

University of Wyoming Enrollment Project Final Report

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*The opinions expressed in this report are solely those of the principle investigators and do not necessarily reflect the views of the University of Wyoming.

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1. Introduction

The primary purpose of this project is to predict future enrollment at the University of Wyoming. The focus is on predicting enrollment for a five-year planning horizon, although we also build a statistical model that is also capable of predicting one year into the future. Figure 1 shows total fall enrollment at the University of Wyoming between the years 1950 and 2006. Although there is a clear upward trend in the number of students, the trend is far from smooth. For example, enrollment was stagnant or falling in the early 1970s, while in the early 2000s enrollment grew sharply. Enrollment at UW is likely to depend on a number of factors that vary from year-to-year such as tuition differentials, primary and secondary school enrollments, community college enrollments, regional demographics, economic conditions and recent UW athletic achievements, to name a few.

[Insert Figure 1]

We build a statistical model that incorporates these features and is capable of forecasting future UW enrollment. The predictions from the model, as is true with all predictions, are subject to error. We incorporate these errors into our final estimates and provide confidence intervals around the predicted enrollment figures.

We use four separate models to arrive at a final UW enrollment prediction. The first attempts to explain total enrollment of resident undergraduate students. The second attempts to explain total enrollment of regional (i.e., CO, NE, MT and SD) undergraduates. The third attempts to explain graduate enrollment, while the fourth explains undergraduate enrollment for all students not from WY or the region. Taken together, these four populations make up the total enrollment at the University of Wyoming.

The estimates from all four models are summarized in a user-friendly Microsoft Excel spreadsheet. The spreadsheet allows the user to enter desired values of the

explanatory variables and instantly obtain predicted enrollment numbers either one-year or five-years ahead.

We now provide a brief review of the literature on forecasting college enrollments.

2. Literature Review

Several studies have been conducted in the area of projecting enrollment in higher education. These studies have served as a base for developing our enrollment model at the University of Wyoming.

First, Ahlburg et al. (1994) assess model based prediction models for higher education in the United States. They review prior studies of aggregate enrollment data for the United States, studies of enrollment demand at individual institutions, and studies of enrollment and college choices of individual students. They conclude that it is not advisable to use behavioral coefficients from individual schools to aggregate up to a national level, or vice versa. They find that the following variables are generally statistically significant predictors in enrollment studies:

- Family Income (positive correlation)
- Parents' education attainment (positive correlation)
- Tuition levels (negative correlation)
- Student aid levels (negative correlation)
- Student's academic aptitude (positive correlation)
- Rate of return on education (positive correlation)
- Unemployment rate (undefined correlation).

This paper goes into significant detail about studies that attempt to identify variables that influence long-term enrollment changes in higher education. The authors caution that these variables are often difficult to translate into successful short-term forecasting.

Second, Guo (2002) investigates the issue of accuracy in forecasting enrollment and asks the question “Does a more complex model do a better job than a simpler one?”. The author answers this question using the following three models:

1. Linear Regression Model. Total enrollment was regressed linearly on the population (ages 16-55), college budget, and college tuition.
2. Autoregressive Model. Total enrollment was regressed on the same variables as the Linear Regression Model and a persistence parameter of 0.05. The fundamental difference between this model and the linear regression model is that the autoregressive model weights data for more recent years heavier than data from prior years.
3. Three-Component Model. This model broke enrollment into three distinct subgroups: first-time credit students, returning credit students, and non-credit students. The autoregressive model was used to forecast the first-time and non-credit students using four population subgroups as independent variables. Returning student rates were predicted using a three- year moving average.

The results were used to predict enrollment in six California community colleges. Each model did well in predicting enrollment, producing relatively small errors. Guo (2002) concludes that complex projection methods may fail to yield more accurate predictions and the best model is likely to depend on the situation.

We also highlight enrollment studies by two Florida universities. The University of North Florida (2007) built an enrollment prediction model with the goal of predicting future enrollment five years ahead. Students are broken into four separate groups:

1. First-Time College Students

2. Florida Community College Transfers
3. Other Transfers
4. First-Time Graduate, Post-Baccalaureate, or Non-Degree Seeking Students

The UNF model uses ten years of prior enrollment and retention data for each group to predict the following year's enrollment. First-time college students have shown the largest and most stable growth over the last five years, while transfers from community colleges have shown a decline over the same period. The prediction goals of the UNF model are in many ways similar to the goals of the UW model. Both universities are below their enrollment caps and currently have the ability to accommodate more students. One major difference between the UNF and UW model is our greater focus on identifying changes in specific economic and demographic that have had an historical impact on enrollment.

The University of Central Florida (2007) builds a sophisticated model to predict enrollment one-year ahead by combining the returning undergraduate fall students (based on retention rates from the previous ten years) and predicted incoming students. Returning graduate students are based on the past two-year return rate and combined with predicted incoming graduate students. Each year predicted enrollment is adjusted so that predicted enrollment perfectly "fits" the actual enrollment of the prior year. This allows for continual updating of the "base coefficients" that may influence enrollment, attaching highest weight to the most recent year of enrollment data. These base coefficients are then used in conjunction with the explanatory variables to determine the new enrollment prediction. This model has proven to be a successful predictor of both short- and long-term enrollment at UCF. Short-term prediction errors are in the neighborhood of 0.5% and 2% for long-term prediction errors.

3. Variable Definitions and Data Sources

In this section, we describe the dependent and explanatory variables used in the project, as well as the sources for the data. All monetary variables are measured in 2006 dollars.

3.1. Dependent Variables

UW Resident Undergraduate Enrollment

- Definition. The number of University of Wyoming undergraduates that claim Wyoming as their permanent home address. During the academic years 1950-55, enrollment is for the fall quarter; during the years 1955-89 enrollment is for the fall semester; and during the years 1989-07, enrollment is for the end of the fall semester.
- Sources.
 - 1950-88 University of Wyoming Statistical Summary
 - 1989-06 University of Wyoming Office of Institutional Analysis

UW Regional Undergraduate Enrollment

- Definition. University of Wyoming undergraduate students who claim Colorado, Montana, South Dakota, or Nebraska as their state of permanent residence. This information was unavailable prior to 1966. We estimated enrollment prior to 1966 based on the percentage of the student body that was enrolled at UW from the four surrounding states during the academic years 1966-71. We looked to these four regional states because they have consisted of a large percentage of our non-resident enrollment.
- Sources.
 - 1966-88 University of Wyoming Statistical Summary
 - 1989-06 University of Wyoming Office of Institutional Analysis

UW Graduate Student Enrollment

- Definition. Enrollment of University of Wyoming graduate and professional students. This data only contains degree-pursuing graduate students attending the Laramie and Casper College campuses.
- Sources.
 - 1950-88 University of Wyoming Statistical Summary
 - 1989-06 University of Wyoming Office of Institutional Analysis

“All Other” UW Undergraduate Students

- Definition. Enrollment of University of Wyoming undergraduates not from the five-state region.
- Sources.
 - 1950-88 University of Wyoming Statistical Summary
 - 1989-06 University of Wyoming Office of Institutional Analysis

3.2. Explanatory Variables

UW Resident Annual Tuition and Fees.

- Definition. Total resident UW annual tuition and fees.
- Sources.
 - 1950-60 University of Wyoming Bulletin
 - 1961-2006 University of Wyoming Office of Institutional Analysis

Regional Tuition Differential.

- Definition. Regional Tuition Differential is the difference between non-resident annual tuition and fees for University of Wyoming undergraduates and a weighted average of in-state tuition for undergraduate students for the regional schools. To properly weight the tuition and fee figures, we totaled non-resident undergraduate enrollment of students from the four regional

states and assigned each state its weight according to the percentage of regional undergraduate students attending UW.

- Sources.
 - Colorado State University
 - 1950-05: www.budgets.colostate.edu/docs/tuitionbk.pdf
 - 2006 CSU Website: welcome.colostate.edu/
 - 2006 Fact Book: www.colostate.edu/Dept/OBIA/pdf/fbk/0607/fctbk0607.pdf
 - University of Colorado at Boulder
 - 1950-72: University of Colorado Course Catalogs
 - 1972-06: www.colorado.edu/pba/budget/tuitionfees/history.html
 - University of Northern Colorado
 - 1950-69: Colorado State College of Education at Greeley Bulletin
 - 1970-07: University of Northern Colorado Bulletin
 - Black Hills State University
 - Ven Thompson, Director of Institutional Research, via e-mail
 - VenThompson@bhsu.edu
 - University of Nebraska at Lincoln
 - 1949-94: University of Nebraska Class bulletin
 - 1995-07: UNL Factbook <http://irp.unl.edu/ir/index.shtml#Factbooks>
 - University of Montana-Missoula
 - 1950-06: UM-Missoula Course Catalogs

University of Colorado-Boulder Undergraduate Enrollment

- Definition. Total number of CU-Boulder undergraduate students.
- Source. www.colorado.edu/pba/records/index.htm

University of Wyoming Athletic Success

- Definition. Post-season play by University of Wyoming men's basketball, women's basketball, or bowl game appearance during a less than three-loss season for the men's football team.
- Sources.
 - UW 2006 Football Media Guide
 - UW 2006 Women's Basketball Media Guide
 - UW 2006 Men's Basketball Media Guide

Change in Colorado K-12 Enrollment

- Definition. Change in the number of students enrolled in Colorado's K-12 educational system, measured as both a one-year change and a five-year change.
- Sources.
 - 1975-present: Tilak Mandal via e-mail Mandal_T@cde.state.co.us
 - 1964-76: Dennis St. Hilaire, Colorado Department of Education st.hilaire_d@cde.state.co.us
 - 1950-64 Statistical Abstract of the United States Census

WY 8-12th Grade Enrollment

- Definition. Number of students enrolled in the eighth through twelfth grade in Wyoming's educational system.
- Source.
 - Shirley Winter via e-mail swinte@educ.state.wy.us

WY 12th Grade Enrollment

- Definition. Number of students enrolled in 12th grade in Wyoming's educational system.
- Source.

- Shirley Winter via e-mail swinte@educ.state.wy.us

WY Community College Enrollment

- Definition. Enrollment in Wyoming's community colleges based on full- time equivalence, where 12 credit hours equal one full- time equivalent.
- Sources.
 - 1950-91: Wyoming Data Handbook
 - 1992-02: Annual Enrollment Report Wyoming Community College System Academic Year 2002-03
www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/1b/9d/30.pdf
 - 2002-06 Wyoming Community College System Enrollment Report April 2007

Energy Prices

- Definition. The average annual cost of a barrel of crude oil in 2006 dollars.
- Source. www.inflationdata.com/inflation/inflation_rate/Historical_Oil_Prices_Table.asp

U.S. Unemployment Rate

- Definition. Annual average of the unemployed work force in the United States.
- Source. www.bls.gov/cps/cpsaat1.pdf

4. Statistical Models and Estimation Results

We estimate four statistical models corresponding to our four categories of UW enrollment: resident undergraduates, regional undergraduates, graduate students, and “all other” UW undergraduates.

Model #1. Resident Undergraduate Enrollment

Model #1 is a linear regression model estimated over the time period 1957 – 2005. Figure 2 shows the actual path of UW resident undergraduate enrollment over the sample period (black line). There is a clear upward trend in resident undergraduate enrollment between 1957 and 1989, with peak enrollment occurring at 7,045 students in 1989. Since 1989, resident enrollment has fluctuated around a mean of approximately 6,500 students.

[Insert Figure 2]

Table 1 shows the estimation results for Model #1. All five variables have a statistically significant impact on UW resident enrollment. The signs of the coefficients are as expected: all else equal, higher tuition and energy prices lead to declines in enrollment while higher 8th – 12th grade WY enrollment, community college enrollment and NCAA postseason achievements lead to increases in enrollment. Figure 2 also shows the predicted UW resident enrollment over the sample period (red line). Predicted enrollment does a good job of tracking actual enrollment with a R² measure of 92.5%.

[Insert Table 1]

Model #2. Regional (CO, NE, SD and MT) Undergraduate Enrollment

Model #2 is a semi-log regression model, which captures the exponential upward trend in regional UW enrollment. Figure 3 shows the actual time path of regional enrollment at UW (black line). Regional enrollment starts out at nearly 250 students in 1957, increasing to nearly 1,700 students in the most recent academic year. There were also three periods of temporary decline in regional UW enrollment: 1969-74, 1982-1986, and 1991-1997.

[Insert Figure 3]

In Table 2, we show the estimation results for Model #2. All five explanatory variables are statistically significant predictors of regional enrollment. The “Marginal Effect” column gives the impact of a unit change in an explanatory variable on regional enrollment, all else equal. For example, an increase of \$1000 in the differential between UW’s non-resident and regional average tuition leads to 129 fewer regional undergraduate students. Conversely, increases in Colorado’s K-12 student growth, Colorado’s college enrollment and UW’s NCAA post-season performance leads to significant increases in regional undergraduates. Figure 3 also shows the predicted regional undergraduate enrollment (red line), which tracks actual enrollment closely with a R^2 measure of 94.2%.

[Insert Table 2]

Model #3. UW Graduate Students

Model #3 is a linear regression model designed to explain UW enrollment of graduate students. Between 1957 and 1989, the enrollment of these students exhibited steady linear growth. In 1989, the University started counting Outreach students in the UW graduate student figures. Since 1989, this category of UW students has fluctuated around a mean of approximately 3,500 students (black line). Estimates for model #3 use data from 1957 through 2005 and allow a permanent shift in the regression line in 1989.

[Insert Figure 4]

UW graduate students are more difficult to predict than resident and regional undergraduates. Table 3 shows that the economic condition in the U.S. (measured by the U.S. unemployment rate) is a statistically significant predictor of graduate

student enrollment. As Figure 4 shows, although predicted enrollment (red line) does a good job of tracking actual enrollment, much of the explanatory power is due to the linear trend and the permanent shift in 1989. The R^2 is equal to 91.9%.

[Insert Table 3]

Model #4. “All Other” UW Undergraduate Students

Model #4 is a simple linear trend regression model designed to explain UW undergraduate enrollment not from the five-state region. We could not find any reliable statistical predictors for this category. As a result, we simply use a linear trend between 2000 and 2005 to explain variation in this category of students. Figure 5 shows the actual number of “all other” UW undergraduate students (black line).

[Insert Figure 5]

Table 4 and Figure 5 show that there has been a steady linear increase in the number of “all other” UW undergraduate students over the period 2000 through 2005. Figure 5 shows that predicted enrollment (red line) tracks actual enrollment very well over this short period. The R^2 is equal to 97.4% with all the explanatory power due to the linear trend.

[Insert Table 4]

5. Prediction Accuracy and Out-of-Sample Goodness-of-Fit

Before turning to our UW enrollment predictions for the academic year 2011-12, we test the model to see how it would have performed in predicting UW enrollment for the 2006-7 academic year. This is an out-of-sample forecast because the model is estimated using data up to (and including) AY 2005-6. We do this both as a one-

year forecast (i.e., standing in AY 2005-6) and as a five-year forecast (i.e., standing in AY 2001-2). The explanatory variables are set at their actual past values when making the predictions.

Table 5 shows the accuracy of the three models for predicting enrollment out-of-sample. Overall, the out-of-sample accuracy for total 2006-07 UW enrollment is very good. The one-year and five-year prediction errors are negative (under-estimate enrollment) and amount to 72 and 194 students, respectively. This corresponds to a margin of error of -0.5% and -1.5%, respectively.

As a final note, we emphasize that the 2006-07 predictions do not account for the introduction of the *Hathaway Scholarship Program*. The estimates for the model use data through the academic year 2005-06, the year before the first Hathaway scholarships were awarded. By not incorporating the Hathaway scholarships in our estimation, we might expect the model to under estimate the number of resident undergraduate students in 2006-07. As Table 5 indicates, the one-year ahead prediction for UW resident undergraduate enrollment was short by 172 students. One interpretation of this under-estimate is that the Hathaway Scholarship Program may have resulted in approximately 172 more students than would have been expected based solely on economic and demographic conditions.

[Insert Table 5]

6. UW Enrollment Prediction 2011-2012

We focus on a five-year planning horizon, which from the perspective of AY 2006-07 implies making a prediction of enrollment for AY 2011-12. Three different hypothetical scenarios are considered.

Scenario #1. Low Enrollment Growth

- No significant post-season athletic appearance

- 5% annual increase in UW resident tuition
- 5% annual increase in regional tuition differential
- Constant WY community college enrollment
- 5% annual energy price increase
- Constant CO college enrollment
- Constant CO K-12 enrollment

Scenario #2. Medium Enrollment Growth

- Significant post-season athletic appearance
- 2.5% annual increase in UW resident tuition
- Constant regional tuition differential
- Constant WY community college enrollment
- 2.5% annual energy price increase
- 2.5% annual increase in CO college enrollment
- 2.5% annual increase in CO K-12 enrollment

Scenario #3. High Enrollment Growth

- Significant post-season athletic appearance
- Constant UW resident tuition
- Constant regional tuition differential
- 5% annual increase in WY community college enrollment
- Constant energy prices
- 5% annual increase in CO college enrollment
- 5% annual increase in CO K-12 enrollment

The results in Table 6 show that depending on regional economic and demographic conditions, UW enrollment could be as low as 12,541 and as high as 16,670. The probability of observing these enrollment levels depends on the likelihood of the conditions in the three hypothetical scenarios. In our opinion, the medium-growth scenario is probably closer to recent economic and demographic conditions than the

low- and high-enrollment scenarios. The medium-growth scenario predicts enrollment in 2011-12 to be 14,327.

[Insert Table 6]

7. Conclusions

The purpose of this project was to build a statistical model capable of predicting future enrollment at the University of Wyoming. UW enrollment was broken into four distinct categories: resident undergraduates, regional undergraduates, graduate students, and “all other” undergraduate students. For each category of student, we estimated a separate statistical model using data from 1957 through 2005. The results from the models are summarized in a user-friendly Microsoft Excel spreadsheet capable of predicting UW enrollment either one- or five-years ahead. The prediction accuracy of the models is very good with R^2 measures generally well above 90%. Out-of-sample predictions errors for the academic year 2006-07 were in the neighborhood of -1% of actual enrollments. The fact that UW resident undergraduate enrollment in 2006-07 was under-estimated may be due to the introduction of the Hathaway Scholarship Program.

Predictions of UW enrollment for the academic year 2011-12 are also provided. These predictions are contingent upon unknown future values for economic conditions in the state, region and the U.S., as well as other regional demographic factors. Using three different hypothetical scenarios, it is hypothesized that UW enrollment in 2011-12 could be as low as 12,541 or as high as 16,670. A third projection that is more in line with recent conditions, predicts that UW enrollment in 2011-12 will be equal to 14,327 students.

References

- Ahlburg, Denis, Michael McPherson and Morton Owen. 1994. Predicting Higher Education Enrollment in the United States: An Evaluation of Different Modeling Approaches, unpublished manuscript.
- Guo, Shuqin. 2002. Three Enrollment Forecasting Models: Issues in Enrollment Projection for Community Colleges, unpublished manuscript.
- University of Central Florida. 2007. Enrollment Projection Modeling, University Analysis and Planning Support. <http://uaps.ucf.edu/enrollment/methods.html>.
- University of North Florida. 2007. Enrollment Projections, Office of Institutional Research, www.unf.edu/dept/inst-research/special_reports.htm.

Table 1. Estimation Results for Model #1

Dependent Variable		Mean	Min	Max
WY Undergrads (t)		5446.0	2334.0	7111.0

Explanatory Variables	Coefficient	t Statistic	Mean	Min	Max
Intercept	342.440	0.4337	--	--	--
Resident Tuition (t)	-0.295**	-2.522	2025.3	1205.6	3536.7
WY 8 th – 12 th Grade (t-5)	0.134***	4.089	32623.8	21067.0	39742.0
Community College (t-1)	0.176***	4.664	8673.7	915.0	14774.9
UW Athletics (t-1)	293.286*	1.819	0.18	0.0	1.0
Energy Prices (t)	-9.381*	-1.645	27.24	13.44	70.43

Sample Size	49
R ²	0.925

Notes. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 2. Estimation Results for Model #2

Dependent Variable		Mean	Min	Max
Log Regional Undergrads (t)		6.506	5.487	7.413
Regional Undergrads		769.8	241.0	1658.0

Explanatory Variables	Coefficient	t Statistic	Marginal Effect	Mean	Min	Max
Intercept	4.902***	22.816	--	--	--	--
Tuition Differential (t)	-7.799e-5***	-2.832	-0.129	3326.09	1343.99	5866.25
CO K-12 Growth (t-1)	2.111e-6**	2.154	0.004	499908	-23095	111345
CO College Enrollment (t-1)	4.137e-5*	1.969	0.069	17072	9047	24710
UW Athletics (t-1)	0.098*	1.815	162.484	0.184	0.00	1.00
Trend (t)	0.032***	6.338	--	--	--	--

Sample Size	49
R ²	0.942

Notes. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level. Marginal effect is measured using the 2005 level of the explanatory variables.

Table 3. Estimation Results for Model #3

Dependent Variable		Mean	Min	Max	
UW Graduate Students (t)		2062.9	398	4194	
Explanatory Variables	Coefficient	t Statistic	Mean	Min	Max
Intercept	154.843	0.706	--	--	--
D89 (t)	1243.756***	6.028	0.35	1.00	0.00
US Unemployment Rate (t)	83.085**	2.098	5.85	3.50	9.70
Trend	39.608***	5.727	--	--	--
Sample Size		49			
R ²		0.919			

Notes. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 4. Estimation Results for Model #4

Dependent Variable		Mean	Min	Max	
Other UW Undergrads (t)		1169.0	1101	1253	
Explanatory Variables	Coefficient	t Statistic	Mean	Min	Max
Intercept	1068.20***	117.60	--	--	--
Trend	28.80***	12.35	--	--	--
Sample Size		6			
R ²		0.974			

Notes. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.
The "Other" category includes undergraduate students not from WY, CO, NE, SD or MT.

Table 5. Out-of-Sample Prediction for AY 2006-7

Category		1-Year Ahead	5-Year Ahead
Regional Undergraduate Enrollment	Actual	1,695	1,695
	Predicted	1,808	1,808
	Error	113	113
	% Error	6.7%	6.7%
WY Undergraduate Enrollment	Actual	6,423	6,423
	Predicted	6,251	6,129
	Error	(172)	(294)
	% Error	-2.7%	-4.6%
UW Graduate Student Enrollment	Actual	3,735	3,735
	Predicted	3,803	3,803
	Error	68	68
	% Error	1.8%	1.8%
All Other UW Undergraduate Students	Actual	1,253	1,253
	Predicted	1,270	1,270
	Error	17	17
	% Error	1.4%	1.4%
Total	Actual	13,203	13,203
	Predicted	13,131	13,009
	Error	(72)	(194)
	% Error	-0.5%	-1.5%

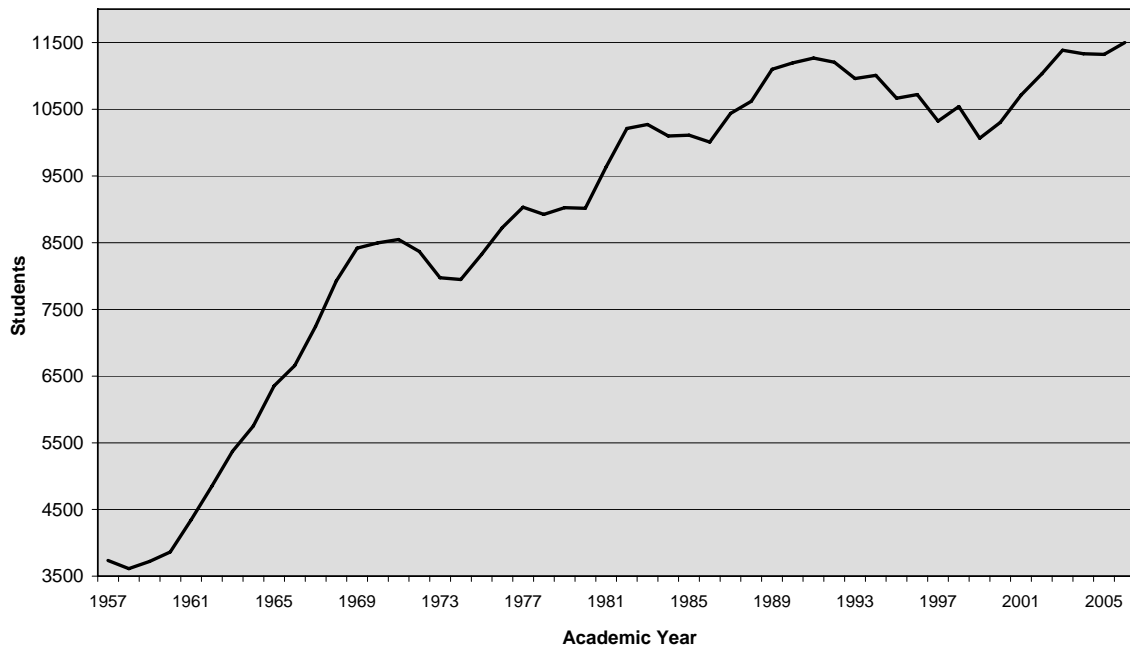
Notes. The "All Other" category includes undergraduate students not from WY, CO, NE, SD or MT.

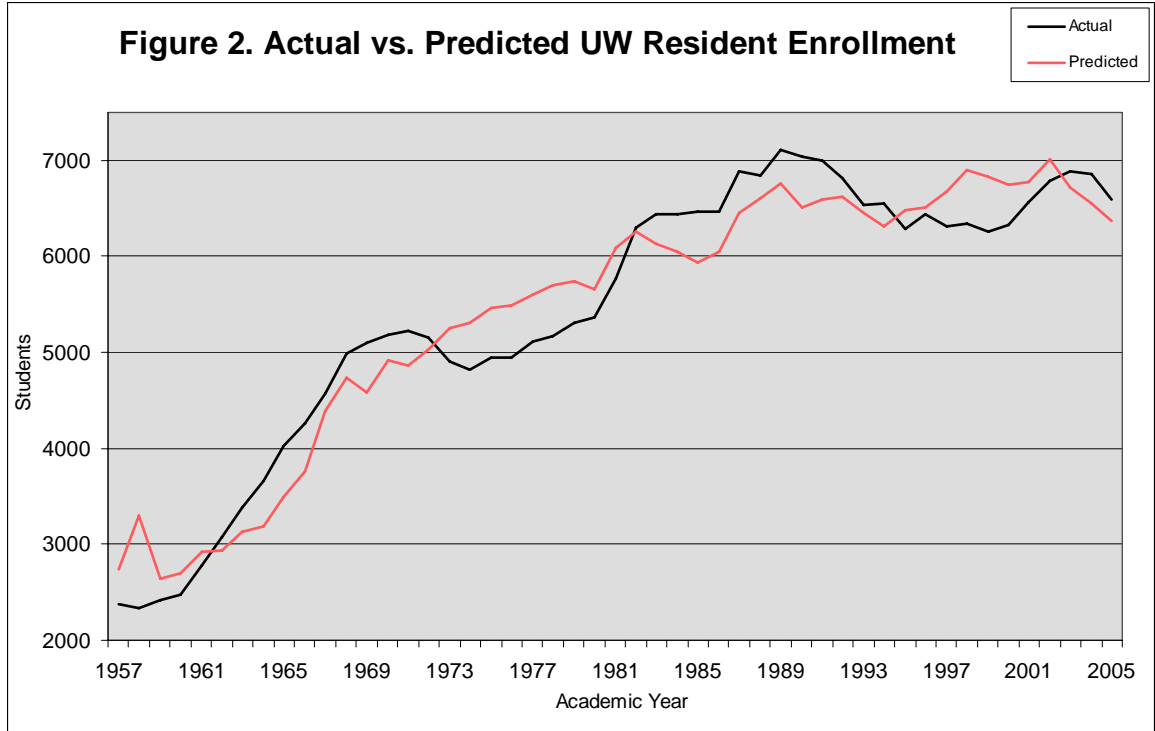
Table 6. UW Enrollment Prediction 2011-12 (Five Years Ahead)

Category	Statistic	Prediction Scenario		
		Low Enrollment	Medium Enrollment	High Enrollment
Regional Undergraduate Enrollment	Estimate	1,734	2,997	4,424
	Confidence Interval	[1,271, 2,196]	[2,013, 3,980]	[1,980, 6,867]
WY Undergraduate Enrollment	Estimate	5,393	5,915	6,831
	Confidence Interval	[4,437, 6,348]	[5,026, 6,805]	[5,995, 7,667]
UW Graduate Students	Estimate	4,001	4,001	4,001
	Confidence Interval	[3,394, 4,607]	[3,394, 4,607]	[3,394, 4,607]
All Other UW Undergraduate Students	Estimate	1,414	1,414	1,414
	Confidence Interval	[1,365, 1,462]	[1,365, 1,462]	[1,365, 1,462]
Total	Estimate	12,541	14,327	16,670

Notes. The "All Other" category includes undergraduate students not from WY, CO, NE, SD or MT. The confidence interval is measured at 90%.

Figure 1. Total Enrollment at the University of Wyoming





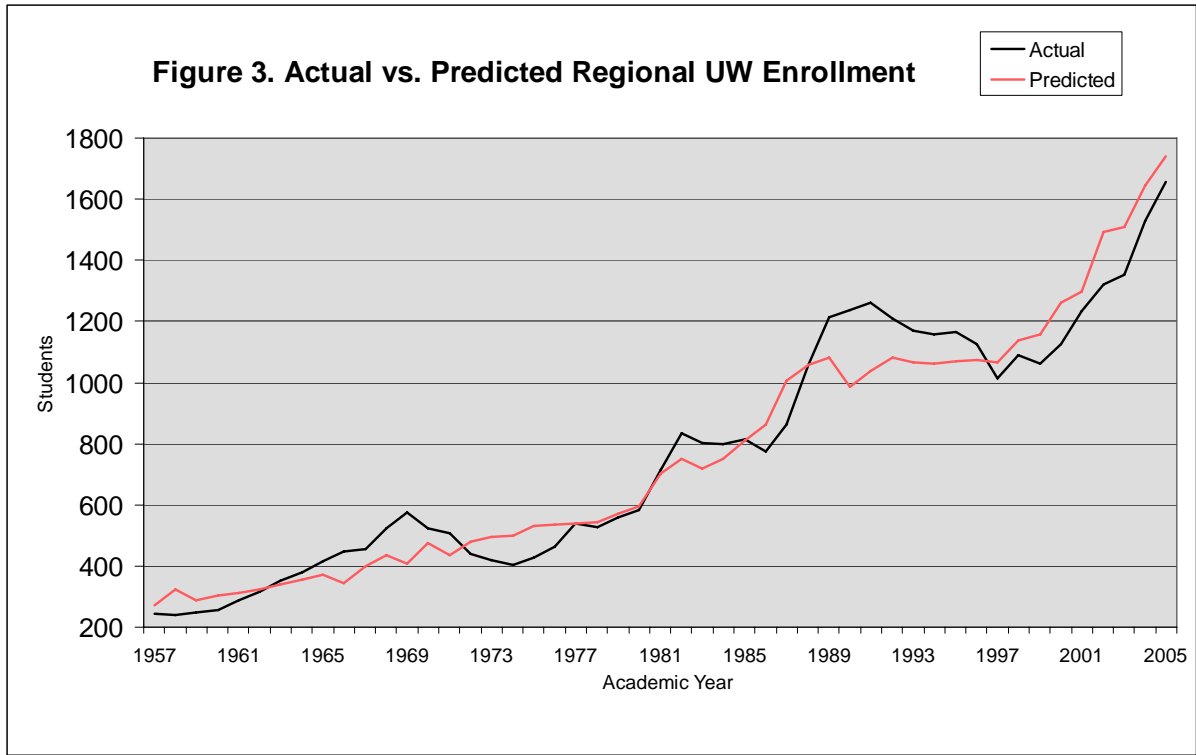
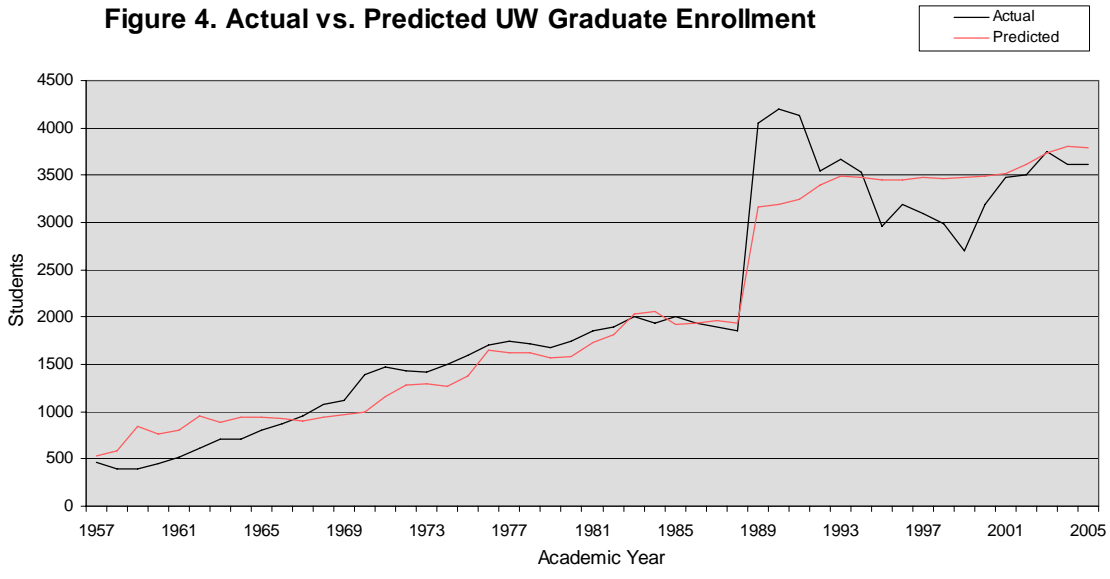


Figure 4. Actual vs. Predicted UW Graduate Enrollment



**Figure 5. Predicted vs. Actual
UW " All Other" Undergraduate Enrollment**

