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A copy of the Excel simulation tool is available by contacting the author via e-mail: stephendesjardins@uiowa.edu.

This article describes the development and use of a simulation model designed to assist institutional policy makers in assessing a proposal to discount non-resident student tuition by offering a new institutional scholarship. The model proved to be a valuable tool for administrators in evaluating a wide range of policy alternatives, in the areas of enrollment, quality of the class, and net tuition revenue effects.

In May 1999 administrators at the University of Iowa faced the prospect of declining non-resident student enrollment, which presented a financial challenge because non-resident tuition rates are three times that of resident students. Administrators also focused on non-resident students because the number of Iowa residents likely to attend college is projected to remain flat or even decline over the next decade (DesJardins, 1997; Western Interstate Commission for Higher Education, 1996).

One response to remedying the situation was a proposal to discount non-resident student tuition by offering a new institutional scholarship, the University of Iowa National Scholars Award (NSA). The author developed two analytic tools, an econometric model and a simulation model, to analyze the potential impacts of this proposal. (See DesJardins, forthcoming, for information about the econometric model.) The econometric model results were coupled with the simulation model results, which were intended to "find groups of students for whom higher grants would raise enrollment enough to increase net revenue despite the higher apparent financial aid costs" (Brooks, 1994, p. 2). The simulation model was constructed to inform institutional decision-makers about the impact of the suggested policy change on the quality of the entering freshman class, as well as how the NSA would affect enrollments and net tuition revenues. This paper demonstrates how the simulation model was constructed and used to analyze the effects of the change in institutional aid policy.

Student Price-Response: Concepts and Related Research

From an economic perspective, tuition is a "price" charged to students (National Commission on the Cost of Higher Education, 1998); proposals such as the NSA reduce the net price of attendance. Economic theory and student price-response research indicate that, other things equal, enrollments will rise (decline) when tuition is reduced (increased) for a particular group (Heller, 1997; Leslie & Brinkman, 1988; St. John, 1993).

Past studies have found that the college choice decision process involves a number of stages (Hossler, Braxton, & Coopersmith, 1989; Paulsen, 1990). Financial factors such as providing tuition discounts or other forms of financial inducement tend to have the most impact in the enrollment phase, when admitted students consider whether to matriculate at a particular institution. Thus, it is the admit-to-enrollment stage that is the focus of most research examining the role of financial factors on matriculation.

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Many of these studies have found that the factors affecting student enrollment decisions fall under two general categories: "academic, biographic, demographic, and institutional variables" and "economic and finance variables" (Braunstein, McGrath, & Pescatrice, 1999, p. 248). When studying financial aid effects, researchers often use regression methods to isolate the independent effects of economic variables by statistically controlling for background, demographic, and other (possibly) confounding variables. Including controls for confounding variables is important because prospective students respond differently to changes in the prices they face depending on their socioeconomic status, preference for the institution, home location, ability level, and a host of other factors. In the project discussed herein, the objective was to determine how responsive students would be to changes in institutional aid. A logistic regression model was estimated with the objective of isolating how non-resident student enrollments would change if the institution offered these students a new scholarship (see Brooks, 1996, or DesJardins, forthcoming, for how to apply logistic modeling to this issue).

Of particular interest was the effect that the Institutional Grant variable had on enrollment probabilities, since it is through this variable that the proposed scholarship was hypothesized to operate. The econometric model results produced an estimate of the responsiveness of non-resident students to changes in the amount of institutional grants offered. This coefficient value (.000073) was converted to a delta-P (see Petersen, 1984) and the result indicated how much the probability of enrollment changed for each one-dollar change in the offer of an institutional grant. For example, a $1,000 increase in institutional aid was estimated to increase the "yield" of non-resident students by about 7.3 points. This estimate was used to guide the yield increase assumptions used in the simulation model discussed below. The literature supports the plausibility of this price-response estimate (Brooks, 1998; Braunstein, McGrath, & Pescatrice, 1999; Chapman & Jackson, 1987; Ehrenberg & Sherman, 1984 as cited in Becker, 1990; St. John, 1990; Trusheim & Gana, 1994).

Constructing the Simulation Model

The simulation model (Table 1) allowed us to vary important policy parameters. For instance, we were able to vary (by ability level) scholarship recipients (see Table 1, Section A). Ability was operationalized by using the institution's Admission Index Score (AIS) (calculated as [2 * Composite ACT score] + High School Rank Percentile). After considerable internal discussion, we settled on offering the scholarship to students with Admission Index Scores of 129 or better ("high-ability students"). These students were targeted because increases in enrollments among this group would tend to improve the quality of the entering freshman class (the average non-resident AIS score was 126, a few points below the 129 "cut score"). Also, high-ability students have admit-to-enrollment yields that are considerably lower than other students (see Table 1, Section C); one objective of the strategic use of institutional aid is to more evenly distribute admit-to-enrollment yields across the category of interest (Brooks, 1998).

The simulation model also permitted varying the parameter informed by the statistical model—how responsive students would be to changes in institutional aid. The model was constructed to allow varying the admit-to-enrollment yields for three high-ability categories (129-139, 140-153, 154-171). We were also able to vary the amount of institutional aid offered to each of the three targeted high-ability categories (e.g., $500/$1,000/$1,500, etc.).

By varying the yield and award parameters (by high-ability group), we were able to estimate how the assumed yield changes would impact enrollments in the 129 to 171 AIS groupings (see Table 1, Section C). This functionality allowed us to compare increases in matriculants to the fall 1998 status quo.

Table 1, Section D was included to estimate the amount of additional institutional aid that would have to be budgeted beyond the cost of the new scholarship. For instance, high-ability students historically receive Presidential, Provost's, and Dean's Scholarships and a myriad of other forms of institutional support. Therefore, we needed to budget for any increase in this type of aid due to NSA-induced enrollment increases. To estimate this revenue requirement we assumed that new matriculants would be awarded institutional aid in the same proportion as it was awarded for the 1998 entering class. The average 1998 institutional aid award was calculated for five high-ability groups (Table 1, Section B) and used as an estimate of how much each new matriculant would require in non-NSA institutional aid.

Table 1, Section E focuses on establishing the revenue implications of the NSA proposal. Gross tuition revenue for fall 1998 high-ability students was estimated by multiplying fall 1998 tuition by the number of high-ability matriculants in 1998. (Actually, fall 1998 tuition was set to the fall 2000 estimate so that we could examine the effects of the proposed policy

TABLE 1
The Simulation Model

Section A: Computer Simulation Model Inputs

Targeted Ability Groups (Based on Admissions Index Scores)	Estimated Change in Admissions Yield	New Award	Fall 2000 Tuition	Fall 1998 Tuition
129-139	*6.0*	*$1,000*	*$10,813*	*$10,813*
140-153	*7.0*	*$1,500*	*$10,813*	*$10,813*
154-171	*8.0*	*$2,000*	*$10,813*	*$10,813*

Note: italicized numbers are inputs that are variable.

Section B: Average Institutional Grants in 1998 by Range of Admissions Index Scores (AIS)

AIS	129-134	135-139	140-146	147-153	154-171
Average Institutional Grant	*$2,788*	*$4,199*	*$4,095*	*$3,178*	*$4,493*

Note: italicized numbers are inputs that are variable.

Section C: Predicted Increase in Number of Matriculants

Admissions Index Score Deciles	1998 Admits *N*	1998 Matriculants *N*	1998 Yield Percentage	2000 Yield Percentage	2000 Matriculants *N*	2000 Increase in Matriculants *N*
129-134	555	102	18.4	24.4	135	33
135-139	473	95	20.1	26.1	123	28
140-146	533	82	15.4	22.4	119	37
147-153	446	86	19.3	26.3	117	31
154-171	390	56	14.4	22.4	87	31
Total Net Tuition Revenue	4944	1280	25.9	23.4	1441	161

Section D: Predicted Change in Institutional Aid Recipients

Admissions Index Score	Received No Institutional Aid			Received Some Institutional Aid		
	1998	2000	1998	1998	2000	1998
Deciles	*N*	*N*	Percentage	*N*	*N*	Percentage
129-134	86	114	84.3	16	21	15.7
135-139	72	94	75.8	23	30	24.2
140-146	50	73	61.0	32	47	39.0
147-153	30	41	34.9	56	76	65.1
154-171	15	23	26.8	41	64	73.2
Total Net Tuition Revenue	1068	1160	83.4	212	239	16.6

TABLE 1
The Simulation Model (cont.)

Section E: Actual and Predicted Change in Net Tuition Revenue

AIS Deciles	1998-99 (actual) Gross Tuition Revenue	1998-99 (actual) Financial Aid Awarded	1998-99 (actual) Net Tuition Revenue	2000-01 (predicted) Gross Tuition Revenue	2000-01 (predicted) Cost of the Scholarship	2000-01 (predicted) Financial Aid Awarded	2000-01 (predicted) Net Tuition Revenue
129-134	$1,102,926	$ 44,448	$1,058,478	$1,462,999	$135,300	$ 58,959	$ 1,268,740
135-139	$1,027,235	$ 96,577	$ 930,658	$1,334,108	$123,380	$125,428	$ 1,085,300
140-146	$ 886,666	$131,040	$ 755,626	$1,290,099	$178,965	$190,663	$ 920,471
147-153	$ 929,918	$177,968	$ 751,950	$1,267,500	$175,830	$242,575	$ 849,095
154-171	$ 605,528	$184,213	$ 421,315	$ 942,894	$174,400	$286,846	$ 481,648
Total Net Tuition Revenue	$4,552,273	$634,246	$3,918,027	$6,297,599	$787,875	$904,471	$ 4,605,254

Section F: Predicted Change in Net Tuition

Admissions Index Score Deciles	Predicted Change in Net Tuition Revenue 2000 vs. 1998	Predicted Percentage Change in Net Tuition 2000 vs. 1998
129-134	$210,262	19.9%
135-139	$154,642	16.6%
140-146	$164,845	21.8%
147-153	$ 97,145	12.9%
154-171	$ 60,333	14.3%
Total Net Tuition Revenue	$687,227	17.5%

Section G: Predicted Increase in Index Scores and Matriculants 2000

Index Score	Matriculants
2.8	161

independent of any tuition increases from 1998 to 2000). Financial aid awarded for 1998 was estimated by multiplying the number of high-ability students with aid by the relevant average institutional grant amount. Net tuition revenue (NTR) for the status quo (1998) was calculated by taking the difference between the 1998 gross tuition revenue and the amount of institutional financial aid awarded that year.

Estimating NTR for the 2000 entering class included an extra step compared to the calculation of NTR for the status quo. Gross tuition for 2000 was calculated using the same logic as above. To estimate how much financial aid would be required for fall 2000 matriculants (excluding the cost of the discount), we multiplied the estimated number of high-ability students who would be eligible for institutional aid by the corresponding average institutional grant amount calculated from fall 1998 data.

In addition to this "typical" financial aid award, the dollar cost of the new scholarship was determined by multiplying the estimated number of matriculants in fall 2000 by the corresponding new scholarship award. The NTR for fall 2000 was calculated as gross tuition less the sum of the cost of the new scholarship plus other institutional financial aid.

Table 1, Section F indicates the dollar and percentage change in NTR, respectively, from 1998 to 2000. The change in total NTR was of particular interest to University of Iowa policy makers because this estimate provides an indication of the financial feasibility of the scenario being modeled. In addition to estimates of NTR, the simulation model also allowed us to predict changes in new enrollments and the quality of the class (see Table 1, Section G).

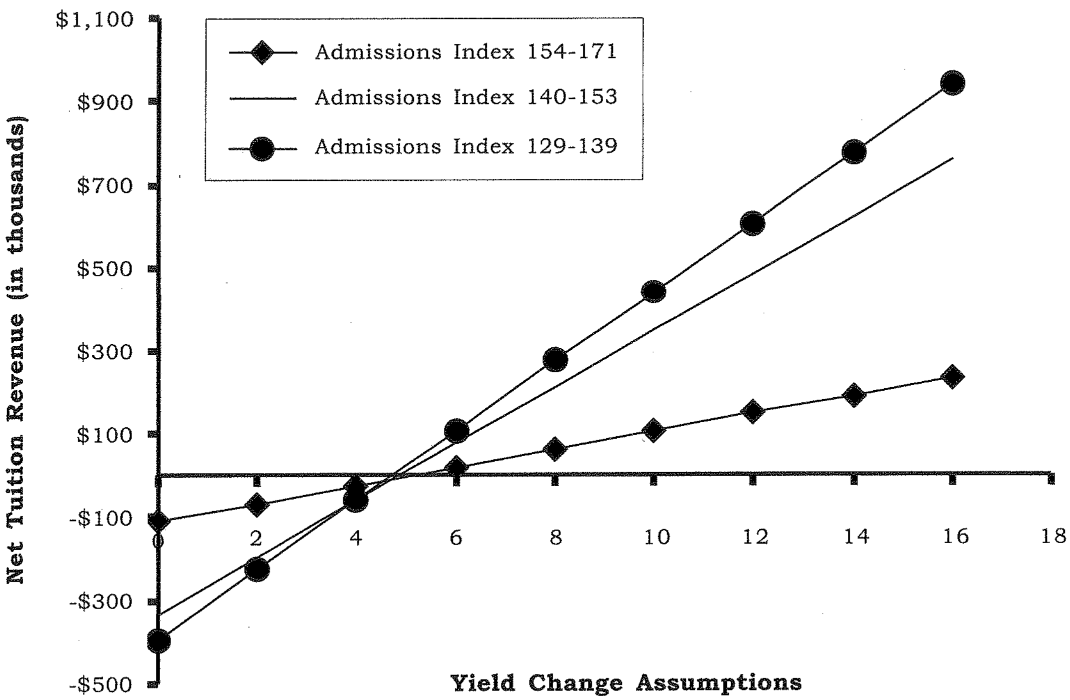
Applying the Simulation Model

The simulation model was used to explore a variety of policy options, including the implications of offering all high-ability students the same scholarship amount ($2,000). The NTR implications of this policy scenario are presented in Figure 1. Assuming an award of $2,000 to each high-ability student, yields must increase (in each ability group) by about 5 percentage points to achieve NTR neutrality. At the break-even point we would expect non-resident enrollments to rise by about 120 students and the average AIS of enrollees (the quality measure) would increase by about 2 points (as displayed in Figure 2, when yields increase by 5 points).

This simulation demonstrated that providing a flat $2,000 scholarship to all high-ability students was risky if yield increases did not materialize. For instance, if no yield increases were realized, enrollments and the quality of the class would remain the same, but NTR would decline by about $842,000 ($394,000 for the 129-139 index group, $336,000 for the 140-153 group, and $112,000 for the 154-171 group). The model helped University of Iowa administrators, especially those responsible for the financial viability of the institution, to conclude that providing a flat-rate scholarship to high-ability students was too risky.

Knowledge about student price response and the simulation tool proved to be very helpful in searching for alternatives to the flat-rate approach. High-ability students tend to have more schooling options than other students do; what would hap-

FIGURE 1
Net Tuition Revenue Assuming Constant Yield Rate Changes and a $2,000 Scholarship Offer for Each Ability Group

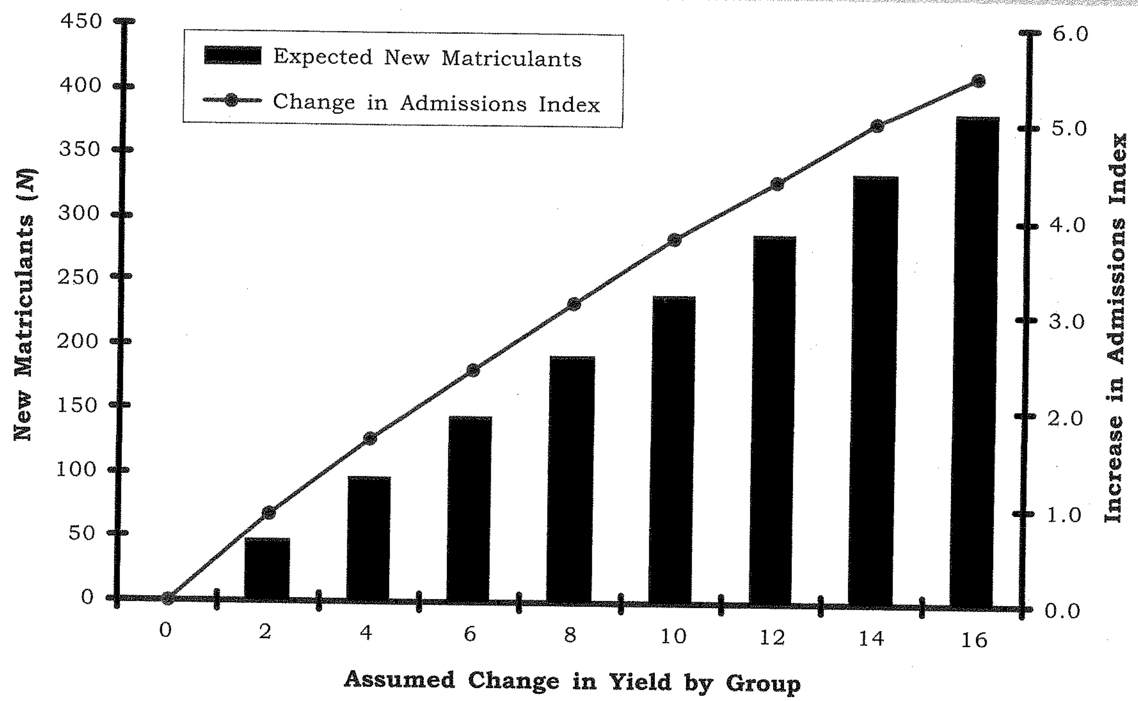


pen if the scholarship offer increased with ability? This strategy reduced the NTR risk in the flat-rate strategy (see DesJardins, forthcoming, for details), and the results suggest that the risk inherent in providing price reductions can be decreased by offering differential amounts to targeted students.

Yield increases could be expected to vary depending on the amount of the award. Other things equal, students who receive $2,000 are likely to be more responsive than students who are offered only $1,000. Additional simulations were conducted using a variety of award and yield-increase assumptions (by ability group), and the results were graphed to allow decision-makers to visualize the ramifications of different scenarios. For example, we graphed the results of simulations where the scholarship amounts and yields were allowed to vary for each of the targeted ability groups.

Table 2 provides a visual description of the NTR outcomes under one such scenario. In this simulation, yield rates were assumed to decline (slightly) by ability group even though the scholarship offer increased by ability group (simulated scholarship awards were set at $500, $1,000, $1,500; $1,000, $1,500,

FIGURE 2
Enrollment and Quality of the Class Changes Assuming Constant Yield Rate Changes and a $2,000 Scholarship Offer for Each Ability Group



$2,000; and $1,000, $2,000, $3,000 for the 129-139, 140-153, and 154-171 index groups, respectively). Thus we found that if yields were assumed to increase by 5 points for the 129-139 group, 4 points for the 140-153 group, and 3 points for the 154-171 group, the NTR was projected to be positive regardless of the scholarship amount.

Charting the simulation results permitted us to see the results of a myriad of combinations of yield rate and discount amount assumptions. We also modeled what would happen to NTR, enrollments, and the quality of the class if yields increased with the amount of aid offered (not displayed; see DesJardins, forthcoming, for details about the reasons for these different assumptions and other graphical displays of the simulation results).

Implications and Conclusions

Models like the one detailed here enable institutional decision-makers to see, in real time, the impacts of changes in important policy parameters. University of Iowa administrators appreciated being able to evaluate the pros and cons of a range of policy alternatives. For instance, the results displayed in Table 1 reflect just one of many scenarios that were produced. Under

TABLE 2
Differential NSA Scholarship Amounts Per Ability Index Score Group

Percentage Point Change in Admission Yields for Each AIS Group*	Differential Scholarship Offers: $500/$1,000/$1,500	Differential Scholarship Offers: $1,000/$1,500/$2,000	Differential Scholarship Offers: $1,000/$2,000/$3,000
	Net Tuition Revenue Dollars (in thousands)		
0,0,0	-350	-561	-701
2,1,0	-75	-300	-445
3,2,1	126	-112	-265
4,3,2	327	77	-86
5,4,3,	527	266	94
6,5,4	728	454	274
7,6,5	928	643	454
8,7,6	1,129	831	634
9,8,7	1,330	1,020	814
10,9,8	1,530	1,209	993

* *Note: 2, 1, 0 (etc.) refers to projected admissions yield rate changes of 2 points for the 129-139 ability group; 1 point for the 140-153 ability group; and 0 points for the 154-171 ability group.*

Thus, when the projected admissions yields change by 2,1,0 and the differential NSA scholarships are offered at $500 (for the 129-139 ability group); $1,000 (for the 140-153 ability group); and $1,500 (for the 153-171 ability group), the net tuition revenue dollars are -$75,000. When the differential scholarships are offered at $1,000/$1,500/$2,000, the net tuition revenue dollars are -$300,000. Differential scholarships offered at $1,000/ $2,000/$3,000 yield a net tuition revenue of -$445,000, etc.

this scenario, yields were assumed to increase by 6, 7, and 8 points for each ability group, respectively. The scholarships were assumed to start at $1,000 for the 129-139 AIS group and increase to $2,000 for the highest ability group. Decision-makers at the University of Iowa could observe that under this scenario NTR would increase by about $687,227, the AIS index would increase by 2.8 points, and enrollments of non-resident high-ability students would increase by about 160 students. The application of this simulation model helped university administrators to decide to implement the $1,000/$1,500/$2,000 proposal for the fall 2000 class (for more on the interaction with campus policy makers, see DesJardins, forthcoming).

This paper demonstrates how knowledge about student price sensitivity and a relatively simple simulation model can inform an important institutional policy decision. The model proved to be a valuable tool in informing decision-makers about a wide-range of policy alternatives. Our ability to vary important policy parameters allowed us to estimate simultaneously the number of new matriculants, the average change in the quality of the class, and the likely net tuition revenue effects.