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Individual and aggregate demand for higher education: the role of strategic scholarships

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Individual and aggregate demand for higher education: The role of strategic scholarships

by

Darin Ray Wohlgemuth

**A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of**

DOCTOR OF PHILOSOPHY

Major: Economics

Major Professor: Peter F. Orazem

Iowa State University

Ames, Iowa

1997

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Major Professor

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For the Major Program

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For the Graduate College

to Deanna
my best friend

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ABSTRACT

Undergraduate enrollment increased over 50 percent nationally from 1973 to 1994. The proportion of high school graduates enrolling in college increased from 46.6 to 61.9 percent. These increases occurred despite increases in real tuition prices since 1985, constant (nominal) levels of federal Pell grants per recipient, and declining numbers of high school graduates. This dissertation examines the admitted applicant's decision to enroll and aggregate (state/county) enrollment at a large public institution.

The aggregate enrollment model investigates the extent to which national trends in enrollment can be captured within the context of a model of enrollment demand at a specific university. State or national data sources do not allow sufficient time-series to test competing explanations for the increasing enrollment rates. A two stage process models the decision to attend a university as the product of the probability of attending college and the probability of attending the specific institution, conditional on college attendance.

Analysis of college enrollment aggregated to the state or county level reveals that increased per capita income and increased expected returns to higher education have played major roles in increasing college enrollments. These factors led to rising college enrollments, even as rising tuition lowered college incentives. The model finds freshmen enrollment is negatively related to price and distance, with an inelastic own-price response.

The individual level model determines the applicant's reservation price. Four issues are discussed. 1) Can increases in tuition be offset with equal increases in grant aid? 2) Holding the probability of enrollment constant, how much must tuition increase to increase a desirable

student attribute (academic ability, protected group status)? 3) How can institutions maximize revenues by price discriminating, and do they? 4) Based on computed reservation prices, what are the characteristics of the demand curve for the institution?

The probit estimates reveal that the response to tuition is larger than grant aid and women, minorities, and high ability students have higher reservation prices. The last dollar of grant aid decreases net revenue by more than one dollar and the institution is not maximizing revenue. Finally, the own-price elasticity in the individual level model is also inelastic.

CHAPTER 1

THE DEMAND FOR HIGHER EDUCATION

Introduction

The decision to invest in a college education is both important and complex. In the past 20 years real tuition at public institutions increased nearly 50 percent. The President's budget request for the federal Pell Grant Program in 1998 is \$7.6 billion. This is more than 3 times the 1980 allocation of \$2.4 billion (U.S. Department of Education, *State Tables for Formula-Allocated and Selected Student Aid Programs, by Program Fiscal Year 1998*, June 1997). However, the average Pell Grant declined by more than \$100 in real terms from 1980 to 1993.¹ Thus, the budget increase reflects an increase in the number of Pell grant recipients and not an increase in the size of the individual Pell Grant. These factors lead to increased costs of attending college. In spite of the increased costs, the proportion of high school graduates going directly to college has increased from 46.6 to 61.9 percent and college enrollment has increased by more than 50 percent over the past 20 years (U.S. Department of Education, *Digest of Education Statistics*, 1996).

The median salary of college graduates in 1995 was 85 percent above the median salary of high school graduates. In 1973, the college wage premium was only 36 percent. Topel (1997) and Katz and Murphy (1992) examined the relationship between enrollment in higher education and the wage gap of college and high school graduates. Both use a straightforward

¹ The average nominal Pell grant increased from 883 to 1,606 from 1980 to 1993. (U.S. Department of Commerce, *Statistical Abstract of the U.S.*, 1996)

supply and demand framework, where changes in the relative supply of inputs (high skilled workers relative to low skill workers) leads to declines in the relative wage (high skilled wage over low skilled wage). They also examine changes in the relative demand for high versus low skilled labor. Changes in the relative demand for skilled labor are caused by biased technological change in production (toward high skilled jobs), changes in trade patterns (away from low-skilled jobs), and changes in consumer demand for "skill-intensive products". These papers found that the best explanation for the simultaneous increase in the college wage premium and the number of college graduates since the 1980s is that the growth in the demand for educated labor has been larger than the growth in the supply.

There are important policy related questions regarding higher education at the state and federal level. The affordability of education is of particular interest at the federal level. Congress recently approved the President's "Hope Scholarship", which provides a tuition tax credit for low and middle income families for the first two years of college education. As noted above the federal government spends over \$7 billion on the Pell Grant Program, which targets grant dollars to low and middle income students. This does not include the federal work-study or loan programs, which have even larger appropriations. William Bennett, former secretary of education, raised the issue that increases in federal support of higher education have merely allowed institutions to raise their prices (McPherson, Schapiro, and Winston, 1989). It is important to understand the enrollment affects of these changes in federal support for higher education. If former Secretary Bennett is correct, the presumed increase in enrollment of low and middle income students from these policies is likely to be

overstated.

Individual institutions also have a keen interest in understanding the students' decision to enroll in college. In the face of restricted state and federal funding for higher education, the public institutions are under increased pressure to generate revenues from tuition. Recent press reports indicate that a 3.9 percent increase in tuition at the Iowa Regents institutions will lead to an \$8.1 million increase in tuition revenues (ISU Daily, Sept. 8, 1997). Presumably, the revenue calculations are based on some notion of the underlying price elasticity of demand for higher education at the Regents schools.

Universities may have objectives aside from increasing revenues from tuition. Improving the educational environment by increasing the number of academically gifted students on campus, or increasing the enrollment of traditionally under-represented groups are two possible institutional goals. To achieve these goals, universities can engage in the strategic allocation of financial aid, to increase the probability that a certain type of student will enroll.² It is important that the institution be well informed about the impact on revenue and enrollment from changes in policy, such as an increase in price. It is also important that institutions understand how various groups are likely to respond to changes in the net price of attending college.

Using the framework formalized by Becker (1964), this research examines the enrollment demand for a Midwest land grant institution, Iowa State University. Chapters 2 and 3 examine aggregate first-time freshmen nonresident and resident enrollment at ISU, by state

² See "Expensive Lesson: Colleges Manipulate Financial Aid Offers, Shortchanging Many." The Wall Street Journal, A7, April 1, 1996.

and county, respectively. Undergraduate enrollment and the number of admission applications are also examined to test the robustness of the first-time freshman enrollment results. Modeling the decision to enroll as a two stage process, the factors that influence the decision to attend college are separated from the factors that influence choosing to enroll at Iowa State. Recommendations for optimal tuition policies and their impact on revenues and enrollment are discussed.

Chapter 4 presents a model of the individuals' decision to enroll at Iowa State. The empirical results are discussed in Chapter 5. Using admissions and financial aid records of admitted applicants, these chapters examine the factors that influence the probability of enrolling at ISU. Four questions are examined in light of the empirical results. First, What is the students' response to a change in tuition versus a change in financial aid? Next, the model gives insight into the cost of targeting specific characteristics. For example, What is the required change in scholarships to increase the ACT score by one at ISU, holding the probability of enrolling constant? Third, To what degree is the university using targeted aid to achieve their enrollment objectives? This question is examined by comparing revenue measures across student groups. Finally, the model determines the " α -level reservation scholarship", or the minimum scholarship necessary to set the probability of enrolling to at least α . The expected enrollment demand curve for the institution is mapped out using the individual's reservation price.

The remainder of Chapter 1 is organized as follows. The next section presents some important trends in the demand for higher education. The third section in Chapter 1 provides

a brief literature review of the demand for higher education.

Overview

The decision to enroll in a particular college depends on several factors. Prospective students have many options: community colleges, 4-year schools in and outside their home state, private colleges, or work. Prospective college students and their parents consider the student's human capital acquired in elementary and secondary school, the quality of the post-secondary institution, the family's resources, current information on returns to college, and the cost of attending the institution. Enrollment levels will be influenced by the individual factors mentioned above as well as by the population of potential college students. The latter is often measured by the size of the high school graduating class. This section discusses the time paths of these factors on a national level. The time paths specifically for ISU, the state of Iowa, and the states bordering Iowa are discussed in Chapters 2 and 4.

The national case

The majority of undergraduate students enter college directly from high school. In 1993, 62.3 percent of the U.S. undergraduates were under age 25 (U.S. Department of Education, *Digest of Educational Statistics*, 1995). The size of the high school graduating class is a good indicator of the potential size of the market for undergraduate education. Figure 1.1 shows the national trend of public high school graduates.³ Nationally, the high school graduating class peaked in 1976. The decline since then has been moderated somewhat by a decline in high school dropouts from 15.7 percent in 1973 to 12.7 percent in 1993 (U.S.

³ A consistent series for private and public high school graduates by state is not available.

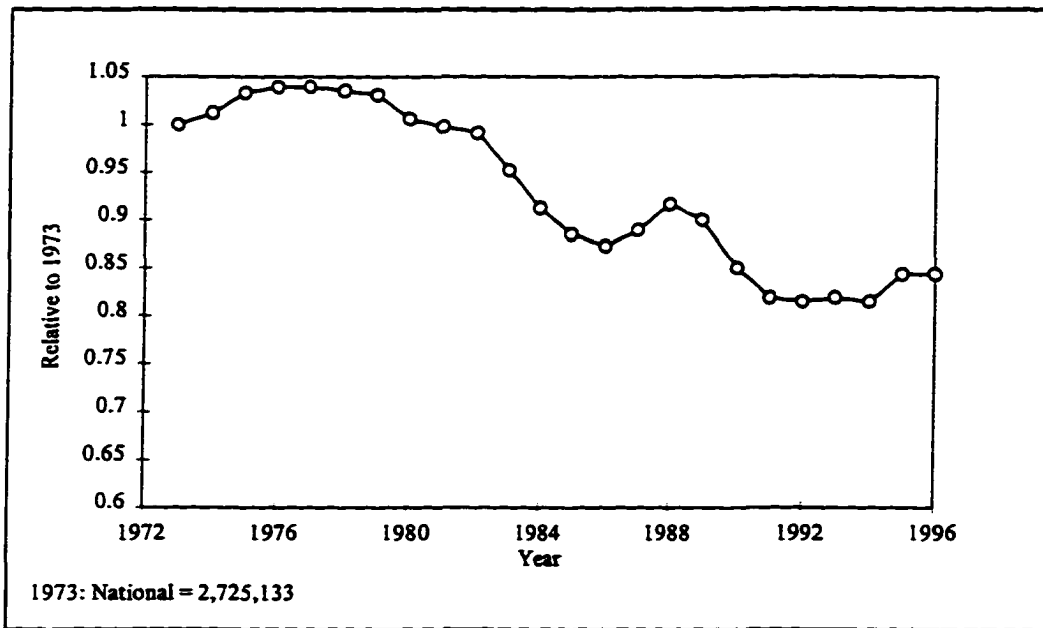


Figure 1.1: High school graduating class size in the United States, 1973-1996.

Department of Commerce, *Statistical Abstract of the United States*, 1995). Nevertheless, it is clear that colleges and universities have faced declining market size as measured by new high school graduates. While nontraditional students represent a growing segment of the market, they may not make up for the decline in high school graduates. Increased college enrollments in the face of rising real tuition suggest that there must have been a dramatic outward shift in demand for college services that has counteracted the declines in supply of high school graduates.

One factor that would lead to an outward shift in the demand for higher education is an increase in the returns to a college education. Returns to college are measured by the ratio of median salary of college graduates to median salary of high school graduates. The time path of this ratio is shown in Figure 1.2. Clearly earnings from a college degree have grown faster than earnings from a high school degree. The ratio of college to high school salaries has

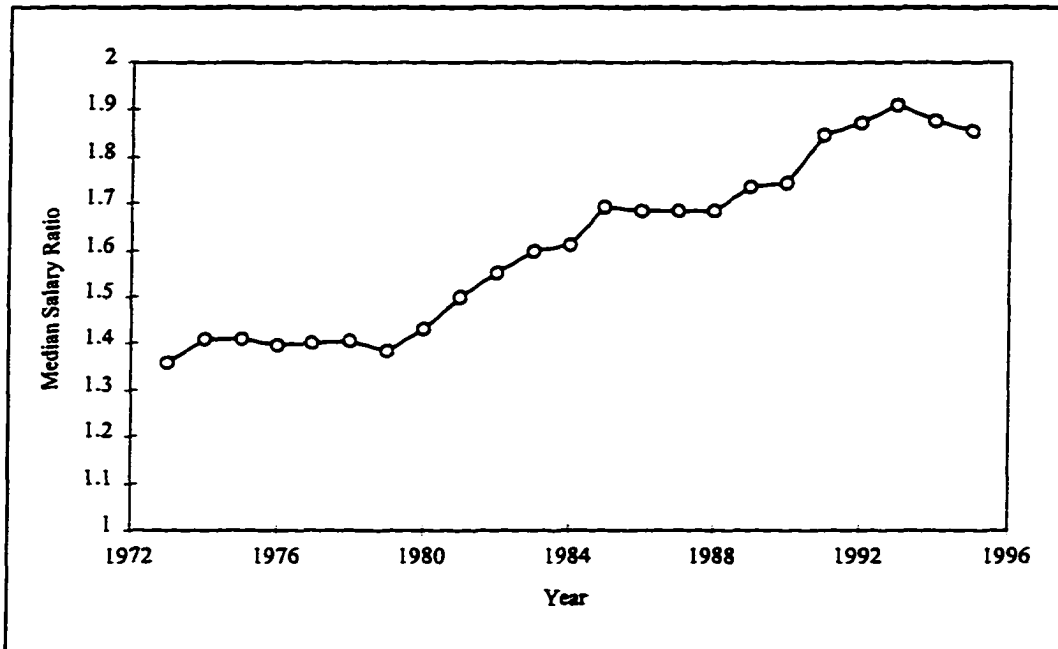


Figure 1.2: Ratio of national median college salary over national median high school salary, 1973 - 1995.

increased from 1.36 in 1974 to just over 1.85 in 1995. This would be consistent with an upward shift in the demand for higher education in general.

Increases in income may also lead to increased enrollment, as more families are able to pay tuition. National average per capita income was relatively stable from 1973 to 1983, but has increased since then. As shown in Figure 1.3, 1994 per capita income was 22 percent above the 1973 level. If higher education is a normal good, then an upward trend in income would cause an outward shift in the demand for higher education over time. Empirical research to date, reviewed in the next section, overwhelmingly found positive income elasticities, supporting the presumption that investment in higher education is a normal good.

Another factor that would lead to an increase in the number of students entering college is the degree of preparation provided at the primary and secondary levels. Schools with better

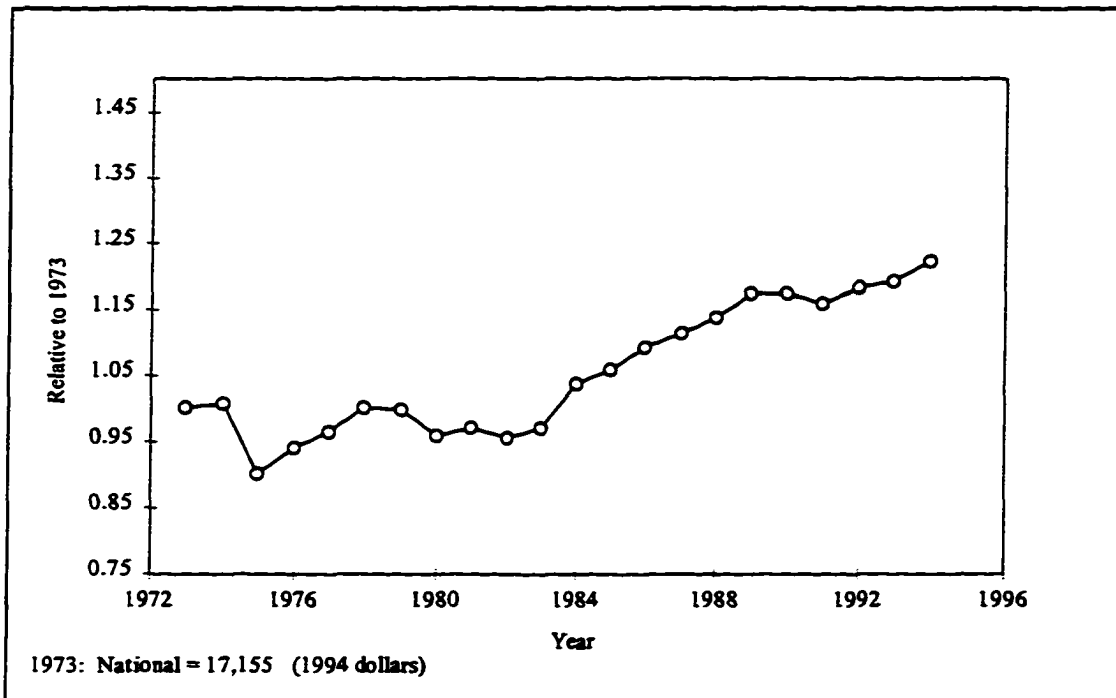


Figure 1.3: National average real per capita income, 1973-1994 (in 1994 dollars).

technology and better equipped teachers may produce better prepared students. These students may have less difficulty succeeding in college, and as a result, may be more likely to attend. The link between spending per pupil and achievement is debated in the literature on education production functions. For example, Hanushek (1986, 1996) argued that the correlation between per pupil spending and the quality of the education is weak. On the other hand, McPherson et al. (1993) indicated that expenditures may be an appropriate measure of school quality in some aggregate studies. Card and Krueger (1992, 1996) also showed a link between dollars per pupil and lifetime earnings.⁴ Figure 1.4 shows that real per pupil spending on public elementary and secondary education (labeled primary) increased in 15 of

⁴ Instead of per pupil spending, Card and Krueger (1992) use teacher/pupil ratios and average teacher salary as quality measures.

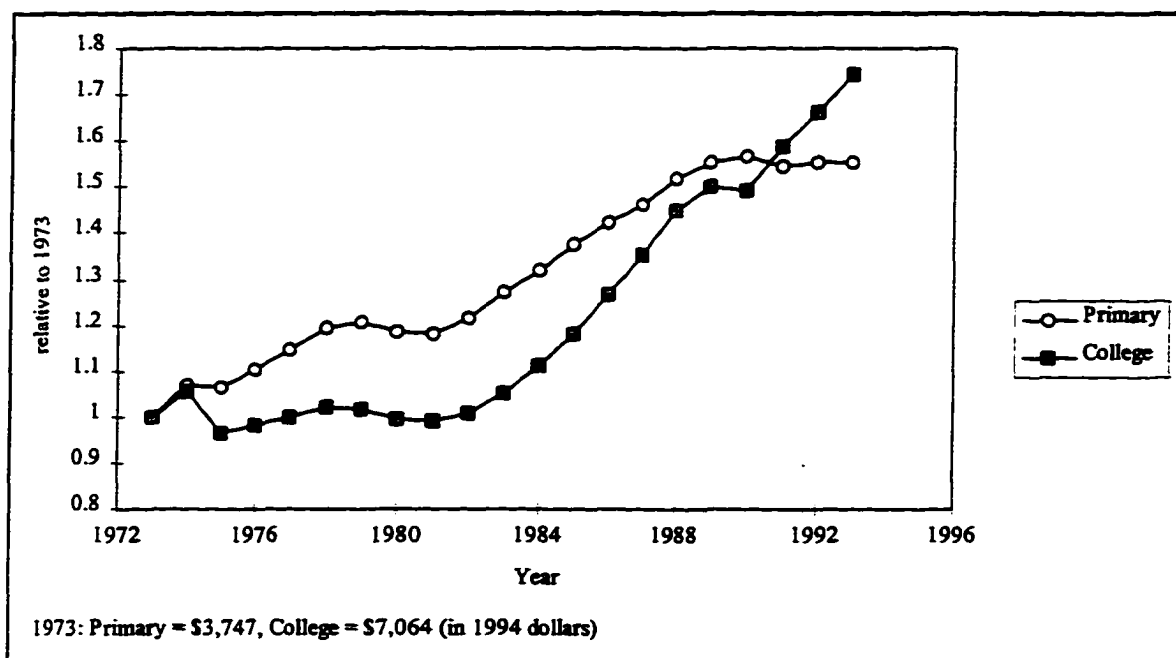


Figure 1.4: Average of current fund expenditures per pupil in public elementary and secondary schools (by state). Average of current fund expenditures in public institutions of higher education over the sum of the previous 4 years of high school graduates (by state), 1973 - 1993.

17 years between 1973 and 1990, before leveling off in the 1990s. The 1993 level is approximately 55 percent above the 1973 level.

Expenditures at public institutions of higher education may also influence the demand for their services. An institution with better facilities, newer equipment, or more student services will be more attractive to prospective students. These state expenditures on public higher education are a subsidy for resident students. This subsidy can be viewed as being offered exclusively to residents because nonresident students face significantly higher tuition. Figure 1.4 shows that state subsidies for higher education were relatively constant from 1973 to 1982.⁵ Since 1982, the spending has increased dramatically. In 1993, spending was 75

⁵ This measure is converted to "per pupil" by dividing current fund expenditures by the sum of 4 previous years of high school graduates.

percent above the 1973 level. The increased subsidy would also cause the demand curve for educational services to shift outward.

Assuming the law of demand holds in the undergraduate education market, the price of obtaining a college degree would also have an impact on enrollment. Figure 1.5 shows average public 4-year tuition rates from 1973 to 1995. The average U.S. resident real tuition fell 32 percent from 1973 to 1980. Since 1980, tuition has increased steadily and is currently 27 percent above the 1973 level.

First-time student enrollments at 4-year institutions in the U.S. are shown in Figure 1.6. The series has three peaks: 1975, 1980, and 1988. First time student enrollment in 1992 is 702,000, almost equal to 1973 level. For the purposes of this section, the most important characteristic about the pattern of first-time freshman enrollment is that it does not mimic the time path of high school graduates. First-time student enrollment is above the 1973 level for all years in the sample. However, the number of high school graduates has decreased since 1977. Clearly, the number of first-time freshmen enrolling in college is being influenced by more than just demographics. The impacts of these factors on enrollment will be discussed at the aggregate level in Chapter 2 and at the individual level in Chapter 3.

Review of Literature

The economic study of investment in higher education was formalized by Gary Becker's *Human Capital* (1964). This provided a framework in which the decision to invest in training could be analyzed. Becker's model provides the theoretical framework for examining all types of human capital investment, from formal high school or college

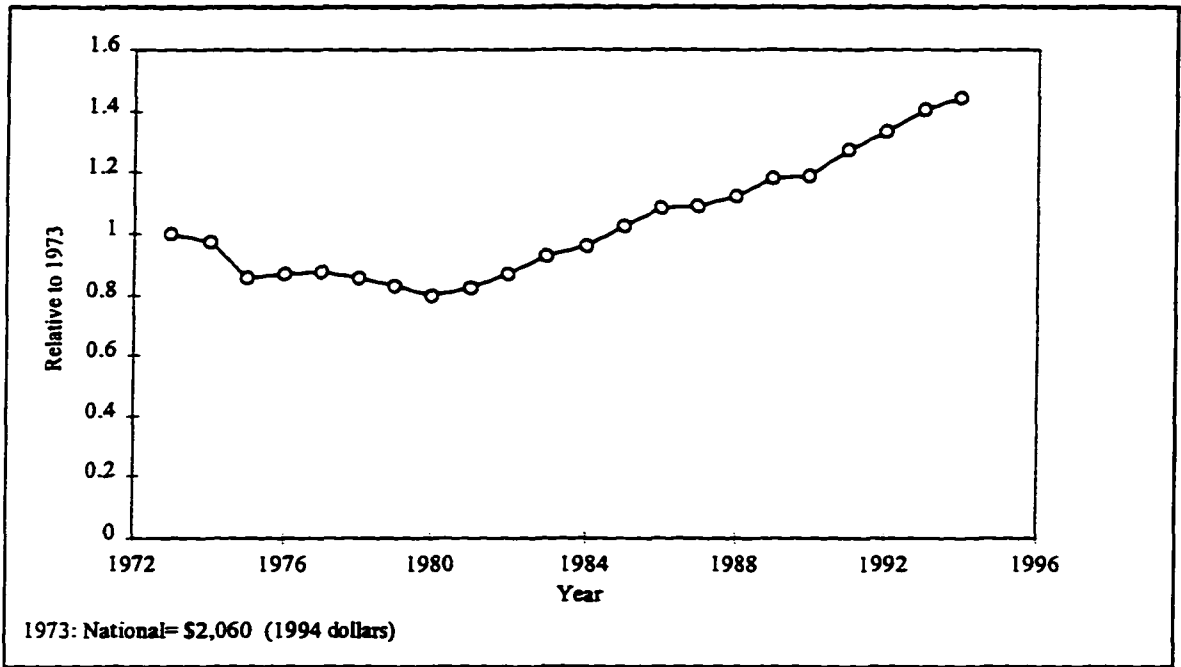


Figure 1.5: Real national average resident tuition, 1973-1994 (in 1994 dollars).

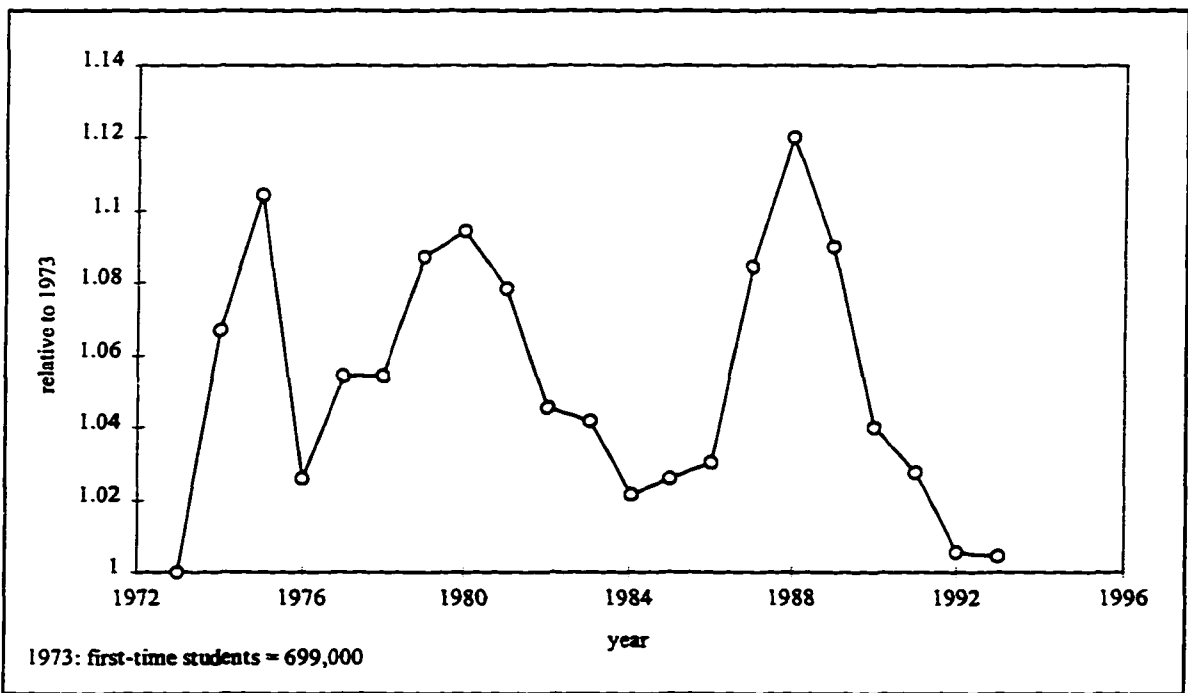


Figure 1.6: National first-time enrollment in 4-year public institutions, 1973 - 1993.

education to on-the-job training. This review focuses on the choice to invest in formal training, specifically the decision to invest in higher education.

The body of literature since Becker's seminal work is large and diverse. For this review, the literature is categorized into 2 groups, those dealing with aggregate enrollment and those dealing with an individual's decision to enroll. The first group uses enrollment levels or proportions to examine national, state, or institutional enrollment. The second group utilizes individual student data to examine the decision to invest in higher education. A common element in most of this literature is the effect of price and income on enrollment in higher education. In simplified form, most studies can be characterized with a regression model of the following form.

$$E = \beta_0 + \beta_1 T + \beta_2 I + \mathbf{X}\mathbf{B} + \varepsilon \quad (1.1)$$

where

E = enrollment, or share of population enrolled

T = tuition or cost of attending college

I = family income

\mathbf{X} = vector of individual, economic, and/or institutional factors that influence enrollment

ε = random error term

Aggregate college enrollment literature

This section reviews the empirical literature that examines the demand for higher education at an aggregate level. These studies use actual enrollment or the share of enrollment as their dependent variable. Table 1.1 summarizes the price and income

Table 1.1: Price and Income elasticities of aggregate studies of demand for higher education

Study	Period	Method	Type	Price Elasticity	Income Elasticity
National Enrollment Studies					
Campbell & Siegel (1967)	1919 - 64	linear regression	all 4 yr institutions	-0.44	1.20
Galper & Dunn (1969)	1919 - 64	distributed lag	all institutions		0.69
Hight (1975)	1927 - 72	linear regression	public institutions	-1.058	0.977
Kim (1987)	1958 - 82	translog - LES	national income accounts	-1.31	1.34
State Enrollment Studies					
Lehr & Newton (1978)	1960 - 74	linear regression	Oregon Freshmen	-0.659	1.88
Strickland et al. (1984)	1980	GLM	Virginia Freshmen	-1.51	0.023
Individual Institution Studies					
Hoernack (1971)	1967	linear regression	California Freshmen	-0.85	
Hoernack & Weiler (1975)	1948 - 72	linear regression	College of Liberal Arts Freshmen, MN	-1.2	> 0
Chressanthis (1986)	1964 - 83	linear regression	SVSC freshmen	-1.74	3.38
Parker & Summers (1993)	1988 - 90	linear regression	82 selective liberal arts colleges	-0.36	

elasticities of the studies discussed here. Enrollment analysis at the national, state, and institutional levels are present in this section.

National enrollment studies

Early research on the demand for higher education nationally was conducted by Campbell and Siegel (1967) and Galper and Dunn (1969). Campbell and Siegel (1967) examined the rate of return to higher education. The model used in their analysis is straightforward. The enrollment ratio is a function of disposable household income and tuition. They estimated the own-price elasticity of national college enrollment to be -0.44 . Their income elasticity was 1.23.

Galper and Dunn (1969) were primarily interested in estimating the impact of the G.I. bill and the size of the armed forces in general on college enrollments. Their reanalysis of Campbell and Siegel's data yielded an income elasticity of 0.69. They found that the size of the military negatively influenced college enrollments (elasticity of -0.26) and that the number of discharges was positively (elasticity 0.13) related to the enrollment rate over the period. Galper and Dunn (1969) also estimated the elasticity of college enrollments with respect to the high school graduates at 0.94. Thus, college enrollments move in near direct proportion to high school graduating class sizes. This supports the notion that a good measure of the eligible population of college freshman would be the number of high school graduates.

Corazzini, Dugan, and Grabowski (1972) examined the enrollment rate of high school graduates by state. They included four distinct tuition measures: junior college, public

university, teachers colleges, and private schools. They found that these four tuition measures negatively influence enrollment rates across most income quartiles. The three exceptions were teachers colleges for the second income quartile, and junior college and private college for the highest income quartile. The price coefficient for public institutions was 3 times larger than the response for private schools, -0.027 and -0.009, respectively. They state that the impact of a \$100 decrease in tuition in 1963 is associated with a 2.65 percent increase in the nation's enrollment.

Corazzini et al. (1972) showed that the average education level of the father and the states' college enrollment rate are positively related. They include the unemployment rate as a proxy for the opportunity cost of attending college. Corazzini et al. found that the unemployment rate was negatively related with enrollment for the two lowest income quartiles and positively related for the two highest income quartiles.

Hight (1975) examined enrollment in public and private institutions separately. Jackson and Weathersby (1975) report that the own-price elasticities estimated from Hight (1975) were -1.058 and -0.64 for public and private institutions, respectively. He used tuition minus the average financial aid award for public and private colleges as the price of attending college. Using disposable family income he found the income elasticities of 0.977 and 1.70 for public and private schools, respectively. The cross-price effects (public tuition for private enrollment and vice versa) were both positive. Therefore, public and private school enrollment are substitutes for one another.

Hopkins (1974) divided the impact of a tuition change into two parts, a substitution effect

(students enroll in another college), and a discouragement effect (students do not enroll).

Hopkins examined the enrollment rates by state for the 1963 - 64 academic year. Consistent with economic theory and other literature, Hopkins found the own-price effects were negative for public and private enrollment, and the cross-price effects were positive. This indicates again that public and private school enrollment are substitute goods. He also found that public school enrollment was an inferior good but that private school enrollment was a normal good.

Kim (1987) used national income accounts data from 1958 - 82. He estimated price and income elasticities for private spending on education. Kim found an elastic price response, -1.31, and an income elasticity of 1.34.

McPherson and Schapiro (1991) examined enrollment across the United States to see if the goal of "promoting the enrollment of the less-affluent students" has been achieved by targeted aid from the federal government (McPherson and Schapiro, 1991. p.309). They examined enrollment rates of 6 subgroups (3 income groups across public and private school enrollment) as well as differences in gender. The results were reported for whites only because of the small sample size of minority students in the CPS data series at their level of aggregation. They found that increases in the net cost of attending college had a negative and significant effect on enrollment rates of low-income students. McPherson and Schapiro also found that the enrollment rates of the high-income groups had not declined as a result of the increased college costs. There was not a significant gender effect on enrollment across the income groups, but the enrollment rate was about 5 percent higher for women than men.

State enrollment studies

Two studies used enrollment data restricted to a single state. Lehr and Newton (1978) examined freshmen enrollment in Oregon from 1960 - 74. The explanatory variables used were tuition, per capita income, unemployment rate, size of the armed forces and the number of high school graduates. The price elasticity was -0.659, in the inelastic range. Oregon higher education was found to be a normal good, with an income elasticity of 1.88. Freshmen enrollment changed in almost direct proportion to the changes in high school graduates (elasticity 1.08). Lehr and Newton also found that the unemployment rate and the size of the armed forces had positive effects on freshmen enrollment.

Strickland, Bonomo, McLaughlin, Montgomery, and Mahan (1984) examined 1980 enrollment for the state of Virginia. The goal of their research was to explain the ratio of enrollment (enrollment over high school graduates) by geographic area (county and city level analysis). Along with the usual price and income measures they also included the wage rate, the unemployment rate, and educational attainment of the area. The estimated price elasticity for all institutions was -1.51. The income elasticity was 0.023, but not statistically significant. They hypothesized that the income effect enters the enrollment decision through the cost factors and that the income effect may be clouded by the educational attainment variables.

Individual institution enrollment studies

The final group of aggregate demand studies investigated enrollment at a specific institution. These include studies of enrollment demand at UCLA (Hoenack, 1971), the

University of Minnesota (Hoenack and Weiler, 1975), and Saginaw Valley State College (Chressanthis, 1986).

Hoenack (1971) reviewed the enrollment of California High School graduates at UCLA. Since there was no variation in the price of enrolling across high schools, he used the distance from the high school to the main campus (UCLA) as a cost of enrolling in college. The price elasticity of the entire sample was -0.85. The low income quartile had a price elasticity of -1.12, while the high income quartile had an inelastic response of -0.71. He noted that other California state colleges are close substitutes and that their prices are correlated. Therefore, this elasticity represents the enrollment response of all institutions increasing price, and not the specific institution in isolation.

Hoenack and Weiler (1975) examined the enrollment implications of a cost-related tuition policy at the University of Minnesota. The time-series analysis at the University of Minnesota, College of Liberal Arts found that the demand was elastic, -1.2. They used the distance to each campus to account for variations in the price of attending, since the prices were highly correlated. This is a common problem among studies that examine enrollment at public institutions, since prices at several public institutions within a state are often set by a common governing body, such as a Board of Regents.

Chressanthis (1986) examined enrollment at Saginaw Valley State College, a public four-year school northwest of Detroit, Michigan. He included the usual regressors of tuition, income, and unemployment rate. He also included the prices of attending the other institutions in the area. The own-price elasticity was rather large, -1.74. Enrollment in

SVSC had a very large income elasticity, 3.38. As Chressanthis stated, SVSC is located in an industrial manufacturing area, where higher education was traditionally less important because of the availability of blue collar jobs. The four cross-price effects in Chressanthis had mixed signs. Therefore, some institutions act as substitutes for SVSC (Michigan State University) and others as complements (Delta College, a two-year community college). SVSC has a large number of juniors that transfer after their sophomore year at Delta College. Thus, as tuition at SVSC increased, more students choose to attend Delta College for the first two years instead of SVSC.

Chressanthis (1986) examined the response to price as students progressed in school. He found that freshmen were the most responsive (-1.74) and that seniors were the least responsive (-0.59). The own-price elasticity for juniors was positive (0.45) and significant. However, this may be due to the large number of transfer students who enroll in SVSC after completing 2 years at Delta College.

Finally, Parker and Summers (1993) examined the share of admitted applicants who choose to enroll at 82 selective colleges. They estimated separate equations for the groups of students who applied for financial aid and those who did not apply. Parker and Summers found negative elasticities of tuition and room and board for both groups. Their cost measure was the own-tuition relative to the average tuition at all 82 institutions. The elasticities for the aid and non-aid applicants were -0.48 and -0.36, respectively. This indicates that students who apply for financial aid are more sensitive to the price. Parker and Summers used the SAT score as a quality measure. They found that the proportion of financial aid applicants

who enrolled was negatively related to the SAT score. However, among those who did not apply for financial aid, the share enrolling was positively related with the SAT score.

The aggregate studies of the demand for higher education found negative price elasticities and positive income elasticities. The price elasticities are in both the elastic and inelastic ranges. However, there have been significant changes in the economic incentives to enter college, as addressed in the overview of this chapter and in work by Topel (1997) and Katz and Murphy (1992). The relationship between the recent increase enrollment and the changes in the incentives to attend college should be examined.

Individual's college enrollment decision

The second section reviews studies of the decision to invest in higher education at an individual level. Typically, this group of empirical work uses discrete choice models to examine the enrollment decision. Much of the research uses longitudinal data or a survey specifically designed for the institution. Within this group two types of analysis exist, the decision to enroll at any institution, or the decision to enroll at a specific institution versus some alternative or set of alternatives.

General college enrollment

Manski and Wise (1983) presented a 5 stage sequential model of the entire process of investing in higher education. This is an extremely comprehensive model of the college investment decision. The first stage examines the decision to apply for admission. Stages 2 and 3 are made by the institution, admittance and financial aid. In stage 4, the student decides at which institution (if any) to enroll. Finally, Manski and Wise model the

persistence decision of the college student.

Manski and Wise (1983) used the National Longitudinal Study of the High School Class of 1972 (NLS_72) to test their model. A few of their results are repeated here. These calculations hold all other characteristics fixed at the sample mean values. They found that the probability of attending college increased from 34 percent to 82 percent when the SAT score increased from 700 to 1300 (with Rank = 100). Similarly, as class rank moved from 25 to 100 (with SAT = 1300) the probability of enrolling increased from 43 percent to 82 percent (See Table 1.6, Manski & Wise, 1983, p. 6). Increases in the parents income increased the probability of applying to college and the probability of enrolling, but decreased the probability of dropping out. Manski and Wise estimated the probability of enrolling and persisting in college across race and region. Minorities in the south had a 45 percent and 68 percent probability of enrolling and persisting, respectively. Whites in the south were less likely to enroll (20 percent probability) and less likely to persist (42 percent) (See Table 1.9, Manski and Wise, 1983, p. 17).

The price effects measured by Manski and Wise were reported as the change required to make the individual indifferent between the status quo and a \$100 per month decrease in tuition. They found that tuition reductions were equivalent to: A reduction of equal size in scholarships, an increase of equal size in room and board fees, a decrease in expected labor force earnings of 2.5 times the change in tuition, and an increase in the average SAT score at the school when the student's score is above the average. "Also, a \$100 per month decrease in tuition at a four-year college for a student whose family income is \$10,000 is

approximately equivalent to a \$300 per month decrease in tuition at a four-year college for an individual whose family income is \$30,000 per year.” (Manski and Wise, 1983, p 20)

Fuller, Manski, and Wise (1982) presented stage four of the above model: the college choice decision. The NLS_72 data allowed them to estimate a multinomial logit model with the following dependent variables: (i) all colleges to which the individual was admitted, (ii) open enrollment schools in the area, (iii) labor force participation, and (iv) military service, homemaking and part-time school/work alternatives. They found that the tuition of each institution had a negative impact on the probability of choosing that alternative. The own-price elasticity of enrollment was -0.23, given application and admission. Fuller et al. also estimated the impact of financial aid scholarships to be positive.

Savoca (1990) examined the decision to apply to college with the NLS_72 data. She included male and white dummy variables to account for the presence of affirmative action in the probability of being admitted. She states that “in the presence of affirmative action efforts the probability of admission may be higher for a nonwhite or a female student.” (Savoca, 1990. p 125)

Savoca (1990) estimated that controlling for the probability of applying, the price elasticity was twice as large as previous work. She estimated the elasticity of applying was -0.26. Taking the own-price elasticity of enrolling (-0.23), estimated by Fuller et al. (1982), Savoca indicated that the sum of these two elasticities (-0.49) would be the unconditional own-price elasticity. The income elasticity of the application decision was positive and relatively small (0.24).

Weiler (1996) utilized data from the 1993 "College Board Admitted Student Questionnaire Plus" to study the enrollment choices of high ability students. The survey provides student rankings of at least two colleges where the student was admitted. It also includes socioeconomic data such as gender, ethnicity, family income, home address and SAT score. As in Savoca (1990), Weiler included dummy variables for males and minorities. Weiler found that students place equal weight on the academic and non-academic considerations in the enrollment process. These non-academic factors include such items as availability of housing and recreation facilities. Instead of including a net price, Weiler included the student's opinion regarding the price at the institution. As would be expected, if the student indicated the net price was high, they were much less likely to enroll. If the respondent indicated costs were moderate, the impact was still negative, but smaller in magnitude. The models reported in the text did not include the race, gender, or financial aid variables.

Specific college enrollment

The second group of literature examining the individual's decision to enroll in college focuses on enrollment at a particular institution. The two papers presented here examined the individual's enrollment behavior at a selective university. Ehrenberg and Sherman (1984) examined the decision to enroll at Cornell University. Moore, Studenmund, and Slobko (1991) replicate the previous model with data from Occidental College.

Ehrenberg and Sherman (1984) examined 1981 freshmen enrollment at Cornell University. The data used in their analysis came from admission and financial aid

applications, as well as a survey mailed to all admitted applicants. This survey gathered data on the other colleges the student was admitted and the financial aid offered by these competing colleges.

A “selective university” is defined by Ehrenberg and Sherman as an institution where the number of applications for admission far exceed the number of available positions. They reported that admission rates at Cornell were approximately 25 percent. Ehrenberg and Sherman modeled the university behavior with a utility function that depends on the number of quality units from each sub-group of enrolled students. A quality unit is defined as the product of the number of admitted applicants, the probability of enrolling (which is an increasing function of the share of costs paid by the university), and the quality of the group of admitted applicants (i.e. academic ability measures such as SAT or class rank, which decrease with the number of students admitted). The general form of the utility function allows the quality units from each group to be weighted to reflect the preferences of the institution. The subgroups included in their model were defined by ethnicity, gender, income class, and being the relative of an alumnus.

Ehrenberg and Sherman (1984) used probit analysis to determine the probability of the individual enrolling at Cornell University. Briefly, they found that males were less likely than females to enroll. Similarly, minorities were less apt to enroll. If the applicant had a parent, grandparent, or sibling who attended Cornell, they were also less likely to enroll. Ehrenberg and Sherman found that as distance to Cornell increases students were less likely to enroll. Finally, if the best alternative school listed by the applicants’ survey response was

an Ivy league school, the student was less likely to enroll.

They discuss six propositions regarding the financial aid policies of the institution. Two are relevant to the current research. First, groups that are more desired by the university should be given a lower net price. Second, groups that are more likely to enroll should be charged a higher price.

Their results “unambiguously suggest” that the high ability students should be charged a lower net price. Among other things, the high ability group tended to have a lower propensity to enroll. Their results supported the notion that minority students should receive larger aid packages, other things equal, “because, in addition to being relatively attractive to the university, minorities have a lower propensity to enroll and a higher elasticity of average quality” (Ehrenberg and Sherman, 1984. p 224). However, minorities did have a lower elasticity of yield, so the policy of a larger financial aid offer was not unambiguously supported. The elasticity of enrollment with respect to the net price was -1.09 in Cornell’s private school and -0.28 in the public school.

Moore et al. (1991) applied the Ehrenberg and Sherman (1984) framework to data from the 1989 applicant pool at Occidental College, a selective liberal arts college. They also had a survey which provided data on the other schools where the student was admitted. They used the logit model to examine the probability of enrolling at Occidental against the best alternative listed on the survey. Moore et al. found the price elasticity over all applicants was -0.72. Their results indicated that minorities and females were more likely to enroll, and that increases in income were negatively related to the probability of enrolling.

The sensitivity to net price was estimated by Moore et al. (1991) across parental income, academic ability, and ethnic groups. The own-price elasticity became more elastic as income increased in all but the highest income group. The own-price elasticity increased from the lowest to the middle range of academic ability, but declined as academic ability moved above the mid-range. The elasticities for minorities and non-minorities were -0.18 and -0.87, respectively.

Moore et al. (1991) extended the Ehrenberg & Sherman (1984) framework by examining the group of students that did not apply for financial aid. They found that the own-price elasticity for this group was much smaller (-0.35) than the group that did apply for financial aid. Within the group of students who did not apply for aid, the price elasticity did not vary across minorities or whites. The students with higher academic ability were more responsive to price.

A financial aid package is made up of a combination of scholarships, loans, and work study funds. Moore et al. (1991) tested for different responses to each type of financial aid. They found that the probability of enrolling respond positively to scholarships, but loans and work-study opportunities had a much smaller effect on the probability of enrollment. They noted that if the federal government continues the shift from grant to loan aid, the institutions would be likely to come up with larger scholarship funds to target their desired students.

Summary

The consensus of the literature is that higher education has negative own-price elasticities and positive income elasticities. This is consistent with the theoretical framework developed

by Becker (1964) and used in most subsequent research. There is not a consensus on the magnitude of the enrollment impact from a price change. In the aggregate empirical research examined here, 4 of the 9 studies had inelastic own-price responses. In the studies of an individual's college decision, most of the studies found an inelastic price response. However, Cornell Universities' public school had an elastic response (Ehrenberg and Sherman, 1984). The income elasticity is much the same. The conclusion can be drawn that higher education is a normal good, however, there is no clear evidence that it is a necessity or luxury good.

The current research fills several gaps in the literature. The studies of a student enrolling at a specific institution (Ehrenberg and Sherman, 1984 and Moore et al. 1991) examined "selective" universities. The institution examined in this research is a large public institution, with a comparatively open enrollment policy. Iowa State University admits nearly 75 percent of the applicants. Chapters 4 and 5 study enrollment at Iowa State University from 1976 to 1994, the two papers mentioned above used enrollment records for a single year.

The individual level analysis also provides a method of examining institutional enrollment without a survey of the admitted students. While there is certainly valuable information that can be gathered from such a survey, it is costly to undertake. This research examines if a model of enrollment behavior can be consistent with economic theory and previous research without the beneficial, but costly survey.

The current aggregate research is also both time-series and cross-sectional. Previous work examined does not allow cross-sectional variation, since enrollment was aggregated to the national, state, or institutional level. The current aggregate work examines enrollment

from 49 states and 99 counties over a 20 year period. The current research tracks the enrollment impact of increased returns to college, increased family income, increased real tuition, and declining high school graduating class sizes over the past 20 years. National enrollment effects are separated from the institution specific effects using the two stage decision process in Chapter 2.

This research provides an up-to-date study of aggregate enrollment at an individual institution. The number of students enrolled at ISU from a state or county are examined from 1973 - 93. While the previous empirical research on aggregate enrollment did study large public institutions, they did not make special consideration of the large differences in tuition between resident and nonresident students. Nonresident tuition at ISU is 3 times the resident rate. The dramatic difference in price indicates that resident and nonresident enrollment are separate markets. The current research provides separate analysis of resident and nonresident enrollment.

The purpose of this research is to determine the effect of the factors that influence enrollment, using data for a large public university. Specifically, the response to tuition and scholarships are of interest, since they are frequently choice variables of institutions. The response to a change in tuition is examined at the aggregate level and the individual level.

The implications of this research, while of interest to administration officials at Iowa State University, are useful to those outside ISU. Like ISU, universities across the nation face declining high school graduating classes and increased pressure to generate revenues from tuition. The results from this study should not be used in specific policy

recommendations for institutions other than ISU. However, the general findings presented here aid in our understanding of the enrollment trends over the past 20 years. Together with previous research, this work adds to the understanding of the factors that influence the demand for higher education.

CHAPTER 2**EXPLANATIONS FOR RISING FIRST-TIME STUDENT ENROLLMENTS,
1973-1994: EXTRACTING NATIONAL INFLUENCES FROM LOCAL DEMAND**

Iowa State experienced increasing undergraduate enrollments from 16,605 in 1973 to 21,657 in 1985. Since then, enrollments have fallen to 18,949 in 1995. Increased enrollments occurred, despite a decrease in high school graduates of 20 percent nationally and despite a 63 percent increase in real nonresident tuition. Yet in the face of increased costs and declines in the size of the potential market, ISU has been able to modestly increase total enrollment by 15 percent (Iowa State University, *Enrollment Services Annual Statistical Report*, 1973 - 1995).

Nationally college enrollment has been increasing over the past 20 years, as noted in Chapter 1. This chapter presents a two stage theoretical model of college enrollment for a single institution. It is plausible that the increased enrollments are in response to rising rates of return to college education and increases in real family income over the period. This chapter investigates the extent to which national trends in enrollment can be captured within the context of a model of enrollment demand at a specific university. It also illustrates the impact of university tuition policies on enrollment.

These questions are addressed, using data from Iowa State University. The focus on a single university is necessary because of the lack of consistent time series data on first-time freshman enrollment by state. While data are available at the national level, such aggregate

data make it difficult to distinguish demand-side from supply-side responses or to distinguish among competing trend variables for explanatory power.

Iowa State University, as most public universities, faces two markets for undergraduate education. Nonresident and resident enrollment behave as different goods. The price charged to each group is the most significant indicator that these markets are distinct. The 1994 resident tuition at ISU is \$2,471, while nonresidents were charged \$7,731. Therefore, each market is analyzed separately. Chapter 2 contains the empirical results for nonresident enrollment by state. Chapter 3 presents the county enrollment model for resident students at ISU.

Iowa State might be gaining enrollment from the increased share of students enrolling in college nationally, may be “stealing” potential students away from other institutions or even losing students to other institutions because of the relative increase in tuition at ISU. To address these questions, this paper examines first-time student enrollment, undergraduate enrollment, and applicants for admission for the 49 states and 99 counties of Iowa from 1973 to 1994.

Overview: The Iowa Case

This section reviews the time trends of some of the factors that influence the demand for higher education, as was presented in Chapter 1. However, it is useful to examine the Iowa State University enrollment experience in light of the trends in Iowa, the surrounding states, and the nation. Resident students make up 77 percent of the undergraduate population. The nonresident students from the U.S. account for 17 percent of the undergraduates.

Nonresident demand for Iowa State is disproportionately from the Midwest. Only 22 percent of U.S. nonresident students at ISU come from states that do not border Iowa, and Illinois alone accounts for 43 percent of nonresident freshmen. The new undergraduate students at Iowa State are predominately (68 percent) made up of students who entered the year following high school graduation. Only 13 percent of the undergraduates are over age 25 (ISU Annual Statistical Report, Fall 1995). Therefore, the size of the high school graduating class is a good indicator not only of college enrollment nationally but of the potential size of the undergraduate enrollment at Iowa State.

Figure 2.1 shows the paths of public high school graduating class sizes for Iowa, states that border Iowa and the United States.¹ The decline in graduating class sizes in Iowa and its surrounding states is even steeper than the national trend. In 1973, the Iowa high school graduating class peaked at 44,521. The 1996 Iowa high school graduating class was nearly 30 percent lower. The states that border Iowa have a time trend that lies between the national and Iowa trend.

In 1975, Iowa real per capita income had decreased 15 percent, relative to 1973 (Figure 2.2). In 1983, per capita income was again 15 percent below 1973. The 1994 per capita income, following a steady increase from 1983, is 7 percent above the 1973 level. If higher education is a normal good, then an upward trend in income would cause an outward shift in the demand for higher education over time.

As was true nationally, the real price of tuition rose at Iowa State University over the

¹ The national time-series are repeated in these graphs for comparative purposes.

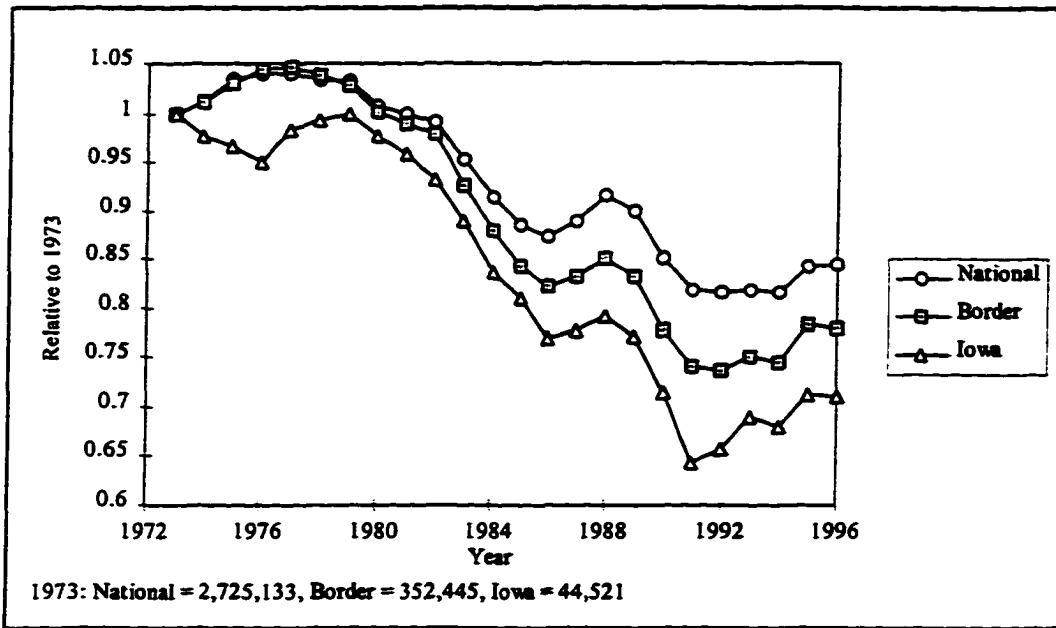


Figure 2.1: High school graduating class size in the United States, states bordering Iowa, and Iowa, 1973-1996.

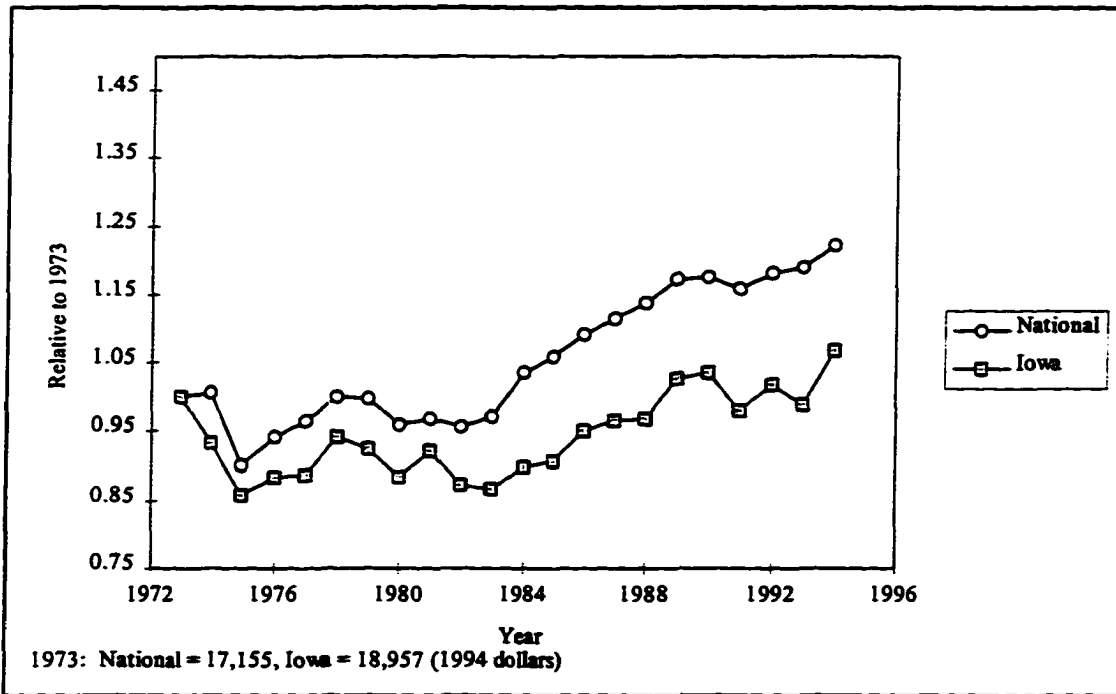


Figure 2.2: National average and Iowa real per capita income, 1973-1994 (in 1994 dollars).

period. The time paths of resident and nonresident tuition at ISU are compared with average resident tuition in the border states and the nation as a whole (Figure 2.3). Nonresident tuition at ISU has risen faster than resident tuition in the surrounding states and in the nation as a whole. The price of ISU nonresident tuition began to increase faster in 1983, and has continued at the increased rate thereafter, aside from a slight leveling in 1990. The 1994 level, in real dollars, is 64 percent above the 1973 level.

Resident tuition at ISU followed a similar pattern, falling until 1980, then steadily increasing, although at a lower rate than even the national average, to 16 percent above the 1973 level. Many studies have verified a negative relationship between tuition and enrollment. The six papers that examined enrollment at a state or institutional level of aggregation, found elasticities of -0.36 and -1.74.²

That Iowa State faced a larger than average decline in high school graduates, even as it increased its relative price of tuition would suggest declining enrollments, other things equal. First-time freshmen enrollments should be particularly sensitive to changing tuition. Upper class students face higher costs (in terms of lost credit hours and increased time to graduation) if they transfer, and so are less likely to respond to changing prices. For example, Chressanthis (1986) found that the demand elasticity for freshmen was -1.74, but only -0.589 for seniors.

Figure 2.4 shows the time paths of Iowa State first-time freshmen resident and nonresident enrollments for the United States and the states that border Iowa. First-time resident freshmen enrollment is relatively constant over the sample despite the 30 percent

² Table 1.1 reports the price and income elasticities of each of the six papers.

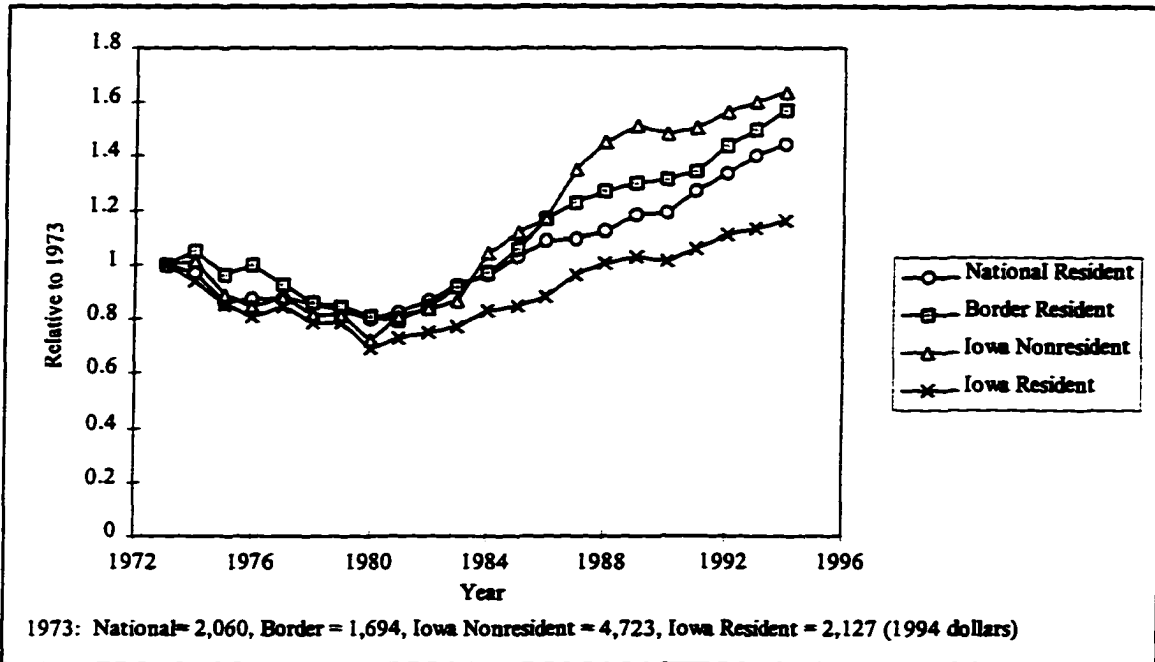


Figure 2.3: Real national average resident tuition, real average resident tuition of states that border Iowa, ISU resident tuition, and ISU nonresident tuition, 1973-1994 (in 1994 dollars).

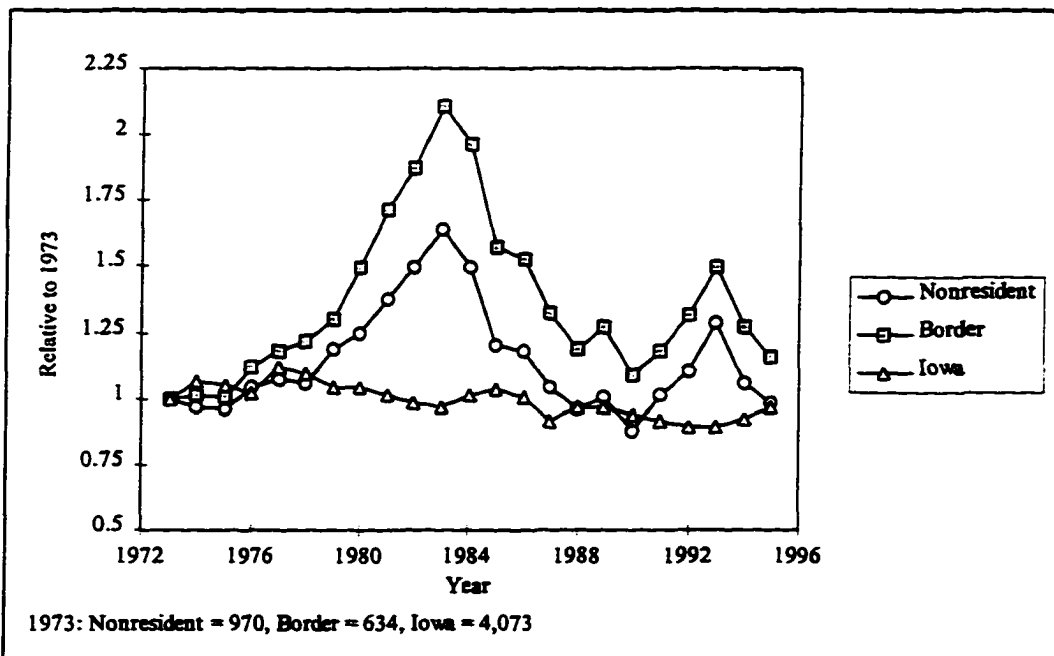


Figure 2.4: First-time enrollment at Iowa State University: resident, nonresident, and border states, 1973-1995.

drop in Iowa high school graduates since 1973. Nonresident first-time student enrollments at ISU have a markedly different pattern. The largest increase, in percentage terms, occurred in the states that border Iowa. Despite declining high school graduating classes, nonresident enrollment actually grew until 1983. The downturn in nonresident enrollment coincides with the 1983 increase in nonresident tuition relative to resident tuition elsewhere. The deviation between freshmen resident and nonresident enrollment at Iowa State suggests that nonresident enrollments at ISU may be responding to some of the same factors that are altering college enrollments nationally, even though tuition policies and other local factors may cause ISU enrollments to deviate from national trends.

Economic Model

This chapter uses a two-stage process to model the decision to invest in higher education. Prospective college students compare utility from available alternatives. In the first stage, an individual chooses whether or not to attend college. In stage two, conditional on choosing college, the individual selects which college to attend.

Two stage model of college enrollment

The model uses the following notation

Y^f	= Current family income
Y^c	= Expected future income with a college education
Y^{hs}	= Expected future income with a high school education
Q^p	= Quality of primary (elementary and secondary) education
N	= Eligible population of college students

p^{isu}	= Direct price of attending Iowa State University
D	= Distance to Iowa State University
P^c	= Direct price of attending a college other than ISU
P^p	= Direct price of attending a private college or university
S^c	= State provided subsidy for public higher education
τ	= Tastes, preferences

The first stage decision involves the choice of whether to attend college or enter the labor force. Consider two indirect utility functions:

$$\begin{aligned} U_{LF} &= U(Y^{hs}, \tau_1) \\ U_C &= U(Y^c, Y^f, P^c, S^c, P^p, Q^p, \tau_c) \end{aligned} \quad (2.1)$$

The individual's utility from entering the labor force (U_{LF}) is increasing in the expected income from entering the labor force directly from high school (Y^{hs}). The utility from attending college (U_C) is positively related to future anticipated income, current family income, and the quality of primary education. Family income lowers the cost of financing a college education, while better primary and secondary schools are assumed to increase the efficiency of the human capital production process in college. The utility of attending college is negatively related to the direct price of attending a college (at both public and private institutions) and positively related to the per capita state college subsidy.

The individual will choose to invest in higher education if the utility from attending college is greater than the utility from entering the labor force. This can be written as

$$\Pr(C) = \Pr(U_C > U_{LF}) = f(\underbrace{Y^c}_{(+)}, \underbrace{Y^{hs}}_{(-)}, \underbrace{Y^f}_{(+)}, \underbrace{P^c}_{(-)}, \underbrace{S^c}_{(+)}, \underbrace{P^p}_{(-)}, \underbrace{Q^p}_{(+)}, \underbrace{\tau_1}_{(-)}, \underbrace{\tau_c}_{(+)}), \quad (2.2)$$

where the probability of attending college ($\text{Pr}(C)$) depends positively on future earnings from college, current family income, public higher education subsidy, quality of primary education, and tastes for college; and depends negatively on future earnings from high school, the price of attending college (public or private), and tastes for labor force participation after high school.

Conditional on college being chosen, the next decision is which college to attend. The goal of this model is to explain enrollment at a particular institution, so the school choice is subdivided into attending the representative institution or attending any other institution. The choice is made by comparing the utilities from available alternatives.

$$\begin{aligned} U_{\text{isu}} &= U(Y^c, Y^f, P^{\text{isu}}, D, Q^p, \tau^{\text{isu}}) \\ U_c &= U(Y^c, Y^f, P^c, S^c, P^p, Q^p, \tau^c) \end{aligned} \quad (2.3)$$

The indirect utility from attending Iowa State (U_{isu}) is increasing in future expected income, current family income, quality of primary education, and the tastes for ISU. Utility is decreasing in the cost of attending ISU. The two measures of costs are tuition and distance. If the utility of attending ISU is greater than the utility of the other available alternatives, the individual will choose to make his/her human capital investment at Iowa State.

If the utility of income from attending ISU is equal to the utility of income from attending another college, then the conditional probability of selecting ISU will not be affected by college income. Similar arguments for family income and quality of primary education suggest that these factors will not affect the ISU choice conditional on attending college. Therefore, the conditional probability of attending Iowa State can be written in reduced form as

$$\Pr(\text{ISU}|\text{C}) = \Pr(U_{\text{isu}} \geq U_c) = g(\underbrace{P^{\text{isu}}}_{(-)}, \underbrace{D}_{(-)}, \underbrace{P^c}_{(+)}, \underbrace{S^c}_{(-)}, \underbrace{P^p}_{(+)}, \underbrace{Q^p}_{(+)}, \underbrace{\varepsilon^c}_{(-)}). \quad (2.4)$$

The unconditional probability of an individual enrolling at ISU is the product of the conditional probability of attending ISU and the unconditional probability of attending college, or

$$\Pr(\text{ISU}) = \Pr(\text{C}) \Pr(\text{ISU}|\text{C}) = f(\cdot) g(\cdot). \quad (2.5)$$

Suppose that equations (2.2) and (2.4) are of the form $\Pr(\text{C}) = W^{\alpha_1} X^{\alpha_2}$ and

$\Pr(\text{ISU}|\text{C}) = W^{\gamma_1} Z^{\gamma_2}$, respectively. Let W represent the variables common to equations (2.2) and (2.4), X represent the variables only entering equation (2.2), and Z represent the variables only entering equation (2.4). Then the unconditional probability of enrolling at ISU will be

$$\Pr(\text{ISU}) = W^{\alpha_1 + \gamma_1} X^{\alpha_2} Z^{\gamma_2}. \quad (2.6)$$

The signs of variables in X and Z can be established immediately, whereas the signs of the variables in W depend on the signs and magnitudes of α_1 and γ_1 . Using (2.2), (2.4), (2.5), and the assumed Cobb-Douglas functional forms, we have the following predicted signs

$$\Pr(\text{ISU}) = h(\underbrace{Y^c}_{(+)}, \underbrace{Y^f}_{(+)}, \underbrace{Y^{\text{hs}}}_{(-)}, \underbrace{P^{\text{isu}}}_{(-)}, \underbrace{P^c}_{(?)}, \underbrace{S^c}_{(?)}, \underbrace{P^p}_{(?)}, \underbrace{Q^p}_{(+)}, \underbrace{D}_{(-)}, \underbrace{\varepsilon^{\text{isu}}}_{(+)}, \underbrace{\varepsilon^i}_{(-)}, \underbrace{\varepsilon^c}_{(?)}). \quad (2.7)$$

The individual's decision to enroll at ISU is modeled as depending positively on future income from college, family income, quality of primary school education, and the tastes for ISU. The enrollment decision is negatively related to the price of attending the particular school, future income with a high school degree, distance, and the tastes for entering the labor force directly from high school. Four factors (public and private college prices, the

local subsidy for public higher education, and the tastes for other schools) enter positively in the probability of enrolling in college, but negatively in the conditional probability of enrolling in the representative institution. Therefore the predicted effect is ambiguous.³ The next section specifies the econometric model for nonresident first-time student enrollment. The model for resident enrollment is presented in the following chapter. Both of these models will test predictions regarding the coefficients as well as provide information on the effects of which variables for which the theory generated ambiguous predictions.

Econometric model for nonresident enrollment

The econometric model imposes the Cobb-Douglas specification in log form. Table 2.1 summarizes the variables used in the econometric model.⁴ The observed probability of attending ISU is the number of first-time freshmen from state s and year t , $E_{s,t}$ divided by the number of high school graduates in the state, $N_{s,t}$ or $\frac{E_{s,t}}{N_{s,t}}$. Taking logs and moving $\log(N_{s,t})$ to the right-hand side, we get first-time nonresident enrollment as a function of the previously discussed variables and the size of the eligible population ($N_{s,t}$),

$$\ln(E_{s,t}) = \beta_0 + \alpha_1 \ln(Y_{s,t}^f) + \alpha_2 \ln(Y_t^c / Y_t^{bs}) + \alpha_3 \ln(Q_{s,t}^p) + \gamma_4 \ln(N_{s,t}) + \gamma_5 \ln(P_t^{isu}) + \gamma_6 \ln(D_s) + \gamma_7 \ln(\tau_{s,t}) + \beta_8 \ln(P_{s,t}^c) + \beta_9 \ln(S_{s,t}^c) + \lambda \ln(t) + \varepsilon_{s,t} \quad (2.8)$$

where $\beta = \alpha + \gamma$. The analysis covers 49 states and 20 years. Three dependent variables are examined, first-time nonresident student enrollment, nonresident undergraduate enrollment,

³ A further difficulty in using the private school price is that a third college price leads to correlation among the regressors. The simple correlation between national average private school tuition and ISU nonresident tuition is 0.994. Therefore, private school tuition is not included in the empirical model.

⁴ The appendix has a detailed discussion of the variables, including sources of the data used in the analysis.

Table 2.1: Brief definitions of variables used in the nonresident enrollment analysis.

Variable	Definition: (variables are by state and year, unless noted)
Dependent Variable ($E_{s,t}$)	
First-time Freshmen	Iowa State University new fall freshmen enrollment
Undergraduate Enrollment	Iowa State University total undergraduate enrollment
Applications	Iowa State University applications for admission
Independent Variables	
Y^f	real income per capita in the home state
$Y^c, (Y^{hs})$	national average annual income of males with 4 yrs. of college (high school) as highest degree completed
Q^p	real current fund expenditures per pupil in average daily attendance at public elementary and secondary school in home state
N	number of high school graduates
p^{isu}	real Iowa State University annual nonresident tuition
D	distance from Ames, Iowa to the nearest border of the home state (by state)
τ^{isu}	number of Iowa State alumni living in each state, proxy for local ties to ISU
P^c	real annual tuition and fees at public 4-year institutions in the home state
S^c	real current fund expenditures on public institutions of higher education over sum of previous 4 years of high school graduates (in the home state)

and the number of nonresident applications for admission to Iowa State University.

The variables that enter the probability of enrolling only through equation (2.2), include family income, relative salary and the quality of primary education. Family income is an indicator of ability to pay. If higher education is a normal good, increases in income would increase enrollment. The ratio of expected college salary over expected high school salary captures the expected increase in income from a college degree. This concept was formalized by Gary Becker (1964). Real spending per pupil in public elementary and secondary schools is used to proxy the quality of training that the state provides at that level.

In addition, the number of high school graduates from each state enters the analysis as a measure of the eligible population. The coefficient on $\ln(N_{s,t})$ should be one if high school graduates represent a homogenous population. However, if an increase in the population of high school graduates going to college implies selecting from a different distribution of students at the margin, the changes in enrollment may not be proportional to the changes in high school graduates. For example, presumably the students finishing high school and going to college come disproportionately from high ability students. Those students on the margin of labor force participation versus college come disproportionately from the middle and lower-tail of the ability distribution. These middle and lower ability students may be less willing to pay nonresident fees to attend an institution outside their home state. Since changes in the number of high school graduates in this period come from both lower drop-out rates and population declines, the population of high school graduates may be adding more of these middle or lower ability students relative to the high ability students.

The price of attending ISU is the nonresident ISU tuition divided by the consumer price index. The other cost of attending ISU is distance from the home state. The distance from ISU is included as a measure of both the physical and psychic distance from home. A trip home is more expensive, in both time and direct cost of travel, if the student is farther away. The number of ISU alumni in each state and year is included as a proxy of tastes for ISU. Alumni have personal experience with the campus and can communicate their recollections to prospective students in the area. These are the variables that affect ISU enrollment through the conditional demand equation (2.4).

Assuming that public 4-year institutions in the home state are substitutes for ISU, the own-state price is defined as the average resident tuition at the home state public universities. These costs are less important the more the home state provides subsidies to its resident students. Expenditures on higher education in the home state per high school graduate from the previous four years is the measure of the subsidy that a state provides its in-state students.

The final term in the empirical model is a logarithmic time trend that captures the impact of the national or general college enrollment demand factors at the specific institution over the sample. A positive sign would indicate that ISU has captured an increasing share of national enrollment over the sample period.

Empirical Analysis of Nonresident Enrollment by State

The variation of the logarithm of nonresident enrollment by state was first analyzed using Ordinary Least Squares (OLS).⁵ Durban-Watson tests on the OLS specification indicated the

⁵ The drawback of the log specification is that some states may generate no new fall enrollees at ISU in some years. Therefore, $\log(\text{ISU enrollment} + 0.1)$ was used.

presence of autocorrelated errors. The Maximum Likelihood Estimator (MLE), first suggested by Cochrane and Orcutt (1949), was used to generate the estimates reported herein. The coefficients of the regression are interpretable as elasticities. The elasticities reveal the percentage impact on nonresident enrollment or applications from a one percent change in an independent variable.

First-time nonresident freshmen enrollment regression results

The MLE coefficients for first-time nonresident freshman enrollment at ISU are presented in Table 2.2. The results and implications are discussed below.

The first 4 variables appear only in the decision to go to college. The income elasticity is positive and significant. A 10 percent increase in family income causes an estimated 16 percent increase in nonresident first-time freshmen enrollment. This suggests that nonresident enrollments are procyclical, rising during expansions and contracting during recessions. The positive relationship between income and the level of enrollment verifies that ISU nonresident enrollment is a normal good.

The expected returns to college education have a positive effect on enrollments, but the coefficient is not significant at the 10 percent level. While the estimate is imprecise, it implies that a 10 percent increase in the returns to college increases nonresident enrollments by 16 percent.

State expenditures on primary and secondary education have a positive and significant impact on nonresident enrollments from that state. The elasticity implies that a 10 percent increase in per pupil primary and secondary expenditures increase ISU nonresident

Table 2.2: MLE regression coefficients for full sample (49 States), 1973-1993 (log-log specification)

Coefficient	First-time Freshmen	Undergraduate Enrollment	Applications ¹
Intercept	-7.670*** (-2.67)	-1.079 (-1.27)	-1.864** (-2.07)
Income per capita	1.655*** (2.62)	1.296** (2.52)	1.435** (2.47)
College over High School Salary	1.684 (1.02)	1.047 (1.00)	-0.694 (-0.70)
Primary spending	0.942*** (2.59)	0.657** (2.11)	0.254 (0.75)
High school graduates	-0.300*** (-2.98)	-0.168 (-1.25)	0.006 (0.04)
ISU nonresident tuition	-0.971** (-2.18)	-0.723** (-2.19)	-0.648** (-2.15)
Distance	-0.913*** (-6.86)	-1.018*** (-5.84)	-0.910*** (-5.20)
Alumni	1.141*** (10.77)	0.920*** (7.04)	0.755*** (5.78)
Resident tuition	0.234 (1.55)	0.109 (0.79)	0.328** (2.30)
State subsidy	-0.650*** (-3.08)	-0.097 (-0.58)	0.384*** (2.61)
Time trend	-0.937*** (-3.23)	-1.221* (-1.95)	-0.322 (-0.41)
n	980	980	780
R-squared	0.6775	0.8885	0.8950
MSE	1.252	0.345	0.242

() t-ratios

*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent

¹ 1976 - 1993

enrollments by 9.4 percent.

The decline in the number of high school graduates have not adversely affected college enrollments. In fact, the literal interpretation of the estimated effect is that decreases in the number of high school graduates over the period actually led to an increase in nonresident enrollment, other things equal. As previously discussed, the coefficient of this variable is expected to be 1, if the high school graduating population were homogeneous. The coefficient is not only less than one, but negative. The coefficient supports the explanation that the high school classes are increasing in the low and middle ability ranges, rather than the high ability. These low and middle ability students would be less like to attend an out-of-state institution, since the tuition alone is significantly higher than the in-state institutions that are available.

The next three variables only appear in the conditional demand of choosing which college to attend, equation (2.4). The own-price elasticity of demand is significant and marginally in the inelastic range. The elasticities of tuition with respect to first-time nonresident student enrollment at Iowa State is estimated to be -0.971. A 10 percent increase in nonresident tuition leads to a 9.7 percent decrease in nonresident enrollment yielding a very modest increase in revenues. Statistical tests for unit elasticity cannot be rejected, indicating that nonresident tuition at ISU is at the revenue maximizing level. The implication of this result is discussed later in this chapter.

Another cost of attending Iowa State is the distance to ISU. Distance from Ames, Iowa has a negative and significant effect on first-time nonresident freshmen enrollments. States

farther from Ames tend to have fewer freshmen attending ISU. The number of alumni in a state has a positive and significant effect on first-time nonresident enrollment, indicating that those states with more alumni tend to have larger nonresident freshmen enrollments.

The last two variables enter in both the decision to go to college and the conditional decision to attend Iowa State. The signs indicate the relative magnitudes of α and β . The coefficient on the price of the in-state institution is positive but not significant. This indicates that increases in the resident tuition of other states lead to modest increases in nonresident freshmen enrollments at ISU. Since the coefficient is not significantly different from zero, the magnitudes of α and β are apparently equal. The negative sign also indicates that the own-state public schools are substitutes for nonresident ISU enrollment.

The home state subsidy of resident public higher education has a negative and significant effect on ISU nonresident enrollments. The impact of local spending on higher education is stronger for the conditional decision of attending ISU than the decision to go to college. Thus, larger spending on higher education in the home state results in smaller nonresident freshmen enrollment at ISU from that state.

In review, the number of first-time nonresident freshmen enrolled at Iowa State is positively related to family income, own-state resident tuition, number of ISU alumni, own-state spending on primary education, and expected returns from a college degree. These enrollments are negatively related to ISU nonresident tuition, distance from Ames, own-state subsidy for higher education, and high school graduating class size.

Total undergraduate enrollment and applications

The robustness of the results above is tested by regressing ISU nonresident undergraduate enrollment and nonresident applications for admission to ISU on the same set of explanatory variables. These regressions should yield similar results, except that the elasticities should be smaller in magnitude for total undergraduate nonresident enrollment. Those already attending ISU should be less price and income sensitive than entering freshmen because of the higher cost of transfer relative to selecting a school. Applications should also be less price sensitive because the cost of an application is much lower than the cost of enrollment. The results in Table 2.2 confirm these expectations. The findings are similar to the first-time nonresident freshmen enrollment regression. The signs are identical in the undergraduate enrollment regression and in 6 of the 9 coefficients in the applications model. Moreover, the own-price elasticities are smaller in magnitude relative to those in column 1.

Nonresident undergraduate enrollment

The own-price elasticity of nonresident undergraduate enrollment is -0.723 and is significant. The magnitude of the own-price elasticity is smaller than first-time nonresident freshmen enrollment. This implies that nonresident students already attending ISU are less price sensitive than the freshmen. The implication of this result is discussed later in this section.

Family income, per pupil expenditures on primary and secondary schooling, and college over high school salary all have positive effects on undergraduate nonresident enrollments. The size of the high school graduating class and the state subsidy for higher education have

negative effects but are not significant. Distance has a negative and significant impact on nonresident undergraduate enrollment at Iowa State. While the number of alumni has a smaller effect on undergraduate nonresident enrollment than first-time freshman nonresident enrollment, the effect remains positive and significant.

Nonresident applications for admission

The findings for applications are similar to the previous regressions. Since the decision to apply does not involve paying nonresident tuition, but only the prospect of paying tuition if the individual is granted admission and accepts, one might expect a less elastic price response. The coefficient on ISU nonresident tuition is negative and significant (-0.648), and it implies that applications are less price elastic than are freshmen or undergraduate nonresident enrollment. Two other factors that are negatively related to nonresident applications to ISU are distance from Ames and the ratio of college to high school salary. The coefficient of relative salary is not significant from zero. Family income has a positive and significant effect on the decision to apply, with an income elasticity of 1.435. The number of ISU alumni, high school graduates, expenditures on primary and secondary education, and home state subsidies for higher education have positive effects on nonresident applications for admission to ISU.

The estimates in Table 2.2 are generally consistent with economic theory. The various measures of demand for ISU yield elasticities that are consistent in sign and indicate more elastic responses for first-time nonresident enrollments than for applications or total undergraduate enrollments. College education is shown to be a normal good. ISU

enrollments and applications are sensitive to price changes with own-price elasticities in the inelastic range. Finally, ISU nonresident enrollments increase with the number of alumni and decrease with distance.

Simulations of nonresident enrollment

While the sign and magnitude of the coefficients indicate the direction and size of a response averaged over the sample period, simulations can illustrate the magnitude of the effect of a specific factor for each period in the sample. Figure 2.5 shows the actual and predicted first time nonresident enrollment over the sample. Figures 2.6 and 2.7 show the

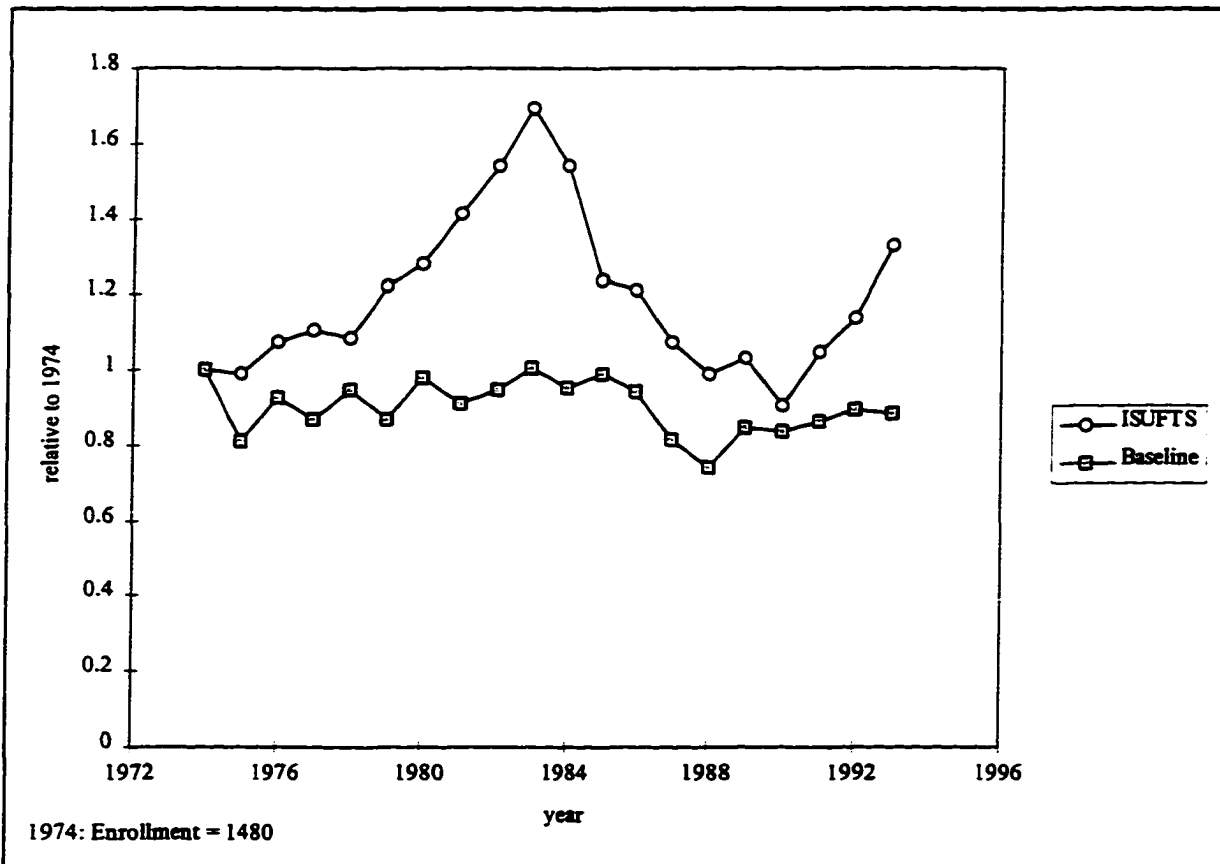


Figure 2.5: Actual and Baseline nonresident first-time freshmen enrollment, 1974-1993.

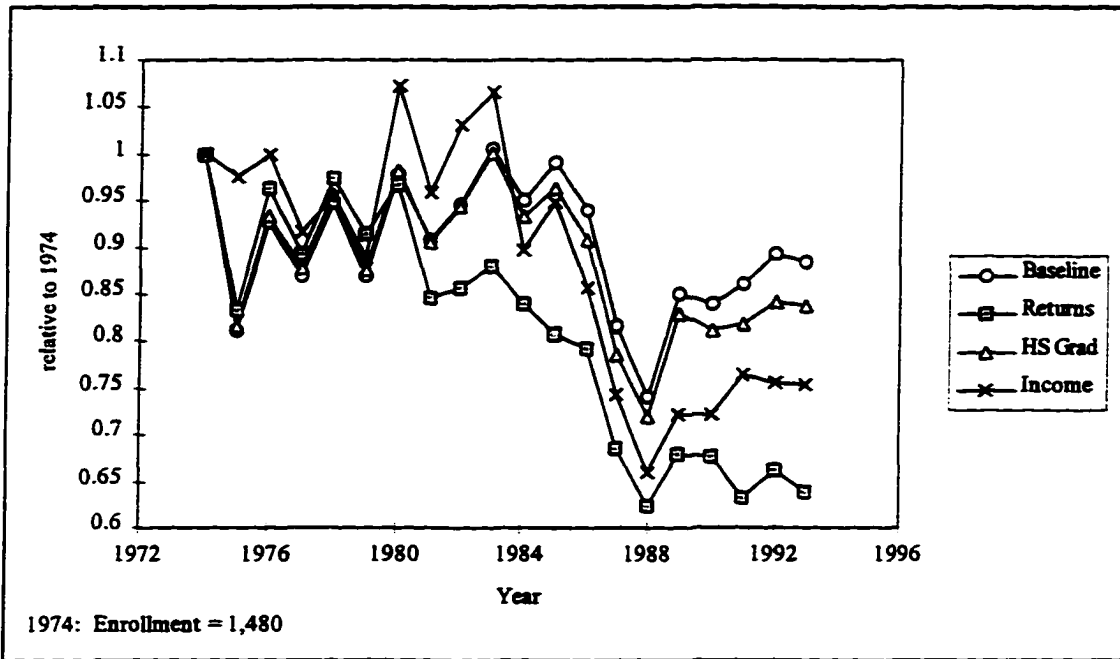


Figure 2.6: Baseline and simulated nonresident first-time freshmen enrollment, 1974-1993. Simulations hold a factor (returns to college (salary ratio), high school graduates, or per capita income) constant at the 1973 level.

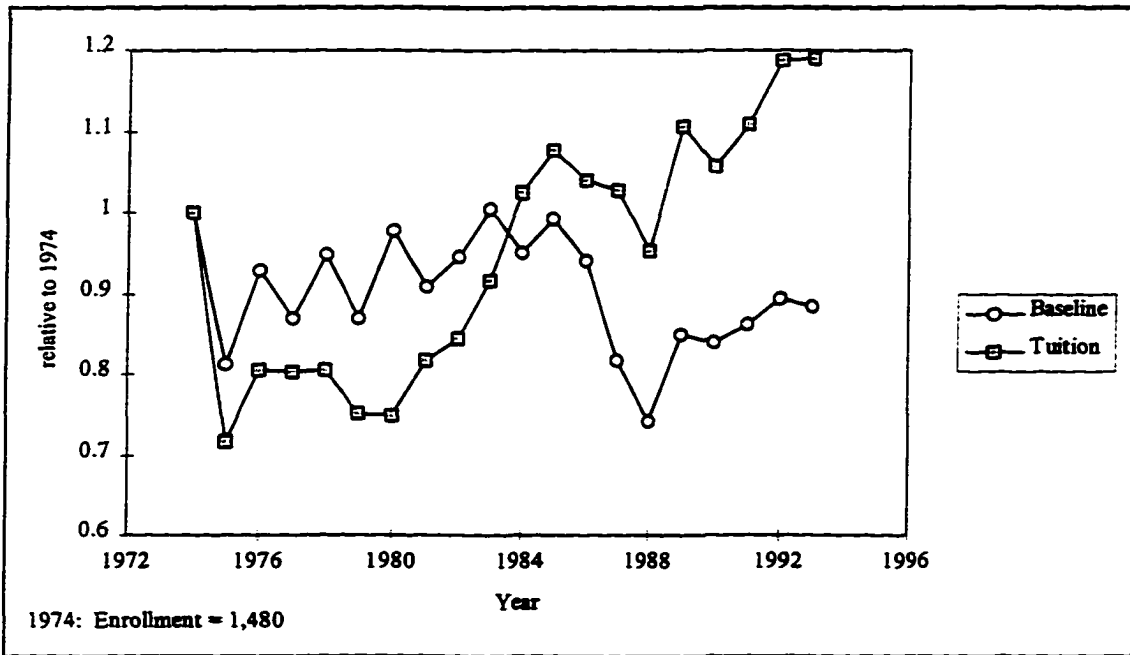


Figure 2.7: Baseline and simulated nonresident first-time freshmen enrollment, 1974-1993. Simulation holds real ISU nonresident tuition constant at the 1973 level.

predicted enrollment level evaluated at the historical values of the regressors (labeled baseline). The figure also contains three simulated enrollment paths that hold college over high school salaries, then per capita income, and finally the number of high school graduates constant at their 1973 levels. Deviations of simulated first-time nonresident enrollments from the baseline illustrate the impact of changes in the variable on enrollments over time. Simulations show that 15 percent of the nonresident freshmen enrollment at Iowa State in 1993 can be attributed to increases in per capita family income over the last 21 years. Similarly, 5 percent of the enrollment in 1993 can be attributed to changes in the high school graduating class size. Finally, the increases in the salary ratio account for 28 percent of the increased nonresident first-time freshmen enrollment at ISU in 1993.

The University has some control over enrollments by setting the price (tuition) charged to nonresident students. More accurately, the Board of Regents sets the price with input from officials at ISU. Figure 2.7 simulates nonresident freshmen enrollment at ISU holding real nonresident tuition constant at the 1973 level. Real tuition initially declined relative to the 1973 level so simulated enrollment is below the baseline enrollment until 1984. Thereafter, simulated nonresident enrollment rises above baseline when real nonresident tuition is held constant. Over the period, an average of 70 more first-time nonresident students per year would have enrolled had real tuition remained constant. Specifically, in 1993 nonresident freshmen enrollment is 34 percent lower than if tuition had remained constant (in real dollars) at the 1973 level. Had family incomes not increased, the policy of increasing real tuition would have caused dramatic reductions in enrollments. Alternatively,

one can presume that the increase in real tuition allowed universities to absorb some of the rents of the increased returns to college.

Policy implications of the nonresident enrollment analysis

The goals of revenue maximization and enrollment maximization cannot be achieved simultaneously.⁶ Revenue maximization suggests that tuition be increased, since the demand is inelastic. However, according to the law of demand, enrollment falls as tuition rises. The estimates of the own-price elasticity from the models of first-time and undergraduate nonresident enrollment are -0.971 and -0.723, respectively. In each case, the elasticity is in the inelastic range. This implies that revenues can be *increased* by *increasing* the price of attending ISU. The question that a “revenue maximizing policy maker” would now ask is, “What percentage increase in nonresident tuition will maximize revenues?”

Suppose that a proposed percentage change in ISU tuition is X . Let T be current tuition and current enrollment be E . The change in enrollment from a change in T is determined by the own-price elasticity of demand η , where $\eta < 0$. Revenue from tuition R , is

$$R = (1 + X)T \cdot E(1 + \eta X). \quad (2.9)$$

When $X=0$, $R = TE$ or current tuition times current enrollment. As X changes, tuition changes to $(1+X)T$ and enrollment changes to $E(1+\eta X)$. Maximizing equation (2.9) with respect to X ,

$$\frac{dR}{dX} = TE(1 + \eta + 2\eta X) = 0. \quad (2.10)$$

Finally, solving for X in (2.10), the optimum percentage change in tuition is

⁶ It is beyond the scope of this paper to discuss the merit of maximizing revenue over other goals.

$$X^* = \frac{-(\eta + 1)}{2\eta}. \quad (2.11)$$

In general, when $\eta = -1$, X^* is zero. This would be the case under the unit elasticity assumption. If the price elasticity were inelastic, $\eta > -1$, the optimal strategy is to raise tuition ($X^* > 0$). Finally, if an elastic price response were found, $\eta < -1$, the optimal strategy is to lower tuition ($X^* < 0$).

It is worth noting again that statistical tests do not reject that the price elasticity is equal to -1. Unit elasticity, (price elasticity equal to -1) is by definition the price that maximizes revenues. Thus, under the unit elasticity assumption a policy that holds real nonresident tuition constant at the current level would be recommended as optimal.

Predicted revenue and enrollment changes from proposed changes in tuition are shown in Table 2.3. If officials are interested in maximizing nonresident tuition revenue they should support an increase in nonresident tuition of 1.5 percent, when the nonresident first-time freshmen model is used. Since more senior students are less sensitive to changes in price, the

Table 2.3: Tuition adjustments with predicted changes in enrollment and revenues (in 1994 dollars).

(Group) Elasticity	Initial Price Δ Price % Δ Price	Enrollment Δ Enrollment % Δ Enrollment	Revenue Δ Revenue % Δ Revenue
(Freshmen) -0.971	\$7,731 +115 +1.49%	982 -14 -1.47%	7.6 mill +1,643 +0.02%
(Undergrad) -0.723	\$7,731 +1,481 +19.16%	3,632 -503 -16.08%	28.1 mill. +744,976 +2.65%

revenue maximizing tuition increase is 19 percent with the undergraduate enrollment model. However, the freshmen enrollment is the more appropriate estimate since it will reflect the long term enrollment response to the tuition policy. The short term tuition revenue increase is estimated to be \$744,976, but at the expense of 503 fewer nonresident undergraduate students per year. The increased revenue from the freshmen class is only \$1,643, with an estimated decline of 14 nonresident freshmen per year. After 4 years of reduced freshmen enrollments, assuming an annual drop-out rate of 15.7 percent, the added annual revenue from a 1.5 percent nonresident tuition increase relative to no increase would be just \$5,182 per year.

These results indicate that nonresident tuition at ISU has approached the revenue maximizing level. Large increases in tuition, above the inflation rate, would lead to a decline in revenues for the university. A price increase that does not cover inflation (or a real price decrease), would lead to larger enrollments, but a decline in revenues. It is important to keep in mind that any increase in price will lead to fewer students enrolling.

To review, the results are similar across first-time nonresident student enrollment, undergraduate nonresident enrollment, and nonresident applications for admission. The empirical results regarding the national trends in college enrollment indicate that:

- Increases in per capita income lead to increases in enrollment and the number of applicants.
- Increased returns to education have increased nonresident freshmen enrollment, but the estimates are not precise.

- Declines in the number of high school graduates actually lead to increased college enrollment.
- Primary school expenditures have a positive effect on enrollment.

The results of those variables that enter the analysis in the choice of “which college to attend”, conditional on choosing college in the first stage are:

- The own-price elasticity of demand for nonresident enrollment is inelastic and a modest increase in tuition leads to modest increases in revenues but declines in enrollments.
- Distance from Ames is negatively related to nonresident enrollment.
- The number of alumni in a state is positively related to nonresident enrollment at ISU.
- State subsidies for higher education have a negative effect on enrollment.

CHAPTER 3**RESIDENT ENROLLMENT BY COUNTY, 1976 - 1994****Introduction**

This section examines resident enrollment at Iowa State University by county. Resident students account for 74 percent of the new undergraduates and 77 percent of undergraduates at Iowa State University (Iowa State University, *Enrollment Services Annual Statistical Report*, 1995). The underlying economic theory presented earlier is consistent for both resident and nonresident enrollment. The factors that affect a student's decision to enroll in college are generally the same for an in-state, out-of-state, or private institution. Enrollment at an in-state public institution can be used to examine the factors that influence the decision to go to college and the decision of which college to attend.

One important difference between enrolling in an in-state versus out-of-state institution is that in-state public tuition is much lower than out-of-state or private tuition. Typically, resident tuition is one third of the non-resident or private rates. Basic economic theory predicts that goods that are lower priced will be less responsive to price changes. The difference in price indicates that in-state students behave as "different economic agents" than students who enroll at out-of-state or private institutions. A second reason for expecting a lower price elasticity for resident enrollment is that goods with fewer substitutes will be less responsive to price than a good with several substitutes. Relative to nonresident enrollment, where there are 605 public and 1,610 4-year private schools, there are relatively few public

institutions in Iowa (i.e. the 3 Regents institutions, Iowa State University, the University of Northern Iowa, and the University of Iowa). Therefore, nonresident and resident enrollment are treated in separate models.

This section examines three measures of the demand for education at Iowa State University: first-time resident enrollment, resident undergraduate enrollment, and the number of resident applications for admission. The data for these models are available by county from 1976 to 1994.

The Iowa Case Reviewed

The underlying demographic and background information was discussed at length at the beginning of this chapter. The number of high school graduates in Iowa has decreased over 30 percent since 1973. Because a large proportion of undergraduates enter ISU directly from high school, this would indicate a decline in the eligible population of new undergraduates. However, if the proportion of Iowa high school graduates going to college is increasing, as is the case nationally, then it is not necessary that enrollments fall. Resident students consider the increased income with a college degree in their decision to enroll at ISU. The ratio of college to high school salaries has been steadily increasing over the period. This would indicate an increase in the demand for enrollment at ISU. Unlike the national trend, per capita income in Iowa has increased only modestly since 1973. By 1994, Iowa real per capita income was 7 percent above the 1973 level. Nevertheless, if resident enrollment at ISU is a normal good, this increase would lead to an increase in enrollment.

Iowa State's closest competitors for resident students are the other two Regents

institutions and the Iowa community colleges. Tuition at all three Regents institutions is determined by the Board of Regents. Over time, tuition has increased by the same proportion in the three institutions, so there is no way to isolate the effect of an ISU tuition increase without simultaneously experiencing an increase in tuition of its competing in-state universities. Hoenack (1971) and Hoenack and Weiler (1975) also noted this issue. Therefore, a measure of the price of a substitute university (other than tuition) is required. To account for the presence of the University of Iowa, distance to Iowa City is used as a cost of attending U of I.

National average two-year tuition is used as the price at a substitute institution of higher education. The Des Moines Register (July 7, 1997) reported that enrollment at Iowa two-year colleges has increased 45 percent since 1986. If the price of attending these two-year schools has increased slower than ISU tuition, students may be enrolling in the two-year institutions instead of ISU. Students attending a two-year college also have the option, with very little difficulty, to transfer to a university. Thus, increases in community college enrollments may lead to declines in the number of freshmen attending ISU, but increases in the number of undergraduates, as a result of increased transfer students.

Econometric Model of Resident Enrollment by County

The econometric model below explains resident demand for Iowa State University as a function of prices, income, and population. The dependent variable is enrollment from county c and year t ($E_{c,t}$). The specification used in this analysis is

$$\ln(E_{c,t}) = \beta_0 + \underbrace{\alpha_1 \ln(Y_{c,t}^f)}_{(+)} + \underbrace{\alpha_2 \ln(Y_t^c / Y_t^{hs})}_{(+)} + \underbrace{\alpha_3 \ln(N_{c,t})}_{(+)} + \underbrace{\gamma_4 \ln(P_t^{isu})}_{(-)} + \underbrace{\gamma_5 \ln(D_c^{isu})}_{(-)} + \underbrace{\beta_6 \ln(P_t^c)}_{(?)} + \underbrace{\beta_7 \ln(D_c^{isu})}_{(+)} + \varepsilon_{c,t} \quad (3.1)$$

The variables are described in Table 3.1. The analysis covers 99 counties and 19 years. Three dependent variables are used as measures of $E_{c,t}$, first-time student enrollment (1976 - 1994), resident undergraduate enrollment (1976-1983, 1986-1994)¹, and the number of applications for admission (1976 - 1994) to Iowa State University.

The factors that enter the decision to enroll in college or the labor force are current income, expected increased earnings from college and the number of high school graduates. County per capita income is expected to increase enrollments, if higher education is a normal good. Increases in the salary of college graduates relative to those without a college degree, should also increase demand for Iowa State. Roughly 75 percent of incoming freshmen are recent high school graduates, so larger county high school graduating classes would be expected to increase the number of county residents enrolling at ISU the following fall.

The price of attending ISU is real resident tuition in 1994 dollars, P_t^{isu} . As the real price of attending ISU increases, enrollments are expected to fall according to the law of demand. Therefore, the coefficient β_2 is expected to have a negative sign. The other measure of the cost of attending ISU is distance from the county to Ames, D_c^{isu} . The expected sign β_3 , the coefficient on the distance to Ames, is also negative.

The University of Iowa is the largest public university in Iowa and is ISU's single largest

¹ The undergraduate enrollment data by county for 1984 and 1985 are not available.

Table 3.1: Brief definitions of variables used in the analysis of resident enrollment by county.

Variable	Definition: (variables are by county and year, unless noted)
Dependent Variable ($E_{s,t}$)	
First-time Freshmen	Iowa State University new fall freshmen resident enrollment
Undergraduate Enrollment	Iowa State University total undergraduate resident enrollment
Applications	Iowa State University resident applications for admission
Independent Variables	
Y^f	real income per capita
$Y^c, (Y^{hs})$	national median annual income of males with 4 yrs. of college (high school) as highest degree completed
N	number of high school graduates
P^{isu}	real Iowa State University annual resident tuition
D^{isu}	distance from Ames, Iowa to the county (in miles)
P^c	real national average annual tuition and fees at public 2-year institutions
D^{ui}	distance from Iowa City, Iowa to the county (in miles)

competitor for Iowa high school graduates. Increased distance from the University of Iowa is expected to increase county enrollment at ISU. Students that reside farther from Iowa City may be more likely to attend ISU both because of the lower moving costs and for presumed stronger tastes or loyalties to the closer state school.² Other competitors for resident students at ISU are the 25 public two-year colleges in Iowa. As tuition at two-years colleges increases enrollment at ISU is expected to increase.

Resident County Level Empirical Analysis

The variation of the logarithm of resident enrollment by county was first analyzed using Ordinary Least Squares (OLS). As in the nonresident model, Durban-Watson tests on the OLS specification indicated the presence of autocorrelated errors. The Cochrane-Orcutt Maximum Likelihood Estimator (MLE) was used to generate the estimates in this section. The coefficients of the regression remain interpretable as elasticities.

First-time resident freshmen enrollment

The MLE coefficients for first-time resident freshman enrollment at ISU are presented in Table 3.2. The results and implications are discussed below. The first three variables enter the analysis in the first decision, "go to college or enter the labor force". The coefficient of per capita county income is positive and significantly different from zero. The income elasticity is 0.569, which indicates that the first year of college enrollment is a normal good and in the "necessity" range (less than 1). A 10 percent increase in real per capita county income would lead to a 5.7 percent increase in first-time resident enrollment at ISU.

² Distance from the county of residence to the University of Northern Iowa and the presence of a two-year college in the county or neighboring county were also examined. These measures were not significant in explaining enrollment or applications at Iowa State.

Table 3.2: MLE regression coefficients for full sample (99 Counties), 1976-1994 (log-log specification)

Coefficient	First-time Freshmen	Undergrad. Enrollment	Applications
Intercept	-4.781*** (-5.84)	0.124** (2.45)	-4.133*** (-6.59)
Income per capita	0.569*** (5.53)	-0.062 (-1.60)	0.642*** (7.21)
College over High School Salary	0.134 (0.47)	-0.128 (-0.85)	0.709*** (2.78)
High school graduates	0.937*** (55.03)	-0.004 (-0.14)	0.930*** (58.04)
ISU nonresident tuition	-0.088 (-0.47)	-0.069 (-1.04)	-0.041 (-0.26)
Distance to ISU	-0.489*** (-22.59)	-0.711 (-1.29)	-0.425*** (-20.65)
2 yr public tuition	0.219 (0.87)	-0.197** (-2.01)	0.060 (0.28)
Distance to U of Iowa	0.176*** (10.26)	-0.374 (-0.88)	0.161*** (9.85)
n	1782	1485	1782
R-squared	0.8684	0.9831	0.9043
MSE	0.090	0.012	0.068

() t-ratios

*** significant at 1 percent

** significant at 5 percent

* significant at 10 percent

Resident enrollment is less sensitive to business cycles than nonresident enrollment.

The college over high school salary ratio has a positive effect on resident enrollment but the coefficient is not significantly different from zero. First-time resident enrollment does not appear to have responded to the recent increase in returns to college. The coefficient on the number of high school graduates in a county is 0.937. The impact of a 10 percent increase in high school graduates is predicted to be 9.4 percent. Statistical tests fail to reject that this coefficient is different from 1. This would indicate that first-time resident enrollment changes in direct proportion to the number of high school graduates in Iowa.

The own-price elasticity of first-time resident enrollment at ISU is -0.088. This is in the inelastic range and the coefficient is not significantly different from zero. The model predicts that a 10 percent increase in resident tuition would lead to an enrollment decline of less than 1 percent, so that aggregate tuition revenues would increase substantially. This small price elasticity may be misleading in that every price increase at ISU is accompanied by a similar increase at the University of Iowa and UNI. Therefore, this elasticity represents the net effect of a price increase at all three Regents schools. Hoenack (1971) and Hoenack and Weiler (1975) reach a similar conclusion in their study of enrollment at UCLA and the University of Minnesota, respectively. If ISU tuition were to increase while fees at U of I and UNI remained constant, the implied reduction in enrollment at ISU presumably would be significantly larger.

The distance from Ames has a negative and significant effect on ISU first-time enrollments. Counties that are farther from Iowa State tend to have smaller enrollments, all

else equal. Similarly, counties that are farther from the University of Iowa tend to have larger freshmen enrollment at Iowa State. The distance results are consistent with the price results. A 10 percent increase in distance to both Iowa State and Iowa leaves ISU enrollment lower. Similarly, a 10 percent increase in tuition at ISU and U of I tuition would leave Iowa State's enrollment lower. Since tuition at Iowa State University and the University of Iowa are virtually identical, distance from home represents one way that the cost of enrollment differs between the two schools. The distance results suggest a policy of offering larger tuition scholarship to resident applicants as distance to ISU increases and as distance to U of I falls.

The national average two-year public college tuition positively affects ISU first-time resident enrollment, however, the coefficient is not significantly different from zero. While the coefficient is imprecise, a 10 percent increase in the price of two-year colleges leads to a predicted increase in first-time resident freshmen of only 2 percent.

Resident undergraduate enrollment and applications for admission to ISU

To test the robustness of the previous results, undergraduate enrollment and applications for admission by county are regressed on the same set of explanatory variables.

Undergraduate enrollment appears to behave differently than first-time resident enrollment.

The model for applications for admissions is very similar to first-time resident enrollment.

The signs and significance levels of first-time resident enrollment and applications are identical. The model of undergraduate enrollment has some sign changes, relative to the first-time student enrollment.

Resident undergraduate enrollment by county

Manski and Wise (1983) present a model of college enrollment that treats the decision to continue in college as a separate decision from the decision to initially enroll. Undergraduate enrollment implicitly includes the issue of persistence. Students may come to a university and find that college is not for them. This is perhaps one explanation for the findings that only two of the coefficients have the same sign in the undergraduate enrollment model, relative to the first-time freshmen model. It may also explain why only one coefficient is statistically significant from zero.

ISU resident tuition remains negative and insignificant. Recall that this small coefficient may be a direct result of the tuition at all Regents institutions moving together. The coefficient of two-year college tuition changes sign and is significant. The difference is due to the possibility of transferring into ISU after attending two years at one of the community colleges in the state.³ In 1995, 31 percent of the new students at ISU were transfer students, and of these transfer students, 46 percent came from an Iowa area community college (ISU Annual Statistical Report, 1995). If the process of transferring from a community college to ISU is relatively simple, students may choose to attend the community college for 2 years because of the lower price, with the intention of transferring to ISU. This would make undergraduate enrollment at ISU and 2-year schools complementary goods. Thus, as the price of attending a community college increases, enrollment at the 2-year school will decrease. Therefore, the number of transfer students will decline resulting in smaller

³ Chressanthis (1986) found that the own-price response for juniors was positive. He attributed this to the large number of two-year transfer students into SVSC.

undergraduate enrollment at Iowa State. However, recall that 2-year school enrollment is a substitute for first-time student enrollment at ISU, with a positive cross price elasticity of 0.22. However, the substitution effect of freshmen enrollment does not outweigh the upper-class effect of 2-year tuition.

The effect of distance to ISU is negative, but not significantly different from zero. The coefficient of distance to Iowa City changes sign from the previous regression, but becomes insignificant. The insignificance of the two distance coefficients may result from the increased cost of transferring out of the university. Once a student has invested a year at ISU, the cost of leaving for another college becomes more expensive. Therefore, the cost of attending ISU, proxied by the distance to the University of Iowa and ISU becomes less important.

Family income, returns to college, and the number of high school graduates enter the analysis in the first stage decision between college and the labor force. The coefficients of these three variables are negative but not significantly different from zero. The lack of significance indicates that, while these variables do explain the initial decision to enroll, they do not explain the decision to continue in college. These results indicate that further study on the issue of retention may be necessary to determine what factors are important in explaining undergraduate enrollment.

Resident applications for admission to ISU by county

The theoretical model predicts that the application results should be similar to first-time resident enrollment. These expectations are confirmed. Signs on coefficients are identical in

the two regressions. The income and price elasticities are similar in magnitude in the two models.

A 10 percent increase in county per capita income leads to a 6.4 percent increase in the number of applications. Resident applications for admission are not strongly influenced by ISU tuition. Consistent with economic theory, the price elasticity is smaller for applications than for enrollment, although both estimates are imprecise.

The coefficients of the two measures of distance are significant and have the expected signs, negative for distance to ISU and positive for distance to Iowa City. All else equal, a county that is farther from Iowa City will have more applications for admission to Iowa State. Similarly, counties closer to Ames will have more applicants. The national average two-year tuition coefficient is positive, but again not significant. The number of high school graduates and the ratio of college to high school salaries have strong positive effects on applications for admission to ISU. The ratio of salaries is significant for applications. This indicates that the relative returns from college appear to be generating interest in college, but that Iowa State has not converted this increased interest (i.e. increased applications) into increased enrollment.

Simulations of resident first-time enrollment

Resident enrollment has remained relatively stable over the 19 years. Resident enrollment in 1977 was 4,449. It peaked in 1979 at 4,934. Since 1979, first-time resident enrollment decreased to 3,517 in 1994. The model predicts an enrollment path that is very similar to the actual path shown in Figure 3.1. Four simulated enrollment paths are presented

for first-time resident enrollment. Figures 3.2 and 3.3 show the predicted enrollment level at historical values of the regressors (baseline). The simulations in Figure 3.2 show implied first-time resident enrollment time paths were the number of high school graduates, per capita income, or the ratio of college to high school salaries held fixed at their 1976 level. Differences between the simulated and actual paths illustrate the impact of the factors on enrollment.

The simulations show that the ratio of college to high school salaries had a small impact on the resident enrollments at Iowa State. If the salary ratio had not increased since 1976, resident enrollment at ISU would be 2.5 percent lower in 1994. The model also indicates that the 20 percent increase in Iowa per capita income since 1976 accounts for a 6.5 percent increase in first-time resident enrollment in 1994.

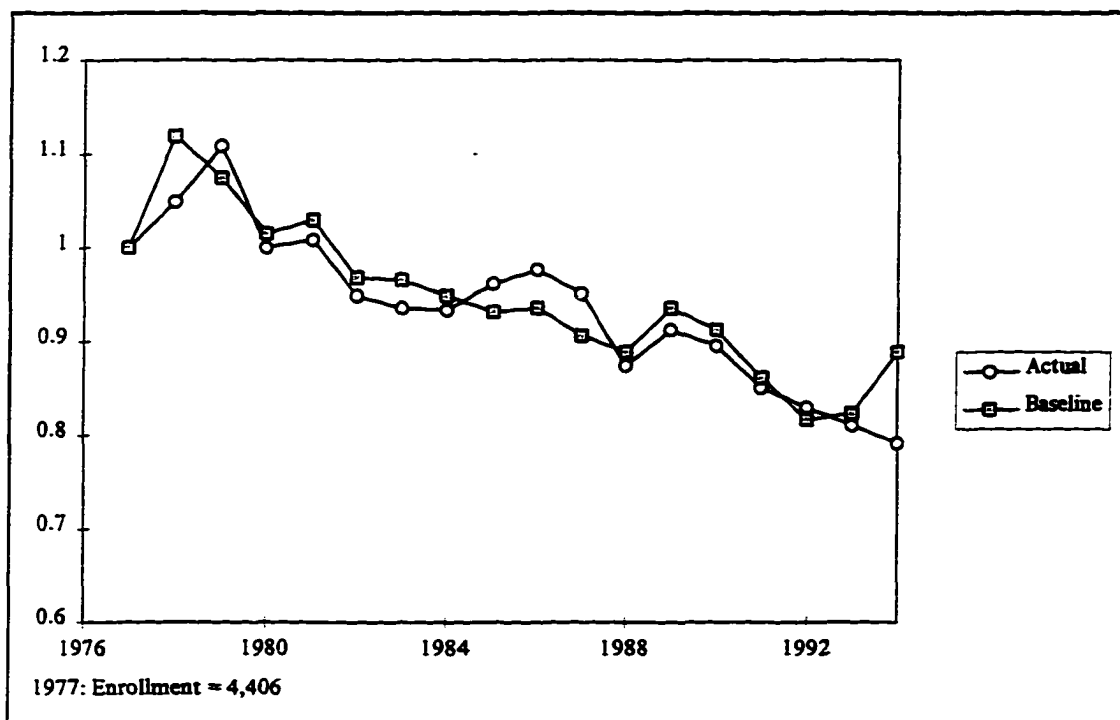


Figure 3.1 Actual and baseline first-time resident enrollment, 1977 - 1994.

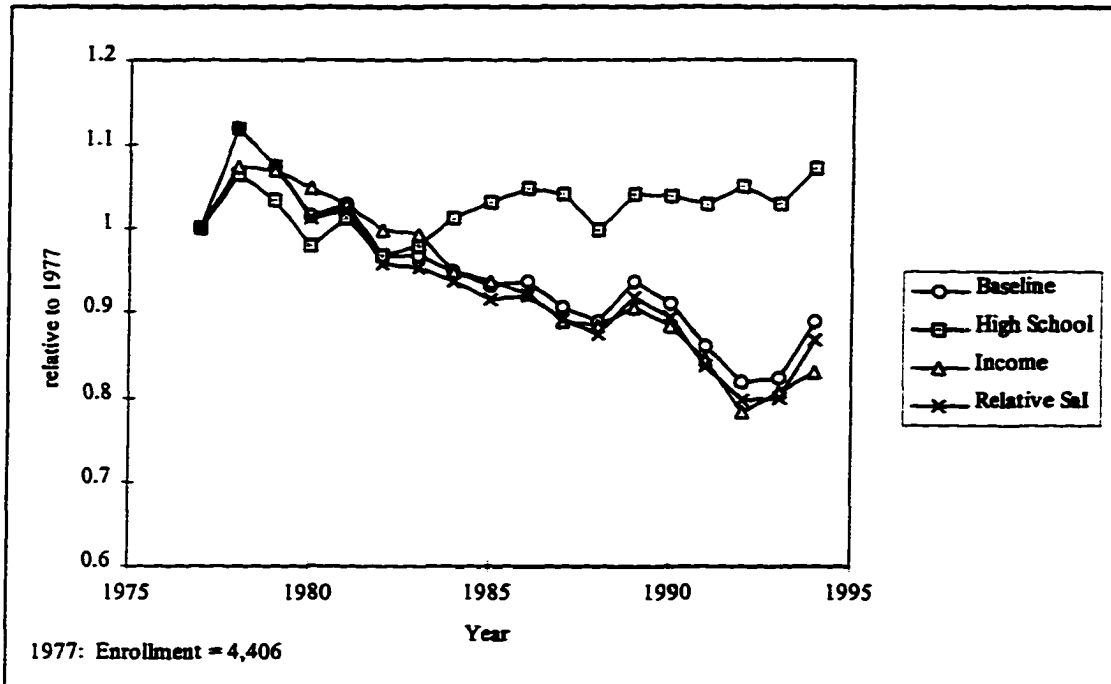


Figure 3.2 Baseline and simulated first-time resident enrollment, 1977 - 1994. Simulations hold a factor (college over high school salaries (returns), the number of high school graduates, or per capita income) constant at the 1976 level.

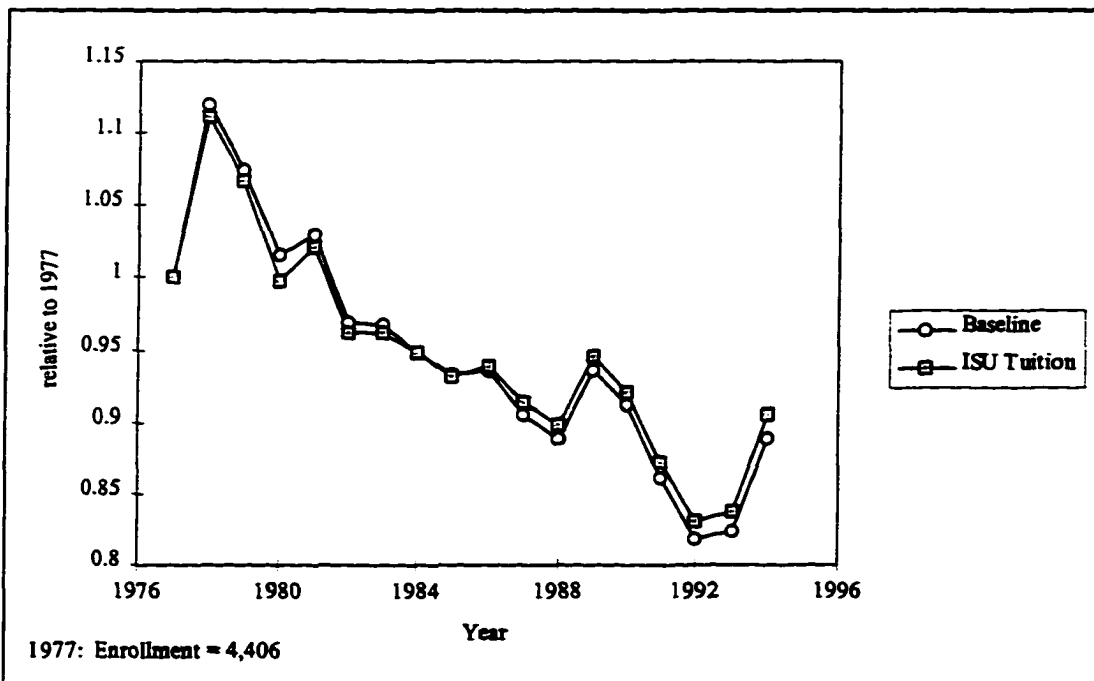


Figure 3.3 Baseline and simulated first-time resident enrollment, 1977 - 1994. Simulation holds real ISU resident tuition constant at the 1976 level.

The 20 percent decline in the number of high school graduates since 1976 is responsible for an estimated reduction of 806 resident students by 1994. The simulated enrollment path when real resident tuition at ISU is held fixed at the 1976 level (Figure 3.3) also shows a very small effect, implying that increases in real resident tuition since 1976 reduced resident enrollment by 1.8 percent. However, since tuition levels at the Regents institutions are set by the Regents and tend to move together, the predicted path of enrollment reflects the impact of enrollment at Iowa State University as tuition at all Regents institutions remained constant at the 1976 level.

Policy Implications of Resident Enrollment

The finding of an inelastic price response to resident tuition suggests that if the university wants to maximize tuition revenue, it should raise the price that resident students are charged. While the estimate of the own-price elasticity of demand is very imprecise, the 99 percent confidence region for the coefficient is (-0.565, 0.389), clearly in the inelastic range. However, the strong correlation between tuition at the Regents institutions clouds this measure of the own-price elasticity of demand for Iowa State University. Because of the strong correlation in the prices, this effect captures the impact on enrollment when all 3 Regents institutions increase tuition by 1 percent, not ISU in isolation. The effect of prices captured by the two distance measures indicate that ISU and U of I are substitutes. Thus a the price to attend the U of I increases, enrollment at ISU would be expected to increase.

There are reasons to maintain low resident tuition that are unrelated to the goal of maximizing revenue. However, the results suggest that tuition revenues would increase by

increasing resident tuition. The remaining factors behave as expected. Iowa high school graduating class sizes play a very strong role in determining first-time resident enrollment at Iowa State. Enrollments change in rough proportion to changes in high school class sizes. Coefficients on the two distance measures indicate that recruiting efforts might be more productive in areas closer to Ames, and farther from Iowa City. Targeting the central and western sections of the state may be relatively more productive. Alternatively, larger scholarship inducements may be necessary to increase enrollments from eastern Iowa.

In summary, the models of first-time freshmen resident enrollment and applications for admission find that

- Resident enrollment and applications are almost unresponsive to changes in tuition.
- First-time resident enrollment is positively related to changes in the tuition at two-year colleges, but the effect is very small.
- Increases in Iowa per capita income lead to increased resident enrollment.
- Distance from Ames negatively influences first-time resident enrollment at ISU, while distance from the University of Iowa is positively related to enrollment at Iowa State.
- Resident applications for admission are very responsive to increased relative college salaries, but first-time resident enrollment is not strongly driven by the increased salary ratio.

Comparing Resident and Nonresident Results

The two empirical models presented here examined enrollment at Iowa State University. The impacts of the changes in the incentives to attend college in general were separated from

the changes in the incentives to attend Iowa State University. Within each classification of resident and nonresident, first-time freshmen enrollment, undergraduate enrollment and applications for admission yielded similar results. The one exception is resident undergraduate enrollment.

The results show that first-time resident enrollment is relatively unresponsive to increases in tuition (own-price elasticity of demand or -0.088), while first-time nonresident enrollment will respond to an increase in tuition with an equal decrease (in percentage terms) in enrollment (own-price elasticity of demand = -0.971). Increases in nonresident tuition will not lead to increases in revenue, but will cause declines in enrollment. Increases in resident tuition will lead to modest declines in enrollment, but relatively large increases in revenue. The policy, if the goal is to maximize tuition revenue, is to increase resident tuition above the inflation rate and increase nonresident tuition only to cover inflation.

Resident first-time freshmen enrollment is less responsive to increases in income than are nonresident enrollments. The income elasticities for resident and nonresident first-time student enrollment are 0.569 and 1.655 , respectively. A policy that increased the per capita income (such as the recently passed "Hope Scholarship" (tax credit)) would lead to larger percentage increases in nonresident enrollment than resident enrollment.

This chapter presented a two-stage model of the decision to invest in higher education. The model captures the changes in incentives to invest in higher education generally and the changes in the incentives to invest in a particular institution. The econometric results are consistent with previous research and the underlying intuition of the demand for higher

education. The empirical results also attribute the large increase in enrollment in higher education nationally to increased family income and increased expected returns to higher education.

CHAPTER 4
THE INDIVIDUAL'S DECISION TO ENROLL AND THE PRICE
DISCRIMINATING INSTITUTION

Introduction

The college choice decision is a complex process. In 1994, there were 3,688 institutions of higher education in the United States alone. James et al. (1989) studied a school's importance in explaining earnings of college graduates. They found that the proportion of earnings attributable to the college attended was small. Choice of major, courses studied, and grades received explained a larger share of the wage variation across individuals.

... while sending your child to Harvard appears to be a good investment, sending him to your local state university to major in Engineering, to take lots of math, and preferably to attain a high GPA, is an even better private investment. Apparently, what matters most is not which college you attend but what you do while you are there, (p. 251 - 2)

If private and public degrees yield comparable earnings after college, college choice is likely to depend heavily on the relative cost of attending college. If the desired major and courses are available at similar institutions, the student may choose the school with the lowest net price of attending. On the other hand, the college needs to understand the effect of their policies on the individual's decision to enroll. The administration should be able to evaluate which prospective students are likely to enroll, and what the effect of financial aid would be on the probability of enrolling.

This chapter examines an individuals' decision to enroll at Iowa State University. The model examines first-year freshmen admitted applicants. Four empirical tests are discussed

in this chapter. The first test deals with the individual's response to changes in price, income and other factors. The elasticities of demand and income are discussed in this section. Next, the empirical results determine the cost of targeting specific factors, (such as increasing the ACT or class rank) in terms of the tradeoff in tuition. Third, the results can test if the university is effectively price discriminating. Finally, the model is used to map the expected enrollment demand curve for the institution. The model predicts reservation prices for each individual, given a target probability of enrollment. Once the reservation price and target probability of enrollment are known, the expected enrollment demand curve and expected revenue can be determined. Furthermore, various tuition policies are examined to determine the response of enrollment and revenues under each policy.

Overview of Data

The data used in this analysis was obtained through the Office of Financial Aid and the Office of Student Affairs. Admissions applications, financial aid applications, and financial aid awards are merged with the aggregate data used in the previous chapter. This section reviews the demographic trends of enrollment and admission applicants at ISU from 1976 to 1994.

A brief overview of the applicant pool may be helpful. The average age of an applicant is 18.3 years old. Females make up 45 percent of resident applicants and 42 percent of nonresidents. Ethnic minorities account for 3 percent of resident applicants and 18 percent of nonresidents. Fourteen percent of resident applicants and 5 percent of nonresidents are children of ISU alumni. The average applicant has a class rank in the top quarter and an ACT

score of 24.5, which is 4 points above the national average.¹ Of the financial aid applicants, average parental income is \$27,472 in 1994 dollars.

The time paths of the number of admitted resident and nonresident students are shown in Figure 4.1. The number of nonresidents admitted to ISU rapidly increased in the early 1980s. The nonresident applicant pool peaked in 1983 at 3,480. The number of nonresidents admitted to ISU declined for the next 8 years to 2,228 students in 1991. In the last 4 years the number of applicants has increased and in 1994 was back at the 1983 level.

The resident applicant pool has remained relatively constant over the period. In 1976 4,144 students from Iowa were admitted to Iowa State University. The number of admitted applicants remained above the 1976 level until 1990. In 1991, the number of admitted resident applicants fell to 3,504. In 1994, 3,835 resident applicants were admitted, which is 8 percent below the 1976 level.

Figure 4.2 shows the enrollment rates of residents and nonresidents over the period. There is a downward trend in both time paths. A downward trend in the enrollment rate can be caused by a relative increase in applications or a relative decline in the number of students enrolling. The nonresident enrollment rate is 30 to 40 percent below the resident rate. This is due, in part, to the higher tuition that the nonresident students would be required to pay if they enrolled at ISU. Nonresident enrollment rates have declined from 47 percent to 21 percent. Recall that Figure 2.4 shows that the 1994 nonresident enrollment at ISU was slightly above the 1976 level. It is clear that the declining enrollment rate of nonresidents is

¹ The 1995 national average ACT score was 20.8 according to an ACT internet press release dated 8/13/97.

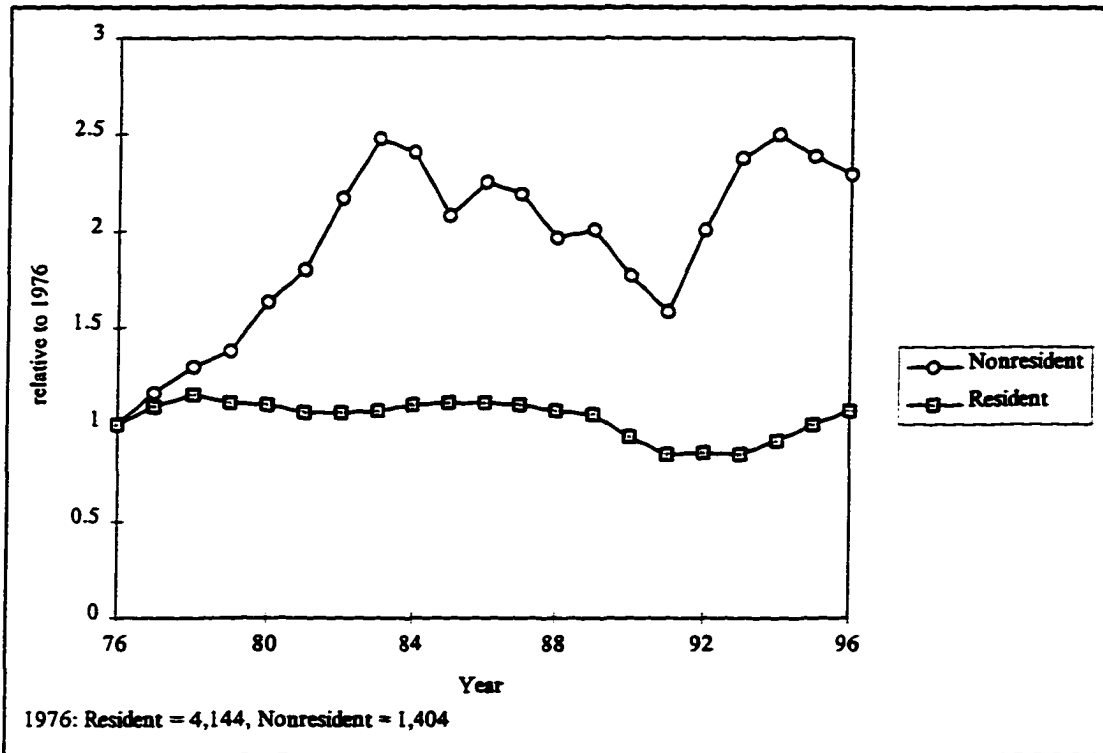


Figure 4.1: Number of students admitted to Iowa State University, 1976 - 1996, relative to 1976.

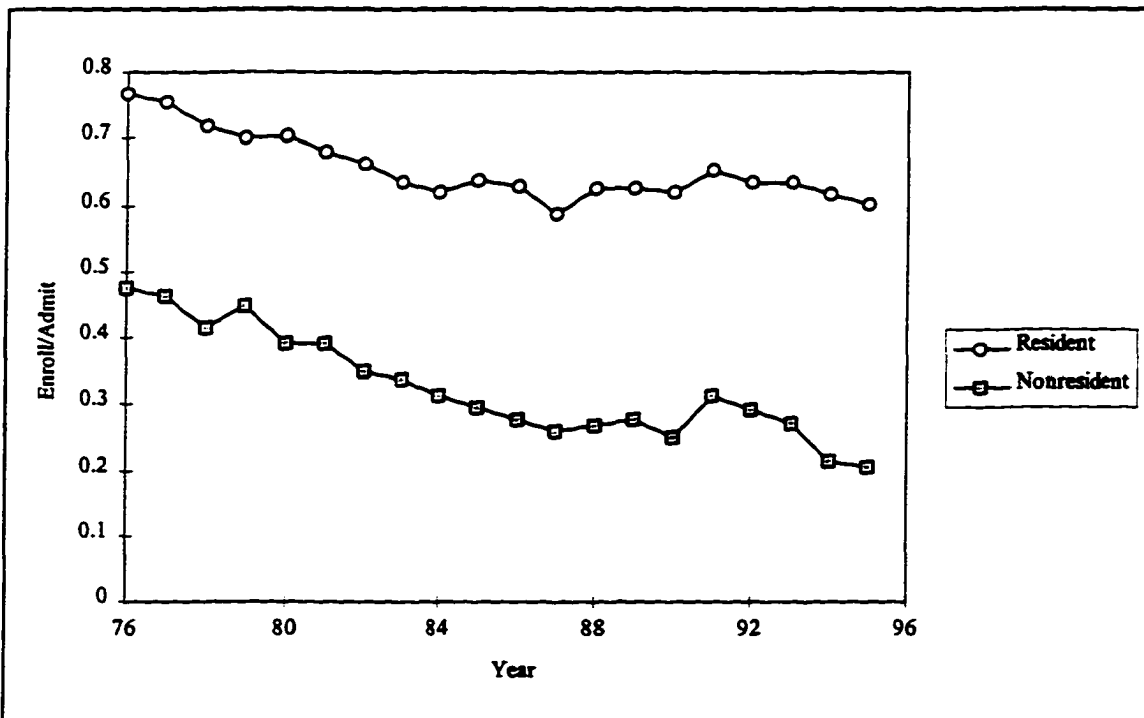


Figure 4.2: Enrollment rate of resident and nonresident students at ISU, 1976 - 1995.

due to increased applications and not decreased enrollment. This has significant implications for tuition revenues, since the number of people paying tuition did not decline.

However, the decline in the resident enrollment rate appears to be caused by a decrease in the number of students enrolling, since the number of applications has remained relatively stable. The resident enrollment rate dropped from 76 to 61 percent over the past 20 years. Figure 2.4 confirms that 1994 resident enrollment is below the 1976 level. Thus, there are fewer resident students paying tuition.

Universities are not only concerned with the number of people enrolling, but also the composition of students on campus. Savoca (1990) noted that the presence of affirmative action programs may increase the probability of minorities and females being admitted. These groups are traditionally under-represented on campus and many colleges compete for them. Universities also target those students who have high academic ability with several scholarship programs. Figures 4.3 to 4.8 show the composition of the applicant pool at ISU.

The time paths of female applicants are very similar to the overall paths (Figure 4.3). The number of nonresident females admitted to ISU has grown significantly, from 851 in 1991 to 1,586 in 1995. Figure 4.4 shows the enrollment rates of admitted resident and nonresident females. The enrollment rate of nonresident females dropped from 50 percent to a low of 20 percent in 1993. Female enrollment rates are slightly below the overall enrollment rate. However, the difference is at most 3 percent.

The time path of the number of admitted minority applicants is shown in Figure 4.5.²

² Student records containing information on ethnic background became available in 1983.

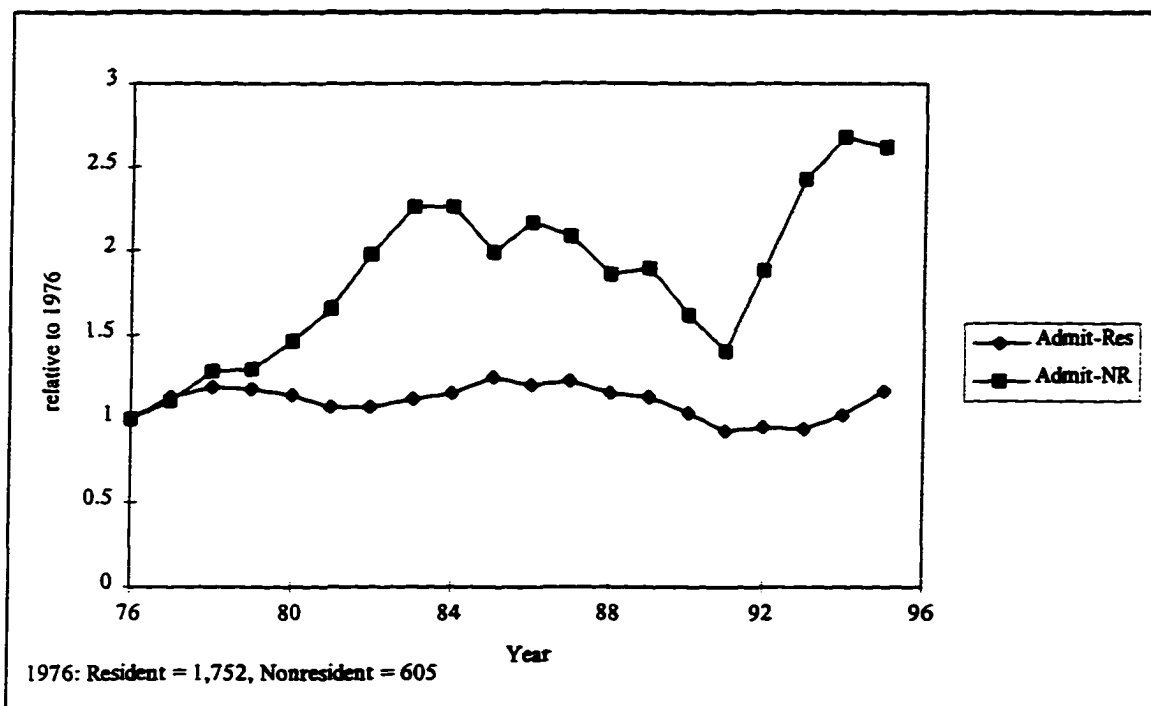


Figure 4.3: Number of female applicants to ISU 1976 - 1995, relative to 1976

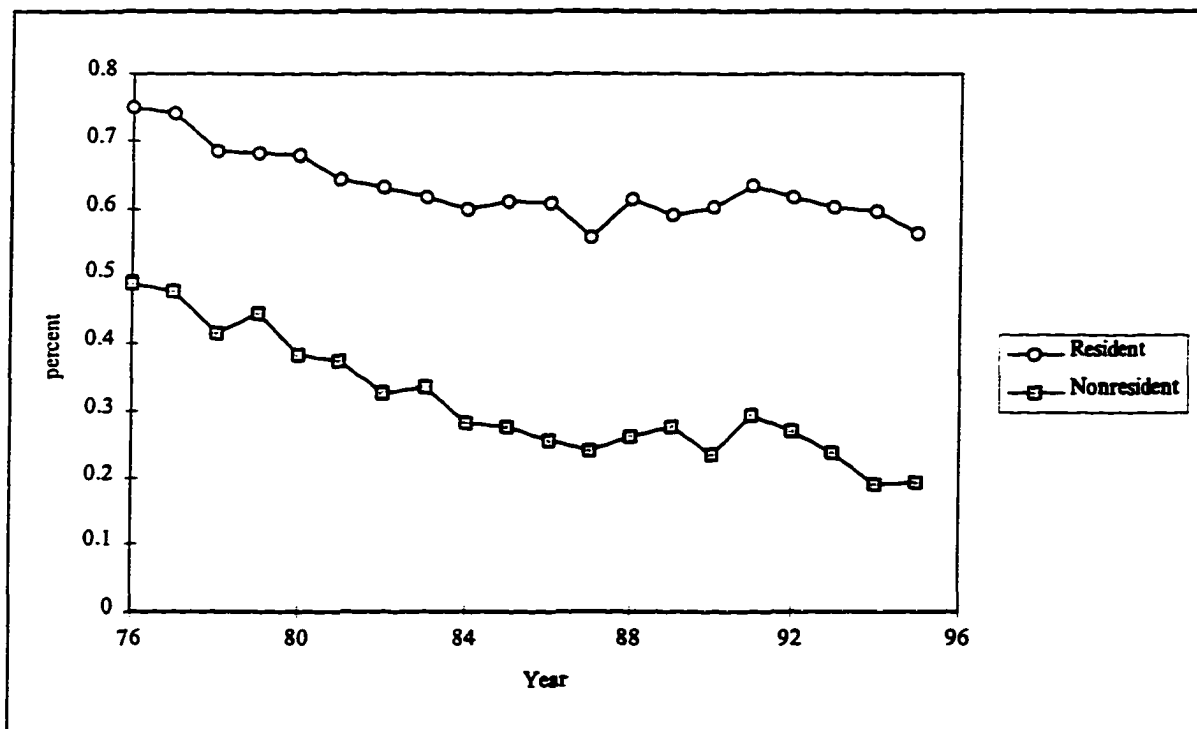


Figure 4.4: Female enrollment rates at Iowa State University, by resident status, 1976 - 1995.

Minority applicants come disproportionately from outside of Iowa. There were 570 nonresident minority students admitted in 1976 and only 145 resident minority students. This reflects the small percentage of ethnic minorities that live in Iowa.³ In fact, there are several years in which the number of minorities *enrolling* from out-of-state exceeds the number *applying* from Iowa. The enrollment rates of minorities (shown in Figure 4.6) do not exhibit the steady decline found in the overall and female samples. The enrollment rate of minority applicants is 3 to 12 percent below the rate for all applicants.

Student academic abilities influence the decision of which institution to attend. High ability students will be admitted to more prestigious institutions and may also qualify for merit based scholarships which raise their incentives to enroll in higher priced institutions. Rothschild and White (1995) discussed the externalities associated with certain groups of students. Grossman (1995) indicated that colleges target high (academic, athletic, or artistic) ability students because faculty prefer to teach them and these students establish a reputation effect for the school. "This effect pleases alumni, who are the main benefactors of private colleges, and also makes a college more attractive to other prospective students." (Grossman, 1995 p. 519.)

The fourth student group in this discussion are the applicants who graduated in the top 5 percent of their high school class. The trends for high ability applicant are shown in Figures 4.7 and 4.8. Rank is a measure of the academic ability of prospective students. The number of nonresident high ability applicants has a similar trend to the other nonresident applicants.

³ In 1992, ethnic minorities made up 3.3 percent and 19.8 percent of the population in Iowa and the U.S., respectively (U.S. Department of Commerce, *Statistical Abstract of the United States*, 1996).

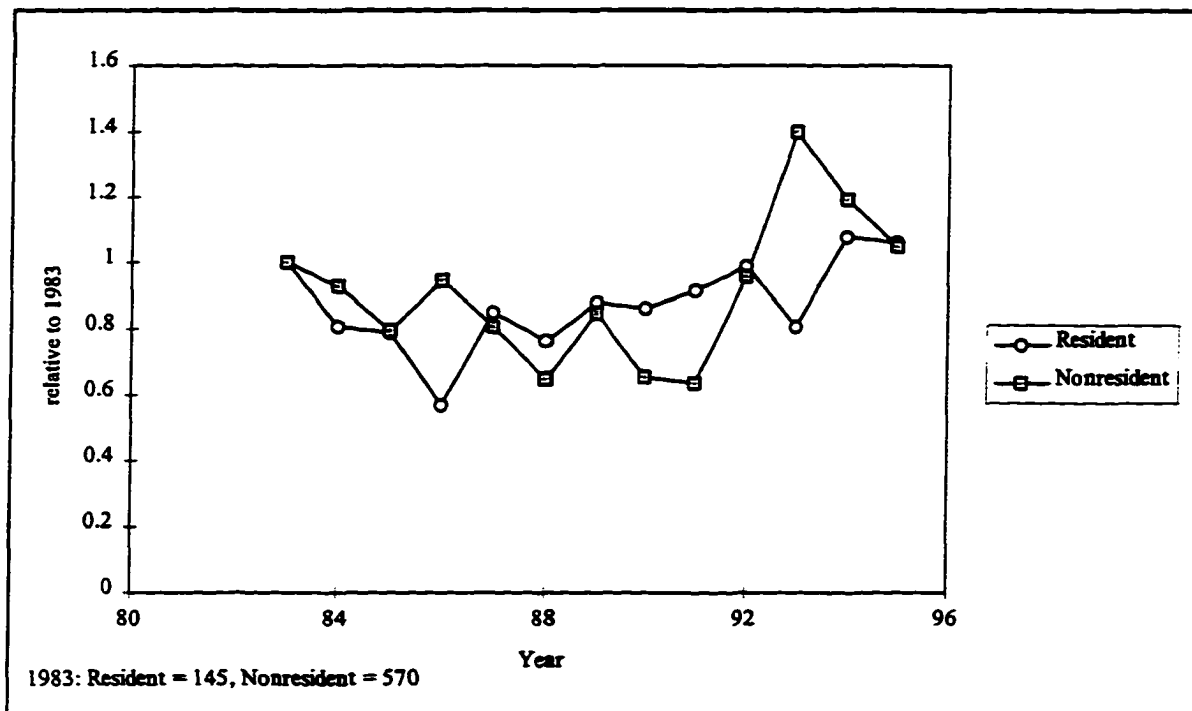


Figure 4.5: The number of minority students admitted to ISU, by residency 1983 - 1995, relative to 1983.

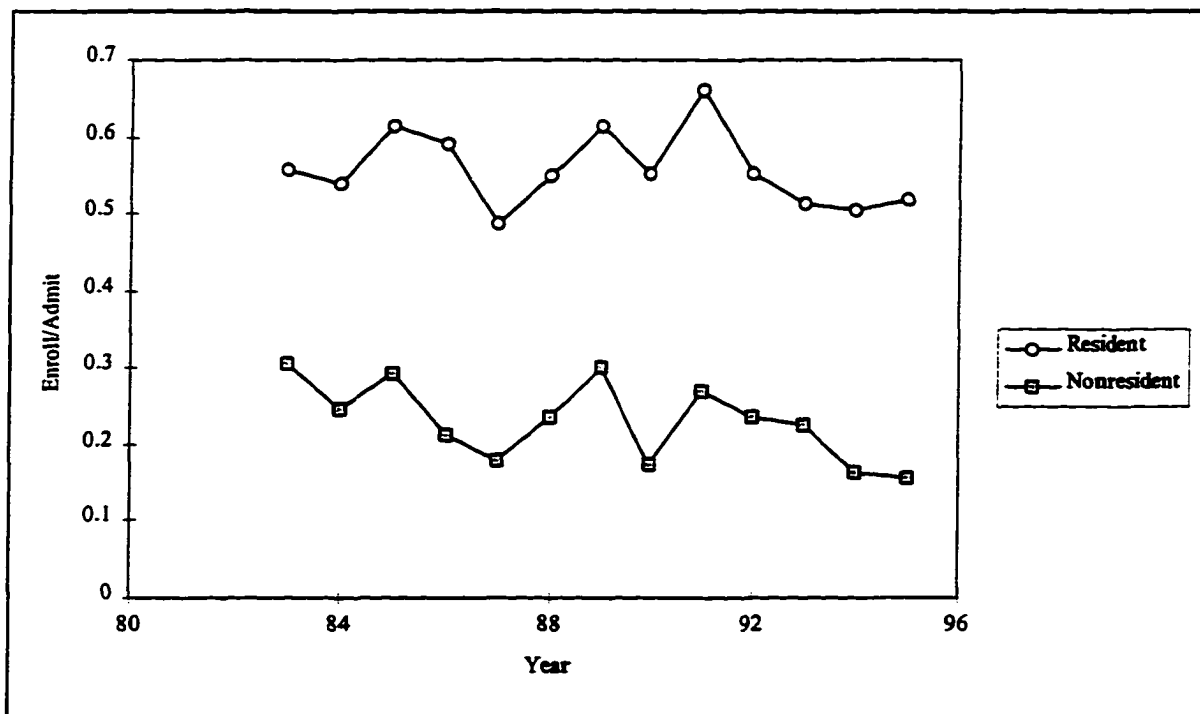


Figure 4.6: Minority enrollment rate at ISU, by residency 1983 - 1995

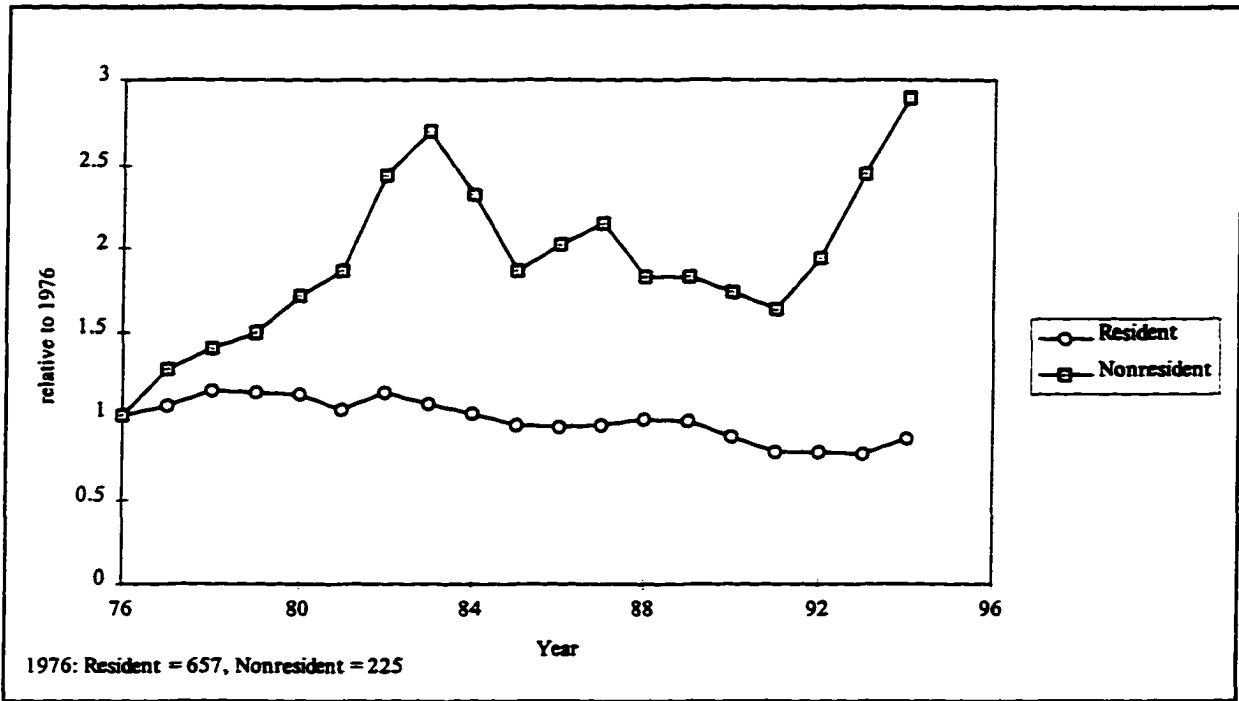


Figure 4.7: The number of admitted high ability students to ISU, by residency. 1976 - 1994.

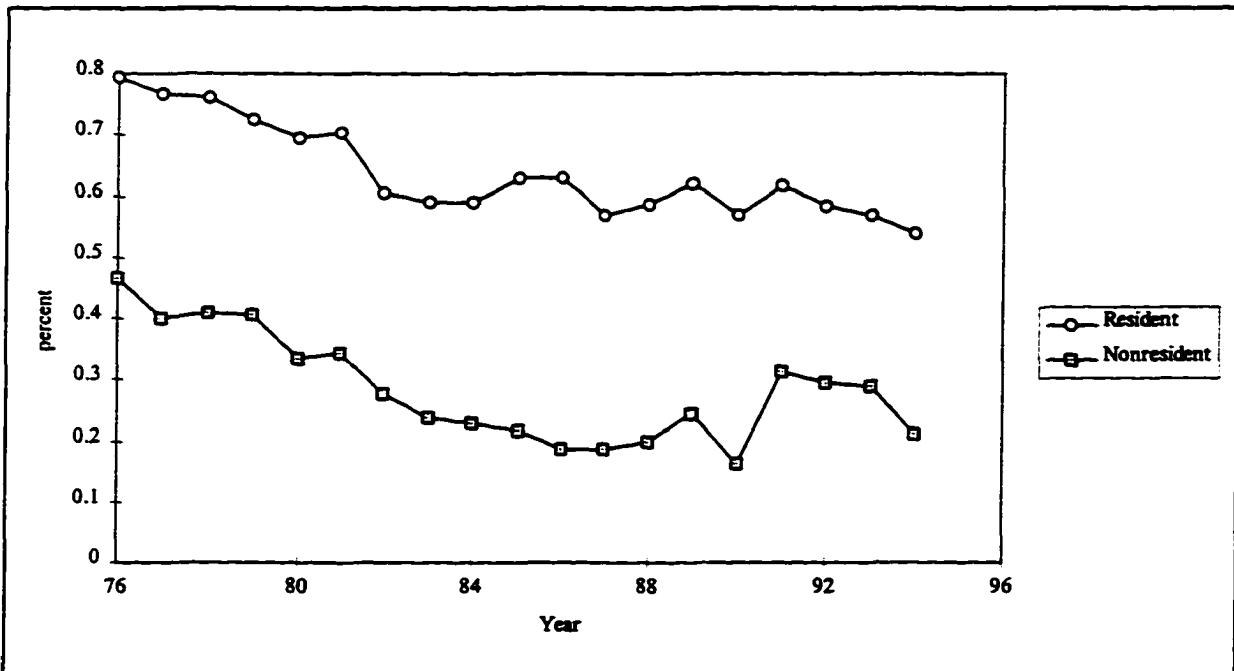


Figure 4.8: Enrollment rate of high ability students at ISU, 1976 - 1994.

Similarly, resident high ability applicants are relatively stable over the period. The enrollment rates of high ability applicants also show a downward trend. In 1976, the enrollment rate of resident high ability applicants was 3 percent higher than the overall rate. Since 1982 the enrollment rate of resident high ability applicants has been below the average rate. The enrollment rate of high ability resident applicants was 8 percent below the average in 1994.

The student's college choice may also be influenced by his parents' college history. The alumni parents may "lobby" the prospective student to attend their alma mater. There are also university programs that recruit college-age (or younger) children of alumni. For example, in the early 1990s, ISU started the "Legacy Program". When an alumnus has a child, the "Legacy Program" sends a children's story book and information about the importance of higher education to the family.

Information on family financial status is available in the financial aid application. Parents adjusted gross income is used in the current model. In reviewing the data, it was found that prior to 1985 and in 1990 and 1991, the data were incomplete. Only those students who enrolled were included in the data. Therefore, the enrollment rate of financial aid applicants with retained records was 1. This would create a serious bias problem and so these years were not used in the analysis.

The percent of admitted applicants that applied for financial aid is shown in Figure 4.9. The years used in the analysis (shown with bold lines) indicate that over 70 percent of the admitted resident students and 30 percent of the nonresident students applied for financial

aid.

The average family income (parents reported adjusted gross income) of financial aid applicants is shown in Figure 4.10. Both resident and nonresident income has increased significantly. There are two factors that explain this increase. First, there was a general increase in per capita income over the past 20 years, as shown in Figure 2.2. However, average parental income of financial aid applicants doubled since 1985. National and Iowa per capita income increased only 16 and 18 percent, respectively, over the same period. An additional reason for the increase in the average parental income may be that more families with larger incomes are applying for financial aid.

Finally, an important tool for recruiting students is the financial aid offer. The prospective student will consider the financial aid award at each school, along with the other factors important in the college choice. Students are offered combinations of grants, loans and work-study opportunities in their financial aid packages. If the student qualifies for federal grant or loan aid at one school, it is likely that the student will also qualify for similar federal aid at other institutions. A grant reduces the cost of attending college dollar for dollar. However, loan aid only reduces the current out-of-pocket expense of attendance. The student will treat the various types of financial aid differently. The federal loan programs open (or provide easy access to) financial markets to low and middle income students who otherwise might not have the financial ability to pay for a college education. Moore et al. (1991) found that of the three types of financial aid, grants had the largest effect on the probability of enrolling.

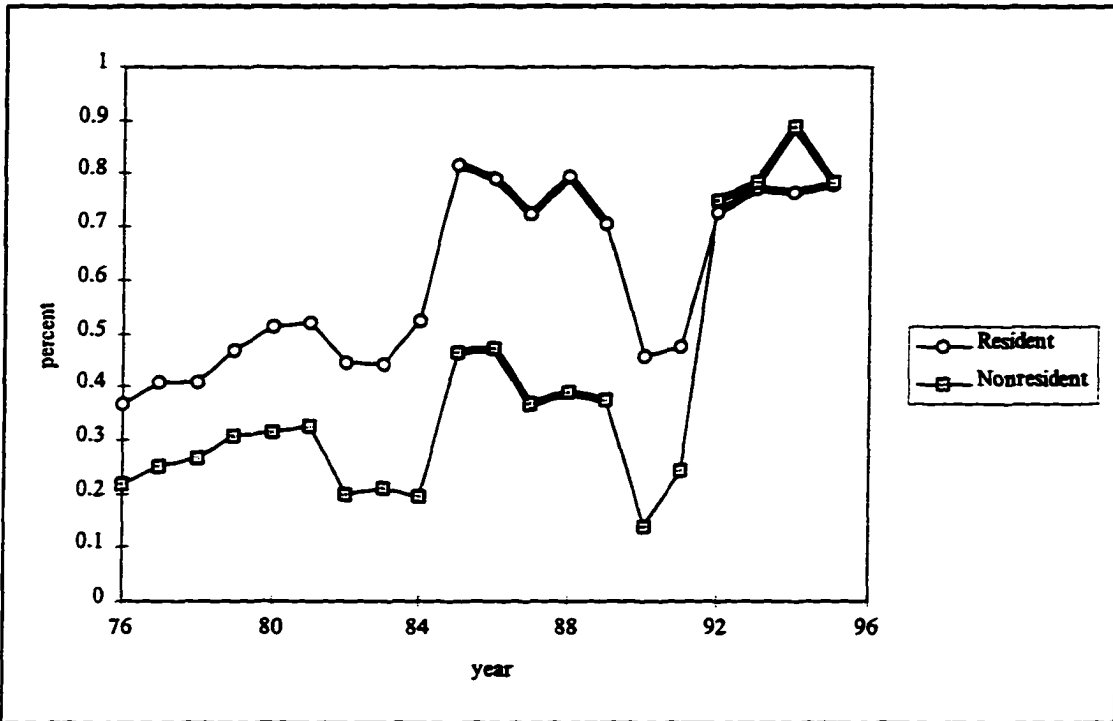


Figure 4.9: Percent of admitted students who apply for financial aid at ISU, 1985 - 1989, 1992-1995 used in the analysis.

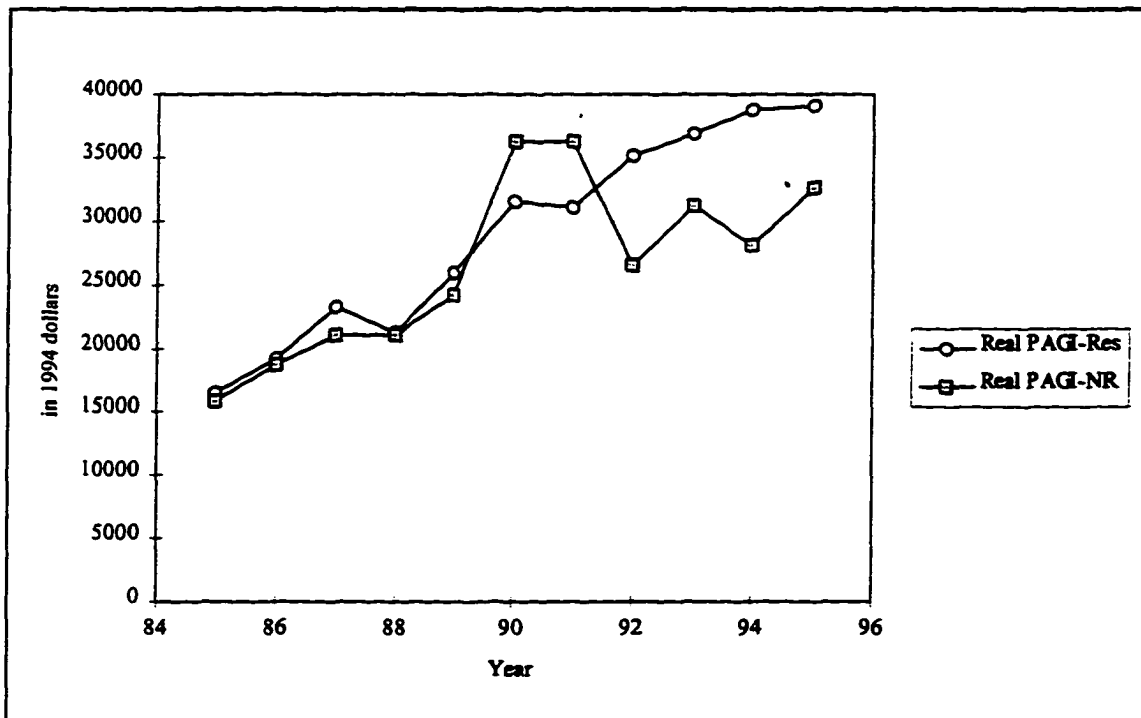


Figure 4.10: Average parents adjusted gross income of financial aid applicants, 1985 - 1995.

Data on the financial aid award are available from 1976 to 1994. The records include the final package, which may be different from the initial offer. This is especially true of loan and work-study aid, where the student may decline all or part of her eligibility. The other problem is that only grant offers to students who enrolled at ISU were kept. Thus, according to the data, a student who did not enroll was not offered a financial aid package. Since financial aid offers are made well in advance of the enrollment decision, this problem must be addressed. The predicted grant award for those students who applied for financial aid was used.⁴ The average actual and predicted grant aid are shown Figures 4.11 and 4.12, for resident and nonresident financial aid applicants, respectively. In both cases the predicted grant mimics the actual annual variation closely.

The decision to enroll at a particular school depends on several factors, from the academic ability of the student to the increased income as a result of the college degree. The next section develops a model that can determine how these factors affect the probability of enrolling at Iowa State University.

Modeling the Individual's College Choice Decision

In this section, an economic model describing an individual's college choice decision is discussed. Specifically, the individual is deciding which institution of higher education to make his or her human capital investment. The student chooses among those schools to which they have applied and been granted admission.

The college choice decision has been modeled as a sequential process by Manski & Wise

⁴ The details of the predicted grant model are found in Appendix B.

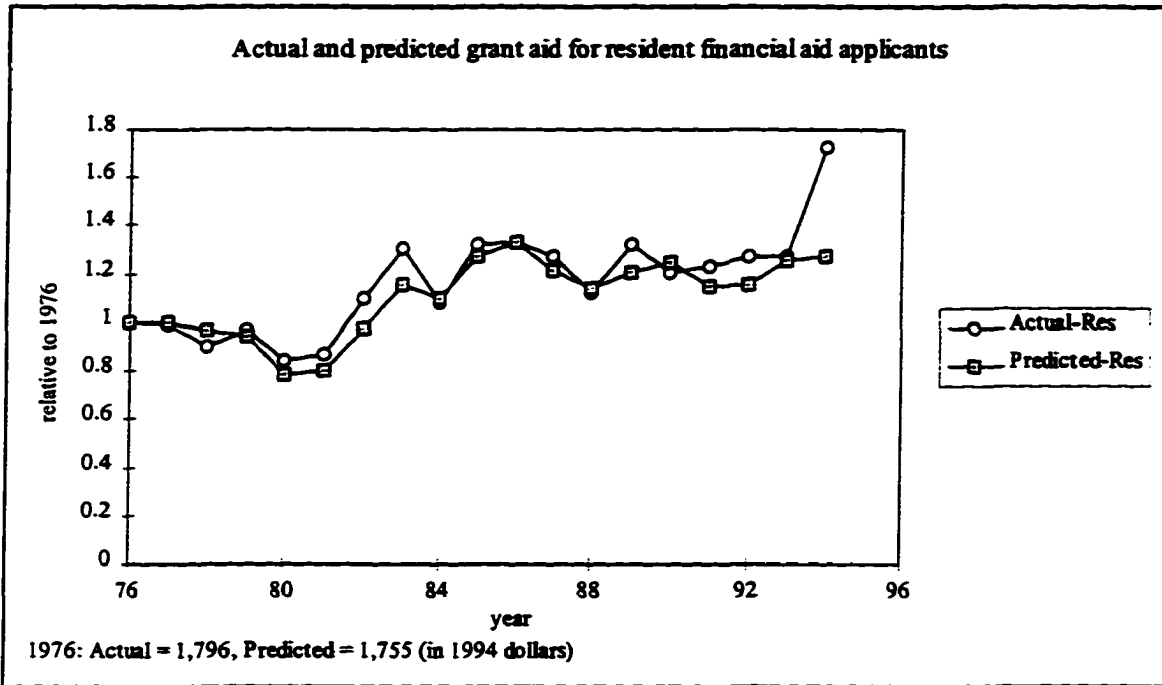


Figure 4.11: Actual and predicted real grant aid for resident financial applicants, 1976 - 1994.

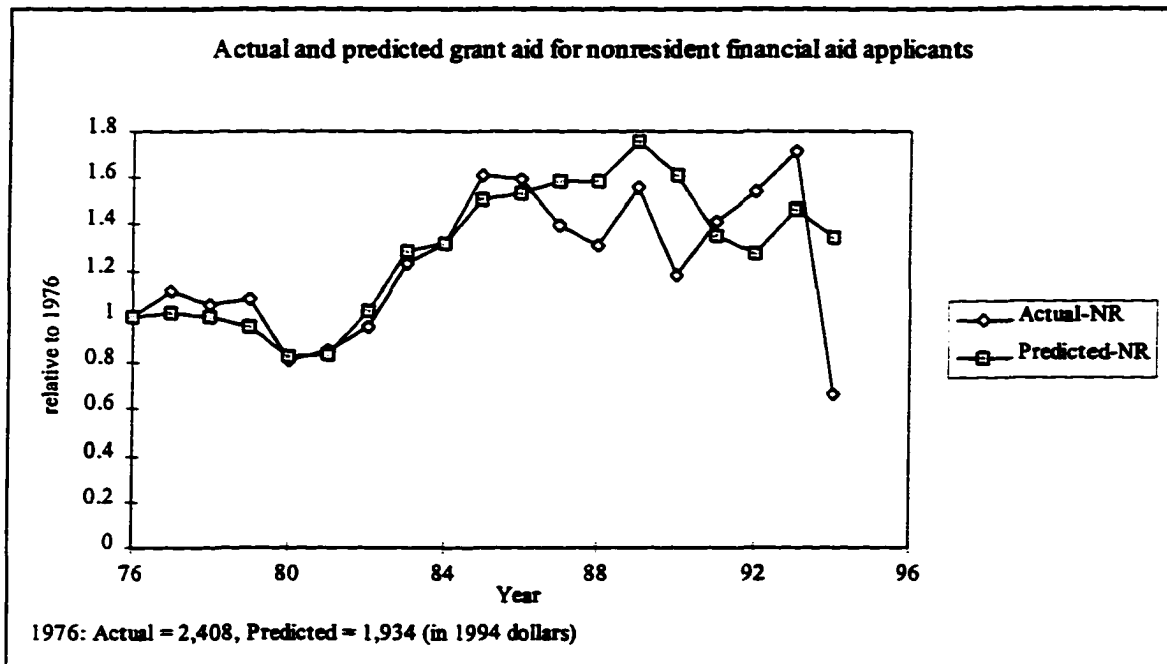


Figure 4.12: Actual and predicted real grant aid for nonresident financial aid applicants, 1976 - 1994.

(1983), where the students' decisions are: first, which colleges to apply for admission; second, given admission and financial aid, which college to attend; and finally, whether to remain in college through graduation. This paper examines the second stage of the individual's decision, using data from a single university.

The reservation price of attending a college: A theoretical model

The individual compares the available colleges and chooses to attend the one that maximizes utility. The decision to enroll depends on the characteristics of the individual, the characteristics of alternative institutions of higher education, and the current economic situation. In general, any factor that increases a student's range of college options will make the student more sensitive to the price of any one option.

The cost of attending the school of interest, the cost of other schools, the returns to higher education and the quality and reputation of each school are factors that enter the college choice. The time paths of these variables were reviewed in Chapters 1 and 2.

The economic model used in this analysis considers individual i 's indirect utility of attending college I . The utility is a function of the tuition, the financial aid package, the individual's characteristics, the characteristics of the institution, and a random error term.

$$U_i^I = U(\underbrace{T^I}_{(-)}, \underbrace{S_i^I}_{(+)}, \mathbf{X}_i, \mathbf{Z}^I) + \varepsilon_i^I \quad (4.1)$$

where

T^I = tuition at school I

S_i^I = student i 's scholarship package offered by school I

\mathbf{X}_i = a vector of student i 's characteristics

$Z^I =$ a vector of characteristics of school I

$\varepsilon_i^I =$ stochastic portion of student i's utility from school I (random error).

The individual's college choice will depend on the net cost of attending each college to which they have been admitted. For example, suppose an individual is considering two colleges of equal quality and reputation. Since all else is equal, he will attend the institution with the lower net cost. Considering the perspective of the institution, to ensure that the individual will enroll, the institution must offer a scholarship that decreases net cost just below the cost of the other institution.

This same thought experiment can be applied to schools of unequal quality or reputation. If the institution perceived to be of lesser quality can offer a net cost of attending sufficiently below the higher quality institution, the individual may choose to attend the lesser quality school.

In the spirit of the reservation wage models used in the study of labor force participation, the "reservation scholarship" can be defined as the level of scholarship that makes the individual indifferent between enrolling at one college over another, taking into account the differences between the schools. Standard assumptions on the indirect utility function guarantee the existence and uniqueness of a "reservation scholarship", S_i^{I*} , such that

$$E[U(T^I, S_i^{I*}, X_i, Z^I) + \varepsilon_i^I] = E[U(T^J, S_i^J, X_i, Z^J) + \varepsilon_i^J]. \quad (4.2)$$

By the implicit function theorem

$$S_i^{I*} = g(\underbrace{T^I}_{(*)}, \underbrace{T^J}_{(*)}, \underbrace{S_i^J}_{(*)}, X_i, Z^I, Z^J, \varepsilon_i^I, \varepsilon_i^J). \quad (4.3)$$

A linear approximation of the deterministic portion of (4.3) gives the predicted reservation scholarship.

$$\hat{S}_i^{I*} = \beta_0 + \beta_1 T^I + \beta_2 T^J + \beta_3 S_i^J + X_i \beta_4 + Z^I \beta_5 + Z^J \beta_6 \quad (4.4)$$

where $\beta_4, \beta_5, \beta_6$ represent vectors of coefficients.

The decision to enroll in college I can be characterized as a function of the predicted reservation scholarship and the actual scholarship offered. The individual attends college I according to the following rule:

$$\text{enroll}_i^I = \begin{cases} 1 & \text{if } S_i^I - \hat{S}_i^{I*} \geq \varepsilon_j - \varepsilon_i \\ 0 & \text{if } S_i^I - \hat{S}_i^{I*} < \varepsilon_j - \varepsilon_i \end{cases} \quad (4.5)$$

Individual i 's probability of enrolling in school I can be written as a function of the tuition and financial aid package of each school, the characteristics of the two institutions, and the characteristics of the individual.

$$\Pr(\text{enroll}_i^I = 1) = F(\underbrace{S_i^I}_{(+)}, \underbrace{T_i^I}_{(-)}, \underbrace{T_i^J}_{(+)}, \underbrace{S_i^J}_{(-)}, X_i, Z^I, Z^J). \quad (4.6)$$

Econometric model

The econometric specification is a linear approximation of equation (4.6), the probability of enrolling at I. It also assumes the error terms are identically and independently distributed (i.i.d.) normal random variables. Making the appropriate transformation to obtain unit variance, equation (4.6) leads to a probit specification. Implicit in the i.i.d. assumption of the probit model is that the enrollment decision of one individual is independent of other decisions to enroll.

The two sources of data allow two separate econometric models to explain the decision to

enroll at Iowa State. The first model will examine the decision to enroll based on the data from the admission application. The second model will examine the decision to enroll at ISU with the additional data contained in the financial aid application. The two econometric models used in the analysis are described below. Table 4.1 gives a brief description of the variables used in the analysis, detailed information is available in Appendix B.

Admissions model:

$$\begin{aligned} \text{enroll}_i^I = & \beta_0 + \beta_1 T^I + \beta_2 T^J + \beta_3 S^I + \beta_4 S^J + \beta_5 \text{CoInc}_i + \beta_6 \text{Col / HS} + \beta_7 \text{Rank}_i + \beta_8 \text{ACT}_i \\ & \beta_9 \text{PALum}_i + \beta_{10} \text{Female}_i + \beta_{11} \text{Minority}_i + \beta_{12} \text{Dist}_i^I + \beta_{13} \text{Dist}_i^J + \beta_{14} \text{CChoice}_i + \varepsilon_i \end{aligned} \quad (4.7)$$

Financial aid model:

$$\begin{aligned} \text{enroll}_i^I = & \beta_0 + \beta_1 T^I + \beta_2 S_i^I + \beta_3 T^J + \beta_4 S^J + \beta_5 \text{PAGI}_i + \beta_6 \text{Col / HS} + \beta_7 \text{Rank}_i \\ & + \beta_8 \text{ACT}_i + \beta_9 \text{PALum}_i + \beta_{10} \text{Female}_i + \beta_{11} \text{Minority}_i \\ & + \beta_{12} \text{Dist}_i^I + \beta_{13} \text{Dist}_i^J + \beta_{14} \text{CChoice}_i + \varepsilon_i \end{aligned} \quad (4.8)$$

The probit model converts the observed discrete choice of enrolling at ISU into a continuous probability of enrolling at ISU. The estimated model can be used to examine the behavior of the prospective student as well as the behavior of the institution.

Empirical test #1: The behavior of the prospective student

The tests of student behavior deal with estimates of the coefficients. The own-price elasticity of demand and income elasticity can be determined. This will give insight into the responsiveness in the probability of enrolling to changes in tuition, income, or subsidies (such as the proposed "Hope Scholarship/tax credit" for college tuition). Furthermore, for the financial aid model, the elasticity of grant aid can be determined. This is the change in the probability of enrolling from a 1 percent change in the scholarship offer.

Table 4.1: Brief description of variables used in the econometric analysis.

Variable:	Sign	Description
Dependent Variable		
enroll ⁱ		dummy variable = 1 if admitted student enrolls at ISU, = 0 otherwise.
Independent Variables		
T ⁱ	-	ISU tuition (resident or nonresident)
S ⁱ	+	predicted financial aid grants offered by Iowa State University
T ^j	+	DMACC tuition(resident) own-state public 4-yr. Tuition (nonresident)
S ^j	-	local subsidy of higher education
CoInc	+	county per capita income (application model) or parents adjusted gross income (financial aid model)
Rank	?	High School Class Rank
ACT	?	ACT composite test score
PAlum	+	dummy variable = 1 if parents are ISU alumni, = 0 otherwise
Female	?	dummy variable = 1 if female, = 0 otherwise
Minority	?	dummy variable = 1 if minority, = 0 otherwise
Dist	- +	distance to Ames, IA (resident and nonresident) in miles distance to Iowa City, IA (resident) in miles
CChoice	-	reports students ranking of which schools they want the ACT scores sent (range [1,7], where 7 least favorable response).

Specifically, the hypothesis that the impact of a dollar increase in tuition can be offset by a dollar increase in grant aid is tested.

$$\begin{aligned} H_0: \beta_1 &= -\beta_2 \\ H_A: \beta_1 &\neq -\beta_2 \end{aligned} \quad (4.9)$$

If this is the case the institution can maintain revenues by charging 1 more dollar in tuition and offering an additional dollar in scholarships. However, if the effect of a dollar increase in tuition is larger than the effect of a dollar increase in scholarships, then maintaining the number of students while tuition increases will require that scholarships be increased by a larger percentage than the tuition increase.

The behavior of the university

The empirical model above provides the foundation to examine the behavior of the institution. The university awards various financial aid packages to different groups, based on specific characteristics of individuals in the group (i.e. high ability, residency status, financial need/ability to pay). The choice variable for the institution is $S_{1,i}^I$, the financial aid offer. The financial aid offer is packaged by group, as well as by individuals within a group. For example, the university might try to attract high ability nonresident students by offering a scholarship to all nonresident students that graduated in the top 5 percent of their high school class, or had an ACT test score in the top 5 percent. In addition, these students may also qualify for grants and loans that are conditional on their family financial status (i.e. federally calculated student need index or family contribution), such as the Pell grant or Stafford loan. Thus, a financial aid package varies by individual and group.

The financial aid packages can be used to achieve the enrollment or revenue goals of the

institution. One goal might be to achieve a targeted level of enrollment or enrollment mix. Another feasible goal is to maximize net revenue from students. The following provides a method to infer the goal of the university based on the empirical estimates.

Empirical Test #2: The cost of targeting specific characteristics

Since enrollment is sensitive to tuition and scholarships, changing the average characteristics of the applicants can be achieved by a change in tuition or financial aid, while holding the probability of enrolling constant. For example, how much does tuition have to decrease to increase a characteristic x , (e.g. ACT, rank, male to female, etc.) by 1 unit, holding the probability of enrolling fixed? Denote the offsetting adjustment to the tuition as t and the initial tuition as T .

$$F(\beta_0 + \beta_1(T+t) + \beta_x(x+1) + \mathbf{XB}) = F(\beta_0 + \beta_1T + \beta_x x + \mathbf{XB}) \quad (4.10)$$

Since $F(\cdot)$ is monotonic,

$$\beta_0 + \beta_1(T+t) + \beta_x(x+1) + \mathbf{XB} = \beta_0 + \beta_1T + \beta_x x + \mathbf{XB}. \quad (4.11)$$

Subtracting the right hand side from the left,

$$\beta_1 t + \beta_x = 0. \quad (4.12)$$

Finally, the required tuition tradeoff is,

$$t = \frac{-\beta_x}{\beta_1}. \quad (4.13)$$

The same results hold if the policy variable were scholarships instead of tuition. These tradeoffs are discussed for each variable used in the analysis. Since separate models are estimated for residents and nonresidents, the tradeoffs are allowed to vary across residency status.

Empirical Test #3: Price discrimination and switching revenues

The university can use group specific financial aid policies to achieve their enrollment goals. Charging different groups different prices for the same product is called price discrimination. The group that has a less elastic demand curve would be charged a higher price (Scherer and Ross 1990, Varian 1989, Tirole 1989). In this case, the group that has more options available would presumably have a larger elasticity, all else equal. These groups would be charged a lower net price of attending. In theory, the revenue maximizing university would set the price for each group so as to equalize the marginal revenue of each group.⁵ On the other hand, if the marginal revenues are not equal, the university is not maximizing revenues by price discriminating.

It is important that the university understand the revenue implications of awarding additional dollars of scholarship funds. If the marginal revenue of a scholarship is positive, revenues increase as aid increases. As noted in the literature, students with specific characteristics may be more desirable to the university (Savoca 1990, Manski and Wise 1983). Thus, this analysis uses groups of students with specific targeted characteristics. The pool of applicants is divided into mutually exclusive pairs based on academic ability, residency, ethnic background, or gender. The expected net revenue (ENR) from group 1 is the product of the group size, net tuition per student, and the probability of a member in the group enrolling.

⁵ Revenue maximization is equivalent to profit maximization when the marginal cost is equal to zero, which is assumed here. Marginal cost is also assumed to be constant (and equal to zero) across groups. The zero marginal cost assumption means that adding the last student in cost free, which may be a good approximation of the marginal cost until capacity is reached.

$$ENR_1 = N_1(T - S_1)F(\hat{\beta}_2 S_1) \quad (4.14)$$

where

$N_1 =$ number of admitted applicants in group 1 ($N_1 > 0$)

$F(\hat{\beta}_2 S_1) =$ probability of group 1 enrolling (i.e. the reduced form of (4.6))

where $F(\cdot)$ is a cumulative distribution function (CDF), $f(\cdot)$ is the

corresponding probability density function (pdf), and $\hat{\beta}_2$ is the coefficient on grant aid.

$T - S_1 =$ net tuition revenue per person in group 1.⁶

The choice variable available to the institution is the scholarship offer. Partially differentiating (4.14) with respect to the scholarship gives the expected change in net revenues generated from the last dollar of grant aid offered to the group.

$$\frac{\partial ENR_1}{\partial S_1} = N_1[-F(\hat{\beta}_2 S_1) + (T - S_1)f(\hat{\beta}_2 S_1)\hat{\beta}_2] \quad (4.15)$$

The expected marginal revenue is the sum of the infra-marginal effect (the change in revenue attributable to those already participating, which is $-N_1 F(\hat{\beta}_2 S_1)$) and the marginal effect (the change in revenue attributable to those people who start (or stop) participating, which is equal to $N_1(T - S_1)f(\hat{\beta}_2 S_1)\hat{\beta}_2$).

If the university is price discriminating, the marginal revenue of each group would be equal to the marginal cost of taking on one more student. The hypothesis test of price

⁶ Variables that represent school J do not enter this analysis, therefore, the superscript denoting the school is dropped.

discriminating behavior is

$$\begin{aligned}
 H_0: \frac{\partial \text{ENR}_1}{\partial S_1} &= \frac{\partial \text{ENR}_2}{\partial S_2} \\
 H_A: \frac{\partial \text{ENR}_1}{\partial S_1} &\neq \frac{\partial \text{ENR}_2}{\partial S_2}
 \end{aligned}
 \tag{4.16}$$

Under this framework the expected revenue of recruiting one group relative to another group can be determined. The expected enrollment of group 1 (EN_1) is the product of the group size and the probability of enrolling, which is positively related to the scholarship.

$$\text{EN}_1 = N_1 F(\hat{\beta}_2 S_1) \tag{4.17}$$

Partially differentiating (4.17) with respect to the scholarship offer gives the marginal effect of a dollar of scholarship aid on the enrollment of group 1.

$$\frac{\partial \text{EN}_1}{\partial S_1} = N_1 \hat{\beta}_2 f(\hat{\beta}_2 S_1) \tag{4.18}$$

For this discussion, consider two student groups, 1 and 2. The scholarships necessary to increase the enrollment of the first group by 1 student and decrease the enrollment of their counterpart, group 2, by 1 student are

$$\begin{aligned}
 \frac{\partial \text{EN}_1}{\partial S_1} = \omega_1, \quad \Delta \text{EN}_1 = 1 &\Rightarrow \Delta S_1 \approx \frac{1}{\omega_1}, \\
 \frac{\partial \text{EN}_2}{\partial S_2} = \omega_2, \quad \Delta \text{EN}_2 = -1 &\Rightarrow \Delta S_2 \approx \frac{-1}{\omega_2},
 \end{aligned}
 \text{ where } \omega \text{ is defined in (4.18).} \tag{4.19}$$

Using the approximate changes in scholarship (4.19), the resulting change in revenue for each group is

$$\begin{aligned} \frac{\partial \text{ENR}_1}{\partial S_1} = \theta_1, \quad \Delta \text{ENR}_1 \approx \Delta S_1 \theta_1 \approx \frac{1}{\omega_1} \theta_1 \\ \frac{\partial \text{ENR}_2}{\partial S_2} = \theta_2, \quad \Delta \text{ENR}_2 \approx \Delta S_2 \theta_2 \approx \frac{-1}{\omega_2} \theta_2 \end{aligned}, \text{ where } \theta \text{ is defined in (4.15).} \quad (4.20)$$

Finally, the difference in total revenue from increasing the enrollment of group 1 by 1 student and decreasing the enrollment of group 2 by 1 student is

$$\Delta \text{ENR} = \Delta \text{ENR}_1 + \Delta \text{ENR}_2 \approx \frac{(T - S_1) f(\hat{\beta}_2 S_1) \hat{\beta}_2 - F(\hat{\beta}_2 S_1)}{\hat{\beta}_2 f(\hat{\beta}_2 S_1)} - \frac{(T - S_2) f(\hat{\beta}_2 S_2) \hat{\beta}_2 - F(\hat{\beta}_2 S_2)}{\hat{\beta}_2 f(\hat{\beta}_2 S_2)}. \quad (4.21)$$

Thus, the difference in expected marginal revenue is a function of the net tuition, the estimated pdf and CDF from the probit model, and the coefficient on the scholarship ($\hat{\beta}_2$) for each group. This requires two scholarship policies to be implemented simultaneously. One policy would be to increase the amount of grant aid to all women so that female enrollment increased by 1. The second policy would be to decrease the grant aid to all males so that male enrollment decreased by 1. The difference in revenues (gain or loss) are reported for the mutually exclusive pairs and relative to the full sample.

Empirical Test #4: The expected enrollment demand curve

The probability of an applicant enrolling is negatively related to the gap between the actual and reservation scholarship (when the actual is less than the reservation) conversely, the probability of enrolling is monotonically decreasing in the net price, $\left(\frac{\partial F}{\partial (T-S)} < 0 \right)$.

Given the estimated coefficients from the probit model, define $S_{1,i}^\alpha$, the “ α -level reservation scholarship”, such that the probability of enrolling is equal to α , where $(0 \leq \alpha \leq 1)$,

$$F(\hat{\beta}_2 S_{i,i}^\alpha) = \alpha. \quad (4.22)$$

This is the level of grant aid at which individual i , in group 1 has a predicted enrollment probability equal to α .⁷ In this example, contrary to most of the reservation wage/price literature, the individual's probability of participating is variable. Using the implicit function theorem, equation (4.22) can be rewritten as

$$S_{i,i}^\alpha = h(\underbrace{T^I}_{(+)}, \underbrace{T^J}_{(-)}, \underbrace{S_i^J}_{(-)}, X_i, Z^I, Z^J, \alpha). \quad (4.23)$$

The student's α -level reservation net price (referred to as the reservation price) for which she has a probability of enrolling equal to α is $(T - S_{i,i}^\alpha)$. For each enrollment probability, α , there exists a vector of net reservation prices of the form,

$$P_1^\alpha = \begin{bmatrix} T - S_{1,1}^\alpha \\ T - S_{1,2}^\alpha \\ T - S_{1,3}^\alpha \\ \vdots \\ T - S_{1,N_1}^\alpha \end{bmatrix}. \quad (4.24)$$

Assume that the reservation prices are arranged in descending order. The demand curve is defined by the set of N_1 ordered pairs:

$$(\alpha i, T - S_{i,i}^\alpha), \quad (4.25)$$

where the first element is the probability of enrolling (α) multiplied by the index variable (i)

⁷ Alternatively, if the university chooses not to price discriminate (i.e. charging the same price to all applicants in a group) the probability of enrolling would vary across individuals. In this case expected enrollment is the sum (over the applicant pool) of each individual's enrollment probability. Expected net revenue is the product of expected enrollment and the net price. The graph of this line of thinking is also presented in Chapter 5 along with calculations of expected enrollment and expected revenue under various tuition levels.

denoting the row of the vector.⁸ The second element is the α -level reservation price of attending.⁹ In this discussion two important assumptions are made. First, the university is a perfect price discriminator, charging each applicant his reservation price. The second assumption is that if the university's price is above the applicant's reservation price the probability of enrolling is zero.

Figure 4.13 illustrates the demand relationship for two probabilities of enrolling, $\alpha_1 < \alpha_2$. The end points of the demand curves are characterized by the minimum and maximum reservation prices, the probability of enrolling, and the number of applicants. However, without the empirical results, the path between these end points is not clearly defined.

Each enrollment probability has a individual with the highest net reservation price, defined as $P_{Max}^{\alpha_1}$.¹⁰ This price decreases as the probability of enrolling increases $P_{Max}^{\alpha_1} > P_{Max}^{\alpha_2}$, since $\left(\frac{\partial F}{\partial (T-S)} < 0 \right)$. Thus, the points $(\alpha_1, P_{Max}^{\alpha_1})$ and $(\alpha_2, P_{Max}^{\alpha_2})$ are well defined (labeled I, J, respectively).¹¹ The maximum expected enrollment under each probability scenario is the product of the total number of applicants (N_1) and the probability of enrolling (α). Thus, as the probability of enrolling increases, so does the maximum expected enrollment, $E_{Max}^{\alpha_1} = \alpha_1 N_1 < \alpha_2 N_1 = E_{Max}^{\alpha_2}$. This defines the other end points of the two demand curves,

⁸ For example, if the lowest net price were $T - S_{1,1}^{0.5}$ and the probability of enrolling was 0.50, then expected enrollment would be $(0.50) * 1$ or 0.50. Suppose instead, the university charged each of the first 200 applicants their reservation price, under a 25 percent enrollment probability. The lowest price offered is $(T - S_{1,200}^{0.25})$, to the 200th applicant. The expected enrollment under such a pricing scheme would be 50 applicants.

⁹ Since the index variable (i) is used in plotting the demand curve, it is crucial that the reservation prices be sorted in descending order.

¹⁰ Since the reservation prices are sorted in descending order $P_{max}^{\alpha_1} = P_{1,1}^{\alpha_1}$.

¹¹ Recall that α is a probability, bounded between 0 and 1.

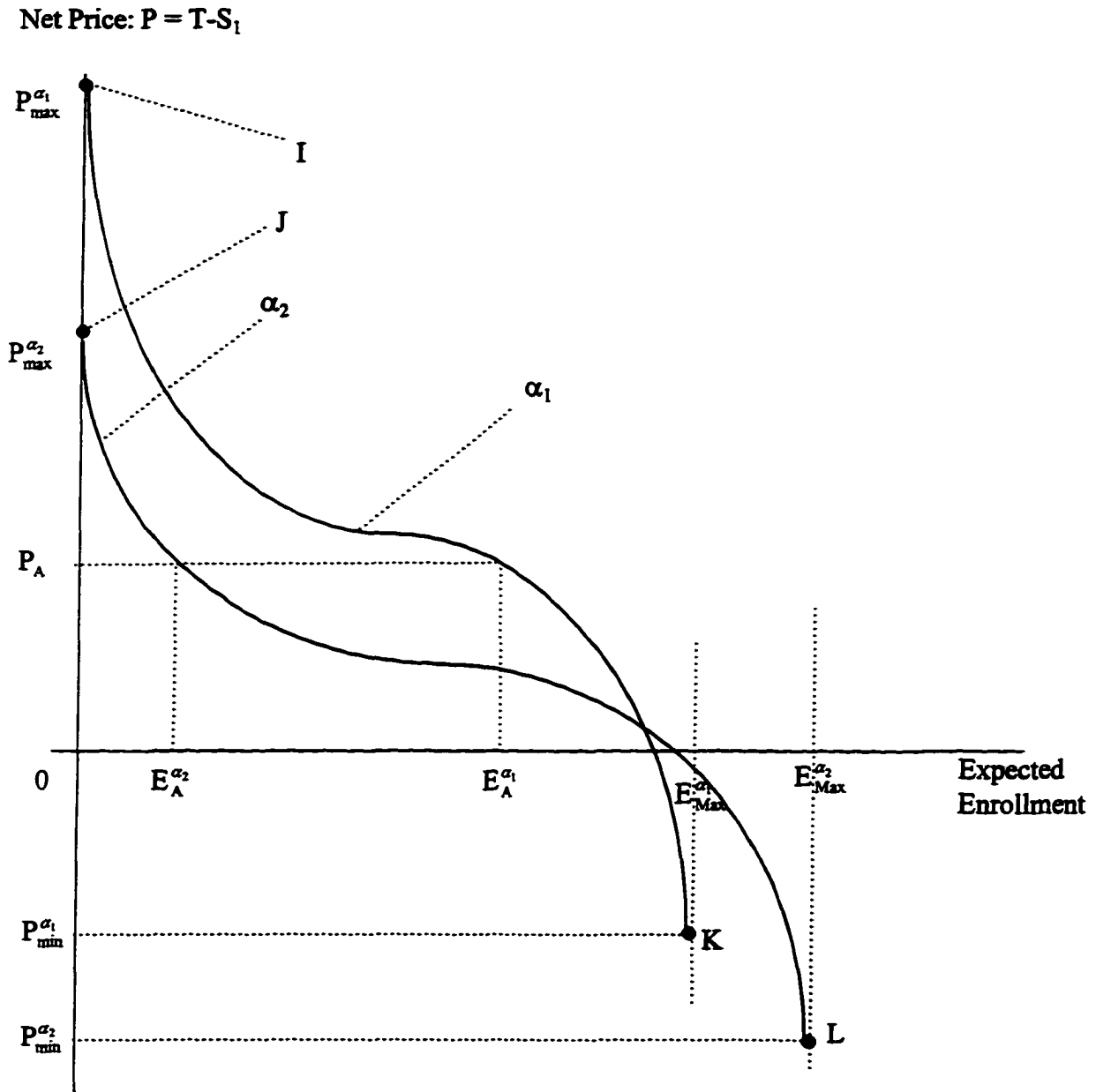


Figure 4.13: Expected enrollment demand curves for two enrollment probabilities, $\alpha_1 < \alpha_2$.

$(E_{\max}^{\alpha_1}, P_{\min}^{\alpha_1})$ and $(E_{\max}^{\alpha_2}, P_{\min}^{\alpha_2})$, labeled K, L, respectively.

As stated, it is not theoretically possible to determine the path between the end points. In particular, it is not possible to determine if the demand curves will cross. This depends on the magnitude of the end points and the slopes of the curves. The curvature is influenced by the choice of distribution. In the figure below, the normal distribution assumed in the current research is evident in the shape of the demand curve. Figure 4.13 illustrates the case where the demand curves do cross.

If the university were able to perfectly price discriminate and charge each applicant his reservation price, the university could extract the entire consumer surplus. Thus, expected revenue would be the area under the demand curve and above the marginal cost curve. Expected enrollment would be determined by the probability of enrolling times the number of applicants whose α -level reservation price is greater than or equal to the marginal cost of educating another student. For students whose reservation price is below marginal cost, the university has no economic incentive to recruit them, since doing so would not generate sufficient revenues to cover the marginal cost.

The probit models for the admission and financial aid are presented in the next chapter. The four empirical questions are answered in the next chapter for resident and nonresident applicants.

CHAPTER 5

EMPIRICAL RESULTS OF THE INDIVIDUAL ANALYSIS

The empirical results of the admissions and financial aid models of the previous chapter are presented here. Separate models for resident applicants and nonresident applicants are presented. The data used in the admissions estimation covers 19 years, from 1976 - 1994. The financial aid model is estimated with data from 8 years, 1985 - 1989, 1992 - 1994. An overview of the data was presented in Chapters 1, 2, and 4. Chapters 4 and 5 deal solely with the enrollment decision of admitted first-time freshmen applicants to ISU.

The first section of this chapter discusses the results of admissions model (equation 4.7). The next section presents the findings from the financial aid model (equation 4.8) and discusses the first empirical test. Section 3 examines the behavior of the institution using the empirical tests 2, 3, and 4. The estimated tuition and grant tradeoffs from increasing a specific characteristic of the population are presented (empirical test #2). A discussion of price discriminating behavior is presented next. The last empirical test in this section shows the expected enrollment demand curve for the institution. Finally, the policy implications drawn from the individual demand analysis are discussed.

Admissions Model

The results from the probit estimation of the admissions model are reported in Table 5.1. The resident sample includes 81,307 admitted admissions applicants, out of which 53,622 enrolled. The nonresident sample includes 50,027 admitted prospective students from which

Table 5.1: Probit regression results for admissions model, 1976 - 1994.

Variable	Resident	Nonresident
Intercept	1.584*** (127.937)	1.947*** (242.734)
ISU Tuition/1,000	-0.220*** (22.669) [-0.230]	-0.106*** (43.151) [-0.674]
ISU Distance/1,000	-0.303*** (30.917) [-0.015]	-0.271*** (150.913) [-0.111]
Alternative tuition/1,000 (DMACC -Resident) (Own-state public -NR)	0.384*** (38.325) [0.257]	0.025 (2.216) [0.058]
U of I Distance/1,000	-0.047 (0.448) [-0.003]	
Local subsidy/100		2.089*** (27.470) [0.195]
County Income/10,000	-0.006 (0.063) [-0.006]	-0.037** (5.304) [-0.091]
College/HS Salary	-0.651*** (46.634) [-0.188]	-1.142*** (132.680) [-0.707]

Table 5.1: (Continued)

Variable	Resident	Nonresident
ACT/100	0.340** (5.609) [0.045]	-0.632*** (13.484) [-0.148]
Rank/100	-0.094*** (8.644) [-0.039]	-0.644*** (280.796) [-0.558]
Female	-0.116*** (144.404) [-0.029]	-0.071*** (32.871) [-0.033]
Minority	-0.151*** (20.131) [-0.002]	-0.135*** (44.219) [-0.019]
Parents Alumni	0.233*** (140.914) [0.010]	0.259*** (69.945) [0.015]
College Choice	-0.425*** (754.899) [-1.454]	-0.209*** (122.239) [-1.556]
Log Likelihood	-51,040	-30,327
Observations	81,307	50,027
Events	53,622	15,892

() Chi-Squared significance test.

[] Elasticities at the mean.

*** Significant at 1 percent

** Significant at 5 percent

* Significant at 10 percent

15,892 enrolled. Table 5.1 reports the coefficient, Chi-Squared test for significance and the point estimates of the elasticity (evaluated at the mean) for the variables used in the analysis.¹ The probit model elasticities indicate the change in the probability of participating from a 1 percent change in the variable.

The coefficient of ISU tuition is negative and significant for both residents and nonresidents. The elasticities are in the inelastic range, -0.23 and -0.67 for residents and nonresidents, respectively. A 10 percent increase in resident tuition would lead to a 2.3 percent decrease in the probability of a resident applicant enrolling at ISU, all else constant. A 10 percent increase would lead to a 6.7 percent decrease in the probability of a nonresident enrolling. The fact that nonresident applicants are 3 times more responsive to price than resident applicants is due, in part, to the higher tuition they face if they attend ISU. It may also be a result of ISU resident tuition being correlated with tuition at the other 2 Iowa Regents institutions.

This is also consistent with the aggregate findings of enrollment by state and county presented earlier. The state level nonresident own-price elasticity for first-time freshmen was -0.97, while the county-level resident first-time freshmen own-price elasticity was -0.088. The negative and inelastic own-price effect of the individual analysis is consistent with the literature reviewed in Chapter 1. Corrazini et al. (1972) found an own-price elasticity for public (state level) enrollment of -0.027. Fuller, Manski and Wise (1982) found the elasticity was -0.23, using longitudinal data. Ehrenberg and Sherman (1984) found an own-price

¹ Table 4.1 provides a brief description of the variables used in the analysis, a detailed summary is presented in the appendix. Appendix Table B.3 presents standard errors for the point estimates of the elasticities.

elasticity of admitted students to Cornell University's public school to be -0.28. While nonresident enrollment at Iowa State may not be directly comparable to enrollment at either of the "selective colleges" examined in the literature (Ehrenberg and Sherman 1984 and Moore et al. 1991), the elasticity of nonresident tuition at ISU and the selective private schools are relatively close. Ehrenberg and Sherman showed the price elasticity for Cornell's private school was -1.09. The own-price elasticity estimated in the current research is very close to Moore's price elasticity of -0.72.

The other measure for the cost of attending ISU is the distance from home. The coefficients are negative and significant for both samples. Holding all other variables at the sample averages, a 10 percent increase in distance to ISU leads to a 1.5 percent or 11 percent decline in the probability of enrolling for resident and nonresident applicants, respectively.

Two measures of the price of competing educational opportunities are examined for residents and nonresidents. The distance to the University of Iowa and the tuition at Des Moines Area Community College (DMACC) are used for residents. The own-state public tuition and the local subsidy for higher education are used in the nonresident model. Tuition at DMACC is positively related to the probability of an applicant enrolling at ISU. A 10 percent increase in tuition at the community college leads to a 2.5 percent increase in the probability of enrolling at ISU. The own-state tuition has a positive effect on the probability of an individual enrolling at ISU, but is not significant. In both cases the cross-price effects are positive, indicating that the alternative schools are substitutes for freshmen enrollment at Iowa State.

As distance from the applicants home to the University of Iowa increases, a resident applicant is less likely to enroll at Iowa State. The coefficient is not significantly different from zero. The local subsidy for higher education also has a positive effect. The theory predicts that higher spending on home-state schools would decrease the probability of enrolling at ISU and that increased distance to alternative in-state schools would increase the probability of enrolling. The model indicates the opposite signs for these coefficients, however, only the local subsidy is significantly different from zero.

Hoенack (1971) and Hoенack and Weiler (1975) examined aggregate enrollment at large public universities. They noted, as was found here, that tuition at in-state institutions is highly correlated over time. They used the distance measures to capture some of the variation in the cost of attending. However, in the current research, the coefficient of distance to U of I is not precisely estimated. Another problem that is especially important for the resident results, is that ISU tuition is highly correlated with changes in tuition at the other Regents institutions. The high correlation among the tuition at Regents institutions may mean that the own-price elasticity reflects the change in the probability of a resident applicant attending ISU when tuition at the Regents schools increases by 1 percent. These issues indicate that even though the coefficient of ISU tuition is significant, it may not reflect the response of increased tuition at ISU, without similar increases at the other Regents schools. It is important to keep this in mind in the discussion of the empirical tests.

Theory predicts that increases in income would be associated with increased ability to pay for college, and therefore, increase the probability of enrolling. The resident probit

model shows that increases in county income lead to decreases in the probability of a resident applicant enrolling at ISU. Similarly, the probability of a nonresident enrolling at ISU is also negatively related to county per capita income. The income elasticities are -0.006 and -0.091 for resident and nonresident applicants, respectively. The income coefficient for residents is not significant, and the nonresident coefficient is significant at the 5 percent level of significance. Perhaps the aggregation to the county level does not accurately reflect the true income of the families applying to ISU. On the other hand, it may indicate that increases in income lead to increased enrollment in private schools, and therefore declines in enrollment at Iowa State. Yet another explanation is that Iowa State, being a land grant institution, draws a large number of applicants from rural areas, which are traditionally lower income areas.

The coefficient of the returns to college is negative and significant for residents and nonresidents. The returns to college are measured by national median salary of males with 4 or more years of college over national median salary of males with a high school degree, adjusted for the unemployment rate and the 4 additional years of wage work for those who enter the labor force directly after high school.² A 10 percent increase in the returns to college leads to a 1.8 percent decrease in the probability of a resident applicant enrolling and a 7 percent decline in the probability of enrolling for a nonresident applicant. As the college wage premium increases applicants are less likely to enroll at ISU. The literature indicates that increases in wage gap between college and high school graduates increase the incentives

² A similar adjustment was suggested by Orazem and Mattila (1991).

to attend college (i.e. shifts the demand for higher education out and to the right) (Topel 1997 and Katz and Murphy 1992). It is not clear if the coefficient captures a relative increase in probability of enrolling at other schools, or simply decreases the incentives to enroll at ISU. To determine this would require information on the applicants choice if they did not enroll at ISU, which is not available.

Two variables are used to measure the academic ability of an applicant, ACT test score and class rank. In the resident model, the coefficient of the ACT score is positive and significant. The coefficient on class rank is negative and significant at 1 percent. While the elasticities for class rank and ACT scores are computed, it is not clear which effect dominates. The change in academic ability captured by a 1 percent change in the ACT score does not necessarily equal the change in ability from a 1 percent change in the class rank. At issue here is the fact that academic ability is not easily quantifiable. However, it is clear that the effects work in opposite directions. Therefore, with the admissions model results, it is not possible to conclude if resident applicants with higher academic abilities are more or less likely to enroll at Iowa State University.

In the nonresident model both coefficients of the academic ability variables are negative and significant. This indicates that, all else equal, individuals with a higher ACT score or higher class rank are less likely to enroll at ISU. Since both effects work in the same direction it is clear that nonresident applicants with higher academic ability (measured by ACT score or class rank) are less likely to enroll at Iowa State.

The coefficients of the dummy variables for gender and ethnic minority are negative and

significant in both samples. The signs indicate that minorities and females are less likely to enroll at ISU. The three preceding results can be explained as follows. High ability, women, and ethnic minorities are sought after by institutions of higher education. Since these groups are more desirable, they may have more options available to them. Therefore, they are less likely to enroll in any single school. This also indicates that despite the efforts that ISU may be conducting to recruit these groups, they remain less likely to enroll.

If the applicant's parents are Iowa State alumni, the applicant is more likely to enroll. This coefficient is positive and significant for resident and nonresident applicants. One of the policy implications of this result (as well as the others in the model) is discussed in the second empirical question of tradeoffs. The college choice variable is significant and has the anticipated negative sign. If ISU is listed as the student's first choice to receive their ACT scores, the applicant is more likely to enroll. The lower that ISU is placed on this list, the less likely it is that the prospective student will enroll.

Finally, there are differences between the resident and nonresident models. The own-price elasticity, and distance elasticities are very different. The signs of the variables that appear in both models are the same, except for the ACT score. While the signs are generally the same, the magnitudes differ by a factor of at least 2. The difference in the price elasticities is sufficient to justify separate treatment of the two price effects. However, controlling for the difference by separate price variables (price interacted with a dummy variable for residency) would restrict the other coefficients to be equal. These observations support using separate models for resident and nonresident applicants.

Financial Aid Model and Empirical Test #1

The results of the financial aid model (equation 4.8) are presented in this section. As before, separate regressions for resident and nonresident students are examined. Table 5.2 presents the results from the probit analysis. These results have similar signs to those discussed previously for the admissions model. The first empirical test asks if the changes in tuition can be offset by equal changes in financial aid. The hypothesis of equal tuition and grant effects, described in equation (4.9), is rejected for residents and nonresidents. The log-likelihood ratio test rejects that the effect of a dollar increase in grant aid is equal to the effect of a dollar increase in tuition for both groups.³ Therefore, the discussion of results focuses on the model with tuition and grant aid as separate regressors.

The ISU price variables all have the anticipated signs. The coefficients of resident and nonresident tuition are negative and significant. The elasticities (-0.24, -0.70) are very similar to those found in the admissions model (-0.23, -0.67). Ehrenberg and Sherman (1984), found a more elastic response to price in the group of applicants that applied for financial aid. The current research is consistent with this finding, but the difference found is very small. A 10 percent increase in tuition leads to a 2.4 percent decline in the probability of enrolling at ISU for a resident financial aid applicant. A 10 percent increase in the nonresident tuition is associated with a 7 percent decline in the enrollment probability of a nonresident financial aid applicant.

The coefficient of grant aid is positive, but not significant in the resident model. A 10

³ $\chi^2(1, .95) = 3.84$, $-2(\ln L_r - \ln L_0) = -2(-14,943 - (-14,940)) = 5.535$ (resident)
 $-2(\ln L_r - \ln L_0) = -2(-8,086 - (-8,082)) = 7.21$ (nonresident)

Table 5.2: Probit regression results: Financial aid model, 1985 - 1989, 1992 - 1994.

Variable	Resident	Nonresident	Resident (Net Tuition)	Nonresident (Net Tuition)
Intercept	2.941*** (106.787)	5.285*** (307.001)	2.827*** (101.460)	5.065** (304.826)
ISU Tuition/1,000	-0.232*** (6.732) [-0.238]	-0.151*** (18.337) [-0.704]	-0.026 (1.963) [-0.005]	-0.059** (51.783) [-0.259]
ISU Grant Aid/1,000 (Predicted)	0.023 (1.480) [0.019]	0.054*** (42.368) [0.117]		
ISU Distance/1,000	-0.057 (0.355) [-0.003]	-0.085** (4.047) [-0.026]	-0.060 (0.388) [-0.003]	-0.096** (5.125) [-0.035]
Alternative tuition/1,000 (DMACC -Resident) (Own-state public -NR)	0.218 (0.905) [0.127]	0.025 (0.732) [0.041]	-0.054 (0.074) [-0.031]	-0.011 (0.167) [-0.028]
U of I Distance/1,000	-0.346*** (7.458) [-0.020]		-0.347*** (7.502) [-0.020]	
Local subsidy/100		0.151 (0.052) [0.010]		-0.710 (1.490) [-0.078]
Parents AGI/10,000	0.066*** (534.431) [0.082]	0.104*** (918.332) [0.064]	0.065*** (529.035) [0.082]	0.103** (912.399) [0.273]
College/HS Salary	-1.699*** (16.876) [-0.468]	-6.037*** (122.873) [-2.735]	-1.795*** (19.002) [-0.495]	-6.520** (160.852) [-4.051]

Table 5.2: (Continued)

Variable	Resident	Nonresident	Resident (Net Tuition)	Nonresident (Net Tuition)
ACT/100	-1.574*** (33.375) [-0.184]	-1.053** (9.091) [-0.180]	-1.577*** (33.504) [-0.184]	-1.085** (9.671) [-0.253]
Rank/100	-0.272*** (19.062) [-0.101]	-1.006** (163.337) [-0.639]	-0.266*** (18.301) [-0.099]	-0.999** (161.349) [-0.851]
Female	-0.066*** (13.978) [-0.014]	-0.049** (4.173) [-0.017]	-0.067*** (14.359) [-0.014]	-0.050** (4.425) [-0.022]
Minority	-0.157*** (9.824) [-0.002]	-0.256** (52.690) [-0.026]	-0.161*** (10.437) [-0.002]	-0.269** (59.442) [-0.060]
Parents Alumni	0.088*** (9.735) [0.006]	-0.017 (0.115) [-0.001]	0.108*** (16.440) [0.007]	0.056 (1.744) [0.006]
College Choice	-0.421*** (394.508) [-1.138]	-0.188** (60.757) [-1.023]	-0.420*** (392.823) [-1.136]	-0.187** (60.409) [-1.196]
Log Likelihood	-14,940	-8,082	-14,943	-8,086
Observations	25,536	13,872	25,536	13,872
Events	17,961	5,017	17,961	5,017

() Chi-Squared significance test.

[] Elasticities at the mean.

*** Significant at 1 percent

** Significant at 5 percent

* Significant at 10 percent

percent increase in grant aid results in a modest 0.1 percent increase in the enrollment probability for resident financial aid applicants. This may lead to imprecise estimates for the empirical tests in the next section. The grant coefficient for nonresidents is significant, but the impact of a 10 percent increase in grant aid is only a 1 percent increase in the probability of enrolling. The net effect of increasing tuition and grant aid by 10 percent leads to a 2.2 percent and 6 percent decline in the probability of enrolling for resident and nonresident applicants, respectively. The decision to enroll at ISU is not heavily influenced by the grant aid that an applicant is offered.

One reason for the small effect may be from using the predicted award instead of the actual offer. However, the original award data were not available for the time period examined. A second reason for the small effect is that this measure only includes grant aid. It is true that loans and work-study do require future commitments from the student. However, as the federal budget allocations show, these financial aid instruments are widely used in financing higher education. The loan and work-study aid *offer* is hard to determine from the actual amount received since students may not accept the full amount offered.

The coefficient on the distance from the applicants home to Iowa State is negative. It is significant at the 5 percent level of significance for nonresident applicants and not significantly different from zero for residents. The distance elasticities in the financial aid model are less than one-fourth the magnitude of the distance elasticity in the admissions model. This indicates that financial aid applicants are less responsive to distance than are the group of admitted applicants.

Des Moines Area Community College and the in-state public institutions are substitutes for ISU freshman enrollment, with a cross-price elasticities of 0.13 and 0.04, respectively. The coefficients are not precisely estimated. The price of ISU's largest competitor for resident students, The University of Iowa, is highly correlated with ISU's tuition. This maybe one reason the alternative college cost effects (U of I distance and DMACC tuition) are imprecise. The effect of the returns to college on the probability of enrolling are negative and significant, as found in the admissions model.

Among financial aid applicants, enrolling at ISU is a normal good. The coefficient of parents adjusted gross income is positive and significant for resident and nonresident applicants. The elasticity is approximately equal across resident and nonresident applicants. A 10 percent increase in family income would lead to a 0.8 and 0.6 percent increase in the probability of enrolling at ISU for resident and nonresident financial aid applicants, respectively. That enrollment in ISU is a normal good is consistent with the literature, but the studies examined in Chapter 1 found elasticities that were much larger.

The coefficients of the academic ability measures show that financial aid applicants with stronger academic abilities are less likely to enroll at ISU. The signs of the coefficients for the ACT score and class rank are negative and significant for residents and nonresidents. An increase of 10 percent in the class rank is associated with a decline of 1 percent or 6.4 percent in the probability of enrolling for residents or nonresidents, respectively. Similarly, an increase in the ACT score by 10 percent leads to a 1.8 percent drop in the probability of enrolling at Iowa State for both groups. Among financial aid applicants, those with higher

academic abilities, measured by class rank and ACT score, are less likely to enroll at Iowa State University.

The coefficients of the minority and female dummy variables in the financial aid models are consistent with the admissions model. Female financial aid applicants are less likely to enroll than are males. Minority financial aid applicants are also less likely to choose to attend ISU than non-minority applicants. Again, the academic ability, gender, and minority variables show that groups that have more options available are less likely to enroll at Iowa State.

The coefficient for the parent's being alumni of ISU is positive for residents and negative for nonresidents. The admissions model has a positive effect for both. The coefficient for the nonresidents is not significantly different from zero. Finally, the college choice variable, used to indicate interest in ISU, has the anticipated negative effect on enrollment.

In review, the financial aid model results are consistent with the admissions model as well as the anticipated signs in most cases. The own-price elasticities are in the inelastic range. The results indicate that financial aid applicants are more responsive to changes in tuition than changes in financial aid. High ability, minority and female financial aid applicants are less likely to enroll at ISU. These findings have significant policy implications that will be discussed later in this chapter.

Institutional Behavior

Empirical test #2: The tuition and grant tradeoffs

The last three empirical tests are discussed in this section. The tradeoffs from targeting specific characteristics are shown in Tables 5.3 and 5.4 for residents and nonresidents, respectively. These tradeoffs show the change in tuition or grant aid that is required when there is a unit increase in one of the variables, while holding the probability of enrolling and all other variables constant at the sample averages. This is similar to comparing two "average" applicants, who aside from a unit difference in a single characteristic, are identical. The dollar values given in the tables show the tradeoff of this difference in terms of the tuition or grant aid that would be required to equate the probability of both applicants enrolling.

Columns 1 and 2 of Table 5.3 show the tuition tradeoff using the admissions and financial aid models, respectively. The third column shows the grant aid that is required to neutralize a change in the factor. For example, if tuition were to increase by \$1, grant aid would need to increase by \$10.19 to leave the probability of enrolling unchanged. Recall that the grant aid coefficient is not precisely estimated, so these effects are likely to be overstated.

If there are two resident applicants who differ only in the distance to Ames, tuition for the person who lives 1 mile farther away would have to be reduced by \$1.38 to equate the probability of enrolling. The distance results indicate that the scholarship tradeoff per mile is \$2.52.

Table 5.3: Tuition tradeoff for a unit increase in a characteristic, for resident students

Variable with a Unit Increase	Admissions ¹ (Tuition)	Financial Aid ² (Tuition)	Financial Aid ³ (Grant)
ISU Tuition	-1.00	-1.00	10.19 (25.89)
ISU Grant		0.10 (0.15)	-1.00
ISU Distance	-1.38 (0.42)	-0.25 (0.67)	2.52 (16.76)
DMACC Tuition	1.75 (0.41)	0.94 (1.33)	-9.55 (42.77)
U of I Distance	-0.22 (0.32)	-1.49 (1.27)	15.15 (47.51)
Income (County Income Col 1) (Parents AGI Col 2,3)	0.003 (0.010)	0.03 (0.022)	-0.29 (8.20)
College/HS Salary	-2,965.56 (867.59)	-7,307.12 (5,883.36)	74,469.32 (220,288.93)
ACT	15.50 (8.19)	-67.70 (52.21)	689.99 (2160.77)
Rank	-4.29 (1.58)	-11.68 (9.37)	119.07 (367.58)
Female	-527.89 (126.14)	-283.91 (240.68)	2,893.45 (8,958.04)
Minority	-687.47 (226.26)	-674.00 (527.44)	6,868.94 (21,664.22)
Parents Alumni	1,060.96 (316.00)	376.87 (404.65)	-3,840.76 (14,250.73)
College Choice	-1,933.44 (478.51)	-1,810.86 (1345.61)	18,455.11 (52,629.73)

¹. Uses admissions model Table 5.1 Column 1.

². Uses financial aid model Table 5.2 Column 1.

³. Uses financial aid model Table 5.2 Column 1, in terms of the grant aid.

() Standard errors from a parametric bootstrap of 100 draws.

Table 5.4: Tuition tradeoff for a unit increase in a characteristic, for nonresident students.

Variable with a Unit Increase	Admissions ¹ (Tuition)	Financial Aid ² (Tuition)	Financial Aid ³ (Grant)
ISU Tuition	-1.00	-1.00	2.77 (0.83)
ISU Grant		0.36 (0.12)	-1.00
ISU Distance	-2.60 (0.49)	-0.57 (0.37)	1.57 (0.90)
Own-State Tuition	0.24 (0.16)	0.16 (0.19)	-0.45 (0.57)
Local Subsidy	-3.51 (0.36)	10.04 (52.45)	-27.83 (134.34)
Income (County Income Col 1) (Parents AGI Col 2,3)	0.03 (0.016)	0.07 (0.21)	-0.19 (0.03)
College/HS Salary	-10,818.16 (1,997.00)	-40,109.58 (14,565.70)	111,175.39 (22,238.57)
ACT	-59.86 (20.71)	-69.93 (31.19)	193.83 (68.69)
Rank	-60.98 (9.48)	-66.82 (21.29)	185.22 (37.89)
Female	-672.24 (173.84)	-324.45 (217.52)	899.29 (524.16)
Minority	-1,276.46 (311.32)	-1,698.28 (585.38)	4,707.28 (779.16)
Parents Alumni	2,451.77 (593)	-113.72 (385.03)	315.22 (-424.15)
College Choice	-1,981.73 (394.49)	-1,247.89 (443.54)	3,458.89 (810.08)

¹Uses admissions model Table 5.1 Column 2.

²Uses financial aid model Table 5.2 Column 2.

³Uses financial aid model Table 5.2 Column 2, in terms of the grant aid.

() Standard errors from a parametric bootstrap of 100 draws.

The resident model shows that an increase of \$1 in real tuition at DMACC would allow ISU to increase tuition by \$1.75 without affecting the probability of an average individual enrolling. The impact of a \$1 increase in county income or parents adjusted gross income are very small. To maintain the same probability of enrolling when county income increase by \$1, tuition could increase by less than three-tenths of a cent. Each dollar increase in parental income requires tuition to increase by 3 cents, or grant aid to decrease by \$0.29 , to hold the probability of enrolling constant.

The measures of academic ability, minority status, and gender are also of interest. In the resident sample, each unit increase in the class rank requires a \$4.29 decrease in tuition or a \$119 increase in scholarships. An increase in the ACT score allows ISU to increase tuition by \$15.50 and leave the probability of enrolling unchanged when the admissions model results are used. An increase in the ACT score of 1 point, however, does require an increase in grant aid of \$690 with the financial aid model. If two applicants differ only by gender, to equate the probability of enrolling, the female's tuition would be reduced by \$527, or her grant aid could be increased by \$2,893. A minority applicant would require a \$687 tuition cut or a \$6,868 grant aid increase, to make the probability of enrolling equal. Finally, if the parents of the applicant attended ISU the model indicates that they would have the same probability of enrolling as an applicant whose parents did not attend ISU, were the tuition \$1,060 higher. This indicates that those applicants who are children of alumni are more likely to attend, even if the price is increased.

In the nonresident sample, similar results are obtained. Briefly, the amount of grant aid

required to offset a \$1 increase in tuition is \$2.77. Using the admissions model for nonresident applicants, if the home-state tuition goes up by \$1, ISU nonresident tuition can increase by \$0.24 and leave the probability of enrolling unchanged. If the distance increased by one mile, nonresident tuition would have to decrease by \$2.57 to hold the probability of enrolling constant. The "tuition per mile" is almost double for nonresidents relative to residents. This may be an indication of the large increase in tuition and other costs of attending ISU when an applicant crosses the state boundary.

To hold the probability of enrolling constant, a unit increase in class rank requires a tuition reduction of \$61 for a nonresident applicant. Similarly, if the university wanted to increase the ACT score by 1 unit and maintain the same probability of enrolling, the required decrease in tuition would be \$60.

If the only difference between two individuals is minority status, to equalize the probability of enrolling the nonresident minority applicant would need a \$1,276 decrease in tuition, or a scholarship increase of \$4,707. Similarly, if the difference were gender, the nonresident female would require a decrease in tuition of \$672, or a grant aid increase of \$899.

Empirical test #3: Price discrimination and switching revenues

Tests for price discriminating behavior for the nonresident and resident samples are shown in Tables 5.5 and 5.6. These tests use the nonresident financial aid model with tuition and grant aid as separate regressors. Equation (4.15) shows the expected marginal revenue formula used here. The switching revenues are computed as shown in equation (4.21). The

Table 5.5: Expected marginal revenue and expected marginal value per applicant by group, for nonresidents. Using a parametric bootstrap of 100 draws.

Group	Sample Size	Expected Marginal Net Revenue wrt Grant Aid ¹	Marginal Value per Student ²	Switching Revenue relative to Full Sample ³	Switching Revenue across groups ⁴
Full Sample	13,820	-0.291 (0.010)	-16,754 (2,957)		
Female	5,714	-0.267 (0.011)	-15,795 (2,823)	959 ⁵ (207)	1,604 ⁶ (342)
Male	8,106	-0.308 (0.011)	-17,400 (3,051)	-645 (135)	
Minority	2,878	-0.2765 (0.010)	-16,383 (2,727)	371 (207)	464 (435)
White	10,942	-0.295 (0.011)	-16,847 (3,019)	-92 (87)	
Top 5	2,518	-0.206 (0.010)	-12,844 (2,372)	3,910 (629)	4,701 (753)
Lower 95 th	11,302	-0.310 (0.011)	-17,545 (3,077)	-790 (124)	

¹ Equation 4.15.

² Equation 4.20.

³ Equation 4.21.

⁴ Equation 4.21.

⁵ This is the net change in revenue two scholarship policies. One increases the female enrollment by 1. The other decreases overall enrollment by 1.

⁶ This is the net change in revenue from policies that increase female enrollment by 1 and decrease male enrollment by 1.

() Approximate standard errors from a parametric bootstrap of 100 draws.

Table 5.6: Expected marginal revenue and expected marginal value per applicant by group, for residents. Estimates are from a parametric bootstrap of 100 draws.

Group	Sample Size	Expected Marginal Net Revenue wrt Grant Aid ¹	Marginal Value per Student ²	Switching Revenue relative to Full Sample ³	Switching Revenue across groups ⁴
Full Sample	25,536	-0.701 (0.004)	-180,966 (2,031,112)		
Female	11,491	-0.691 (0.005)	-175,497 (1,966,411)	5,469 ⁵ (66,375)	10,075 ⁶ (122,527)
Male	14,045	-0.710 (0.004)	-185,572 (2,085,865)	-4,606 (56,153)	
Minority	749	-0.654 (0.017)	-159,871 (1,765,565)	21,095 (270,339)	21,774 (279,100)
White	24,787	-0.702 (0.004)	-181,645 (2,039,722)	-679 (8,761)	
Top 5	3,599	-0.652 (0.006)	-159,780 (1,774,837)	21,186 (256,387)	24,916 (301,746)
Lower 95 th	21,937	-0.709 (0.004)	-184,696 (2,076,452)	-3,729 (45,358)	

¹ Equation 4.15.

² Equation 4.20.

³ Equation 4.21.

⁴ Equation 4.21.

⁵ This is the net change in revenue two scholarship policies. One increases the female enrollment by 1. The other decreases overall enrollment by 1.

⁶ This is the net change in revenue from policies that increase female enrollment by 1 and decrease male enrollment by 1.

() Approximate standard errors from a parametric bootstrap of 100 draws.

estimates are computed from a parametric bootstrap of 100 draws.⁴

The expected marginal revenue of each student group is shown in column 2. The marginal revenue is negative for the full sample and for each subgroup. This would indicate that the university is over-awarding grant aid from a revenue or profit maximizing perspective. On average, the last dollar of grant aid decreases net tuition revenue by 30 cents. The marginal revenue for each group (high ability/lower 95th, minority/non-minority, and female/male) is also shown.⁵ The test for price discriminating behavior is equality of marginal revenue across groups. Statistical tests reject that the marginal revenues are equal across the groups.⁶

Two conclusions can be drawn from these findings. First, since the marginal revenue is negative, the University is under-priced with respect to the net tuition, or over-awarding scholarships. This indicates that the University's behavior is more consistent with the goal of maximizing nonresident enrollment than maximizing nonresident tuition revenue. The results indicate that ISU is willing to pay for some nonresidents to attend. However, at the margin, that payment is less than a dollar. It may be the case that these students generate external benefits for the University, as Grossman (1995) discussed. Alternatively, this may be more precisely estimated if revenues from room and board were included.

Second, the University is not maximizing revenue by price discriminating across the

⁴ See Efron and Tibshirani, 1993 and Kinsky and Robb 1986 for details of the parametric bootstrap.

⁵ A high ability student is defined by a class rank of 95 or above. Those students not in this group are referred to as the lower 95th. Recall that the ISU admission standard require that a student graduate in the top half of their class for unconditional admission.

⁶ t-tests for equality yield test statistics of 94, 88, and 463 for female/male, minority/non-minority, and high ability/lower 95th, respectively.

various groups of potential nonresident students. While the differences are statistically significant, they are not large in magnitude. The differences in marginal revenues across groups range from 5 to 10 cents, not hundreds of dollars. Although the University is not equalizing marginal revenue from each group, the magnitude of the differences are relatively small.

As discussed in Chapter 4, this framework can be extended to examine the change in revenues from changing the enrollment mix by 1 student. The expected revenues from increasing enrollment of a group by 1 and decreasing enrollment of the other group by 1 are shown in Table 5.5: Columns 4 and 5. The findings relative to overall enrollment are that adding a female, minority, or high ability student leads to increases in net tuition revenue of \$959, \$371, or \$3,910, respectively. If the overall enrollment were reduced and one more male, non-minority, or applicant in the lower 95th percentile were added, revenues would decrease by \$645, \$92, or \$790, respectively. Since females, minorities and high ability students consistently have a lower probability of enrolling, it seems that revenues would have to decrease in order to increase enrollment. However, these results indicate that the college may be able to increase the enrollment of the “more desirable” groups, and gain revenues in the process.

The same results hold when the experiment is to increase enrollment of 1 group (minority, female, or high ability) and decrease the enrollment of their counterpart (non-minority, male, or lower 95th, respectively). Recall, this requires two scholarship policies to be implemented. One policy increases the amount of grant aid to all female applicants so that

female enrollment increases by 1. The second policy decreases the grant aid to all male applicants so that male enrollment decreases by 1. The results indicate that the decline in revenues from adding one more female would be larger than the decline in revenue from the scholarship policy that decreases male enrollment by 1. Revenue from males would decrease less (or even increase) because the infra-marginal effect toward increased revenues (i.e. increased revenue from current male enrollment caused by a decrease in grant aid) outweighs the marginal effect toward reduced revenues (i.e. decreased revenue from decreased male enrollment). This is due in part to the difference in enrollment rates between the groups. As discussed in the beginning of Chapter 4, the enrollment rates of females, minorities and high ability students are below the enrollment rates of the overall applicant pool. Therefore, the enrollment rates of males, non-minorities, and applicants in the lower 95th must be above the average enrollment rates.

The results of the tests for price discrimination among resident financial aid applicants are shown in Table 5.6. Since the state heavily subsidizes resident education, the marginal revenue from residents is much lower than the nonresidents. For all resident applicants, the last dollar in scholarships decreases net tuition revenues by \$0.70. This is an indication that resident students receive larger subsidies than nonresident students. While it can be argued that tuition of nonresident students covers the cost of their education, this is certainly not the case for resident students. In spite of subsidizing their services for resident students, the University can still price discriminate by charging different net prices to different resident applicants for the same service.

The tests for maximizing revenue by price discrimination are rejected. The marginal revenues are not equal, statistically. However, the difference in males and females is less than 2 cents. Minority and non-minority students have a difference in marginal revenues of almost 5 cents. The largest difference for the resident applicants is the high ability and lower 95th groups, which is only 5.7 cents. Again, if the University is not setting prices to equate marginal revenues, they are relatively close to such a policy. The magnitudes are relatively small, as found in the nonresident case. It is also important to note that the coefficient of grant aid for residents was not significantly different from zero. Therefore, these results may be imprecisely estimated as well.

Another issue with these results is that they examine policies that change the price for the entire group. The estimates for increasing enrollment of 1 group and decreasing enrollment of another group are very imprecise, as shown by the large standard errors. Clearly, as is one goal of this research, scholarship policies can be specific to the individual. The individual's reservation price and the resulting demand curve for enrollment at ISU are discussed in the next section. The institution can use the predicted reservation price information to strategically award financial aid.

Empirical test #4: The expected enrollment demand curve

The fourth empirical test suggests a method for deriving the expected enrollment demand curve. This uses the financial aid model to predict each applicants " α -level net reservation price". The demand curve discussed in Chapter 4 shows the expected enrollment at each net price, for a specific enrollment probability. Along a given demand curve, expected

enrollment and reservation prices change, but the probability of enrolling is constant. Before illustrating the demand curve that holds probability fixed, and determines the maximum willingness to pay, it may be helpful to have some idea about the probability of enrolling at current prices. Figures 5.1 to 5.4 show the number of applicants at each probability of enrollment for current tuition and a 10 percent increase in tuition for nonresidents (Figures 5.1 and 5.2) and residents (Figures 5.3 and 5.4). These probabilities are estimated using the admissions model presented in Table 5.1. Under current tuition, the median probability of enrolling for residents is 68 percent and 30 percent for nonresidents. The expected revenue under the current tuition policy is 7.4 million from residents and 4.7 million from nonresidents. Expected enrollment is 832 for nonresidents and 3,500 for residents.⁷

Suppose that the university wanted to examine the impact of a price change on expected enrollment. The sensitivity to price changes at the aggregate level should be determined using aggregate data, as presented in Chapters 2 and 3. These individual results are useful in examining how the distribution of enrollment probabilities change, not the aggregate price elasticity. Figures 5.2 and 5.4 show the distribution of enrollment probabilities for a 10 percent increase in tuition. The histograms under price changes are almost parallel shifts of the current price figures. Notice also that the height (number of applicants) is decreased in the 10 percent tuition graph. The expected enrollment under a 10 percent tuition increase is 3,431 resident students and 826 nonresidents. These calculations use the admissions model,

⁷ The average first-time freshmen enrollment at ISU, from 1976 - 1994, was 4,019 residents and 1,140 nonresidents.

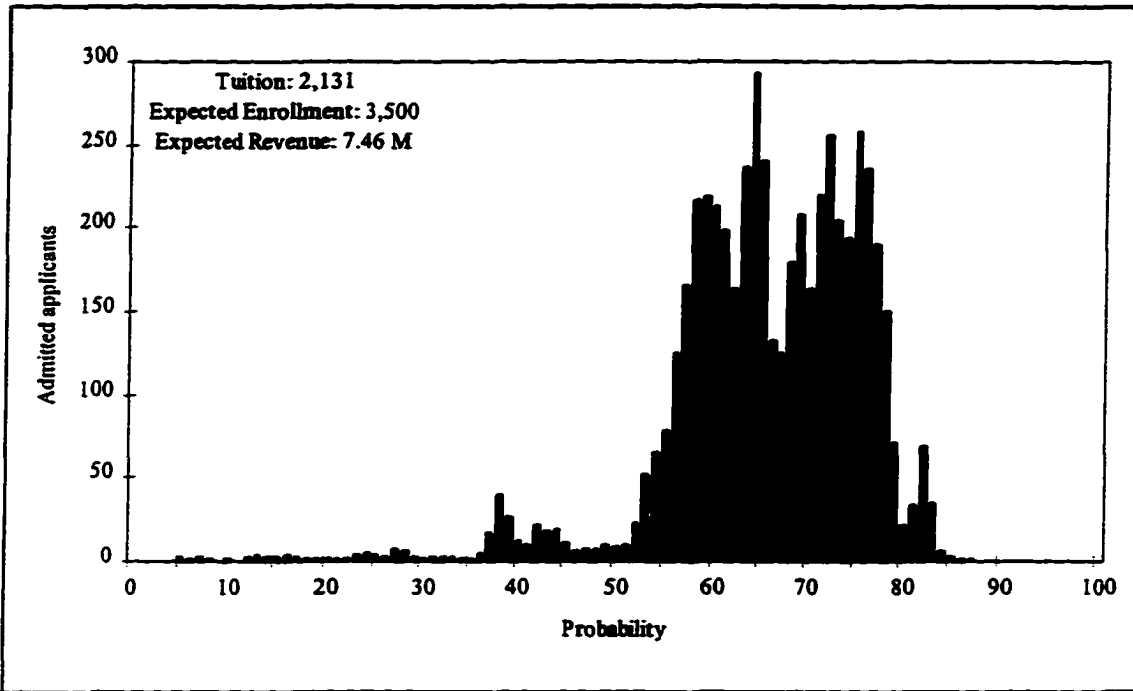


Figure 5.1 Enrollment probability of admitted resident applicants, 1985-1989, 1992-1994.

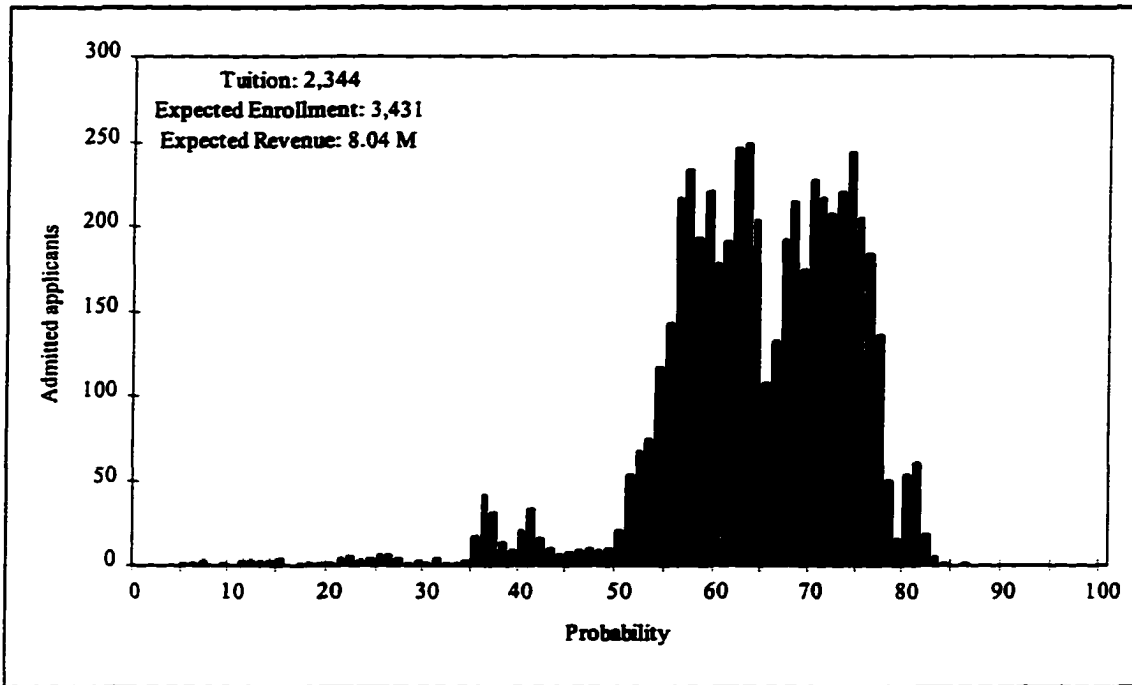


Figure 5.2: Enrollment probability of admitted resident applicants under a 10 percent increase in tuition, 1985-1989, 1992-1994.

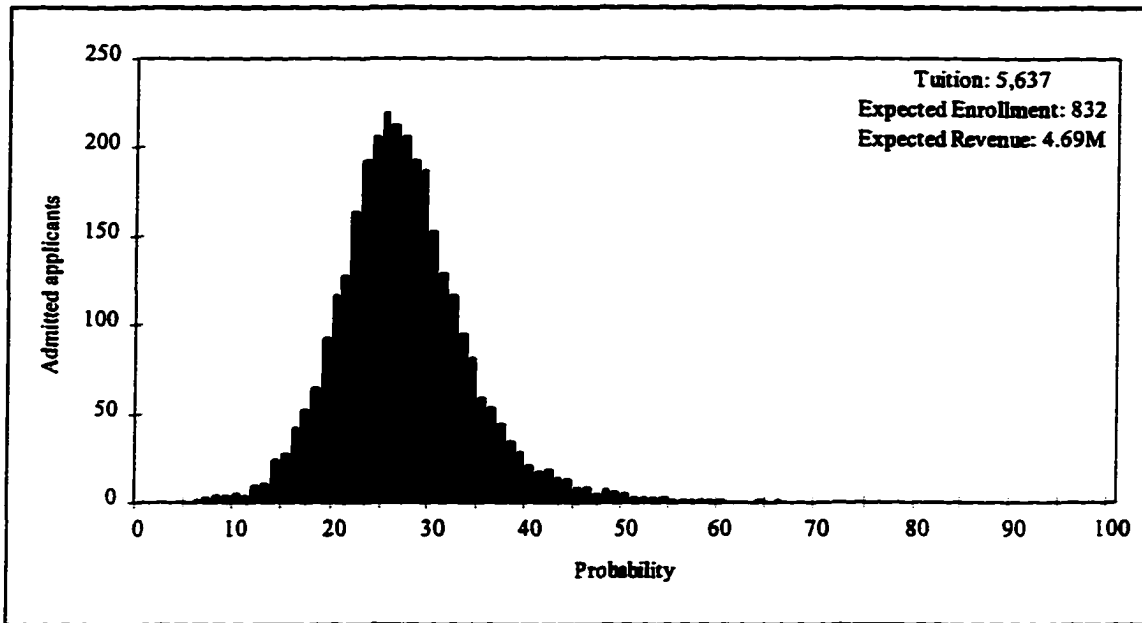


Figure 5.3: Enrollment probability of admitted nonresident applicants, 1985-1989, 1992-1994.

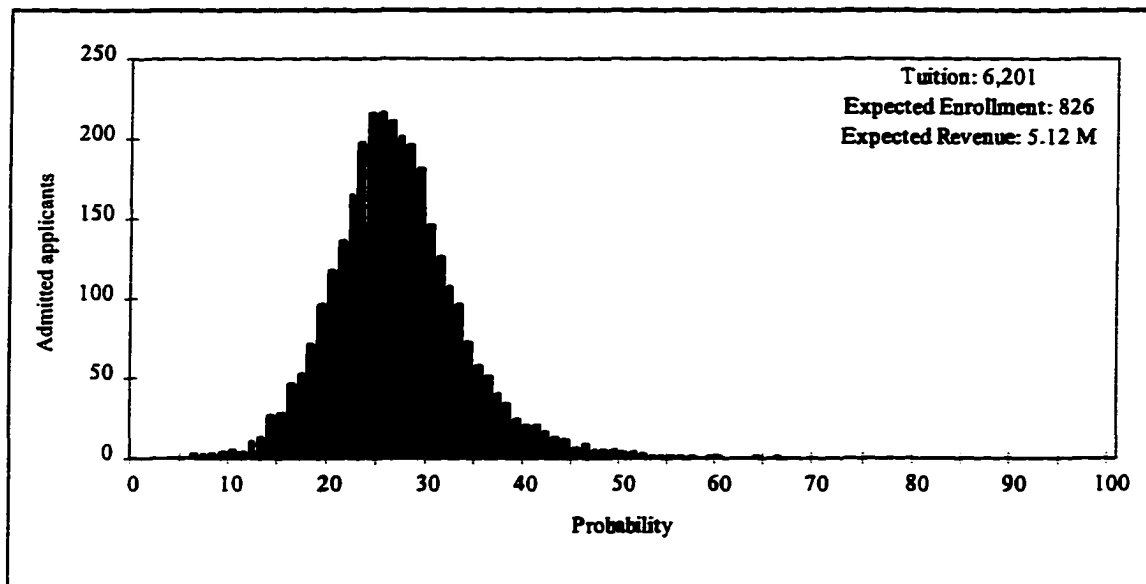


Figure 5.4: Enrollment probability of admitted nonresident applicants under a 10 percent tuition increase, 1985-1989, 1992-1994.

but simulate the enrollment probabilities for a 10 percent tuition increase. Expected revenues under a 10 percent tuition increase would be 8 million for residents and 5.12 million from nonresident tuition.

Finally, the expected enrollment demand curves for 3 enrollment probabilities (50, 25, and 10 percent) are plotted in Figures 5.5 and 5.6. These graphs use the results from the financial aid model, with tuition and grant aid as separate regressors. Therefore, these calculations represent enrollment of financial aid applicants, not enrollment of all admitted applicants.⁸ Along a demand curve the probability of enrolling is constant and the reservation price varies. The panels A, B, and C show the expected enrollment and reservation price relationship described in equation (4.24) for $\alpha = 50, 25,$ and 10 percent, respectively. The revenue calculations use constant marginal cost equal to 0 and assume perfect price discrimination. The expected enrollment and expected net revenue from tuition are given in each panel.

The nonresident demand curve for a 50 percent enrollment probability is shown in Figure 5.5, Panel A. The model predicts that 288 financial aid applicants are expected to enroll. Under a 25 percent target, expected enrollment increases to 368 students per year. Of the three probability targets shown, the 25 percent probability of enrolling maximizes expected net revenue. Revenues from tuition, under perfect price discrimination, would be \$4.37 million from nonresident applicants. The assumption of perfect price discrimination is that each student pays his reservation price.

⁸ Over the years included in the financial aid model, the average number of resident financial aid applications was 3,201, of which 2,251 enrolled. The average number of nonresident financial aid applicants was 1,744 and enrollment was 630.

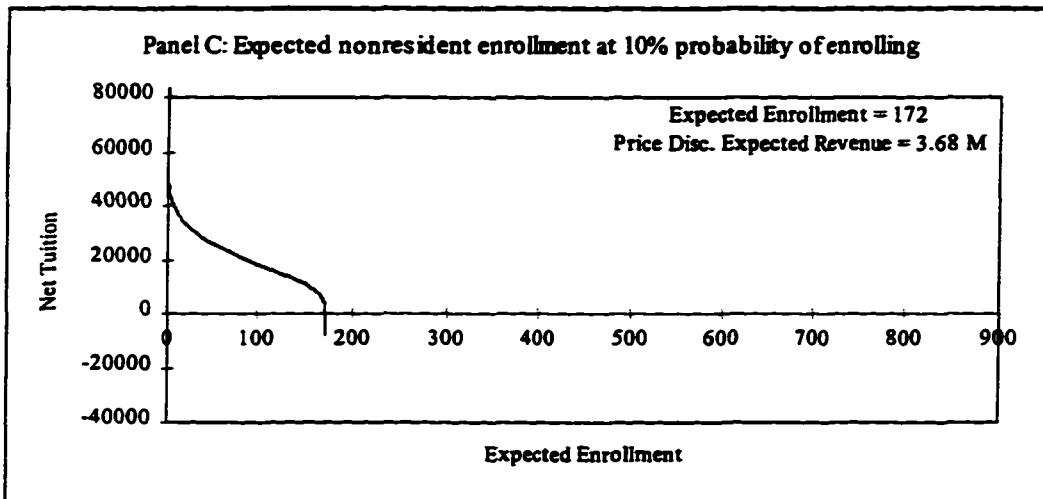
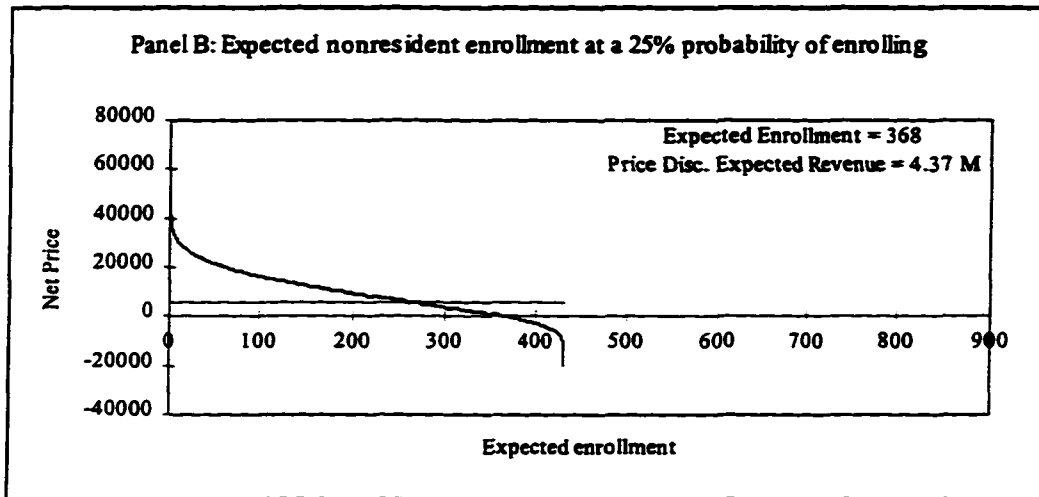
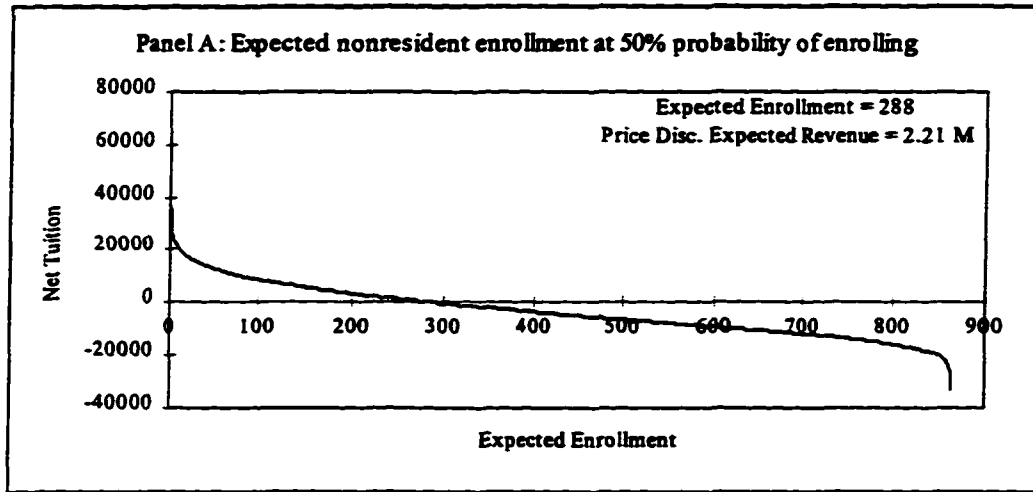


Figure 5.5: Expected enrollment demand curves for nonresidents at various enrollment probabilities.

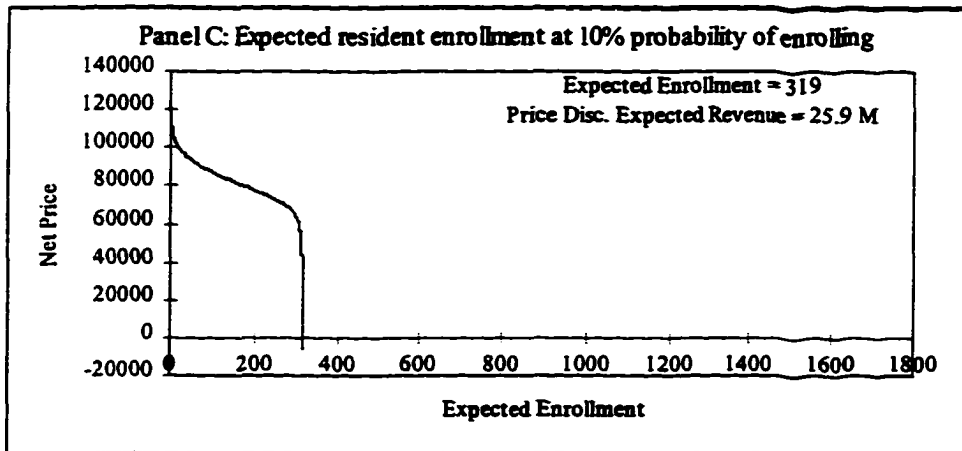
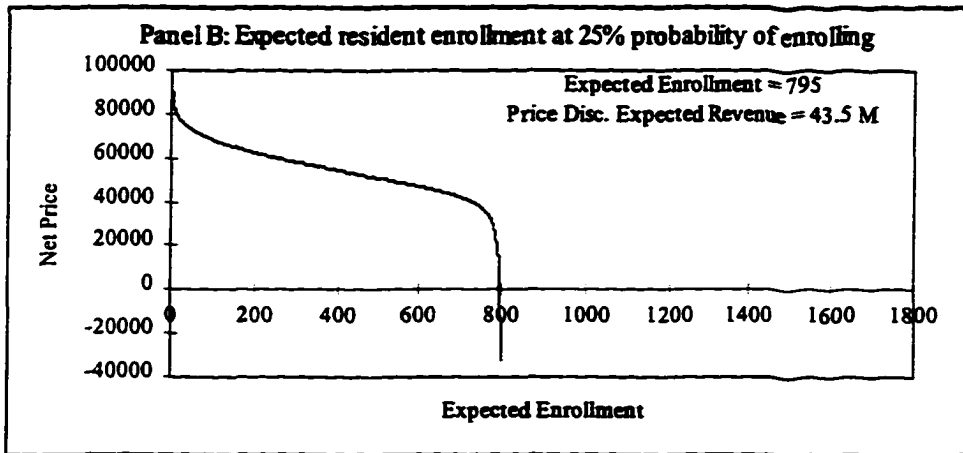
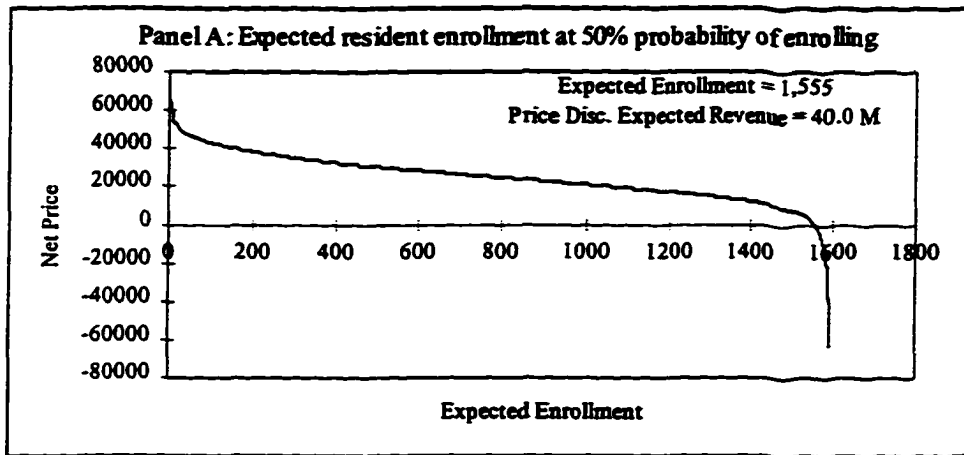


Figure 5.6: Expected enrollment demand curve for residents at various enrollment probabilities.

The demand curve can be used to illustrate how to strategically award financial aid. The horizontal line in panel B represents current tuition. Those applicants whose reservation price is above tuition should receive no grant aid. There are 268 applicants whose reservation price is above the tuition (with a 25 percent enrollment target). For these 268 financial aid applicants, the model predicates that at a 25 percent probability of enrolling, they are willing to pay at least full price to attend ISU (with a 25 percent probability of enrolling). Applicants whose reservation price is above marginal cost and below tuition should receive a scholarship equal to the difference between tuition and their reservation price. In panel B these are the 269th to 368th financial aid applicants. Those applicants who have a reservation price below the marginal cost should not be awarded financial aid, since the price they are willing to pay is below the marginal cost of educating them.

If the university wanted to maximize enrollment, they would pick the target probability that had maximum expected enrollment. If they were interested in maximizing revenue, they would pick the target probability that maximized expected revenues. However, if the goal were some mix of the two, an optimal probability of enrollment may be more difficult to determine. For the 3 nonresident enrollment probabilities shown here, a 25 percent target would maximize expected enrollment and expected revenues.

Figure 5.6 shows the expected enrollment demand curves for resident financial aid applicants. In these samples, expected enrollment is maximized under a 50 percent probability of enrolling, while expected revenues are maximized under a 25 percent probability of enrolling. The optimal choice of a target depends on the relative importance of

each of the two goals. If the financial support from other sources, such as the state subsidy, is tied to enrollments, the goal of maximizing enrollment will receive more weight.

The reservation prices for residents are much higher than the reservation prices for nonresidents. The maximum reservation price of residents is almost double the nonresident maximum. This indicates that large number of resident students are willing to pay to attend ISU. In the 50 percent probability of enrolling, there are 1,555 resident financial aid applicants willing to pay some positive price to attend ISU. For all but the last 100 of these applicants, the price they are willing to pay is above \$10,000. For comparison, average resident tuition over the period is a modest \$2,131.⁹

Conclusion

The results found in the admissions and financial aid models are generally consistent with economic theory and previous literature. The own-price elasticities are consistently in the inelastic range and statistically different from zero. While the resident financial aid model imprecisely estimates the response to grant aid, the coefficient in the nonresident sample is significant. These elasticities indicate that a 10 percent increase in the price of attending ISU leads to a decrease in the probability of enrolling in ISU of less than 10 percent, for an average applicant.

The financial aid model found that changes in tuition lead to a larger enrollment response than do changes in grant aid. Therefore, if the University were to target a group of students

⁹ The excessively high willingness to pay might be due to the imprecise coefficient of grant aid obtained in the resident financial aid model (Table 5.2 Column 1). A small coefficient (β_2) will imply a larger scholarship to equate the probabilities (Equation 4.22). The same issue is seen in the nonresident model (Table 5.2 Column 2), but is not as pronounced as in the resident demand.

by lowering their price, the tuition and grant elasticities suggest that the impact on net tuition revenues can be minimized by using tuition as the policy instrument, instead of grant aid. However, grant aid can be awarded strategically, while tuition is set for the entire student body (either resident or nonresident). The tradeoff of a 1 dollar increase in nonresident tuition, to hold the probability of enrolling constant, is an increase in the average nonresident grant award of \$2.77. Therefore, if tuition is set above the optimal level, the increase in financial aid to compensate for the tuition is rather large. The optimal tuition policy was examined in Chapter 3, using aggregate data. The results may also be imprecise as a result of using the predicted grant, since the actual offer data were not available.

The results also indicate that high ability students, minorities and females are less likely to enroll at ISU. There are programs to increase the presence of women in science and engineering, stated goals of increasing the number of national merit scholars on campus, and a continued interest in increasing the ethnic diversity on campus. However, even with these programs the targeted groups are less likely to enroll. An extension of the current research would be to remove the presence of special programs that attract these groups, and simulate the enrollment of each group. This would test if the programs are indeed increasing the enrollment of the desired groups on campus.

Finally, using the framework presented in the 4th empirical question, an estimate of the α -level reservation price of enrolling at Iowa State University is determined. A lower net reservation price means that the student requires a larger scholarship to reach the targeted probability of enrolling. Another extension of the current research would be to map the

relationship between expected revenue and expected enrollment over the entire range of enrollment probabilities.

CHAPTER 6**SUMMARY**

This dissertation examined undergraduate enrollment at the aggregate and individual level. Chapter 1 introduced the national time trends of the factors that influence the demand for higher education. The current status of the literature dealing with the demand for higher education at the aggregate and individual level was also presented in Chapter 1. Chapter 2 presented a two-stage theoretical model for examining aggregate enrollment at a single institution. This model defined the factors that influence enrollment nationally and those that influence enrollment at the institution. The results for nonresidents were presented in the last section of Chapter 2. Chapter 3 focused on resident enrollment by county, using the same model set forth in Chapter 2. Chapters 4 and 5 examined the individual's decision to enroll in college, using separate models for the admissions and financial aid applicants, as well as resident and nonresident applicants.

Nonresident State Level Empirical Results

This section reviews the findings of the aggregate state level analysis. In 7 out of 10 cases the signs of the coefficients are the same for all three dependent variables, first-time freshmen enrollment, undergraduate enrollment and the number of applications for admission. The factors that influence national enrollment in college are per capita income, the returns to college, public spending toward primary education, and the number of high school graduates. A 10 percent increase in family income would cause an estimated 16

percent increase in nonresident first-time freshmen enrollment. This suggests that nonresident enrollments are procyclical, rising during expansions and contracting during recessions.

State expenditures on primary and secondary education had a positive impact on nonresident enrollments from that state. The elasticity implies that a 10 percent increase in per pupil primary and secondary expenditures increases ISU nonresident freshmen enrollments by 9.4 percent. The coefficient of the college graduate over high school graduate wage ratio was positive, but not significant. While the estimate was imprecise, it implied that a 10 percent increase in the returns to college would increase nonresident freshmen enrollments by 16 percent and undergraduate enrollment by 10 percent.

Changes in the number of high school graduates have not adversely affected nonresident enrollments at ISU. In fact, the literal interpretation of the estimated effect indicated that decreases in the number of high school graduates over the period actually led to an increase in nonresident freshmen enrollments, other things equal.

Three variables captured the factors that influence enrollment at the institution being examined. Two measures captured the cost of attending ISU. The own-price elasticity of demand was significant and marginally in the inelastic range. The elasticities for first-time freshmen enrollment and undergraduate enrollment were -0.971 and -0.723, respectively. This suggests that revenues from tuition are very close to the revenue maximizing level, and that a policy holding real tuition constant would be optimal. The other measure of the cost of attending ISU was distance from Ames. The coefficient was negative and significant for all 3

dependent variables. States farther from Ames tend to have fewer freshmen attending ISU.

The other institution specific variable captures tastes for ISU. The number of alumni in a state had a positive and significant effect on first-time nonresident enrollment, indicating that those states with more alumni tend to have larger nonresident freshmen enrollments and applications.

The remaining variables entered the demand for higher education in both the conditional demand for a specific institution and the decision to attend college in general. The coefficient on the price of an alternative institution for ISU was positive but not significant. This indicates that increases in the resident tuition of other states leads to larger nonresident freshmen enrollments at ISU. The home state subsidy of resident public higher education had a negative and significant effect on ISU nonresident freshmen enrollments.

The robustness of the results above was tested by regressing ISU nonresident undergraduate enrollment and nonresident applications for admission to ISU on the same set of explanatory variables. The results were similar to those found using first-time nonresident freshmen enrollment. These results suggest that nonresident tuition is set at the revenue maximizing level.

Resident Enrollment by County

The same theoretical framework was used to examine resident enrollment at ISU by county. The same three dependent variables were analyzed in this section as well. In general, high school graduates played an important role in determining the number of first-time freshmen and the number of applications for admissions, but not undergraduate

enrollment. The models of first-time freshmen and applications for admissions were consistent with theory and previous empirical research.

The factors that influence enrollment in college used in this model were the per capita income, returns to college, and number of high school graduates. Per capita income and high school graduates were at the county level. To measure the expected increase in income with a college degree, the ratio of national median college graduate over high school graduate salaries was used. The coefficient of per capita county income was positive and significantly different from zero. The income elasticity was 0.569, which indicates that ISU enrollment is a normal good and in the "necessity" range (less than 1). A 10 percent increase in real per capita county income would lead to a 5.7 percent increase in first-time resident enrollment at ISU. Resident enrollment was less sensitive to business cycles than nonresident enrollment.

The coefficient of the number of high school graduates in a county was 0.937. The impact of a 10 percent increase in high school graduates was predicted to be 9.4 percent. Statistical tests did not reject that first-time resident enrollment changes in direct proportion to the number of high school graduates in Iowa. The coefficient of college over high school salaries was positive but not significantly different from zero. First-time resident enrollment at Iowa State does not appear to have responded to the recent increases in returns to college.

The own-price elasticity of first-time resident enrollment at ISU was -0.088. This is in the inelastic range and the coefficient was not statistically significantly different from zero. The model predicts that a 10 percent increase in resident tuition would lead to an enrollment decline of less than 1 percent, so that aggregate tuition revenues would increase substantially.

This small price elasticity may be misleading in that every price increase at ISU is accompanied by a similar increase at the University of Iowa and UNI. Therefore, this elasticity represents the net effect on ISU resident freshmen enrollment of a price increase at all three Regents schools. If ISU tuition were to increase while fees at the U of I and UNI remained constant, the implied reduction in enrollment would be larger. The distance from Ames had a negative and significant effect on ISU enrollments. Counties that are farther from Iowa State tend to have smaller enrollments, all else equal.

Two measures of the cost of alternative opportunities for higher education were examined, distance to the U of I and 2-year college tuition. Counties that are farther from the University of Iowa tended to have larger freshmen enrollment at Iowa State. The impact of distance (in absolute value) was greater on ISU than on the University of Iowa. Since tuition at ISU and the U of I are virtually identical, distance from home represents one way that the cost of enrollment differs between the two schools. The distance results suggest a policy of offering larger scholarships to resident applicants as distance from ISU increases and as distance to the U of I falls. The national average two-year public college tuition positively affects ISU first-time resident enrollment, however, the coefficient was not significantly different from zero. While the coefficient was imprecise, a 10 percent increase in the price of two-year colleges would lead to a predicted increase in first-time resident freshmen of only 2 percent.

To test the robustness of the previous results, applications for admission by county was regressed on the same set of explanatory variables. Signs on coefficients were identical

across the two regressions and the income and price elasticities were similar in magnitude.

Individual's Enrollment Decision

Chapters 4 and 5 examined the admitted applicant's decision to enroll in higher education. Admissions and financial aid records were used to examine what factors influenced enrollment at Iowa State as well as modeling the behavior of the institution. The probit model was used to determine the probability that an individual would enroll, given they had applied and been admitted to ISU. The empirical results were used to determine the individual's α -level reservation price for enrolling. Separate regression were run for resident and nonresident applicants. Since only a portion of the applicants applied for financial aid, a separate model was tested for the subset of students who applied for financial aid.

The findings indicate that increases in tuition lead to declines in the probability of an applicant enrolling. The own-price elasticities in the admissions model were -0.67 and -0.23, for nonresidents and residents, respectively. In the financial aid model, applicants were less likely to enroll as the tuition increases, with elasticities of similar magnitude. Distance to ISU was also used as a cost of attending. The coefficient of distance was negative and significant for both residents and nonresidents. The financial aid applicants were less responsive to distance than all admissions applicants. Furthermore, according to Savoca (1990) these elasticities do not include the probability of enrolling, which in the aggregate model was -0.69 for nonresidents. The sum of the two elasticities would be -1.36, which is in the elastic range. This would be the own-price elasticity of an average individual prior to the application decision.

Per capita county income did not strongly influence the enrollment decisions of admitted applicants. The effect of parents income on the probability of enrolling among financial aid applicants was also relatively small. A 10 percent increase in the parents adjusted gross income led to a less than 1 percent increase in the probability of enrolling for financial aid applicants. The college over high school salary measure negatively influenced the probability of enrolling at ISU. This may indicate that increased returns to college have shifted the applicants decision away from ISU toward enrollment at other schools.

The empirical results indicated that females, minorities and high ability students were less likely to enroll at ISU. These groups may be recruited by other institutions, and therefore have more college options available to them. Finally, those applicants whose parents are ISU alumni were more likely to enroll at Iowa State.

The individual level analysis posed 4 empirical questions. The first question dealt with the behavior or response of the individual, while the last three dealt with the institutions behavior. The first question was, Can increases in tuition be offset with equal increases in grant aid? The financial aid model rejected the hypothesis that the two effects were equal. In fact, a 10 percent increase in scholarships led to an estimated 1 percent increase in the probability of a nonresident enrolling at ISU. A 10 percent increase in tuition would have led to a 7 percent decline in the probability of enrolling. It is clear that the effects are not equal, but result in a net decline in the probability of enrolling.

The second issue examined was, Holding the probability of enrollment constant, how much must tuition increase to increase a desirable student attribute (academic ability or

protected group status)? This section determined the change in tuition required to equate the probability of enrolling for two average applicants, who aside from a unit difference in a single characteristic, were identical. If the difference was gender, the nonresident female applicant requires a tuition reduction in tuition of \$672 or an increase in grant aid of \$899 to equate the probability of enrolling. Likewise, if the difference was ethnic background, to equate the probability of enrolling, the minority applicant required an increase in grant aid of \$4,707 or a decrease in nonresident tuition of \$1,276.

Grant aid must increase \$2.77 to hold the probability of enrolling constant, when nonresident tuition was increased by 1 dollar. For resident students, the required increase in grant aid to compensate for a \$1 increase in tuition was \$10.19. However, this result was imprecise, since the coefficient of grant aid was not precisely estimated and it is likely that the own-price effect was likely under-stated because of the correlation with the tuition at the University of Iowa. The model found that a nonresident applicant whose parents were ISU alumni would have the same probability of enrolling as a nonresident applicant whose parents were not ISU alumni, if tuition increased by \$2,451.

The third question tested if the institution maximizes revenues by price discriminating. If the institution is maximizing revenue, the marginal revenue of each group would be equal to marginal cost. The model found that the marginal revenue was negative for both nonresidents and resident applicants. This means that the last dollar of financial aid reduces net tuition revenue by more than 1 dollar. This indicates that ISU was "over-awarding" financial aid, if the goal of the university were revenue maximization. Another interesting

finding of this section was that the loss in revenue at the margin was twice as large for residents, relative to nonresidents, (-0.70 and -0.29, respectively). This indicates that resident students were receiving a larger subsidy at their state institution than nonresidents.

The findings on price discrimination were mixed. Statistically, the marginal revenues were not equal. However, the magnitude of the difference was relatively small, ranging from 2 to 10 cents. The cost of increasing enrollment of one group, while decreasing enrollment of another, indicates that adding a female, minority, or high ability student would lead to an increase in revenues. Since the enrollment rates of males, non-minorities, and the lower 95th students were higher than the average, a decrease in their scholarships did not have as large of a negative effect on revenues as the negative impact that would result from attracting a student from the other group (female, minority or high ability). The results indicated that the university could increase the enrollment of the more desirable groups and gain revenues in the process.

The last section of the individual analysis presented the individual's α -level net reservation price for enrolling at Iowa State. Using these computed reservation prices, the demand for freshmen enrollment was drawn. Two types of graphs were shown to illustrate the demand for the institution. The first held the price constant and showed the changes in the probability of enrolling across individuals. The second held the probability of enrolling constant and showed the variation in reservation price across individuals. Expected enrollment and expected revenue were calculated for each type. The actual average annual enrollment was 4,019 residents and 1,140 nonresidents. Average revenues from 1976-1994

were \$8.56 million from resident tuition and \$6.11 million from nonresident tuition, not counting the reductions in tuition revenues from financial aid.¹ The model holding price constant predicted enrollment to be 3,500 residents and 832 nonresidents. Expected revenues were estimated at \$7.46 million and \$4.69 million from residents and nonresidents, respectively.

The model that held the probability of enrolling constant assumed that each applicant was charged their reservation price. The reservation price estimates may have been overstated because of the imprecise estimates of the grant coefficient. The reservation price model, under a 50 percent probability of enrolling, showed expected enrollment of 1,555 residents and 288 nonresidents financial aid applicants. Under a 25 percent probability of enrolling, expected resident enrollment was 795 and nonresident enrollment was projected to be 368. Estimates of expected revenues from residents were dramatically over-stated, since the price coefficients were imprecise. The nonresident revenue under perfect price discrimination ranged from \$4.37 million to \$2.21 million for a 25 and 50 percent probability of enrolling.

Finally, a method for strategically allocating scholarships was, illustrated with the demand curve under perfect price discrimination. For each applicant whose reservation price is above tuition, the financial aid should be set to zero. For those applicants whose reservation price is below tuition and above marginal cost, the University should offer a grant equal to the difference between tuition and their reservation price. Finally, those students who have a reservation price below marginal cost should not be offered financial aid. The

¹ Average resident and nonresident tuition from 1976 - 1994 is \$2,131 and \$5,637, respectively.

model predicts that these applicants would require so much financial aid that the marginal revenue would be below the marginal cost.

APPENDIX A**DISCUSSION OF AGGREGATE VARIABLES**

This project utilized data for each state in the United States. Data for Washington, D.C., was omitted. Data was recorded in current (nominal) dollars and changed to constant (real) dollars by the Consumer Price Index (CPI) for 1987, using 1994 as the base year. The time period used for this report is 1973 to 1994. The following is the list of variables used and their sources. The variable definitions are summarized in Table 2.1.

Variable Definitions and Sources

- **Iowa State University Enrollment:** This is the number of new ISU fall undergraduate enrollees and total undergraduate enrollment by state or county. Source: *Iowa State University Enrollment Services Annual Statistical Report*.
- **Iowa State University Applications:** The number of admissions applications per entry year, in each state or county. Source: data calculations.
- **Iowa State University Tuition and Fees:** Annual nonresident tuition and fees were used as a measure of the cost of attending ISU for nonresidents. The annual measure automatically adjusts for the change from quarters to semesters. Source: *Iowa State University Enrollment Services Annual Statistical Report*.
- **Alumni:** This is the number of Iowa State alumni living in each state. Data were provided by the ISU Alumni Association and the *Iowa State Fact Book*. The data for 1983 were not available. For that year, linear interpolation between the years of 1982 and 1984

was used.

•**Distance:** The distance from Ames, Iowa (and Iowa City within Iowa) to each state or county. Uses latitude and longitude (in radians) for each zipcode.

$$\text{Dist} = 3949.99 \left(\text{Arccos}(\sin(\text{lat1}) * \sin(\text{lat2}) + \cos(\text{lat1}) * \cos(\text{lat2}) * \cos(\text{long1} - \text{long2})) \right)$$

Formula provided by the Technical Support team at the SAS Institute.

•**College Salary:** National median annual salary of all males 25 and over, who have completed four or more years of college. Published in the *Current Population Survey*.

•**High school salary:** National median annual salary of all males 25 and over, who have completed 4 years of high school. Published in the *Current Population Survey*.

•**National relative annual salary:** The ratio of college annual salary over high school salary.

•**Higher education expenditures:** The current fund expenditures of public institutions of higher education. This was reported in the *Digest of Educational Statistics*, published by the United States Department of Education, National Center of Educational Statistics..

•**State subsidy for higher education:** Higher education expenditures divided by the sum of the four previous years of high school graduates. This was used as a measure of quality and state support of higher education.

•**High school graduates:** The number of public high school graduates in each state as reported in the *Digest of Educational Statistics*, by the United States Department of Education, National Center for Educational Statistics.

•**Own State Resident Tuition:** A measure of tuition and fees for residents at public

universities in the state. Three different sources were used to obtain tuition data. The *Digest of Educational Statistics*, compiled by the United States Department of Education, National Center for Educational Statistics, provides state average tuition and fees at public 4-year universities. This is the most reliable data and was used whenever available (1981, 1983, 1986, 1989, and 1991 - 1994). Tuition and fees were also taken from *Barron's Profiles of American Colleges* and *The College Blue Book*. These two sources listed data for individual schools rather than a state average. The 4-year public university with the largest enrollment was used from each source. The institutions are listed in Appendix Table 1. *Barron's* was used when available (1963, 1967, 1971, 1973 and 1981). *The College Blue Book* was used to fill in the years when *Barron's* was not available (1978 and 1980). Linear interpolation was used when there was no data for a given year.

Using two measures of college tuition and fees poses a problem of comparability. Since the *Digest of Educational Statistics* reported state averages and the other two sources used individual college the two observations are not comparable. To remove this problem the following weighting method was used.

Let

D_{ti} = *Digest Of Educational Statistics* observation for the average 4-year tuition and fees for the t^{th} time period and the i^{th} state.

B_{ti} = *Barron's Profile of American Colleges* observation of the largest school's tuition and fees for the t^{th} time period and the i^{th} state.

T_{ti} = The observation used in the regression analysis for the t^{th} time period and the i^{th} state.

Then

$$T_{it} = \begin{cases} \frac{D_{81i}}{B_{81i}} B_{it} & \text{for } t < 1981 \\ D_{it} & \text{for } t \geq 1981 \end{cases} \quad (1)$$

This translates all observations into units consistent with the *Digest of Educational Statistics*.

• **Public School Expenditure:** The current fund expenditure per pupil in average daily attendance in public elementary and secondary schools was used as a quality measure specific to each state. Reported by the U.S. Department of Education, National Center for Education Statistics in the *Digest of Educational Statistics*.

• **Consumer Price Index (1987):** Reported by the Department of Labor, Bureau of Labor Statistics in the *Statistical Abstract*. Standardized to 1994 in the analysis.

• **Per capita Income (by state):** The state personal income per capita in current dollars. It is published by the U.S. Bureau of Economic Analysis, Survey of Current Business in the *Statistical Abstract*.

• **Per capita Income (by county):** County income per capita in current dollars. Published by the U.S. Bureau of Economic Analysis, Economic and Statistical Administration, *Regional Economic Information System (REIS)*, REIS CD-ROM.

Table A.1: Universities selected to represent the state when *Barron's Guide to Colleges* and *The College Blue Book* were the source for information on tuition and room-and-board.

State	Institution	State	Institution
Alabama	Auburn	Montana	Montana State Univ.
Alaska	Univ. of Alaska at Fairbanks	Nebraska	Univ. of Nebraska at Lincoln
Arizona	Arizona State Univ.	Nevada	Univ. of Nevada at Reno
Arkansas	Univ. of Arkansas at Fayetteville	New Hampshire	Univ. of New Hampshire
California	Univ. of California at L. A.	New Jersey	Rutgers Univ. & College
Colorado	Univ. of Colorado Boulder	New Mexico	Univ. of New Mexico
Connecticut	Univ. of Connecticut	New York	State Univ. of NY at Buffalo
Delaware	Univ. of Delaware	N. Carolina	Univ. of N. Carolina Chapel Hill
Florida	Univ. of Florida Gainesville	N. Dakota	Univ. of N. Dakota
Georgia	Univ. of Georgia Athens	Ohio	Ohio State Univ.
Hawaii	Univ. of Hawaii Manoa	Oklahoma	Oklahoma State Univ.
Idaho	Univ. of Idaho Moscow	Oregon	Oregon State Univ.
Illinois	Univ. of Illinois U/C	Pennsylvania	Pennsylvania State Univ.
Indiana	Indiana Univ. at Bloomington	Rhode Island	Univ. of Rhode Island
Iowa	Iowa State Univ.	S. Carolina	Univ. of S. Carolina
Kansas	Univ. of Kansas	S. Dakota	S. Dakota State Univ.
Kentucky	Univ. of Kentucky	Tennessee	Univ. of Tennessee at Knoxville
Louisiana	Louisiana State Univ. A&M	Texas	Univ. of Texas at Austin
Maine	Univ. of Maine Orono	Utah	Univ. of Utah
Maryland	Univ. of Maryland College Park	Vermont	Univ. of Vermont
Massachusetts	Univ. of Massachusetts Amherst	Virginia	Virginia Polytech.
Michigan	Michigan State Univ.	Washington	Univ. of Washington
Minnesota	Univ. of Minnesota Twin Cities	W. Virginia	W. Virginia Univ.
Mississippi	Mississippi State Univ.	Wisconsin	Univ. of Wisconsin at Madison
Missouri	Univ. of Missouri at Columbia	Wyoming	Univ. of Wyoming

Table A.2: Means and standard deviations of the data (in levels) used in MLE regressions

Coefficient	Nonresident	Resident
First-time enrollment	22.74 (76.73)	42.04 (70.21)
Total Undergraduate Enrollment	74.69 (258.55)	163.30 (282.89)
Applications for Admission	77.28 (265.97)	65.82 (109.14)
Income per capita	17,220.82 (1,207.45)	16,970.00 (1,933.57)
College over High School Salary	1.57 (0.17)	1.64 (0.17)
Primary Spending	2906.63 (1848.74)	
High school graduates	51521 (51579)	398.33 (527.77)
ISU tuition	3389.96 (2198.39)	1953.25 (323.64)
Distance to ISU	898.29 (607.58)	92.43 (35.64)
Alumni	1,359 (1,790)	
Alternative public tuition (NR: own-state and Res: 2 yr.)	1680.52 (768.76)	890.94 (161.89)
Distance to U of I		128.82 (66.48)
State Subsidy	5.12 (3.51)	
Time Trend	11.68 (1.78)	11.50 (6.34)

APPENDIX B**DISCUSSION OF INDIVIDUAL ANALYSIS VARIABLES**

- **ISU Tuition:** Same as aggregate study
- **ISU Distance:** Same as aggregate study.
- **Own-state tuition:** Same as aggregate study.
- **U of I Distance:** Same as aggregate study using Iowa City as base.
- **Local Subsidy:** Same as aggregate study.
- **County Income:** Per capita personal income, by county (converted to 1994 dollars).

Same as aggregate study.

- **Parents Adjusted Gross Income:** Financial aid applications (converted to 1994 dollars).

$$\text{PAGI} = \begin{cases} \text{PAGI} & \text{if reported} \\ 0 & \text{if missing} \end{cases}$$

$$\text{miss_pagi} = \begin{cases} 1 & \text{if PAGI missing} \\ 0 & \text{if PAGI reported} \end{cases}$$

- **Parents Alumni:** Admissions records.

$$\text{Palum} = \begin{cases} 1 & \text{if yes} \\ 0 & \text{if no or missing} \end{cases}$$

$$\text{Miss_palum} = \begin{cases} 1 & \text{if missing} \\ 0 & \text{otherwise} \end{cases}$$

- **ACT Composite Test Score:** Admission records.
- **Class Rank:** Admission records (100 = top of class).
- **Female:** Admission records

•Minority: Admission records

$$\text{minority} = \begin{cases} 1 & \text{if ethnic minority} \\ 0 & \text{if withheld or missing} \end{cases}$$

$$\text{Miss_minority} = \begin{cases} 1 & \text{if missing} \\ 0 & \text{otherwise} \end{cases}$$

•Predicted Grant Aid: The following regression predicted the grant aid (in real terms) for all financial aid applicants.

Table B.1: OLS Regression results for the grant award prediction equation.

Variable	Coefficient	t-statistic
Intercept	-1,110.78***	-2.90
Rank	1.62**	2.10
Miss_Rank	873.80*	1.95
ACT Test	68.59***	21.14
Miss_ACT	1,733.69***	18.41
Female	75.11***	3.38
Minority	1,103.26***	21.61
Miss_ethnic code	-239.71***	-5.18
Resident	-13.01	-0.41
Real Student Need	0.307***	85.12
Real Family Contribution	0.028***	11.56
Real Parents AGI	-0.006***	-11.46
Real County Income	-0.140**	-2.00
Miss_Parents AGI	-15.88	-0.12
Parents Alumni	331.99***	7.77
Miss_Parents Alumni	408.11***	8.71
Age	-14.45	-1.60
ISU Distance	0.388***	5.65
TotalGrant/Number of Fin. Aid App's	0.871**	2.38
(TotalGrant/Number of Fin. Aid App's) ²	-0.000292**	-2.39
TotalGrant/Total Need	-556.97	-1.00
(TotalGrant/Total Need) ²	724.99**	2.00

•College/High School Salary: College over high school salary, adjusting for 4 extra years of labor force participation (using the 1 year Treasury Bill rate) and the probability of being

employed without a college degree (unemployment rate of 18 - 19 year olds). Salary measures as defined in the aggregate study.

$$= \frac{\text{College Salary}}{\text{High Salary} \left(\frac{1 - \left(\frac{1}{1 + \text{TBill}} \right)^4}{1 - \left(\frac{1}{1 + \text{TBill}} \right)} \right) (1 - \text{unempl. rate})}$$

•ACT College Choice: Admission records. Reports the student's ranking of ISU in the colleges that the student is sending their ACT test scores. The range is 1 to 7, where 1 is most favorable, 7 is least favorable. If missing, CChoice = 7 and dummy variables = 1, else dummy variable = 0.

Table B.2: Mean and Standard Deviations of data used in the probit analysis.

Variable	Resident (Admissions) ¹	Nonresident (Admissions) ²	Resident (Financial Aid) ³	Nonresident (Financial Aid) ⁴
ISU Tuition/1,000	1.902 (.297)	5.638 (1.518)	2.132 (.231)	6.955 (.872)
ISU Grant Aid/1,000 (Predicted)			1.748 (0.488)	2.822 (1.599)
ISU Distance/1,000	0.088 (0.082)	0.362 (0.321)	0.091 (0.088)	0.343 (0.304)
Alternative tuition/1,000	1.215 (0.111)	2.024 (0.684)	1.210 (0.056)	2.514 (0.560)
U of I Distance/1,000	0.117 (0.066)		0.119 (0.067)	
Local subsidy/100		0.082 (0.026)		0.103 (0.026)
Income/10,000	1.794 (0.227)	2.177 (0.424)	2.610 (3.121)	2.485 (3.417)
College/HS Salary	0.525 (0.092)	0.546 (0.079)	0.573 (0.027)	0.583 (0.028)
ACT/100	0.238 (0.057)	0.206 (0.098)	0.242 (0.051)	0.219 (0.090)
ACT Missing	0.029 (0.168)	0.161 (0.367)	0.019 (0.135)	0.120 (0.325)
Rank/100	0.759 (0.177)	0.766 (0.176)	0.774 (0.170)	0.799 (0.167)
Rank Missing	0.001 (0.023)	0.001 (0.025)	0.001 (0.025)	0.0004 (0.0208)
Female	0.449 (0.497)	0.410 (0.492)	0.450 (0.498)	0.413 (0.492)
Minority	0.018 (0.134)	0.121 (0.327)	0.029 (0.169)	0.208 (0.406)
Miss Minority	0.407 (0.491)	0.312 (0.463)	0.020 (0.139)	0.017 (0.129)
Parents Alumni	0.080 (0.272)	0.052 (0.221)	0.141 (0.348)	0.101 (0.301)
Miss Alumni	0.598 (0.490)	0.524 (0.499)	0.274 (0.446)	0.155 (0.362)
College Choice	6.212 (1.945)	6.564 (1.423)	5.619 (2.414)	5.994 (2.030)
Miss College Choice	0.856 (0.351)	0.910 (0.287)	0.748 (0.434)	0.793 (0.405)
n	81307	50027	25536	13872

Table B.3: Elasticities and standard errors, using a parametric bootstrap of 100 draws.

Variable	Resident (Admissions) ¹	Nonresident (Admissions) ²	Resident (Financial Aid) ³	Nonresident (Financial Aid) ⁴
ISU Tuition/1,000	-0.230 (0.051)	-0.674 (0.101)	-0.238 (0.095)	-0.704 (0.272)
ISU Grant Aid/1,000 (Predicted)			0.019 (0.017)	0.117 (0.025)
ISU Distance/1,000	-0.015 (0.006)	-0.111 (0.008))	-0.003 (0.004)	-0.026 (0.0159)
Alternative tuition/1,000		0.058 (0.033)	0.127 (0.150)	0.041 (0.081)
U of I Distance/1,000	-0.003 (0.004)		-0.020 (0.007)	
Local subsidy/100		0.195 (0.035)		0.010 (0.072)
Income/10,000	-0.006 (0.022)	-0.091 (0.036)	0.082 (0.003)	0.064 (0.009)
College/HS Salary	-0.188 (0.026)	-0.707 (0.062)	-0.468 (0.115)	-2.735 (0.327)
ACT/100	0.045 (0.020)	-0.148 (0.036)	-0.184 (0.029)	-0.180 (0.082)
Rank/100	-0.039 (0.012)	-0.558 (0.030)	-0.101 (0.024)	-0.639 (0.066)
Female	-0.029 (0.002)	-0.033 (0.005)	-0.014 (0.004)	-0.017 (0.011)
Minority	-0.002 (0.0003)	-0.019 (0.002)	-0.002 (0.001)	-0.026 (0.009)
Parents Alumni	0.010 (0.001)	0.015 (0.001)	0.006 (0.002)	-0.001 (0.005)
College Choice	-1.454 (0.052)	-1.556 (0.118)	-1.138 (0.051)	-1.023 (0.150)

¹ Table 5.1 Column 1.² Table 5.1 Column 2.³ Table 5.2 Column 1.⁴ Table 5.2 Column 2.

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