.

Decision making for enrollments is again a matter of individual college for graduate enrollments. The issue is overseen by the vice provost, who focuses mostly on undergraduate enrollments (Int'l Student Office Director Dec. 4, 2006).

The president of the institution sets the tone for the direction that the domestic and international enrollment management would follow (Dean of the Graduate School Dec. 14, 2006).

Interview participants highlighted events and conditions that have influenced the flow of international graduates in the U.S. Demographic changes in the U.S. graduate student cohorts; the increasing participation of foreign-born faculty in the U.S. higher education; and the increasing use of technology by the prospective applicants internationally stood out as most influential on international enrollment.

Immigration laws did not have a dramatic impact on our institution, as they have on other institutions. 9/11 was not as decisive factor as some may want to present it. It sounds that it is a confounding factor that obscures other factors already in place (Dean of International Enrollment Dec. 12, 2006).

9/11 was an astrophysical shock. It was not the determining cause of declines in ECE graduate programs. Declines had started before that event (Dean of the Graduate School January 12, 2007).

It is true that we are losing the technology mission in the U.S. I cannot be overly optimistic (ECE Chair December 21, 2006).

The last 15 years, the age of the U.S. cohort of graduate applicants has declined, while the sheer number of international graduate students has increased in percentages and quality (Dean of International Enrollment Dec. 12, 2006).

The introduction of the World Wide Web is a landmark event that has changed the application process and the contact of international students with U.S. institutions. The use of Internet has skyrocketed enrollments of international students in our institution Another important evolution

among legislators and administrators in higher education is the increased awareness of globalization and the realization that building a wall around them is not going to work for their institutions (Dean of the Graduate School Jan. 12, 2007).

Changes in the research paradigm of engineering and new market demands have broadened the scope of the curriculum.

If you ask me what the core knowledge is in my department, I cannot tell you. The field has become very broad. The curriculum can serve now a broad spectrum of graduates; there are options for every body. For instance, bottom half of my class can take bench designers jobs, management or sales (ECE Chair Dec. 15, 2006).

According to the survey results, over half of the participant ECE department chairs agreed that the increasingly interdisciplinary character of electrical engineering has created an atmosphere of competition with graduate programs in other fields.

Surprisingly, only 15 out of 54 respondents agreed that changes in the higher education of developing countries have an effect on graduate enrollments. Depending on the prestige and reputation of the program and on selected members of the faculty, the ECE chairs follow a more or less aggressive strategy of recruitment from institutions in Asian countries that consider “feeders” or “pipelines” of international students for their graduate programs (ECE Chair Dec.21, 2006 and Interim Dean of Graduate Studies Dec.14, 2006).

Limitations of the Data Gathering Techniques

Although the response rate of the survey is reasonable, the small number of participants from every individual group may compromise the ability to predict with confidence parameters regarding the respondents’ position on the statements of the survey. Another limitation concerns the multiple regression method and rests in the

nature of the relationships described in the results. The unique contributions of the independent variables on the dependent outcome are expressions of their unique *relationships*, and do not necessarily indicate any underlying causal mechanism of those relationships. The explanation of the relationships between variables included in a multiple regression analysis may not be entirely transparent. Thus, there is the potential for alternative causal explanations that may be explained by variables outside the analyses. Additional limiting factor may occur from potential alternative outcomes deriving from the missing and incomplete data that were not received from the survey, as about 50 percent of the ECE chairs, International Office and Graduate School Directors did not participate. The results and conclusions are based upon completed survey and those participating in follow-up interviews.

Inability to reach all eligible, selected respondents in the sample of phone interviews affects the generalizability of the findings, since those who responded to the phone interviews may have different opinions from those who did not (Frey & Oishi, 1995). Furthermore in telephone interviews, rapport cannot be established as easily as in person, and there are more omissions and incomplete responses, as many respondents tend to talk fast without necessarily completing a sentence before starting another (Frey & Oishi, 1995).

CHAPTER 5

SUMMARY OF FINDINGS AND DISCUSSION

The present research was triggered by continuous and alarming information on declines of international enrollment, due to a variety of factors within and outside the U.S. Projections on international enrollment reported during the 1980s were not proven accurate, as current numbers of international students in the U.S. are half of what it was estimated 20 years ago. Although reports by related agencies offer heads-up to policy makers, they do not provide in-depth information on the reasons disproportionate participation of international students continues in the U.S. graduate programs. They do not also offer in depth information on what accounts for the observed declines in graduate programs that are mostly comprised of international students.

The rationale for selecting ECE, as an area to highlight existing strategies that higher education in the U.S. follows to manage graduate international enrollment, was based on the following facts: it is a field with high concentration of international graduates, it belongs to a less politicized and culture free discipline, it is extensively internationalized; and academic research outcomes are disseminated and affect the world at a faster pace than one could encounter in humanities and social sciences.

Following the theory of organizational decline, the results of the study confirmed that ECE academic programs belong to these groups of graduate academic units that interact with multidimensional environments; within these environments, graduate programs are distinguished by a variety of research networks and faculty connections that

support and enhance international enrollment flow.

ECE departments adjust their priorities to meet challenges set by their “task environments.” Task environments include the competitor graduate programs within the U.S. and overseas; the “regulators,” i.e. the governmental agencies that monitor student visas, and American companies that move their operations in Asia and employ ECE graduates from Asian institutions. In response to a dramatically changing environment, American ECE programs have a well-established network of peer institutions, and they use these institutions as “feeders” for the recruitment of new graduates. In addition, faculty with international reputation who has joined ECE programs operates as a pole of attraction for international graduates.

The environments and interests of academic fields are diverse, and the jurisdiction and knowledge of administrators regarding international enrollment management at a graduate level are often limited. The survey and interview results confirmed that the response of institutions of higher education to changes in international graduate enrollment is not supported by a centralized system of decision-making, but it is subject to departmental interest and discretion. Participants in the study have endorsed the significance of international presence in higher education, but they are unable to react in a concerted manner to international enrollment changes.

Perceptions of administrators and academic leaders do not suffice to define adequately the outcomes of actions to forestall potential declines, when a combination of institutional attributes, such as quality ranking, expenditures and systematic collaboration with international institutions are not present. One institutional attribute alone cannot explain enrollment variations, as was the case with many ECE departments during the

1990s, when funding cutbacks did not necessarily affect international enrollment.

The regression results may offer insights to administrators and ECE department chairs to develop effective models for predicting and managing enrollment, focusing on the factors that appear associated with international enrollment and they are related to the ECE field environment, institution and department characteristics. For example, regression analysis revealed that foreign ECE graduate enrollment was greater in departments ranked lower on quality ranking and that greater agreement was reported for the statement concerning international ECE graduate students being associated with academic quality.

It cannot be concluded that international students contributed to ECE department quality ranking. However, based on the participants' agreement to the statement that international students enhance department quality, it may be presumed that ECE programs at lower quality ranking recruited international students with the purpose to improve the quality of the department.

Summary of Findings

1. The distinct finding of the study is that a clear and strong academic *niche* favors the support of international graduate enrollment; without that *niche*, enrollment management mechanisms cannot have a *raison d' être*, and there is no compelling need for related policy formulation and implementation.

2. The ECE programs that manifest *dependence* on international graduate enrollment belong to the middle and low quartiles in quality ranking. However, even academic programs in the top quartile for quality ranking have experienced up to 60

percent decline in international ECE enrollment the last 5 years, and this holds true, even controlling for the size of the institution and R&D expenditures. There was concurrence among the survey participants from all types of institutions that dependence on international enrollment will become more pronounced in the future.

3. Quality ranking was not statistically significant in the regression equation with percent international enrollment for the 1982-2003 years in relation to strategy of response variables.

4. Type of governance (public/private) was not statistically significant either, controlling for expenditures and quality along with five statements answered by all participants (Table 7).

5. Following the regression equation (Table 5), there is support for the view that state policy formulation can impact international enrollment. Representatives of institutions with fewer international ECE graduates agreed more strongly with the statement addressing the need for state policies regarding support of international enrollment. This statement may concern more participants from public institutions, as they are not autonomous, and they are more dependent on state support than participants from private institutions. An interesting finding concerns the mean differences between international student office directors and ECE chairs on that statement (Table 2 & 3). This finding may address an occupational interest of the international student office directors, who link the viability of their position with the presence of international students in their institution. However, ECE chairs are concerned about the imposition of out-of-state student fee that is a burden for the departments that subsidize the doctoral study of international students.

6. ECE programs, where department chairs stated that they have the ultimate authority on decisions related to international enrollment management, have lower percentage of international enrollment. Nonetheless, those who agreed could be expressing how things should be and not necessarily how things are. In other words, departments with lower percentages of international graduates may be conveying the need to have more authority in international enrollment matters. The finding may also convey the opinion of chairs from departments that have enough domestic graduates and therefore, fewer positions for international graduates.

7. Disagreement with the statement related to the association of funding decreases and international enrollment may be attributed to the generous funding that ECE departments in the top quartile receive, and participants may not relate with the meaning and purpose of the statement.

8. Contrary to the literature, some ECE chairs disagreed with the statement addressing the labor market effects on the international graduate enrollment; and with the statement on the negative effects that improvements in the higher education of developing countries may have on higher education in the U.S. Again, this may imply that ECE chairs, given their ties with industry, can support their international graduates in finding employment in the U.S. after graduation, and, therefore, may not perceive the changes in the labor market, so directly threatening for their international enrollments.

9. The observed mean differences between the ECE chairs and international student office directors can be attributed to some critical differences that characterize their roles. ECE chairs have direct and consistent contact with students who originate in countries that have experienced dramatic political changes; Iran, China, Taiwan, India,

South Korea, and Russia are some of the countries that have become subject to dramatic political and economic changes within the last 25 years. On the other hand, international student office directors see a broader range and variety of students from other countries and they cannot afford to focus only on students directed to a single field or program. In addition, stakeholders with service for more than 15 years have a more thorough view of the impact that political changes internationally can have on the ethnic composition of the international student body.

10. The ECE chairs were neutral in implicating changes in admission standards to international student declines. The directors of international student offices and graduate schools were even less likely to implicate admission standards as a factor in declining enrollments. The reason for this discrepancy may be due to the better idea that ECE chairs have in equating international cohorts and thus, they may not see admission standards as relevant as other factors.

11. ECE departments that presented increases during the 1995-1999 period rebounded from earlier enrollment decreases (Fig.4), and had a higher percentage of international students than over the extended period (1982-2003), i.e. $B = -1.123$ with a significance of .024 (Table 6). Also, departments at a lower quality ranking enrolled a greater percentage of international graduates. This finding may imply that a notable event triggered an influx of international graduate enrollments in ECE programs. For instance, during the 1995-1999 years, many Chinese students fled China, they obtained U.S. citizenship as political refugees, and they joined graduate programs in science and engineering.

12. Contrary to the knowledge-based finding about the negative association of quality ranking and percent enrollment, there is an opinion/perception-based finding from

the survey and interview results and revealed that administrators and academics attribute the quality of ECE department in their institution to international participation (Table 7).

13. The greatest consensus was observed for the strategy statement asserting that existing international students support future recruitment, which implies that the existing ethnic networking of graduates within and outside the U.S. supports and attracts new graduates, as a mechanism independent from the institutions.

14. Flexibility in admission standards seems to have a positive contribution ($\beta=.23$) to enrollment, indicating possible support for reviewing admission standards. This does not necessarily mean that ECE departments compromise quality. It may mean that they value differently the credentials of their graduates, placing sometimes emphasis on qualitative rather than quantitative skill data. Both qualitative and quantitative data suggest that the chairs of ECE programs, graduate school administrators and international student office directors may have some distinct viewpoints on enrollment strategies; yet, the implementation depends upon the discretion of the ECE departments and is far from being an outcome of concerted action.

15. Through qualitative data, it was confirmed that there is a network of collaborations with institutions in developing countries in Asia that are feeders of international graduates. Faculty members are a strong link in this process as many of them are natives of those countries.

16. None of the ECE chairs confirmed that he/she had been confronted with restrictions in accessing information controlled by the federal government for academic research purposes, due to potential international student participation in that research.

17. Interviews have revealed that participants have different perceptions of the degree that ECE graduate programs experience declines in the applicant pool or in the actual graduate enrollments. Although the events of 9/11 may reasonably count as more influential for international enrollment change in the mind of most people, several participants did not consider this tragedy as the main cause of international enrollment decline and stated that there is a combination of factors that accounted for declining international enrollments long before 9/11.

18. Although all institutions of the sample have an international student office with several staff members, there is no concrete set of policies or systematic operations for international enrollment management either at institutional or departmental level. Only two of the participants shared information on newly established programs that are intended for recruitment of international students.

19. Participants other than the ECE chairs were not aware of the specifics of international graduate enrollment management in the ECE department in their institution, and they did not articulate any unique role that their division plays on the decision making for management of international ECE graduate enrollment. They emphasize that decision making for this matter is clearly in the hands of the Engineering School or the actual ECE program. Some participants emphasize that they welcome the best and the brightest from wherever they come, whereas others added that international graduates provide distinct and positive inputs in their programs.

20. In managing the issue of even distribution of international graduates in the U.S., participants from the international student offices implied that specific policies should be implemented at a federal and state level, indicating that their role is not

sufficient to alter regional discrepancies in international enrollment.

Discussion

ECE departments were established and grew as a result of the industrial and military expansion of the U.S. after the World War II. Initially a branch of physics departments, they became independent academic units towards the end of the 19th century. Computer engineering developed into science several decades later, when in the beginning of the 1970s, Stanford and MIT established the first computer science departments. On the road to technological superiority, ECE departments in research and doctoral universities received the support of generous funding from the federal government.

Like all academic departments, ECE departments have their own *niche* that determines enrollment trends for graduate students. International students have contributed considerably to the graduate education of the ECE field and the last two decades, they are the majority in most ECE programs. In their effort to maintain international student participation, some ECE units have shown more resilience and success than others. The present study considered this phenomenon and intended to explore the main reasons for its occurrence. It also intended to contribute to existed research and information for the stakeholders and students in international education. Other administrative units related to international enrollment may also find useful the following insights from this study:

Although academic departments have, in most cases, great autonomy over graduate admissions and recruitment, they may not be particularly effective, if they do

not consider the knowledge and assistance of other administrative units. Also, designated individuals, who oversee international enrollment at the Graduate Schools, may not be well aware of the particularities in the environment of an academic field, and the compelling need for international presence. As it was shown in this study, there are variations in agreement among administrators and academics on the type of strategies for the management of international enrollment and on the consideration of the risks that certain environmental factors pose for enrollment. Communication among stakeholders within an institution, therefore, is a necessary condition for successful international enrollment management.

As conveyed by the survey responses, state policies are considered important contributors to international enrollment management. Knowledge-based campaigns on the merits of international presence in graduate education, and concerted communication from stakeholders within an institution to the state boards of higher education are also necessary in support of favorable state policies for international students.

As discussed in the introduction, successful international graduate enrollment management is the outcome of coordinated actions among state officials and academic and administrative stakeholders; it is also related to the institutional leadership perception of the significance that international presence holds for graduate levels. ECE programs have a tradition in interacting with international students. In the coming decades, this tradition may be seriously challenged, as the curriculum of the field evolves, the domestic graduate enrollments are decreasing and higher education in the world that was once developing may determine the future of some academic units in the U.S.

Recommendations for Further Research

Through regression analysis, studies can be conducted for selected periods involving additional predicting variables for international enrollment changes, such as tuition increases in the U.S. and currency exchange rates. More qualitative studies, using a case study methodology, will highlight the unique niche of individual ECE departments; will highlight potential causes of declines, as experienced by the actual stakeholders in the field, as well as successful steps for controlling international enrollment at graduate level. Studies can also explore other academic fields, unravel the difficulties they experience, and the interests their individual programs have at stake, in their interaction with international students.

How enrollment data is gathered, tabulated and reported by national and other databases regarding international students is another critical issue worth researching.

APPENDIX

LETTER TO THE ECE CHAIRS

Dear:

I am a doctoral student at American University in Washington, DC. I am conducting a research for the completion of my doctoral dissertation on the factors that are associated with declines in international graduate student enrollments in the US in selected academic programs during a 21-year period (1983-2003) and on the possible strategies effective in reversing these declines. I selected electrical engineering, as the focus of my research, because it is one of the fields with the highest concentration of international students in graduate programs. Participants in this survey include directors of graduate schools, chairs of the departments of electrical engineering and directors of international student and scholar services.

As chair of the department of electrical and computer engineering at your institution, you can provide valuable insights to my inquiries. You are kindly requested to participate in a 5-minute survey through the link that I provide below.

All information, personal, departmental and institutional obtained from this survey will be strictly confidential and under no circumstances will ever your identity be associated with your responses. The conduct of this research and administration of survey have been approved by the IRB of the institution I attend.

Thank you very much, in advance for your cooperation and assistance.

<http://www.surveymonkey.com/s.asp?u=46502324482>

Sincerely,

Adamantia Tsoumpa

Ph.D. candidate, School of Education

American University, Washington, DC

LETTER TO THE DIRECTORS OF
THE INTERNATIONAL STUDENT OFFICE

Dear:

I am a doctoral student at American University in Washington, DC. I am conducting a research for the completion of my doctoral dissertation on the factors that are associated with declines in international graduate student enrollments in the US in selected academic programs during a 21-year period (1983-2003) and on the possible strategies effective in reversing these declines. I selected electrical engineering, as the focus of my research, because it is one of the fields with the highest concentration of international students in graduate programs. Participants in this survey include directors of graduate schools, chairs of the departments of electrical engineering and directors of international student and scholar services.

As director of the international student office at your institution, you can provide valuable insights to my inquiries. You are kindly requested to participate in a 5-minute survey through the link that I provide below. All information, personal, departmental and institutional obtained from this survey will be strictly confidential and under no circumstances will ever your identity be associated with your responses. The conduct of this research and administration of survey have been approved by the IRB of the institution I attend.

Thank you very much, in advance for your cooperation and assistance.

<http://www.surveymonkey.com/s.asp?u=46502324482>

Sincerely,

Adamantia Tsoumpa

Ph.D. candidate, School of Education

American University, Washington, DC

LETTER TO THE DIRECTORS OF
THE GRADUATE SCHOOL

Dear:

I am a doctoral student at American University in Washington, DC. I am conducting a research for the completion of my doctoral dissertation on the factors that are associated with declines in international graduate student enrollments in the US in selected academic programs during a 21-year period (1983-2003) and on the possible strategies effective in reversing these declines. I selected electrical engineering, as the focus of my research, because it is one of the fields with the highest concentration of international students in graduate programs. Participants in this survey include directors of graduate schools, chairs of the departments of electrical engineering and directors of international student and scholar services.

As an officer in charge of graduate international admissions at your institution, you can provide valuable insights to my inquiries. You are kindly requested to participate in a 5-minute survey through the link that I provide below.

All information, personal, departmental and institutional obtained from this survey will be strictly confidential and under no circumstances will ever your identity be associated with your responses. The conduct of this research and administration of survey have been approved by the IRB of the institution I attend.

Thank you very much, in advance for your cooperation and assistance.

<http://www.surveymonkey.com/s.asp?u=46502324482>

Sincerely,

Adamantia Tsoumpa

Ph.D. candidate, School of Education

American University, Washington, DC

Foreign ECE Graduate Student Enrollment Survey

The survey will take approximately 5 minutes of your time and you are kindly requested to complete it by October 6, 2006. If you have any questions or suggestions, please, feel free to contact me at mando7t@aol.com.

1. Is your college or university

Private Public

2. Please select your institution from the drop-down menu

3. Please check the box that describes your position?

Director of Graduate School
 Chair/Head of Electrical & Computer Engineering Department
 Director of International Student & Scholar Office
 Other (please specify)

Survey Instructions

The following survey intends to obtain information on the factors that determine foreign graduate enrollments in Electrical and Computer Engineering (ECE) departments and on potential strategies implemented to maintain or increase these enrollments.

The **first column** contains the statement numbers.

The **second column** contains the statements.

The **third column** concerns your level of agreement or disagreement with the statement. In this column, please circle **ONLY ONE** response category identified as follows: SD=Strongly Disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree **OR** circle NR if you find the statement is Not Relevant to your department.

Thank you.

2006 ECE Foreign Graduate Enrollment Management Survey		
ECE Department Chairs		
#	Statements	To what extent do you agree with the statement?
1.	The number of applications that your department has received from foreign students in recent years has declined.	.....SD.....D..... N ...A.....SA..... (NR)
2.	Declines in foreign graduate enrollment have been a major concern for your department.	.....SD.....D..... N ...A.....SA..... (NR)
3.	ECE curriculum has become more interdisciplinary and as a result there is a growing competition with other academic fields for graduate enrollment.	.....SD.....D..... N ...A.....SA..... (NR)
4.	Visa restrictions have decreased the number of foreign applicants to your graduate program.	.....SD.....D..... N ...A.....SA..... (NR)
5.	Governmental regulations concerning foreign students in the U.S. have affected graduate enrollments in your department.	.....SD.....D..... N ...A.....SA..... (NR)
6.	Periods of unemployment in technology fields in the U.S. have been followed by declines in applications from foreign graduate students.	.....SD.....D..... N ...A.....SA..... (NR)
7.	Decreases of federal funding to your department have been followed by decreases in foreign graduate enrollments.	.....SD.....D..... N ...A.....SA..... (NR)
8.	ECE department faculty has greater authority over foreign graduate admissions than graduate school admission officers.	.....SD.....D..... N ...A.....SA..... (NR)
9.	Foreign graduate students in your department are encouraged to take part in privately funded extracurricular research.	.....SD.....D..... N ...A.....SA..... (NR)
10.	Foreign graduate students in your department are encouraged to take part in publicly funded departmental research.	.....SD.....D..... N ...A.....SA..... (NR)
11.	Increasing faculty visits to foreign countries has been an effective strategy for attracting foreign graduates to your department.	.....SD.....D..... N ...A.....SA..... (NR)
12.	Contacting foreign students who have expressed interest in your graduate programs has increased the number of foreign graduate enrollments in your department.	.....SD.....D..... N ...A.....SA..... (NR)
13.	Collaboration of your department with departments in foreign institutions has been an effective strategy for the increase of foreign graduate enrollment.	.....SD.....D..... N ...A.....SA..... (NR)

2006 ECE Foreign Graduate Enrollment Management Survey

Graduate School and International Program Directors and ECE Department Chairs

14.	Responses to declines in foreign graduate enrollment cannot be managed in a centralized manner given the "discipline-specific nature of graduate education."	.....SD.....D..... N ...A.....SA..... (NR)
15.	State policies should be formulated with the purpose of attracting foreign graduate students into your state.	.....SD.....D..... N ...A.....SA..... (NR)
16.	Foreign graduate engineering enrollment is associated with the academic quality of the departments in your institution.	.....SD.....D..... N ...A.....SA..... (NR)
17.	Flexibility in admission standards can be an effective strategy for the increase of foreign graduate enrollments.	.....SD.....D..... N ...A.....SA..... (NR)
18.	Changes in the ethnic composition of foreign engineering graduates at your institution are associated with changes in the political system of sending countries.	.....SD.....D..... N ...A.....SA..... (NR)
19.	Periods of declines in foreign graduate enrollments at your institution are associated with changes in the admission standards of your graduate programs.	.....SD.....D..... N ...A.....SA..... (NR)
20.	Foreign graduate engineering enrollments have decreased in your institution, as a result of improvements in the graduate engineering programs in developing countries.	.....SD.....D..... N ...A.....SA..... (NR)
21.	Currently enrolled foreign graduate students can be considered as a resource for the recruitment of new graduates from their home countries.	.....SD.....D..... N ...A.....SA..... (NR)
22.	Electrical and Computer Engineering chairs and faculty have ultimate authority on decisions regarding foreign graduate student enrollment.	.....SD.....D..... N ...A.....SA..... (NR)
23.	The majority of the foreign graduate engineers in your institution receive teaching and research assistantships for the completion of their graduate work.	.....SD.....D..... N ...A.....SA..... (NR)

INTERVIEW QUESTIONS

To Graduate Officers

In the last 15 years what you would consider as landmark events that may have had an impact on international enrollments in graduate programs of your institution?

Who makes policies on international enrollment in your institution?

What factors determine the strategies to maintain, or increase or possibly decrease existing international enrollment in the graduate programs in your institution?

What strategies has your institution used to maintain or increase international graduate enrollments that have been effective?

To directors of international student office

In the last 15 years what you would consider as landmark events that may have had an impact on international enrollments in graduate programs of your institution?

Who makes decisions on policies for international enrollment in your institution?

What factors determine strategies to maintain or increase existing international enrollment in the graduate programs in your institution?

What strategies has your institution used to maintain or increase international graduate enrollments that have been effective.

What unique role does the international student office play in the decision making for strategies on maintaining, increasing, or possibly decreasing international graduate enrollment?

To ECE department Chairs

What factors do you think contribute to the academic quality of your department?

What characteristics of your graduate students are mostly associated with the quality of your graduate education (high GRE scores, publications, application skills, basic research skills, theoretical knowledge).

During your career as an electrical engineer what you would consider landmark events that have had an impact on international graduate enrollments in terms of increase or decrease?

What factors determine strategies to maintain or increase existing international enrollment in the graduate programs in your institution?

What types of strategies do you consider more effective and why to increase or stabilize international graduate enrollment?

Has international student presence influenced your research agenda? Why? or why not? For instance, would your department obtain easily federal grants or access to governmental information, if your research is conducted by international students?

ECE Department and Institutional Characteristics								
Institutions	Total of 1982-2003 foreign ECE graduate enrollments	Type of institution	Loc	Size of institution	No of graduates	International non-resident aliens	Quality rank	Total Academic R & D Expenditures 1982-2003
University of Southern California	9962	public	CA	32160	15779	5533	4	327762
Stanford University	6113	private	CA	18836	5494	3948	4.83	629202
University of Michigan, All Campuses	5935	public	MI	39533	14705	1216	4.38	605190
University of Texas at Austin	4858	public	TX	50377	10038	1284	3.88	271304
Arizona State University	4381	public	AZ	49,171	5,585	1,130	3	163914
Georgia Institute of Technology	4372	public	GA	16841		2872	3.93	1407019
University of Maryland at College Park	4175	public	MD				3.75	207567
University of Wisconsin-Madison	3535	public	WS	41169	9140	3427	3.77	159769
Virginia Polytechnic Institute and State Univ	3533	public	VA	27619	6289	555	3.3	211933
University of Texas at Arlington	3518	public	TX	25297	2847	3017	2.59	50882
University of Illinois at Urbana-Champaign	3338	public/land	IN	40687	7823	4748	4.7	352810
Rensselaer Polytechnic Institute	3194	private	NJ	7521	1202	203	3.44	142714
University of California-Berkeley	3131	public	CA	32814		2537	4.69	736257
University of Florida	3114	public	FL	47858	14875	574	3.26	94184
Ohio State University, All Campuses	2983	public	OH	50995	6996	1188	2.22	167672
University of Minnesota, All Campuses	2975	public	MN				3.73	91613
North Carolina State University at Raleigh	2899	public	NC	10030	1315	52	3.54	201896
Texas A&M University, All Campuses	2781	public	TX	7299	1477	116	3.25	100221
Massachusetts Institute of Technology	2723	private	MA	10320	5907	2485	4.79	846483
University of Colorado, All Campuses	2373	public	CO	32423		421	3.17	137334
Pennsylvania State U, All Campuses	2246	public	PA	41289	38596	3204	3.28	442356
Carnegie Mellon University	2217	private	PA	9803	4274	719	3.94	225120
Iowa State University	2213	public	IA	26380	5026	747	2.78	95263

ECE Department and Institutional Characteristics								
Institutions	Total of 1982-2003 foreign ECE graduate enrollments	Type of institution	Loc	Size of institution	No of graduates	International non-resident aliens	Quality rank	Total Academic R & D Expenditures 1982-2003
Cornell University, All Campuses	2185	private	NY	19578	5893	967	4.35	235673
University of Washington - Seattle	2174	public	WA	39199	11467	915	3.42	85396
University of California-Santa Barbara	2114	public	CA	21026	17529	259	3.71	243096
Columbia University in the City of New York	2091	private	NY	21648	14415	492	3.79	100625
New Jersey Institute Technology	2047	public	NJ	8249	1145	1384	1.66	44300
Louisiana State Univ, All Campuses	1994	public	LA	31561		1830	1.75	30733
SUNY at Buffalo, All Campuses	1732	public	NY	11072	543	120	2.6	54259
Clemson University	1658	public	SC	17110	2128	891	2.44	88029
Oregon State University	1642	public	OR	19153	3451	330		33265
Mississippi State University	1632	public	MS	14497	1877	423	1.67	42605
SUNY at Stony Brook, All Campuses	1625	public	NY	21685	2743	2055	2.63	31964
University of Missouri, Columbia	1554	public	MO	27003	2514	1400		34518
Rutgers the State Univ of NJ, All Campuses	1469	public	NJ	50552	5535	2876		71661
University of Oklahoma, All Campuses	1364	public	OK	28636	2545	1620		35379
University of New Mexico, All Campuses	1218	public	NM	26339	9050	906		75010
University of Notre Dame	1189	private	IN	11479	2302	322		42929

REFERENCES

- Aldrich, H. E. (1999). *Organizations evolving*. Thousand Oaks: Sage Publications.
- Aldrich, H. E. (1979). *Organizations and environment*. Englewood Cliffs: NJ: Prentice Hall.
- Altbach, P. G. (2004). Globalization and the University: Myths and realities in an unequal world. *Tertiary Education and Management*, 1 , 1-20.
- Altbach, P.G. (2005). India: A world-class country without world-class higher education. *International Educator*, 14(6), 14-17.
- Altbach, P.G. (1998). *Comparative Higher Education: Knowledge, the University and Development*. Greenwich, CT: Ablex Publishing Corporation.
- Altbach, P. G. (2004) . Doctoral Education: Present Realities and Future Trends, *College and University*, 80(2), 3-11.
- American Council on Education. (1982). *International students and institutional policy: Toward an agenda for action*. A report of the committee on international students. Washington, D.C.
- Aspray, W. et al. (Ed.). (2006). *Globalization and off-shoring of software*. New York: Association for Computing Machinery.
- American Association of Engineering Societies. Engineering Workforce Commission (2003) . *Engineering Degrees 2003*. Washington, D.C. Available at <http://www.aaes.org>.
- Association of American Universities. (1998). *Committee on Graduate Education: Report and Recommendations*. Washington, D.C.
- Bain, O., & Cummings, W. K. (2005) . Where have the international students gone? *International Educator*, 14(2), 18-27.
- Barber, E. G. (1985). *International students flows: Their significance for American higher education*. New York: Institute of International Education.

- Bess, J. L. (Ed.). (1984). *College and university organization. Insights from the behavioral sciences*. New York: New York University Press.
- Bollag, B. (2006). Enrollment of international students holds steady. *Chronicle of Higher Education*, 53(13), A44-45.
- Bollag, B. (2006). America's hot new export: Higher education. *The Chronicle of Higher Education* 52(24), A44.
- Bornsztein, B. (1987). Why did they come? A study of major factors which influence the international student's decision to apply for admission to selected graduate schools of education in the United States (Doctoral Dissertation, University of Minnesota, 1987). *Dissertation Abstracts International* 48 (01) AAT8710289.
- Braxton, J. M., & Hargens, L. L (1996). Variations among academic disciplines: Analytical frameworks and research. In J. Smart (Ed.), *Higher Education: Handbook of Theory and Research* Vol. XI. (pp.1-46) . New York: Agathon Press.
- Brinkman, P.T. & McIntyre, C. (1997). Methods and techniques of enrollment Forecasting. *New Directions for Institutional Research*, 93 Jossey-Bass Publishers.
- Brown, H.A. (2006). *Graduate enrollment and degrees: 1986 to 2005*. Washington, D.C.: Council of Graduate Schools. Available at www.cgsnet.org Retrieved October 29, 2006.
- Brown, H. A. (2005). *Findings from 2005 CGS International Graduate Admissions Survey I*. Washington, D.C.: Council of Graduate Schools.
- Cameron, K. S., Sutton, R.I & Whetten, D.A. (Eds.). (1988). *Readings in organizational decline*. Cambridge, MA: Ballinger Publishing Company.
- Cameron, K.S. (1983). Strategic responses to conditions of decline. Higher education and the private sector. *The Journal of Higher Education*, 54(4), 359-380.
- Cohen, L., Manion, L. & Morrison, K. (Eds.) . (2000). *Research Methods in Education* New York: Routledge Falmer.
- Committee on Science, Engineering and Public Policy (COSEPUP). (2005). *Implications of International Graduate Students and Postdoctoral Scholars in the U.S.* Washington, D.C.: The National Academy of Science. Available at: www.nap.edu/catalog/11289.html. Retrieved July 13, 2005.
- Cong, C., & Suttmeier, R.P. (2001). China's new scientific elite: Distinguished young scientists, the research environment and hopes for Chinese science. *The China Quarterly* , 960-984.

- Connell, C. (2006). Engineering for Internationalization. *International Educator*, 15(6), 41-48.
- Connor, K. (2006, March 10-14). Why Globalization? In Presentation as part of the symposium *Globalization opportunities for electrical and computer engineering* at the Annual Meeting of the Electrical and Computer Engineering Department Heads Association (ECEDHA). Hawaii. Available at <http://www.ecedha.org>.
- Creswell, J.W. (2003). *Research Design. Qualitative, Quantitative and Mixed Method Approaches*. Thousand Oaks: Sage Publications.
- Deutch, J. (1991). The International policy of U.S. universities. *Science*, 253, 492.
- DeVellis, R. F. (2003). *Scale Development*. Thousand Oaks Ca: Sage Publications.
- Driessner, J. R. (1993). Environmental and institutional characteristics and academic strategic action variables in small private colleges, and their relationship to enrollment changes in the 1980s. (Doctoral Dissertation, Portland State University, 1993). Dissertation Abstracts International 55(01) AAT 9412554.
- Engineering Task Force. (2005). *The Engineering Workforce: Current State, Issues and Recommendations*. Arlington: VA: National Science Foundation.
- Engineering Trends Quarterly Newsletter. (2006 Winter) . Available at http://www.engtrends.com/et_quarterly_summer-2006.htm.
- Epstein, E.H & Kuo W. (1991). Higher Education. In Douglas C. Smith (Ed.) . *The Confucian Continuum: Educational Modernization in Taiwan*. New York: Praeger Publishers.
- Farrell D. & Grant, A. (2005). China's looming talent shortage *TheMcKinsey Quarterly*, 4. Available at: <http://www.mckinseyquarterly.com>
- Fortescue, A. & Newland, K. (2004). A hard line on visas can only harm America *Financial Times* (UK) 17.
- Frei, J. H. & Oishi-Mertens, S. (1995). *How to conduct interviews by telephone and in person*. Thousand Oaks: Sage Publications.
- Fulton, I. A. School Engineering. Department of Electrical Engineering. (2005, Spring). *EE Connections*. Electrical Engineering Alumni Newsletter 2(2) ,1-8. Retrieved May 5, 2005 from Arizona State University web site: http://www.fulton.asu.edu/~eee/alumni/documents/EE_07_newsletter.pdf

- Gamal, A. et al. (2006, September 25). *A strategic plan for electrical engineering at Stanford*. Stanford University :Available at <http://wwwee.stanford.edu/forms/eeplan.pdf>
- Geiger, R. L.(1993). *Research and relevant knowledge. American research universities since World War II* . New York: Oxford University Press.
- Gilman, V. & Schultz, W. G. (2004) . U.S. Schools Losing International Talent. *Chemical and Engineering News*, (82) 14, 67-70.
- Goodwin, C. D. & Nacht, M. (1983). *Absence of decision*. New York: Institute of International Education.
- Graziano, A. & Michael Raulin, M. (2000). *Research methods: A process of inquiry*. Boston: Allyn Bacon.
- Greenberg, D. S. (2004, May 19). What scientist shortage?" *The Washington Post*, A23.
- Gueverra, J. (2001) . Women's Colleges in Massachusetts: Responses to Enrollment Declines. *The Review of Higher Education*, (24)4 , 351-368.
- Hannan, M. T. & Freeman, J. (1977). The population ecology of organization. *American Journal of Sociology*, (82) 5, 929-964.
- Heenan, D. (2005) . *Flight Capital*. Mountain View, CA: Davies-Black Publishing.
- Heller, D. E. (1999). The effects of tuition and state financial aid on public college enrollment. *Review of higher education*, 23(1), 65-89.
- Hira, R. (2003). *Boom-Bust Cycles: A New Paradigm for Electrical Engineering Employment*. Available at: <http://www.todaysengineer.org/2003/Aug/Unemployment.pdf>
- Holden, C. (1993). International nationals change the face of U.S. Science. *Science New Series*. 261(5129) , 1769-1771.
- Hossler, D. (1987). Enrollment management: Institutional applications. *College and University* 62 (2) , 106-116.
- Hossler, D. (1990). *The strategic management of college enrollments*. San Francisco: John P. Bean & Associates.

- Hsiung, D. (2005). *China's science and technology system: Challenge and change: Report for the environment, science, technology and health section*. (U.S. Embassy, China: 2005. Forthcoming).
- Institute of International Education. (2005). *Open Doors Report*. New York
- Jenkins, H. M. (Ed.). (1980). *International Student Recruitment: Realities and Recommendations*. New York: College Entrance Examination Board.
- Jenkins, H. M. (1983). *The role of international student in the process of development*. Washington DC: National Association of Foreign Student Affairs.
- Kannankutty, N. (1996). Academic engineering research in the United States: Characteristics and trends (Doctoral Dissertation, Washington University, 1996) Dissertation Abstracts International 58(01) AAT 9719220 .
- Kaplan, R. (1987). International students: Developing institutional policy. *The CollegeBoard Review*, 143 .
- Kenney, M & Dossani R. (2005). Off-shoring and the future of U.S. engineering: An overview. *The Bridge 35(3)* Available at <http://www.nae.edu/NAE/bridgecom.nsf> Retrieved March 24, 2007.
- Kotkin, J. (1993, February 24). Enrolling international students will strengthen America's place in the global economy. *The Chronicle of Higher Education*.
- Kraatz, M. & Zajac, E. (1996). New institutionalism and illegitimate organizational change. *American Sociological Review*, 61, 812-836.
- Levinson, E. (1998). Is the U.S. losing its edge in international recruitment? OSEAS survey says "Yes!" *OSEAS PEG Report*. Washington, D.C.
- Lewington, J. (1997, October 24). Canadian universities see US as a fertile ground. *The Chronicle of Higher Education* , A63-A64.
- Litwin, Mark S., (1995). How to Measure Survey Reliability and Validity. In A. Fink *The Survey Kit* . Thousand Oaks, Ca: Sage Publications.
- Lochhead, C. (2003, October 1). Congress cuts visas for skilled international workers. *San Francisco Chronicle*, A3.
- Maddox, A. B. & Smith-Maddox, P.R. (1990) . Developing graduate school awareness for engineering and science: A Model. *The Journal of Negro Education* (59) 3, 479-490.

- Magaya, A. (2004). Recruitment strategies of international students. Trends and patterns in public universities in the state of Illinois. (Doctoral Dissertation, Southern Illinois University at Carbondale, 2004). Dissertation Abstracts International 65(09) AAT 3147101.
- Malaney, G. D. (1985). An organizational perspective of graduate student recruitment: A resource dependence approach. *The Review of Higher Education* 8(4), 375-386.
- Malaney, G. D. (1987). Efforts to recruit graduate students: An analysis of Departmental recruiting practices, *College and University*, 62 (2), 126-136.
- Matthews, C. M. (2006, January 3). *International Science and Engineering Presence in U.S. institutions and the labor force*. Congressional Research Service. (Order Code 97-754). Washington, D.C.
- McHenry, D. & Associates. (1977). *Academic Departments*. San Francisco: Jossey-Bass Publishers.
- Merrill, S. A. (Ed.). (2001). *Trends in federal support of research and graduate Education*. Washington, D.C: National Academy Press.
- Meyer, A. D. (1988). Organizational Decline from the Organizational Perspective. In K. S. Cameron, R.I. Sutton, D.A. Whetten, (Eds.) . *Readings in Organizational Decline* Cambridge, MA: Ballinger Publishing Company
- Mikolusky, M. (1983). The management of decline in university departments: An exploratory study. (Doctoral Dissertation, The Ohio University, 1983) . Dissertation Abstracts International 44(01), AAT 8311778.
- Milliken, F. J. (1990). Perceiving and interpreting environment change: An examination of college administrators interpretation of changing demographics. *The Academy of Management Journal*, 33 (1), 42-63.
- Mooney, P. (2006, May 19). The long road ahead for China's universities. *The Chronicle of Higher Education* 52 (37), A42.
- Mooney, P. & Neelakantan, S. (2006, September 8). International Academics Question the Quality of their Countries' Engineering. *The Chronicle of Higher Education* Vol 53(3) , A20.
- National Science Foundation. Division of Science Resources Statistics . (2005 August). *Info Brief* Graduate Enrollment in Science and Engineering Programs up in 2003, but declines for first –time international students. National Science Foundation. Division of Science Resources Statistics (*NSF 05-317*) Arlington, VA: Oliver, J.

- National Science Foundation (NSF) & Electrical and Computer Engineering Department Heads Association (ECEDHA) . (2003, June 17-18) . *Agents of Change: Achieving Diversity in Electrical and Computer Engineering Research and Education*. A Workshop. Available at: http://www.ecedha.org/reports/AoC_Report.htm .
- National Research Council (1999). *Funding a Revolution: Government Support for Computing Research*. Washington, D.C. National Academy Press.
- National Research Council (1995). *Research-Doctorate Programs in the United States. Continuity and Change* . Appendix-Table K-5: Selected Characteristics of Research-Doctorate Programs in Electrical Engineering. Washington, D.C: National Academy of Sciences.
- North, D. (1995). *Soothing the establishment. The impact of foreign-born scientists and engineers in America*. Lanham: University Press of America.
- Olson, C. (1992). Is your institution user-friendly? Essential elements of successful graduate student recruitment. *College & University* , Vol. LXVII (3), 203-207.
- Patton, M.Q. (2002). *Qualitative Research and Evaluation Methods*. 3rd ed. Thousand Oaks: Sage Publications.
- Pong, W. (2005, March 1-5). Contemporary issues in undergraduate engineering education. *Exploring Innovation in Education and Research CEER Tainan, Taiwan*.
- Prados, J. W. (1998). *Engineering Education in the United States: Past, Present, and Future*. Available at <http://www.ineer.org/Events/ICEE1998/ICEE/papers/255.pdf>
- Prescott, J. E. (1990). Environments as moderators of the relationship between strategy and performance. *Academy of Management Journal*, 33(1), 42-63.
- Prisco, A., Hurley, A.D., Carton, T.C & Richardson , R.C. (2002). *Federal Policies and Higher Education in the United States*. New York: Alliance for International Higher Education Policy Studies AIHEPS.
- Schmidtlein, F. & Taylor, A. (1996) . Responses of American Research universities to issues posed by the changing environment of higher education *Minerva*, 34 , 291-308.
- Shopshire, A. P. (1980) . The organizational response of small, private, four-year colleges in the south to declining enrollments and fiscal restraints. Doctoral Dissertation, Georgia State University, 1980) Dissertation Abstracts International, 41(06), AAT 8027111.

- Skolnikoff, E. B. (1993). Knowledge without borders? Internationalization of the research universities. *Daedalus*, 122(4), 225-253.
- SPSS. (2003). *How to get more value from your survey data*. Technical Report. Available at :http://www.spss.gr/white_papers/morevaluefromsurvey.pdf Retrieved October 10, 2006.
- Stangor, C. (1998). *Research Methods for the Behavioral Sciences*, Boston: Houghton- Mifflin.
- Stuart, J.C. (Ed.). (1986). *Higher Education. Handbook of Theory and Research* Vol.II NewYork: Agathon Press.
- Terrence, K.K. et al. (Ed.). (2004) . *The U.S. Scientific and Technical Workforce. Improving data for decision making*. Santa Monica: The RAND Corporation.
- Thompson, J. D. (1973). *Organizations in Action*, New York McGraw-Hill, 1973.
- Thompson, J. D. (2003). *Organizations in Action. Social Science Bases of Administrative Theory*. New Brunswick: Transaction Publishers.
- Tierney, W. G. (Ed.). (2004). *Competing conceptions of academic governance*. Baltimore: The John Hopkins University Press.
- Tolbert, P. S. (1985). Institutional Environment & Resource Dependence: Sources of Administrative Structure of Institutions of Higher Education. *Administrative Science Quarterly* 30, 1-13.
- Trice, A. G. (2000, May 21-23). Navigating in a global learning community: Academic departments' response to graduate international students. Paper presented at the *Annual Forum of the Association for Institutional Research 40th*, Cincinnati, OH ERIC, ED 445 645.
- U.S. Department of Education. National Center of Education Statistics. (2002). *Student Financing of Graduate and First-Professional Education, 1999-2000*. Washington, D.C. : Choy, S. & Geis, S. Available at <http://nces.ed.gov/das/epubs/2002166/student6.asp>.
- U.S. Chamber of Commerce. (2007). *Skilled Worker Visas: H 1-B and L-1 visa*. Available at <http://www.uschamber.com/issues/index/immigration/h1b.htm>
- U.S. Department of Education. National Center for Education Statistics. *Degrees and other formal awards conferred*. Higher Education General Information Survey (HEGIS) 2003. Table 285. Washington, D.C.

- U.S. Department of Education. National Center of Education Statistics. (2006). *Science and Engineering Indicators 2006. Chapter 2. Higher Education in Science and Engineering*. Washington, D.C.
- U.S. Department of Labor. Bureau of Labor Statistics. Occupational Outlook Handbook, (Chart 7) 2004- 2005 Edition. Washington, D.C.
- Vaira, M. (2004). Globalization and higher education organizational change: A framework for analysis. *Higher Education* 48, 483-510.
- Wadhwa, V. & Gereffi, G. (2005, December). *Framing the engineering outsourcing debate: Placing the United States on a level playing field with China and India*. from Master of Engineering Management Program. Duke University web site: <http://memp.pratt.duke.edu/>
- Wallich, P. (2005, November 24). Electrical Engineering's Identity Crisis *Spectrum* Online. Available at <http://www.spectrum.ieee.org> Retrieved on November 24, 2005.
- Williams, R. (2002). *Retooling: A historian confronts technological change*, Cambridge, MA: MIT Press.
- Wilson, R. (1999, May 14). A university uses quotas to limit and diversify its international enrollments. *The Chronicle of Higher Education*, Vol. 45(36), A15.
- Wilson, R. (2004, October 8). Settling for less. *The Chronicle of Higher Education* 51(7), A39.
- Woo, S. (2006, October 27). Competition increases for foreign students *Chronicle of Higher Education* 53(10), A43.
- Zammuto, R. F. & Cameron, K. S. (1985). Environmental decline and organizational response. *Research in Organizational Behavior*, 7, 223-262.
- Zammuto, R. F., Whetten, D.A. & Cameron, K.S. (1983). Environmental change, enrollment decline and institutional response: Speculations on retrenchment in colleges and universities *Peabody Journal of Education* 60 (2), 93-107.