Final Report – Scholarship Reform Update

Rob Godby

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Introduction:

This report summarizes the work performed, analysis and findings to update the existing Scholarship Reform model used by the University of Wyoming Financial Aid and Admissions Offices and other entities within UW. The original model was for the most part retained as previous results indicate it has performed reasonably since developed. Maintaining the same general model specification and research methodology with changes made only as necessary to accommodate new data and other relevant institutional details allows direct comparison of outcomes in the new model to previously found results. Some changes were made to accommodate new data now being collected by the University of Wyoming on student characteristics. The goal of this update was to (1) utilize new data available since 2005 to recalibrate the enrollment model used by Financial Aid and Admissions personnel previously developed for this purpose, (2) to update the forecast tool used to predict student enrollment decisions based on the effects of scholarship and other financial aid support, including student characteristics with respect to merit, need and diversity, and (3) create separate tools to analyze and create tools to predict the impact on students' decisions of current student support designs (specifically the Peak, Pride, Promise and Hathaway award criteria). The update utilizes financial aid, enrollment and student characteristics data from Fall admissions only of the academic years 2006-07, 2007-08 and 2008-09.

The report is organized as follows: first the general characteristics of the data used are presented. Afterward the general econometric model used to predict the enrollment decisions is described. A non-technical review of results then follows describing and including any caveats or limitations suggested in the use of the model based on data limitations and data requirements. Final conclusions regarding the use of the model are then presented. A technical appendix follows the conclusions as does a general summary of the data regarding the merit characteristics among applicants over time.

Model Summary:

Following the model work done previously for this project, the model was estimated using historical data from student applicants offered admission in each academic year of the study based on admissions and financial-aid characteristics. Specifically an enrollment probability was estimated based on four general characteristics as stated in the functional form below:

*Pr(*enrollment*)* = *f(*academic characteristics, student financial support and financial need, student-specific characteristics, enrollment year*).*

The following data was identified that would proxy the four postulated general determinants of a student's enrollment decision to be used in the statistical model estimating this relationship.

Academic Characteristics	**Student Financial Support and Financial Need**	**Student-Specific Characteristics**	**Enrollment Year**
• ACT Composite Score • High School GPA • College GPA (if applicable) • Class rank • If student wrote both ACT and SAT • College-prep classes (non-transfer students only)	• Financial need computed in FAFSA application (if applicable) • Whether student is listed by parents as a dependent • Total loans offered • Total grant funding offered • Total scholarship support offered	• Sex • Race: o White o Black o Hispanic o American Indian o Asian o Bi-racial o Other • State of Residence • Transfer or freshman applicant • College of intended major • UW preference among schools applied to • Whether student visited UW • Legacy student (alumni parents)	• Year of enrollment application: 2006-07, 2007-08 or 2008-09.

Statistical Model Used

The model used in this analysis is a "binary choice model," or a model designed to predict how a person will choose between two options based on known characteristics of the individual and the

choice being considered. In this case, the binary choice being considered is whether an admitted student will choose to enroll or not enroll at UW based on their individual characteristics, financial aid from outside sources, and financial aid offered by the University. The specific model used here is commonly referred to as a "Probit model," or probabilistic distribution model that allows consideration of a binary choice variable, in this case the modeling of the decision to enroll or not. The coefficient estimates from the Probit model, when run through appropriate calculations, describe how the probability to enroll is affected by changes in the characteristics of the person making the decision and/or changes in characteristics of the decision being considered. These estimates are referred to as the "marginal effects" on probability of enrollment, and describe how a one-unit change in an explanatory variable or characteristic relevant to the decision being made will affect the probability of a positive decision to enroll. These marginal effects are then used to define a decision model that can be used for predicting enrollments based on past enrollment data.

Variables used to predict Enrollment Decision

The estimated model included data from all admitted freshman or transfer students in the academic years 2006-07, 2007-08 and 2008-09. The model used hypothesizes that the probability of a student enrolling at UW is a function of several variables, summarized in Table 1. Variables may enter the function linearly or non-linearly. To test whether a non-linear relationship is present for some variables both the values and squared values of these variables are used. For example, a student's scholastic ability, as measured by their previous GPA or and ACT or SAT standardized test score may have a non-linear relationship with the decision to enroll. Students with lower ability may be less likely to enroll than those with higher ability. The effect may be captured by using the variable value. As ability continues to increase, however, a student may be less likely to enroll at UW in favour of some more prestigious institutions and therefore the relationship between ability and enrollment may resemble an inverted-U. Alternatively as student ability increases, the probability of UW enrollment may increase at an increasing rate as would be the case with an exponential function. To capture either possible effect, the squared term is added. If this effect actually holds across students in the data, the estimated coefficients for GPA and/or ACT/SAT scores would be positive, while the sign of the squared term would be negative if the probability were declining as ability rose,

and the coefficients of both the linear and squared terms would be positive if the probability were increasing exponentially.

All dollar values in the analysis were scaled by dividing by $1000 thus direct interpretations from the model are the marginal effects for a $1000 change in monetary value of the variable in question.[1] Scholarships were separated between single year awards and renewable scholarships and entered as the single year total award for each type. Total grant awards from all sources, as well as total loans awarded or available to the student were also included as separate explanatory variables.

Variables were tested for statistical significance – that is the likelihood that they do actually impact the decision to enroll is statistically significant using standard criteria (whether the estimated model coefficient is statistically different from zero). Standard levels of significance criteria often differ among disciplines but the most frequently used levels are that the 99%, 95%, or 90% confidence intervals of the estimated coefficient values in the model do not include zero. For convenience, instead of reporting whether the statistical significance threshold preferred is attained, a probability value or "*p-value*" is computed of the variable being equal to zero. If the preferred significance is 5% (implying the 95% confidence interval of the estimated coefficient does not include zero) and an estimated coefficient attained this level of significance, the reported p-value would be less than or equal to 0.05. To allow easy identification of significant coefficients, those with p-values achieving at least 5% significance are indicated in bold-type.

Since state of residency is a characteristic of special interest to UW's Admissions and Financial Aid Office as they set scholarship and admissions policies, the analysis also included the applicant's state of residency as an explanatory variable to determine whether students coming from particular states change the likelihood of enrollment. If this is the case, there may be reason to use targeted admissions policies to exploit this behavior. Historically, applicants from

[1] Due to statistical and interpretive considerations, the scales of the explanatory variables used in the analysis were scaled to comparable magnitudes. Dollar values in the tens of thousands were sometimes present in this analysis, while other variables such as ACT scores were less than 30 on average. In such cases where one variable is three orders of magnitude larger than another, the estimated marginal effects will also be of different orders of magnitude, making the interpretation of estimated results less clear unless the described scaling is carried out. Additionally, the statistical routine required to compute the estimates may break down if the orders of magnitude among the explanatory variables are significantly different.

the bordering states of Colorado, Idaho, Montana, Nebraska, South Dakota, and Utah have been well-represented at UW and admission efforts have typically targeted students from these neighboring states. Given this, and given a potential use of the results may be to determine how residency and previous admissions efforts have impacted the likelihood of enrollment of students from these states on average, the impact of residency in these neighboring states was also estimated in the analysis. To accomplish this, a binary variable or "dummy" variable was used to indicate whether a student was from any of these particular states.[2] If such a variable proves significant in an analysis care must be taken to ensure appropriate interpretation of the estimated effect. Residency may affect a student's preference for a university due to proximity and interest, or a residency variable may capture state-specific effects that make a student more likely to enroll at UW, due for example, to higher tuitions in that state.[3]

To capture effects or influences that may be commonly experienced by all students in a given year (for example the influence of a national recession), dummy variables for each of the three academic years (AYs) were also included in the model. This also allows for a direct test to determine if enrollment patterns were significantly different in any of the three years considered. The AY dummy variables additionally capture all of the effects of changes at UW and competing schools across the years in the sample. As shown below, some of the dummy variables across states and AYs are highly significant and indirectly capture many of the reasons why a student might choose to enroll at UW versus their home state institutions without actually identifying these reasons. State and year specific dummy variables capture the changes occurring over time within states relevant to the UW enrollment decision without explicitly identifying these considerations. The use of a combination of state-specific and year-specific variables avoids issues of improperly defining the relevant variables, improperly specifying the model by adding

[2] A "dummy" variable is simply an indicator variable coded as a "1" or "0" by individual student observation to indicate residency (value = 1) within a particular state for that student.

[3] An alternative to using dummy variables is the use of direct measures of the relevant variables in other states that may influence the decision to come to UW, such as tuition levels at comparable universities, cost of living, etc. To estimate the specific effects of such influences would require the inclusion of measures of each of these potential effects in the estimated model. Given the lack of data for some of these potential variables and also the possibility of omitting other important variables, the dummy-variable approach was used. This avoids the omitted variable problem as it effectively captures the cumulative effect of all state-specific residency influences. The drawback is that the specific effects of separate influences cannot be estimated (such as the effect of tuition levels alone in other states).

additional considerations not relevant, or inadvertently omitting those considerations important to the decision; all issues of which could prove problematic to the estimation otherwise.

Occasionally student characteristic data was missing with respect to particular student, due for example if they did not fill out an application for financial aid. In such circumstances special procedures were used to account for this problem.

Table 1 – Variables used to predict enrollment

Academic Measures

Variable	***Description***
Test score	ACT Composite Score or SAT Total Score converted to ACT equivalent
High School GPA	4.0 scale
Cumulative College GPA (if applicable)	4.0 scale
College Preparation	Dummy variable - for incoming Freshman, a College GPA indicates college prep work
Percentile rank in class	computed as (class size- class rank + 1)/class size $0 \leq$ Percentile Rank ≤ 1
Took both ACT and SAT	Dummy variable – yes or no

Student Characteristics

Variable	***Description***
Ethnicity	Dummy variables for the following: Black, Hispanic, American Indian, Asian, Bi-Racial, or Other (values of zero in all categories indicates Caucasian)
Dependent	Dummy variable – yes or no
Gender	Dummy variable – male or female
Residency	Separate dummy variables for residents of Wyoming, Colorado, Idaho, Montana, Nebraska, South Dakota, or Utah
Visit to UW	Dummy variable – yes or no
Alumni's child	Dummy variable – yes or no
Applicant type	Dummy variables for Transfer students (0 indicates a Freshman)
Major declared	Dummy variables - defined by college (Agriculture, A&S, Business, Education, Engineering, Health Sciences, Undeclared)

Student Financial Need and Support Characteristics

Variable	***Description***
Financial Need (if applicable)	Derived From Free Application for Federal Student Aid estimate (FAFSA) – measured in dollars
UW Preference	Dummy variable for UW being first or second choice: Derived from choice information stated on ACT and Financial aid documents
Loan Support Total	Annual loan dollars offered
Grant Support Total	Annual grant dollars offered
One-Year Scholarship Support Total	Dollars offered for one-year scholarships
Four-Year Scholarship Support Total	Total dollars offered in a single year for four-year renewable scholarships.

Enrollment Year

Variable	*Description*
Application year	Dummy variable for academic years 2006-07, 2007-08, 2008-09

Samples and Stratifications Used

The model was run using enrollment data from applicants in academic years 2006-07, 2007-08, 2008-09 using the explanatory variables summarized in Table 1 to predict average student probability of enrollment.[4] Additionally, three sub-samples of the data were used to estimate student enrollment probabilities within the Hathaway award classifications, which have been used to award student aid over the sample period to both Wyoming and non-Wyoming resident students. Specific samples and sub-samples for which the prediction model was estimated separately included:

- All applicants to U.W., AY 2006 through AY 2008 (13,400 applicants)
- "Honors" Applicants – freshman and transfer applicants with GPA and test score in line with the Hathaway Honors Scholarship (GPA's greater than or equal to 3.50 on the 4.0 scale, ACT's of 25 or higher) (2,859 applicants)
- "Performance" Applicants – freshman and transfer applicants with GPA and test score in line with the Hathaway Performance Scholarship (GPA's greater than or equal to 3.00 but less than 3.50 on the 4.0 scale, ACT's of 21 or higher) (2,039 applicants)
- "Opportunity" Applicants – freshman and transfer applicants with GPA and test score in line with the Hathaway Opportunity Scholarship (GPA's greater than or equal to 2.50 but less than 3.00 on the 4.0 scale, ACT's of 19 or higher) (1,302 applicants)

[4] In the original model estimation work performed in 2005, four years of data were available and an additional sub-sample was used to estimate a model over the first three years of the sample to use in predicting outcomes in the fourth year of the sample. Such "out-of-sample" testing of the model is very useful in determining possible biases; however, this was not possible in the current sample due to a lack of data. While the first two years of data could have been used to estimate a model to predict outcomes in the third year, the Hathaway Scholarship program was implemented in the first year of the sample. The first year of that program appeared to have a one-time impact on enrollment probabilities and applications to UW that appears to have changed over subsequent years. The presence of such an effect would have biased any predictions based only on the first two years of data and therefore the exercise of "out-of-sample" prediction was not performed using this dataset. Such an exercise may be useful after an additional year of data becomes available.

Before the model results are reported, a summary of the data for the full data set are reported in Table 2 where the mean outcome of each explanatory variable is included along minimum and maximum values.

Table 2 - All Data summary Statistics (13400 observations)

Academic Measures

Variable	Mean	Min	Max
Enrollment (1= yes)	52.5%	0	1
ACT Composite score (if applicable)	23.43	10	36
College GPA (if applicable)	3.33	0.3	4
High School GPA (if applicable)	3.41	1.41	4
Class rank (100%=1 if applicable)	70.4%	1%	100%
Took ACT and SAT	12.0%	0	1
College prep classes (freshman only)	15.4%	0	1

Student Characteristics

Variable	Mean	Min	Max
Caucasian	81.9%	0	1
Asian	2.0%	0	1
Black	1.1%	0	1
Hispanic	3.6%	0	1
American Indian	1.1%	0	1
Bi racial	1.1%	0	1
Unknown race	7.3%	0	1
Other	9.2%	0	1
Female	53.8%	0	1
Transfer	29.7%	0	1
Freshman	70.3%	0	1
Alumni child	13.9%	0	1
Visited UW	22.7%	0	1
WY resident	50.3%	0	1
CO resident	21.5%	0	1
NE resident	4.3%	0	1
MT resident	1.5%	0	1
ID resident	0.5%	0	1
SD resident	2.2%	0	1
UT resident	0.6%	0	1
US resident	98.7%	0	1
Agriculture	6.2%	0	1
Arts & Science	28.3%	0	1
College of Business	11.0%	0	1
Education	8.4%	0	1
Engineering	14.5%	0	1
Health Science	16.1%	0	1
Undeclared	15.4%	0	1
UW 1st choice	40.6%	0	1
UW 2nd choice	10.9%	0	1
UW 3rd choice	4.7%	0	1

Student Financial Need and Support Characteristics

Variable	Mean	Min	Max
1 year scholarship dollars	$216.72	0	$16,500.00
1 year scholarship dollars	$2,486.47	0	$14,592.00
Total loans	$1,990.00	0	$21,659.00
Total grants	$334.09	0	$9,643.00
Financial need	$4,134.92	0	$36,545.00
Listed as a dependent	53.1%	0	1

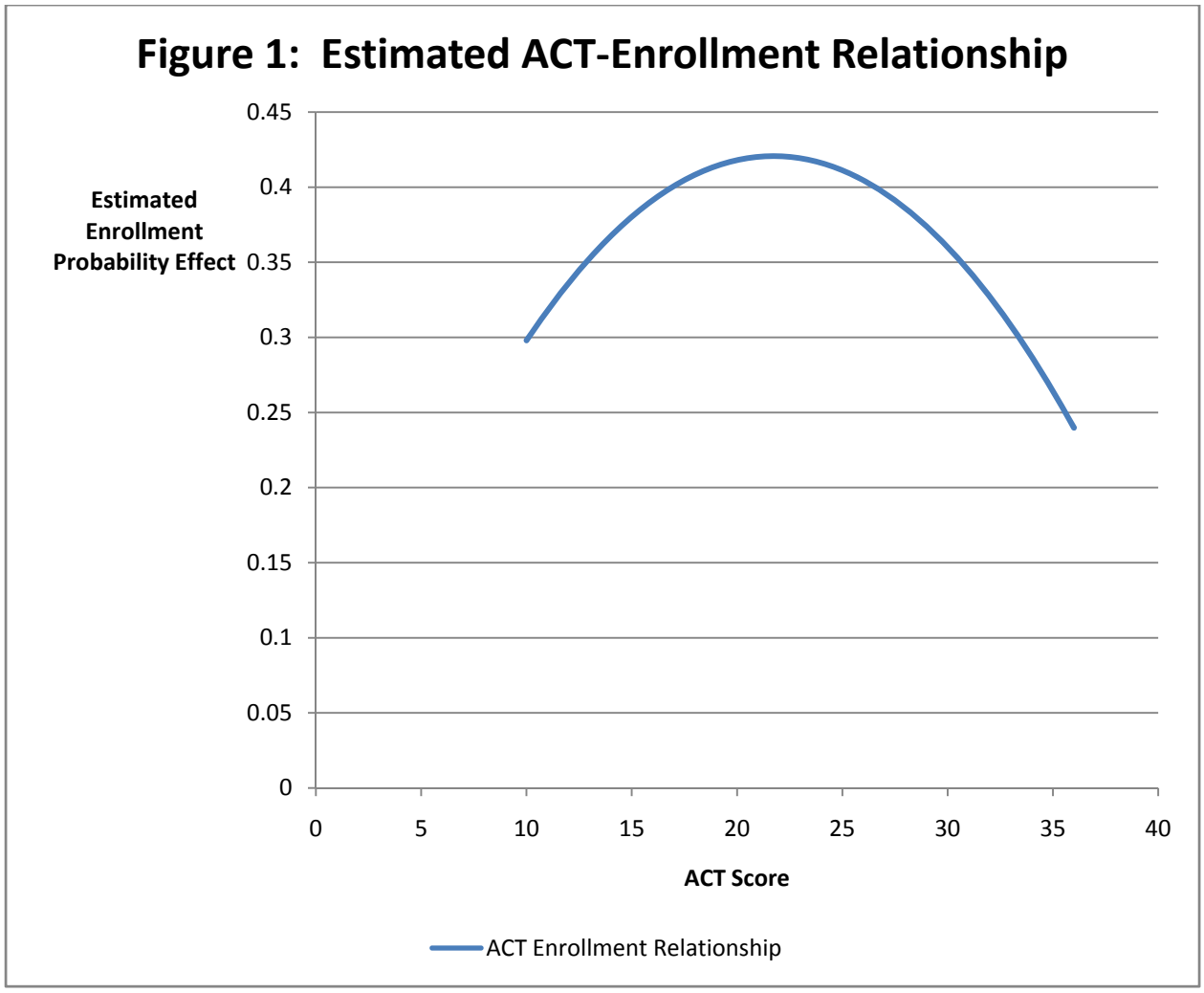
Enrollment Year

Variable	Mean	Min	Max
AY 2006-07	32.8%	0	1
AY 2007-08	32.4%	0	1
AY 2008-09	34.9%	0	1

Summary of Full Sample Model Results

Table 3 below summarizes the results for the full model estimated using all data from all applicants in all years. As noted previously, bolded variables indicate those found to be significant at the 5% level and p-values are listed for all variables. The table reports "marginal effects" or the effect on the probability of enrollment expressed as a percentage for a one unit increase in the variable considered. Negative values indicate the probability is inversely related to the variable. Marginal effects for all variables denominated in dollars are for an increase of $1000.

Estimates based on the three Fall admission samples from years AY2006-2008, ACT scores were the only statistically significant variable with respect to impact on enrollment probability. A one-point increase in ACT score increased the probability of enrollment by 3.8% at the mean; however, the negative sign with respect to this variable squared indicates that as ACT scores increased the positive impact on enrollment was diminishing. More capable students are therefore less likely to come to Wyoming than less capable students as measured by the ACT score. Specifically, the estimated probability of enrollment- ACT relationship is parabolic, increasing as ACT scores rise and the effect is maximized at an ACT score of 22. At scores above 22, enrollment probabilities begin to fall relative to those students with an ACT of 22. This effect is shown in Figure 1.



Class rank also showed a similar characteristic, reinforcing the finding that students with higher ability and therefore class ranks were less likely to come to the University of Wyoming. The average class rank of UW applicants was in the 70th percentile (of those reporting a class rank) and at the mean a 1% increase in class rank reduced the probability of enrollment at UW by 1%.

Table 3 - All Data Model Estimates (13400 observations)

Variable	Marginal Effect	P-value	Mean Value
ACT Comp Score	**0.038702**	**0.003**	**23.4268**
ACT Comp Score^2	**-0.00089**	**0.001**	**548.815**
College GPA	-0.05085	0.582	3.332
College GPA^2	0.012688	0.399	11.102

High School GPA	-0.03306	0.838	3.414
High School GPA^2	0.002631	0.916	11.655
Class Rank	**-0.10292**	**0.025**	**0.704689**
Total Loans	-0.00112	0.657	1.99
Total Grants	0.006102	0.256	0.334086
1 Yr. Scholarships	**0.043668**	**0.000**	**0.216717**
4 Yr. Scholarships	**0.010966**	**0.000**	**2.48647**
Financial Need	0.001125	0.263	4.13492
took both ACT and SAT	-0.00179	0.911	0.119851
College Prep courses	0.135351	0.063	0.154179
Visited UW	**0.149764**	**0.000**	**0.227463**
Black	-0.01961	0.678	0.011194
Hispanic	-0.05193	0.051	0.035746
American Indian	-0.05664	0.224	0.011418
Asian	-0.00873	0.806	0.019851
Bi-Racial	0.078717	0.085	0.010821
Other	**0.1096**	**0.000**	**0.09209**
Female	**-0.04467**	**0.000**	**0.538209**
Alumni child	**0.095743**	**0.000**	**0.139478**
Transfer	**0.147039**	**0.044**	**0.296567**
Dependent Child	0.03135	0.152	0.531194
UW First Choice	**0.512177**	**0.000**	**0.406194**
UW Second Choice	**0.131392**	**0.000**	**0.108806**
Agriculture College	0.017559	0.452	0.062164
College of Business	-0.00987	0.611	0.11
Engineering	0.027442	0.142	0.145373
Health Science	-0.00762	0.671	0.161119
Arts and Science	-0.00073	0.963	0.283358
Education	0.005057	0.812	0.083731
Wyoming Resident	**0.220971**	**0.000**	**0.502537**
Colorado Resident	0.015284	0.344	0.215448
Idaho Resident	0.043039	0.533	0.004925
Montana Resident	0.016208	0.693	0.014627
Nebraska Resident	-0.01457	0.590	0.04291
South Dakota resident	**0.080511**	**0.016**	**0.02209**
Utah Resident	-0.12952	0.053	0.005821
AY 2007-2008	**0.037259**	**0.002**	**0.323582**
AY 2008-2009	0.019451	0.111	0.348507

Financial Aid and support results indicate that awarding applicants either a 1-year or 4-year scholarship increases the probability of enrollment. The mean 1-year award in the dataset was $216.72, and the mean 4-year annual award was $2486.47. An increase of $1000 in 1-year scholarship support increased enrollment probability by 4.3%, while a $1000 increase in 4-year support increased enrollment probability by 1.1%. This is somewhat surprising as a $1000 increase in a 4-year scholarship is equivalent to an additional $4000 in support over four years. The original model estimated in 2005 found that 4-year scholarships are more effective in

increasing enrollment probabilities as would normally be expected. Since that model was estimated though new admissions and scholarship policies, including the Hathaway scholarship have been introduced. These policies have had the effect of letting students know what their anticipated 4-year scholarship support would be if they achieved certain ACT and GPA targets. No such policies were implemented regarding 1-year scholarships, thus the estimated coefficients may be describing the effects of anticipated scholarship support (4-year scholarships such as the Honors, Performance and Opportunity Scholarships and Hathaway levels defined by university and State policy), versus unanticipated support. Students applying to UW during the period of this study were made aware of scholarship support they could anticipate if they had specific GPA and ACT scores. Applications were likely then made to UW on the basis of these assumptions. Any additional awards made to the students in the form of 1-year scholarships would not have been anticipated thus the effect noted in this study may indicate that unanticipated scholarship support is more effective at increasing enrollment probability than specific scholarship promises like those used in admissions and University marketing currently.

With respect to student characteristics and preferences, the fact a student visits UW increases the probability they will enroll by almost 11% over one that does not, while students indicating that UW is their first choice have a 51% increase in enrollment probability over a student that does not state UW is their first or second choice. Students who indicate that UW is their second choice are 13% more likely to enroll than those who do not indicate UW is their first or second choice. These two variables indicate that visits and stated preferences for UW should be taken as signs on the student's part of strong interest in coming to UW. Similarly, family ties to the university also appear to be an influential determinant in a student's decision to enroll at UW. Children of alumni were 10% more likely to enroll than non-alumni children. Students transferring from other institutions were also 13.7% more likely to enroll than freshman applicants coming from high-school or without other post-secondary experience. This effect is likely is driven by the fact that many students going to community colleges in the State of Wyoming do intend to pursue later studies at UW, while others come to UW after having gone elsewhere due to advantages at UW which may include cost or location closer to home, etc.

Some sex, race and residency effects were also observed in the years studied. Specifically, females were 4.5% less likely to enroll than males. Those in the racial group "other" were 10% more likely to enroll than white students and this was the only statistically significant racial effect. Residency also had a significant effect on enrollment choice with Wyoming resident students estimated to be 22% more likely to enroll than students not coming from Wyoming or the states bordering Wyoming, while South Dakotans were 8% more likely to enroll than residents of states not bordering Wyoming.

Finally, academic year 2007-2008 applicants were 3.7% more likely to enroll than in AY 2006-2007. We do not attempt to explain this observation as it may have been driven by economic conditions in that year relative to others, relative cost advantages in that year between UW and other schools, the preferences of the admitted students in that year, or other state policies or unobserved effects unanticipated in the study. Remaining variables that were individually insignificant were found to be significant as a group, indicating the total effect of the other variables included in the model was significant implying that in combination, the addition of these additional variables increases the predictive power of the model over one that includes only those variables found to be significant and described above (ACT, scholarship support, preference and alumni information, past post-secondary experience and race, sex and residency variables). It should be noted that the college the stated major of the applicants resided in appeared to have no impact on the probability of enrollment relative to students who apply as an undeclared student.

Stratified Model Results

Stratifications of the data along the Hathaway criteria show similar patterns, however within the stratifications ACT scores are no longer relevant. This could be expected as since Hathaway stratifications are defined by GPA and ACT levels and the enrollment probability being computed is the enrollment *conditional* on the fact that the students considered meet the Hathaway criteria defined by the relevant stratification. This effect holds true for all of the merit based variables in the stratifications thus it is other variables that then determine within this

group the likelihood of enrollment.[5] This effect holds true for both transferring students as well as freshman coming from high school thus results are not stratified across those two samples. In all three Hathaway-criteria stratifications, scholarship aid increases probability of enrollment (at least at the 10% level of significance) and the estimated 1-year scholarship effect was always stronger than the 4-year effect, lending credence to the hypothesis that this variable captures the effect of unanticipated scholarship funding relative to the effect of anticipated scholarships. Again, the applicant indicating UW was their first choice, whether they visited UW and if they were a Wyoming resident also influenced the enrollment decision positively. All other variables either were insignificant in the estimate results or there was no systematic pattern across stratifications with respect to enrollment prediction.

Table 4 – High GPA Hathaway Criteria GPA Model Estimates (2859 observations)

Variable	Marginal Effect	P-value	Mean Value
ACT Comp Score	0.1591702	0.135	27.6922
ACT Comp Score^2	-0.0028964	0.119	772.134
College GPA	-0.424213	0.321	1.39864
College GPA^2	0.0649499	0.318	5.26981
High School GPA	1.024989	0.804	3.83593
High School GPA^2	-0.1731061	0.752	14.7387
Class Rank	-0.0036075	0.984	0.717311
Total Loans	-0.0001917	0.982	2.09354
Total Grants	0.0175702	0.238	0.225377
1 Yr. Scholarships	**0.0366613**	**0.001**	**0.53841**
4 Yr. Scholarships	0.0079473	0.099	4.95421
Financial Need	-0.003826	0.130	3.6991
took both ACT and SAT	-0.0327588	0.252	0.209864
College Prep courses	-0.0658548	0.843	0.318643
Visited UW	**0.1131654**	**0.000**	**0.302553**
Black	0.0360726	0.875	0.002798
Hispanic	-0.021471	0.796	0.019237
American Indian	-0.0988769	0.624	0.002798
Asian	-0.0939085	0.229	0.023085
Bi-Racial	0.0072016	0.947	0.010493

[5] The exception to this statement regarding merit based variables is the class rank in the low GPA stratification, where rank is highly significant but has a negative effect on enrollment. Interpreted differently, a student with a lower class rank is more likely to enroll at UW than a student with a higher class rank in this stratification, possibly because they have fewer alternatives to consider if they wish to go to a four-year univeristy.

Other	0.0546656	0.199	0.069255
Female	-0.0102074	0.680	0.555089
Alumni child	**0.0916982**	**0.002**	**0.202518**
Transfer	-0.0532875	0.872	0.058762
Dependent Child	0.0697813	0.780	0.688702
UW First Choice	**0.5519328**	**0.000**	**0.41483**
UW Second Choice	0.0701849	0.084	0.119972
Agriculture College	0.0323532	0.529	0.06156
College of Business	0.0137957	0.787	0.064008
Engineering	0.0137637	0.702	0.235747
Health Science	-0.0237721	0.570	0.128716
Arts and Science	-0.0013808	0.968	0.272123
Education	0.0758087	0.145	0.058412
Wyoming Resident	**0.2265779**	**0.000**	**0.540399**
Colorado Resident	0.0311988	0.418	0.201119
Idaho Resident	0.1776859	0.171	0.004547
Montana Resident	0.0478547	0.599	0.014341
Nebraska Resident	-0.0197402	0.733	0.054914
South Dakota resident	**0.1459391**	**0.016**	**0.028681**
Utah Resident	-0.0459947	0.770	0.005946
AY 2007-2008	**0.0954748**	**0.001**	**0.334033**
AY 2008-2009	**0.0832806**	**0.006**	**0.366562**

Table 5 – Medium GPA Hathaway Criteria GPA Model Estimates (2039 observations)

Variable	Marginal Effect	P-value	Mean Value
ACT Comp Score	-0.0405252	0.628	24.1229
ACT Comp Score^2	0.0007046	0.671	588.251
College GPA	-0.1754874	0.524	0.676709
College GPA^2	0.0422358	0.379	2.19159
High School GPA	3.373995	0.444	3.26129
High School GPA^2	-0.5155333	0.447	10.6572
Class Rank	-0.1755428	0.196	0.487397
Total Loans	0.0103603	0.279	1.83191
Total Grants	0.0209083	0.197	0.264051
1 Yr. Scholarships	**0.0642042**	**0.017**	**0.146556**
4 Yr. Scholarships	**-0.0182413**	**0.034**	**3.35473**
Financial Need	-0.001169	0.671	3.74962
took both ACT and SAT	**-0.0751025**	**0.037**	**0.165768**
College Prep courses	-0.3206274	0.195	0.153507
Visited UW	**0.1839528**	**0.000**	**0.300147**
Black	-0.1768105	0.160	0.01128

Hispanic	**-0.1749211**	**0.016**	**0.032859**
American Indian	**-0.3464549**	**0.000**	**0.007847**
Asian	-0.1031658	0.284	0.018637
Bi-Racial	0.1159283	0.299	0.012261
Other	0.0407529	0.412	0.069642
Female	-0.0001389	0.996	0.446788
Alumni child	0.0521623	0.176	0.143207
Transfer	**-0.3855835**	**0.039**	**0.06719**
Dependent Child	-0.1530019	0.287	0.622364
UW First Choice	**0.5673582**	**0.000**	**0.406081**
UW Second Choice	**0.2087765**	**0.000**	**0.117705**
Agriculture College	-0.001453	0.981	0.054438
College of Business	0.0542746	0.262	0.105934
Engineering	0.069137	0.122	0.175086
Health Science	0.0776315	0.095	0.12359
Arts and Science	0.0520598	0.177	0.284453
Education	0.0221064	0.698	0.06768
Wyoming Resident	**0.2281394**	**0.000**	**0.40412**
Colorado Resident	0.0699587	0.078	0.293771
Idaho Resident	-0.0654975	0.830	0.002452
Montana Resident	-0.0013937	0.990	0.014713
Nebraska Resident	0.0724785	0.303	0.042178
South Dakota resident	**0.1584352**	**0.030**	**0.028445**
Utah Resident	-0.1360108	0.614	0.002452
AY 2007-2008	0.0602292	0.063	0.335459
AY 2008-2009	-0.0028699	0.930	0.35998

Table 6 – Low GPA Hathaway Criteria GPA Model Estimates (1302 observations)

Variable	Marginal Effect	P-value	Mean Value
ACT Comp Score	-0.0379029	0.593	22.4312
ACT Comp Score^2	0.0005412	0.716	511.204
College GPA	0.2144848	0.460	0.405504
College GPA^2	-0.0380271	0.489	1.20162
High School GPA	7.267115	0.145	2.77734
High School GPA^2	-1.323835	0.144	7.73308
Class Rank	**-0.3346265**	**0.033**	**0.306311**
Total Loans	0.0066096	0.516	1.587
Total Grants	-0.0087705	0.683	0.22125
1 Yr. Scholarships	0.0970767	0.086	0.056843
4 Yr. Scholarships	**0.0628785**	**0.000**	**0.760493**
Financial Need	**0.0078549**	**0.019**	**3.64785**

took both ACT and SAT	0.0840113	0.070	0.16129
College Prep courses	-0.1045593	0.676	0.079109
Visited UW	**0.174517**	**0.000**	**0.27957**
Black	-0.1766321	0.096	0.019201
Hispanic	-0.0217954	0.787	0.041475
American Indian	**-0.2982576**	**0.002**	**0.010753**
Asian	0.0272419	0.812	0.019969
Bi-Racial	0.1488948	0.258	0.014593
Other	-0.0531833	0.360	0.077573
Female	-0.0085435	0.815	0.360215
Alumni child	**0.2773294**	**0.000**	**0.093702**
Transfer	0.0827606	0.756	0.071429
Dependent Child	-0.0514674	0.728	0.529954
UW First Choice	**0.5162692**	**0.000**	**0.351767**
UW Second Choice	0.084279	0.284	0.095238
Agriculture College	-0.0427186	0.582	0.054531
College of Business	-0.0472878	0.409	0.139017
Engineering	0.0959486	0.111	0.139785
Health Science	0.048896	0.453	0.099078
Arts and Science	-0.019787	0.679	0.315668
Education	0.0743321	0.314	0.06682
Wyoming Resident	**0.2496338**	**0.000**	**0.313364**
Colorado Resident	0.0030693	0.948	0.378648
Idaho Resident	0.2433827	0.325	0.003072
Montana Resident	**-0.2722019**	**0.009**	**0.012289**
Nebraska Resident	-0.0762933	0.412	0.034562
South Dakota resident	-0.009339	0.927	0.02765
AY 2007-2008	0.0483511	0.244	0.340246
AY 2008-2009	0.0330543	0.431	0.356375

Spreadsheet Utility

The spreadsheet utility to estimate enrollment probabilities by admissions staff and developed after the first estimates were made in 2005 has been updated for the current models. Additionally, the original spreadsheet utility included three additional calculators created using subsets of the total applicant pool that corresponded to the then anticipated Hathaway categories that were yet to be implemented. These calculators allowed the University to assess the estimated enrollment probabilities of the proposed Hathaway program given data available at the time. These original calculators included models developed using Wyoming residents only.

Since 2005, in addition to Hathaway funding for Wyoming residents, UW instituted a scholarship program that created standardized scholarship tiers identical to the Hathaway criteria for all non-Wyoming residents who applied to UW for admission. The new spreadsheet utility models for these Hathaway tiers now develop enrollment probabilities based on the data for all applicants within these tiers instead of the models originally developed and that were based on Wyoming resident data only. The new utilities include a Wyoming resident choice (which is shown to be highly significant in the analysis above) to allow for estimation of Hathaway effects for Wyoming residents or scholarship effects on no-resident students.

Conclusions: Anticipated Issues with the Estimated Model in the Future

The model originally developed in 2005 was developed using admissions and scholarship data from the previous four years. Additionally, at the time the data was collected, scholarship policies at the University were discretionary in the sense that in general, students were unaware of the exact amounts of scholarship aid they might receive thus amount of scholarship aid any individual student might receive was unanticipated.[6] Further, it was likely that this created a particular pool of applicants to UW – specifically those who did not require or expect a certain level of support. Since 2005, however, the Hathaway Scholarship and UW Scholarship policies have defined guaranteed offers for in-state and out-of-state students defined using the Hathaway merit criteria which sets a specific funding level for certain GPA and ACT-score outcomes. Given that this information is public and actually publicized in university and state marketing efforts, students applying to UW since these policies went into effect are aware of the minimum scholarship funding they should expect. Given this policy change it is possible and in fact likely that this has affected the applicant pool. Specifically, it is possible that students now apply based on the scholarships they anticipate and then make a decision to enroll as opposed to what would have happened previously when students would apply with less certainty of potential offers, and accept an offer of admission based on the offer received. It is not difficult to imagine that after such a policy change it may be the case that more students needing student aid may apply and

[6] Specifically, students may have expected some scholarship offer to be made based on their personal, residency and merit characteristics but they generally would be uncertain as to how much they would receive.

possibly others who need more than what is available do not, where previously had they no idea what to expect they may have applied anyway.

With respect to the effect on the model, the stability of any estimated model over time depends on the underlying characteristics of the applicant pool remaining the same as when the model was estimated. For that reason it is not surprising to see that the estimated model has changed since 2005. It is difficult or impossible to determine how selection bias effects have occurred once institutional policy changes take place as we have no way of identifying those who change their decision to apply to UW after such changes occur. This is a concern that should be kept in mind when future policies regarding financial aid are developed. The use of predictive models like the one developed here to create announced scholarship policies may cause the future success of enrollment prediction to be undermined if changes to the current policies change the applicant pool. With this caveat in mind users of the model described here should be aware that the predictions are only relevant as long as there are no significant changes in the variables we cannot measure such as competing school's tuitions relative to UW's or population preferences. Additionally the model results are conditional on the current scholarship policies in effect. Should any of these conditions (tuition, preferences or policy) change in the future, the stability of the model and its predictive power cannot be guaranteed. For this reason it is strongly recommended that the use of model after such changes or after some time has passed is cautious.

Changes in the current model over those in 2005 are best described using a direct comparison. Table 7 shows the estimated marginal effects for the model variables used in the current model and the model estimated in 2005. The first obvious change is the number of variables no longer significant in the model at the 5% or better level. Specifically, High School GPA, which one might initially expect to be very important in the estimation of college enrollment probability is no longer significant in 2009 while the influence of ACT remains as significant and actually increases in its estimated effect on enrollment. This may be explained by the change in scholarship policy since the original model was estimated. Major 4-year awards are primarily determined by both ACT and High School GPA, for example the highest Hathaway criteria sets a requirement of ACT scores of at least 25, and a GPA of at least 3.5. Those in the applicant pool with ACT and high school GPA scores appear to find it more difficult to meet the ACT score, as

the average ACT score for those students with a GPA of at least 3.5 is 24.64. Further, of the students who applied to UW with a 4.0 High School GPA (808), 22% (179) did not achieve an ACT score of 25 or better.

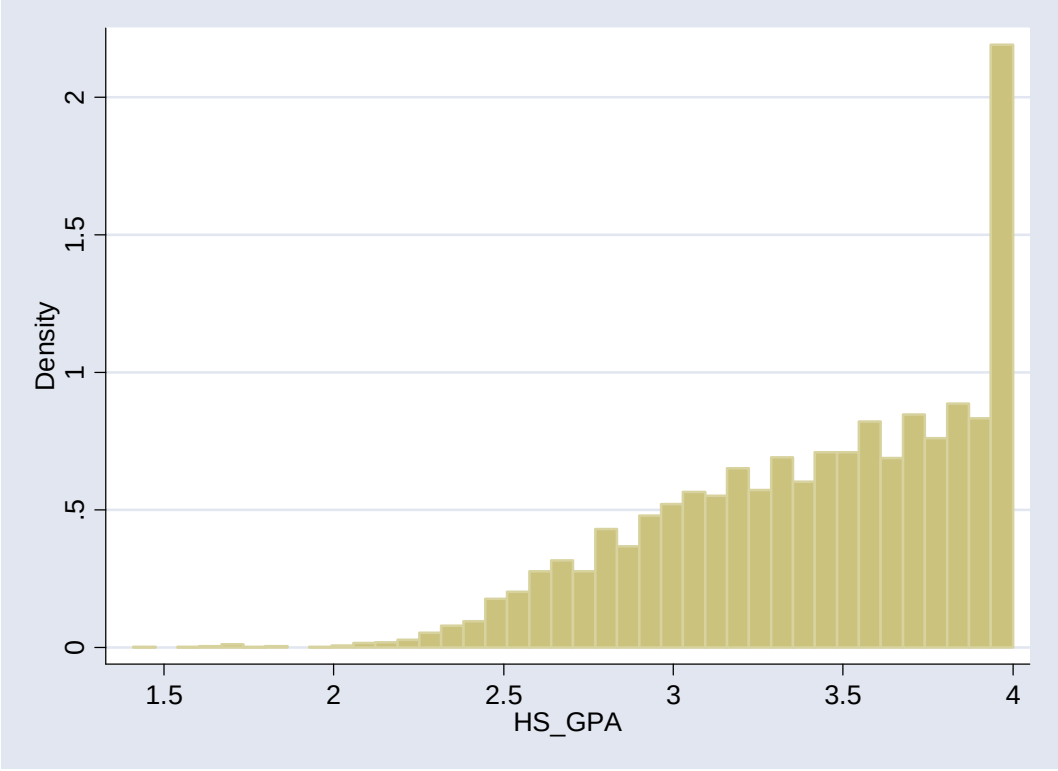
Table 7: Comparison of 2005 to 2009 Model results

Variable	Estimated Marginal Effect 2009	Estimated Marginal Effect 2005
ACT Comp Score	**0.038702**	**0.0197**
ACT Comp Score^2	**-0.00089**	**-0.0006**
College GPA	-0.05085	-0.1396
College GPA^2	0.012688	0.0207
High School GPA	-0.03306	**0.2888**
High School GPA^2	0.002631	**-0.0613**
Class Rank	**-0.10292**	**-0.1222**
Total Loans	-0.00112	**0.0127**
Total Grants	0.006102	0.00104
1 Yr. Scholarships	**0.043668**	**0.046**
4 Yr. Scholarships	**0.010966**	**0.00302**
Fee Reduction and Support	N/A	0.0627
Financial Need	0.001125	N/A
took both ACT and SAT	-0.00179	**-0.0621**
College Prep courses	0.135351	**-0.025991**
Visited UW	**0.149764**	**0.1683**
Black	-0.01961	0.036
Hispanic	-0.05193	**-0.0788**
American Indian	-0.05664	**-0.1779**
Asian	-0.00873	-0.025
Bi-Racial	0.078717	-0.076
Other	**0.1096**	0.0232
Female	**-0.04467**	**-0.0425**
Alumni child	**0.095743**	**0.0775**
Transfer	**0.147039**	**0.3428**
Dependent Child	0.03135	0.0371
UW First Choice	**0.512177**	**0.4096**
UW Second Choice	**0.131392**	**0.0975**
Agriculture College	0.017559	**-0.1043**
College of Business	-0.00987	-0.0342
Engineering	0.027442	**-0.0511**
Health Science	-0.00762	-0.0253
Arts and Science	-0.00073	-0.0181

Education	0.005057	-0.0054
Wyoming Resident	**0.220971**	**0.2357**
Colorado Resident	0.015284	**0.075**
Idaho Resident	0.043039	-0.0148
Montana Resident	0.016208	**0.0888**
Nebraska Resident	-0.01457	0.0382
South Dakota resident	**0.080511**	**0.0765**
Utah Resident	-0.12952	0.0404

*bolded values indicate statistical significance at the 5% level or better (p-values less than or equal to 0.05).

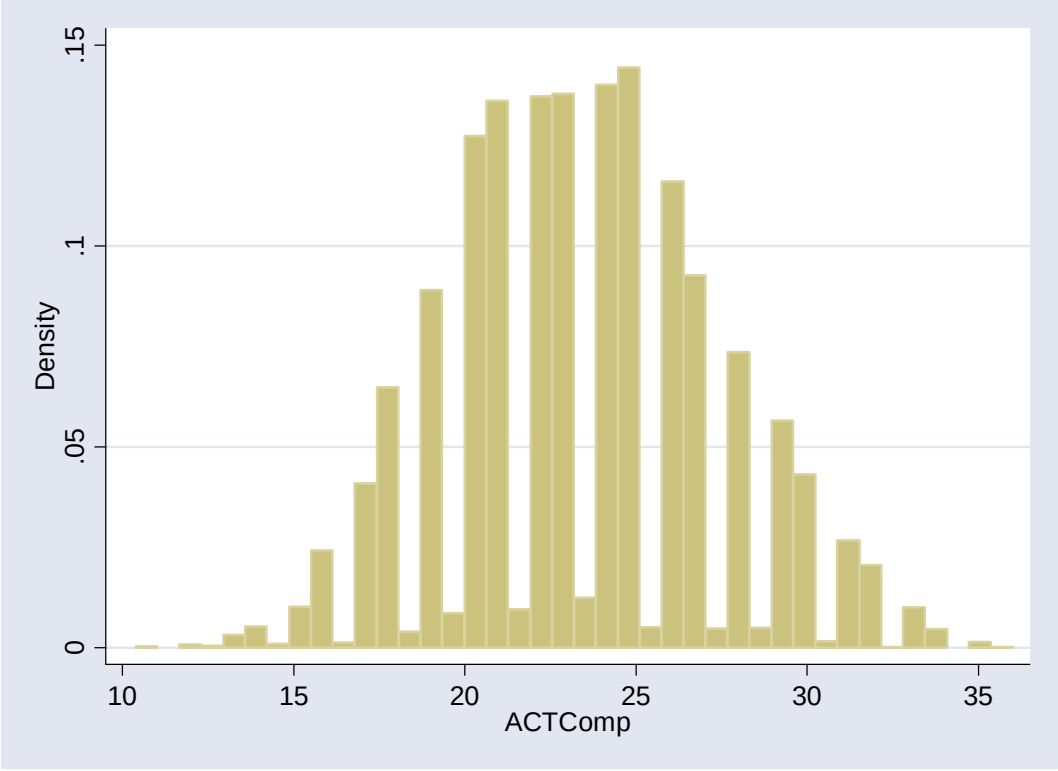
Figure 2: High School GPA histogram



Analysis of the applicant data indicates that while ACT scores appear to be normally distributed around the mean, high school GPAs are skewed toward the high end of the scale with the modal score a 4.0 GPA and median of 3.49, both values being greater than the mean observed GPA of 3.41. These characteristics are demonstrated in Figures 2 and 3.

With respect to other variables that previously were estimated to have a significant on enrollment decision, loan support is no longer significant. It may also be the case that loans are no longer significant due to the much larger scholarship funding pool available to students applying to UW since the institution of scholarship policy changes and the Hathaway Scholarship. Further, the loss of significance of college prep work and the completion of both the ACT and SAT tests could be due to a similar reason. If all that matters to gain a scholarship is ACT and high school GPA and the high school GPA is the easier of the two to achieve, ACT would be the most important variable affecting application and enrollment decision and there would be no reason to believe that taking both the SAT and ACT or doing college prep work will increase scholarship offers thus it may be the case within the UW applicant pool currently less of such effort takes place. While it cannot be proven, it appears it is possible that the incentives created by the new scholarship policies instituted since the last model was estimated have potentially changed the applicant pool and the types of scholastic efforts made by applicants to gain admission, and possibly other characteristics of the students applying.

Figure 3: ACT Score histogram



Given the analysis presented, it is recommended that the predictive model provided to the University be used carefully and should not be expected to have continuing accuracy if major policies such as scholarship or admission guidelines are changed. Model stability and accuracy will potentially deteriorate over time and should be expected to deteriorate more quickly if such policy changes are implemented. It would also appear that there may be some change in the applicant pool applying to Wyoming, possibly due to policies implemented at the University with respect to scholarships. For this reason it is strongly recommended that policy changes do not rely on the continued use of the current model but allow for some a newly estimated model once data under the new policy regime has been collected.

Appendix 1: Technical Model Description (reprinted from Aadland, Alexander and Godby, UW Scholarship Reform Report, 2005)

Econometric Model

Our econometric model can be written as

$$ENROLL_i^* = X_i'\beta + \varepsilon_i, \quad (1)$$

where X_i is a vector of explanatory variables, β is a vector of coefficients that are constant across individuals, ε_i is an error term and i = 1,…,N indexes the observations. The variance of the error terms ε_i is assumed to follow

$$\sigma_i^2 = \exp(Z_i'\gamma), \quad (2)$$

where Z_i is a vector of variables (possibly intersecting with X_i) and γ is a vector of parameters. The variable $ENROLL_i^*$ is a latent variable that indicates the likelihood of enrolling in UW. Although we do not observe $ENROLL_i^*$, we do observe the binary variable $ENROLL_i$ which takes on the value of one (if the student enrolled at UW) or zero (if the student did not enroll at UW).

The probability that student *i* enrolls at UW is given by

$$P_i = \Pr ob(Enroll_i = 1) = \Pr ob(Enroll_i^* > 0). \quad (3)$$

Assuming that the error terms are mutually independent, normally distributed random variables, substituting (1) and (2) into (3), and rearranging gives

$$P_i = F\left(\frac{X_i'\beta}{\sqrt{\exp(Z_i'\gamma)}}\right) \quad (4)$$

where F is the standard normal cumulative distribution function (CDF). The (log) likelihood function is then

$$\ln(L) = \sum_{i=1}^{N}\{ENROLL_i \times \ln(P_i) + (1 - ENROLL_i) \times \ln(1 - P_i)\} \quad (5)$$

and is maximized by choosing β and γ using the Newton-Raphson nonlinear optimization routine. See Greene (2004), chapter 21 for details.

References

Greene, W.H. 2004. *Econometric Analysis*, 5th ed. Upper Saddle River NJ: Prentice Hall.

Appendix 2: Changes in Applicant Merit Characteristics over time:

The following tables present a comparison of applicant GPA merit characteristics applying for admission in 2001, 2006 and 2008.

Table A1: High School GPA Applicant Statistics

	2001 Academic Year (mean GPA = 3.38)		2006 Academic Year (mean GPA = 3.41)		2008 Academic Year (mean GPA = 3.42)	
	Number of applicants	Percentage of Applicants	Number of applicants	Percentage of Applicants	Number of applicants	Percentage of Applicants
3.9 or higher	481	17%	536	17%	679	18%
3.8 or higher	724	25%	825	26%	1013	28%
3.7 or higher	919	32%	1076	33%	1281	35%
3.6 or higher	1,140	40%	1309	41%	1554	42%
3.5 or higher	1,334	47%	1572	49%	1844	50%
3.4 or higher	1,531	54%	1782	55%	2082	57%
Greater than mean in reporting year	1,569	55%	1749	54%	2033	55%
3.0 or higher	2,218	78%	2587	80%	2973	81%
Total students reporting a High-School GPA	2,837		3231		3683	

Table A2: College GPA Applicant Statistics

	2001 Academic Year (mean GPA = 3.13)		2006 Academic Year (mean GPA = 3.32)		2008 Academic Year (mean GPA = 3.33)	
	Number of applicants	Percentage of Applicants	Number of applicants	Percentage of Applicants	Number of applicants	Percentage of Applicants
3.9 or higher	204	15%	490	23%	429	22%
3.8 or higher	251	18%	587	27%	514	27%
3.7 or higher	316	23%	711	33%	646	34%
3.6 or higher	390	28%	837	39%	752	39%
3.5 or higher	453	33%	979	45%	894	47%
3.4 or higher	513	37%	1113	51%	991	52%
3.3 or higher	581	42%	1224	57%	1106	58%
3.2 or higher	655	48%	1335	62%	1217	64%
Greater than mean in reporting year	694	51%	1187	55%	1167	61%
3.0 or higher	847	62%	1626	75%	1435	75%
Total students reporting a High-School GPA	1,369		2163		1915	

Table A2: ACT Score Applicant Statistics

	2001 Academic Year (mean ACT = 22.9)		2006 Academic Year (mean ACT = 23.1)		2008 Academic Year (mean ACT = 23.5)	
	Number of applicants	Percentage of Applicants	Number of applicants	Percentage of Applicants	Number of applicants	Percentage of Applicants
ACT 35 or higher	2	0.07%	2	0.06%	5	0.13%
ACT 30 or higher	163	5.78%	190	5.46%	298	7.78%
ACT 28 or higher	376	13.34%	448	12.86%	654	17.08%
ACT 26 or higher	759	26.92%	939	26.96%	1152	30.08%
ACT 25 or higher	986	34.98%	1253	35.97%	1506	39.32%
ACT 21 or higher	1,940	68.82%	2549	73.18%	2897	75.64%
ACT 19 or higher	2,423	85.95%	3071	88.17%	3457	90.26%
Greater than mean in reporting year	1,456	51.65%	1633	46.88%	1857	48.49%
Total students reporting an ACT score	2,819		3483		3830	