BUS 735: Business Decision Making and Research
Instructor: Dr. James Murray
In-class Exam 1 - Fall 2014
Answer Key

Directions: Write your answers in the space provided. For every problem, first write down what statistical test or procedure you are using to answer the question. Some statistical procedures, like regression and analysis of variance, include many hypothesis tests. In such events, write down both the statistical procedure, and the hypothesis test you are using. For every hypothesis test, be sure to include every step of hypothesis testing.

1. The dataset `TeacherRatings.sav` contains data on average course evaluations (on a continuous scale from 0.0-5.0) for 463 courses for the academic years 2000-2002 at the University of Texas at Austin. The dataset includes a dummy variable for whether the instructor identified himself or herself and a racial minority (`minority=1` if a minority, `minority=0` otherwise), age (in years), gender (`female = 1` if female and `female = 0` otherwise, whether or not the course was a one-credit course (`onecredit=1` if one credit, `onecredit=0` otherwise), a rating of instructors' physical appearance by a panel of six students, averaged across the six panelists, on a continuous scale from 1-10, and whether or not the course was an introductory course (`intro=1` if introductory, `intro=0` otherwise).

   (a) Test the hypothesis that minority instructors have different evaluation scores on average than non-minority instructors.

   Independent Samples T-test
   H_0: **Mean evaluation score equal between minority and non-minority.**
   H_1: **Mean evaluation scores are different between minority and non-minority.**

Group Statistics

	minority	N	Mean	Std. Deviation	Std. Error Mean
course_eval	0	399	4.02	.546	.027
	1	64	3.89	.602	.075

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
course_eval	Equal variances assumed	1.807	.180	1.651	461	.099	.123	.075	-.023	.270
	Equal variances not assumed			1.538	80.512	.128	.123	.080	-.036	.282

P-value = 0.099
Reject Null Hypothesis at 10% level
We found sufficient statistical evidence that there is a difference in average evaluation scores between minority and non-minority instructors.

(b) Estimate a regression that uses all the given instructor and course characteristics to predict an instructor's expected evaluation score. Write down the estimated regression equation.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.843	.169		22.783	.000
	minority	-.226	.073	-.141	-3.107	.002
	age	-.002	.003	-.035	-.739	.460
	female	-.178	.051	-.158	-3.469	.001
	onecredit	.646	.112	.273	5.776	.000
	beauty	.079	.016	.225	4.941	.000
	intro	.029	.054	.025	.543	.587

a. Dependent Variable: course_eval

$$\mathbf{Eval_i = 3.843 - 0.226\ Minority_i - 0.002\ Age_i - 0.178\ Female_i + 0.646\ OneCredit_i + 0.079\ Beauty_i + 0.029\ Intro_i + e_i}$$

(c) Using the regression results in question (b), test whether or not the physical appearance of the instructor affects his or her evaluation score.

T-test on Regression Coefficient

$H_0 : \beta_{Beauty} = 0$

$H_0 : \beta_{Beauty} \neq 0$

P-value = 0.000

We found strong statistical evidence that physical appearance does influence an instructor's evaluation score.

(d) Describe whether and how instructor age influences evaluation scores.

T-test on Regression Coefficient

$H_0 : \beta_{age} = 0$

$H_0 : \beta_{age} \neq 0$

P-value = 0.460

We failed to find statistical evidence that age influences an instructor's evaluation score.

(e) What percentage of the variability in course evaluation is predicted by your explanatory variables. Note that none of your explanatory variables capture anything about teacher quality. Can you draw a recommendation for university policy makers using instructor evaluations for personnel decisions?

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.382[a]	.146	.135	.516

a. Predictors: (Constant), intro, beauty, minority, female, onecredit, age

R-square is 0.146, so 14.6% of the variability in evaluation scores are explained by these variables that have nothing to do with teaching quality, and for which the instructor has no control over. While this is not extremely high, making personnel decisions based on these variables unethical and may be illegal.

(f) What would you predict would be the evaluation score for your BUS 735 instructor, someone who is a male non-minority instructor, 35 years old, is not teaching a one-credit course or introductory course, and is incredibly good looking (beauty=10)?

$$\hat{\text{Eval}}_i = 3.843 - 0.226\ \text{Minority}_i - 0.002\ \text{Age}_i - 0.178\ \text{Female}_i + 0.646\ \text{OneCredit}_i + 0.079\ \text{Beauty}_i + 0.029\ \text{Intro}_i$$

$$\hat{\text{Eval}}_i = 3.843 - 0.226\ (0) - 0.002\ (35) - 0.178\ (0) + 0.646\ (0) + 0.079\ (10) + 0.029\ (0) = 4.562$$

2. The dataset `salesrev.sav` contains the monthly sales revenue (in thousands of dollars) for 200 sales people for a large national corporation. The sales people focus on one of two categories of products, which are labeled as Product 1 and Product 2 in the dataset. Also included in the dataset is the years of experience each sales person has. The company introduces a new sales person training program. The training program involves three full day training sessions, one training session is offered each month for three months. The 200 sales people participate in the training program, and the company gathers data on the monthly sales before the training (`Sales0`), after the first training session (`Sales1`), after the second training session (`Sales2`), and after the third and final training session (`Sales3`). For the following questions, test the appropriate hypothesis and report your conclusion.

(a) Is there evidence that the three-part training program positively influences sales (comparing before the first training session and after the last training session)?

Paired Samples T-test: Compare Sales 0 with Sales 1

H_0 : Mean Sales 0 = Mean Sales 3

H_1 : Mean Sales 0 < Mean Sales 3

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Sales0 - Sales3	-1586.850	1939.572	137.148	-1857.301	-1316.399	-11.570	199	.000

P-value = 0.000

Reject Null Hypothesis

We found statistical evidence that the training program series positively influences sales.

(b) Do all of the training sessions lead to an increase in sales revenue? If not, which training sessions do you find evidence that are effective, and which training sessions do you fail to find evidence that they are effective? **Paired Samples T-test: Compare Sales 0 with Sales 1**
H_0 : Mean Sales 0 = Mean Sales 1
H_1 : Mean Sales 0 < Mean Sales 1
P-value = 0.000 (one-tailed)
Reject Null Hypothesis
We found statistical evidence that the average level of sales is higher after the first training session.

Paired Samples T-test: Compare Sales 1 with Sales 2
H_0 : Mean Sales1 = Mean Sales 2
H_1 : Mean Sales1 < Mean Sales 2
P-value = 0.000 (one-tailed)
Reject Null Hypothesis
We found statistical evidence that the average level of sales is higher after the second training session.

Paired Samples T-test: Compare Sales 2 with Sales 3
H_0 : Mean Sales2 = Mean Sales 3
H_1 : Mean Sales2 < Mean Sales 3
P-value = 0.950 (One-tailed is 0.05, but that is the wrong tail! Mean sales volume is greater for Sales2, not Sales3)
Fail to reject Null Hypothesis
We failed to find statistical evidence that the average level of sales is higher after the second training session.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Sales0 - Sales3	-1586.850	1939.572	137.148	-1857.301	-1316.399	-11.570	199	.000
Pair 2	Sales0 - Sales1	-1235.620	2163.199	152.961	-1537.253	-933.987	-8.078	199	.000
Pair 3	Sales1 - Sales2	-590.550	1966.936	139.083	-864.816	-316.284	-4.246	199	.000
Pair 4	Sales2 - Sales3	239.320	2047.827	144.803	-46.226	524.866	1.653	199	.100

(c) Taking into account the effect of years experience, is there a difference in sales revenue after the final training session between sales people who sell Product 1 versus Product 2?

ANCOVA with Sales3 as the dependent variable, experience as a covariate explanatory variable, and product as a fixed factor explanatory variable.

Test: F-test on variable, Product

Null: The average sales revenue is equal for employees selling product 1 as product 2.

Alt: The average sales revenue is different for employees selling product 1 as product 2.

P-value = 0.000

Reject Null Hypothesis

Accounting for years experience, there is statistical evidence that product type influences sales revenue.

Univariate Analysis of Variance

Between-Subjects Factors

		N
Product	1	100
	2	100

Tests of Between-Subjects Effects

Dependent Variable: Sales3

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	264242208[a]	2	132121104.0	10.892	.000
Intercept	1.464E+10	1	1.464E+10	1206.785	.000
Experience	21887878.35	1	21887878.35	1.804	.181
Product	223301453.1	1	223301453.1	18.408	.000
Error	2389722865	197	12130572.92		
Total	6.442E+10	200			
Corrected Total	2653965073	199			

a. R Squared = .100 (Adjusted R Squared = .090)

(d) Taking into account the effect of product type, does years experience influence sales revenue after the final training session?

Same ANCOVA as above.

Test: F-test on variable, Product

Null: The average sales revenue is not influenced by years experience

Alt: The average sales revenue is influenced by years experience.

P-value = 0.181

Accounting for product type, we failed to find statistical evidence that years experience influences sales revenue.

3. The dataset `cps.sav` contains information about union membership and background characteristics for 1084 individuals. The variables include,

   - `educ`: years of education
   - `south`: dummy variable = 1 if employee lives in the South
   - `nonwhite`: dummy variable = 1 if employee is not white
   - `female`: dummy variable = 1 if employee is female
   - `exper`: years of experience
   - `y85`: dummy variable = 1 if year of the observation is 1985, = 0 if the year of the observation is 1978
   - `union`: dummy variable = 1 if the employee is a member of a labor union.

   (a) Estimate a logistic regression that predicts the probability that a person is a member of a union based on all the other variables given above. What is your estimated regression equation?

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	educ	-.031	.029	1.159	1	.282	.969
	south	-.936	.187	25.203	1	.000	.392
	nonwhite	.654	.223	8.618	1	.003	1.924
	female	-.715	.159	20.288	1	.000	.489
	exper	.025	.006	16.913	1	.000	1.025
	y85	-.659	.152	18.702	1	.000	.517
	Constant	-.504	.443	1.296	1	.255	.604

a. Variable(s) entered on step 1: educ, south, nonwhite, female, exper, y85.

$$\mathbf{l_i = -0.504 - 0.031(Educ_i) - 0.936(South_i) + 0.654(Nonwhite_i) - 0.715(Female_i) + 0.025(Exper_i) - 0.659(y85_i) + e_i}$$

   (b) Is there evidence that males and females have different propensities to be a member of a union, given the other variables in your model? If so, which gender is more likely to be a member of a union?

T-test on Regression Coefficient

$H_0 : \beta_{Female} = 0$

$H_0 : \beta_{Female} \neq 0$

P-value = 0.000

We found strong statistical evidence that gender influences whether or not the person will be in a union. Since the coefficient is negative, females are less likely to be a union member.

(c) Use your regression model to predict the probability that a white woman from Wisconsin with 12 years of education and 12 years of experience was a member of a union in 1985.

$\hat{l}_i = -0.504 - 0.031(12) - 0.936(0) + 0.654(0) - 0.715(1) + 0.025(12) - 0.659(1) = -1.95$

$\mathbf{P(\widehat{union_i} = 1|X_i) = \frac{1}{1+e^{-\hat{l}_i}} = \frac{1}{1+e^{1.95}} = 0.1246}$

12.46% chance.

(d) What is the marginal effect on the probability of union membership for living in the South, for a person similar to the one described in the previous question?

$\hat{l}_i = -0.504 - 0.031(12) - 0.936(1) + 0.654(0) - 0.715(1) + 0.025(12) - 0.659(1) = -2.886$

$\mathbf{P(\widehat{union_i} = 1|X_i) = \frac{1}{1+e^{-\hat{l}_i}} = \frac{1}{1+e^{2.886}} = 0.0528}$

Difference = 0.0528 - 0.1246 = -0.0717.

The person from the south is 7.17% less likely to be a member of a union.