

# Analysis of Covariance and Cell Means Coding on the Cars data

```
/****** mcarsancova.sas *****/
options linesize=79 pagesize=100 noovp formdlim='- ' nodate;
title 'Metric Cars Data Part Two: Cell means coding and ANCOVA';

data auto;
  infile 'mcars2.data' firstobs=2 ;      /* Skipping the header on line 1 */
  input id country $ kpl weight length;
/* Indicator dummy vars: All three */
  if country = 'US' then c1=1;
  else if country = 'Japan' then c1=0;
  else if country = 'Europ' then c1=0;
  if country = 'Europ' then c2=1;
  else if country = 'US' then c2=0;
  else if country = 'Japan' then c2=0;
  if country = 'Japan' then c3=1;
  else if country = 'US' then c3=0;
  else if country = 'Europ' then c3=0;
  label country = 'Country of Origin'
        kpl = 'Kilometers per Litre'
        weight = 'Weight in kg'
        length = 'Length in cm';

proc glm;
  title2 'No Covariates';
  class country;
  model kpl = country;
  means country;
  means country / bon;

proc reg;
  title2 'Cell Means Coding';
  title3 'Controlling for weight, Country F = 3.07, USvsEURO F = 0.16';
  model kpl = weight c1 c2 c3 / noint;
  country:    test c1 = c2 = c3;
  USvsEURO:  test c1=c2;
  USvsJAPAN:  test c1=c3;
  EUROvsJAPAN: test c2=c3;

proc glm;
  title2 'Weight is Covariate (Illustrating WRONG Bonferroni tests!)';
  class country;
  model kpl = weight country; /* Remember Country is Euro Japan US */
  contrast 'USvsEURO' F = 0.16' country 1 0 -1;
  contrast 'USvsJAPAN' F = 4.64' country 0 1 -1;
  contrast 'EUROvsJAPAN' F = 5.11' country 1 -1 0;
  lsmeans country; /* Y-hat with covariates set to sample mean values */
  means country / bon; /* Does something strange -- not what we want! */
```

Metric Cars Data Part Two: Cell means coding and ANCOVA 1  
 No Covariates

The GLM Procedure

Class Level Information

Class	Levels	Values
country	3	Europ Japan US
Number of Observations Read		100
Number of Observations Used		100

Metric Cars Data Part Two: Cell means coding and ANCOVA 2  
 No Covariates

The GLM Procedure

Dependent Variable: kpl Kilometers per Litre

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	121.5923240	60.7961620	10.09	0.0001
Error	97	584.2969720	6.0236801		
Corrected Total	99	705.8892960			

R-Square	Coeff Var	Root MSE	kpl Mean
0.172254	27.90648	2.454319	8.794800

Source	DF	Type I SS	Mean Square	F Value	Pr > F
country	2	121.5923240	60.7961620	10.09	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
country	2	121.5923240	60.7961620	10.09	0.0001

Metric Cars Data Part Two: Cell means coding and ANCOVA  
No Covariates

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The GLM Procedure

Level of country	N	-----kpl----- Mean	Std Dev
Europ	14	11.1600000	4.24407641
Japan	13	9.8215385	2.39767195
US	73	8.1583562	1.97608129

Metric Cars Data Part Two: Cell means coding and ANCOVA  
No Covariates

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The GLM Procedure

Bonferroni (Dunn) t Tests for kpl

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than Tukey's for all pairwise comparisons.

Alpha	0.05
Error Degrees of Freedom	97
Error Mean Square	6.02368
Critical Value of t	2.43621

Comparisons significant at the 0.05 level are indicated by \*\*\*.

country Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
Europ - Japan	1.3385	-0.9645	3.6414	
Europ - US	3.0016	1.2571	4.7462	***
Japan - Europ	-1.3385	-3.6414	0.9645	
Japan - US	1.6632	-0.1368	3.4631	
US - Europ	-3.0016	-4.7462	-1.2571	***
US - Japan	-1.6632	-3.4631	0.1368	

The REG Procedure  
 Model: MODEL1  
 Dependent Variable: kpl Kilometers per Litre

Number of Observations Read 100  
 Number of Observations Used 100

NOTE: No intercept in model. R-Square is redefined.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	8171.06221	2042.76555	727.18	<.0001
Error	96	269.67779	2.80914		
Uncorrected Total	100	8440.74000			

Root MSE 1.67605 R-Square 0.9681  
 Dependent Mean 8.79480 Adj R-Sq 0.9667  
 Coeff Var 19.05728

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value
weight	Weight in kg	1	-0.00604	0.00057080	-10.58
c1		1	17.46248	0.90078	19.39
c2		1	17.68593	0.76217	23.20
c3		1	16.22634	0.76312	21.26

Parameter Estimates

Variable	Label	DF	Pr >  t
weight	Weight in kg	1	<.0001
c1		1	<.0001
c2		1	<.0001
c3		1	<.0001

Metric Cars Data Part Two: Cell means coding and ANCOVA 6  
 Cell Means Coding  
 Controlling for weight, Country F = 3.07, USvsEURO F = 0.16

The REG Procedure  
 Model: MODEL1

Test country Results for Dependent Variable kpl

Source	DF	Mean Square	F Value	Pr > F
Numerator	2	8.61683	3.07	0.0511
Denominator	96	2.80914		

Metric Cars Data Part Two: Cell means coding and ANCOVA 7  
 Cell Means Coding  
 Controlling for weight, Country F = 3.07, USvsEURO F = 0.16

The REG Procedure  
 Model: MODEL1

Test USvsEURO Results for Dependent Variable kpl

Source	DF	Mean Square	F Value	Pr > F
Numerator	1	0.45529	0.16	0.6881
Denominator	96	2.80914		

Metric Cars Data Part Two: Cell means coding and ANCOVA 8  
 Cell Means Coding  
 Controlling for weight, Country F = 3.07, USvsEURO F = 0.16

The REG Procedure  
 Model: MODEL1

Test USvsJAPAN Results for Dependent Variable kpl

Source	DF	Mean Square	F Value	Pr > F
Numerator	1	13.02249	4.64	0.0338
Denominator	96	2.80914		

Metric Cars Data Part Two: Cell means coding and ANCOVA 9  
 Cell Means Coding  
 Controlling for weight, Country F = 3.07, USvsEURO F = 0.16

The REG Procedure  
 Model: MODEL1

Test EUROvsJAPAN Results for Dependent Variable kpl

Source	DF	Mean Square	F Value	Pr > F
Numerator	1	14.35601	5.11	0.0260
Denominator	96	2.80914		

Metric Cars Data Part Two: Cell means coding and ANCOVA 10  
 Weight is Covariate (Illustrating WRONG Bonferroni tests!)

The GLM Procedure

Class Level Information

Class	Levels	Values
country	3	Europ Japan US

Number of Observations Read	100
Number of Observations Used	100

Metric Cars Data Part Two: Cell means coding and ANCOVA 11  
 Weight is Covariate (Illustrating WRONG Bonferroni tests!)

The GLM Procedure

Dependent Variable: kpl Kilometers per Litre

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	436.2115072	145.4038357	51.76	<.0001
Error	96	269.6777888	2.8091436		
Corrected Total	99	705.8892960			

R-Square	Coeff Var	Root MSE	kpl Mean
0.617960	19.05728	1.676050	8.794800



The GLM Procedure

Bonferroni (Dunn) t Tests for kpl

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than Tukey's for all pairwise comparisons.

Alpha	0.05
Error Degrees of Freedom	96
Error Mean Square	2.809144
Critical Value of t	2.43665

Comparisons significant at the 0.05 level are indicated by \*\*\*.

country Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
Europ - Japan	1.3385	-0.2345	2.9115	
Europ - US	3.0016	1.8101	4.1932	***
Japan - Europ	-1.3385	-2.9115	0.2345	
Japan - US	1.6632	0.4338	2.8926	***
US - Europ	-3.0016	-4.1932	-1.8101	***
US - Japan	-1.6632	-2.8926	-0.4338	***

Warning: This last set of Bonferroni tests is garbage!