TUITION ELASTICITY AT THE COLLEGE LEVEL AND ITS EFFECT ON DIFFERENTIAL TUITION RATES

A Dissertation

by

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ABSTRACT

Increasing higher education enrollment and decreasing state and national funding has created a fiscal problem for higher education institutions in the United States. Differential tuition charged to a variety of subsets of students is increasingly used to close funding gaps. This research uses demand analysis and elasticities to determine differences between eight colleges at a public university to determine which, if any, should be charging differential tuition. Impacts of potential changes to tuition rates on student access are discussed.

Demand equations were created using ordinary least squares for eight colleges, Agriculture, Architecture, Business, Education, Engineering, Geosciences, Liberal Arts, and Sciences, using college applications as the dependent variable and assorted cost and macroeconomic variables as independent variables. A second model was determined using Directed Acyclic Graph theory and used to create a model for to answer policy questions.

Own-price elasticities (OPE) calculated from the colleges with significant variables in the policy models ranged from .3 to -1.64. Two colleges showed as elastic, OPE with an absolute value of greater than 1, indicating that a decrease in tuition would increase revenue and enrollments. One college was inelastic, OPE with an absolute value of less than 1, indicating that while an increase in tuition would lower enrollment, it would increase revenue. Engineering had a calculated OPE that was positive, indicating the possibility that demand changed at a faster rate than supply. Charging the correct form of differential tuition at a 10% level change to these colleges could result in over $4 million additional revenue from first-year students alone.

It is suggested to consider differential tuition plan based on calculated elasticities to generate more revenue. If implemented, a large percentage of the funds should be used to create

institution-level, need-based, financial aid for students from low socioeconomic and minority backgrounds. The aid should be in the form of grants to reduce the risk of students graduating with high student debt.

DEDICATION

This work is dedicated to my family, my mother and father, LaWanda and Duery Menzies, my sister and brother-in-law, Misti and Decky Spiller, my nieces, Menzi and Chastain Spiller, and my nearly countless aunts, uncles, and cousins.

I want to especially dedicate this to my dad and mom. Dad, you have been the constant guiding light for me personally and for our entire family. You have been the solid foundation for all our lives and the way you have lived your life fills me with pride and a desire to be just like you. Love you Pop!

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Contributors

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

TABLE Page

CHAPTER I

STATEMENT OF THE PROBLEM

This chapter provides a description of the problem associated with increasing student tuition at universities around the United States that has been magnified by the combination of decreasing state appropriations and rising costs. The theoretical framework the study is based on is presented as well as the relevant research questions and hypotheses. Key terms and definitions are provided at the end of the chapter.

Problem Statement

Higher education in the United States has reached a critical mass. Population numbers continue to rise taking student enrollment demand with them. Since 1980, enrollment in higher education has increased in all areas and is now approaching 18 million undergraduate and 3 million graduate students (U.S. Department of Education, 2013). State and federal funding has risen in response, but has not kept pace with growth or inflation. The gap between expenditures and public funding has widened, causing increases in tuition and fees in many states. A parallel problem resulting from the funding gap is a reduction in the quality of education, student success rates, and student access. Barring a paradigm shift in how higher education is viewed in America, the only solutions to the funding shortfalls appear to be massive increases in public support or in student tuition.

The problem with either alternative is that the American public increasingly sees higher education institutions as caring more about their bottom line and less about the student. A 2010 survey from the National Center for Public Policy and Higher Education found that people were concerned with some of the ways colleges were mimicking the business world. The subjects of the survey related their frustration with higher education and their belief that universities could be cost-effective and allow greater access without substantial increases in funding. In fact, nearly 65% of the respondents believe that college costs are rising faster than other costs including food, energy, and health care (Immerwahr, Johnson, Ott, & Rochkind, 2010). Tuition has increased at a rapid pace the past three decades. Since the scholastic year 1980-81, tuition and fees have increased in inflation-adjusted prices from 2.3% to 4.1% per year for private schools, 3.7% to 4.3% per year for four-year public schools, and 1.9% to 5.0% for public two-year schools. Public four-year tuition prices are 331% higher than comparable prices in 1983 even after factoring in inflation (College Board, 2013).

In addition to concerns about higher tuition, recent economic downturns have shown that increased public funding, be it state or federal, will not be forthcoming. The intervals it takes for state higher education funding once reduced to return to pre-cut levels have been increasing the past few decades. In the 1980s, 76% of the states that cut funding restored the cuts within five years. In the 1990s, that number had fallen to 58%. Recent trends are more serious. In the 2000s, fewer than 40% of states that have cut higher education have recovered in five years (Ciciora, 2010). Most experts believe it will take at least ten years for many states to recover from the current round of cuts. This has dramatic repercussions for all parties involved. Paul Lingenfelter, President of the State Higher Education Executive Officers, commented, “No country has ever increased the quality and size of its higher education system by consistently decreasing its budget for education” (Lingenfelter, 2009, p. 1). The reality of the current situation in America is one of public demands for both increasing enrollment and increasing quality of education. Increasing tuition may be the only possible answer. However, differential tuition rates, charging different types of individuals differing tuitions for the same education, could prove an interesting counter solution.

Differential tuition is a difficult political issue. Is it fair to charge different people different rates for the same education? Differential tuition is accepted for areas such as graduate school, professional school, and more recently, distance education. Is there justification, however, for charging an Engineering major higher tuition than an English major? One of these certainly can expect higher salaries than the other upon graduation, but the possibility of pricing low-income students out of certain majors raises concerns. Additionally, one of the goals of the United States is to increase interest in the disciplines of science, technology, engineering, and mathematics (STEM) among all students. Would making those educations cost more limit ability of those disciplines to grow?

Tuition increases across the board may not be economically viable or even wise. Several summaries of enrollment demand studies find that students are relatively unresponsive to changes in tuition price (Heller, 1997; Leslie & Brinkman, 1987). However these studies have been mostly focused on education in general. Looking at individual colleges or departments may show different results. One measure of responsiveness in economic theory is *elasticity* or how much one variable changes in response to changes in another variable. Variables can be *inelastic*, not responsive, or *elastic*, responsive. Economic theory may be used to classify a department or college's enrollment demands as inelastic or elastic and provide recommendations for differential tuition rates that would maximize revenues for either case. Goods with inelastic demands can increase revenue with higher prices, while elastic demands increase revenue with lower prices. Thus high demand departments would cost more causing enrollment to decrease slightly, while increasing revenue. Conversely, low demand departments would cost less increasing enrollment and revenue at the same time. From a pure economic standpoint, utilizing differential tuition to charge different amounts to different students according to these elasticities could increase revenue beyond that received from simple straight-line tuition.

Theoretical Framework

One of the fundamental building blocks of economic analysis is the concept of demand (Henderson, 2008). The school of economic theory revolves around the law of demand. The law of demand states that, *ceteris paribus* or all other things equal, as the price of a good decreases, consumers will buy more of that good. Inversely, if the price goes up, consumers buy less of a good. This results in a downward sloping demand curve or an inverse relationship between price and quantity as shown in Figure 1. For example as the price of the good goes from 1 to .75, the quantity demanded goes up from 5 to 10

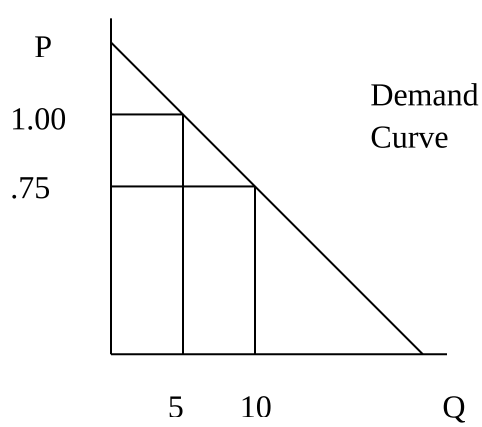

Figure 1. Typical Demand Curve.

Yet the quantity of a good purchased cannot only depend on price. The quantity of any good demanded is not only a function of price, but also of buyer/consumer income, buyer need, prices of *substitutes* and *complements*, consumers tastes and preferences, and expectations of the future (Leslie & Brinkman, 1987). These determinants of demand reveal consumers' ability to pay for an item, their willingness to pay for an item, and partially their reasoning for purchasing said item. Demand theory lays the foundation of pricing models.

The theoretical framework used most often by economists in analyzing college choice is human capital theory. Human capital theory originated in the early 1960s from the work of Schultz (1961) and Becker (1962). They analyzed the decision to attend college as an investment in human capital. The cost of schooling is the payment to acquire a good, knowledge, that can be rented by employers in exchange for wages (Paulsen & Toutkoushian, 2008). Investments in higher education or in other forms of human capital including health care or job searches are additions to an individual's human capital. Economic theory assumes individuals are utility maximizers so they try to find the highest possible satisfaction subject to their budget. Thus, students seeking a college education will allocate their budget between investments in education and consumption in order to maximize their utility over their lifetime (DesJardins & Toutkoushian, 2005). In order for students to maximize their utility, they will choose the university, college, and major that will maximize their expected benefits minus expected costs (future earnings minus current costs and opportunity costs) within the boundaries of what they know. Those colleges or universities that produce graduates who earn higher lifetime salaries will generate a higher demand from prospective students and will likely have an inelastic demand. Such colleges or universities are candidates for differential tuitions to have a great impact on revenue.

Determining price based on the law of demand and human capital theory becomes critical for all universities. Price determination is the interaction between the demand for a good and the willingness of the market to supply the good. The textbook example of this is the market-clearing price or equilibrium point shown in Figure 2. The market-clearing price is determined where the demand curve of a good (downward sloping) and the supply curve of a good (upward sloping) cross.

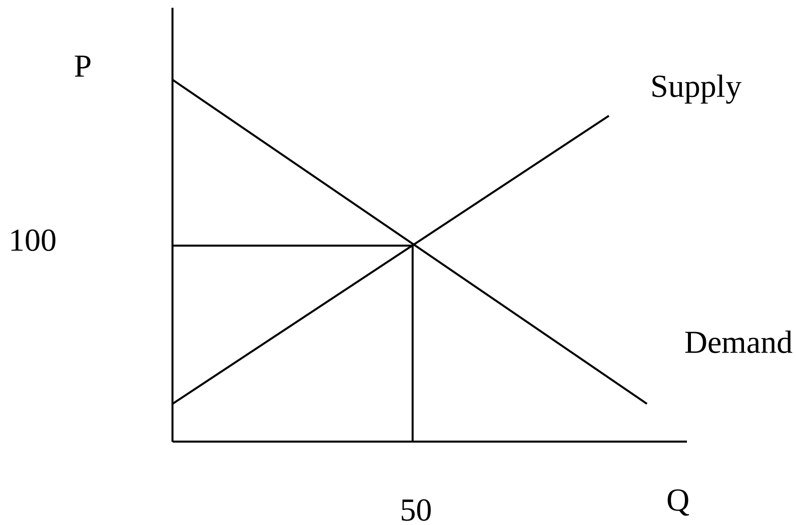

Figure 2. Market-clearing or Equilibrium Point.

For a university, price determination is a more difficult process. University administrators must seek a tuition rate that attracts new students, provides adequate revenues for the university, retains current students, and helps achieve the university's long-range goals (Bryan & Whipple, 1995). Determining students' price elasticity of demand is one way to ascertain where price could be set.

Price elasticity of demand or own price elasticity (OPE) is a measure of the responsiveness on the quantity demanded of a good to a change in the price of that same good. Specifically, OPE is the percent change in quantity of a good divided by the percent change in price of the same good. Devised by economist Alfred Marshall, OPE is used to make price determinations on any type of product (Marshall, 1920). OPE is a unit-less measure because it is a result of proportionate changes. This means elasticities can be compared across products. As mentioned above, the law of demand shows that demand curves are downward sloping. This means that OPE will always be negative. To interpret them correctly, the absolute value is taken. Goods that have an OPE with an absolute value of greater than one are relatively elastic meaning a price change will result in a greater proportionate change in quantity. A good with an OPE that has an absolute value of less than one is relatively inelastic. A price change causes a relatively smaller change in quantity. This means that an elastic good can generate more revenue only if its price is lowered. Conversely, an inelastic product will have higher revenue if its price is raised.

Higher education scholarship has found price elasticity of demand for tuition to be inconsistent. Several studies have shown that as economic theory suggests, an inverse relationship exists between tuition and college enrollment (Ghali, Miklius, & Wadak, 1977; Allen & Shen, 1999). Other studies have shown a different result. O'Connell and Perkins (2003) and Clotfelter (1991) found that tuition did not significantly affect enrollment. Similar inconsistencies exist across studies that have been conducted on a national and institutional level, and with public and private institutions.

Income elasticity, a measure of how responsive college enrollment is to changes in consumer's income, is generally found to be positive and greater than one, indicating that higher education is a normal good, but also more of a luxury good.

Tuition differentials have been around for as long as there have been institutions of higher learning. It is customary for undergraduates and graduates to be charged different rates. There has also been widespread use of differential tuition based on residency. Professional school students also usually pay increased amounts, generally due to higher program costs, higher expected future earnings, and higher demand. Other examples of differential tuition include those based on student level, program level, institution level, course level, student load, or student demand (Yanikoski & Wilson, 1984). The differential tuition rates that vary according to demand are of interest as the more popular a field, the higher the potential rate. Thus, students in business might pay more than students in history (Hoenack, 1982). There is however a noticeable lack of scholarship measuring the demand and particularly the elasticity of demand for different majors, departments, or colleges. If differential tuition rates are to be considered as a method of increasing higher education funds in public colleges, a model for finding these elasticities and measuring their impact on revenues is needed.

Research Objectives

The main objective of this study is to estimate demand for enrollment in different colleges at a land grant university, hereafter known as State U. The model will be made generic enough to function at other land grant and public universities throughout the United States. State U is a flagship university with over 40,000 undergraduate and 10,000 graduate students. Nearly 30,000 high school graduates apply for admittance every fall with admittance approaching 10,000. Over 250 degree programs are offered, spread over 10 different colleges. The size of the colleges vary tremendously from Engineering having over 10,000 students and Liberal Arts with over 7,000 students in fall 2012, to Architecture and Geosciences with fewer than 2,000 students during the same time period. Prior to fiscal year 2004-05, tuition was set by the state legislature. In 2004-05, the legislature removed the restrictions limiting what state universities could charge. State U's tuition has risen from $46 per credit hour in 2004-05 to $176.55 per credit hour in 2013-14. Continuing budgetary shortfalls indicate that tuition will increase, creating the need for understanding the relationship between enrollment and tuition, including identifying potential targets for differential tuition.

Demand for enrollment is estimated using a variety of determinants including cost variables and macroeconomic variables. Due to the high overall interest in State U, demand is modeled using the number of applications instead of enrollments [as used in Bezmen and Depken (1998)]. The primary research question is "**What is the elasticity of demand for enrollment for different colleges at State U and what are the implications for the university?**" Determining elasticities for each of eight colleges would give State U officials information on the relative tuition sensitivities by college. Consequently, those colleges that have more inelastic demands, students with higher tuition sensitivity, would be candidates for higher tuition were a differential tuition program to be implemented. The inelasticity of demand would mean a decrease in the enrollment in those colleges, but at a lower percentage than the increase in tuition, generating higher revenues. Colleges with more elastic demands could have tuition lowered, while simultaneously increasing enrollment, which would also result in higher revenues.

Research Hypotheses

Investigating elasticity of demand for various colleges at State U involves both research hypotheses and questions. The most basic hypothesis is that all price elasticities of demand (OPE) should be negative. The law of demand states that as price goes up, quantity purchased goes down. Thus, as tuition increases, enrollment (applications) should decrease. This can be formalized with the hypothesis given in Equation 1. The null hypothesis to be tested is the OPE is equal to zero, indicating that price has no effect on quantity. The alternative hypothesis is that

OPE is negative. This hypothesis will be tested by looking at the sign of the coefficient on tuition, TUI, in the model for each college.

$$\mathbf{H_O : \ TUI_{\mathit{i}} \ = \ 0}$$
$$\mathbf{H_A : \ TUI_{\mathit{i}} \ < \ 0} \tag{1}$$

In Equation 1, *i* = 1 to 8 for each college reviewed at State U. As prices and quantities will always have positive signs, the sign of the coefficient on TUI will be the same as the sign on OPE. Furthermore, the OPE of various colleges may change over time. This could be due to changes in perceived value of the degree or changes in demand from industry. Calculating OPE over time could give insight into whether there are changes and if they are significant. The resulting own price elasticities will be interpreted to answer the following questions:

Question 1: Are there differences in the price elasticity of demand for different colleges?

Question 2: Does any college's price elasticity of demand classify that college as having an *inelastic* demand for enrollment with respect to tuition?

Question 3: Does any college's price elasticity of demand classify that college as having an *elastic* demand for enrollment with respect to tuition?

Question 4: Does any college's price elasticity of demand change over time?

Question 5: What is the estimated effect charging differential tuition rates according to elasticities would have on State U's general revenue?

The second hypothesis is that income elasticity (IE) for each college will be positive or that State U's education is considered a normal good. As the level of student's income increases, enrollment (applications) will also increase. The null hypothesis is that the IE for all colleges is equal to zero, indicating income does not affect applications. The alternative is that IE is positive or the good in question is normal. As in Equation 1, i = 1 to 8 for each college at State U. The coefficient for income, INC, will be used to test the hypothesis in Equation 2.

$$\mathbf{H_O : INC}_{\boldsymbol{i}} \mathbf{= 0}$$

$$\mathbf{H_A : INC}_{\boldsymbol{i}} \mathbf{> 0} \qquad (2)$$

A secondary test will be applied to determine if any of the colleges are luxury or necessity goods.

As with OPE, IE could change over time due to changes in tuition price, value of the degrees conferred by the various colleges, or changes in students' annual income itself. Thus calculating the IE for each college over the time of the data available will be used to provide information about potential changes. The resulting income elasticities will be interpreted to answer the following questions:

Question 6: Are there differences between colleges in income elasticities?

Question 7: Are any of the colleges considered *luxury* goods?

Question 8: Are any of the colleges considered *necessity* goods?

Question 9: Does any college's income elasticity change over time?

Definitions

Elasticity

Elasticity is the percent change in one variable divided by the percent change in a second variable as shown in Equation 3 (DesJardins & Bell, 2006). Thus, it is a measure of the responsiveness of one variable to changes in another.

$$\mathbf{E_{y,x}} = \frac{\%\,\Delta\, \boldsymbol{y}}{\%\,\Delta\, \boldsymbol{x}} \tag{3}$$

Another method of finding elasticity is using calculus as in Equation 4.

$$\mathbf{E_{y,x}} = \frac{\boldsymbol{\partial\, y}}{\boldsymbol{\partial\, x}} * \frac{\boldsymbol{x}}{\boldsymbol{y}} \tag{4}$$

Using derivatives, elasticity is the derivative of the function *y* with respect to variable *x*, multiplied by the ratio of *x* to *y*.

Price Elasticity of Demand

Price elasticity of demand is the percent change in the quantity of a good purchased divided by the percent change in the price of that same good (Equation 5) (DesJardins & Bell, 2006). It is also known as own-price elasticity (OPE).

$$\textbf{OPE} = \frac{\%\,\Delta\,\boldsymbol{Q_x}}{\%\,\Delta\,\boldsymbol{P_x}} \tag{5}$$

As with the generic elasticity formulas, calculus can be used to find OPE. Using derivatives, OPE is the derivative of the quantity of *x* with respect to price of *x*, multiplied by the ratio of quantity of *x* to price of *x* (Equation 6).

$$\textbf{OPE} = \frac{\boldsymbol{\partial\, Q_x}}{\boldsymbol{\partial\, P_x}} * \frac{\boldsymbol{P_x}}{\boldsymbol{Q_x}} \tag{6}$$

The law of demand (as prices go up, quantity goes down) means that most, if not all, OPE will be negative. OPE has three generic results: elastic, inelastic, or unit elastic.

Elastic Goods

Goods that are relatively more responsive to changes in price are elastic goods. The OPE for an elastic good will have an absolute value greater than one. Absolute values are used because most OPE are negative. For example, a 1% increase in the price of an elastic good (*x*) will result in a greater than 1% decrease in quantity of *x*. To increase the revenue generated by an elastic good, a company would need to decrease the price of the good, which would cause quantity to increase by a larger amount.

Inelastic Goods

Goods that are relatively less responsive to changes in price are inelastic goods. The OPE for an inelastic good will have an absolute value of less than one. For example, a 1% increase in the price of an inelastic good (*x*) will result in a less than 1% decrease in quantity of *x*. To increase the revenue generated by an inelastic good, a company would need to increase the price of the good, which would cause quantity to decrease by a smaller amount.

Unit Elastic Goods

Goods that are proportionately responsive to changes in price are unit elastic goods. The OPE for a unit elastic good will have an absolute value equal to one. For example, a 1% increase in the price a unit elastic good (*x*) will result in **exactly** a 1% decrease in quantity of *x*. Revenue is maximized at the point where a good is unit elastic.

Cross-Price Elasticity

Cross-price elasticity (CPE) is the percent change in the quantity of a good divided by the percent change in the price of a different good (Equation 7) (DesJardins & Bell, 2006).

$$\mathbf{CPE} = \frac{\%\,\Delta\,\boldsymbol{Q_x}}{\%\,\Delta\,\boldsymbol{P_y}} \tag{7}$$

As with the generic elasticity formulas, calculus can be used to find CPE. Using derivatives, CPE is the derivative of the quantity of *x* with respect to price of *y*, multiplied by the ratio of price of *y* to quantity of *x* (Equation 8).

$$\textbf{CPE} = \frac{\partial\, Q_x}{\partial\, P_y} * \frac{P_y}{Q_x} \qquad (8)$$

CPE has three interpretations: substitutes, compliments, and independents.

Substitutes

Substitute goods are those with positive CPE. If the price of good *y* goes up, the quantity of good *x* will also go up. For example, if a soft drink company raises the price of their product, the quantity sold of a second soft drink company's product that is a substitute good will increase. The higher price of the first company's drink will cause consumers to purchase more of the substitute good.

Compliments

Compliment goods have negative CPE. If the price of good *y* goes up, the quantity of good *x* will go down. An example is if the price of french fries were to increase, the quantity sold of hamburgers would decrease if french fries and hamburgers were compliments. The higher price of french fries causes consumers to purchase less of the compliment as well.

Independents

Independent goods have CPE that are equal to zero. An increase in the price of good *y* causes no reactions from good x. Independent goods are completely unrelated.

Income Elasticity

Income elasticity (IE) is the percent change in the quantity of a good divided by the percent change in the income of the consumers of the good (Equation 9) (DesJardins & Bell, 2006).

$$\mathbf{IE} = \frac{\% \, \Delta \, \boldsymbol{Q_x}}{\% \, \Delta \, \boldsymbol{I}} \tag{9}$$

As with the other elasticity formulas, calculus can be used to find IE. Using derivatives, IE is the derivative of the quantity of *x* with respect to income, multiplied by the ratio of income to quantity of *x* (Equation 10).

$$\mathbf{IE} = \frac{\boldsymbol{\partial \, Q_x}}{\boldsymbol{\partial \, I}} * \frac{\boldsymbol{I}}{\boldsymbol{Q_x}} \tag{10}$$

IE has two basic interpretations: inferior or normal. Normal goods can be further categorized as luxury or necessity.

Inferior Goods

Inferior goods have a negative IE. Thus, as income rises, consumers will buy less of the good. Generally, inferior goods are relatively inexpensive, non-staple foods such as generic equivalents of brand-name foods.

Normal Goods

Normal goods have a positive IE. As income rises, consumers buy more of the good. Normal goods can be further differentiated into necessities and luxuries. Necessities have an IE of between zero and one. These are staple products such as food and clothing. Luxury items have an IE of greater than one and usually include much more expensive products.

Opportunity Costs

Opportunity costs are the next best alternative to the chosen option. Put another way, what is given up to receive something else or the opportunities given up by making a decision.

Linear Regression

Linear regression involves a linear dependent and independent variables. No log transformation is applied so linear regression is the regression of the raw values of the dependent (y) variable on the raw values of the independent (x) variable(s). The coefficient(s) that results is(are) the marginal effect of the independent variable(s).

Log-Log Regression

Log-log models use the natural log transformations of the y variable and regress them on the natural logs of the x variables. The coefficients that result are the elasticities of the x variables. Log-log models are useful in dealing with data that may be skewed or not normally distributed. Much higher education data is positively skewed because the population of the United States is ever increasing. Thus log-log modeling has many benefits in higher education studies.

CHAPTER II

LITERATURE REVIEW

The literature review chapter is broken into three main sections. The first will describe human capital theory as a basic framework for modeling student college choice. The second section will detail many previous studies into enrollment demand theory, specifically focusing on elasticity studies. The final section will discuss differential tuition research as it affects student demand and institutional revenue.

Human Capital Theory

The framework of human capital theory begins with the assumption that people consider education as an investment in human capital. When the benefits to be gained from this investment outweigh the cost of the investment, people will choose to attend college (Schultz, 1961; Becker 1962). Benefits are usually future wages to be earned or the wage premium associated with the chosen education. Costs are the tuition, fees, and opportunity costs that arise from enrolling in college (Canton & de Jong, 2005).

Students are faced with a choice upon graduating from high school: enter college or enter the job market. If they go to college, they forego the salary they would receive during the time they are in college. This is their opportunity cost of attending college. They also pay direct costs such as tuition, fees, and living expenses. However, they are able to add to their knowledge, skills, attitudes, and talents, which can enhance their productive capacities and enable them to become more sought after in the job market (Becker 1993; Woodhall, 1995). They will receive higher salaries than their counterparts that did not invest in their human capital. This difference equates to the wage premium of attending college. If high school graduates go to the job market, they forego the wage premium, but they begin earning a salary at an earlier date.

The wage premium that exists between the salaries of high school graduates and those of college graduates is quite large and has for the most part risen over time. In 1971, the wage premium on after-tax earnings was 40%. In 2008, that number had risen to 60% (College Board, 2010). Research has shown that the premium will also increase throughout the working life of individuals (Murphy & Welch, 1989; McMahon & Wagner, 1982). Lifetime earnings show even greater differentiation. In 2008, college graduates with a bachelor's degree could expect to earn 66% more over their lifetime than high-school graduates (College Board, 2010).

Human capital theory assumes that students will engage in rational behavior. Students behave rationally if they make choices about their resource allocation according to their budget in a manner that maximizes their utility or satisfaction (DesJardins & Toutkoushian, 2005; Paulsen & Toutkoushian, 2008). Students that follow rational investment decision criteria will choose to go to college if the value of college, usually the value of the wage premium, is greater than the direct costs (tuition and fees) and the opportunity costs (foregone salary) of going to college (Corazzini, Dugan, & Grabowski, 1972).

It follows from the framework of human capital theory that students will find it more attractive to invest in human capital when the economy is in a downturn. The opportunity costs of education are lower because it is harder to find a job and salaries are lower. Thus, when unemployment is higher, more people typically enroll in higher education (Bean, 1990; Saint-Paul, 1993).

Human capital theory focuses on the relationship between the benefits and costs of education. The costs include direct and indirect costs. Direct costs are tuition, fees, and living expenses. The need to establish how institutions set tuition rates led Rusk and Leslie (1978) to model tuition using a variety of variables including net costs, competitor prices, competitor market shares, net income, and quality. They tested one state institution from each state and found that 1976-77 tuition levels were linked to historical practices common to geographic regions.

Prices at the universities were highly correlated with competitors' prices, both in-state and in adjacent states. However, adjusting state appropriations was the major way to affect the level of tuition. Rusk and Leslie concluded that tuition levels appeared to be the result of an evolutionary process rather than a concentrated planning process (Rusk & Leslie, 1987).

While most scholars believe that education follows a human capital model as discussed in the previous section, some evidence exists for viewing education as a consumption good as well as an investment. Becker and Waldman (1987) examined the demand for higher education based on a student's utility function. A portion of the student's utility arises from the wage premium that they are striving for with an education, but a significant part of utility comes from the "experience" of college. This consumption value includes friendships, sporting events, parties, and other outside activities, but may be limited to undergraduate students as graduate or professional students are more interested in furthering their education (Quinn & Price, 1998). While it is difficult to quantify the value of consumption variables, Gullason (1989) used the ability of male students in the 1960s and 70s to avoid the draft by going to college as consumption good. He found that consumption goods have an empirically positive outcome on undergraduate enrollment. Quinn and Price (1998) followed Gullason's work using the draft as an explanatory variable for medical school enrollment, as well as a dummy variable indicating if the U.S. was at war (during time periods of Korean and Vietnam Wars). They found that adding consumption variables did not significantly affect medical school enrollments.

Human capital theory demonstrates that increasing the benefits of going to college or decreasing the costs of attending will affect a student's likelihood of attendance. Thus, variables that affect the cost or benefits are important factors in assessing demand for enrollment. The wage premium associated with higher education is the main benefit and will be included in the demand analysis in this study. Cost variables included will be direct costs and indirect costs of attending college such as tuition, fees, interest rates, and unemployment. Consumption theory indicates that modeling undergraduate students' demand may require using consumption variables to be accurate. The difficulty in obtaining usable consumption variables may limit their practicality in this study.

Enrollment Demand Elasticity

Enrollment demand elasticity studies have been conducted for approximately 50 years. They can be ordered in several ways, such as data, level, or statistical methodology. The following section will further break the literature on enrollment elasticity into several parts. The first will be a discussion of several meta-analysis works on enrollment elasticity. These works contain summaries of previous literature. The second section will discuss individual studies that occur on the national level. Institution level studies will follow. The last section will cover several miscellaneous projects that complete a robust review of the current literature.

Meta-analysis Studies

The first review of elasticity studies was Jackson and Weathersby (1975). The authors reviewed seven studies conducted between 1967-75 to compare their quantitative results. The results of these early studies show that own-price elasticity (OPE) is negative and usually inelastic. The price effect ranged from -.06 to -1.9 % response to a $100 increase in tuition. The seven studies also generally found income elasticity (IE) to be positive and greater than one, indicating education was a luxury good. The authors found that across all studies, the income effect became less as income increased. Another finding was the high negative correlation between enrollment and net cost. Thus, increasing student financial aid does improve access to higher education.

The major influence of the Jackson and Weathersby (1975) paper was the development of a method of comparing results across the variety of research in higher education finance. Many different data sets, functional forms, statistical estimations, and conceptual approaches are used in the field and a method of comparison is necessary. The authors created a standardized "typical" individual. This person had an income of $12,000 in 1974 and faced a college cost of $2,000 per year. The participation rate was set at 26.2% of the eligible population being enrolled in college. This allows calculation of the change in enrollment predicted by a $100 increase in tuition.

Elasticity was defined as the percent change in quantity (change in enrollments per eligible population divided by enrollments per eligible population) divided by the percent change in price (tuition cost) as shown in Equation 11. Using the "typical" student, the percent change in tuition cost is $100 (the predicted increase in tuition) divided by $2000 (the actual cost), so $(\Delta C/C) = (100/2000) = .05$. (E/P) is the base participation rate of 26.2%.

$$\textbf{OPE} = \frac{\frac{\Delta(\frac{E}{P})}{E/P}}{\frac{\Delta C}{C}} \qquad (11)$$

Rearranged, the formula shows that to find the change in enrollment per population (Δ(*E/P*) for each study would equal the elasticity times the cost ratio and the participation ratio as shown in Equation 12.

$$\Delta\ (E/P) = \ OPE\left(\frac{\Delta C}{C}\right)\left(\frac{E}{P}\right) \qquad (12)$$

Thus, any study that produces an OPE can be converted to a comparable student price response coefficient (SPRC). The seven studies in Jackson and Weathersby (1975) had SPRC that ranged from -.06 to -1.90, indicating that a $100 increase in tuition would result in a drop of attendance that ranges from .06 % to 1.9%.

A second review of demand studies was conducted by Leslie and Brinkman (1987). Using the SPRC technique developed by Jackson and Weathersby (1975) and correcting for errors in the original authors mathematics, Leslie and Brinkman calculated SPRCs for 25 studies, including those from Jackson and Weathersby. The data was converted to 1982-83 dollars to allow for comparable analysis. The authors acknowledge that different studies present different omitted variables that make comparison difficult. Any meta-analysis of demand functions with such a variety of variables, forms, and specifications must simply rely on well-designed studies.

The results were similar to those found in Jackson and Weathersby (1975). All the SPRCs are in the expected direction, enrollment declines when tuition rises. The mean response was 2.1 or if tuition were raised by $100, enrollment would be expected to drop by 2.1%. The results vary and many of the studies are lower than the mean. The modal results was 1.8%. Studies with private universities generally showed lower SPRCs than public universities, most likely due to the higher average family incomes of students attending private schools and the higher general costs of such schools. SPRCs for community colleges was above the mean, which is expected as students' responsiveness should be greater in a low-cost environment.

Heller (1997) updated Leslie and Brinkman (1987) by looking at the studies that had appeared in the intervening decade. Heller found results that were consistent with Leslie and Brinkman. SPRCs were found to be between -1.5 and -3.0, so that a $100 increase in tuition would lead to decreases in enrollment of 1.5% to 3%. Heller also found that decreases in financial aid lead to decreases in enrollment. As with Leslie and Brinkman, Heller's results showed that lower-income students are more sensitive to changes in tuition than upper-income students, and community colleges were more sensitive than public four-year schools or private schools. Heller was able to analyze racial differences due to several studies estimating different demand curves for different races. He found that Black students were more sensitive to changes in tuition and aid than White students were, but information on Hispanic students was inconclusive.

A fourth meta-analysis study looks at the variety of tuition and income elasticity studies and treats the elasticity estimates as dependent variables and the attributes of each study as the independent variables (Gallet, 2007). The study is designed to inform policymakers and researchers which modeling procedures are most impactful in determining elasticities. The data used was a collection of 60 different enrollment elasticity studies drawn from several literature reviews including the three listed previously. The mean OPE of the studies was -.60 and IE was 1.07. Standard deviations were 1.00 and 1.97, respectively.

Results show that tuition elasticity is more inelastic in the short-run than in the long-run, consistent with economic theory. The use of the linear functional form tends to result in more elastic estimates when compared to the log-log form. Studies that use state or local data are more elastic as are U.S. results compared to the rest of the world. There were no significant differences in using cross-sectional versus time-series data. Non-white students' demands are generally more elastic than students are in general. Many other characteristic variables such as gender, level, or residency status are not statistically significant in regards to influencing tuition elasticity.

National-level Studies

Arguably, the most influential study of higher education demand was one of the first. In their 1967 paper, Campbell and Siegal measured over the period 1919-64 the ratio of undergraduate enrollment in four-year institutions to the number of 18-24 year olds with a high school diploma and not in the military. This was a more accurate measure of the enrollment rate in higher education than using the standard ratio of enrollees compared to the entire 18-24 year old age group due to the Select Service draft during this era. The authors chose to model enrollment demand based on disposable income and average real tuition. Statistically, those two variables accounted for 87% of the variation in the stated enrollment ratio. From this analysis, the authors found a price elasticity of demand or own price elasticity (OPE) of -.44 and an income elasticity (IE) of 1.2 (Campbell & Siegel, 1967). In other words, a 10% increase in the price of tuition would result in a 4.4% decrease in enrollment, while a 10% rise in income would increase enrollment 12%. That means that student enrollment demand was inelastic or relatively unresponsive to changes in tuition prices. The high IE was consistent with a luxury good. The signs of the elasticities were notable. Economic theory predicts that OPE will have a negative sign or as price goes up, quantity goes down, which was what Campbell and Siegal found. The positive sign on IE was also expected for higher education as it is accepted as a normal good. With a normal good, as individuals' income rises, they consume more of the good.

Campbell and Siegel's work is important for several reasons, not the least of which in the pioneering nature of the study. Empirically, the use of a log-log (log-linear) functional form for the regression is worth investigating. Regressions are calculated in a variety of manners, but the log-log form is more easily interpreted when calculating elasticities. OPE is the percent change in quantity of a good divided by the percent change in price of the same good. The linear functional form in a regression gives a coefficient for tuition that is equivalent to the marginal effects of the linear model. The individual elasticity will depend on the data set. Using the log-log functional form transforms the data to logarithms. A result is that elasticity is now constant over all the values of the data set. The tuition coefficient is now the elasticity itself, not the marginal effects. A log-log functional form does not require any additional work to compute the elasticity. The coefficient is the elasticity, thus results can be reported in a consumer-friendly manner.

At the end of World War II, many soldiers took advantage of the G.I. Bill to attend college. As many as 50% of the college students that enrolled between 1946 and 1949 were financed by the G.I. Bill making college very inexpensive. Inexpensive goods are sometimes thought to be inferior goods, or have a negative IE. Galper and Dunn (1969) investigated the sizable negative effect the continuation of the military draft had on the demand for higher education in the years after World War II. Increasing the size of the military invariably leads to a decrease in the number of students going to college. Using the same data set as Campbell and Siegel (1967), the authors found the elasticity for enrollment with respect to the size of the armed forces to be -.26. Thus, an annual growth rate of 10% in the armed forces would decrease college enrollments by 2.6%. Income elasticity was .69, making higher education a normal good despite the inexpensive tuition (Galper & Dunn, 1969).

Beginning in 1947, there was a decline in the ratio of students enrolled in private colleges versus public universities. Hight (1975) investigated this shift to determine the elasticity of public and private education. Estimated OPE for private schools was -.71 while public schools had an OPE of -1.78. Public schools were more elastic thus more responsive to changes in tuition. More importantly, the IE for private schools was significantly greater than public. This should imply that rising family income in the decades after World War II would have resulted in an increase in the private to public enrollment ratio. However, Hight suggests that increases in tuition at private schools resulted in much higher costs in comparison to public institutions, dwarfing any impact of rising income.

Demand studies have for the most part tried to estimate the effect of tuition increases on enrollment, but Savoca (1990) looked at the effect on the decision to apply. Using a two-step maximum likelihood procedure, Savoca estimated a model with cost, quality, income, and a matrix of other variables as the independent variables. The resulting coefficient and elasticity were similar to those found in strict enrollment studies. However, if the school's tuition policy and admission policy are independent, then the OPE for true enrollment is actually the sum of the OPE for enrollment and the OPE for application, making the true OPE higher than the estimates reported in the literature.

McPherson and Schapiro (1991) investigated demand from the viewpoint of net costs. Their study looked at time-series data from 1974-84 and modeled demand as a function of net cost (tuition minus financial aid), gender, and income levels. The data used was from the Current

Population Survey in which there was not enough years of data to allow time-series analysis for Blacks or Hispanics, thus the analysis is for White students. They find that a $100 increase in net cost leads to a 1.6% (adjusted for inflation) decline in attendance for low-income students. No significant corresponding decline is found for high or medium income students. This indicates that estimating different demand equations for different income levels might be a better approach than simply using income as an independent variable.

The conventional method of describing the relationship between tuition and enrollment is the theory of demand. As such, the higher the tuition of an institution, the fewer people will choose to enroll in that institution. However, signaling theory postulates a different idea. Signaling is the hypothesis that a higher rate of tuition signals potential applicants of the high quality education offered by the institution (Spence, 1973). This is similar to the idea of Giffen goods, goods that have a positively sloping demand curve. Giffen goods are theoretical goods that consumers will purchase more of when the price of the good increases (Dougan, 1982).

Bezmen and Depken (1998) test the signaling hypothesis using demand for 772 U.S. colleges. The signaling model of education states that a person's productivity is identifiable by the time they spent in school, but not increased by the time spent in school. In other words, a more educated worker might receive higher pay because they hold a degree rather than because they work better. The implication is that education is more credential based than skill based and thus where a person receives their education is as important as what is the education.

Bezmen and Depken's model is unique in that in addition to income, unemployment rate, and a variety of characteristic variables (similar to other demand studies), Bezmen and Depken include both in-state tuition and out-of-state tuition as a test of signaling. Higher tuition prices are a measure of signaling in that higher quality education can be promoted by charging more.

Using a log-log functional form, the model for public schools returns estimates of in-state OPE of -.018 and out-of-state OPE of .29, both statistically significant. This implies that institutions that engage in signaling of quality to their applicants will be achieving the best results with out-of-state students. The opposite seems true for in-state students. This result could be accurate for out-of-state students, but the in-state result could also come from a large number of students wanting to attend school close to home.

Several studies on private higher education institutions have found OPE for enrollment to be positive or enrollment as a Giffen good. O'Connell and Perkins (2003) studied liberal arts colleges in 1996. They built a model that included price, but also included some consumption variables, following Quinn and Price (1998) and Gullason (1989). The resulting OPE ranged from .017 to .366. All were positive, which is a characteristic of Giffen goods. Thus, the results indicate that if these colleges raise price, their enrollment will actually increase. Clotfelter (1991) used a similar model on 24 selective universities for the years 1981-88. He found positive impacts of tuition on enrollment or applications. Both sets of authors conclude that reputation has more of an impact on enrollment than does tuition cost for private institutions.

Noorbakhsh and Culp's (2002) project involving Pennsylvania public higher education institutions analyzed in-state versus out-of-state tuition. In the 1990s, Pennsylvania adopted a "full-cost recovery" program for non-residents. Non-resident tuition more than doubled in a six-year period. Consequently, non-resident enrollment had fallen nearly 40%. The authors modeled demand for non-resident and resident students in an effort to provide factual evidence for policymakers. The models used were log-log forms with first-time freshman enrollment as a function of institution tuition rates, competing institution rates, and income. Non-residents had an OPE of -1.15, meaning their OPE is elastic. Resident students had an OPE equal to -.37. The results showed non-resident students to be far more elastic in their demand and thus much more responsive to a higher tuition rate. A second result was that IE for non-residents was 3.8 and was significant at the 5% level. Residents had a non-significant IE of .4. Thus, non-residents have a normal, luxury demand with respect to income. Pennsylvania's use of "full cost recovery" tuition policies for non-residents sent many of those students to other states. Subsequent legislative sessions revoked some of the language on non-resident tuition and allowed universities to set tuition within a more reasonable prescribed range (Noorbakhsh & Culp, 2002).

Elasticities can be used to compare different classifications of consumers. One method of differentiating students in an elasticity study is to compare students that apply for financial aid with students that do not apply for aid. Students who apply for aid should have a more elastic E_d because they are much more likely to be affected by tuition increases. Parker and Summers (1993) used a pooled time-series method to look at liberal arts college matriculation rates. They estimated demand curves for students that received aid, students that applied and qualified, but did not receive aid, and students that did not apply for aid. The OPE for the non-aid students was -.3 to -.36,while the aid students was -.29 to -.48, meaning students that receive aid are more sensitive to changes in tuition, but only marginally so.

A study extending Parker and Summers work on the differences in elasticity between students with financial aid and those without is found in a 2004 paper from Buss, Parker, and Rivenburg on liberal arts colleges that analyzed over 100 schools using cost variables, aid, quality, and macroeconomic variables. Data was split into aid applicants and non-aid applicants and an OLS model was estimated for each using multiple functional forms. Non-aid applicants had an OPE that ranged from -.6 to -.76, comfortably inelastic. Aid applicants had OPE between -1.18 and -1.27, confirming that students who apply for financial aid are more responsive to changes in tuition. Furthermore, gross tuition levels are found to matter more to students than net cost (tuition minus aid). One explanation is that students look beyond the net cost and consider tuition and aid separately because they are uncertain about continuation of aid over four years of college (Buss, et al., 2004).

These two studies show how small differences in the models can result in very different elasticity calculations. The Parker and Summers (1993) study did not include any macroeconomic variables such as income or interest rates. It also included six measures of the quality of the institution. The Buss (2004) paper included interest rates and income as well as a time trend variable. It also included twelve quality variables as well as multiple measures of competitor's prices.

One aspect of state budgetary policies that is underappreciated is the contribution of community colleges or two-year institutions to state education. Many times these are the first institutions to feel the budget cut. In 2009-10, the California State Legislature leveled a $520 million (8%) cut on the California Community College system. In 2010-11, the legislature proposed additional cuts of $400 to 800 million (6- 12%) (Californian Community Colleges, 2011). A study by Hilmer (1998) makes the case that states should be increasing funding to community colleges in eras of budget cuts. During 1991-92, the average expenditure for a full-time undergraduate at a four-year institution was $19,403. A student at a two-year cost $5,737. Hilmer used an ordered probit model to test the CPE of two-year and four-year schools. He found that increasing fees at a two-year institution caused enrollment to increase at four-year schools and vice versa. Thus, the institutions are substitute goods with a positive CPE. The difference was that the magnitude was ten times greater for two-year schools than for four-year schools, meaning two-year institutions are far more responsive to changes in prices at four-year schools.

Two of the most important studies for the current research project to consider were conducted by Shin and Milton (2006, 2007). Shin and Milton (2006) studied the effects of tuition level on enrollment in public colleges over the time period 1998-2002. They used all U.S. public colleges with yearly enrollment data for the period considered for a total of 436 colleges. The dependent variable was the number of in-state, first-time freshman enrollees. Shin and Milton chose to include not only own-price effects (tuition and fees), but cross-price effects (competitor's tuition). They also included wage premium as a measure of the future benefits of college. Unemployment rates were added to examine the opportunity cost of college, while financial aid was included to test a measure of net cost. Shin and Milton used many components of previous studies, but were the first to combine all the above aspects into a single study.

The hypotheses postulated by Shin and Milton included the following: tuition will have no effect on enrollment growth, competitor's price will have a positive effect on growth, and the wage premium will have a positive effect on enrollment growth. A hierarchical linear model (HLM) was used to allow description of changes over time in time-series data. Shin and Milton used HLM because they were more concerned with the changes over time or a growth analysis than in elasticity measurement.

As they expected, tuition had little effect on enrollment. The best estimate was that colleges would have a 1.13% decrease for an increase in tuition. This is much lower than many of the comparative studies such as Leslie and Brinkman (1987), Heller (1997), or Dynarski (2000) who found decreases in tuition resulted in 3-5% increases in attendance. Enrollment was much more sensitive to changes in competitor's prices. Private four-year institutions had a positive CPE, while public two-year institutions had a negative CPE. Thus, enrollment in public four-year schools was more responsive to changes in competitor's prices than to changes in their own tuition rates. Wage premium also had a positive effect. Colleges in states with 1% higher wage premiums had on average 4.25% more enrollment growth each year than colleges with average wage premiums (Shin & Milton, 2006).

Shin and Milton's (2006) first paper is important to the current research in that it establishes the wage premium and competitor's price as needed variables. The finding that an institution's own tuition level does not influence its enrollment growth is intriguing and might induce administrators to raise tuition at a more frequent rate. However, the authors do admit that different time periods and different tuition ranges might lead to different results with respect to tuition responsiveness.

The second paper by Shin and Milton (2007) is unique among the literature in that it explores student responses to tuition increases at the college major level. The premise is that state policymakers are more willing to tie tuition to cost of education, a so called cost-related tuition policy. While this is not true differential tuition, it is worth examining. With a cost-related tuition policy, actual college costs are important. Costs will differ by credit hour, major, level of student, etc. To determine what to charge in such a system, student's responses to tuition changes must be analyzed.

To that effect, Shin and Milton (2007) modeled enrollment as a function of current tuition, tuition changes, other school costs, financial aid, instructional expenditures, and student dormitory capacity. The population of data was all public four-year colleges and universities in the U.S. that reported institutional-level data on the dependent and independent variables. An OLS method was used with a log-linear functional form, thus the coefficients can be interpreted as the proportional change in enrollment caused by a one unit change in the independent variables (Shin & Milton, 2007).

Tuition levels were reported in the overall model with a coefficient of -.011 for 2004 costs. That means that a $100 increase in tuition will result in a 1.1% decrease in enrollment. These results are significantly less than those reported in Leslie and Brinkman (1987) and Heller (1997), but consistent with previous work by Shin and Milton (2006).

There were significant differences across the selected majors. Physics (-.005), Biology (-.009), and Business (-.013) showed negative responses to tuition increases. Enrollment in Physics would decrease .5% with an increase of $100 in tuition. Biology enrollment would decrease by .9% and Business by 1.3%. All three were significant at the .05 level. Engineering, Math, and Education had very small negative or even positive coefficients, but none were significant. Shin and Milton (2007) postulated that those majors with high rates of return would not be sensitive to tuition. The results tend to support this hypothesis. Engineering students, the discipline with the highest rates of return, were not sensitive to tuition increases. Biology, Physics, and Business students, those with medium rates of return and medium costs to the university, were sensitive to changes in tuition price. Education, with lower rates of return and lower costs, were also not sensitive to tuition increases, but the results were not statistically significant.

Shin and Milton (2007) analyzed student's response to tuition changes across majors or colleges. Their study looked at several hundred institutions in the U.S. in terms of cross-sectional data. Further analysis at a single institution using a time-series analysis will provide more information.

Institutional-level Studies

The higher education community functions similar to a monopolistically competitive market, with many firms that each have a differentiated product. Each faces competition from all points and while each is producing education as its commodity, there exists a niche market for each institution. That niche gives each college or university some semblance of control over prices. Estimating demand for enrollment on a national or even regional level may not be the best method of determining what is happening at a single institution. Thus, it is useful to estimate demand at individual institutions. The nature of competition among higher education institutions can be quantified by estimating a demand for enrollment that includes competitor's prices as an independent variable. This results in a measure of two institutions' relationship referred to as cross-price elasticity (CPE).

One of the first institution level demand study was conducted in 1977 using data from the University of Hawaii (Ghali, Miklius, & Wadak, 1977). The model developed estimated enrollment based on cost, income, ability, gender, family size, and the type of high school attended. Results showed an elasticity of demand (OPE) equal to -.476, which is inelastic. Hawaii's geographic isolation and low level of tuition in the early 1970s could have contributed to students' relative indifference to tuition changes. Cross-price elasticities between the University of Hawaii and several competitors across a range of institutional types (two-year, four-year, public, and private) were close to zero and little significance, meaning there is little true competition for the University of Hawaii (Ghali, et al., 1977). The implications are that a significant increase in tuition will not cause a significant drop in enrollment, making the University of Hawaii a logical candidate for increasing revenues by increasing tuition.

Similar studies were conducted for Cornell and Occidental College in the 1980s. The study done for Cornell students looked at categories including family income, SAT score, and legacy and estimated the demand for enrollment with respect to the two components of the Cornell system, statutory colleges (colleges that are part of a private institution that receive state funding) and endowed colleges (privately funded colleges within a private institution). All of the elasticities for the statutory colleges were inelastic with the overall being -.28. The endowed elasticities range from -.41 to -1.58, with the overall at -1.09 (Ehrenberg & Sherman, 1984). Thus, students attending the endowed colleges were far more sensitive to changes in the price of tuition.

Moore, Studenmund, and Slobko (1991) found similar results at Occidental. Using a model that included personal variables such as race, gender and legacy and cost variables, they estimated the enrollment demand using a logit model. They found that the OPE for students that applied for financial aid was -.72, while students that did not apply for aid had an OPE of -.35 (Moore et al., 1991). Both results are inelastic, but students that apply for aid have a relatively more elastic demand. They will respond more to changes in price and with federal grant money trending downward, are less likely to attend. This may force private schools like Occidental to give them some incentive to attend by increasing private grants and scholarships.

In their 1999 paper, Allen and Shen employed a simple demand model to test the environment of competition that exists around small, regional private schools. Their model includes as competitors, a public, comprehensive university within the same area, a public, research university within the same state, and a private university in a neighboring state. Using a log-log functional form, the authors find an income elasticity (IE) of 1.7 and cross-price elasticity (CPE) between the private institution and its nearest private competitor of .51. The data shows this institution to be a normal, luxury good (IE > 1) and the two schools together to be substitutes (CPE > 0). Of note, the CPE of the institution of study and the public universities was minute and insignificant, indicating that the true competitor for this private institution is its fellow private school.

Even more interesting, the OPE for the private institution without including competitors is -.64. Adding the three competing schools increases OPE to -1.09 (Allen & Shen, 1999). Thus adding competition transforms the enrollment in the private institution from inelastic to an elastic good. Without competition, students are not responsive to changes in tuition price. The addition of competitors changes the equation. Competition becomes a limiting factor on revenue generation.

Vasigh & Hamzaee (2004) studied enrollment demand for undergraduates and graduates across two campuses of a private institution. Using a log-log functional form, enrollment is estimated as a function of tuition, income, unemployment, and financial aid. Tuition costs seem to have no impact on enrollment, with some of the OPE actually being positive, indicating potential Giffen goods. Undergraduate OPE ranged from .07 to .44, while graduate ranged from -.24 to .53. An increase in publicity and rank could be a cause of the positive, seemingly Giffen elasticities, as could growth in the industries served by the institution.

Most of the previous studies done on tuition pricing have focused on student's ability to pay, financial aid availability, or college costs. Bryan and Whipple (1996) analyzed the student's willingness to pay. To achieve this result, they asked current students at Mount Vernon Nazarene College (MVNC) a series of questions pertaining to their responses to hypothetical tuition increases. Choosing six elasticities (ranging from -.03 to -.49) from surveys and previous literature, the authors calculated the projected net earnings for MVNC for each scenario. The findings were very informative. At low tuition prices of $6000 per semester, student's demand was highly inelastic. They were very likely to remain at MVNC at those prices, but university earnings were low ($28,885). When prices moved to a mid-range, $7000 per semester, students begin to look for more options and demand became more elastic, however enough students stayed at MVNC for earnings to reach $595,052. As prices reached the highest level,$8000 per semester, demand was much more elastic and MVNC's earnings fell dramatically ($-273,791).

The implications of this paper are clear. Applying the earnings and elasticity model to private colleges should allow those colleges to find a tuition level that will generate the highest possible revenue. One question administrators must ask however is if high net earnings is the only goal of the institution. Most higher education establishments, especially small privates, may have other goals. Balancing economic realities with educational goals is the ultimate question in higher education.

Curs and Singell (2010) investigated enrollment demand as part of a tuition/aid study at the University of Oregon. The authors used net price, instead of tuition, in order compare price responsiveness across groups. The unique aspect of this study is that the authors divided applicants into nine categories covering need and ability. They estimated elasticities for each of the nine categories. Elasticities became more inelastic as the student moved from non-needy to needy and from less able to more able. Thus students with little need for aid, but with less ability were more responsive to price changes and more likely not to enroll if net prices were higher. Students with great need for aid or with great ability were more likely to enroll regardless of the net price. This could be because students with great need were likely to have the same net price regardless of institution. Since the majority of need-based aid is Federal funds, those funds can follow a student to any institution they choose to attend. If they received an increase in funds available for the University of Oregon, they would be able to receive a similar increase at Oregon State. For those students that had little need for aid, price changes at the University of Oregon would have more of an impact because they do not receive funding at all potential choices.

Demographic Based Studies

Some papers have attempted to include racial data in elasticity studies. McPherson and Schapiro's (1991) results showed that White, low-income students were more affected by tuition changes, but they did not have the data to look at Black or Hispanic students. Cameron and Heckman (2001) looked at minority students within a large-scale project encompassing more than costs. They did not measure elasticities, but did model academic attainment for Black, Hispanic, and White males to investigate the sources of racial and ethnic disparity in college attendance. When controlling for family background, minorities are more likely than Whites to graduate from high school and attend college. Tuition has only a limited effect on minority attendance, but what the authors term "early differences in resources" are the main cause of differences in White and minority enrollment. Family income is important, but not for the obvious reason of ability to pay for college. Income is more important in establishing a desire and need to attend college and in preparing a student for college. The authors argue for more funding for high-school education and preparedness than for increased federal loan programs as a way to increase minority college attendance and success (Cameron & Heckman, 2001).

Another study discussing differences in elasticity due to race is Wetzel, O’Toole, and Peterson (1998) which estimated the enrollment demand at Virginia Commonwealth University VCU) based on ethnicity. The study uses net cost (tuition minus aid) as one of the independent variables. The enrollment yields at VCU are relatively insensitive to changes in net price. However, unlike the previous study from Cameron and Heckman, Wetzel, O'Toole, and Peterson did measure elasticities and found that Black students are two thirds more responsive than White students to changes in net cost. The implication is that increases in financial aid to Black students could dramatically increase enrollment yields.

Kane (1994) used the methodology pioneered by Jackson and Weathersby (1975) and used in Leslie and Brinkman's (1987) meta-analysis paper to show student's price responsiveness to tuition changes for black and white students in different income levels. Leslie and Brinkman found that the papers they studied showed a $1000 decrease in the net price of schooling caused a 3 to 5% increase in attendance. Kane found that the responsiveness varied greatly between black and white students and between income levels. In the bottom quartile of income levels, a $1000 increase in costs would decrease black enrollment by 22.1% and white enrollment by 11.4%. In the highest quartile, black enrollment would still decrease by 13.2%, while white enrollment would only fall by 1.7%. Black students were more responsive than whites to tuition changes in all quartile.

Previous studies into elasticity of tuition have ranged from meta analysis over large numbers of institutions to studies only affecting single private or public institutions. While many of these studies provide information about elasticity, none provide the more detailed examination that this paper will attempt. Shin and Milton (2007) looked at tuition response to individual majors over a cross-section of universities, but they did not expand the study over multiple years. Several studies have looked at individual universities over time, but not including examining different colleges at those universities. This study will attempt to fill the gap between the two types of studies that have been conducted in the past.

Differential Tuition

Differential tuition has been used as a method for increasing university revenues at some campuses for many years, but was not in widespread use until relatively recently. Charging different students different rates has led to concerns about access. Will charging higher tuition for higher demand colleges or majors force low-income students to choose to major in lower-cost programs because they are more inexpensive to attend? Nevertheless, many schools use some type of differentiation and this practice will likely continue as higher education institutions seek to diversify funding sources (Ward & Douglass, 2005). The continual decline in state support for higher education has made differential tuition a viable option to be explored at public universities to raise revenues (Heller, 2006).

Types of Differential Tuition

The most basic tuition differentiation is the different rates that undergraduates and graduates pay. According to Saupe & Stephens in 1974, about 25% of the land grant universities surveyed charged a different rate for graduate and undergraduates.. The authors state that universities had begun to use different rates for graduate students because of the higher costs associated with said graduate students. According to a 2010 survey, 91% of institutions charge a different rate for graduate versus undergraduate levels (Simone, 2010).

A second form of tuition differential is that of state resident versus non-resident students. This differential has been used more often than graduate versus undergraduate rates. A 1971 study indicated that tuition differentials for residency were widespread and substantial in all parts of the country (Carbone & Jenson, 1971). Simone found that in 2010, nearly 99% of public four-year institutions and 97% of public two-year institutions charge different rates based on residency (Simone, 2010).

One method of determining tuition rates that has been considered is using class standing (freshmen, sophomore, junior, and senior). This type of differentiation was in use in the late 1970s and early 1980s when it was reported to be in use at the University of Michigan, University of Minnesota, and University of Washington (Yanikoski & Wilson, 1984). As the student gets closer to a degree, the price elasticity becomes much more inelastic. This means the student is willing to pay more at the end of a degree program than at the beginning and is more unwilling to leave the same program. Increasing tuition rates to upperclassmen would theoretically increase revenue and decrease costs for freshmen, increasing access. A study by Chressanthis (1986) estimated demand at Saginaw Valley State College from 1964-1983. The model included tuition, competitor tuition, housing, and unemployment. Different models were estimated for different classes. The own price elasticity (OPE) for freshmen was -1.74, while seniors had an OPE equal to -.59, showing the expected results of student's demand becoming more inelastic as they advanced in classification. However, these results and the economic theory behind this method of differentiation have still only led to less than 10% of schools charging students with different classifications, different tuition rates (Simone, 2010).

Another method of differing tuition is charging students more based on peak load. Peak load differentials involve charging lower rates during non-peak utilities usage to increase efficiency of physical plant and increase classroom usage. With additional class times during non-peak hours, demand was driven from peak times to a more broad range of hours. This allowed a greater utilization of physical plant assets, more revenue per student, and savings of capital expenditures by not constructing new physical plants based upon skewed peak loads (Avila, 1972; Weinberg, 1978).

Most of these types of differentiation are not practiced by institutions around the country. The most prevalent remain graduate versus undergraduate and residency differences. Combining all factors other than residency, nearly 70% of institutions use at least one of these factors to charge a different tuition level. Nearly one-third charge based on two or more factors (Simone, 2010).

Politics of Differential Tuition

Initiating a differential tuition strategy is an exercise in politics. The public has been accustomed to low tuition and low cost education financed through state and federal support since World War II. This has generated a sense of entitlement to a low cost education regardless of the rising costs involved (Ward & Douglas, 2005). In the U.S., the public is usually non-responsive to the government decreasing funding of higher education, but the opposite is true if tuition and fees are increased. This has led to much of the general public calling for higher education to apply industry methods of cost controls and efficiency innovations in order to maintain low tuition levels (Ward & Douglas, 2005).

The main factor contributing to the proliferation of differential tuition is the decreasing amount of funding public institutions receive from state and national sources. There are three main sources of funds for higher education instruction, tuition and fees, federal funds, and state and local funds. Prior to the World War II, tuition and fees and state funds were much greater than federal funding. The passage of the Servicemen's Readjustment Act (GI Bill) in 1944 increased enrollments and the amount of federal funding institutions received, spurring a massive growth in education spending and revenues. From 1960 to 1980, revenues in higher education increased over $50 billion or ten times the amount in 1960 (Heller, 2006). Of the three main sources of revenue for higher education tuition and fees have risen at the fastest rate. State appropriations have increased at the slowest rate. From fiscal year 2000 to 2004, state funds increased only 6.5% per year, while tuition prices increased between 16% and 40% depending on institution type. Percentages of total funding are even more telling. The percentage of total revenue that was gained from state sources has decreased from a high of 34% in 1980 to 26% in 1996. The share of federal funding has declined in the same period from 15% to 12%(Heller, 2006). These numbers have continued to decrease. This decline has been offset by increases in the share of tuition and fees. Tuition and fees have reached the point of generating about 30% of the operating revenue of four-year public universities (Derochers, Lenihan, & Wellman, 2010).

While tuition increases and differential tuition can provide increases in revenue, they may cut off access to low-income students. While the college-going rates have increased for all socioeconomic and ethnic classes at the same rate over the past few decades, despite the continuing differences in those ethnic college-going rates, the net cost of attendance as a portion of income remains highest for the lowest income families. The net cost of attending higher education institutions absorbs 45%, 38%, 30%, 20%, and 11% of the total annual income of families in the five quintiles (Heller, 2001). Increasing tuition further will place a greater burden on the lowest 60% of U.S. families that would need to spend from 30% to 45% of their annual income to send their children to college. Problems with access can be helped with increases in financial aid. The University of California raised tuition in the early 1990s but accompanied this increase with an increase in the amount of aid given to low and middle income students. Universities normally give $.25 in aid for every $1 in tuition raised. The University of California raised this percentage to $.35 in aid for a $1 raised in tuition. The result was no discernible drop in demand or in access (Ward & Douglas, 2005).

Another compelling argument for the introduction of differential tuition is making tuition more equitable to students. In a flat rate tuition scheme, where all students pay the same amount, students in low-cost colleges, such as education, have to pay for the education of students in high-cost colleges, such as engineering. A differential tuition policy or cost-related tuition policy would ensure that students in high-cost colleges would pay a higher amount, while those in low-cost curricula would be charged less. There is some evidence that flat rate tuition plans are actually regressive, reduce access, when compared to differential plans (Hansen, 1970; Windham, 1972).

Rothschild and White (1995) developed a model of higher education pricing based on the supposition that colleges provide human capital as an output and students are clear inputs. The question is if there are pricing schemes that allow an efficient allocation of resources in a zero-profit environment such as in higher education. The authors' model yields intriguing conclusions. First, different students may be charged different tuitions at the same university because they may receive different amounts of human capital at the same university. Students of the same type may receive different amounts of human capital from different universities, but they will pay different tuitions at those universities so that the net gain will be uniform across universities. Universities may use different technologies, admit different types of students, provide different levels of human capital, and charge different tuitions, but the tuition and human capital package that a university offers to a given student must meet the requirement for uniform net gain across all students of all types.

Students that are charged a cheaper tuition rate for lower cost curricula will receive less human capital and lower career earnings or wage premiums. Higher-quality universities that pass on more human capital are able to charge more because their graduates will generate higher future earnings. Rothschild and White (1995) present a competitive equilibrium model that seems to explain the underlying reasoning for differential tuition. The authors admit however, that real world pricing strategies do not resemble those in their model, possibly due to market imperfections or technological differences.

The economics of colleges and universities have become more important as state funding dries up. With a higher percentage of university revenues coming from tuition, differential tuition rates become more attractive. Many universities offer differential rates of at least one or two kinds, but not many choose to differentiate based on colleges. Charging higher amounts to students that are earning degrees in fields that have higher wage premiums may be a way to increase revenues. However, if there are no differences in elasticities, or price responsiveness, across colleges, then universities may lose money and patronage by charging differential tuition.

CHAPTER III

METHODOLOGY

This chapter provides the mechanics of the study. The relevant research questions are presented again and the research design is described. The research design section will include a brief overview of the study as well as the following sections: the data to be analyzed and method of collection, the model, and statistical methods. A summary will reassert the most significant aspects of the design and set the groundwork for the results chapter.

Research Questions

The main objective of this study is to estimate demand for enrollment in different colleges at State U. Demand for enrollment is estimated using a variety of determinants including cost variables, personal characteristic variables, and macroeconomic variables. The demand estimation will allow the researcher to calculate price elasticities (OPE) and income elasticities (IE) for each of eight colleges at State U. Determining elasticities for each college would give State U and government officials information on the relative tuition sensitivities by college. Thus, the primary question is **"What is the elasticity of demand for enrollment for different colleges at State U and what are the implications for differential pricing in higher education?"** This main question can be broken down into the following five research questions:

Question 1: Do differences exist in the price elasticity of demand for different colleges?

Question 2: Does any college's price elasticity of demand classify that college as having an *inelastic* demand for enrollment with respect to tuition?

Question 3: Does any college’s price elasticity of demand classify that college as having an *elastic* demand for enrollment with respect to tuition?

Question 4: Does any college’s price elasticity of demand change greatly over time?

Question 5: What is the estimated effect charging differential tuition rates according to elasticities would have on State U’s general revenue and enrollment?

A secondary question is **“What are the income elasticities for various colleges at State U and how do changes in income affect enrollment?”** There are four research questions for the secondary question of the paper:

Question 6: Are there significant differences between colleges in income elasticities?

Question 7: Are any of the colleges considered *luxury* goods?

Question 8: Are any of the colleges considered *necessity* goods?

Question 9: Does any college’s income elasticity change over time?

Research Design

Overview

The researcher will address the above questions by analyzing historical enrollment data from a flagship, land-grant university, State U. Data will be collected on the number of applications for each of eight colleges at State U and used in an ordinary least squares (OLS) regression to build a demand equation for enrollment in each college. The regression results will provide the researcher the means to calculate price and income elasticities for each of the ten colleges at State U. These elasticities will provide information about the differences across colleges with respect to demand and potential revenue generation. The study will follow the work of Shin and Milton (2007) by looking at individual colleges within State U, as they are the only study to work in this direction.

Data

Data collected for the dependent variable will consist of the number of actual freshman applications to State U over the time period 2003-2015. The decision to use applications instead of freshman enrollment relates to the overall high demand for an education at State U. State U is consistently a top ranked university, both nationally and internationally, and its status as a public university and relatively low tuition make it one of the best values of any college in the United States. The result is far more students applying for State U than are admitted and enrolled. Consequently, enrollment, used in the majority of demand studies listed in Chapter Two (Vasigh & Hamzaee, 2004; Ghali, et al., 1977; Moore, Studenmund, and Slobko 1991; Ehrenberg & Sherman, 1984), would not lend itself to the most useful interpretation. Instead, this researcher will use applications as the dependent variable as Bezmen and Depken (1998) did in their study of signaling.

Independent variables to be used in estimating application demand are divided into two main categories: cost variables and macroeconomic variables. The data required for the independent variables is available from State U records as well as United States Federal Reserve databases.

Variables

This study will entail the development of a time-series model for enrollment in each of eight colleges at State U based on the number of freshman applications into those colleges. The colleges are Agriculture and Life Sciences, Architecture, Business, Education, Engineering, Geosciences, Liberal Arts, and Sciences. The theoretical model is shown in Equation 13, with applications as a function of a set of cost variables and macroeconomics variables.

Applications = *f* (State U Tuition, State U Fees,

Two-Year Competitor Costs, Four-Year Competitor Costs, Income,

Unemployment Rate, Interest Rate, Wage Premium) (13)

Applications for the eight colleges are shown in Figure 3. Data was collected from several reports presented by State U (State University, 2016a). Several of the colleges have a relatively flat appearance when graphed in this manner. However, there is a legitimate increasing trend in each college. There are several ambiguities though. First is the manner in which the College of Agriculture tends to have plateaus in applications. From 2003 to 2009, applications for the College of Agriculture go from 923 to 1254, a change of around 5% a year. There is a rapid increase following this stagnation in 2010 – 2013 from 1254 to 2673, over 30% increases per year, followed by stagnation in 2013-2015.

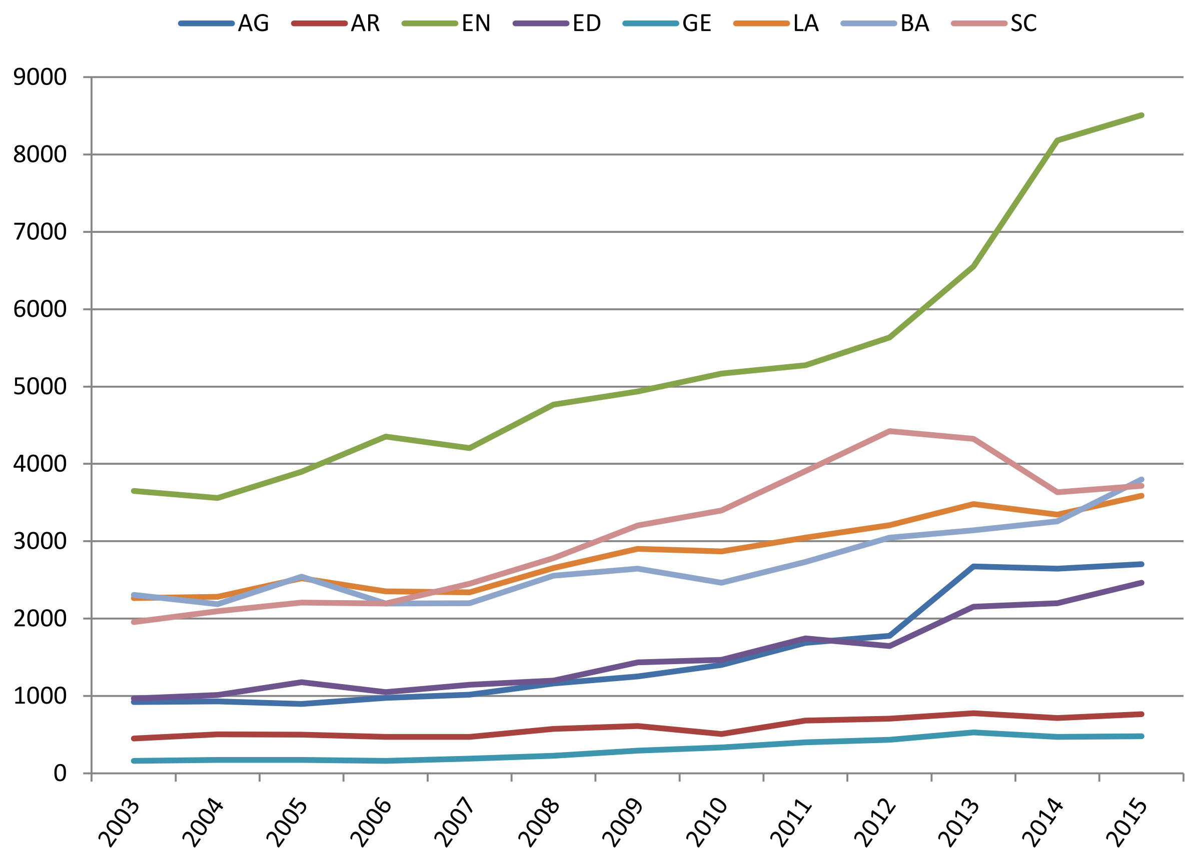

Figure 3. Applications in Eight Colleges at State U from 2003-2015.

Other colleges, such as Business, Liberal Arts, Education, and Architecture show more standard linear progressions. Both the College of Science and the College of Geosciences show a decrease in the years 2013-2015, while Engineering has an explosion in growth of applications over the same time period.

Cost variables include both tuition and fee costs at State U and some competitor costs. In order to calculate elasticities, some measure of the price of attending college is necessary. At the majority of colleges, costs are divided into at least two components, tuition and fees. Tuition and fees are included in the analysis independently to account for the potential of University administration transmitting higher costs of education to students at State U in fees instead of raising tuition costs. Gross tuition is used in order to study the effect of tuition increases on tuition independent of aid. Tuition and fee data was collected from State U's Student Business Services website (State University, 2016b)

State U undergraduate students pay a flat rate for tuition and fees for any amount of hours at full-time status (12 credit hours per semester) or above. Colleges and Departments can impose their own fees for specific courses, but that data is unavailable. In the 2013-14 school year, this amounted to $2648.25 for tuition and $1604.59 for fees for residents in those colleges that did not have differential fees, not including parking fees or sports attendance fees. Four colleges, Architecture, Business, Education, and Engineering, charged a varying fee to their students, above and beyond state mandated tuition. By 2015, every college has different tuition schedules. Figure 4 shows the changes to tuition over the past decade.

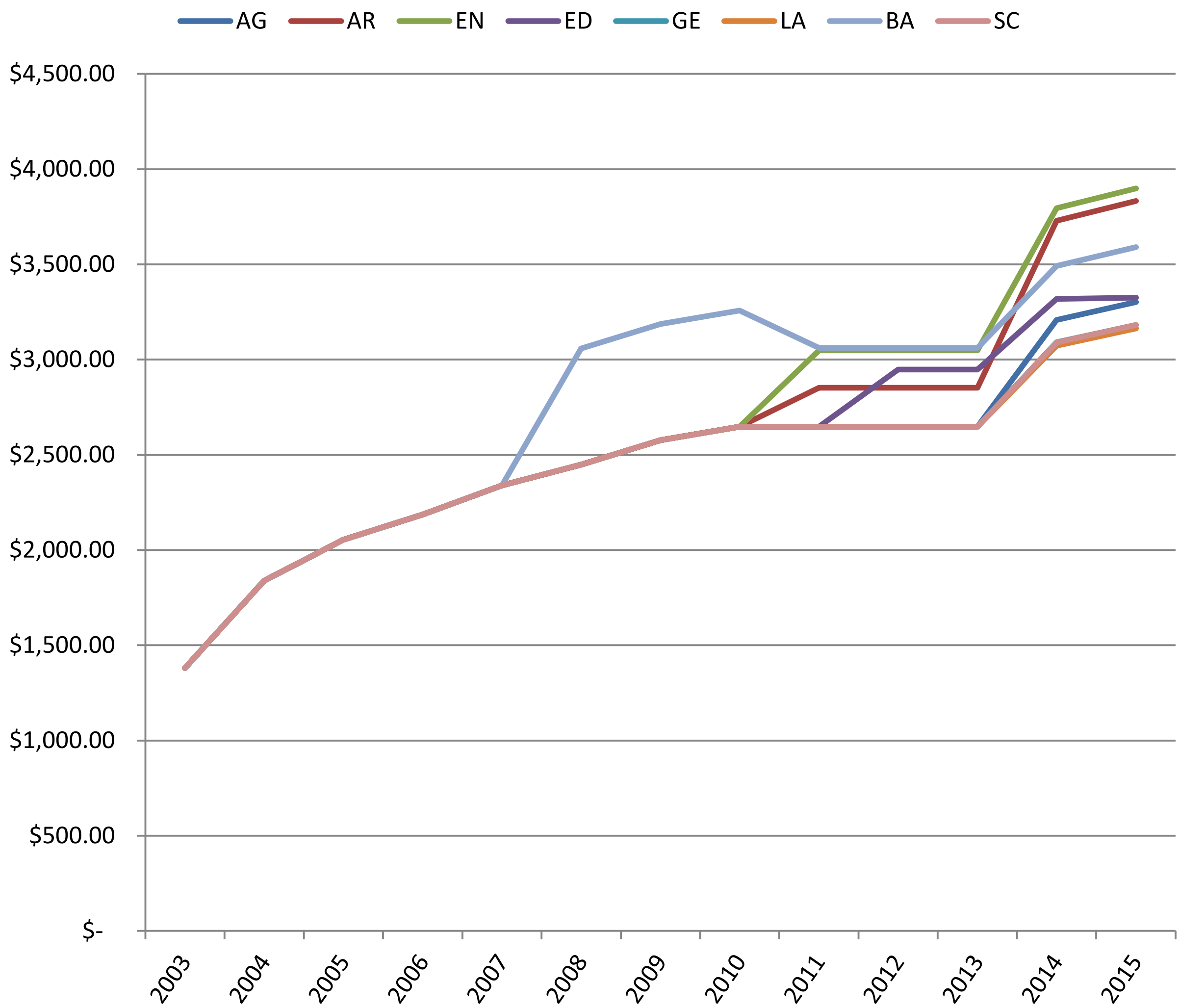

Figure 4. State U Tuition for Eight Colleges During Years 2003-2015.

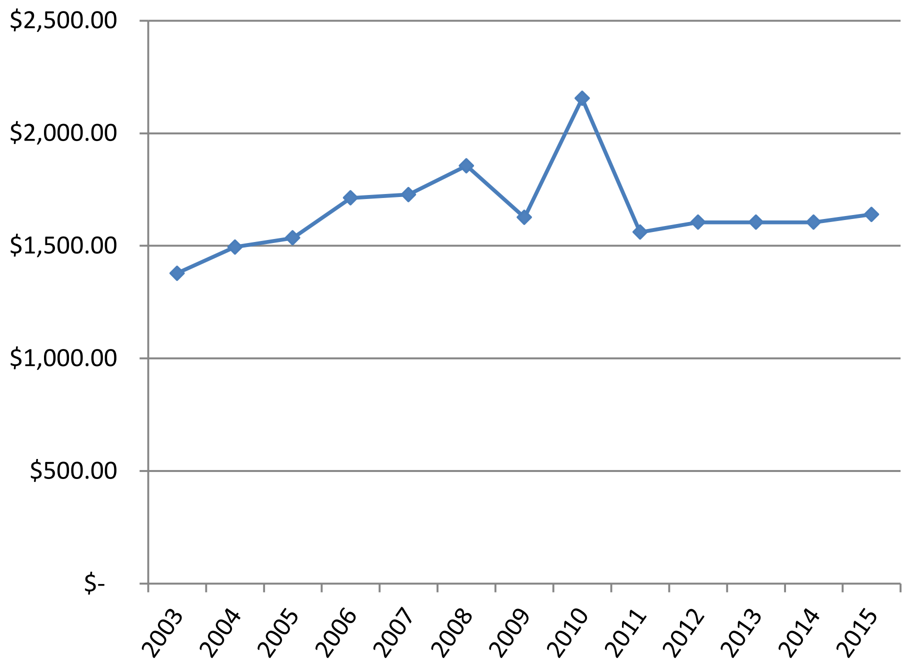

Figure 5. State U University-wide Fees.

While tuition has trended upward since the removal of legislative controls, university-imposed fees have been much more stable (Figure 5).

A second set of cost variables are the annual costs of competitors. Several previous studies in institutional level demand have used competitor pricing (Allen & Shen, 1998; Ghali, et al., 1977; Noorbakhsh & Culp, 2002) and since State U has many competitors in all varieties (public, private, four-year, two-year) it is imperative that some measure of these relationships be included. To measure these relationships and still limit the number of independent variables to a reasonable level, the model will include two competitor variables, two-year college tuition and fee levels and four-year university tuition and fee levels. While two-year colleges may not be a true competitor for State U, the difference in tuition between the two may show a greater level of competition than anticipated. The data for two-year competitors is an average of all public two-year schools in the state. Four-year data was taken from the average of State U's three biggest in-state, public competitors (State Higher Education Coordinating Board, 2016).

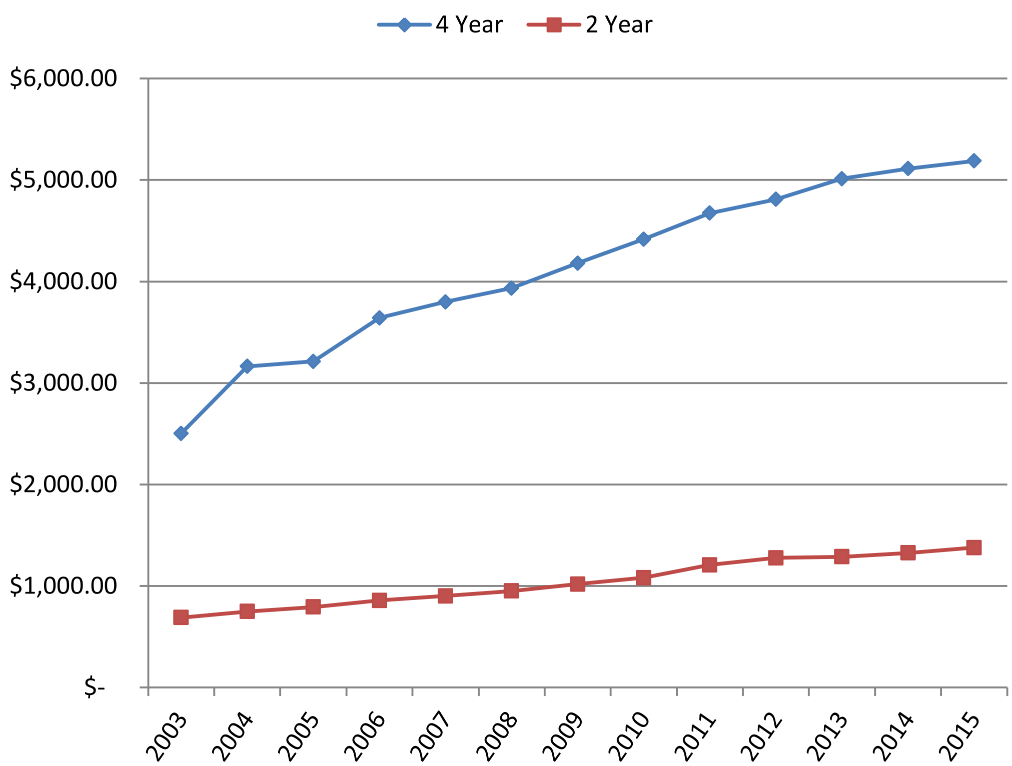

Figure 6. Four-year and Two-year Competitor Tuition Rates for 2003-2015.

Figure 6 shows the four-year and two-year costs. It is easily apparent that State U's four-year competitors have had increases in tuition similar to State U's increases. What is interesting is that the two-year college average has not increased at rapidly. There has been a steady increase in the cost of two-year alternatives, but not on the magnitude of four-year.

The macroeconomics variables of interest include income, unemployment rate, interest rate, and the wage premium. Three variables will be lagged one time period based on the idea that students respond more slowly to changes in macroeconomic variables (Allen & Shen, 1998). Therefore, 2010 student data would be matched to 2009 economic data. The interest rate will not as students apply for current loans not previous year loans. Income will be measured in the form of the State U's state per capita disposable income (PCDI). Disposable income is total personal income minus personal current taxes. PCDI is that measure divided by state population. Income has been included in many demand studies and usually in the form of PCDI (Campbell & Siegal, 1967; Hight, 1975; Allen & Shen, 1998; Buss, et al., 2004). Including income allows the calculation of the income elasticity for each of the ten colleges. This will indicate if enrollment at each college is a normal or inferior good. Using State U's own state PCDI will allow a more accurate estimate of income effects as in most state flagship schools, the great majority of students are from within the state. Figure 7 shows the state's PCDI (U.S. Bureau of Economic Analysis, 2016). As expected, this number has a large positive trend.

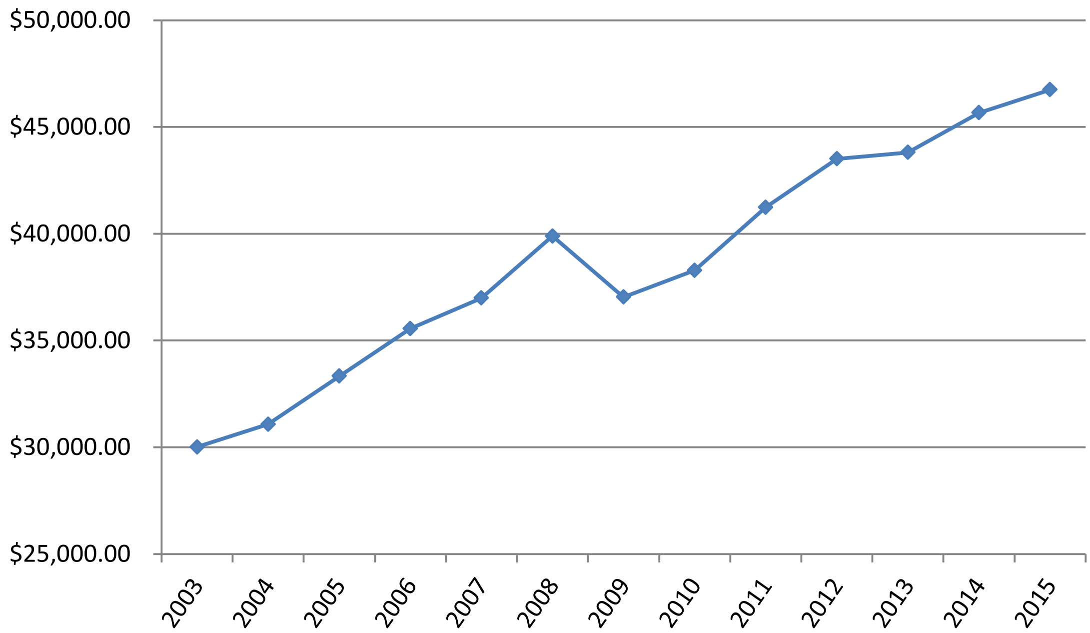

Figure 7. Texas PCDI for 2003-2015.

A second macroeconomic variable is the rate of unemployment. Unemployment is measured as the unemployment rate in the state for each time period. Different states have different responses to recessions and growth periods. Thus it is more useful to include the state unemployment rather than the broader United States unemployment. Higher unemployment rates may lead to higher enrollment rates in colleges. The lower opportunity cost, for example the salary a student could have made as a full-time employee if he/she chose a vocation instead of going to college, directly after high school results in more students foregoing work to consider higher education (Chessanthis, 1986). However, a second observation is that the higher unemployment rate could result in more parents being out of work and thus unable to afford to send their child to college, particularly for State U which as a flagship is more expensive than many of its competitors (Buss, et al., 2004). Texas' unemployment rate is shown in Figure 8. There are decided peaks and valleys in the 13 years of data. Obviously, recessions and periods of growth in the economy spur unemployment.

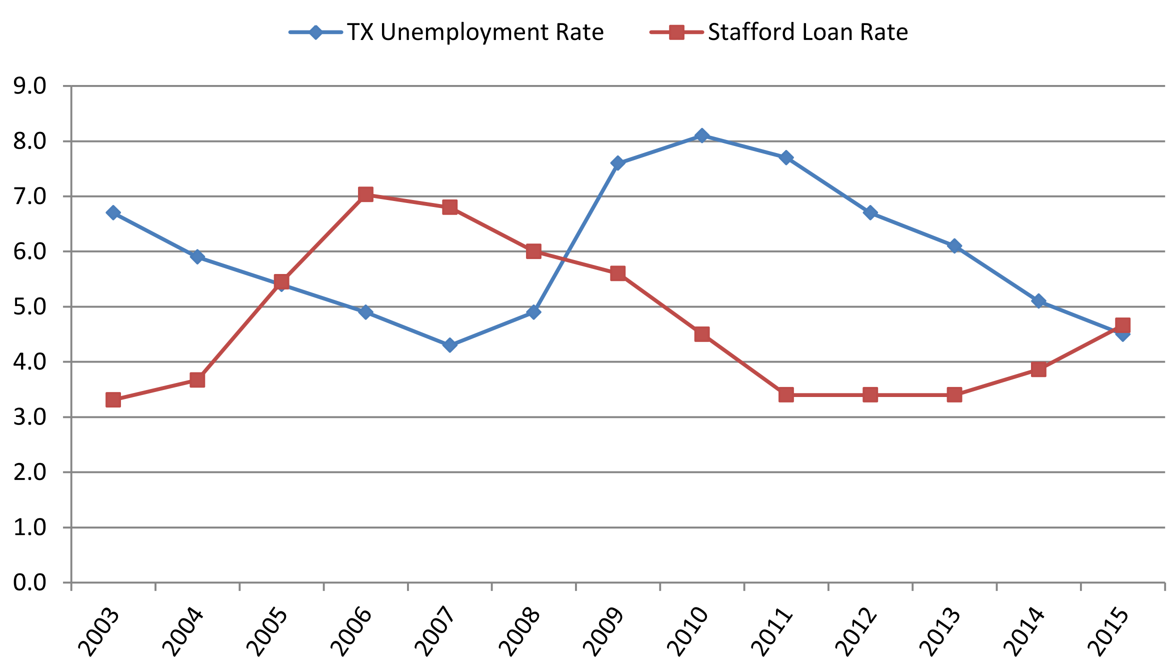

Figure 8. Texas Unemployment Rate and Stafford Loan Rate.

What is interesting is the relationship between unemployment and the third macroeconomic variable, interest rate. Interest rates were included in the model in the form of the Federal Stafford Loan Rate (Educated Risk, 2016). Higher interest rates tend to discourage students from seeking student loans as a form of financial aid to pay for college. If a student knows they will have to pay large rates on their loans, the opportunity cost of college becomes higher. Similarly, with high interest rates, students could earn more money on their investments. Investments made with money that would be spent on an education. This is the opportunity cost of investment. The expectation is that the higher the interest rate, the lower the enrollment demand, hence a negative relationship. As of May 2013, student loans outstanding were greater than $1.25 trillion (Chopra, 2013).

Looking again at Figure 8 shows a distinctive pattern. In times of low unemployment, when the economy is doing well, the loan rate is higher. This is because the Stafford rate is tied to the U.S. Treasury Bill rate. When the economy is doing better, Treasury bills have a higher return.

The final macroeconomic variable is the wage premium. Wage premium is the difference in average salary of an individual that graduated from high-school and entered the work force and an individual that graduated from college before entering the work force. Several studies suggest that the wage premium is a major determinant of demand (Corazzini, Dugan, & Grabowski, 1972; Becker 1993; Woodhall, 1995), but relatively fewer include it in tuition demand estimations (Shin & Milton, 2006).

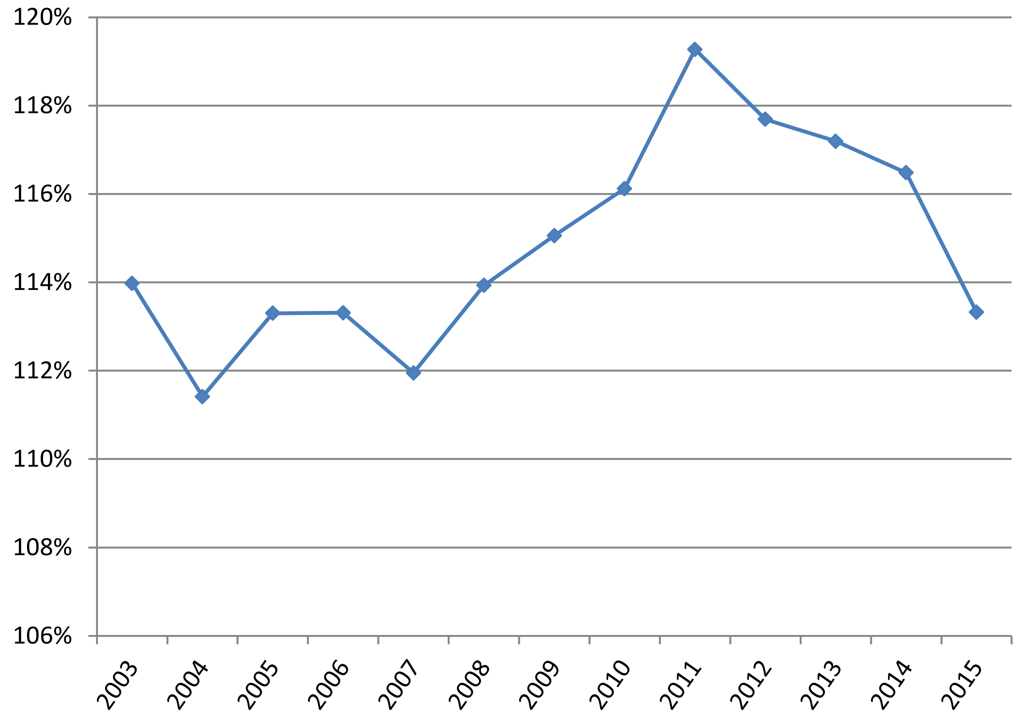

Figure 9. College Graduates Wages as a Percentage of High School Graduates Wages.

Wage premium is calculated for each year from United States Census Data and is measured by the percentage of average income for those with baccalaureate degrees to the average income for high school graduates. Data was collected from the U.S. Census Bureau Current Population Survey 2016 and is shown in Figure 9. Wage premiums were unavailable for the totality of the data set for each college. State U has begun collecting data on the starting salaries of students from individual colleges and degrees, but this data is only available from 2011-2015. Eventually, inclusion of such data will make this study much more robust.

Tests for Stationarity

As shown in the graphs of the data, most of the variables appear to be non-stationary, meaning that the series has a trend and does not return to its mean. Some data behaves like a random walk; new information will change price levels in the short run but not affect the long run mean. Other data series increase or decrease in a pattern or trend. Those trends are non-stationary and make time series analysis impossible. All variables need to be tested for stationarity and corrections applied to those that are non-stationary.

The test for stationarity is the Dickey-Fuller (DF) test. The null for the DF is that the variable's data series is non-stationary. The alternative hypothesis is stationarity. The test for each series is based on an ordinary least squares regression of the first differences of each variable on a constant and one lag of the levels of each variable. The t-statistic is associated with the estimated coefficient on the lagged levels variable from this regression. Under the null hypothesis, the statistic is a non-standard t distribution. The critical values for the DF test for the 95% significance level is are -2.89(5%). The null will be rejected for any t values less than the 5% critical value (Fuller, 1976).

A Dickey-Fuller test was conducted on each of the eight colleges. An initial regression was run to get the residuals for each model. The lagged residuals were used as the independent variable regressed on the change in residuals, the dependent variable. The results of the DF tests are shown in Table 1. All eight colleges had t-statistics less than -2.89 for the DF tests. This means that each model, when taken collectively, is stationary. There are no statistically significant patterns in the data. No adjustments, lags or corrections, need to be applied to the models in order to run regressions.

Table 1

Dickey-Fuller Test Statistics

College	T-statistic
AG	-5.75
AR	-3.92
BA	-3.79
ED	-5.19
EN	-3.89
GE	-4.25
LA	-4.22
SC	-4.67

Model

The variables listed above will be used as predictor variables in the estimation model. The model will be estimated using a log-log and log-linear functional forms. Discussions on the correct functional form end with varying conclusions. The log-log form produces results that can be interpreted more easily as elasticities. In the log-log form, the coefficients on tuition price and income will be the OPE and IE, respectively. However, the log-log form assumes elasticity is equal across all levels of observation (Bezmen & Depken, 1998). The log-linear form assumes that the effects of the independent variables are dependent on the size of the independent variables (Shin & Milton, 2007). Coefficients on tuition price and income are interpreted as proportional changes in applications caused by a specified unit change in tuition or income. Both specifications will be tested to ensure robustness of the analysis.

The empirical model developed for the log-log form is presented in Equation 14. The model will include eight colleges (i = 1 to 8) and 13 years of data (t = 1 to 13).

$$\ln APP_{it} = a + \beta_{1i} \ln TUI_{it} + \beta_{2i} \ln FEES_{it} + \beta_{3i} \ln 4YR_t + \beta_{4i} \ln 2YR_t + \beta_{5i} \ln INC_{t-1} + \beta_{6i} \ln UR_{t-1} + \beta_{7i} \ln FS_t + \beta_{8i} \ln WP_{t-1} \quad (14)$$

APP_{it} refers to the number of applications for each *i* college at each *t* time period. TUI_{it} is the price of tuition for each *i* college at each *t* time period. $FEES_{it}$ is the price of associated fees for each *i* college at each *t* time period. $4YR_t$ is the price of tuition at competitor four-year universities for time period *t*. $2YR_t$ is the price of tuition at competitor two-year universities for time period *t*. INC_{t-1} is the per capita disposable income lagged to time period *t-1*. UR_{t-1} is the unemployment rate lagged to time period *t-1*. FS_t is the federal discount rate lagged to time period *t-1*. WP_{t-1} is the wage premium lagged to time period *t-1*.

The model will be estimated for all eight colleges, yielding eight separate models. Elasticities will be the coefficients of each variable. Specifically, the OPE for each *i* college in the log-log model will be β_{1i}. Income elasticity for each *i* college will be the coefficients β_{5i}.

The model for the linear form will also include eight colleges (*i* = 1 to 8) and 13 years of data (*t* = 1 to 13) and is presented in Equation 15. The variables will have the same designations.

$$APP_{it} = a + \beta_{1i} TUI_{it} + \beta_{2i} FEES_{it} + \beta_{3i} 4YR_t + \beta_{4i} 2YR_t + \beta_{5i} INC_{t-1} + \beta_{6i} UR_{t-1} + \beta_{7i} FS_t + \beta_{8i} WP_{t-1} \quad (15)$$

The coefficients β_{1i} will be the proportionate changes in applications caused by a one unit change in tuition. For example, if $\beta_{12} = -.023$, then for a 1% increase in tuition, applications would decrease for college 1 by 2.3%. Similarly, β_{5i} will be the proportionate change in applications for college *i* with a one unit change in income.

Expected signs for the variables are given in Table 2. The signs on tuition and fees from State U should both be negative. As price of attendance rises, the law of demand says that the amount of attendance will drop. Both four-year and two-year school costs should have positive signs. These schools would be considered substitute goods for State U attendance. If the price of a good increases, the quantity demanded of a substitute will also increase, hence the positive sign. Income will have a positive sign because education is a normal good. Normal good's quantity demanded will increase when income goes up. Unemployment would generally yield a positive sign. Higher unemployment leads to more students attending college instead of joining the job market right out of high school. The interest rate variables should both be negative. The lower the interest rates, the more likely students are to attend school as they can get loans more easily. Wage premium should have a positive sign as the larger the premium received for graduating college, the more likely the student is to attend college.

Table 2

Expected Signs of Independent Variables

Independent Variable	Expected Sign
TUI	negative
FEES	negative
4YR	positive
2YR	positive
INC	positive
UR	positive
DIS	negative
TB	negative
WP	positive

Regression analysis was conducted using Simetar, an Excel Add-In developed at State University (Richardson, Schulmann, & Feldman, 2008). Simetar was developed by faculty at the Agriculture and Food Policy Center to provide simulation tools for studying policy changes on agribusinesses and has regression tools built into the system. Directed graphs were generated using WINTET, a Windows version of TETRAD III developed by researchers at Carnegie Mellon University for causal inference with the correlation matrix associated with a set of variables. (Scheines, et al., 1994).

Directed Acyclic Graphs

In order to reduce the model to an effective policy tool, directed graph analysis will be employed. A directed graph is a picture that represents causal flow between or among a set of variables. Letters are used to represent variables and lines (edges) with directional arrowheads at one end to represent causal flows. A graph with directed edges is called a directed graph (Haigh & Bessler, 2003). An acyclic graph has no path that leads away from a variable only to return to that same variable. For example, the path A→B→C→A is cyclic as it moves from A to B, then returns to A by way of C (Bessler, Wong, & Wongcharupan, 2003). Researchers at Carnegie Mellon University have created software useful for conducting causal flow inference using correlation matrices (Scheines, Sprites, Glymour, & Meek, 1994).

The software, marketed as TETRAD II, begins with a complete, undirected graph. Each variable is connected to the others with a line or edge. TETRAD II uses correlations and partial correlations to remove the edges if the correlations are not significantly different from zero. Any significance level can be used. This study included .005, .01, .05, .10, and .20 levels of significance. Due to the limited number of observations, it was decided to use the .20 level of significance. Edges that remain are then directed by assigning arrows in either direction using the conditions of d-separation as defined by Pearl (1995). Further explanation of the Directed Cyclical Graph methodology and procedures are discussed in Appendix A.

Those variables that have edges remaining, with or without direction, will be used to create a second model, called the policy model. This model should be more beneficial, due to lack of non-significant variables, to making policy decisions based on elasticity calculations. For each college, the complete model and the policy model will be compared using Adjusted R-squared. The models will have different numbers of independent (x) variables, thus the usual measure of R-squared will not suffice. Adjusted R-squared increases only when the corresponding increase in R-squared is greater than possible by chance. The formula for Adjusted R-squared is shown in Equation 16.

$$\textbf{Adjusted } \mathbf{R^2} = \mathbf{1 -} \frac{SS_{res}/df_e}{SS_{tot}/df_t} = \frac{VAR_{res}}{VAR_{tot}} \qquad (16)$$

The model, complete or policy, with the highest Adjusted R-squared will be used for the primary elasticity calculations.

If significant, the own-price elasticity, cross-price elasticity of State U and four-year colleges, cross-price elasticity of State U and two-year colleges, and income elasticity will be calculated for all eight colleges. For the log-log form, elasticities will be single values for each college over the time period of the data set. Own-price elasticity will be collected for each college. These measures will be applied to a basic simulation model that will determine the impact on each college's applications for various increases or decreases in tuition rates. Using current tuition rates and predicted increases, the simulation will find the effect on revenue for State U for the differing tuition increases or decreases.

Income elasticities will show if tuition is a normal, luxury good as expected. Cross-price elasticities will be calculated for both two-year and four-year competitor costs to provide validation that those variables are substitute goods for State U tuition. Elasticities for any other independent, significant variables will be the beta coefficients for each variable. This will be used to determine their marginal affects.

For the linear form, elasticities will be calculated for all eight colleges for all thirteen years. Once the model is specified and the coefficients on TUI_{it} (β_{1i}) determined, they become one half of the elasticity calculation as in Equation 17. An OPE can be calculated for each year.

$$\textbf{OPE} = \boldsymbol{\beta}_{1i} * \frac{TUI_{it}}{APP_{it}} \tag{17}$$

This will allow OPE changes over time for any college to be quantified.

Summary

The main objective of this study is to estimate demand for enrollment in different colleges at State U in order to provide more knowledge concerning tuition pricing. To do so, the researcher will develop a model using applications to the eight colleges at State U as the dependent variable with a series of cost and macroeconomic measures as explanatory variables. The model will be estimated in both log-log and log-linear functional forms to make a complete analysis. Own-price and income elasticities will be calculated from each model to determine the answers to the research questions listed previously. The researcher hopes to find differences in the OPE for each of the colleges. Differences would provide evidence that differential tuition rates for different colleges might generate more revenue for State U without hindering enrollment.

Limitations of the study include the lack of tiered income levels in the income variable. Breaking income into quartiles as in Kane (1994) would allow some inference on how tuition changes impact various socioeconomic groups. Secondly, the available data is smaller than is preferred. Only having 13 usable years of data could be considered a small sample size. The counter argument is that State U had state-mandated tuition up until 2004, so prior years would not have enough variance to provide much insight. Using average prices from two-year and four-year competitors could level out the results. While the model developed could be applied to more universities than State U, the specific elasticities are only applicable to State U.

Another limitation is that the different colleges that are modeled may have different competitor universities. For instance, State U's Business college may compete with West State U, while its Agriculture college competes with Central U. Further studies could be done to include this information, but it is beyond the scope of this research.

CHAPTER IV

RESULTS

The main objective of this study is to estimate demand for applications at each of eight colleges at State U. Estimations of demand will allow calculations of own-price elasticity, cross-price elasticity between State U and its four-year and two-year competitors, and income elasticity. Demand estimations will also allow forecasts for applications in coming years as well as revenue implications of policy decisions.

Complete Forecast Model

Least Square Regressions of the complete model were run for eight State U colleges: Agriculture and Life Sciences (AG), Architecture (AR), Business (BA), Education (ED), Engineering (EN), Geosciences (GE), Liberal Arts (LA), and Sciences (SC). Regressions were of two functional forms, linear and log-log. As reported in Chapter 3, tests for stationarity showed that the inclusion of a trend variable, Year, made each college's data stationary for the complete model. In the reports that follow, both the intercept and the trend variable were included in the results but left out of the interpretations as they do not provide insight into the study. This section will detail information about the complete model as a whole and then break down each college individually. While the complete model is useful in making forecasts, the lack of significant variables is troubling for elasticity calculations. The determination was made to reduce the model using correlations and the directed graphs methodology. This resulted in a policy model that is described in later sections.

The complete model in both linear and log-log form proved to be very good at predicting college applications. As shown in Table 3, R-squared for each college and each form was greater than .95. R-squared is the coefficient of determination and is the percentage of the variation in the applications of each college that is predicted by the x variables of the model. The formula used to calculate R-squared is shown in Equation 18.

$$\mathbf{R^2} = \mathbf{1} - \frac{\sum(\boldsymbol{y_i} - \boldsymbol{f_i})^2}{\sum(\boldsymbol{y_i} - \bar{\boldsymbol{y}})^2} = \frac{\boldsymbol{SS_{res}}}{\boldsymbol{SS_{tot}}} \tag{18}$$

R-squared is the residual sum of squares divided by the total sum of squares of the data. Thus each college’s applications, in both models, is over 95% explained by the eight explanatory or x variables used to create the model.

Table 3

R-squared for Linear and Log-Log Models for Eight Colleges

College	Linear Model	Log-Log Model
AG	0.992	0.999
AR	0.97	0.95
BA	0.985	0.942
ED	0.96	0.976
EN	0.993	0.992
GE	0.968	0.994
LA	0.96	0.966
SC	0.976	0.983

It is interesting to look at the differences among the colleges. AG and EN show the highest R-squared in both models, which combined with the coefficients and p-values obtained from those models and discussed in the next section, provide evidence for these models effectiveness in predicting applications in these colleges. While the other eight colleges do not have the same consistently high values, all are very high and justify the model as a predictor.

Statistical significance is used to determine if anything actually happened in a test or if the coefficients found differ from zero. The null hypothesis, H_O, of any test is the assumption that the coefficient equals zero or nothing happened. The alternative hypothesis, H_A, is the opposite, something in fact did occur or a value is found for the coefficient. The p-value of a test is the probability of observing an effect if the null is actually true. If the p-value is below a certain level, there is statistical evidence to reject the null. The level chosen is the significance level. Another way to describe the significance level is as the probability of rejecting the null if it is actually true. The lower the significance level, the less likely an event occurs by chance. For example, a significance level of .10 versus .20 would mean there is less of a chance that an APPS level predicted by the model happened at random, rather than be caused by variables that are significant at those levels.

While the model as a whole provides statistically significant predictions, the individual variables themselves are a different story. With eight colleges and eight variables, there are 64 total variables for the linear and log-log models to analyze. In the linear model, 13 of the 64 show some level of significance (Table 4). With the small sample size of the model, n = 13, it was decided to test significance levels at .10, .20, and .30 levels. These are indicated in Table 4.

Table 4

P-values for Eight Colleges Using Linear Complete Model

College	TUI	FEES	4YR	2YR	INC	UN	SLR	WP
AG	0.034***	0.041***	0.154**	0.048***	0.092***	0.681	0.794	0.451
AR	0.718	0.973	0.358	0.157**	0.696	0.172**	0.093***	0.882
BA	0.749	0.704	0.282*	0.313	0.62	0.444	0.55	0.663
ED	0.699	0.984	0.883	0.973	0.662	0.727	0.512	0.652
EN	0.208*	0.257*	0.367	0.482	0.979	0.789	0.624	0.671
GE	0.188**	0.905	0.331	0.479	0.864	0.996	0.224*	0.808
LA	0.974	0.763	0.826	0.991	0.828	0.867	0.553	0.72
SC	0.849	0.963	0.655	0.651	0.303	0.508	0.987	0.553

Note. *$p < .30$. **$p < .20$. ***$p < .10$

At the macro level, one of the colleges, AG, provided five of the significant variables, including three that were significant at the .05 level. Three colleges did not have a single significant variable at the .30 level, ED, LA, and SC. Tuition was the variable with the most significant results, three, while wage premium was the only variable that did not have a single significant value across all eight colleges. Wage premium was retained in the model due to the high R^2 value of the complete model.

Results differed using the log-log model (Table 5). Fourteen of the 64 variables were significant with seven coming from the AG model. Three colleges were without significant variables, BA, ED, and LA, while none of the variables had no significant results. The variable with the most significant values was INC, but two of those were only significant at the .30 level.

Table 5

P-values for Eight Colleges Using Log-Log Complete Model

College	TUI	FEES	4YR	2YR	INC	UN	SLR	WP
AG	0.005***	0.011***	0.004***	0.004***	0.038***	0.175**	0.627	0.028***
AR	0.751	0.745	0.873	0.464	0.924	0.296*	0.104**	0.902
BA	0.72	0.591	0.379	0.482	0.573	0.465	0.557	0.865
ED	0.652	0.474	0.709	0.432	0.929	0.713	0.624	0.938
EN	0.451	0.337	0.67	0.225	0.839	0.683	0.912	0.274*
GE	0.719	0.802	0.82	0.447	0.23*	0.464	0.146**	0.506
LA	0.578	0.659	0.68	0.934	0.715	0.93	0.521	0.558
SC	0.707	0.876	0.853	0.42	0.276	0.635	0.503	0.715

Note. $^{*}p < .30$. $^{**}p < .20$. $^{***}p < .10$

Agriculture and Life Sciences

The results of the models for the College of Agriculture and Life Sciences are found in Table 6. The College of Agriculture had the most significant variables in both the linear and log-log forms. It also had the highest R-squared for both models. The signs on TUI and FEES were negative as would be expected. Tuition and fees are costs associated with education and would negatively impact quantity variables such as applications. There were interesting results with regards to competitors. Four-year competitors had a positive sign, which is indicative of being a substitute good. That is what was expected for that variable. The three schools used to determine four-year cost are all major competitors for State U. However, the two-year competitors had a negative sign. This means that State U and its two-year competitors are actually compliments. While this does not follow logically, the presence of a large two-year school in the same city as State U resides in could factor into this relationship. The fact that all the TUI, FEES, 4YR, and 2YR variables were significant for the College of Agriculture means there is statistical evidence that those four variables affect applications.

Table 6

Regression Results for the College of Agriculture and Life Sciences Complete Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-2424087.26	515829.55	-761.44	56.59
TUI	-1.76***	0.47	-1.64***	0.22
FEES	-1.36***	0.39	-0.56***	0.10
4YR	0.89**	0.47	2.99***	0.37
2YR	-12.46***	3.84	-5.39***	0.64
INC	-0.18***	0.07	-1.6***	0.45
UR	-63.71	140.47	-0.22**	0.13
SLR	-23.47	82.16	-0.04	0.07
WP	-2776.30	3208.36	3.45***	0.86
Year	1220.44***	258.78	0.41***	0.03

Note. *$p < .30$. **$p < .20$. ***$p < .10$

The other four variables had several significant variables as well. Income, with a negative sign, was significant in both models. The formula used to calculate income elasticity (IE) for the linear model is shown in Equation 19. For the log-log model, the IE is read off as the coefficient for INC.

$$\mathbf{IE} = \frac{\partial\, Q_x}{\partial\, I} * \frac{I}{Q_x} \tag{19}$$

The first term is a derivative and is found by taking the coefficient on INC in the linear regression. The second term is income divided by quantity. Income is normally positive and quantity is always positive, therefore the second term is normally positive. The first term, the

coefficient in the regression, determines the sign of income elasticity. Positive IE is a normal good, negative is an inferior good, and positive that is greater than one is a luxury good.
The results show that the College of Agriculture is an inferior good for both models. As income rises, less applications will occur for the College of Agriculture.

While that result may surprise, data collected at State U show that the average starting salary for Agriculture graduates is one of the bottom three colleges and is only 66% that of the highest college, Engineering, and much less than Architecture, Business, Geosciences, and Science (State University, 2016c). As income rises, students matriculate to the higher earning colleges. Without stratified income data or income data for each individual college, further conclusions cannot be drawn.

Unemployment rate showed a negative coefficient and was significant in the log-log model. That is an odd result as theoretically as unemployment rises, college applications rise as well. The relationship between applications and the student loan rate was not significant in either model. Wage premium shows a negative coefficient in the linear model, but a positive coefficient in the log-log model. Wage premium in the linear model is not close to being significant, but in the log-log model it is significant at the .05 level. The relationship between wage premium and applications should be positive. The mixed results could be the result of the difficulty in finding information about wage premiums for most students. They could also result from a non-linear relationship due to the small sample size of 12 used for the study. A non-linear relationship would be represented by the log-log model but not by the linear model.

Architecture

The College of Architecture results are in Table 7. Five of the variables for Architecture in both models were significant at one of the three chosen levels. Most of the significant variables were in the macroeconomic set, with unemployment and the student loan rate being significant in both linear and log-log models. The signs of the coefficients showed several unexpected results. In the log-log model, the sign on tuition was positive. If that is correct, it would mean that as cost rises, applications for Architecture would rise. Also, the income coefficients in both models were negative, meaning Architecture is an inferior good. These two results conflict, however as none of those variables were significant, the reason could be lack of data. Fees and wage premium were not significant in either model.

Table 7

Regression Results for the College of Architecture Complete Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	147765.53	119416.05	175.48	220.49
TUI	-0.04	0.11	0.24	0.70
FEES	0.00	0.10	-0.14	0.39
4YR	0.15	0.14	0.19	1.12
2YR	1.48**	0.79	1.87	2.24
INC	-0.01	0.03	-0.20	1.93
UR	-82.08**	46.01	-0.67*	0.53
SLR	-55.05***	22.58	-0.54**	0.23
WP	224.12	1391.63	0.49	3.66
Year	-73.82	60.10	-0.09	0.12

Note. *$p < .30$. **$p < .20$. ***$p < .10$

Two-year and four-year competitors all had positive coefficients, indicating that for Architecture those competitors are substitutes, which was predicted. Two-year competitor cost was significant at the .20 level in the linear model. Equation 20 shows the cross-price elasticity (CPE) formula.

$$\textbf{CPE} = \frac{\partial Q_x}{\partial P_y} * \frac{P_y}{Q_x} \qquad (20)$$

Looking at the second term, price divided by quantity, prices and quantities can never be negative, therefore the entire second term must always be positive. This means the first half of the equation, $\frac{\partial Q_x}{\partial P_y}$, is all that is needed to determine substitutes, those goods with CPE greater than zero, versus complements, CPE less than zero. Quantity in this case is applications and price is two-year and four-year competitors. The coefficients of those variables are that first term and the signs of those coefficients can be used to determine substitutes versus complements. Since two-year and four-year costs have positive signs, those institutions are substitutes to State U's College of Architecture.

Business

The College of Business regression results are in Table 8. Only a single variable was significant for the College of Business and that was only at the .30 level. Even without significant variables, the signs of the coefficients can be interpreted for patterns.

Table 8

Regression Results for the College of Business Complete Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-67389.47	567272.24	-35.65	180.36
TUI	0.12	0.35	0.14	0.37
FEES	-0.19	0.46	-0.22	0.36
4YR	-0.93*	0.71	-1.17	1.14
2YR	5.62	4.64	1.78	2.23
INC	-0.05	0.10	-0.91	1.44
UR	-172.50	196.11	-0.40	0.47
SLR	-71.02	105.77	-0.14	0.22
WP	-3116.37	6472.95	-0.68	3.68
Year	37.33	283.78	0.03***	0.09

Note. *$p < .30$. **$p < .20$. ***$p < .10$

The signs for tuition were positive in both models. If these signs are correct, then the College of Business could have a demand that outpaces supply. However, since the variables are not significant, more data is needed. Equation 21 is the own-price elasticity (OPE) formula from the definitions in Chapter One.

$$E_D = \frac{\partial Q_x}{\partial P_x} * \frac{P_x}{Q_x} \qquad (21)$$

The second term contains price and quantity. As discussed in the Architecture section, price and quantity can never be negative, making the second term always positive. The sign of OPE is found from the derivative term. Quantity for this paper is the applications for each college, while price is the tuition rate. The sign of TUI in each regression gives the sign for OPE for each college.

One possible explanation for the positive signs on the tuition variable is that demand for the College of Business is increasing too fast for supply to respond. If demand and supply increase at the same rate, then the intersections of supply and demand will give a negative slope for the demand curve when studied with regression. However, what if a college does not have the space or resources to admit students as fast as they want to come in to the school? The result is a large increase in demand over time, with a very small supply increase. The supply and demand intersections would actually slope upward for the time period, giving a regression coefficient that is positive. Henry Moore, Yale Professor of Economics in the early 1900s, related this idea for the first time with an example about pig iron (Moore, 1914). [1]

The only significant variable was four-year competitor's costs in the linear model. The sign on the four-year costs variable was negative. That would indicate that State U's College of Business and its four-year competitors were complements. That result is unlikely in rational consumer's eyes. Two-year schools were substitutes, which is as predicted. The other variables were all far from being significant and while some of the signs were interesting, negative signs on wage premium and unemployment rate, the high p-values make discussion of those values difficult.

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[1] A less likely possibility is that of a Veblen Good. A Veblen good has a positive demand curve as well but for quality reasons. If a person assumes that a good is better because it is more expensive, then the demand for that good may increase. For example, luxury cars might see their demand actually rise when price reaches a certain point due to the prestige factor. It is far more likely that college education is a Veblen good rather than a Giffen good.

If the College of Business met these requirements it would lend credence to the idea of the Business College as a Veblen Good. State U's College of Business undergraduate program ranks in the top 20 in both Bloomberg Businessweek and U.S. News & World Report rankings, giving evidentiary support to the superior product idea (State University, 2016d). In truth, this is supposition since the variables are not significant in these models. More data is required for confirmation.

Education

The regression results for the College of Education are reported in Table 9. No variable was significant for the College of Education in either model except the trend variable. In fact in both models, most p-values were well above .5. Statistical interpretations of these results are unlikely to be beneficial as they show there is no evidence that any of the x variables actually predict College of Education applications.

Table 9

Regression Results for the College of Education Complete Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-571802.61	490908.52	-385.46	202.79
TUI	-0.39	0.92	0.54	1.09
FEES	0.01	0.50	0.38	0.47
4YR	-0.14	0.85	-0.66	1.60
2YR	-0.14	3.78	-2.25	2.48
INC	-0.05	0.10	0.17	1.79
UR	-81.60	212.65	0.23	0.58
SLR	-80.50	108.50	-0.15	0.27
WP	-3155.37	6323.28	-0.34	4.04
Year	289.38	246.07	0.20*	0.11

Note. *$p < .30$. **$p < .20$. ***$p < .10$

Engineering

The College of Engineering results are in Table 10. The College of Engineering at State U is ranked in the top 10 among public institutions and top 20 overall for engineering schools (State University, 2016e). Four variables, two from each model, were significant. Oddly, the two were different in each model. In the linear model, both TUI and FEES were significant. Even more perplexing, the signs were different for these two cost variables. The sign for tuition was positive. Similar to the discussion in the College of Business section, this indicates demand may be adjusting faster than supply.[2]

Table 10

Regression Results for the College of Engineering Complete Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-1482533.59	1029353.58	-342.6	114.71
TUI	1.93*	1.21	0.39	0.45
FEES	-1.28*	0.92	-0.25	0.22
4YR	-1.42	1.34	-0.3	0.64
2YR	-6.63	8.29	-2.02*	1.32
INC	-0.008	0.27	-0.26	1.18
UR	-136.98	468.34	-0.14	0.32
SLR	-119.49	219.74	0.016	0.13
WP	6229.32	13267.37	2.84*	2.13
Year	742.71	517.65	0.18*	0.06

Note. $*p < .30$. $**p < .20$. $***p < .10$

The significant, negative sign on fees is easier to explain. Fees are a cost and as costs rise, demand drops. However, why would one cost have a positive sign and the other negative? The best explanation is the relative smooth nature of FEES in the data set. While tuition for the College of Engineering rose 182.6% from 2003 to 2015, fees only rose 16.4% over the same period.

[2] The College of Engineering might be even more suited to be called a Veblen Good than the College of Business. It is ranked as highly as the College of Business, but lacks competitors among the major four-year competitor schools in the state. State U's College of Engineering is the main campus to secure an Engineering degree in the entire state. These facts lend credence to the idea of the College of Engineering having a positive sloping demand curve.

Both two-year and four-year costs were negative in all models, making those competitors complements for Engineering. As there is no real alternative for students pursuing engineering degrees in the state, this makes sense. The macro variables were for the most part highly insignificant, but the wage premium was significant in the log-log model and showed a positive sign in both models. A higher-earning degree like engineering would appeal to students when the premium between high-school degree earners and college-degree earners becomes larger.

Geosciences

The College of Geosciences is the smallest at State U with 159 applicants in 2003 up to 530 in 2013. Geosciences showed four significant variables, with two from each model (Table 11). The student loan rate was significant in both models and had a negative sign. This is an expected sign for as the loan rate increases, applications would be expected to decrease. Tuition is significant in the linear model and is negative, which is the expected sign. However, in the log-log model it turns positive, while being non-significant.

Table 11

Regression Results for the College of Geosciences Complete Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-101072.74	71763.65	-184.62	170.91
TUI	-0.17**	0.10	0.31	0.78
FEES	-0.007	0.06	0.09	0.33
4YR	0.1	0.09	0.29	1.18
2YR	-0.39	0.48	-1.66	1.90
INC	0.0024	0.01	2.11*	1.40
UR	-0.14	23.60	0.35	0.41
SLR	-19.87*	13.01	-0.41**	0.21
WP	200.86	756.64	2.25	2.98
Year	50.56*	36.07	0.087	0.09

Note. *$p < .30$. **$p < .20$. ***$p < .10$

Income is significant in the log-log model. Using the properties of the log-log model, where the coefficients are the elasticities without the need for calculation, the coefficient of 2.11 indicates that the College of Geosciences is a normal, luxury good. It is positive, making it a normal good, and it is greater than 1, which qualifies it as a luxury good. The practical applications of a geosciences degree, mainly working in the oil and gas sector, could be the cause of this outcome. The oil and gas sector is cyclical and the time period of this data included a big upswing in the oil and gas market. The lure of high paying jobs in peak times might cause students to pick the College of Geosciences during those times and avoid it during lulls. This is somewhat confirmed by the coefficients on wage premium. In both models they are relatively large, positive numbers. However, the utility of those numbers is constrained by the lack of statistical significance.

Liberal Arts

The regression results for the College of Liberal Arts are shown in Table 12. Like the College of Education, there are no significant variables in either model and none have a p-value lower than .5. Statistical interpretations of these results are unlikely to be beneficial as they show there is no evidence that any of the x variables actually cause College of Liberal Arts applications.

Table 12

Regression Results for the College of Liberal Arts Complete Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-220482.81	519761.24	-55.11	142.77
TUI	0.03	0.75	0.41	0.66
FEES	-0.14	0.42	-0.14	0.28
4YR	-0.16	0.65	-0.46	1.00
2YR	-0.04	3.53	-0.14	1.60
INC	0.02	0.09	0.47	1.18
UR	-31.18	171.56	-0.03	0.35
SLR	-63.34	95.20	-0.13	0.18
WP	2165.27	5499.45	1.65	2.52
Year	110.18	261.19	0.03	0.08

Note. *$*p < .30$. $**p < .20$. $***p < .10$*

Sciences

The final college is Sciences (Table 13). Only one variable was significant for sciences, income in the log-log model, but income in the linear model was very nearly a second. In both instances the sign on income was positive, which is expected. Using the log-log model, the income elasticity can be determined as 1.94. That would place the College of Sciences in the same category as Geosciences, as a normal, luxury good. Many scholars would claim that all higher education would be normal, luxury goods, so this result is not unexpected. What is unexpected is that only two of the eight colleges showed this result.

Table 13

Regression Results for the College of Sciences Complete Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	639364.59	837458.67	225.54	177.98
TUI	-0.25	1.19	0.33	0.81
FEES	-0.03	0.66	-0.06	0.34
4YR	0.51	1.03	-0.25	1.23
2YR	2.82	5.63	1.85	1.98
INC	0.18	0.15	1.94*	1.46
UR	206.39	275.48	0.23	0.43
SLR	2.65	151.94	-0.17	0.22
WP	5883.67	8831.43	1.25	3.11
Year	-326.31	420.90	-.13*	0.09

Note. *$p < .30$. **$p < .20$. ***$p < .10$

Conclusion

The complete model demonstrated very high R-squared values, indicating its fitness for prediction, and had several significant variables at key, expected locations. There were numerous anomalies including why the College of Agriculture and Life Sciences had a high percentage of significant variables and the propensity of the colleges to be inferior goods. These factors limit the use of the complete forecast model as a policy tool. A reduced model was determined using directed graph principles in order to assist policymakers and lawmakers to a greater extent.

Policy Model

The complete model was reduced to a policy model through the Directed Graph procedure. Correlation matrices were collected for each college. These matrices are presented in Appendix B. The matrices were fed into the TETRAD II program and that program removed edges that did not have statistically significant correlations and partial correlations at the .20 level. The results of the TETRAD II are shown in Table 14.

The TETRAD results show that several variables have little or no causal influence on applications. For TETRAD purposes applications was X1. FEES, INC, UN, and SLR had no statistically significant correlations with applications. Therefore, the decision was made to remove those four variables from the policy model. Wage premium (X9) was an indicator of applications for one of the eight colleges, Sciences. It was decided to remove wage premium from the policy model despite this result. The lack of confidence in the wage premium variable was the deciding factor. Without differing premiums for each college, there is a lack of data that relates at the college level. The presence of a directed edge gives credence to the idea that wage premium does affect application decisions, but more data is needed.

The TETRAD results leave TUI, 4YR, and 2YR as the only variables in the policy model. Even though all three variables were not given edges for every college, all were left in the policy model for each college. Each of those three showed some relationship between themselves and applications. Both TUI and 2YR showed a directed edge on at least one college. That is enough evidence for inclusion if taken with the lack of observations in the data. The directed acyclic graphs for each of the eight colleges are shown in Appendix C.

Table 14

TETRAD II Results for Eight Colleges

.20 SL	AG	AR	ED	EN	GE	LA	BA	SC
X2 (TUI)	-- X4		-- X4	→X1	-- X4	→X4	-- X4	→X4
X3 (FEES)								
X4 (4YR)	-- X5	-- X5	-- X5	-- X5	-- X5		→X5	
X5 (2YR)	→X1	→X1	→X1		→X1 ; → X4	→X1 ; → X4		→X1 ; → X4
X6 (INC)								
X7 (UN)	**	**	**	**	**	**	**	**
X8 (SLR)								
X9 (WP)								→X1

Notes.** X7 -- X8, X7 -- X9

As shown above, directed graph analysis led to the reduction of the model to three x variables, tuition (TUI), four-year competitors (4YR), and two-year competitors (2YR). Regressions were then run with those three x variables and the eight college's applications as the dependent variable. R-squared values obtained from the regressions are shown in Table 15. As with the complete model, R-squared values are high. However, R-squared values cannot be compared across models of different sizes. R-squared will automatically increase in value with the inclusion of any variable, significant or random. Simply increasing the size of the model will make R-squared increase and make a model look like a better predictor.

Table 15

R-squared Results for Policy Model

College	Linear Model	Log-Log Model
AG	0.922	0.983
AR	0.878	0.854
BA	0.924	0.916
ED	0.942	0.962
EN	0.97	0.986
GE	0.982	0.968
LA	0.959	0.949
SC	0.948	0.964

Comparing two models that have different sizes, different numbers of x variables, requires comparing the Adjusted R-squared. Table 16 shows the Adjusted R-squared values for both linear and log-log and both the complete and policy models. The comparisons need to be made between the complete and policy model for each of the linear and log-log format. Values that are bolded were higher for that particular model. For the majority of the colleges, the policy model had a higher adjusted R-squared, meaning the policy model is better for analysis. For the AG, AR, and GE colleges, the complete model was better in at least one form. For this reason, elasticity calculations will include the complete and policy models for those three colleges. For the other five, only the policy model is included in elasticity calculations.

Table 16

Adjusted R-squared Values for Complete and Policy Models

	Complete Model		Policy Model	
College	Linear Model	L-L Model	Linear Model	L-L Model
AG	0.967*	0.997*	0.883	0.974
AR	0.88*	0.802*	0.817	0.781
BA	0.84	0.768	0.885*	0.873*
ED	0.84	0.903	0.913*	0.942*
EN	0.939	0.966	0.955*	0.979*
GE	0.972	0.975*	0.973*	0.953
LA	0.871	0.862	0.939*	0.924*
SC	0.903	0.931	0.922*	0.945*

Notes. *Higher Adjusted R^2

In both the linear and log-log models for the reduced, policy model, there were a much greater percentage of significant variables. In the linear model, 12 variables out of 24 were significant (Table 17). The log-log model had 10 out of 24 significant (Table 18). That means 46% of the variables were significant in the reduced model, while only 21% (27 out of 128) were significant in the complete model. All three variables were significant for multiple colleges. Only one college lacked a significant variable in either model, Liberal Arts, and Education did not have one in the log-log model.

Table 17

P-values for Linear Policy Model

College	TUI	4YR	2YR
AG	0.159**	0.369	0.39
AR	0.725	0.402	0.244*
BA	0.715	0.018***	0.92
ED	0.613	0.185**	0.796
EN	0.033***	0.006***	0.2**
GE	0.005***	0.259*	0.872
LA	0.325	0.548	0.988
SC	0.129**	0.11**	0.22**

Note. *$p < .30$. **$p < .20$. ***$p < .10$

Table 18

P-values for Log-log Policy Model

College	TUI	4YR	2YR
AG	0.006***	0.13**	0.031***
AR	0.772	0.646	0.545
BA	0.733	0.091***	0.966
ED	0.646	0.846	0.592
EN	0.243*	0.204*	0.02***
GE	0.102**	0.578	0.464
LA	0.845	0.587	0.592
SC	0.287*	0.728	0.03***

Note. *$p < .30$. **$p < .20$. ***$p < .10$

Agriculture and Life Sciences

The results of the regression run on the policy model for the College of Agriculture and Life Sciences are shown in Table 19. Tuition was significant in both the linear and log-log models and had the expected negative sign in both. Four-year and two-year competitors were significant in the log-log model. In that model, four-year schools had a positive value, meaning they are substitutes. Two-year schools had a negative value, indicating complements. Both ideas make sense relative to the conditions of State U. The College of Agriculture is large at State U, but there are other colleges in the state that provide competition. The college has over thirty degree programs which also increase the amount of potential substitutes.

Table 19

Regression Results for College of Agriculture Policy Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-1237465.78	497792.57	-560.40	96.61
TUI	-0.98**	0.63	-1.6***	0.43
4YR	-0.56	0.59	1.44**	0.85
2YR	-3.47	3.82	-3.0031***	1.15
Year	620.89**	249.96	0.29***	0.05

Note. $^*p < .30$. $^{**}p < .20$. $^{***}p < .10$

Two-year schools would generally be considered substitutes for State U as well. However, the presence of a large, reputable two-year college in the same town as State U makes it possible to justify the results as complements. Many students attend the two-year college for one to four semesters because it is cheaper than State U and they can still enjoy the atmosphere that goes along with being a part of State U. The university also has partnership agreements with the local junior college in order to allow some students not initially accepted into State U the opportunity to apply at a later date. The behavior pattern of the two schools indicates a complementary role in higher education between the two; a pattern that is backed up by the data for the College of Agriculture.

Elasticity calculations for own-price elasticity (OPE), cross-price elasticity between State U and four-year competitors (CPE4), and cross-price elasticity between State U and two-year colleges (CPE2) were made in several ways. The log-log model allows elasticity to be calculated as the estimated percent change in the dependent variable for a percent change in the independent variable. This measure is the elasticity over the entire time period of the data set. The College of Agriculture had a higher adjusted R-square value for the complete model, therefore elasticity was found for both the complete and policy model (Table 20).

Table 20

Log-log Form Elasticities for College of Agriculture Models

	OPE	CPE4	CPE2
Complete	-1.637	2.99	-5.387
Policy	-1.600	1.44	-3.003

Since most OPE are negative, taking the absolute value allows interpretation. Recall from the definitions in Chapter One, if the absolute value is greater than 1 that is called an elastic good. If the absolute value is less than 1, it is an inelastic good. If the elasticity has an absolute value of greater than 1, then the numerator of the equation is greater than the denominator. OPE is percent change in quantity of percent change in price. If that value is greater than 1, then if price increases by 1%, quantity must decrease by greater than 1%, decreasing revenue. In order to increase revenue, price must drop. The opposite is true for an inelastic good.

OPE for the complete model was -1.637, making it an elastic good and meaning a 1% increase in the cost of tuition for the College of Agriculture would result in a 1.637% decrease in the number of applications. The policy model gives the OPE as -1.6, making it an inelastic good and resulting in a 1% increase in the cost of tuition causing a 1.6% drop in applications. The two models give similar results, calling the College of Agriculture an elastic good. Thus lowering tuition would generate more applications and more revenue.

The elasticities can also be calculated for the linear model. There is a difference. These elasticities can be calculated for each year. They must be calculated using the OPE formula given in Equation 22

$$\mathbf{OPE} = \frac{\partial Q_x}{\partial P_x} * \frac{P_x}{Q_x} \tag{22}$$

The coefficients, the first term, will be the same for every year, while the tuition cost and applications change every year. The results for the complete model and policy model are shown in Tables 21 and 22, respectively. They provide more clarity. Every OPE in the complete model has an absolute value greater than 1. They are all elastic. The policy model shows similar results, all years but one are elastic. Again, this indicates that the College of Agriculture is an elastic good and to lower costs would increase applications and increase revenue.

Table 21

Elasticities for College of Agriculture Linear Complete Model

Year	OPE	CPE4	CPE2
2003	-2.683	2.457	-9.498
2004	-3.508	3.048	-10.14
2005	-3.792	2.992	-10.392
2006	-4.451	3.743	-12.41
2007	-3.829	3.137	-10.471
2008	-3.671	2.978	-10.124
2009	-3.52	2.883	-9.877
2010	-3.31	2.787	-9.605
2011	-2.618	2.332	-8.479
2012	-2.674	2.451	-9.155
2013	-1.73	1.653	-5.971
2014	-2.236	1.798	-6.562
2015	-2.101	1.666	-6.221

Table 22

Elasticities for College of Agriculture Linear Policy Model

Year	OPE	CPE4	CPE2
2003	-1.471	-1.527	-2.59
2004	-1.942	-1.913	-2.792
2005	-2.251	-2.014	-3.068
2006	-2.205	-2.102	-3.058
2007	-2.266	-2.105	-3.081
2008	-2.077	-1.91	-2.849
2009	-2.021	-1.877	-2.821
2010	-1.86	-1.775	-2.684
2011	-1.544	-1.56	-2.488
2012	-1.465	-1.522	-2.494
2013	-0.975	-1.056	-1.673
2014	-1.193	-1.088	-1.741
2015	-1.202	-1.081	-1.771

Tables 21 and 22 also show how the OPE changes over time. Both spike in the 2005-2007 range and start to drop. Perhaps this is a result of the increase in tuition in some of the other colleges at State U. If the College of Engineering increases tuition, Agriculture has become relatively cheaper, pushing OPE closer to 1. That time period also corresponds to the last large increase in farm commodity prices. Higher prices certainly could have increased demand for jobs in the agriculture sector, boosting demand for the degree.

The two models differ in regards to their CPE4 valuations. The complete model has positive values, substitutes, in both the linear and log-log formats, while the policy model has negative values, complements. As the complete model does have a higher Adjusted R-squared and the 4YR variable is significant in both the complete model formats, evidence is greater that the College of Agriculture is substitutes with its four-year competition.

The models have similar results for CPE2, only differing in magnitude. All four models place the College of Agriculture and the two-year colleges as complements. Anecdotal evidence suggests that the College of Agriculture has a higher percentage of transfer students than the other State U Colleges. This would lead to a complementary relationship for the two entities.

Architecture

The results of the policy model regression for the College of Architecture are in Table 23. Contrary to the results in the complete model, only a single variable, linear model 2YR, is significant. This limits the impact of the policy model in this case.

Table 23

Regression Results for College of Architecture Policy Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-6658.63	71.14	-44.22	143.23
TUI	-0.03	0.21	-0.15	0.50
4YR	-0.09	0.56	-0.43	0.90
2YR	0.82*	0.81	0.93	1.47
Year	3.42	0.04	0.02	0.08

Note. **p < .30. **p < .20. ***p < .10*

As with Agriculture the complete model gave higher Adjusted R-squared values and had more significant variables. Therefore, elasticity calculations were obtained for both the complete and policy models. The calculation for the log-log forms is given in Table 24.

Table 24

Log-log Form Elasticities for College of Architecture Models

	OPE	CPE4	CPE2
Complete	0.244	0.194	1.87
Policy	-0.149	-0.429	0.931

The policy value for OPE has Architecture as an inelastic good. The complete model log-log form actually shows Architecture with a positive OPE. As tuition costs rise, applications rise as well. Calculated values for the linear complete model in Table 25 give similar results to the policy model in both log-log and linear. All values are between -.12 and -.22. The very consistent results help place Architecture as an inelastic product. If State U were to raise tuition prices in the College of Architecture, applications would fall a small amount, but revenue would rise a much larger percentage.

In both the log-log and linear models, CPE4 and CPE2 are positive for the complete model. Both four-year and two-year schools act as substitutes for the College of Architecture. This is consistent with the predictions made in Chapter Three. It is also consistent with the idea of competition between higher education entities and the lack of prestige and recognition of State U's College of Architecture.

Table 25

Elasticities for College of Architecture Linear Complete Model

Year	OPE	CPE4	CPE2
2003	-0.126	0.807	2.183
2004	-0.156	0.945	2.198
2005	-0.193	1.063	2.584
2006	-0.201	1.178	2.734
2007	-0.201	1.15	2.684
2008	-0.176	0.995	2.368
2009	-0.185	1.058	2.537
2010	-0.217	1.272	3.068
2011	-0.18	1.04	2.647
2012	-0.169	1.001	2.616
2013	-0.162	1.005	2.541
2014	-0.218	1.053	2.688
2015	-0.218	1.041	2.721

Business

The regression results for the College of Business are reported in Table 26. The College of Business results had a higher Adjusted R-square for both the log-log and linear models in the policy model than in the complete model. Elasticities were calculated only using the policy model. There was only a single significant variable in each model, outside of the trend, 4YR. In both cases it was significant at the .10 level. The coefficients for 4YR in both forms of model are negative. The College of Business functions as a complement to other four-year schools in the state. This is an interesting result and probably comes from the removal of legislative controls for tuition in 2004-2005. All four-year schools were allowed to set their tuition rates and the numbers have dramatically increased for all.

Table 26

Regression Results for College of Business Policy Model

	Linear Model		Log-Log Model	
	B	SE B	B	SE B
Intercept	-726861.71	283036.61	-175.77	71.14
TUI	-0.09	0.24	0.07	0.21
4YR	-1.19***	0.40	-1.08***	0.56
2YR	0.24	2.26	-0.035	0.81
Year	365.59***	142.09	0.1***	0.04

Note. *$p < .30$. **$p < .20$. ***$p < .10$

For both models, TUI and 2YR were far from significant. Given the limits of the data set, there is hesitation to draw conclusions from those two variables. In the case of both tuition and two-year competitors, the signs switch from one model to the next. This indicates that either the true value is close to zero for each or there is not enough data to determine the true relationship. In the case of tuition, if the value is close to zero, that provides insight. A very small coefficient in the log-log model means a highly inelastic product. This is confirmed by looking at Table 27 which has the linear elasticity calculations. The OPE calculations are all between -.05 and -.12. While there is not enough statistical evidence to say for certain that the College of Business is an inelastic good, that conclusion is somewhat supported by the evidence. The College of Business has led the way in differential tuition at State U and it will require more data to confirm that this was the proper policy.

Table 27

Elasticities for College of Business Linear Policy Model

Year	OPE	CPE4	CPE2
2003	-0.054	-1.293	0.07
2004	-0.076	-1.725	0.081
2005	-0.073	-1.506	0.074
2006	-0.09	-1.975	0.092
2007	-0.096	-2.058	0.097
2008	-0.108	-1.835	0.088
2009	-0.108	-1.883	0.091
2010	-0.119	-2.136	0.104
2011	-0.101	-2.039	0.104
2012	-0.09	-1.88	0.099
2013	-0.088	-1.9	0.097
2014	-0.097	-1.87	0.096
2015	-0.085	-1.627	0.086

Education

In the complete model, the College of Education was one of the colleges that had no significant variables. While the policy model for Education does not have many significant variables, the 4YR variable is significant in the linear model and the trend variable is significant. All coefficient values for Education are negative (Table 28). The signs on TUI would agree with economic theory. However, those on 4YR and 2YR relate that the College of Education would be complements with its four-year and two-year competitors. Under ordinary circumstances, that would seem illogical. As with several other colleges, it could be argued that two-year schools are complements to State U due to the proximity of a junior college and the partnerships that exist between State U and that junior college. It is harder to argue that the College of Education is a complement to its four-year competition.

Table 28

Regression Results for College of Education Policy Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-622517.03	282769.36	-278.85	103.00
TUI	-0.27	0.51	-0.3	0.62
4YR	-0.57**	0.39	-0.21	1.03
2YR	-0.54	2.03	-0.65	1.17
Year	312.39***	141.96	0.15***	0.05

Note. *$p < .30$. **$p < .20$. ***$p < .10$

Elasticities from the log-log model show a -.30 OPE. Results from the linear model, shown below in Table 29, are similar. The value of OPE for Education does not change much over time and is inelastic. This would place Education in the position of raising tuition costs to generate more revenue. Again, the lack of significance of the TUI variable prevents these statements from being more conclusive, but the data does provide evidence that the option to increase Education tuition costs should be considered.

Table 29

Elasticities for College of Education Linear Policy Model

Year	OPE	CPE4	CPE2
2003	-0.38	-1.466	-0.385
2004	-0.483	-1.768	-0.4
2005	-0.464	-1.543	-0.365
2006	-0.553	-1.961	-0.442
2007	-0.544	-1.878	-0.426
2008	-0.544	-1.859	-0.43
2009	-0.478	-1.65	-0.384
2010	-0.48	-1.705	-0.399
2011	-0.403	-1.515	-0.375
2012	-0.476	-1.653	-0.42
2013	-0.364	-1.318	-0.324
2014	-0.401	-1.315	-0.326
2015	-0.359	-1.191	-0.302

Engineering

In the complete model studied earlier, the College of Engineering at State U had four significant variables, but all were only significant at the .30 level. Engineering is the college that gains the most from switching to the policy model. All six variables are now significant at one of the three levels (Table 30). Every coefficient can be interpreted with confidence as there is statistical evidence that those coefficients are different than zero and that the sign if correct. The TUI coefficient is positive for both the linear and log-log models. As discussed in the complete model section on the College of Business, a positive coefficient on TUI would be a sign of a that demand is changing faster than supply. This could result in a positive sloped demand curve, meaning as costs rise, demand also rises. The complete model also had Engineering with a positive demand over the time period of this data set, thus the policy model is more evidence that Moore's problem many exist here (Moore, 1914).

Table 30

Regression Results for College of Engineering Policy Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-1933883.72	600456.75	-325.58	56.16
TUI	1.61***	0.62	0.3*	0.24
4YR	-2.61***	0.69	-0.51*	0.37
2YR	-5.41**	3.87	-1.62***	0.56
Year	971.29***	301.42	0.17***	0.03

Note. **p* < .30. ***p* < .20. ****p* < .10

OPE can be found by looking at the coefficient on TUI in the log-log model, which is .30. Table 31 has the linear model elasticities, which show an OPE of .61 to .93. To increase revenue for a Engineering, price or in this case cost can be increased. The College of Engineering at State U is a prime candidate for increased differential tuition. The data says that increasing tuition would generate more revenue, but would not have the side effect inherent in inelastic goods of decreasing applications.

The 4YR and 2YR coefficients for both models are negative. Engineering and its four-year competitors are complements, as are Engineering and its two-year competitors. While this seems counterintuitive, the circumstances surrounding the College of Engineering at State U support the argument. State U has the only major College of Engineering in the state and thus attracts most of the in-state students interesting in Engineering. The College is also well renowned world-wide and attracts out-of-state and international students in great numbers. Many students use the local junior college as an entry point, taking core curriculum classes prior to transferring to the College of Engineering. The argument that these schools are complements to the College of Engineering is strong and is backed up by the data.

Table 31

Elasticities for College of Engineering Linear Policy Model

Year	OPE	CPE4	CPE2
2003	0.608	-1.791	-1.02
2004	0.83	-2.319	-1.136
2005	0.848	-2.151	-1.101
2006	0.808	-2.182	-1.066
2007	0.895	-2.357	-1.159
2008	0.827	-2.155	-1.079
2009	0.839	-2.21	-1.115
2010	0.824	-2.23	-1.132
2011	0.93	-2.312	-1.239
2012	0.87	-2.227	-1.226
2013	0.748	-1.996	-1.062
2014	0.746	-1.63	-0.876
2015	0.737	-1.591	-0.875

Geosciences

The regression results for the College of Geosciences are shown in Table 32. Geosciences were the one college that was split on whether the complete or policy model was better. The Adjusted R-squared was higher for the log-log model in the complete form of the model, but higher for the linear model in the policy form. In both types of model for the policy, TUI was significant and had a negative sign. This is an expected sign, having a downward sloping demand curve.

Table 32

Regression Results for College of Geosciences Policy Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-105544.46	44843.49	-128.36	133.25
TUI	-0.27***	0.07	-1.28**	0.69
4YR	0.079*	0.06	0.78	1.35
2YR	-0.061	0.37	1.27	1.65
Year	52.89***	22.52	0.064	0.07

Note. $*p < .30$. $**p < .20$. $***p < .10$

Table 33

Log-log Form Elasticities for College of Geosciences Models

	OPE	CPE4	CPE2
Complete	0.306	0.292	-1.66
Policy	-1.28	0.783	1.267

The OPE for Geosciences is problematic. The complete model was the better model to use when looking at the log-log design and the OPE is the coefficient which was .31 (Table 33). This would seem to suggest that Geosciences has a positive demand, like Engineering and Business. However, Table 34 gives the elasticity calculations for the linear, policy model and all the OPE are negative. In fact the absolute value of each is greater than 1, which indicates an elastic good. These results are diametrically opposed. One says to raise price, Giffen, while the other says to lower price, elastic. The only statistical support is the fact that while the log-log model Adjusted R-squared was higher in the complete versus policy model, the variable TUI in the complete model was not significant. If that evidence is considered, then the -1.28 elasticity from the log-log policy model may be a truer indicator of the elasticity of Geosciences. However, more data is necessary in order to confirm this hypothesis.

Table 34

Elasticities for College of Geosciences Linear Policy Model

Year	OPE	CPE4	CPE2
2003	-2.329	1.239	-0.265
2004	-2.866	1.447	-0.266
2005	-3.187	1.461	-0.281
2006	-3.642	1.779	-0.326
2007	-3.339	1.589	-0.293
2008	-2.869	1.352	-0.254
2009	-2.359	1.122	-0.213
2010	-2.134	1.044	-0.199
2011	-1.781	0.922	-0.185
2012	-1.633	0.87	-0.18
2013	-1.341	0.744	-0.149
2014	-1.768	0.857	-0.173
2015	-1.775	0.848	-0.175

Regarding the 4YR and 2YR variables, only the 4YR on the linear model is significant. The signs for three of the four variables are positive, indicating substitutes, as predicted, but the lack of significance hinders drawing any conclusions.

Liberal Arts

The results of the regression involving the College of Liberal Arts and the policy model are in Table 35. The College of Liberal Arts is the only college to not have a single significant variable in the policy model. This is not surprising as it did not have any significant variables in the complete model either. There are several possibilities as to why this occurred. More data could be needed to find a relationship or no true relationship could exist. It is conceivable that the College of Liberal Arts is made of such a diverse group of degrees, ranging from French to Music to Economics that studying the College as a whole will not be beneficial. Detailed study of each major may be required.

Table 35

Regression Results for College of Liberal Arts Policy Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	-414979.29	226668.74	-69.52	59.60
TUI	-0.38	0.36	-0.064	0.32
4YR	-0.21	0.34	-0.35	0.62
2YR	-0.029	1.89	0.41	0.74
Year	208.88**	113.83	0.039*	0.03

Note. $*p < .30$. $**p < .20$. $***p < .10$

Table 36

Elasticities for College of Liberal Arts Linear Policy Model

Year	OPE	CPE4	CPE2
2003	-0.231	-0.235	-0.009
2004	-0.306	-0.295	-0.01
2005	-0.31	-0.271	-0.009
2006	-0.353	-0.329	-0.011
2007	-0.38	-0.345	-0.011
2008	-0.351	-0.315	-0.01
2009	-0.337	-0.306	-0.01
2010	-0.351	-0.328	-0.011
2011	-0.331	-0.327	-0.012
2012	-0.314	-0.319	-0.012
2013	-0.289	-0.306	-0.011
2014	-0.349	-0.325	-0.012
2015	-0.335	-0.307	-0.011

The elasticity calculations for the College of Liberal Arts are shown in Table 36.

Sciences

The results for the College of Sciences are shown in Table 37. Like Engineering, Sciences shows the great improvement in moving from the complete to the policy model. Whereas in the complete model, there was only one significant variable for Sciences, there are now five. TUI is significant and negative for both linear and log-log forms. Again, this is consistent with economic theory and will provide negative OPE as expected. In the log-log model, the OPE is decidedly inelastic, -.53. However, when looking at the linear model and the elasticity over time, the College of Sciences' OPE varies from -.75 to -1.25 (Table 38). More recent calculations show Sciences very close to -1 or a unit elastic interpretation. A value of OPE close to -1 is ideal and it appears that the College of Sciences is operating at that level. Looking at the log-log only, one might say costs can be raised with no issues. However with the split decision, a small tuition increase is acceptable. That would also generate more evidence to adjust the tuition in the future.

Table 37

Regression Results for College of Sciences Policy Model

	Linear Model		Log-Log Model	
	B	*SE B*	*B*	*SE B*
Intercept	456779.19	477871.12	177.15	88.78
TUI	-1.26**	0.74	-0.53*	0.46
4YR	1.25**	0.69	0.32	0.90
2YR	5.24*	3.93	2.88***	1.10
Year	-229.57	239.97	-0.093***	0.05

Note. $^{*}p < .30$. $^{**}p < .20$. $^{***}p < .10$

The coefficients for 4YR and 2YR are all positive with three being significant. This is solid evidence that four-year and two-year colleges are substitutes for the College of Sciences. Every one of State U’s major competitors has a College of Sciences or teaches science courses, so it stands to reason that these institutions would function as substitutes.

Table 38

Elasticities for College of Sciences Linear Policy Model

Year	OPE	CPE4	CPE2
2003	-0.888	1.593	1.842
2004	-1.104	1.88	1.87
2005	-1.172	1.812	1.883
2006	-1.252	2.063	2.047
2007	-1.202	1.93	1.926
2008	-1.108	1.761	1.791
2009	-1.012	1.624	1.665
2010	-0.981	1.618	1.668
2011	-0.854	1.49	1.621
2012	-0.754	1.354	1.513
2013	-0.771	1.443	1.559
2014	-1.071	1.753	1.913
2015	-1.077	1.738	1.941

Conclusion

The policy model resulted in a higher percentage of significant variables. It was also a better model, based on R-squared, in a majority of the colleges than was the complete model. This allowed more precise elasticity calculations to be made. For the eight colleges, there was statistical evidence to find two to be elastic, Agriculture and Geosciences. Taken solely as an economic question, those two colleges would benefit from lowering tuition costs. They would see an uptick in applications and likely enrollments, while also increasing their revenue.

Statistical evidence was found to state Engineering has a positive demand. While this is unlikely to be true over the long term, it is likely to be at least very inelastic. Engineering would benefit from an increase in tuition. Revenues would rise and if it is truly has a positive demand, applications would rise as well. If it proves to be inelastic, applications would fall as revenue increases, but at a much smaller percentage.

The College of Sciences has statistical support to being a unit elastic good. Its OPE in years 2014-15 was calculated as close to -1 and all observations were within 25% of -1. The evidence leads to the idea that Sciences is priced correctly. Elasticity should of course be monitored, but tuition should not be changed drastically.

Three colleges, Architecture, Business, and Education, were found to be inelastic, but did not have significant variables for tuition. However, in each case, there was some evidence that suggests the inelastic classification is correct. All three colleges stand to benefit from increasing tuition. Revenues would increase and while applications and enrollments would drop, the percentage drop would be less than the percentage increase in tuition. Without statistical significance a stronger statement cannot be made, but it seems likely that those three colleges are inelastic.

The last college, Liberal Arts, is extremely hard to read. The elasticities calculated suggest it is inelastic, but none of the variables are significant and there is no additional information that leads to that opinion. Suggesting raising tuition would be a simple guess in the case of Liberal Arts and conclusions need to wait on more information.

CHAPTER V

IMPLICATIONS AND CONCLUSIONS

The implications section provides a summary of the results, including answers to the paper's nine research questions. A conclusion follows stating the implications of the study both from an economic and access perspective. Limitations and future research end the chapter.

Summary

Two types of models were created. The first was the complete model with all eight variables included, while the second used Directed Graphs to remove variables that did not have statistically significant correlations. Both linear and log-log functional forms were used in both cases.

In the complete model, both functional forms showed high R-squared values for all eight of the colleges: Agriculture (AG), Architecture (AR), Business (BA), Education (ED), Engineering (EN), Geosciences (GE), Liberal Arts (LA), and Sciences (SC). High R-squared values indicate the effectiveness of the models in predicting the y value, applications, for each college. Individual variables in the models were not as significant. Of the 64 variables to analyze in each model, eight colleges and eight variables, 13 of 64 were significant at a .30 level or better in the linear model and 14 of 64 significant in the log-log model. In addition, of the 27 significant variables, 12 came from a single college, agriculture. The lack of significant variables for most of the colleges limits the ability to draw policy conclusions from the complete models. However, the high R-squared suggests both functional forms to be good predictors of applications in the future.

The complete model was reduced to a policy model through use of Directed Graphs. Using correlation matrices for each college, the computer program TETRAD II removed connected edges that were not significant. After removal, only tuition (TUI), four-year competitor costs (4YR), and two-year competitor costs (2YR) were left. These three variables all had at least one directed edge and at least six connected edges. In eleven of the sixteen models, the policy model was better than the complete model in terms of Adjusted R-squared. Additionally, 46% of the variables across all colleges were significant in the policy model, while only 21% were significant in the complete model.

There were nine questions asked in Chapter III of this paper. The main question **"What is the elasticity of demand for enrollment for different colleges at State U and what are the implications for differential pricing in higher education?"** was broken down into the five research questions. A secondary question, **"What are the income elasticities for various colleges at State U and how do changes in income affect enrollment?"** was further broken into four questions. These nine questions are addressed in the next few paragraphs.

Question 1

The first question in the paper was do differences exist in the price elasticity of demand (OPE) for different colleges? If only those colleges that have significant TUI values are compared, the OPE for the College of Agriculture is -1.637 using log-log form and ranges from -1.73 to -4.45 using linear form. All of those values indicate an elastic good with an absolute value of the OPE being greater than one. The Colleges of Geosciences and Sciences both had significant results. Geosciences showed similar results to the College of Agriculture with a log-

log form OPE of -1.28 and a range using the linear form of -1.341 to -3.642. Both colleges clearly are elastic goods and applications will fall at a much greater rate that tuition is raised.

The other two colleges with significant results were very different. The College of Science had a log-log form OPE of -.53 and a range using the linear form of -.751 to -1.252. Interpreting just the log-log, yields an inelastic good with an absolute value of the OPE being less than one. If tuition were to be raised, the College of Science should see a smaller percentage decrease in applications.

Engineering was the final college with significant variables. The OPE for the College of Engineering was .3 for the log-log form and ranged from .608 to .930 in the linear model. Raising tuition for Engineering would see a much smaller decrease in applications. The other four colleges had OPE that while not significant, were all between 0 and -1, indicating inelastic goods. Clearly, there are differences in own-price elasticity among colleges.

Question 2

Does any college's price elasticity of demand classify that college as having an inelastic demand for enrollment with respect to tuition? Yes, certainly the College of Engineering can be classified as having an inelastic demand. The College of Engineering was found to have a positive OPE which is apt to be called highly inelastic. A case can be made for the College of Sciences to also be called inelastic. The log-log OPE for Sciences is -.53, solidly inelastic, and five of the 13 years measured are inelastic as well. Inelastic colleges can have tuition increased and revenue will increase as well.

Question 3

Does any college's price elasticity of demand classify that college as having an elastic demand for enrollment with respect to tuition? The Colleges of Agriculture and Geosciences are elastic in both the log-log and linear functional forms. Both colleges have OPE that have an absolute value greater than 1 in both the log-log and linear forms. This indicates that decreasing tuition for both of these would increase revenue from tuition for each.

Question 4

A tougher question to answer is if any of the colleges OPE changed over time. The linear model is the only way to compute this as the log-log model gives the result over the entire data set, not as specific points in time. The policy model in the linear form was significant for the Colleges of Agriculture, Engineering, Geosciences, and Science, while the complete model was significant only for Agriculture, Engineering, and Geosciences. For the College of Agriculture, the complete model had the higher adjusted R-squared, so it is used for comparison purposes, while in the other three colleges the policy model had higher adjusted R-squared values.

The College of Agriculture showed considerable variance over the thirteen years. It peaked in 2006 with a value of -4.451 and had its lowest value in 2013 of -1.73. The College of Geosciences also had a large range with a low of -1.341 in 2013 and a high of -3.642 in 2006. The College of Science had a much smaller range of -.754 to -1.252. The College of Engineering was even smaller, .608 to .930. These results show that colleges OPE do change over time. The patterns and directions of the changes can be used to see if universities are making the proper decisions with regards to tuition changes.

Question 5

What is the estimated effect charging differential tuition rates according to elasticities would have on State U's general revenue and enrollment? In order to attempt to answer this question, several assumptions were made. First, for each college the policy model was used. The log-log or linear functional forms were chosen for each college based on R-squared. The Colleges of Agriculture, Education, Engineering, and Science used log-log, while Architecture, Business, Geosciences, and Liberal Arts used linear. Next, two scenarios were chosen to model, a 5% change and a 10% change. For those colleges that were inelastic, the change was an increase in tuition. For those colleges that were elastic, the change was a decrease in tuition. The new quantity or amount of applications was calculated by rearranging Equation 23.

$$\textbf{OPE} = \frac{\%\,\Delta\, \boldsymbol{Q_x}}{\%\,\Delta\, \boldsymbol{P_x}} \qquad (23)$$

By taking the OPE times the 5 or 10% change in tuition, a percent change in applications was found. This was multiplied by the base applications to get new applications and multiplied by the new tuition rate to get the new revenue. For example, in the College of Agriculture, the OPE was -1.6004 which was multiplied by -.05 to get .08002, or an 8.002% increase in applications if tuition is lowered by 5%. Base applications was 2702 in 2015, thus an 8% increase means they would be 2918 with a 5% drop in tuition and with further calculation 3134 with a 10% drop in tuition.

Table 39

Revenue Changes for 5 and 10% Tuition Changes Per Semester.

		Apps	Attend	Tuition	Revenue	Change in Revenue
AG	No Change	2702	1081	$3,302.01	$3,568,812.41	
	5% Drop	2918	1167	$3,136.91	$3,661,671.32	$92,858.91
	10% Drop	3134	1254	$ 2,971.81	$3,725,972.39	$157,159.98
AR	No Change	763	305	$3,832.94	$1,169,813.29	
	Increase 5 %	757	303	$4,024.59	$1,218,647.89	$48,834.60
	Increase 10%	751	300	$4,216.23	$1,266,562.87	$47,914.98
BA	No Change	3799	1520	$3,591.18	$5,457,157.13	
	Increase 5 %	3783	1513	$3,770.74	$5,705,625.43	$248,468.30
	Increase 10%	3767	1507	$3,950.30	$5,951,770.92	$494,613.79
ED	No Change	2466	986	$3,325.48	$3,280,253.47	
	Increase 5 %	2429	972	$3,491.75	$3,393,138.74	$112,885.26
	Increase 10%	2393	957	$3,658.03	$3,501,154.72	$220,901.25
EN	No Change	8508	3403	$3,899.31	$13,270,131.79	
	Increase 5 %	8635	3454	$4,094.28	$14,140,951.40	$870,819.61
	Increase 10%	8761	3504	$4,289.24	$15,031,515.11	$1,761,383.32
GE	No Change	481	192	$3,181.92	$612,201.41	
	Drop 5%	524	209	$3,022.82	$633,202.31	$21,000.90
	Drop 10%	566	227	$2,863.73	$648,770.47	$36,569.07
LA	No Change	3590	1436	$3,164.01	$4,543,518.36	
	Increase 5 %	3530	1412	$3,322.21	$4,690,759.26	$147,240.90
	Increase 10%	3470	1388	$3,480.41	$4,830,387.30	$286,868.94
SC	No Change	3717	1487	$3,180.87	$4,729,317.52	
	Increase 5 %	3619	1448	$3,339.91	$4,834,662.76	$105,345.24
	Increase 10%	3521	1408	$3,498.96	$4,927,520.33	$198,202.81

To complete the calculations, a further assumption is needed. On average 40% of students that apply to State U are accepted and attend the University. By taking the differences between the base applications and the 5 or 10% changes and multiplying by .4 and the new cost of tuition, a value for increased revenue from first-time students for each semester can be obtained.

Of the eight colleges, Liberal Arts did not have any significant variables in the policy model. Both Education and Sciences only had a single significant variable, while Business had two. These four colleges were included in the forecast. Results are presented below with and without those four colleges.

Table 39 shows the results of the calculations for both scenarios. In two colleges, Agriculture and Geosciences, prices were dropped due to finding those colleges to be elastic goods. For those colleges, revenue increased by $113,859.81 per semester with a 5% decrease in tuition and by $193,729.05 per semester with a 10% decrease in tuition. Also, the number of applicants in the two colleges by 259 or 8.13%, and 518 or 16.27% with the 5 and 10% decreases to tuition.

Engineering was a special case. Raising tuition by 5% increased revenue for Engineering by $870,819.61 and increasing by 10% raised revenue by $1,761,383.32 per semester. Engineering would actually add students in both scenarios, 123 and 256 respectively.

In the other five colleges, raising tuition by 5% increased revenue by $549,889.05 per semester and increasing by 10% raised revenue by $1,027,600.52 per semester. The number of applications would fall by 330 students with the 5% increase and 782 with the 10%. However, as stated, only the College of Education of these five has more than two of the six variables in the policy model as significant. Removing the four colleges means if tuition is increased by 5%, the College of Education gains $112,885.26 per semester and $220,901.25 for a 10% increase.

Table 40 shows that using elasticities to increase or decrease tuition rates on a college basis would generate $3,294,907.47 in yearly revenue from first-time students for State U as a whole if a 5% change was implemented and $6,407,228.26 in yearly revenue with a 10% change. Total applications for State U would increase by 168 or .65% for a 5% change in tuition and by 337 or 1.29% for a 10% change in tuition. Table 41 shows the same information if only the four colleges with at least 50% of the variables in the policy model significant are included. Those four colleges could generate $2,195,129.37 per year with a 5% change and $4,352,027.22 with a 10% change.

Table 40

Total Revenue Effects for State U for 5 and 10% Tuition Changes Per Semester, All Colleges.

	Apps	Attend	Revenue	Change in Revenue	Yearly Revenue Change
No Change	26026	10410	$36,631,205.37		
5% Change	26194	10478	$38,278,659.11	$1,647,453.74	$3,294,907.47
10% Change	26363	10545	$39,883,654.11	$3,203,614.13	$6,407,228.26

Table 41

Total Revenue Effects for State U for 5 and 10% Tuition Changes Per Semester, Only Significant Colleges

	Apps	Attend	Revenue	Change in Revenue	Yearly Revenue Change
No Change	14157	5663	$20,731,399.08		
5% Change	14506	5802	$21,828,963.77	$1,097,564.69	$2,195,129.37
10% Change	14855	5942	$22,907,412.69	$2,176,013.61	$4,352,027.22

Questions 6-9

The four secondary questions dealt with income elasticities (IE). Income was not one of the variables found significant by the Directed Graph procedure therefore, results are only available for the complete model. In that model, per-capita disposable income was significant for the College of Agriculture in both log-log and linear forms, and for Geosciences and Sciences in the log-log form. The College of Agriculture had a negative IE in both forms. In the linear form, IE was between -5 and 06 for the first several years before dropping to -3 the last three. In the log-log form, IE for the College of Agriculture was -1.602. Both indicate that as incomes go up, applications in the College of Agriculture fall, making Agriculture an inferior good.

For Geosciences and Sciences, only the log-log form was significant, thus changes over time are impossible to determine. Geosciences had an IE of 2.106 and Sciences was 1.94. Both are positive and greater than 1, putting them into the categories of normal goods and luxury goods. When income rises, applications in both colleges rise a great deal.

Answering the research questions, even with limited significant variables there are differences in IE between colleges. Agriculture was an inferior good and the other two with significant variables are luxury goods. No necessity goods were found among the colleges. The final question, does income elasticity change over time, was found to be true, but only one college had a significant variable to test.

Conclusions

The percentage of young people attending colleges in the United States continues to rise. Coupled with the increasing population, this means that enrollment in higher education is much greater than ever before. At the same time, federal and state appropriations for higher education have stagnated. In response, many public institutions have increased tuition at a staggering rate. This tuition increase has come at a universal level with no regard to economic factors such as elasticities. In fact, some colleges and universities might benefit from decreasing tuition.

National studies have shown own-price elasticities (OPE) ranging from -.44 (Campbell & Siegel, 1967) to -.60 (Gallet, 2007). However, these aggregated all college students and did not differentiate between a student's choice of college. Shin and Milton (2007) conducted a study across a large number of universities exploring student responses to tuition increases based on college majors. Their findings suggest that some majors do have different elasticities than others, particularly those that have a high rate of return. This would indicate that differential tuition does have a place in higher education.

This study attempts to further the literature by calculating elasticities at a single institution over time on a college basis. There are some drawbacks to this type of study. Tuition at State U has not been free to change for very long. Only in 2004 did the state legislature give up tuition controls. Also, State U's colleges have only recently started charging different amounts to students. This limits the amount of data that is available.

With limited data come limited significant variables and results; however, the results that are significant are very telling. Two colleges were found to have elasticities that were in the elastic range (absolute value of OPE that is greater than one), the College of Agriculture and the College of Geosciences. Both colleges had OPE that changed over time in a linear model and both appear to be getting closer to -1. So while they are still very susceptible to changes in tuition, they are becoming less so each year.

The College of Science was an inelastic good using the log-log form, with an OPE of -.53, but was closer to a unit elastic good in the linear model. Tuition could be left alone in the College of Science and more data collected to see which functional form is more correct. It could also be increased due to the evidence. The College of Engineering was even more interesting having an OPE of .3. A positive coefficient means that as costs rise, demand for Engineering rises. Engineering can raise tuition with little fear of losing applications, in fact they might see an increase in applications if they raised the price. The other four colleges in the study, while not significant, had OPE in the inelastic range.

What does this all mean? The first item of significance is that there are measurable differences between colleges in terms of own-price elasticity. This is economic proof that differential tuition can be useful. Inelastic goods can generate more revenue with an increase in price. Elastic goods can generate more revenue with a decrease in price. If the Colleges of Agriculture and Geosciences were to drop their tuition 5%, their revenues would increase by over 8%. If they dropped tuition by just 10%, their revenues would increase by over 16%. This revenue increase comes with an increase in applications and enrollment as well. Conversely, increasing tuition in the Sciences and Engineering colleges would generate more revenue. Demand and applications in those colleges would fall, but not as much as tuition increased. This would boost revenue a great deal.

In fact, making the recommended changes to all eight colleges, decreasing tuition in Agriculture and Geosciences, increasing tuition in the other six, would boost revenue throughout State U. Making a 5% change would give an additional $3.3 million in revenue from first-time students, while changing tuition charged by 10% would boost revenue by over $6.4 million per year. However, this does not take into account additional revenue from continuing students. In 2015, State U had nearly 31,000 continuing students in the eight colleges (State University, 2016a). Most students are not very responsive to tuition changes after they have made their enrollment decision. Therefore, assuming retention rates remain the same, changing tuition 5% would result in over $14 million more revenue per year, while changing tuition 10% would generate over $28 million per year. From a pure economics standpoint, that is nearly $35 million a year in additional revenues generated by charging the appropriate differential tuition rates. Considering State U receives close to $400 million a year in tuition from students, $35 million is a non-trivial amount and it seems like expanding differential tuition rates is an excellent idea.

Changing the way tuition is charged to a university-wide differential tuition rate based on elasticities may be the best way to meet revenue shortfalls for universities, but other considerations remain. Specifically, what is the impact of such a change on access? Particularly, how does such a change impact access for low-socioeconomic students?

Most studies agree that all other things equal, a student with more income should be less sensitive to changes in tuition than a student from a poorer family. Providing lower income students with financial aid opportunities will shift their demand curves upward and bring their probabilities of enrollment much closer to that of the higher income students (Heller, 1997). This is the higher education theory of high tuition/high aid. The high tuition/high aid model revolves around the idea that higher income families can afford higher tuition and will not care about the higher rates. Lower income families can receive greater amounts of financial aid to offset the cost.

There are several problems with this idea. First, the large tuition increases lead to a "sticker shock" where low-income students are scared away because of the massive costs. They never learn about the financial aid packages because they lack explanations of what opportunities are available. Secondly, if aid is primarily given in loans then higher aid leads to students with higher debt when they graduate. Many low-income students can receive grants to attend college. Middle-income students must usually seek loans. The number of students taking out loans to pay for education has risen by over 60% in the last decade, while the size of the debt has increased as well.

Additionally, recent work suggests that increasing federal loan and grant programs may not have the desired effect. Lucca, Nadauld, and Chen (2016) conducted a study in conjunction with the Federal Reserve Bank of New York to look at the effect of increasing federal grant and loan programs on the sticker price of tuition. They found that each additional Pell grant dollar added about 55 cents to the tuition of students. Subsidized loans resulted in a 70% effect while unsubsidized had a 30% effect. The authors went on to conclude that this change in sticker price is represented in all students' net tuition, not just the relatively few that do not have grants or loans. What results is less high tuition/high aid and more simply high tuition.

Other data suggests that the high tuition/high aid programs implemented elsewhere have not been successful. At the University of Michigan, the number of students from households with incomes between $10,000 and $74,999 has decreased by 10% since implementation of a high tuition/high aid plan (Nishimura, 2009). Moreover, the magnitude of the effects of aid is much less than actually reducing tuition. Two studies have found that a $1000 increase in Pell Grants has about a 1% increase in enrollment, while a $1000 decrease in tuition increases enrollment by as much as 6% (Cameron and Heckman, 2001); (Kane, 1994). These results are not universal. A study of the University of California found no discernible drop in demand or access with implementation of a high tuition/high aid plan (Ward & Douglas, 2005).

Besides effects on students from different income groups or socioeconomic backgrounds, differential tuition and changing financial aid policies could have impacts on students from different races. Minority students have been shown to be more responsive to financial aid offers, with black students being more sensitive. Blacks who received grants had an 11.2 % greater probability of enrolling than unaided blacks. To compare, a white student who received aid was only 6.3% more likely to enroll. Hispanic students who received aid offers were no more likely to enter college than those that did not (St. John and Noell, 1989). Similar results are reported from studies that track the net cost of college or tuition and its effect on enrollment. Minorities are found to have a greater sensitivity to cost than white students. Kane (1994) found that in the bottom quartile of income levels, a $1000 increase in costs would decrease black enrollment by 22.1% and white enrollment by 11.4%. In the highest quartile, black enrollment would still decrease by 13.2%, while white enrollment would only fall by 1.7%.

The warning inherent in these studies is that differential tuition is dangerous on its own. Increasing tuition in those colleges with inelastic demand may force low-income students out of those majors and into majors with more elastic demands whose tuition has been lowered. That means low-income students that want to become engineers or accountants may not be able to afford those degrees and may be forced into degrees that they may not have as much interest in, such as liberal arts or agriculture, because the costs are less. Simply changing tuition to meet the results of elasticity calculations could dramatically alter enrollment profiles and lock out low socioeconomic and minority backgrounds students from higher-earning degrees.

Conversely, scholarship suggests that the standard response of high tuition/high aid may not actually work. It does not seem to be as effective on access as lowering tuition. Sensitivity to cost is greater in low socioeconomic students and in minorities. The challenge is to find a middle ground. Universities cannot survive with lower tuition and less government money. If government resources are not going to be available, tuition will have to rise. The best way to do this is through differential tuition based on elasticities. The best way to mitigate the damaging effects of raising tuition is to target those most affected with grant money.

Based on the results of this research, the author advises that differential tuition formulated from calculated elasticities be considered by State U. The increase in revenues that such a plan should generate will be large. This money can be spent on hiring new faculty, faculty raises, increased student services, and financial aid to low-income students. All of which make the college more competitive and more attractive to students and makes differential tuition based on this plan appear an obvious choice. But higher revenue is not the only goal for college administrators. Improving access for minorities and low socioeconomic students is also important. Differential tuition is but one facet of the in the decision-making process at the administrative level.

If differential tuition is implemented by State U, there will need to be considerations on how the money is spent. Administrators may use the money to hire more prestigious professors for research or make significant investments into classroom technology. While these are important to consider, they might leave low-income students out of certain colleges that increase tuition. To prevent this harm, restrictions can be included that require a large percentage of the increased revenues be spent on institutional-level, need-based financial aid. This financial aid should be primarily in the form of grants instead of loans to lower the risk of students graduating with high student debt. Most of these funds should be allocated to students in those colleges that increase their tuition rates.

Along with the dedication of funds to financial aid, a portion of the money should be spent at State U to increase the size of the recruitment staff for low income and low socioeconomic areas. Implementing a high tuition/high aid plan has a real chance of frightening parents and students with low incomes away with a high sticker price. Increasing the amount of recruiters in low income areas should allow more education on the availability of loans and grants at the federal, state, and institutional levels; especially the new funds available as a result of changing tuition policies. If restrictions are not put in place, administrators may use the additional revenue in ways that strengthen the college, but damage access for low socio-economic students.

The economics of public universities have become more important as funds from federal and state levels continue to stagnate. University budgets promise to become one of the most contested political battles in the near future. Charging higher amounts to students that are earning degrees in fields that have higher wage premiums appear to be a way to increase revenues. This approach must be coupled with realistic efforts to mitigate the effects of such an increase on low-income students. Otherwise, differential tuition will only help in widening the stratification and inequality among incomes in the United States.

Limitations

The first major limitation of the current study is the lack of available data. Only having 13 usable years of data could be considered too small a sample size. More data would give more degrees of freedom and add validity to the study. Conversely, State U had state-mandated tuition limits up to 2004. This means prior years may not provide any true insight into price responses by students. Colleges in states without state-mandated tuition limits can use data back as far as can be accumulated. Thus the model may have more use at other public universities instead of at State U. However, the elasticities calculated at State U are only applicable at State U. The model is universal; the results are not.

Limitations of the study also include the lack of tiered income levels in the income variable. Breaking income into quartiles as in Kane (1994) would allow some inference on how tuition changes impact various socioeconomic groups. The lack of directed edges from the income variable to applications led to income being dropped from the policy model. It is possible that using tiered levels might affect the policy model.

A potential limitation is also that the four-year competitor costs were an aggregate of all colleges. Information was not available in an efficient form for competitor colleges at each four-year competitor university. For instance, two of the universities used as four-year competitors do not even have a College of Agriculture. In addition, State U's College of Business may compete with West State U, while its College of Agriculture competes with Central U. Using expert or survey data to determine the main four-year competitors of each college and applying the specific cost for those colleges may provide a better measure of the four-year competitor costs than simple aggregation. Further studies could be done to include this information, but it is beyond the scope of this research.

The final limitation is the wage premium variable. Different measures of wage premium were found and calculated, but none truly represented the eight colleges chosen. The State U Career Center has begun to collect average starting salaries on a college and major basis, which bodes well for this research in the future. That collection began in 2011, however, and not enough data exists yet to include it in this study as of today.

Recommendations for Future Research

Any future research will start with mitigating the limitations of the current study. This would mean improving the eight variables that are included in this paper. First and most basic would be continuing the study each year as more data becomes available. More data would mean more degrees of freedom in the statistical analysis. Second, adding the State U Career Center data on starting salaries will improve the wage premium variable. A single wage premium cannot model every student seeking higher education. Finding more appropriate measures of four-year competitors costs based on colleges would also improve the included variables. Including family income in a stratified manner might give deeper results.

With the ability of the model to determine OPE for individual colleges, the next step becomes applying the model to individual degrees or majors. This would be a significant undertaking and would require assistance from State U to collect application and cost data on a major basis. The same limitations concerning four-year competitor costs would apply to majors, but they could be overcome. Wage premiums could be calculated using State U's Career Center calculations, which already include a starting salary for each major, albeit for only the past four years. The result of such calculations would allow an even finer adjustment to tuition.

REFERENCES

Allen, R. F., & Shen, J. (1999). Some new evidence of the character of competition among higher education institutions. *Economics of Education Review, 18*, 465–470.

Avila, M. (1972). Peak load pricing in higher education. *Journal of Experimental Education, 40*, 6-11.

Bean, C. (1990). Endogenous growth and the pro-cyclical behavior of productivity. *European Economic Review*, *34*(2–3), 355–363.

Becker, G. S. (1962). Investment in human capital: A theoretical analysis. *Journal of Political Economy 70* (Supplement): 9-49.

Becker, G. S. (1993). *Human capital: A theoretical and empirical analysis with special reference to education* (3rd ed.). Chicago: University of Chicago Press.

Becker, W. E. (1990). The demand for higher education. In S.A. Hoenack & E.L. Collins (Eds.), *The economics of American universities: Management, operations, and fiscal environment.* (pp. 155–188). Albany, NY: State University of New York Press.

Becker, W. E., & Waldman, D. M. (1987) The probit model. In W.E. Becker & W. Walstad (Eds). *Econometric Modeling in Economic Education Research* (Edited by Boston: Kluwer-Nijhoff.

Bessler, D. A., Yang, J., & Wongcharupan, M. (2003). Price dynamics in the international wheat market: modeling with error correction and directed acyclic graphs. *Journal of Regional Science*, *43*(1), 1-33.

Bezmen T., & Depken, C. A. (1998). School characteristics and the demand for college. *Economics of Education Review*, *17*(2), 205-210.

Bryan G. A., & Whipple, T. W. (1995). Tuition elasticity of the demand for higher education among current students: A pricing model. *Journal of Higher Education, 66*, 560-574.

Buss, C., Parker J., & Rivenburg J. (2004). Cost, quality and enrollment demand at liberal arts colleges. *Economics of Education Review, 23*, 57-65.

California Community Colleges. (2011). *California community colleges Chancellor Jack Scott expresses disappointment over failure of legislators to place tax extensions on June ballot.* Retrieved from http://www.cccco.edu/Portals/4/News/press_releases/2011/CaliforniaCommunityCollege_PressRelease_MAR_30_2011.pdf on April 21, 2011.

Cameron, S.V., & Heckman, J. J. (2001). The dynamics of educational attainment for black, hispanic, and white males. *Journal of Political Economy*, *109*(3), 455-499.

Campbell R., & Siegal B. N. (1967). The demand for higher education in the United States, 1919-1964. *The American Economic Review, 57*(3), 482-494.

Canton, E., & de Jong, F. (2005). The demand for higher education in the Netherlands, 1950-1999. *Economics of Education Review, 24*, 651-663.

Carbone, R., & Jenson, O. (1971). *Non-resident students at state universities and land grant colleges*. College Park: University of Maryland College of Education.

Chressanthis, G. A. (1986). The impacts of tuition rate changes on college undergraduate headcounts and credit hours over time – a case study. *Economics of Education Review, 5*(2), 205-217.

Ciciroa, P. (2010). *Higher education funding may need decade or longer to recover, scholar says.* Retrieved on February 3, 2011 from http://news.illinois.edu/news/10/0810higheredfunding.html

Chopra, R. (2010). *Student debt swells, federal loans now top a trillion.* Retrieved on September 28, 2014 from http://www.consumerfinance.gov/newsroom/student-debt-swells-federal-loans-now-top-a-trillion/

Clotfelter, C. T. (1991). Demand for undergraduate education. In C.T. Clotfelter, R. Ehrenberg, M. Getz, & J. J. Siegfried (Eds.), *Economic Challenges in Higher Education*. Chicago: University of Chicago Press.

College Board (2010). Education pays 2010. Retrieved from http://trends.collegeboard.org/education_pays on April 20, 2011.

College Board (2013). Trends in college pricing 2013. Retrieved from http://trends.collegeboard.org/sites/default/files/college-pricing-2013-full-report-140108.pdf on September 30, 2014

Corazzini, A. J., Dugan, D. J., & Grabowski, H. G. (1972). Determinants and distributional aspects of enrollment in U.S. higher education. *The Journal of Human Resources, 7*(1), 39-59.

Curs, B. R., & Singell, L. D. (2010). Aim high or go low? Pricing strategies and enrollment effects when the net price elasticity varies with need and ability. *The Journal of Higher Education, 81*(4), 515-543.

Derochers, D., Lenihan, C., & Wellman, J. (2010). *Trends in College Spending, 1998-2008* (p. 56). Delta Project on Postsecondary Education Costs, Productivity, and Accountability.

DesJardins, S. L., & Bell, A. (2006). Using economic concepts to inform enrollment management. In R. K. Toutkoushian & M. B. Paulsen (Eds.), *New directions for institutional research: No. 132. Applying economics to institutional research*. San Francisco: Jossey-Bass.

DesJardins, S. L., & Toutkoushian, R. K. (2005). Are students really rational? The development of rational thought and its application to student choice**.** . In J. C. Smart (Ed.), *Higher education: Handbook of theory and research*, Volume 20 (pp. 191-240). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Dougan, W. R. (1982). Giffen goods and the law of demand. *The Journal of Political Economy, 90*(4), 809-815.

Dynarski, S. M. (2000). Hope for whom? Financial aid for the middle class and its impact on college attendance. *National Tax Journal. 53*(3), 629-61.

Educated Risk. (2016). Student loan analysis and research. Retrieved from http://educatedrisk.org/analysis/student-loan-interest-rates-current-and-historical on June 20, 2016.

Epple, D., Romano, R., & Sieg, H. (2006). Admission, tuition, and financial aid policies in the market for higher education. *Econometrica*, *74*(4),885-928.

Ehrenberg, R. G., & Sherman D. R. (1984). Optimal financial aid policies for a selective university. *The Journal of Human Resources, 19*(2), 202-230.

Fuller, W. (1976). *Introduction to Statistical Time Series*. New York. John Wiley and Sons.

Gallet, C. (2007). A comparative analysis of the demand for higher education: Results from a meta-analysis of elasticities. *Economics Bulletin*, *9*(7), 1-14.

Galper, H., & Dunn, R. M. (1969). A short-run demand function for higher education in the United States. *The Journal of Political Economy, 77*(5), 765-777.

Geiger, D., Verma, T., & Pearl, J. (1990). Identifying independence in bayesian networks. *Networks*, *20*(5), 507-534.

Ghali, M., Miklius, W., & Wadak, R. (1977). The demand for higher education facing an individual institution. *Higher Education, 6*(4), 477-487.

Granger, C. W. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica: Journal of the Econometric Society*, 424-438.

Gullason, E. T. (1989) The consumption value of schooling: an empirical estimate of one aspect. *The Journal of Human Resources*, *24*, 287–298.

Haigh, M. S., & Bessler, D. A. (2004). Causality and price discovery: An application of directed acyclic graphs. *The Journal of Business*, *77*(4), 1099-1121.

Hansen, W. L. (1970). Income distribution effects of higher education. *American Economic Review, 60*, 335-40.

Heller, D. E. (1997). Student price response in higher education: An update to Leslie and Brinkman. *Journal of Higher Education, 68*, 624-659.

Heller, D. E. (2006). State support of higher education: Past, present, and future. In D. M. Priest & E. P. St. John (Eds.) *Privatization and public universities* (pp. 11-37). Bloomington, IN: Indiana University Press.

Heller, D. E. (2001). Trends in public colleges and universities. In D.E. Heller (Ed.), *The states and public higher education policy*. pp. 11-38. Baltimore: Johns Hopkins University Press.

Henderson, D. R. (2008). *Demand*. The Concise Encyclopedia of Economics. Retrieved on February 10, 2011 from http://www.econlib.org/library/Enc/Demand.html

Hight, J. E. (1975). The demand for higher education in the U.S. 1927-1972: The public and private institutions. *The Journal of Human Resources*, *10*(4), 512-520.

Hilmer, M. J. (1998). Post-secondary fees and the decision to attend a university or a community college. *Journal of Public Economics, 67*, 329-348.

Hoenack, S. A. (1982).Pricing and efficiency in higher education. *Journal of Higher Education, 53*, 403-18.

Immerwahr, J., Johnson, J, Ott, A., & Rochkind, J. (2010). *Squeeze play 2010: Continued public anxiety on cost, harsher judgments on how colleges are run.* Report from the National Center for Public Policy; Public Agenda.

Jackson, G. A., & Weathersby, G. B. (1975). Individual demand for higher education: A review and analysis of recent empirical studies. *Journal of Higher Education, 46*(6), 623-652.

Kane, T. J. (1994). College entry by blacks since 1970: The role of college costs, family background, and the returns to education. *Journal of Political Economy*, *102*(5), 878–911.

Leslie, L. L., & Brinkman, P. T. (1987). Student price response in higher education: The student demand studies. *Journal of Higher Education, 58*, 181-204.

Lingenfelter, P. E. (2009). *What next?* Retrieved on January 28, 2011 from http://www.sheeo.org/finance/shef/FY2009tables/WhatNext.pdf

Lucca, D. O., Nadauld, T., & Chen, K. (2016). Credit supply and the rise in college tuition: Evidence from the expansion in federal student aid programs. Staff Report no. 733. Federal Reserve Bank of New York.

Marshall, A. (1920). *Principles of economics.* 8th ed. London: Macmillan and Col, Ltd.

McMahon, W. W., & Wagner, A. P. (1982). The monetary returns to education as partial social efficiency criteria. In W.W. McMahon and T.G. Geske (Eds.), *Financing education: Overcoming inefficiency and inequity.* Urbana, IL: University of Illinois Press.

McPherson, M. S., & Schapiro, M. O. (1991). Does student aid affect college enrollment? New evidence on a persistent controversy. *The American Economic Review, 81*(1), 309-318.

Menzies, M. D. (2004). *Investigating the growth of the Texas cattle feeding industry and the possible need for additional slaughter capacity.* (Master's thesis.) Texas A&M University, College Station, TX.

Moore, H. L. (1914). *Economic cycles: Their law and cause*. The Macmillan Company. New, York, NY.

Moore, R. L., Studenmund, A. H., & Slobko, T. (1991). The effect of the financial aid package on the choice of a selective college. *Economics of Education Review, 10*(4), 311-321.

Murphy, K. M., & Welch, F. (1989). Wage premiums for college graduates: Recent growth and possible explanations. *Educational Researcher, 18*(4), 17-26.

Noorbakhsh, A., & Culp, D. (2002). The demand for higher education: Pennsylvania's nonresident tuition experience. *Economics of Education Review, 21*, 277-286.

O'Connell, J. F., & Perkins, G. M. (2003). The economics of private liberal arts colleges. *The Journal of Business. 76*(3), 499-514.

Parker, J., & Summers, J. (1993). Tuition and enrollment yield at selective liberal arts colleges. *Economics of Education Review, 12*(4), 311-324.

Paulsen, M. B., & Toutkoushian, R. K. (2008). Economic models and policy analysis in higher education: A diagrammatic exposition. In J. C. Smart (Ed.), *Higher education: Handbook of theory and research* (Vol. XXIII, pp. 1–48). Dordrecht, the Netherlands: Springer.

Pearl, J. (1995). Causal diagrams for empirical research. *Biometrika*, *82*(4), 669-688.

Pearl, J. (2009). *Causality*. Cambridge University Press.

Quinn, R., & Price, J. (1998). The demand for medical education: An augmented human capital approach. *Economics of Education Review, 17*(3), 337-347.

Richardson, J. W., Schumann, K. D, & Feldman, P. A. (2008). *Simetar© 2008 Simulation & econometrics to analyze risk*. Simetar, Inc. College Station, TX.

Rothschild, M., & White, L. J. (1995). The analytics of the pricing of higher education and other services in which the customers are inputs. *The Journal of Political Economy, 103*(3), 573-586.

Rusk, J. J., & Leslie, L. L. (1978). The setting of tuition in public higher education. *The Journal of Higher Education, 49*(6), 531-547.

Saint-Paul, G. (1993). Productivity growth and the structure of the business cycle. European Economic Review, *37*(4), 861–890.

Saupe, J., & Stephens, W. (1974). *Differential by level and per credit student charges in major public universities.*. Washington DC: Education Resources Information Center. (ERIC Document Reproduction Service No. ED131739).

Savoca, E. (1990) Another look at the demand for higher education: Measuring the price sensitivity of the decision to apply to college. *Economics of Education, 9*(2), 123-134.

Scheines, R., Sprites P., Glymour, C., & Meek, C. (1994). *Tetrad II: User's Manual and Software*. Hillsdale, New Jersey: Lawrence Erlbaum Associates, Inc.

Schultz, T. W. (1961). Investment in human capital. *American Economic Review, 51*, 1-17.

Shin, J. C., & Milton, S. (2006). Rethinking tuition effects on enrollment in public four-year colleges and universities. *The Review of Higher Education, 29*(2), 213-237.

Shin, J. C., & Milton, S. (2007). Student response to tuition increase by academic majors: empirical grounds for a cost-related tuition policy. *Higher Education, 55*,719-734.

Simone, S. (2010). Tuition and fee differentiation at degree granting postsecondary education institutions. *An AIR/NCES Data Policy Fellowship Report.* National Center for Education Statistics, Washington DC.

Spence, M. (1973). Job market signaling. *Quarterly Journal of Economics, 87*, 355-374.

Suppes, P. (1970). *A Probabilistic Theory of Causality.* Amsterdam: North Holland.

State University (2016a). *Data and reports/students*. Data and Research Services, State University. Retrieved on June 15, 2016 from http://dars.tamu.edu/Data-and-Reports/Student#applied.

State University (2016b). *Student Business Services*. Retrieved on June 20, 2016 from http://sbs.tamu.edu/accounts-billing/tuition-fees/.

State University (2016c). *Career Center*. Retrieved on July 15, 2016 from http://moses.tamu.edu/ccsurveyreports/SurveyReport.aspx.

State University (2016d). Mays Business School Rankings. Retrieved on December 10, 2016 from http://mays.tamu.edu/rankings/.

State University (2016e). *State U Engineering ranked 7th among public universities in latest graduate survey*. Retrieved on December 10, 2016 from http://engineering.tamu.edu/news/2016/03/16/texas-am-engineering-ranked-7th-among-public-universities-in-latest-graduate-survey.

State Higher Education Coordinating Board (2016). *Tuition and fee data*. Retrieved on June 15, 2016 from http://www.thecb.state.tx.us/index.cfm?objectid=D921014A-DF8A-5DB2-0CAA9DAC3DF3D384.

The Washington Monthly. (2010). *The Washington monthly national university rankings.* The Washington Monthly. Retrieved on April 15, 2011 from http://www.washingtonmonthly.com/college_guide/rankings_2010/national_university_rank.php

U.S. Bureau of Economic Analysis. (2016). *Per capita personal income*. Retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/TXPCPI, June 17, 2016.

U.S. Census Bureau (2016). *Current Population Survey*. Retreived from http://www.census.gov/cps/data/cpstablecreator.html on June 25, 2016

U.S. Department of Education. (2013). *Digest of Education Statistics, 2012*. National Center for Education Statistics, NCES 2014-015.

Vasigh, B., & Hamzaee R.G. (2004). Testing sensitivity of student enrollment with respect to tuition at an institution of higher education. *International Advances in Economic Research, 10*, 133-149.

Ward, D., & Douglass, J. A. (2005). The dynamics of variable fees: Exploring institutional and public policy responses. *Research and Occasional Paper Series (CSHE.5.05).* University of California, Berkeley.

Weinberg, I. (1978). *Financing higher education in 1980s and beyond*. Washington, DC: National Institute of Education.

Wetzel, J. O'Toole, D., & Peterson, S. (1998). An analysis of student enrollment demand. *Economics of Education Review*, *17*(1), 47-54.

Windham, D. M. (1972). Tuition, the capital market, and the allocation of subsidies to college students. *School Review*, *80*, 603-18.

Winston, G. C. (1999). Subsidies, hierarchy, and peers: The awkward economics of higher education. *The Journal of Economic Perspectives, 13*(1), 13-36.

Woodhall, M. (1995). Human capital concepts. In M. Carnoy (ed.), *International encyclopedia of economics of education* (2nd ed.). Tarrytown, NY: Elsevier

Yanikoski. R. A., & Wilson, R. F. (1984). Differential pricing of undergraduate education. *The Journal of Higher Education. 55*(6), 735-750.

[3]APPENDIX A

DIRECTED ACYCLIC GRAPH THEORY

The theory of directed acyclic graphs begins with the concept of causality. Granger causality states that a cause precedes its associated effect, while an effect does not precede its cause (Granger, 1969). A directed graph is a picture that represents causal flow between or among a set of variables. Letters are used to represent variables and lines (edges) with directional arrowheads at one end to represent causal flows. A graph with directed edges is called a directed graph (Haigh & Bessler, 2003). An acyclic graph has no path that leads away from a variable only to return to that same variable. For example, the path A→B→C→A is cyclic as it moves from A to B, then returns to A by way of C (Bessler, et al., 2003). A variable is called a collider if arrows converge on it. Consider the path A→B←C; the vertex B is a collider while vertices A and C are directionally separated. To understand directional-separation, conditionality must be understood.

An example of conditional and unconditional association or correlation is a set of three variables M, N, and O. A relationship may exist such that M←N→O. This suggests that unconditional association between M and O is non-zero, but conditional association between M and O is zero because of the common cause, N. This common cause screens off associations between joint effects. Conversely, if M and O cause N such as, M→N←O, then the unconditional association between M and O is zero while the conditional association between M

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and O is non-zero due to the common effect, N. Thus demonstrating that common effects do not screen off associations between joint causes (Bessler et al., 2003).

Direction-separation (d-separation) is a graphical characterization of conditional independence (Pearl, 1995). D-separation can be understood by using three subsets of variables D, E, and F in a graph G. Let p be any path between a variable in set D and a variable in set F. For any p, the set E blocks p if there is a variable k on the path that satisfies one of the following conditions: (i) variable k has converging arrows along p and neither k or any of its descendents are in E; or (ii) k does not have converging arrows along p and k is a member of set E. Set E is thus said to d-separate set D from set F on graph G if and only if E blocks every path from a variable in D to a variable in F (Pearl, 1995). Continuing the example, if G is a directed acyclic graph with vertex set V, if J and K are in V as is H, then G linearly implies the correlation between J and K conditional on H is zero, if and only if J and K are d-separated given H (Geiger, Verma, & Pearl, 1990).

To illustrate component (i) above, return to the path A→B←C. Vertex B is a collider as described, A and C are d-separated. If B is conditioned upon, however, the information flow from A to C is opened up. Conditioning on B makes A and C directionally connected (d-connected). Adding a fourth variable, D, to the original path as below gives a new path

A→B←C
↓
D

If D is now conditioned on instead of B, the flow between A and C is also opened, demonstrating (i) (Bessler et al., 2003).

If the information flow is not characterized by converging arrows, as above, but rather by diverging arrows, then the d-separation condition is different. This is given by component (ii) above. Consider from above, M←N→O, where N is the common cause of M and O. Again the unconditional correlation between M and O will be non-zero, because of the common cause N. If N is conditioned upon, the correlation between M and O will disappear. Conditioning on the common cause blocks the flow of information between common effects. M and O are d-connected in an unconditional sense because they have a common cause, while conditioning on N leaves M and O d-separated (Pearl, 2009).

Another application of component (ii) above is in the causal chain. If M causes N and N causes O then the following results: M→N→O. The unconditional correlation between M and O will be non-zero, but the correlation between M and O conditional on N will be zero. For causal chains, the end points (M and O) are not d-separated, whereas conditioning on the middle vertex N leads to the endpoints being d-separated.

The notion of d-separation has been incorporated into an algorithm (PC algorithm) by Sprites, Glymour, and Scheines (1994). PC algorithm is an ordered set of commands that begin with an undirected, unrestricted graph with every variable connected with every other variable and uses a step-wise procedure to remove edges between variables and direct the causal flow among the variables.

The general procedure of the PC algorithm begins with a complete undirected graph, G on the vertex set M. Lines (edges) are removed sequentially based on zero correlation or partial correlation (conditional correlation). Fisher's z is used to test whether conditional correlations are significantly different from zero. Fisher's z is defined as:

$$z(p(i,j|k),n) = [1/2(n-|k|-3)^{1/2}]\ln\{[|1+p(i,j|k)|] * [|1-p(i,j|k)|]^{-1}\}$$

Where n is the number of observations used to estimate the correlations, p(i,j|k) is the population correlation between series, i and j conditional on series k (removing the influence of series k on each i and j), and |k| is the number of variables in k (that we condition on). If i, j, and k are normally distributed and r(i,j|k)is the sample conditional correlation of i and j given k, the distribution of z(p(i,j|k),n)-z(r(i,j|k),n) is standard normal (Bessler et al., 2003).

The remaining variables are directed then using the idea of sepset, which can be defined as: The conditioning variable(s) on removed edges between two variables is called the sepset of the variables whose edge has been removed (for vanishing zero order conditioning information the sepset is the empty set) (Haigh & Bessler, 2003). Edges are thus directed by considering triples A — B — C, such that A and B are adjacent, as are B and C, but A and C are not. Edges between the triples are directed as such: A — B — C as A→B←C if B is not in the sepset of A and C. If A→B, B and C are adjacent, A and C are not adjacent, and there is no arrowhead at B, then orient B — C ad B→C. If there is a directed path from A to B and an edge between A and B, then direct A — B as A→B (Bessler, et al., 2003).

There are three requirements that can be violated when using directed graphs to correspond to the random assignment experimental models (the counterfactual random variable model) developed by Holland. The first of these requirements is the need to have a causally sufficient set of variables. This refers to not omitting any variable that in fact causes any variable in the study. If X causes both Y and Z and X is omitted, then an apparent causal flow from Y to Z may be due to X and would thus be spurious (Suppes, 1970).

The second requirement is that the graph needs to be constrained to causal flows that respect a causal Markov condition. If X causes Y and Y causes X, the underlying probability distribution can by factored on X, Y, and Z as:

$$Pr(X,Y,Z) = Pr(X)*Pr(Y|X)*Pr(Z|Y)$$

Put another way, the causal flow that is being uncovered must respect the genealogy condition that one need only condition on its parents in order to fully capture the probability distribution generating any variable. One need not condition on grandparents, siblings, or any other relative (Bessler, et al., 2003).

The final condition is that the probabilities that are being captured by graph G are faithful to G if X and Y are dependent if and only if there is an edge between X and Y. These three can all be violated, thus any result that is obtained based on observational data must be viewed with some caution. Failure to include a relevant variable may lead to an edge between two variables when in fact a third omitted variable is causing both. Failure of the Markov condition would lead to ignoring statistical dependency even in experimental designs. Failure of the third condition, the faithfulness condition, can occur if parameters between causes happen to be of the precise magnitude to cancel one another. Care must be taken to ensure that the three requirements are met, especially the first.

APPENDIX B

COLLEGE CORRELATION MATRICES

Table B1

College of Agriculture Correlation Matrix

	APPS	TUI	FEES	4YR	2YR	INC	UR	FS	WP
APPS	1.0000								
TUI	0.8127	1.0000							
FEES	-0.0124	0.3581	1.0000						
4YR	0.8732	0.9508	0.2969	1.0000					
2YR	0.9163	0.9187	0.1798	0.9824	1.0000				
INC	0.9004	0.9309	0.1983	0.9601	0.9602	1.0000			
UR	0.1595	-0.0223	-0.0522	0.1838	0.2461	-0.0002	1.0000		
FS	-0.4480	-0.0474	0.3846	-0.2310	-0.3547	-0.1985	-0.7480	1.0000	
WP	0.5106	0.4433	0.0724	0.6234	0.6659	0.5338	0.6557	-0.5571	1.0000

Table B2

College of Architecture Correlation Matrix

	APPS	TUI	FEES	4YR	2YR	INC	UR	FS	WP
APPS	1.0000								
TUI	0.8311	1.0000							
FEES	0.3441	0.3686	1.0000						
4YR	0.8837	0.9395	0.4598	1.0000					
2YR	0.9255	0.9344	0.4074	0.9824	1.0000				
INC	0.9061	0.9323	0.3910	0.9601	0.9602	1.0000			
UR	0.1988	0.0097	0.0892	0.1838	0.2461	-0.0002	1.0000		
FS	-0.4789	-0.1494	0.0772	-0.2310	-0.3547	-0.1985	-0.7480	1.0000	
WP	0.6251	0.4399	0.5562	0.6234	0.6659	0.5338	0.6557	-0.5571	1.0000

Table B3

College of Business Correlation Matrix

	APPS	TUI	FEES	4YR	2YR	INC	UR	FS	WP
APPS	1.0000								
TUI	0.7406	1.0000							
FEES	0.1411	0.5336	1.0000						
4YR	0.8109	0.9333	0.4598	1.0000					
2YR	0.8782	0.8942	0.4074	0.9824	1.0000				
INC	0.8760	0.9167	0.3910	0.9601	0.9602	1.0000			
UR	0.0458	0.0223	0.0892	0.1838	0.2461	-0.0002	1.0000		
FS	-0.3858	-0.0921	0.0772	-0.2310	-0.3547	-0.1985	-0.7480	1.0000	
WP	0.4207	0.5533	0.5562	0.6234	0.6659	0.5338	0.6557	-0.5571	1.0000

Table B4

College of Education Correlation Matrix

	APPS	TUI	FEES	4YR	2YR	INC	UR	FS	WP
APPS	1.0000								
TUI	0.8983	1.0000							
FEES	0.2683	0.3825	1.0000						
4YR	0.9008	0.9806	0.4598	1.0000					
2YR	0.9394	0.9604	0.4074	0.9824	1.0000				
INC	0.9200	0.9634	0.3910	0.9601	0.9602	1.0000			
UR	0.1496	0.0544	0.0892	0.1838	0.2461	-0.0002	1.0000		
FS	-0.4007	-0.1395	0.0772	-0.2310	-0.3547	-0.1985	-0.7480	1.0000	
WP	0.5177	0.5146	0.5562	0.6234	0.6659	0.5338	0.6557	-0.5571	1.0000

Table B5

College of Engineering Correlation Matrix

	APPS	TUI	FEES	4YR	2YR	INC	UR	FS	WP
APPS	1.0000								
TUI	0.9485	1.0000							
FEES	0.1751	0.3911	1.0000						
4YR	0.8727	0.9597	0.4598	1.0000					
2YR	0.9042	0.9620	0.4074	0.9824	1.0000				
INC	0.9132	0.9444	0.3910	0.9601	0.9602	1.0000			
UR	-0.0018	0.0789	0.0892	0.1838	0.2461	-0.0002	1.0000		
FS	-0.2737	-0.2107	0.0772	-0.2310	-0.3547	-0.1985	-0.7480	1.0000	
WP	0.4007	0.5065	0.5562	0.6234	0.6659	0.5338	0.6557	-0.5571	1.0000

Table B6

College of Geosciences Correlation Matrix

	APPS	TUI	FEES	4YR	2YR	INC	UR	FS	WP
APPS	1.0000								
TUI	0.8193	1.0000							
FEES	0.3152	0.4753	1.0000						
4YR	0.9289	0.9589	0.4598	1.0000					
2YR	0.9671	0.9206	0.4074	0.9824	1.0000				
INC	0.9188	0.9314	0.3910	0.9601	0.9602	1.0000			
UR	0.3453	-0.0053	0.0892	0.1838	0.2461	-0.0002	1.0000		
FS	-0.5280	-0.0372	0.0772	-0.2310	-0.3547	-0.1985	-0.7480	1.0000	
WP	0.7049	0.4693	0.5562	0.6234	0.6659	0.5338	0.6557	-0.5571	1.0000

Table B7

College of Liberal Arts Correlation Matrix

	APPS	TUI	FEES	4YR	2YR	INC	UR	FS	WP
APPS	1.0000								
TUI	0.8619	1.0000							
FEES	0.3135	0.4802	1.0000						
4YR	0.9290	0.9598	0.4598	1.0000					
2YR	0.9651	0.9206	0.4074	0.9824	1.0000				
INC	0.9450	0.9311	0.3910	0.9601	0.9602	1.0000			
UR	0.2108	-0.0026	0.0892	0.1838	0.2461	-0.0002	1.0000		
FS	-0.4296	-0.0356	0.0772	-0.2310	-0.3547	-0.1985	-0.7480	1.0000	
WP	0.6353	0.4733	0.5562	0.6234	0.6659	0.5338	0.6557	-0.5571	1.0000

Table B8

College of Science Correlation Matrix

	APPS	TUI	FEES	4YR	2YR	INC	UR	FS	WP
APPS	1.0000								
TUI	0.7876	1.0000							
FEES	0.4461	0.4756	1.0000						
4YR	0.9142	0.9589	0.4598	1.0000					
2YR	0.9367	0.9206	0.4074	0.9824	1.0000				
INC	0.8735	0.9314	0.3910	0.9601	0.9602	1.0000			
UR	0.4294	-0.0051	0.0892	0.1838	0.2461	-0.0002	1.0000		
FS	-0.4780	-0.0371	0.0772	-0.2310	-0.3547	-0.1985	-0.7480	1.0000	
WP	0.8095	0.4696	0.5562	0.6234	0.6659	0.5338	0.6557	-0.5571	1.0000

APPENDIX C

DIRECTED ACYCLIC GRAPHS

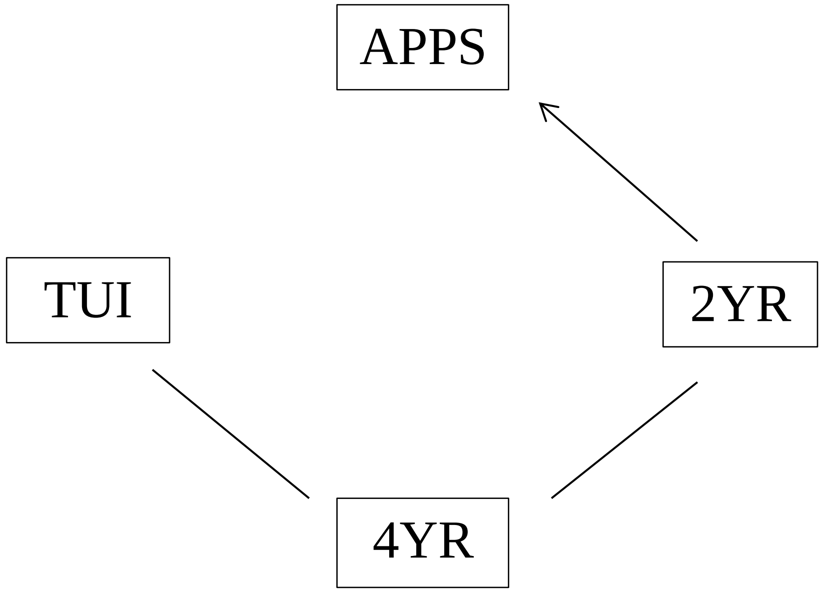

Figure C1. Directed Graph for AG College.

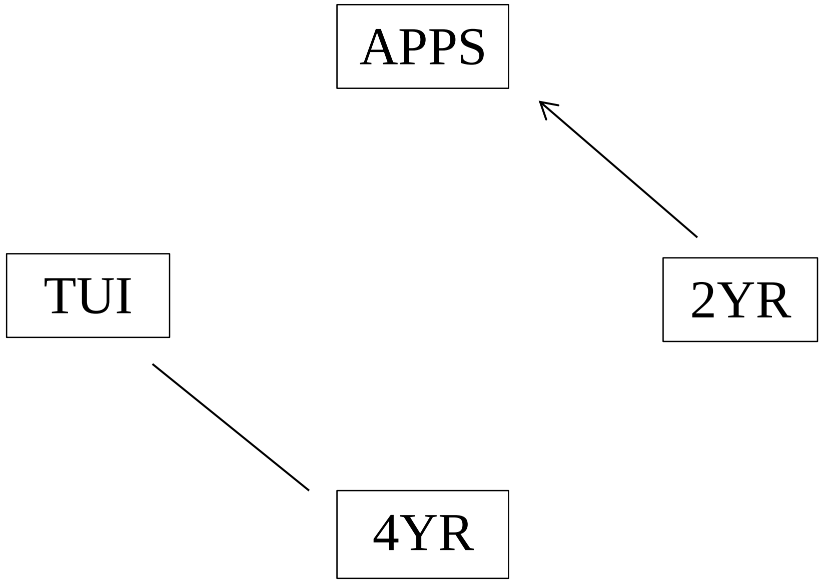

Figure C2. Directed Graph for AR College.

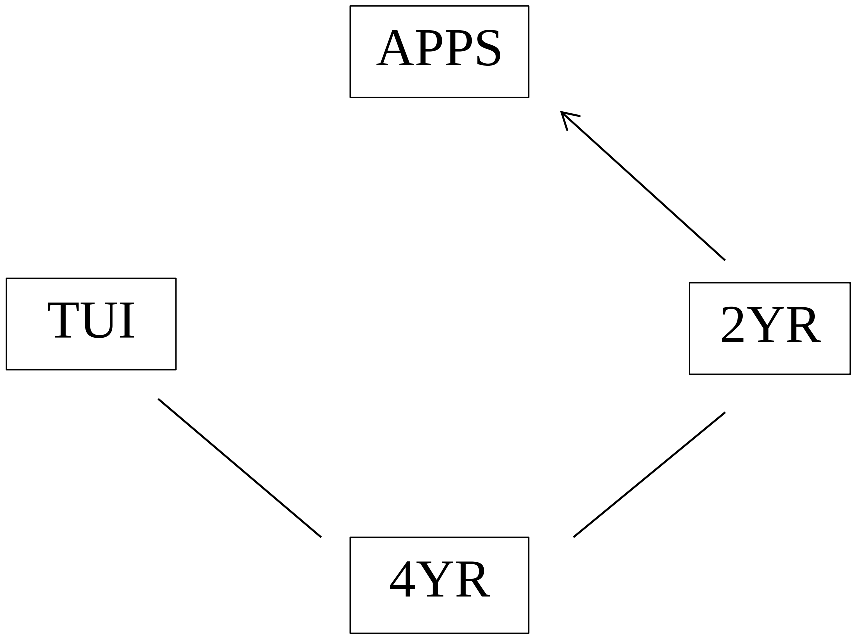

Figure C3. Directed Graph for ED College.

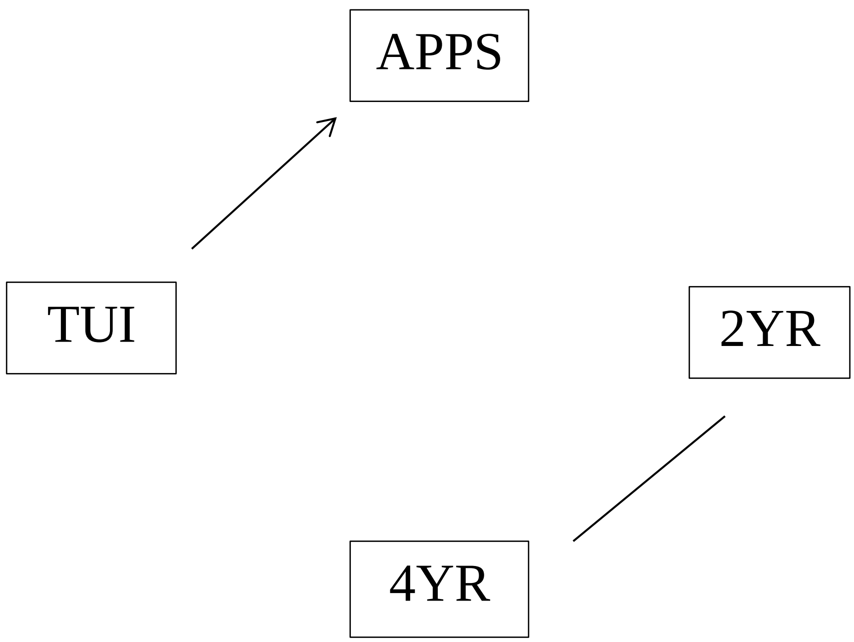

Figure C4. Directed Graph for EN College.

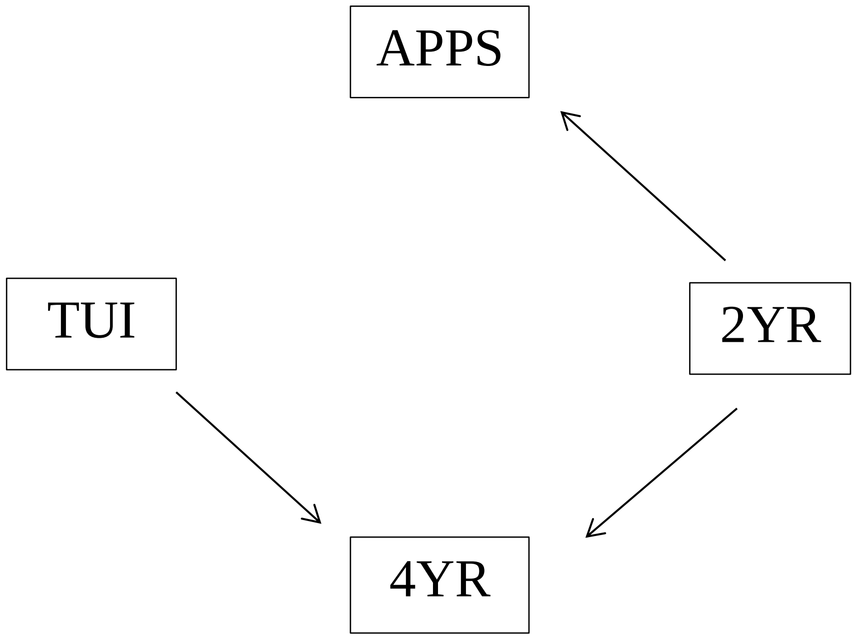

Figure C5. Directed Graph for GE College.

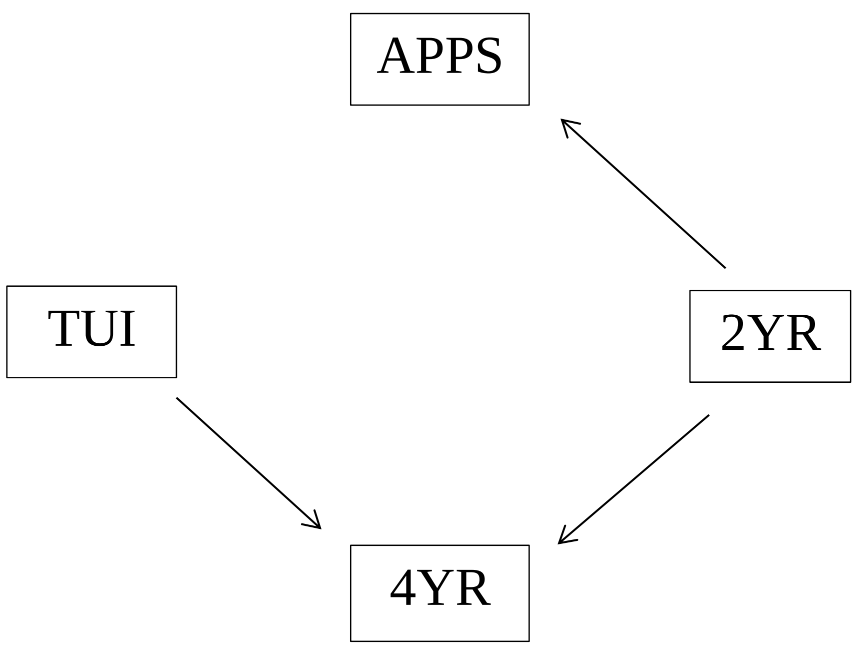

Figure C6. Directed Graph for LA College.

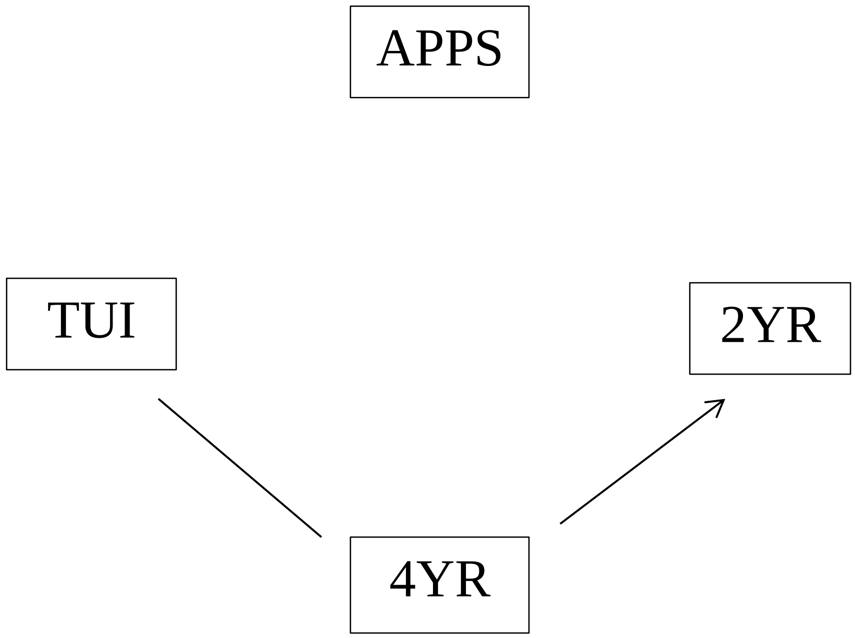

Figure C7. Directed Graph for BA College.

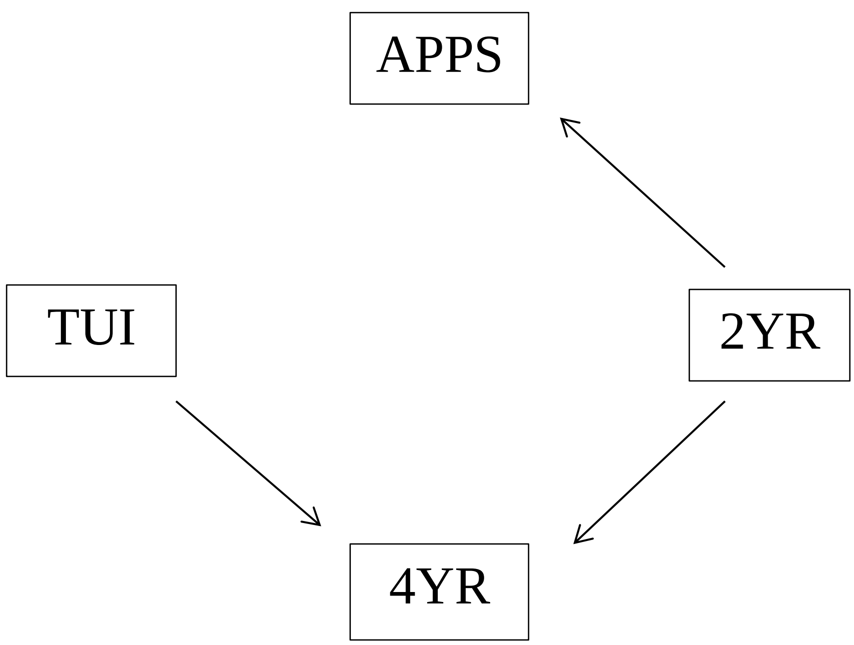

Figure C8. Directed Graph for SC College.