TRENDS OF S&E STUDENTS IN THE UNITED STATES: AN EXPLORATORY ANALYSIS FROM 1993-2008

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CHAPTER I

INTRODUCTION

One of the ongoing conversations in American politics is the need for more students to enroll in Math or Science degrees, in order to continue the United States economic successes of the 20th century[1]. Whether or not this is true is not the point of this thesis – rather, this paper will focus on the correlation between different factors that might influence students' decisions to pursue undergraduate and graduate degrees in the Science and Engineering fields. For the purpose of this thesis, S&E will be taken to mean any major that is based in Engineering, Mathematics or Science. Social Sciences, Economics and Psychology will not be considered. Most of the available literature has focused solely on either Supply or Demand of undergraduates graduating with Science and Engineering Degrees (henceforth referred to as 'S&E'). However, this paper will seek to examine both sides of the equation and look at both the supply of students, as well as the demand for graduates using salary. Due to data for most variables not being available for the required length of time to run a full regression model, instead I will be conducting numerous bivariate analyses for each of the possible factors and examining possible correlations with the dependent variables. This will be done for both graduates and undergraduates. I will use the proportion of high school graduates who graduate college with an S&E degree as my dependent variable for undergraduates, and use independent variables to represent both the Demand Side and the Supply Side of the regressor. The hope is that these

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[1] Rotherham, Andrew. "The Next Great Resource Shortage: U.S. Scientists." *Time*, May 26, 2011. http://www.time.com/time/nation/article/0,8599,2074024,00.html (accessed June 26, 2011).

initial findings can be used to further analyze data as more becomes available, and use those findings for policy considerations.

On the undergraduate level, I will examine the years 1993-2008 and my methodology will be as follows. The dependent variable is the previously mentioned Proportion of High School Graduates Receiving a College Degree in an S&E Field. To capture the demand for S&E graduates, I will be using two variables. I will first look at the average starting salary for S&E graduates, corrected for inflation. The other variable to look at has to take advantage of the potential pull factor of S&E graduates. Research has found that it is often the case that an S&E Degree will be more difficult to obtain than a non-S&E degree[2], thus it is prudent to look at if these graduates are being compensated better by their first jobs in relation to non S&E degree holders.

On the supply side of S&E degrees, I will be looking at factors that determine the proportion of high school graduates that go on to earn S&E degrees. Such factors will include the amount of high school graduates going on to college, as well as the median years of math coursework for a graduating high school student. In addition, I will run a variable detailing the proportion of college graduates that are male, as well as the median cost of four year's tuition corrected for inflation.

I will not just be examining the undergraduate level however – in addition to understanding the causes behind the Proportion of High School Graduates Receiving a College Degree in an S&E Field, I will also examine S&E degrees at the graduate level from the years 1993 to 2006. I will

[2] Degrees of Success: Bachelor's Degree Completion Rates among Initial S&E Majors." *Higher Education Research Institute at UCLA*. no. January (2010). http://www.heri.ucla.edu/nih/downloads/2010%20-%20Hurtado,%20Eagan,%20Chang%20-%20Degrees%20of%20Success.pdf (accessed September 13, 2011).

utilize two different dependent variables; one for American students and one representing foreign students. The dependent variable for American students is the Proportion of College Graduates Receiving a College Degree in an S&E Field. For foreigners the dependent variable is simply the absolute amount which began their degree. However, because of the different career paths that S&E graduates can pursue, such as a large number returning back home abroad, academia or private sector within the United States[3], it is difficult to create a model that incorporates a demand side aspect for these graduates. I will be able though to test my hypothesis that opportunity cost is a barrier for Americans contemplating attending graduate school. To measure opportunity cost, I will use the median amount of time it takes to achieve a degree as well as the average starting salary for an S&E undergraduate degree holder to construct a measure. To reflect overall economic conditions of the United States, the yearly unemployment rate for the United States will also be used as a measure of job opportunities outside of academia. So that I can also see the effect opportunity cost has on international student matriculation rates, I will also examine the growth rate of GDP of the top three sources of foreign students as a substitution for foreign opportunity cost. This is due to salary data for foreign countries being unavailable.

The sample sizes are consistent at 16, and therefore to be statistically significant at 95%, the Spearman R value must be .497[4]. The objective of this paper is therefore to find statistically significant correlations between the proportion of students pursuing their Bachelor's in S&E field and possible predictive variables. In addition, this thesis hopes to find statistically significant correlations in the number of Master's degrees in S&E fields and other variables, hopefully setting the stage for future analysis which can be done with larger data sources.

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[3] "The disposable academic." 2010. http://www.economist.com/node/17723223 (accessed).
[4] Snedecor, George, and William Cochran. *Statistical Methods* . Ames, Iowa: Iowa State University Press, 1983.

Chapter II

LITERATURE REVIEW

Starting Salaries of College Graduates: An Analysis of the 1998-2008 Era

One aspect to look at in the fall of S&E degrees is not just the supply side of the equation, but also the demand side. Starting salaries are therefore an excellent tool in quantifying the demand for graduates in these programs – specifically over a long period of time. The 10 year window from 1998–2008 that Kent Gilbreath examines in his 2010 article *Starting Salaries of College Graduates*: *An Analysis of the 1998-2008 Era* in the Journal of Legal Economics is useful in determining the rise and fall of demand for these S&E degrees over a period of time by employers, indexed to the overall increase in starting salaries for other degrees[5].

Gilbreath's intended use for this paper is in aiding legal attorneys seeking damages for lost income due to death of college aged students. Individuals without work experience and who are young are very difficult to forecast future earnings for, and thus starting salaries are one of the few variables to base future projections off of. For the purposes of this paper, this is excellent as it is examining the exact same type of students that this thesis looks at. Gilbreath makes note that the statistics from the U.S. Bureau of Labor Statistics and the Bureau of the Census only look at average salary over the course of a lifetime, and are thus not suitable for this study. This is appropriate for this thesis as well, as the starting salaries for a major is a much

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[5] Gilbreath, Kent. "Starting Salaries of College Graduates: An Analysis of the 1998-2008 Era ." *Journal of Legal Economics*. 16. no. 2 (2010).

better indication of the immediate demand for graduates in S&E. Gilbreath uses information from the National Association of Colleges and Employers to ascertain average starting salaries.

In addition, this paper also distinguishes between the starting salaries of men and women, so one can examine the possible differences in demand for graduates with an S&E degree depending on gender. Examining the data for women first, it is quite clear that the change in average starting salaries for women from 1998-2008 was highly dependent on the degree. For degrees that were not quantitative in nature such as English, Psychology and other humanities, the change in starting salary between 1998 and 2008 was very small at around a 3% increase a year. However, degrees for women in science and engineering fields such as Mining, Industrial Technology and Physics saw salaries for fresh graduates increase at approximately 5% annually. Doing an analysis of the data, it appears that there has been an increased demand for female S&E graduates by employers relative to other majors.

In examining men, this is not the case. Analyzing the data, there is a much smaller standard deviation of starting salary growth over the past 10 years between different majors. Accordingly, the growth that women graduates in S&E fields have seen is much higher than the growth men's starting salaries have seen in those fields. However, the growth rate of degrees awarded in lower salary growth majors for men is higher than the growth rate of degrees awarded to women in majors that have low salary growth over time. This leads one to see that the different fields for men are growing at a more equitable rate, while many employers see either an overabundance or a lack of qualified women coming into their fields.

There are several problems with Gilbreath's study however. For one, the date he uses only shows the average starting salary. This problem may not seem so egregious at first, but when he is seeking to determine what the starting salary would be for a typical graduate, it is quite clear that the median would be a far more accurate measure for determining what the 50th percentile student could expect when they graduate due to an expected long tail on the higher end[6]. When charting the data against another year to determine growth as Gilbreath did, this problem becomes more serious. We are left unable to determine where the source of the growth came from – did it come from mostly the top students receiving much larger salaries, or was the growth uniform across all percentiles? This problem could be solved by including data for different percentiles in starting salary in each year. Thus, one would be able to draw firmer conclusions on where the source of the growth in average salaries was coming from – just the top end, or a more uniform distribution.

In fact, this problem could have been lessened if Gilbreath simply used the median in his data instead of the mean. Then one could see what the typical student could have expected to earn once he graduated, and the issues of where the growth came from would have been lessened by examining the typical graduates growth rate year over year. Including information on the standard deviation would also have been helpful, to get a better idea of the spread of starting salaries.

[6] Finn, Michael, and Joe Baker. "Future jobs in natural science and engineering: shortage or surplus?." (1993). http://www.questia.com/googleScholar.qst?docId=5000160246 (accessed).

<u>Gender Imbalance In College Applications: Does It Lead To A Preference For Men In The Admissions Process?</u>

The second paper to examine is Baum and Goodstein's article, "*Gender imbalance in college applications: Does it lead to a preference for men in the admissions process?"* published in the Economics of Education Review[7]. This article examines a very critical component of the thesis. It would be incorrect to simply assume that men and women are able to gain access to university and college degrees equally. While being rejected from one school does not mean that one will not attend college in general, there are important aspects to consider. As there is a correlation between the ranking of the school one attends and ones starting salary, one gender being preferred by admissions counselors will lead to a distortion of future statistics. If all things being equal a male applicant is preferred over a female and is more likely to be accepted, four years later the starting salary of his or her first job will be a reflection of attending a "better" school. Thus, this is an important factor to consider when examining future starting salary earnings.

The paper starts by discussing the changing face of today's college student. While universities were predominantly male up through the 1970s, for the last 30 years the majority of college graduates have been female[8]. The authors take care to note also that even though more women are going to and graduating from college; it is not a case of less successful high school female students being more likely to attend college than men. Rather, the bottom quartile of all applicants is disproportionally male, which leads to a disproportionate amount of the bottom quartile of acceptances being given to males.

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[7] Baum, Sandy, and Eban Goodstein. "Gender imbalance in college applications: Does it lead to a preference for men in the admissions process." *Economics of Education Review*. 24. no. 6 (2005): 665-75.
[8] National Center for Educational Statistics, "Associate's degrees conferred by degree-granting institutions, by race/ethnicity and sex of student: Selected years, 1976-77 through 2008-09." Last modified September 2010. Accessed November 29, 2011. http://nces.ed.gov/programs/digest/d10/tables/dt10_293.asp?referrer=list.

This paper used a sample of 13 schools that were representative of selective colleges across the United States. All are currently co-ed, but three were traditionally female while one was traditionally male. The paper finds that overall, females had a higher acceptance rate than men at these 13 schools – 58% acceptance rate for men versus a 64% acceptance rate for women. However, it also found that at every school which released the admitted student's profile, accepted women had a higher GPA significant to 95%. It also found that at most schools the men did have higher SAT scores, but these findings were usually not significant to even 90%. Therefore, one could conclude that women applicants are accepted more frequently simply because they are better qualified.

However, Baum and Goodstein dive deeper. As any sort of "affirmative action" program, even if unofficial, would most likely occur towards the bottom tier of the accepted students' profile, they focus their examinations on this aspect. What they found is that in the bottom accepted quartile when sorted by GPA, a disproportionate amount of men were found compared to the overall admitted student profile. Over the 13 schools, the mean proportion of men in an admitted class was 42%. However, the average percentage of men in the lowest accepted quartile of that class was at 57% compared to 43% women, an average ratio of 4:3. When examining students who decide to enroll, the data is very similar. The paper points out that higher acceptance rates for men in the bottom quartile are common, yet not quite statistically significant. However, it is not necessarily true that this implies there is affirmative action towards males. This can be due to men with low GPA having other favorable characteristics such as a high SAT, and admissions councils viewing high school GPA as a poor predictor of future scholarly success.

Baum and Goodstein thus move onto their fourth aspect – regression analysis. What they find is mixed. While they are able to reject their Null Hypothesis that there is no male gender preference in traditionally female schools, they fail to reject their Null Hypothesis in traditionally co-educational schools. They conclude that men are 6.5% more likely to be accepted at a historically female school, and 9% more likely if they are in the lower tail of the applicant pool. However, there is no significant affect at traditionally co-educational schools.

The two do an excellent job of running multiple regressors and focusing their efforts on the lowest 25% of admitted students, where bias is obviously most likely to occur. They do point out that in many cases there seems to be a pattern of small bias, but in the end it is never statistically significant. They also do well by diving deeper into possible questions that arise during their first looks at the data, which is something that my paper will be focusing on. However, I do take issue with their consistent statements on conclusions that are not statistically significant. For instance, when they see that the bias for males with low GPA is not statistically significant, they do continuously point out that there is a common trend of low GPAs in males seeming to be a bit more overlooked by universities. With this, they seem to be sugarcoating and adopting a "Yes, but…" mentality which does not seem appropriate for their paper. Either the results are statistically significant, or they are not.

The regressions that they run are very important for this paper. Because Baum and Goodstein find that at traditional schools there is no statistically significant bias towards males, I do not have to discount male starting salaries when running my model to reflect potential artificial boost in earnings. If males were receiving a higher starting salary partly due to their education being at better schools than would be expected for a female of a typical background, it would complicate the model and require a correction for the resulting bias. Although the two do find that there is some bias towards males in traditionally female schools in an effort to achieve a more balanced class, the amount of these schools is so few as to render this fact inconsequential to the overall thesis.

Gender Differences in employment and earnings in science and engineering in the US

The third paper that I will examine is written by John Graham and Steven A. Smith, "*Gender Differences in employment and earnings in science and engineering in the US",* in the Economics of Education Review[9]. This paper seeks to explain the gender differences in pay and earnings that are seen by graduates in S&E fields – an important aspect in the differences between the demand curves for male and female graduates with S&E degrees. The data they use is somewhat old, from 1993, but it does provide a historical framework to help capture attitudes and data from the 1980s, and the model they provide is helpful.

Graham and Smith first show data detailing the earnings of men and women with Science and Engineering (S&E) degrees who work in the S&E field or in a non S&E field. They find that to start, the pay gap between men and women is smaller within the S&E field than it is outside of the S&E field. They also find that those with S&E degrees, both men and women, make more than non S&E graduates even when employed in non S&E fields.

The authors create an algorithm designed to include many different predictors for future income. Such predictors include everything from professional societies joined, to command of English language, to geographic location to the amount of children. What the researchers found is that S&E wage gaps were much more explainable than non S&E gaps, which at first glance

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[9] Smith, Steven, and John Graham. "Gender Differences in employment and earnings in science and engineering in the US." *Economics of Education Review*. 24. no. 3 (2005): 341-54.

seems to reject a hypothesis that S&E fields are inhospitable towards women. Instead, it seems to indicate that non S&E fields might be more susceptible to discrimination, as there is a larger unexplained variance in pay between genders. For women, the average value of expected discrimination is 7.2% in S&E jobs, while in non S&E fields it rises to 23.6%.

In conclusion, what the researchers determined is that 60% of the reasons why a worker would select an S&E job can be explained by gender differences in educational background – men are simply more likely than women to have an educational background in S&E. Therefore, an obvious solution to the problem of having few women in the field is for more to receive degrees in S&E. However, attrition away from the S&E fields for those who major in S&E is higher for women than it is for men. The reasons are complex, as men who move away do so for higher expected salaries, while women do so for other yet to be determined reasons. The authors find that 2/3 of the pay gap in the S&E field are explained by technical skills, while 1/3 are unexplained – however, this unexplained gap is even higher in non S&E jobs. Most of the decision by workers to become employed in the S&E fields is made due to the pay disparity between S&E and non S&E jobs, with S&E jobs paying significantly higher on average. In addition, for both sexes there is a negative relationship between expected pay discrimination in S&E jobs, and a positive relationship between expected discrimination in non S&E jobs. That is, a worker is more likely to choose an S&E career if they perceive for there to be more discrimination within the non S&E fields. The writers do not suggest increasing discrimination in non S&E jobs to increase participation into the S&E sector, but do see an opportunity for possible subsidies or lower tax rates for those employed by the sectors.

There are several very interesting points in this article. First, it is very interesting to note that women are far more likely than men to work in the S&E fields when lacking an S&E degree. In fact, 36% of women who work in the field do not have the degree in the field, whereas only 15% of men do. This information has serious ramifications in the model, such that women who are interested in S&E fields are much less likely to study them in school. Further research is needed to determine why. Secondly, in determining which specific S&E field they would like to go into, women do not seem to value starting salaries as much as men. One can see this in the field of engineering, which has the highest average salaries out of any S&E field. Over half of all men with S&E degrees select this field, yet fewer than 20% of women do, even with the same degree.

Some interesting notes that came from the regressions in this study are that while the number of children men have does not seem to be statistically significant with employment in the S&E fields or not being in these fields, there is a large gap for women – women who are employed in the S&E field tend to have fewer children compared to society at large. This is coupled with the fact there is absolutely no difference in the percentage of women married between the S&E fields and the non S&E fields. This information however is not visited in the paper, despite it having large ramifications as being a major utility point for deciding to go into a non S&E field – the opportunity to have more children with fewer career restrictions.

However, they do find running their regression that actually obtaining an S&E degree is by far the biggest indicator of future likelihood to work in the S&E field. All of the gaps in gender employment in the S&E field can actually be explained by the gap in S&E degrees according to Graham and Smith. One wishes though they would spend more time though on factors influencing career choices such as hours worked or flexibility in hours – issues that surely would have an impact on chosen career fields. Instead, they spend most of their time on the fairly obvious point that those who pursue S&E degrees are the most likely to end up in S&E fields.

The point that the authors make on expected discrimination pushing females away from the S&E fields is interesting. One can draw significant conclusions from this that are relatable to the rest of the overall thesis of how to increase the number of S&E graduates. As the largest independent regressor for an individual going into S&E fields is holding an S&E degree, the reverse would hold true that people receive S&E degrees so they can go into S&E fields. However, if there is still a perceived gender bias by females, who currently make up approximately 1/3 of the S&E labor force, there is a self-perpetuating dearth of females.

Double your major, double your return?

The 4th paper to examine is an article by Alison F. Del Rossi and Joni Hersch, "*Double your major, double your return?*" This article discusses the benefits of college students pursuing degrees with double majors[10]. Their key findings are that having a 2nd major improves starting salary earnings by 2.3%. However, that number significantly rises to between 7 and 50% when two degrees in opposing fields are bridged together when compared to having solely a humanities degree. These starting salaries are not statistically significantly different than a student who has but a single major in a business or math related field. When two math or business related degrees are combined though, there is a 50% increase in salary compared to just a single degree.

The purpose of their paper is to expand upon many other papers that focus solely on the starting salaries for single majors. The authors view this as insufficient, as the proportion of students graduating with multiple majors has been steadily rising. Although it is possible that

[10] Hersch, Joni, and Alison Del Rossi. "Double Your Major, Double Your Return." *Economics of Education Review*. 27. no. 4 (2008): 375-86.

some students could be studying the 2nd major because it is less strenuous than a more difficult, practical degree, the authors find that most students who do double major do so because of higher expected future earnings. In this paper the authors used data from a 2003 study by the National Society of College Graduates (NSCG). Specifically, they used the questions pertaining to the primary major, if the student received a second major and if so what field, and finally what the students starting salary was.

The authors found that on average, it did not take any longer to receive a degree for someone majoring in two fields compared to a student with only one degree – an important implication when considering lifetime earnings. The researchers include several indicators to correct for differences in marriage, age, race, sex, place of employment, the highest degree level attained and whether Hispanic or Latino. Incomplete questionnaires or those that selected other when signifying their undergraduate major were dropped from the sample. The final sample size was 66,285 observations, with 36,497 being those with bachelors and the remainder receiving masters.   24% of the full sample had a double major for their undergraduate degree.

The researchers found several interesting things. For one, a double major in undergraduate studies does not impact the starting salary of those who go on to get graduate degrees. They attribute this to only the highest degree attained determining starting salary. When looking at the table for comparing those with single degrees to those with duel majors, it is striking the salary premium that double majors receive when one of those two degrees are S&E based and the second major is also in a quantitative field. The researchers also find that females who double major in both math and science related fields have even higher returns than their male counterparts, which seems to be in indicator of increased demand for females with a dense background in S&E degrees. This evidence is supported by what was found in Gilbreth's previously reviewed work, as well as Graham and Smith's. The authors find that for those having a degree in the highest paying majors there are only marginal benefits to obtaining a second major – however, for those in lesser paying quantitative degrees, there are tremendous benefits if one were to pick up a second major.

The ideas of this paper are very intriguing. Although we do see statistically significant gains in expected income for those who achieve only a BA with two majors versus those who only have one major, the gains are not very large. They are virtually negligent when both majors are more qualitative in nature, but are large when both majors are more technical S&E degrees. The gains in salaries that one sees with a quantitative background versus a qualitative background makes it quite clear that there is still a large demand for students with only a BA in a quantitative field, and that employers value these technical degrees more. The most compelling evidence of this is that a double major, one S&E and one not, will raise an individual student's expected starting salary to the level of someone who has only one S&E major. This quite clearly shows that employers are not assigning as high a value to non S&E degrees, and are placing a premium on more technical ones. This is further evidence that the dearth of American S&E graduates is not due to a lack of demand, but due to a lack of supply.

The authors' conclusion is that the gains for double majors plus the fact that students who graduate with two majors take no longer to receive a degree than those with one major indicate that schools should not limit the options of students to receive double majors. For the purposes of this thesis, the take away is that there is an increased demand for students who receive a degree in quantitative or a technical field, even if it is paired with a major in the humanities. This leads further credence to the idea that there is overtime an increasing demand for S&E majors.

Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership?

The fifth article is written by Richard B. Freeman for the National Bureau of Economic Research, entitled "*Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership*". He starts with four basic premises – 1) The U.S. Share of graduates in S&E degrees is stagnating, while at the same time increasing in European and Asian Universities. 2) The job market in the S&E fields has worsened for graduates in these degrees, but is still attractive enough to bring foreign S&E graduates to the United States. 3) Highly populated countries like China and India can afford to have a lower proportion of S&E students, as they have a much higher population to draw from. 4) There will be a diminished comparative advantage in high tech industries for the United States[11].

The United States' share of worldwide S&E workers was disproportionally high following the end of WWII, due to a variety of factors such as slow recovery of infrastructure in Europe as well as scientists fleeing Germany. By the 1970s, over half of all S&E degrees completed worldwide were being issued in the United States. Now though, only 17% of university degrees given in the United States are to S&E students, compared to the world average of 27% and 52% in China. The author believes that PhD degrees are the most critical for the continuing dominance of the US S&E sector, and points out that the number of degrees the US gives out has stabilized at approximately 18,000 a year while it has grown significantly in the EU. The author estimates that by 2020, the EU will distribute twice as many S&E PhDs as the United States. In addition, approximately 40% of the PhDs in S&E fields that are given out in the US annually are now going to foreign born nationals. Similar statistics hold at the Bachelor's and at the Master's level.

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[11] Freeman, Richard. "Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership." *Innovation Policy and the Economy*. 6. (2006): 123-57.

An additional statistic to be concerned about is in the workforce, according to Freeman. He cites that since 1990, nearly 60% of the growth in new PhD hires in the US workforce has come from foreign born nationals. Freeman does not see the influx of foreign born workers with S&E PhDs into the United States as a good thing – rather he points out, this extra supply diminishes the wages of workers. This in turn further discourages more Americans from pursuing PhD's, as Americans are more reactive to market conditions than foreigners given the opportunity for other careers. Often, foreigners do not have access to other careers outside of S&E. Freeman projects that the current proportion of foreigners in S&E fields will only continue to rise, as American universities will continue to search farther and wider in their hunt for the top students. The National Science Foundation has shown continuous drops in the amount of American research published, as well as American articles cited in other scholarly works. What Freeman does not address however, is how the rise of many universities in China has led to a probable increase in Chinese journals, as well as in other countries.

The effects of this are very straight forward – with the increased supply in foreign born graduates with S&E degrees, US companies are increasingly offshoring jobs to foreign countries where wages are lower. Companies such as CISCO and Microsoft are continuously building new R&D plants not in the United States, but in China. Freeman asserts that by definition there can never be a 'shortage' or a 'surplus' of workers in an industry due to market clearing conditions being satisfied – however, signals can be sent to potential graduates about the quality of jobs that they can expect upon graduation. Those signals can include the quality of institution offered to graduates for post-doctoral work, or starting salaries by firms. In short, Freeman finds that the signals being sent to S&E students are negative ones – the increases in salaries in S&E fields do not match the increases found in the legal and medicine professions. This is further expanded upon when one takes into account the increased amount of time a doctoral student stays in school.

One is left to ask why foreigners continuously flock then to the United States to pursue these jobs? Freeman argues that foreigners do so because of lower opportunity costs than Americans have. Indeed, this point will be examined in the model for graduate student's decisions to pursue an S&E degree. While someone intelligent enough to receive a PhD in S&E is more than likely intelligent enough to receive a JD or an MBA, foreigners likely would not receive the same salaries for these degrees in their home countries as an American would in the United States. Thus, the opportunity costs for obtaining a PhD in S&E is much lower for them. Freeman thus sees the decline of American graduates with S&E degrees as continuous and unlikely to change, at least until wages in foreign countries increase to American levels.

However, this fails to answer the question of why students are not receiving BA degrees in more technical fields. These degrees due not suffer the same opportunity cost problems that one pursuing a PhD will run into, as a degree in Mechanical Engineering will take the same amount of time as a degree in History. This hypothesis of the opportunity cost for foreign born students being lower is substantiated by the number of foreign born students receiving S&E BA's being only 17%, while for MA and PhD's it is 29% and 38% respectively.

Furthermore, this 'problem' of foreign born students obtaining more S&E degrees may be the solution in itself. As long as US real wages continue to be among the highest in the world, and S&E degrees continue to be in demand by employers (which all the other literature has shown to be true) then there will continuously be workers who are coming to the United States with the tools and degrees to succeed in the S&E fields. After all, as long as the work is being completed in the United States and contributing to the economy of the United States, it does not matter where the worker that is contributing to these advances was born. However, he is correct to have some anxiety that as the number of foreigners receiving PhDs in S&E fields increase, corporations can offshore R&D to these countries to take advantage of lower wages.

I take exception to this claim though, as although the number of absolute S&E graduates in China and India is approaching US levels, the concentration is far more dispersed. On top of that, American colleges and universities consistently rank as the top ones in the world, leading to 'better' researchers and better output. In addition to this, Freeman completely skips over the point that US infrastructure and governmental support for R&D far surpasses that of developing countries that might have lower wages. I thus find his views that the number of foreigners achieving advanced degrees in the United States is troubling adn xenophobic. As long as American corporations continue to operate within the United States, these foreign born students will continue to stay and enjoy the higher wages within the United States.

Chapter III

Data Description

Summary of Data

In this research paper, it is important to recognize that one cannot use a “one model fits all” approach when examining the reasons why students choose to pursue an S&E degree in the undergraduate or graduate level. The motivations behind the choices are quite separate, and reflect on the different opportunities available to potential students. After all, a student contemplating studying Engineering in college is unlikely to be primarily deciding between studying Engineering or choosing to not attending college – it is largely a choice on what course of study to pursue in college. However, a college graduate contemplating going back to school to receive his or her PhD in Engineering is not trying to decide between different courses of study. Rather they are weighing the options of pursuing this advanced degree, or staying in the work force. For these reasons, this paper separates the pursuit of an undergraduate S&E degree from the graduate level, and creates two separate analyses to account for this. All dollar amounts in this section are corrected to 2008 terms. All of the independent variables and their correlations are listed in the table below. Spearman values will be used to determine statistical significance due to variables being non-normal with nearly all variables having trends overtime. A variable will be required to have an absolute R Value of |0.49 | to be statistically significant.

TABLE 1 - Correlation of Independent Variables with Dependent Variables

N=16

Independent Undergraduate Variables	**Pearson Correlation**	**Spearmen Correlation**
Average Starting Salary	-0.76	-0.60
Average Starting Salary with Lag	-0.06	-0.39
Proportion of High School Graduates with a BA	0.14	0.22
Mean Years of Math in High School	-0.62	-0.54
Annual Increase in 4 Year's Tuition	0.28	0.50
Proportion of Female Students	-0.57	-0.46
Independent Graduate Variables	**Pearson Correlation**	**Spearmen Correlation**
Opportunity Cost	-0.24	-0.37
Unemployment Rate	0.21	0.26
Weighted GDP Growth Rate	-0.01	0.03

r=|0.49| required for statistical significance

Undergraduate Summary

On the Undergraduate level, I will utilize both Supply and Demand aspects to determine the possible factors behind student's decisions on what to study for the years 1993 to 2008. My dependent variable, percentage of high school graduates who receive S&E degrees, was measured using data from two sources – the National Science Foundation, and the Western Interstate Commission. The NSF was used for compiling the numbers of students who received S&E degrees, while the WIC was used for total High School Graduate numbers. I then backlogged the high school graduates 6 years and manually calculated the proportions. The NSF criteria for what constitutes an S&E degree were used for all independent and dependent variables on the undergraduate level so that there was consistency amongst the variables.

For the independent variables, the variable which represents demand for S&E graduates side will be the average starting salaries for S&E degrees. Although preferably I would choose to utilize a metric comparing the starting salaries for S&E graduates versus those of non S&E graduates, the data is not available. Therefore while simple starting salaries for S&E graduates are not a perfect capture of the decisions that a college student must make when deciding on a major, due to the fact they don't capture the other choice a student has, it still reflects on the demand for S&E graduates over time. The data for this variable was taken from the NSF so that the criteria for what constitutes an S&E degree consistent with the dependent variable. All of these dollar amounts are corrected to 2008 terms.

On the supply side of the equation, I will look at the number of students who are graduating from college as a proportion of those with high school degrees. This seeks to examine if the proportion of S&E students to overall college students is being driven[12] primarily by more mediocre students electing to attend college than in the past, and if there is a relationship. This data was taken from two data sources – one from the previously used Western Interstate Commission that was also used for the dependent variable in determining how many high school graduates there were, as well as the NSF which was used to determine the amount of college graduates.

Another variable to be used is the Mean Years of Math taken in High School for students, backlogged six years. Mean Years of High School Math was taken using NCES data. However, it was only measured for students who took the SAT and is not representative for all high school students. The Annual Growth Rate of Four Year's Tuition is also used, calculated by summing the previous 4 years of average tuition on top of each other to calculate the total tuition paid for a four year college graduate of that year. All values were corrected for 2008 dollars, which allows for the data to accurately be compared over time. Finally, the proportion of male and female students who are graduating from college will also be examined. As there has been a consistent lack of females electing to pursue an S&E degree course of study, the increasing amount of female students on the college campus could be a possible explanation for overall drops in S&E students[13]. Data from the National Center of Educational Statistics was utilized. This data was seen to be consistent with NSF data and thus acceptable to use as a variable, even though the dependent variable used data taken from another measurement source.

[12] National Science Foundation, "Undergraduate Education, Enrollment, and Degrees in the United States." Last modified January 2010. Accessed November 29, 2011.
[13] National Science Foundation," Percentage distribution of bachelor's degrees awarded to women, by major field group: 1966–2008." Last modified December, 2009. Accessed October 13, 2011. http://www.nsf.gov/statistics/nsf11316/pdf/tab10.pdf.

Graduate Summary

The hypothesis for the graduate level is that opportunity cost plays an extremely large role in the decision to pursue a degree. This hypothesis suggests that for many students, the driving question is if the return on pursuing an advanced degree in S&E is worth the opportunity and time costs of leaving the workforce for several years. Unlike undergraduates, it is difficult to create variables that represent the demand side for these graduates as many students go into Academia, where salaries are atypical to those in the private sector. Therefore, this model will focus solely on the supply side of the equation, and examine the opportunity costs of attending graduate school and how much of a driving force that is behind the number of students who choose to attend graduate school for S&E degrees, corrected for population.

Two dependent variables will be used; one for American students, the other for foreign students. The former variable will be the amount of PhD's Begun by American Students in S&E Fields in a year relative to the amount of overall college graduates in S&E fields[14]. I have chosen to examine those "initiated" instead of completed because the long lag in time from beginning to end would mean that only data up until 2000 would be included. This is because the opportunity cost is known to a student beginning their graduate studies in 2000, and the average graduate would not have completed their studies until approximately 2008.The NSF was used to compile data on the amount of S&E college graduates in a given year (data that was

[14] National Science Foundation, "Graduate Education, Enrollment, and Degrees in the United States." Last modified January 2010. Accessed November 29, 2011. http://www.nsf.gov/statistics/seind10/c2/c2s3.htm#s3

previously used for other variables in the undergraduate model), as well as the amount of PhD's begun in a given year by American students[15].

The other dependent variable will be the Number of PhDs Begun by Foreign Students. This variable will only be one against one independent variable, the Weighted GDP Growth Rate of the three countries who are the source for the overwhelming majority of foreign S&E students; China, South Korea and India. This data was taken from the NSF[16].

Opportunity cost will be an independent variable measured by the average starting salary for an S&E Bachelor's degree times the median amount of time taken to for degree completion. Many different measurements were used to calculate this study. 7.7 years was used as a constant time for being in school because of data showing that the average time to completion for a PhD has hovered just below 8 for the last couple of decades, with very small standard deviations although that number has begun to decrease over the last several years[17]. As 7.7 years was used as the time component of opportunity cost, average starting salary for an S&E graduate in a given year was used as the potential salary given up. It is important to note that this number could be expected to be undervalued, as typically it is only above average students that are able to attend graduate school. On top of this, salary growth rates were not taken into account. All salary amounts used were converted into 2008 dollars.

Another independent variable used was Yearly Unemployment Rate was also used as a way to measure the health of the economy at large when students begin graduate school, as in down years students may have no opportunity cost to attend graduate school if they are unable to

[15] National Science Foundation, "Graduate Education, Enrollment, and Degrees in the United States." Last modified January 2010. Accessed November 29, 2011. http://www.nsf.gov/statistics/seind10/c2/c2s3.htm#s5
[16] Ibid.
[17] Ibid.

find employment. The yearly unemployment rate was taken from the Bureau of Labor Statistics[18].

In addition, the aspect of foreign students obtaining degrees will be examined. This will be measured by the weighted GDP Growth Rate in the three countries that are the most frequent source of graduate students, China, South Korea and India[19]. Rising GDP can be translated to rising opportunity costs in their native homeland. This is used instead of salary data because of incomplete data in these countries. Their GDPs were weighted as a percentage of their contribution to enrollment in PhD programs, and these dollar values were then corrected to 2006. The year over year growth was then measured, and finally, each year was given a growth value compared to the average growth rate over the past 16 years which was 9.95%. The weightings for amount of students from each country were taken from an NSF report[20], and the GDP values were taken from published reports[21].

Limitations

Due to data limitations, this thesis is only an exploratory analysis. Correlation between variables is sought, and in instances of statistical significance, the hope is for further analysis to find if these correlations are truly interconnected. However, it should not be assumed in this paper that statistical significance does equal causation.

[18] Bureau of Labor Statistics, "Labor Force Statistics from the Current Population Survey." Last modified February 3, 2011. Accessed November 29, 2011. http://www.bls.gov/cps/prev_yrs.htm.
[19] National Science Foundation, "Graduate Education, Enrollment, and Degrees in the United States: S&E Doctoral Degrees, Table 2-5." Last modified January 2010. Accessed October 14, 2011. http://www.nsf.gov/statistics/seind10/c2/c2s3.htm
[20] Ibid.
[21] Google, "World Bank, World Development Indicators, GDP." Last modified November 1, 2011. http://www.google.com/publicdata/explore?ds=d5bncppjof8f9_.

Chapter IV

UNDERGRADUATE EDUCATION

Dependent Variable

Proportion of High School Graduates Who Receive S&E Degrees

This will be my dependent variable, which is being tested to see which independent variables have statistically significant levels of correlation. I have chosen to use the proportion of High School graduates who go on to receive S&E degrees, and not the absolute number of S&E degrees handed out in a given year, for a variety of reasons. First and foremost is that population growth would be the number one driver behind an increase in graduates over a given time. One only needs to look at the 2nd column of Table 2 to see that the number of graduates is increasing every year, even as the proportions rapidly fluctuate. In addition, I am using the number of S&E graduates and not the proportion of college graduates who obtain S&E degrees because of the negative connotations that brings. One additional student making the choice to go to college to study English does not negate the positive impact that an S&E graduate would have on society at large. It would however drive down the proportion of S&E graduates, giving an appearance of a negative result. Finally, total number of S&E graduates relative to High School students would include those students who fail to finish High School. Although pushing for more students to graduate from High School is a worthwhile goal, for the purpose of this paper it is safe to assume that one who cannot graduate High School should not be included with those who are making the decision on what to study in University.

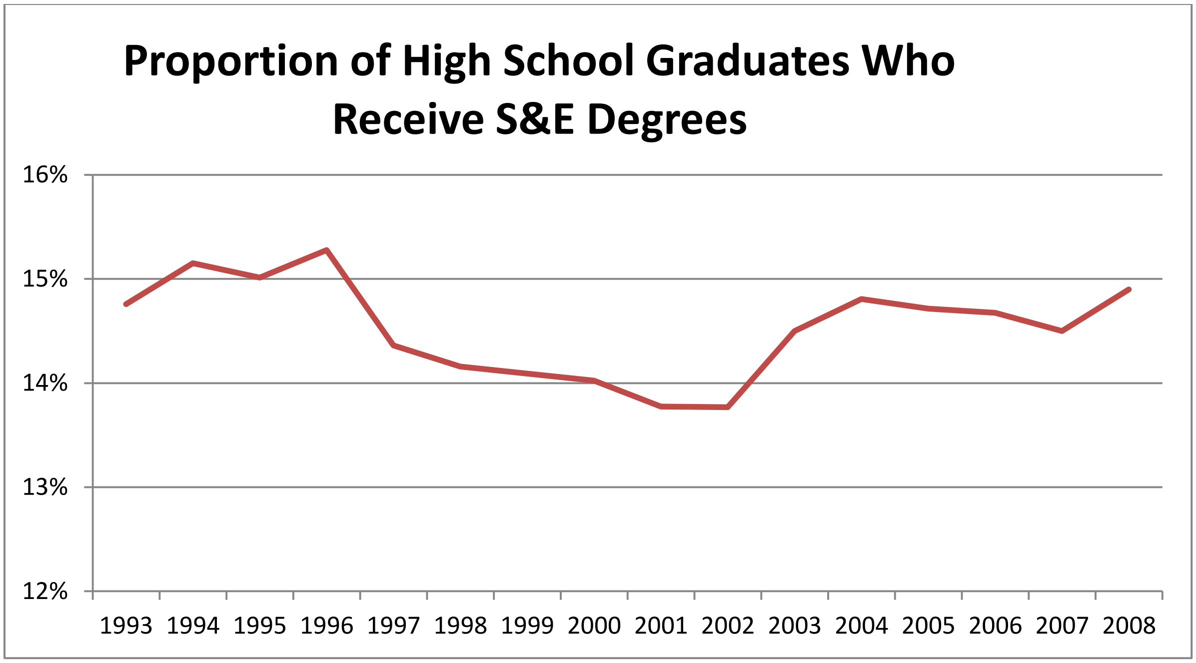
TABLE 2 - Proportion of High School Graduates Who Receive S&E Degrees [22] [23]

Year	S&E Graduates	High School Graduates 6 Years Prior	Percentage
1993	366,035	2,480,519	14.76%
1994	373,261	2,463,728	15.15%
1995	378,148	2,519,084	15.01%
1996	384,674	2,518,064	15.28%
1997	388,482	2,705,110	14.36%
1998	390,618	2,759,069	14.16%
1999	399,143	2,832,879	14.09%
2000	399,686	2,850,006	14.02%
2001	400,905	2,910,665	13.77%
2002	415,653	3,019,234	13.77%
2003	443,437	3,058,145	14.50%
2004	458,525	3,096,834	14.81%
2005	469,340	3,189,538	14.71%
2006	477,589	3,254,432	14.68%
2007	484,350	3,340,235	14.50%
2008	494,627	3,320,163	14.90%

N=16

[22] National Science Foundation, "Bachelor's degrees awarded, by major field group: 1966–2008." Last modified June 2011. Accessed October 10, 2011. http://www.nsf.gov/statistics/nsf11316/pdf/tab5.pdf.
[23] Western Interstate Commission for Higher Education, "Knocking at the College Door: Projections of High School Graduates by State and Race/Ethnicity." Last modified March 2009. Accessed October 10, 2011. http://www.wiche.edu/pub/11556.

CHART 1



When examining the data, a clear trend emerges. There is a large drop off in the middle part of the 1990s, followed by a trend of slowly rising proportions over time. The simple results in computing this variable are surprising, as it was not expected that over the previous 10 years a higher proportion of High School graduates would be going on to receive S&E degrees. Over the past 15 years, we see that the proportion has not changed drastically. Seeing this, it is expected that a large driver behind the increasing amounts of students receiving S&E degrees will be the demand for S&E graduates, as lower overall wages coupled with higher tuition payments following the 2001 Recession coincide with an increase in the amount of S&E graduates. We see a minimum occur in 2001 where only 13.77% of High School graduates from six years prior obtained an S&E degree. The high occurs in 1996 when 15.28% of obtained S&E degrees. The average overtime is at 14.53%, with a standard deviation of just 0.45%.

Independent Variables

Average Starting Salaries

The Average Starting Salaries of college graduates in S&E fields was taken from the National Science Foundation. Looking at Table 1, a clear trend emerges where salaries for those who have just graduated college with an S&E degree. From 1993 up until the 2001 recession, salaries increase very consistently year over year. In 2001 though we see a sharp crash, where in consecutive years there is an almost 10% drop in real salaries. Following these drops, salaries stagnate over time, and are still not back to the 1993 levels.

TABLE 3 - Average Starting Salaries[24]

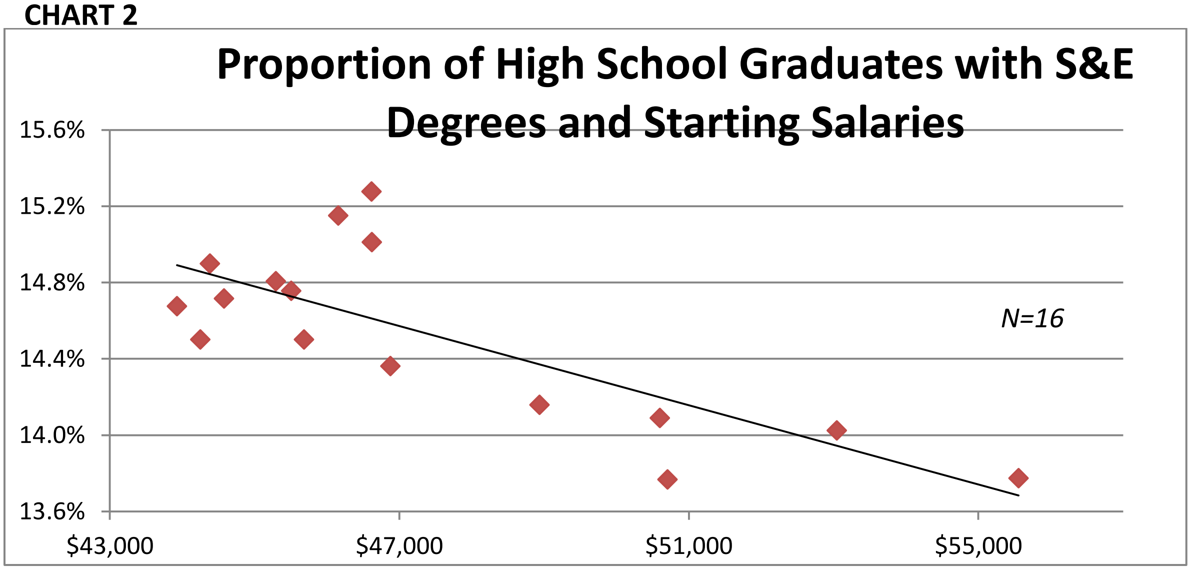
Year	S&E Average Annual Starting Salary (In 2008 Terms)	Yearly Percentage Change
1993	$45,506	N/A
1994	$46,156	1.43%
1995	$46,621	1.01%
1996	$46,618	-0.01%
1997	$46,877	0.56%
1998	$48,939	4.40%
1999	$50,603	3.40%
2000	$53,048	4.83%
2001	$55,556	4.73%
2002	$50,709	-8.73%
2003	$45,685	-9.91%
2004	$45,294	-0.86%
2005	$44,577	-1.58%
2006	$43,928	-1.46%
2007	$44,251	0.74%
2008	$44,383	0.30%

N=16

[24] National Science Foundation, "Compiled from Annual Reports on Market for Recent Graduates." Last modified January, 2011. Accessed October 13, 2011.

We see a minimum value in 2006 with a starting salary of only $43,928. The maximum occurs in 2001 with an average starting salary of $55,556. Over the 16 years, the average is $47,422 with a standard deviation of $3,307. When examining these values against the dependent variable, it is clear that there is a negative relationship between the two, seen below in Chart 2. Using a Spearman's Ranked Correlation Test, we find an exact value of -0.60, and a value of -0.71 using Pearson. It appears that rather than students reacting to higher wages, the private sector is reacting to a shortage of S&E graduates. This is apparent when examining Chart 2, and seeing the two data clusters. When the percentage value is past the 14.4% threshold, the data clusters with no clear correlations. However, the six lowest values are all clustered to the right, with the highest average salaries. This leads one to believe that firms are elastic to the changes in supply, while students decisions on school are not largely affected by wage changes. It remains possible that due to the highest salary years all occurring over a five year span due to the late 1990s tech bubble, there exists the possibility that students were "late to the party". This would also explain why there are such high residuals for a linear line of best fit. Many students who began to learn about the high paying jobs in S&E may have already decided on their S&E studies when salaries collapsed in the early 2000s.

CHART 2



When a four year lag is utilized, for example by pairing starting salaries for S&E graduates in the class of 1989 with the proportion of students who graduate with an S&E degree in 1993, no statistically significant correlation is seen, with a Spearman value of -0.39 and a Pearson value of -0.06. This suggests that yearly fluctuations in starting salaries do not impact the supply of S&E graduates, and that firms are much more elastic than students to changes in supply and demand. Previous research though by Gilbreath, reviewed in Chapter II, leads credence though to the idea that the supply of S&E graduates is largely inelastic to wage changes.

College Graduates as a Proportion of High School Graduates

For this variable, data from the NCES was used for the years 1993 through 2008.

TABLE 4 - College Graduates as a Proportion of High School Graduates [25]

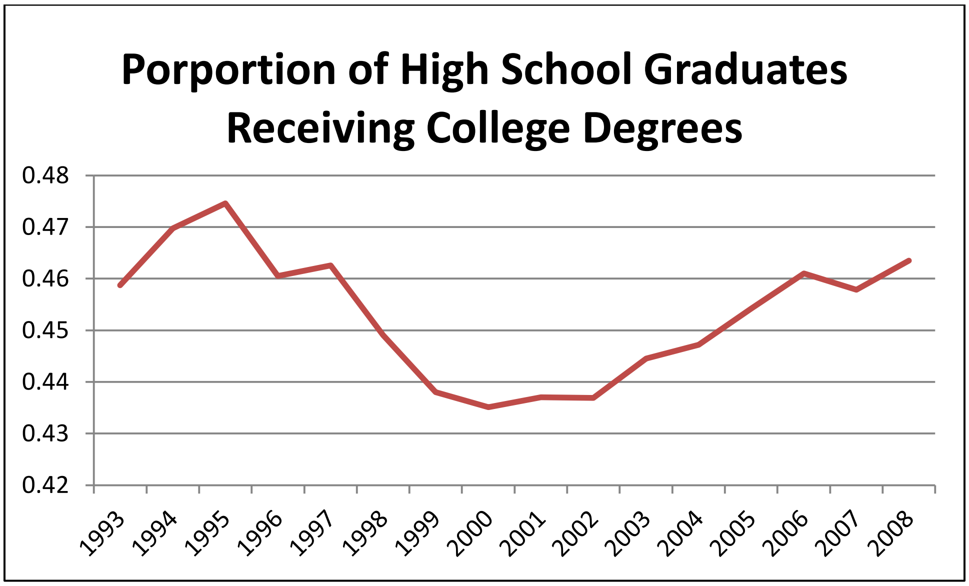
Year	High School Graduates	College Graduates	Proportion
1993	2,477,790	1,136,553	0.459
1994	2,480,519	1,165,178	0.470
1995	2,463,728	1,169,275	0.475
1996	2,519,084	1,160,134	0.461
1997	2,518,064	1,164,792	0.463
1998	2,611,988	1,172,879	0.449
1999	2,704,133	1,184,406	0.438
2000	2,758,655	1,200,303	0.435
2001	2,832,669	1,237,875	0.437
2002	2,847,729	1,244,171	0.437
2003	2,906,302	1,291,900	0.445
2004	3,015,662	1,348,503	0.447
2005	3,081,407	1,399,542	0.454
2006	3,122,152	1,439,264	0.461
2007	3,190,947	1,461,000	0.458
2008	3,240,458	1,502,000	0.464

N=16

[25] National Center for Educational Statistics, "04/10/2011." Accessed October 4, 2011. http://nces.ed.gov/programs/coe/indicator_dai.asp.

In this section, it is surprising to see that there appears to be a trend closely following that of the dependent variable – a decrease beginning in the 1990's, with an increase seen following the 2001 Recession We see a minimum value of 43.5%, and a maximum value of 47.5% for this variable. Interestingly enough, these two occur only several years apart. We find a small standard deviation of only 1.2% and an average of 45.3%.

CHART 3

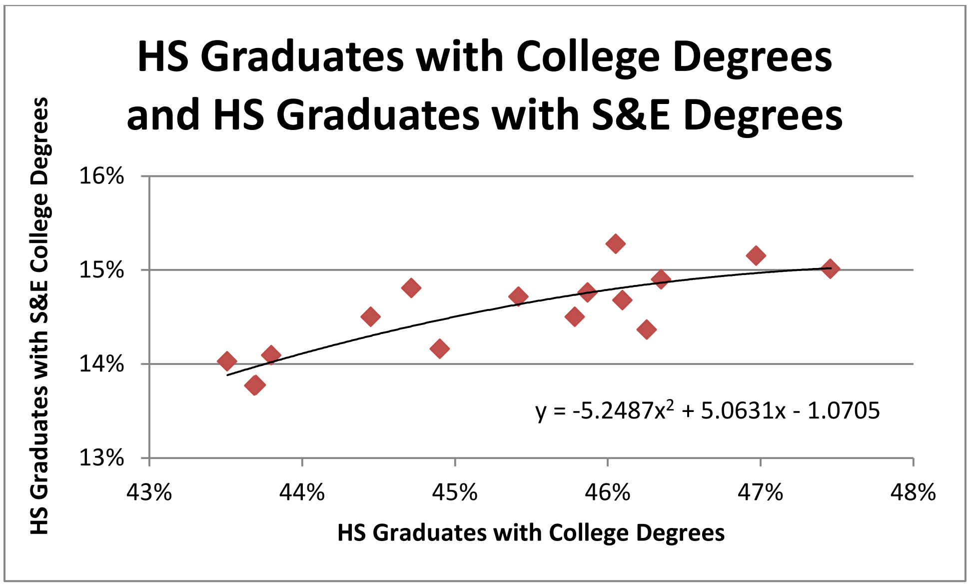


N=16

Running the proportion of high school graduates with a college degree against the dependent variable, seen in Chart 4, a very clear trend line emerges with small residuals. The very small intercept, of just ½%, suggests that this relationship follows very closely all the way to 0. Thus, it seems likely that the increase in students obtaining college degrees has a direct effect on the amount pursuing S&E degrees. While this may seem trivial and obvious, it was possible that as higher amounts of marginal students attend college, they are drawn more towards non-S&E fields. This relationship however shows that that may not be the case, and that the more marginal students who attend college may be attracted more so to technical degrees, rather than liberal arts. Note though that this trend appears to lesson overtime, with diminishing positive relationships as the proportion of students attending college rises. A final correlation of

0.14 is found utilizing Pearson, while a slightly higher one of 0.22 is found using Spearman. The small residual values though lend evidence to the possibility that there is a true relationship between the two, and that future policy decisions can increase the amount of students who aim to complete S&E degrees.

CHART 4



N=16

Mean Math Years Taken in High School

One of the frequent claims made in the public sphere relating to S&E graduates is that the amount of math courses taken by High School students has a direct impact on the ability of students to graduate with an S&E degree[26]. This variable is included to test that claim, and to see if there really is a relationship between the average amount of math courses taken by High School students and the number of S&E graduates. For the purpose of this variable, the average years of Math taken for a high school class is run against the college class of six years later. This is done because over the last 30 years, the average time spent for completion of a BA has

[26] Boundaoui, Assia. "Why would-be engineers end up as English majors." *CNN*, sec. U.S., May 21, 2011. http://www.cnn.com/2011/US/05/17/education.S&E.graduation/index.html (accessed October 10, 2011).

remained constant at approximately 6 years[27]. The data was also only examined for college bound seniors. Some research done has suggested that there is a correlation between minority students taking specific math classes and their completion rates of S&E degrees, but not on the overall number of years of math[28] taken by college bound seniors and its effect on S&E degrees.

TABLE 5 - Mean Math Years Taken in High School

Year	Mean Years of Math
1993	3.68
1994	3.66
1995	3.64
1996	3.64
1997	3.71
1998	3.80
1999	3.85
2000	3.84
2001	3.82
2002	3.85
2003	3.83
2004	3.79
2005	3.86
2006	3.82
2007	3.82
2008	3.86

This data is taken from the College Board, most of which was published in annual surveys of college bound seniors, as well as the National Center of Educational Statistics[29] . When looking at this total, one can see a slow and steady rise in the average amount of high school years of Math taken. The minimum is found in 1993 at 3.57 years of Math on average, and the maximum is found in both 2005 and 2008 at 3.86. The standard deviation is 0.08, with an average value of 3.78 and a median of 3.82. This suggests that there has been skewedness, with outliers towards the bottom. This is clearly seen in the data, with the first few years showcasing much loser values than in more recent years.

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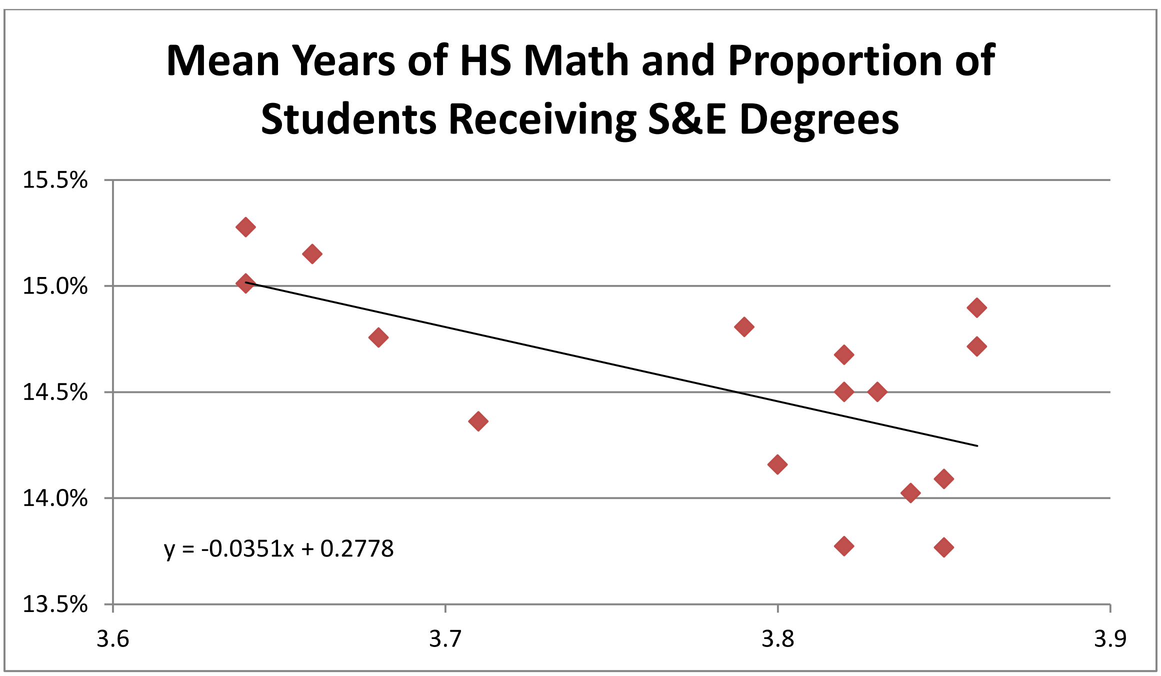
[27] National Science Foundation, "National Survey of Recent College Graduates." Last modified June 28, 2011. Accessed November 29, 2011. http://www.nsf.gov/statistics/srvyrecentgrads/.

[28] Tyson, Will, Hanson ,Mary Ann, Borman, Kathryn, and Lee Reginald." Science, Technology, Engineering and Mathematics (S&E) Pathways: High School Science and Math Coursework and Postsecondary Degree Attainment." *Journal of Education for Students Placed at Risk*. 2007.)

[29] National Center for Educational Statistics, "Digest of Educational Statistics 2009." Last modified April 2010. Accessed February 24th, 2011. http://nces.ed.gov/pubs2010/2010013.pdf.

In Chart 5 below, we see that there may not be a very strong relationship between the years of high school Math and the proportion of students that elect to pursue an S&E college degree. We do see a negative relationship, which is counter-intuitive. However, the correlation is strong found using Spearman and Pearson, showing values of -0.54 and -0.62 respectively. Two data clusters are seen, with a large gap seen on the X axis between 3.7 years and 3.8 years. These two clusters are also separated on the Y axis by a smaller amount, suggesting that it is indeed possible there is a correlation between the two. However, this correlation is of yet undetermined. Additionally, because the Mean Years of Math for high school students has continuously been rising and has not seen upward or downwards fluctuations, it would be difficult to pinpoint the exact relationship between the two without conducting a full regression. More studies are needed.

CHART 5



N=16

Annual Growth Rate of Four Year Tuition

The Median Cost of Tuition is included as a variable so it can be seen whether or not the rising costs of education encourage students to pursue S&E degrees that yearly lead to higher starting salaries, as shown in Table 1. These four year tuition costs were indexed to 2009 prices, and the year listed is the year of the graduating class and the average total four year tuition costs. These were calculated by summing the previous four years of average tuition rates from a National Center of Educational Statistics database. As tuition rates have grown over time yearly, percentage increases in tuition were utilized instead of the absolute values to better determine a relationship.

TABLE 6 - Annual Growth Rate of Four Year Tuition[30]

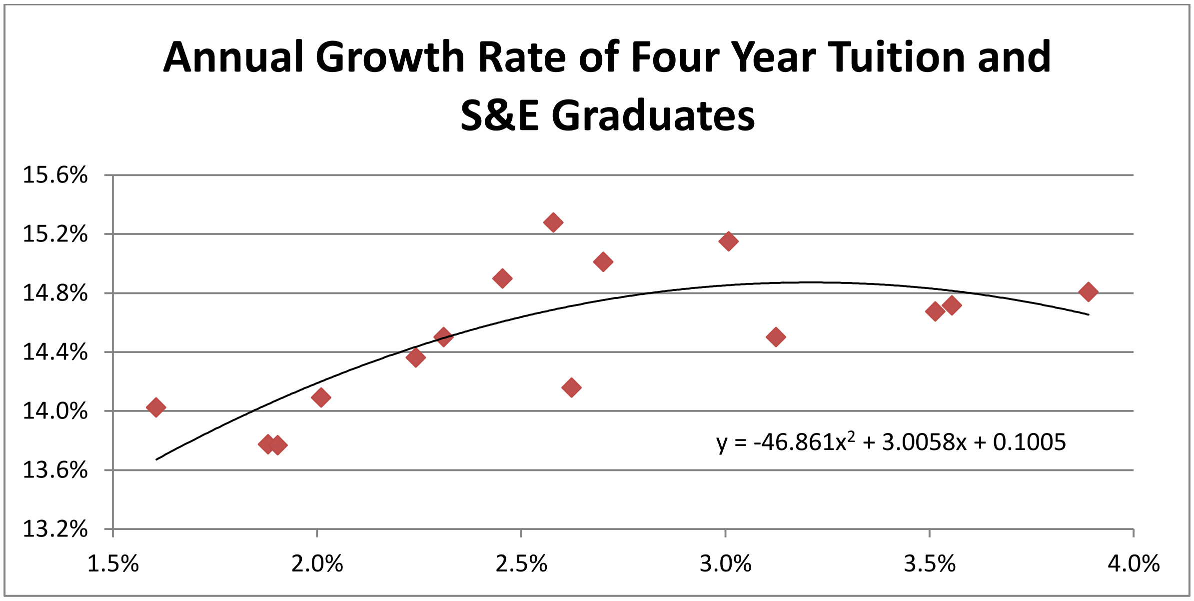
Year	Average 4-Year Tuition (2008 Dollars	Annual Percentage Increase
1993	$44,378	N/A
1994	$45,713	3.01%
1995	$46,948	2.70%
1996	$48,159	2.58%
1997	$49,239	2.24%
1998	$50,531	2.62%
1999	$51,547	2.01%
2000	$52,375	1.61%
2001	$53,360	1.88%
2002	$54,376	1.90%
2003	$56,075	3.12%
2004	$58,256	3.89%
2005	$60,327	3.55%
2006	$62,447	3.51%
2007	$63,890	2.31%
2008	$65,458	2.45%

[30] National Center for Educational Statistics, "Average undergraduate tuition and fees and room and board rates charged for full-time students in degree-granting institutions, by type and control of institution: 1964-65 through 2009-10." Last modified April 2011. Accessed October 10, 2011. http://nces.ed.gov/programs/digest/d10/tables/dt10_345.asp.

As can readily be seen, the average four year tuition costs for graduate's skyrockets over time in real terms, from $44,378 for 1993 college graduates to $65,458 for members of the 2008 graduating class.   Over this time, there is an average yearly increase of 2.6% and the standard deviation for all the tuition values are $6,383 and an average of $53,942. It is expected that there will not be a relationship between rising tuition costs and the amount of students who pursue S&E degree. This projection is based off of how quickly tuition costs are rising.

In a market with such rapidly rising prices it is clear that the consumers in this case, students, still perceive the good being sold to be of higher value than the costs associated with it. As such, due to the apparent continuous undervaluing of the good, there will not be a change in the consumption behavior until the cost reaches a point where it is above the value that a non-S&E degree would offer and the value that an S&E degree would give. When this occurs, one could expect to see a shift in majors as well as a decrease in the percentage real increase of tuition year over year. . There appears to be somewhat of a relationship, with a Spearman value of 0.5 and a Pearson value of 0.28, and a line of best fit that is polynomial in nature with a negative second derivative. The high variance though warrants further analysis, as the positive correlation may not be statistically valid.

CHART 6



N=16

Proportion of Female College Graduates

Over time, the landscape and makeup of higher education in the United States has shifted. What was once largely the domain of young men has now opened up to women, who increasingly make up more and more of each year's college graduates. In 1982, women surpassed men in terms of total degrees and now obtain close to 3/5ths of all college degrees awarded in a given year. Simultaneously, a perpetual gap has existed in the proportion of S&E degrees that are awarded to men and women, with men continuously being awarded a higher amount of S&E degrees on the undergraduate level than women[31]. Therefore, it is prudent to examine whether or not the drop in proportions of students who are obtaining S&E degrees is being affected by the amount of women who are now attending college. As one can see by examining Table 6, there is a rise in the proportion of college graduates who are female over

[31] National Science Foundation, "Percentage distribution of bachelor's degrees awarded to women, by major field group: 1966–2008." Last modified January, 2011. Accessed September 13, 2011. http://www.nsf.gov/statistics/nsf11316/pdf/tab10.pdf.

time. However, this growth is largely stopped by 2001, and the proportion has stagnated since at 57%. A minimum value is seen in 1993 of .5448, and a maximum occurs in 2005 at .5754. However, this number is not significantly higher than any year from 1999 to 2008, as all of these years have values in the low 0.57 range. Additionally, over time there is a non-weighted average of 56.65%, and a miniscule standard deviation of only .009, less than a percentage point.

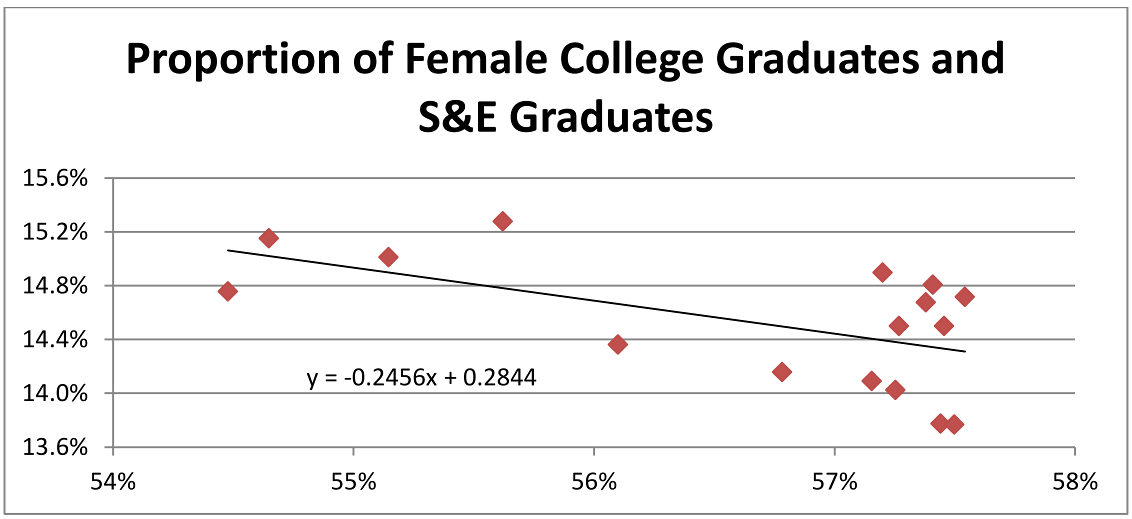
TABLE 7 Proportion of Female College Graduates[32]

Year	Proportion of Female Graduates
1993	0.5448
1994	0.5465
1995	0.5515
1996	0.5562
1997	0.5610
1998	0.5678
1999	0.5716
2000	0.5725
2001	0.5744
2002	0.5750
2003	0.5746
2004	0.5741
2005	0.5754
2006	0.5738
2007	0.5727
2008	0.5720

[32] National Center for Educational Statistics, "Bachelor's degrees conferred by degree-granting institutions, by race/ethnicity and sex of student: Selected years, 1976-77 through 2008-09." Last modified April 2011. Accessed October 10, 2011. http://nces.ed.gov/programs/digest/d10/tables/dt10_296.asp.

When examining the relationship between the percentage of female college graduates and the number of S&E graduates, there appears to not be a very large relationship in the graph below. However, this could possibly be misleading. Because the percentage of female college graduates has hovered in the low 57^{th}% for the last 10 years and does not have a normal distribution, there is a high level of skewedness. Thus, the years of highest female collegiate participation are all focused in years in which S&E graduates have been trending up from a local minimum in 2001. Therefore, the correlation remains inconclusive.

CHART 7



N=16

Chapter V

GRADUATE EDUCATION

Dependent Variable

Graduate Degrees Begun by Americans as a Percentage of College S&E Degrees

This will be my dependent variable for my graduate education model. I am choosing to utilize graduate degrees initiated rather than those that are completed for several reasons. Primarily is that the amount of time it takes to achieve a PhD once initiated has high variance among individuals, thus making it hard to backlog the data. For examine, if examining 2007 graduates, there was an average time of 7.4 years of completion. Therefore, one would examine the starting salary for S&E graduates in 2000 to make an accurate measure of opportunity costs. However, unlike undergraduate students, there is high variance in the amount of time taken to complete a degree. While most college degrees are completed within four to six years if they are to be completed at all, PhD's routinely take anywhere from four to ten years, thus making the backlogging of data exceptionally difficult to accurately do. Additionally, one would not know all of the variables that would exist for what their future graduating class. It is then more rational to use the number of people who chose to begin their studies in a given year, who have current knowledge of what standard salaries are as well as knowledge of past average completion times of a PhD. I chose to utilize proportions of college graduates despite the large amount of foreigners who come to the United States for their graduate degrees who are not included in the number of S&E college graduates.

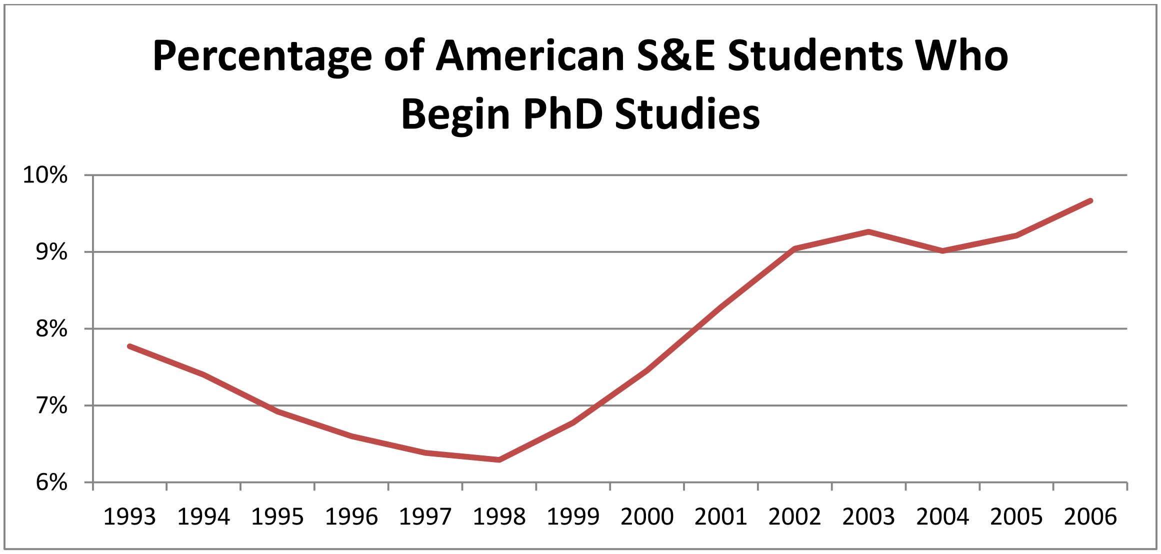
TABLE 8 - PhDs Begun by Americans as a Percentage of College S&E Degrees [33]

Year	American PhD's Initiated	S&E College Graduates	Percentage
1993	28,440	366,035	7.77%
1994	27,615	373,261	7.40%
1995	26,173	378,148	6.92%
1996	25,386	384,674	6.60%
1997	24,791	388,482	6.38%
1998	24,580	390,618	6.29%
1999	27,038	399,143	6.77%
2000	29,789	399,686	7.45%
2001	33,189	400,905	8.28%
2002	37,583	415,653	9.04%
2003	41,066	443,437	9.26%
2004	41,329	458,525	9.01%
2005	43,235	469,340	9.21%
2006	46,160	477,589	9.67%

Examining the data, there is a clear decline in the proportion of students who choose to undertake a PhD, a trend which appears to inversely correlate with the average starting salary available for S&E graduates following colleges that was seen in Table 3. There is a gradual reduction following the early 1990s recession, until the last years of the decade when the numbers begin to rise continuously with the exception of a small dip during the recovery period of the early 2000's recession. This trend is similar to the one seen for Proportion of High School Graduates Who Receive S&E Degrees in Chart 1.

[33] National Science Foundation, "Graduate Education, Enrollment, and Degrees in the United States: Graduate Enrollment in S&E." Last modified January, 2010. Accessed October 12, 2011. http://www.nsf.gov/statistics/seind10/c2/c2s3.htm

CHART 8


Percentage of American S&E Students Who Begin PhD Studies
10%
9%
8%
7%
6%
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

N=16

Foreign Students Initiating PhD's in the United States

This will be the dependent variable for only one independent variable, representing foreign opportunity cost which will be calculated using a weighted GDP ratio. There is an obvious upward trend over time, although it is not necessarily a consistent increase over time. A minimum of 63,309 is observed in 1995 while a maximum of 70,322 is seen in 2006. The proportion of students who are International has stayed consistent over time at approximately 24%[34].

TABLE 9 - PhDs Begun by Foreign Students[35]

Year	Foreign PhD's Initiated
1993	64,308
1994	64,556
1995	63,309
1996	63,598
1997	64,386
1998	66,248
1999	65,176
2000	64,551
2001	64,923
2002	66,601
2003	66,109
2004	65,215
2005	66,984
2006	70,322

[34] National Science Foundation, "Graduate Education, Enrollment, and Degrees in the United States: Foreign Student Enrollment." Last modified January 2011. Accessed October 13, 2011. http://www.nsf.gov/statistics/seind10/c2/c2s3.htm
[35] Ibid.

Independent Variables

Opportunity Cost

While the non-Economist might proclaim that a graduate education is free for many students due to stipends and tuition reimbursement, one with even a cursory background in Economics knows that there is no such thing as a free lunch. Many universities do in fact provide subsidies or tuition waivers for students pursuing a PhD – however the opportunity costs associated with the degree nearly always run well into the hundreds of thousands[36]. As such, it is necessary to see how the growing opportunity costs that exist for holders of Bachelor degrees in S&E fields impact the decision making process for those who are debating going on to the graduate level. This salary uses the Percentage of American S&E Students Beginning Their PhD as the dependent variable for the past generation average time to completion for PhD's has hovered around 7.7 years, although that number has slightly dipped recently[37]. The average time to completion though for a future class would obviously not be known for someone beginning their graduate studies, however they would the historical averages. Thus, for every year the value of 7.7 years is used. Salary growth is not considered, nor is the discount rate.

[36] Bone, Allison. "Pursuing a master's degree:." *Education Quarterly Review*. 8. no. 4 (2002): 16-27. http://www.faculty.de.gcsu.edu/~mtiryaki/masters.pdf (accessed November 29, 2011).
[37] National Science Foundation, "Graduate Education, Enrollment, and Degrees in the United States." Last modified January 2010. Accessed November 29, 2011. http://www.nsf.gov/statistics/seind10/c2/c2s3.htm#s5

TABLE 10 - Opportunity Cost[38]

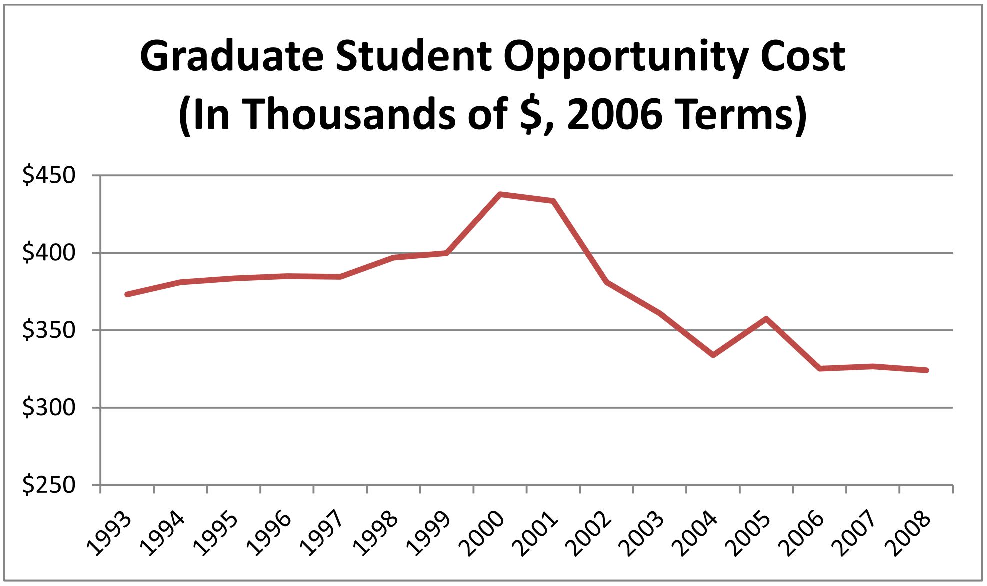
Year	Average Salary (2008 Terms)	Opportunity Cost (In 1,000's)	Percentage of American S&E Students Beginning PhD
1993	$45,506.19	$359.50	7.77%
1994	$45,906.29	$362.66	7.40%
1995	$46,765.46	$369.45	6.92%
1996	$46,357.58	$366.22	6.60%
1997	$46,876.86	$370.33	6.38%
1998	$48,985.00	$386.98	6.29%
1999	$50,603.29	$399.77	6.77%
2000	$54,721.54	$432.30	7.45%
2001	$55,556.49	$438.90	8.28%
2002	$48,210.20	$380.86	9.04%
2003	$45,684.93	$360.91	9.26%
2004	$45,099.32	$356.28	9.01%
2005	$47,018.11	$371.44	9.21%
2006	$43,928.10	$347.03	9.67%

N=14

In this data, several findings emerge. First is that the real average starting salary (all numbers in 2008 terms) for a newly graduated student who holds a Bachelor's in an S&E field rapidly fluctuates. There is a clear maximum of $55,556.49 in 2011 before a regression to much lower levels following the early 2000's recession. With these lower salaries and lower median times to receive a degree following 2001, opportunity costs have obviously decreased. This is observed on a time chart as well.

[38] Ibid.

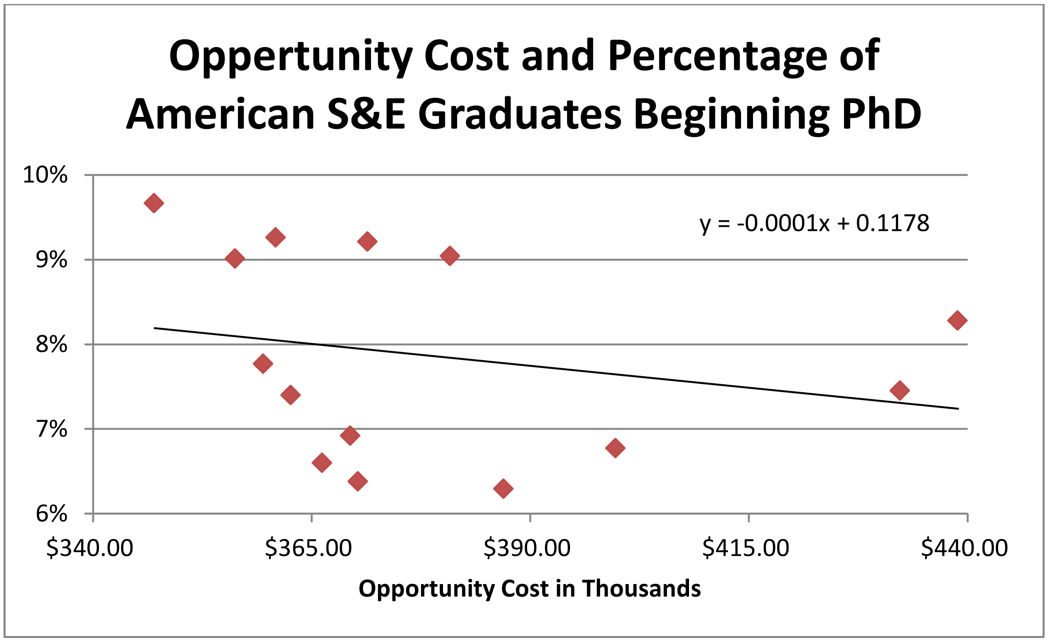
CHART 9



N=14

We find a minimum value of $323,992.91 in 2008 and a maximum value of $437,772.29 in 2000. Due to the steep drop off in opportunity costs, one would expect to see an increase in students beginning the pursuit of their PhDs in the following the early 2000's recession. This is actually seen, and there appears to be a negative relationship between the two variables. As the gradual decrease in the proportion of American S&E Bachelor graduates who pursue their PhD declines through the 1990s, we see this is paired with rising opportunity costs. The gradual decrease that we see in opportunity costs following the end of the Tech Boom around 2000 is matched up with an increase in the percentage of American students who begin their PhD studies. A correlation of -0.24 is found using Pearson, and one of -0.37 utilizing Spearman, and is therefore not statistically valid as it is below an absolute value of 0.497.

CHART 10



N=14

Yearly Unemployment Rate

Unemployment rate is yet another method to capture the opportunity cost of enrolling in graduate school. While the average salary is a good indicator on what possible incomes students are forsaking, that metric does not capture the students who are unable to find employment. Thus, the unemployment rate is a good measure to capture these students who do not have career options.

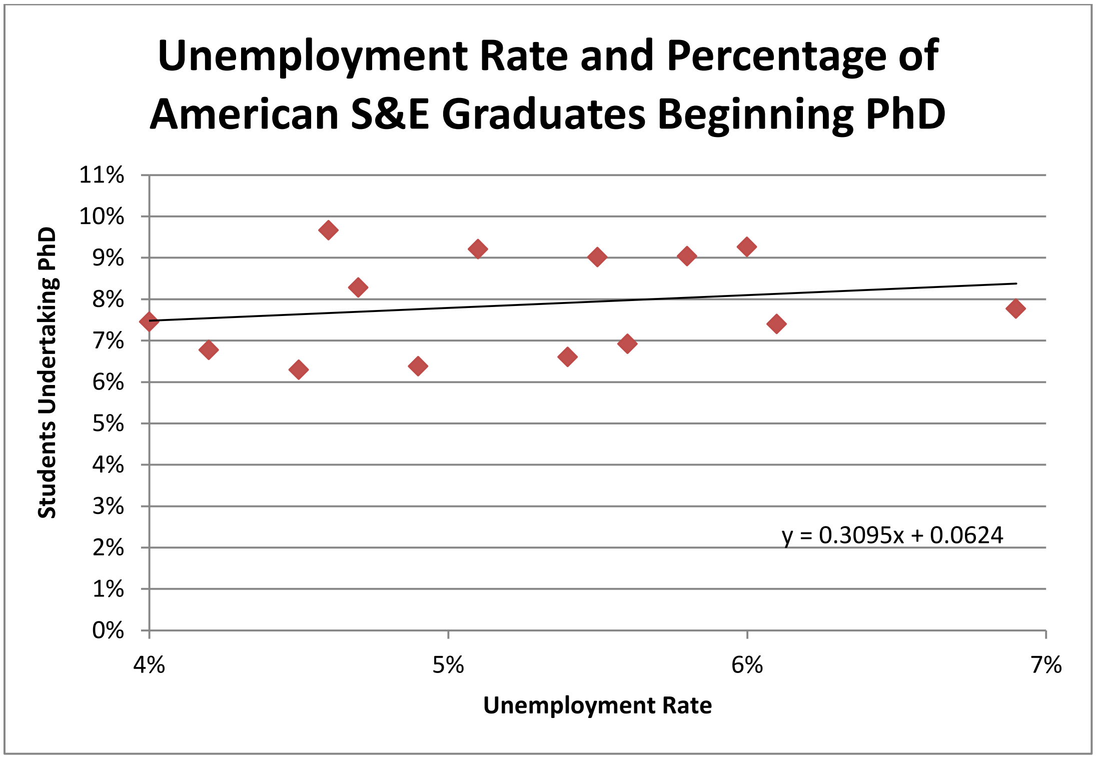
One can see that the unemployment rate fluctuates over time, following cyclical patterns closely related to how the economy as a whole is operating. When comparing these numbers to the proportion of American S&E students who begin their PhD studies, a small correlation is seen. In Chart 11, one can see that for approximately every 1% increase in total unemployment in the American economy, there is a correlation with a 0.3% increase in the percentage of American college graduates in S&E fields who elect to pursue a PhD. Spearman finds a similar correlation. The residuals are fairly consistent throughout as well. This supports the alternate hypothesis that there is a correlation between opportunity cost and the decisions of American S&E students to pursue their PhD.

TABLE 11 Yearly Unemployment Rate[39]

Year	Unemployment Rate
1993	6.9
1994	6.1
1995	5.6
1996	5.4
1997	4.9
1998	4.5
1999	4.2
2000	4.0
2001	4.7
2002	5.8
2003	6.0
2004	5.5
2005	5.1
2006	4.6

[39] Bureau of Labor Statistics, "Labor Force Statistics from the Current Population Survey." Last modified January 2011. Accessed October 13, 2011. http://www.bls.gov/cps/prev_yrs.htm.

CHART 11



N=14

Weighted GDP Growth Rate of India, South Korea and China

To capture the opportunity cost of foreign students, I will utilize the Gross Domestic Product of the three largest sources of graduate students – India, South Korea and China. Although starting salary would be a more useful indicator of opportunity cost, the data for that is incomplete for foreign countries. Utilizing GDP is still an effective measure, as it does capture the overall economic conditions. However, due to the growth that Asia has experienced over the past 20 years, this may not be entirely effective either. What is instead utilized is the Real GDP Growth annual in 2006 Dollars, compared to the average growth rate from 1993-2006 of almost 10%. The GDP numbers listed are not the absolute values; rather they are weighted against the proportion of students that come from that country[40]. This variable will be run against the dependent variable of Total Number of Foreign Students.

TABLE 12 - Weighted GDP Growth Rate of India, South Korea and China [41]

Adjusted to Billions of 2006 US$

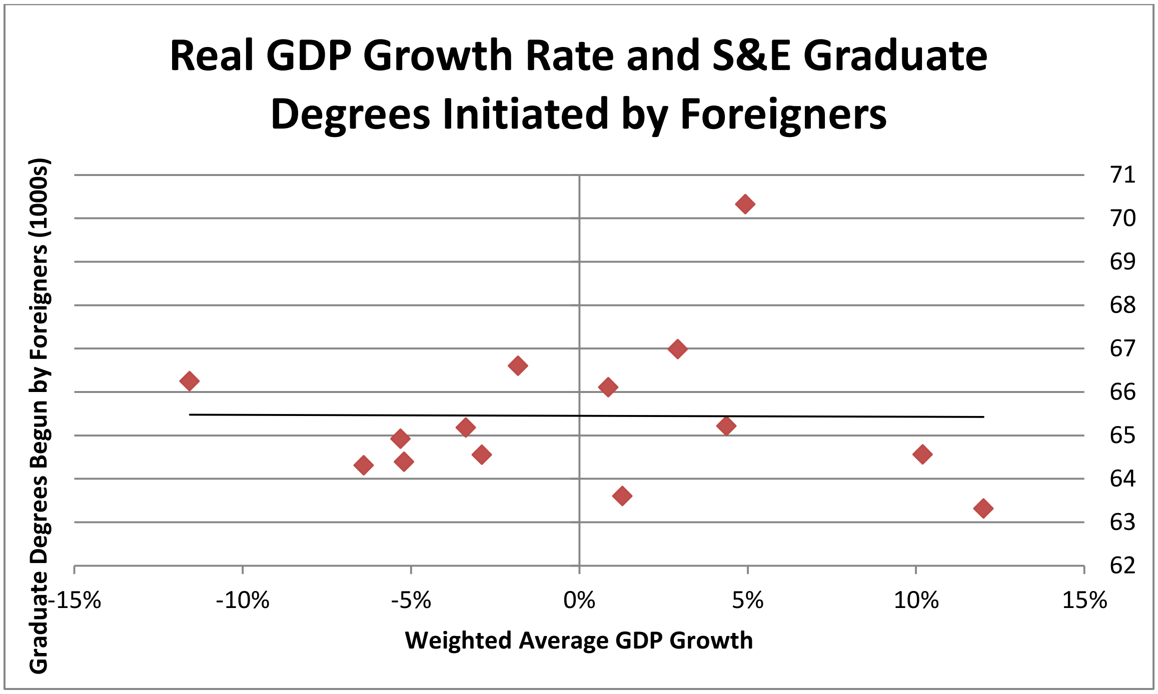
Year	China	India	South Korea	Weighted Total	Adjusted Total	Growth	Compared to Average
1993	$240.13	$63.98	$80.78	$384.90	**$536.99**	3.55%	**-6.40%**
1994	$304.86	$74.99	$94.45	$474.29	**$645.19**	20.15%	**10.20%**
1995	$396.87	$82.59	$115.35	$594.80	**$786.82**	21.95%	**12.01%**
1996	$466.69	$90.01	$124.39	$681.09	**$875.13**	11.22%	**1.28%**
1997	$519.33	$95.25	$115.16	$729.74	**$916.60**	4.74%	**-5.21%**
1998	$555.50	$96.48	$77.05	$729.03	**$901.67**	-1.63%	**-11.57%**
1999	$590.39	$104.42	$99.35	$794.15	**$960.99**	6.58%	**-3.37%**
2000	$653.08	$106.67	$118.98	$878.72	**$1,028.75**	7.05%	**-2.89%**
2001	$722.31	$110.76	$112.55	$945.62	**$1,076.44**	4.64%	**-5.31%**
2002	$792.63	$117.56	$128.47	$1,038.66	**$1,163.95**	8.13%	**-1.82%**
2003	$894.57	$138.95	$143.60	$1,177.12	**$1,289.72**	10.81%	**0.86%**
2004	$1,053.21	$167.25	$161.04	$1,381.51	**$1,474.39**	14.32%	**4.37%**
2005	$1,230.38	$193.32	$188.46	$1,612.16	**$1,664.16**	12.87%	**2.93%**
2006	$1,478.96	$220.51	$212.30	$1,911.78	**$1,911.78**	14.88%	**4.93%**

When examining the “Compared to Average” column, we see trends over time. There is exceptionally high growth in the mid-1990s. During the Asian Financial Crisis in the late 1990s

[40] National Science Foundation, "Science and Engineering Indicators 2010: Graduate Education, Enrollment, and Degrees in the United States Postdoctoral Education International S&E." Last modified December, 2010. Accessed October 9, 2011. http://www.nsf.gov/statistics/seind10/c2/c2s3.htm.
[41] Google, "World Bank, World Development Indicators: Gross Domestic Product." Last modified January 2010. Accessed October 14, 2011.
http://www.google.com/publicdata/explore?ds=d5bncppjof8f9_&ctype=l&strail=false&bcs=d&nselm=h&met_y=ny_gdp_mktp_cd

however, there is below average weighted growth seen. However, the growth picks up in 2003, and from 2003 to 2006 it is above average for the time period.

CHART 12



N=14

When examining the Weighted GDP Growth Rate compared to average for China, India and Korea against the number of Foreign Students Initiating PhD's in the United States, no correlation emerges using either Spearman or Pearson with values of 0.01 and -0.03 respectively; in addition there is extremely high variance. This suggests that foreign economic growth may not play a large role in the decision of foreign students, and that potentially there are different inputs than opportunity cost for their decisions to attend graduate school.

Chapter VI

Conclusion

Undergraduate Level

As stated before, the hope for this thesis is that future research can be done at a more in depth level on variables that are shown to have statistically significant levels of correlation with the independent variables. While all independent variables except for foreign opportunity cost showed some levels of correlation, only a fraction showed statistically significant levels, all of which were in the undergraduate model. Annual Increase in Four Year's Tuition had a positive correlation with the dependent variable Proportion of High School Graduates Receiving a College Degree in an S&E Field, suggesting that there is a positive relationship. Intuitively, students might be more likely to pursue an S&E degree due to the higher incomes associated with these degrees once they are completed when they are feeling the effects of larger tuition increases, and further research into the relationship between the two is warranted. If further research confirms this initial finding that there may be a positive relationship between the two, there could be policy implications.

While not advocating a unilateral increase in the costs of tuition for students, it is important to reflect that due to many schools being subsidized by the government, students often do not pay the full cost of their tuition[42]. If it is indeed in the United States' best interest for there to be a larger amount of S&E graduates like many policy makers claim[43], this is an important point to consider. As students are not realizing the full costs of their education, they could be immune from salary fluctuations in the demand for graduates for specific degrees, and in equilibrium could result.

Mean Years of Math in High School surprisingly seemed to have a statistically significant negative relationship, and the reasons for this remain unclear. The small fluctuations over time though in this variable, coupled with a consistent upward trend, lead one to suspect though that this correlation might not in fact be very straight forward.

Proportion of Female Students Receiving a BA has a 95% statistically significant negative correlation as well with the dependent variable Proportion of High School Graduates Receiving a College Degree in an S&E Field when using Pearson, and a Spearman value that while not significant at the 95% level, is significant to 90%. This is coupled with data showing that women are less likely to pursue S&E degrees than men[44], although the debate is ongoing as to whether this is due to systematic bias or inherent differences in men and women[45] [46]. If future research does back this seemingly statistically significant correlation, the impact on the proportion on the Proportion of High School Graduates Receiving a College Degree in an S&E Field is very

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[42] Carnevale, Anthony, and Richard Fry. "Economics, Demography." (2001). http://www.sasfaa.org/docs/training/ManagementInstitute/2004/presentations/8_Suggested_Reading_by_Don_Heller.pdf (accessed November 28, 2011).
[43] President Barrack Obama. "2011 State of the Union." http://www.pbs.org/newshour/interactive/speeches/4/2011-state-union-address/.
[44] National Science Foundation, "Women, Minorities and Persons With Disabilities in Science and Engineering Fields." Last modified 1994. Accessed November 28, 2011. http://www.nsf.gov/statistics/wmpdse94/chap8/women.htm
[45] American Association of University Women, "Why So Few?." Last modified 2010. http://www.aauw.org/learn/research/whysofew.cfm.
[46] Jones, Diane. Chronicle of Higher Education, "Are Women Partly to Blame for the Gender Gap in STEM Fields?." Last modified March 28, 2010. http://chronicle.com/blogs/brainstorm/are-women-partly-to-blame-for-the-gender-gap-in-stem-fields/22106.

important. Note that this variable is not the proportion of college students who receive S&E degrees, which would obviously be expected to decrease with a larger influx of women who are less likely to major in these fields. Rather, this variable is the proportion of High School graduates, and would seemingly be unaffected if more women choosing to attend college had no externalities. Purely speculating, if future findings do confirm this relationship, root causes could be in universities shifting of funding towards fields that women are typically more drawn to which in turn decreases the likelihood of men choosing to study in the field.

Average Starting Salary for S&E Graduates had an interesting data set, with two distinct clusters being seen. In years where there was a low Proportion of High School Graduates Receiving a College Degree in an S&E Field, there appeared to be no correlation. However, in the six years where the proportion was lowest, the six highest wages were also seen. This suggests that wages are not reactive unless there is a severe shortage on the supply side, otherwise average starting salaries fluctuate with no clear cause. This suggests that it is firms who are reactive towards supply, whereas the lack of correlation between Average Starting Salary for S&E Graduates with Lag and Proportion of High School Graduates Receiving a College Degree in an S&E Field suggests that students do not react towards increases in demand.

The other variable, Average Starting Salary for S&E Graduates with Lag, and Proportion of High School Students Graduating from College, do not appear to have any significant relationship with the Proportion of High School Graduates Receiving a College Degree in an S&E Field.

Graduate Level

On the Graduate Level, none of the variables were found to have statistically significant levels of correlation with the proportion of American S&E College Graduates Who Began S&E Studies. Both the variables used to measure opportunity cost for Americans had absolute R values between 0.2 and 0.3 in Spearman and Pearson. However, it is believed that more research is warranted on the role that the unemployment rate plays in the decision process of individuals to attend graduate school. Although there were large residuals, the residuals are at a somewhat consistent absolute amount of approximately 1% Unemployment from the trend line. No correlation at all could be seen between the variable used to represent foreign graduate student cost, GDP Growth for Source Countries, and the absolute number of foreign students who attended graduate school. There might perhaps be a better variable for measuring foreign opportunity costs, or as more data becomes available future research could choose to utilize demand variables such as average salary.

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