AC 2012-5293: EXAMINING THE EXPLANATORY VARIABLES THAT IMPACT GRADUATE ENGINEERING STUDENT ENROLLMENT

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Prof. Reginald Amory, Morgan State University

Reginald L. Amory is professor and Chair of the Department of Civil Engineering at Morgan State University. Presently, he is engaged in developing innovative programs which will be used to deliver a much more comprehensive level of undergraduate engineering education to new civil engineering students. Having served on engineering faculties at Rensselaer Polytechnic Institute, North Carolina A&T State University, and Northeastern University, he is using his particular knowledge and experience to guide Morgan State University's civil engineering thrust in the School of Engineering's new, innovative master's and doctorate of engineering degree programs. In particular, he has positioned the department to conduct research and pursue entrepreneurial activities in civil infrastructure and service systems and broaden its traditional technological thrust to include more comprehensive interdisciplinary areas which include problems in human resource development, economic development and competitiveness, public health, biological processes, and environmental security. Amory, the first African American to receive a Ph.D. in engineering from Rensselaer Polytechnic Institute, has had a distinguished career which is noted for its breadth as well as its depth. His career has spanned professional practice, teaching, administration, research, and consulting in the private, university, industry, and government sectors. Early in his career, he participated with other engineers in the design of many of the earliest prestressed concrete structures in the eastern part of the United States. Having served on the faculties of four universities, he has taught more than 8,500 students and taught 33 different courses in the disciplines of structural engineering, structural mechanics, the mechanical behavior of materials, and architectural engineering. Amory has been particularly successful in engineering education. As one of the youngest engineers, at 31 years of age, ever appointed Dean of a School of Engineering, he received North Carolina A&T State University's initial Outstanding Educator's Award. During his tenure at Northeastern University, he held the ALCOA Chair in Civil Engineering and served as professor of civil engineering. He has held positions at Westinghouse Laboratories as Senior Engineer and General Electric Research Laboratories as Research Engineer, where he conducted research into problems in dynamic plasticity and high-pressure physics, respectively. He has served as Chief Scientist for Corporate Research for B&M Technological Services and President of RMS Science and Technology, a research and development firm he owns. Amory's government experience includes service as a Special Assistant in the U. S. Department of Energy and the Energy Research and Development Administration, where he also served as a consultant to business, labor, and governmental affairs. A Fellow of the American Society of Civil Engineers, he has served as a consultant to many organizations

including the U.S. Department of Transportation, the U.S. Department of Energy, National Academy of Engineering, National Science Foundation, General Electric Company, and Mobil Oil Corporation. On an international level, Amory has served as Visiting Scholar at Cambridge University, Cambridge, England where he conducted research in the area of buckling of steel plate bridges. Amory has received many honors and awards including the 1999 Outstanding Civil Engineering Educator Award from the Maryland Section of the American Society of Civil Engineers for sustained and unusual contributions to the advancement of the civil engineering profession and service to mankind. Amory is married to Dr. Marion Amory, an Assistant Professor of education and Coordinator of the Graduate Elementary Education program at Bowie State University.

Examining the Explanatory Variables that Impact Graduate Engineering Student Enrollment

Abstract

Studies suggest that graduate education is vital to the innovation and economic well-being of a nation. Historically, the U.S. academic institutions have seen a larger fraction of international students enrolling in graduate engineering programs compared to undergraduate engineering programs. Several studies have been reported that address some of the concerns of low enrollment of U.S. born students in graduate engineering programs. This paper examines some of the explanatory variables that impact the graduate engineering student enrollment in the U.S. We study the enrollment pattern of undergraduate and graduate students at some major U.S. universities and examine key socioeconomic variables responsible for that enrollment pattern. Using Morgan State University as an example, we also examine the pattern of African-American students seeking graduate engineering education. It is found that better quality of life and competitive employment prospects coupled with excellence of U.S. engineering programs are key factors affecting the decision of international students to seek a U.S. graduate engineering program. On the other hand, lower household income and cost of education are key factors affecting the decision of U.S. born students to seek a U.S. graduate engineering program. For the African-American student, additional variables are also at play regarding this complex problem. The study has wider policy implications in the face of current employment and economic trends in the U.S.

Introduction

It is widely acknowledged that education is directly linked to economic prosperity and well being of a nation. The 1979 economics Nobel prize winner Prof. Theodore Schultz in his 1963 book titled "The Economic Value of Education" articulated and quantified the economic value of education. Traditionally, U.S. has led the world in economic prosperity, science, and technological innovation. However, in recent years, we have observed several alarming patterns that are having an impact on U.S. leadership in those fields. For example: (1) U.S. economy is generally not doing well and about 9% of the people are still unemployed; (2) U.S. students generally underperform in science and math. compared to students from some other countries; (3) U.S. produces fewer engineers compared to countries, such as China and India; (4) U.S. manufacturing and service industry increasingly rely on outsourcing, and imports household commodities from countries, such as China and India in an effort to save on labor costs; (4) Countries, such as China, India, South Korea, and Japan are quickly catching up in critical fields, such as manufacturing, software, space, infrastructure, technological innovation, and science in general (measured for example, by number of refereed publications, patents, etc.). Added to this vexing problem is a significantly lower number of U.S. born students (especially from the minority population) seeking graduate studies in science and engineering, which is heavily dominated by international students (in particular, students from Asian countries).

The main objective of this paper is to review some literature related to the disparity in enrollment trends of U.S. born students at undergraduate and graduate levels, study the enrollment pattern of undergraduate and graduate engineering students at some majority U.S. academic institutions, pose some questions pertaining to policy implications, and try to examine the causes of lower U.S. born graduate student population. In addition, in view of the changing demographics of the U.S., the graduate enrollment pattern of minority students is examined using Morgan State Uni-

versity as an example. Morgan State University is designated as a Historically Black College and University (HBCU) and the quality of its engineering program and infrastructure has significantly grown in the last 10 years. Finally, we will discuss the socioeconomic pattern of U.S. households as well as those in India which is one of the countries from where a sizeable number of graduate students are drawn in U.S. engineering programs.

LITERATURE REVIEW

The U.S. graduate programs in Science, Technology, Engineering, and Mathematics (STEM) disciplines is heavily dominated by international students. In fact a significant reduction in the influx of international students may force some graduate programs to shut down. The post 9/11 era saw a decline in international students seeking graduate education in the U.S. The impact of low international student enrollment in the immediate aftermath of 9/11 was clearly felt by most of the U.S. academic institutions. As a result a number of studies were undertaken[19] in an effort to make policy changes to increase the number of U.S. born students to seek graduate education in STEM disciplines and reinforce the value of graduate engineering education and technological innovation for economic well being of the U.S.

The low graduate enrollment of U.S. born students has clear policy implications since it reduces the possibility of U.S. born population to seek employment in various public, private, and academic sectors where a graduate degree is required. Academia is affected the most as a terminal degree is generally required for academic jobs. In view of the changing demographics and growing minority population it is imperative that the pattern of minority population in seeking graduate engineering education be carefully examined.

Perna and Thomas[18] developed a conceptual model for understanding student success and identifying ways to reduce gaps in success across income, class, and racial/ethnic groups. According to them, efforts to identify the most effective policies and practices for ensuring success for all students and reducing "success gaps" were limited by at least three factors. First, existing policies and practices generally focused on discrete components, aspects, or predictors of student success with no attention to other forces or processes that also influenced it. Second, efforts by policymakers, practitioners, and researchers to improve student success were hampered by the absence of a clear, consistent, and comprehensive definition of such success. Third, policymakers and practitioners who attempted to use findings from prior research as tools to improve student success must first reconcile the broad array of theoretical and methodological approaches that characterized such research.

Anderson and Swazey[4] shared insight gained from a survey of doctoral students by the Acadia Institute's Project on Professional Values and Ethical Issues in the Graduate Education of Scientists and Engineers. The survey included 1,440 respondents selected randomly from ninety-nine departments of chemistry, civil engineering, microbiology, and sociology in major research universities in the U.S. Students were asked to report their level of agreement with 5 questions. The results of the survey suggested that there was room for improvement in doctoral programs, both academically and socially.

In a similar vein as the main objective of this paper Crede and Borrego[5] argued that If the U.S. was to remain a globally recognized source of technological and scientific development, it must continue to recruit and retain domestic students into engineering master's and doctoral programs. They collected and analyzed online data of more than 1,000 respondents related to the perception of graduate school. Results of their data analysis indicated that the presence of role models and students' perceptions of their chance of success and level of knowledge about several aspects of graduate school contributed to the decision to enroll. They further developed a Social Cognitive Career Theory (SCCT) framework focusing on student self efficacy, and how they perceived graduate school's alignment to their interests and future goals.

Other studies[16, 8, 20] reported in recent years have advocated the attainment of a masters degree program as the basis for professional engineering practice due to the complexities of today's engineering problems and engineered products that surrounds us, and sustainability, globalization, and ethical aspects of engineering systems and engineered products that is part of our daily lives.

METHODOLOGY

The Enrollment Trend at U.S. Academic Institutions

Traditionally, domestic students in the U.S. have been less aggressive in seeking graduate education (especially at the doctoral level) compared to international students in Science Technology Engineering and Mathematics (STEM) fields. This issue has been widely recognized and extensively discussed in recent years by agencies, such as the National Academy of Engineering (NAE), National Science Foundation (NSF), and the American Society of Engineering Education (ASEE). The famous NAE press book entitled "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future"[19] attempts to delve deeper into this issue and offers many recommendations, including increased funding for graduate studies and research. Several recommendations of the book have already been implemented by the U.S. government. However, it is not clear as to what extent those measures have been effective in boosting the graduate engineering school enrollment numbers of U.S. born students.

A review of the international engineering student enrollment data compiled by some major U.S. universities[8-13], such as MIT, Purdue, Stanford, Cornell, and U.C. Berkeley reveal that there is a wider gap between U.S. and international students seeking undergraduate and graduate degrees. For example, Table 1 shows the graduate and undergraduate enrollment pattern at Cornell[13] over the last 8 years. It can be seen that while the percentage of international students ranged from 14 to 19 % in overall undergraduate programs, that number ranged from about 72 to 86% in overall graduate programs. In the engineering undergraduate program at Cornell the international student percentage ranged from about 23 to 27% which is slightly higher than schoolwide average in this category. While we could not obtain graduate engineering data, it is expected that the international student percentage in this category may be slightly higher (in the 85-90% range) than the schoolwide average. Similar patterns were observed at other majority schools[8-10].

Table 1. Graduate and Undergraduate International Student Enrollment Pattern at Cornell University

Academic Year	Percentage of international students in overall undergraduate programs	Percentage of international students in overall graduate programs	Percentage of international students in engineering graduate programs
2011	18.58	83.63	23.21
2010	17.93	79.26	25.08
2009	17.46	77.24	26.34
2008	17.25	74.44	26.85
2007	15.83	77.40	25.62
2006	15.63	85.48	25.95
2005	15.06	84.36	26.12
2004	14.41	72.19	25.03

Another interesting observation is that the fraction of international student population is generally higher from China, South Korea, and India. For example, out of 2,765 international students at Cornell in 2010, China, South Korea, and India contributed 835, 507, and 457, respectively. Similar trend was observed at other majority institutions.

Policy Implications

The above observations have wider policy implications and raise the following important questions:

- Why do a larger fraction of U.S. undergraduate degree recipients don't seek graduate school
- Why do a higher number of international students from Asian countries (China, South Korea, and India in particular) are attracted to the U.S. graduate programs.
- Are the larger fraction of international graduate degree recipients staying in the U.S.? If so, what is the quality-of-life and economic impacts on U.S. households, especially those in low-income bracket.
- What impact can the lower number of graduate degree awarded to U.S. born students have on the quality-of-life of U.S. households and livability of neighborhoods and communities
- Can the U.S. still lead the world in science and technological innovation

In order to address some of the above issues we will first examine the socioeconomic factors that influence a typical U.S. household from where students are drawn. In order to compare the socioeconomic conditions of the U.S. household with that of an Asian country from where a sizeable portion of graduate students are drawn to U.S. universities, we will use the socioeconomic conditions of India as an example with which the first author is familiar.

Socioeconomic Factors of U.S. Household that influence Student Learning

Education provides individual children with the knowledge and skills necessary to advance themselves and their nation economically. Socioeconomic factors, such as family income level, parents' level of education, race and gender, all influence the quality and availability of education as well as the ability of education to improve life circumstances[11].

Family Income Level

A family's financial status influences a number of factors that can help or hinder a child in gaining an education. Wealthy families have the financial resources to send a son or daughter to high-quality schools, hire tutors and obtain supplemental education sources. Some students from low-income families may not be able to attend school because no school may be available. Where school is available, the teachers may have insufficient education or training. Financial stress on the parents can cause a child to leave school early to work. Worries about the financial lack at home can negatively affect low-income children's ability to learn.

Parents' Level of Education

Parents' education level directly correlates to the importance and influence of education in their children's lives. Educated parents can assess a son or daughter's academic strengths and weaknesses to help that child improve in overall academic performance. The educated parent also sets expectations of academic performance that propel students forward in their achievement levels. However, even if educated, parents who struggled academically and do not think highly of formalized education may have negative attitudes toward education that can still hinder the child academically.

Gender

The availability of education to girls and women varies by country. Restrictions on education for girls and women are based on gender bias prevalent with the culture. Some cultures will allow education for girls and women but limit the content of the education or skew the education to prepare for few certain social roles. In the United States, the availability of education to girls and women expanded to become coeducational in most schools within the 20th century.

Race

While race is not a predictor of how a student will perform in school, African American students have trailed behind European American students in reading and mathematics. The No Child Left Behind Act of 2002 sought to improve academic performance for students in predominantly African American or Hispanic schools by placing an emphasis on teacher quality and performance. Likewise, National Assessment for Educational Progress (NAEP) reading scales make it possible to examine relationships between students' performance and various background factors measures by NAEP, such as race. However, a relationship that exists between achievement and

another variable does not reveal its underlying cause, which may be influences by a number of other variables[17].

Explanatory Variables Affecting Graduate Education

The immediate earning potential upon graduation from a baccalaureate degree intertwined with family income status and amount of college loan seem to be the key reasons of the reluctance of going to graduate school immediately upon graduation for U.S. born students. As an example, Table 2 below shows the number or engineering baccalaureate degree recipients from Morgan State University, and the number of those graduates immediately going to graduate school at Morgan and elsewhere in the country over the past 10 years. The authors also conducted a survey of transportation engineering graduates regarding their future plans upon graduation which is shown in Table 3. The 10 year trend of engineering baccalaureate degree recipients is also shown in Figure 1.

As can be seen from Table 2 and Figure 1, electrical engineering produces highest number of graduates followed by civil and industrial engineering. The number of students pursuing graduate school has been very low and nearly half of them have pursued their degree at Morgan. Table 3 points to some interesting revelations, that is the majority of the graduates in civil-transportation engineering indicate immediate earning potential, economic status of family, and student loan burden as reasons for not pursuing graduate school immediately upon graduation. Clearly then, these three socioeconomic explanatory variables are strongly correlated to a student's decision to pursue graduate school immediately upon graduation.

Table 2. Morgan State University Engineering Graduation Data for 2002-2011

Year	Number of Engineering Baccalaureate Degrees awarded				An Estimate of the Number of Baccalaureate Degree Recipients Immediately going to Graduate School Full-Time*	
	BSEE	BSCE	BSIE	Total	At Morgan	Elsewhere
2011	62	22	18	102	6	6
2010	57	15	11	83	7	5
2009	45	23	11	79	8	4
2008	56	21	13	90	5	6
2007	65	21	12	98	6	7
2006	55	13	15	83	8	4
2005	58	11	10	79	5	5
2004	64	15	10	89	6	6
2003	57	23	11	91	7	8
2002	57	25	12	94	10	7

* these numbers are estimates based on student feedback

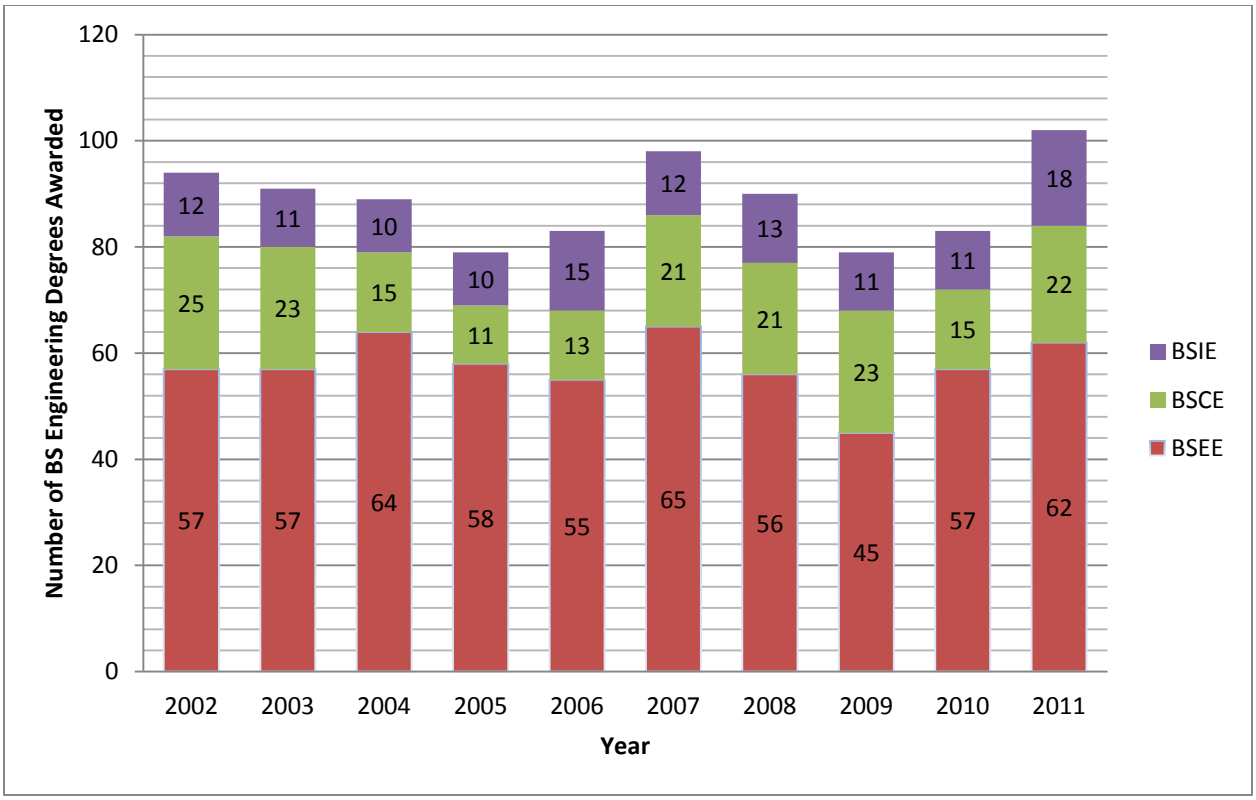

Figure 1. Morgan State University Engineering Graduation Data for 2002-2011

Table 3: Survey Results of Civil-Transportation Engineering Baccalaureate Degree Recipients Regarding their Plans to go to Graduate School

Survey Year	Number of Participants	Top 3 reasons for pursuing graduate school full-time immediately upon graduation	Top 3 reasons for not pursuing graduate school full-time immediately upon graduation		
			Immediate earning potential	Economic status of family	Student loan burden
2011	2	N/A	2	2	1
2010	3	N/A	3	2	1
2009	4	N/A	4	2	2
2008	5	N/A	5	3	4
2007	5	N/A	5	2	3
2006	6	N/A	6	3	3
2005	7	N/A	7	4	5
2004	6	N/A	6	3	4
2003	6	N/A	6	4	4
2002	7	N/A	7	4	5

International Student Perspective

International students, especially from Asian countries, on the contrary are not subjected to the socioeconomic factors reported above due to the disparity of quality-of-life between Asian and western countries and better employment opportunities in the U.S. The authors conducted a survey of international students attending Morgan State University Engineering program over the last 10 years and asked them reasons for pursuing a graduate degree at Morgan. The survey finding, including the top 3 reasons for pursuing a graduate degree by international students are reported in Table 4. As it can be seen from the survey results, the majority of the students responded by choosing the following top 3 reasons for pursuing a graduate degree in the U.S.: (1) quality and marketability of U.S. education; (2) availability of graduate assistantships/fellowships/scholarships to finance graduate education; and (3) job opportunities and Plans to stay in the U.S. upon graduation. Clearly then, these three factors constitute major explanatory variables for the international students to pursue a graduate degree in the U.S.

Table 4: Survey Results of International Engineering Baccalaureate Degree Recipients Regarding their Decision to go to Graduate School in the U.S.

Survey Year	Number of Participants	Top 3 reasons for pursuing graduate school full-time in the U.S.		
		Quality and marketability of U.S. education	Availability of graduate assistantships/fellowships/scholarships to finance graduate education	Job opportunities and Plans to stay in the U.S. upon graduation
2011	5	5	5	3
2010	4	4	4	2
2009	5	5	5	2
2008	4	4	4	3
2007	4	4	4	2
2006	5	5	5	3
2005	4	4	4	2
2004	3	3	3	1
2003	3	3	3	2
2002	2	2	2	1

The Socioeconomic Conditions of International Students Back Home: Case of India

Studies and the first authors own observation suggest that despite poverty, malnutrition, and poor educational infrastructure, the socio-cultural system of India (like perhaps China and South Korea) encourages K-12 students to work harder and seek college education in the STEM fields. Since the independence in 1947, the Indian government has established strong education system in STEM disciplines. Graduate students coming to the U.S. and other western countries from top notch engineering institutions, such as the Indian Institutes of Technology (IITs) have performed extremely well in their respective fields.

There has long been a tradition of Indian baccalaureate degree recipients in engineering to come to the U.S. and upon finishing their U.S. education, the majority of them have received competitive job offers in the U.S. as a result of which they never went back to their country. This phenomena has widely been recognized as "brain drain." It is not until recently that a fraction of them have begun to return back to their home country due to competitive employment opportunities and better quality-of-life back home.

According to Wikipedia[7], India's gross national income per capita has experienced astonishing growth rates since 2002 and its per capita income has tripled from $ 423 in 2002–03 to $ 1219 in 2010–11, averaging 14.4% growth over these eight years. In terms of poverty, as of 2005, according to World Bank statistics, 75.6% of the population lived on less than $2 a day, while 41.6% of the population was living below the new international poverty line of $1.25 per day. However, data released in 2009 by the Government of India estimated that 37% of the population lived below the poverty line.

Housing in India is modest. According to The Times of India, a majority of Indians had a per capita space equivalent to or less than a 100 square feet (9.3 m^2) room for their basic living needs, and one-third of urban Indians lived in "homes too cramped to exceed even the minimum requirements of a prison cell in the US." The average is 103 sq ft (9.6 m^2) per person in rural areas and 117 sq ft (10.9 m^2) per person in urban areas.

Around half of Indian children are malnourished. The proportion of underweight children is nearly double that of Sub-Saharan Africa. However, India has not had any major famines since Independence. Since the early 1950s, successive governments have implemented various schemes to alleviate poverty, under central planning, that have met with partial success. All these programs have relied upon the strategies of the Food for Work program and National Rural Employment Program of the 1980s, which attempted to use the unemployed to generate productive assets and build rural infrastructure. In August 2005, the Parliament of India, in response to the perceived failure of economic growth to generate employment for the rural poor, passed the Rural Employment Guarantee Bill into law, guaranteeing 100 days of minimum wage employment to every rural household in all the districts of India. The Parliament of India also refused to accept Union Government's argument that it had taken adequate measures to reduce incidence of poverty in India. The question of whether economic reforms have reduced poverty has been strongly debated. Recent statistics of 2010 point out that the number of high income households has exceeded lower income households.

In recent years, there has been a greater acknowledgement of the value of higher education in India as a result of which many government subsidized colleges and universities have been opened, especially in STEM fields. For example, in order to provide opportunities for a higher percentage of deserving students, the number of IITs have been increased and been founded in many economically disadvantaged states, such as Assam, Bihar, and Orissa. It appears that such actions may slow down the influx of graduate degree seeking students in the U.S. in STEM fields, which may in turn, narrow the gap between U.S. born and international students seeking graduate education in U.S. universities. The consequence may be negative to the U.S. economy if the country does not do enough to raise the graduate numbers of domestic U.S. born students.

The Minority Student Perspective: Case of Morgan State University

In addition to those reasons mentioned earlier, "The usual suspects" portend regarding why African-Americans do not pursue engineering degrees at the bachelor's level:

- Lack of knowledge regarding "What is engineering?"
- Lack of preparedness in mathematics and science.
- Lack of preparedness in reading comprehension.

While first generation African-American students are still enrolling in engineering schools - not to mention graduate engineering programs, presently, those who do seek such advanced technological education for the following reasons:

- Gain additional knowledge not learned in undergraduate engineering school.
- A number of African-American graduates are "tired of the rigor" associated with undergraduate engineering programs and the lack of electives available to them in the curriculum and opt to pursue masters or other degrees in such areas as business, law, or transportation studies.
- It is evident regarding the engineering environment in which they work that it is necessary to pursue graduate engineering degrees if they hope to remain employed there or be promoted.

The uniqueness of Morgan State University's (MSU's) civil engineering doctoral program and how the analysis (explanation of variables) of the question has a good base from which to discuss this question. For example, most of the approximately 20 engineering schools which graduate African-American doctorates produce perhaps one (and hardly ever two) civil engineering doctorates in a single engineering department (i.e., civil engineering) at graduation in May of any particular year. For example, while Dr. Reginald Amory, one of the authors of this paper, is the first African-American to receive the doctorate in engineering from Rensselaer Polytechnic Institute (RPI) - 45 years ago, it is doubtful whether RPI has produced more than perhaps 5-8 African-American civil engineering doctorates since that time while MSU's civil engineering program has produced 10 African-American civil engineering doctorates (out of approximately 20 civil engineering graduates) since 2002.

Dr. Reginald Amory mentioned over thirty years ago in a presentation to the Black Caucus[1] that the question regarding what steps to take in order to increase BS engineering degrees among African-Americans is far more complex than most persons realize. Similarly, seminal work done by Dr. Marion Amory that was done over 15 years ago[2] and recently updated[3] has not been investigated thoroughly in regard to how it relates to reading preparedness of African-Americans for advanced technological education. Since most African-Americans are attending public schools in urban areas, this report has implications for all such schools in these areas.

Lack of preparedness has a "domino effect" on the production of the number of African-Americans who should enroll in engineering schools and their level of aspirations for graduate engineering education (particularly at the doctoral level). The small number of African-American students who are prepared for engineering school and produced in an urban school system where they constitute the largest ethnic group, manifests a "squeeze down" process

wherein these students are simply "hoping to graduate with a BS engineering degree" and not be thinking about pursuing a masters degree - and certainly not a doctorate in engineering.

The juxtaposition of the variables that impact the pursuit of graduate engineering by international students and the enrollment of African-American students in the doctoral program in civil engineering provides a "unique opportunity to explore a number of parameters that affect this problem at a "unique" civil engineering department that is involved in graduating doctorates that impact civil systems and the civil infrastructure. What makes MSU "unique" is that it has the only stand-alone civil engineering program graduating students at the doctoral level - and not in conjunction with another major university. Moreover, the underrepresentation of African-American students in engineering programs is neither a "race problem" nor a "culture problem." African-Americans have had the same aspirations to invent, create, tinker, engage in flight, build, etc. like other ethnic groups. The major factors contributing to the underrepresentation of African American students in engineering can be summarized as follows:

- Suppressed opportunities in employment and graduate education as late as the 1950's and the 1960's
- The lack of what engineering entails
- Guidance counselors who deliberately steer African-American students away from engineering careers
- Taking the appropriate mathematics and science courses too late or not at all for them to be competitive on SAT or ACT examinations for not only for them to gain entrance but to sustain themselves at major engineering schools
- Inadequate exposure at the elementary and middle school levels to the proper reading comprehension environment which activates and accelerates their capacity to break-down technologically-oriented material at the Proficiency level (this is an area which has been overlooked for the past 15 years.

The growth of the white population has leveled-off over the past 30 years and any substantial increase in engineering enrollment of approximately 350,000 in the United States must come from the "so-called" minority population. Maintaining the theme of this paper, if one simply "does the math" regarding the black population of approximately 40 million, and adheres to the fact that only about 6 percent of the high school population seeks engineering careers (a standard that has not changed appreciably over the past 50 years), if correct parameters were put into place it is possible that 300,000 African-American high school graduates would be available to enroll in the nation's engineering schools. Of this number perhaps 5 percent might seek the doctorate in engineering.

Returning to MSU's unique position in civil engineering at the doctoral level, this program has produced 10 civil engineering African-American doctorates since 2002. This feat has been accomplished with students who are employed in outside jobs, have virtually no scholarship, fellowship, or teaching assistantship support at the masters level, and little financial support at the doctoral level (except for a few Title III fellowships and a few research assistantships). In contrast, the highly touted and successful Meyerhoff Scholars Program at the University of Maryland Baltimore County(UMBC) has produced 48 African-American doctorates in science and engineering during the 2005-2009 period[6] (perhaps 40 percent were in engineering). The

Meyerhoff Scholars Program has required the intense recruitment of the small percentage of African-American high school students with very high SAT or ACT scores, extraordinary financial support targeted toward these students, constant monitoring of their academic progress, and direct involvement in this program by the President of the University, Dr. Freeman Hrabowski, III. It has been reported that this program has produced the largest number of African-American science and engineering doctoral graduates of any non-HBCU institution[6]. It should be noted that each of these programs (at MSU and UMBC) is contributing to the output of African-American doctorates in its own special way. However, what is not known is that MSU's civil engineering program now has the research and facilities capacity, but if today it gained the necessary scholarship, fellowship, and assistantship support for its doctoral students, it would be able to triple the output associated with its already number one ranking as the largest producer of African-American civil engineering doctorates in the country during the past 8 years.

RESULTS AND CONCLUSION

In this paper we studied the graduate engineering enrollment pattern of some U.S. universities and used Cornell University's enrollment numbers as an example to understand that pattern. We also studied the perspectives of African-American students seeking graduate engineering programs and used the case of Morgan State University's civil engineering department as an example. The objective of the study has been to understand the causes of the wider gap between domestic and international students graduate engineering enrollments.

The results suggest that the gap between domestic and international graduate student enrollment is far wider than that between undergraduate students. Using some survey data from Morgan State University, we identified three key socioeconomic variables responsible for the reluctance of engineering baccalaureate degree recipients to pursue graduate school upon graduation, which are: (1) immediate earning potential; (2) economic status of family; and (3) student loan burden. The findings have significant policy implications, since they clearly indicate that increased graduate school scholarships and fellowships alone that are specifically targeted to attract U.S. born major white students to graduate school may not comprehensively address the lower graduate school enrollment numbers. On the other hand, a quantum increase in undergraduate financial support coupled with an exponential increase in graduate scholarships and fellowships would have a significant effect on increasing the number of African-American master's and doctoral engineering graduates.

The survey results regarding international students seeking graduate studies in the U.S. indicate that the three key reasons attracting international students to U.S. graduate education are: (1) quality and marketability of U.S. education: (2) availability of graduate assistantships/fellowships/scholarships to finance graduate education; and (3) job opportunities and plans to stay in the U.S. upon graduation. Given the high unemployment rate and struggling U.S. economy intertwined with increased funding in higher education support infrastructure in countries, such as India, this trend may reverse in the future and we may see a decline in number of international students enrolling in U.S. graduate programs. This, in turn, may also have significant policy implications.

Many of the preceptors and overlooked factors associated with successful reading achievement at the Proficiency level of urban African-American elementary and middle students have been identified by Dr. Marion Amory and are amenable to quantitative technological development[3]. This has implications for hundreds of urban school districts in the country. In addition to the three factors which impede African-American student progress toward pursuing doctoral degrees, at work is the lack of discernment and understanding by the educational community that the proper and creative use in a quantitative manner of the aforementioned qualitative factors serves as a catalyst that creates a positive, domino effect on teachers and their utilization of the vast but ordered array of reading-related preceptors to propel African-American students to the Proficiency level of reading achievement. The natural progression of a significant expansion of African-American engineering students will result in a significant increase in African-American doctoral graduates in civil engineering.

FUTURE WORKS

Having established the key socioeconomic variables responsible for the wider gap between domestic and international student enrollment in U.S. graduate programs, we may develop an analytical procedure (such as the Binary Probit Analysis or the Social Cognitive Career Theory offered by Crede and Borrego[5]) in future works, to predict the likelihood of potential engineering baccalaureate degree recipients to enter graduate school immediately upon graduation. Such a model may allow the prediction for a region or state using socioeconomic data, such as household income, college tuition and fees, and historic enrollment trends at the colleges and universities of a particular region or state.

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