Appendix B

Joint Model with Data from Both Indiana and Michigan

The SAS System 11:40 Monday, December 6, 2010 1

The QLIM Procedure

Discrete Response Profile of KAcr

Index	Value	Frequency	Percent
1	0	5052	96.56
2	1	170	3.25
3	2	10	0.19

Discrete Response Profile of BCcr

Index	Value	Frequency	Percent
1	0	4416	84.40
2	1	576	11.01
3	2	168	3.21
4	3	45	0.86
5	4	20	0.38
6	5	7	0.13

Discrete Response Profile of PDOcr

Index	Value	Frequency	Percent
1	0	3580	68.43
2	1	843	16.11
3	2	355	6.79
4	3	184	3.52
5	4	116	2.22
6	5	51	0.97
7	6	24	0.46
8	7	79	1.51

Model Fit Summary

Number of Endogenous Variables	3	
Endogenous Variable	KAcr BCcr PDOcr	
Number of Observations	5232	
Missing Values	17	
Log Likelihood	-7721	(44 parameters/d.o.f.)
Maximum Absolute Gradient	0.01556	
Number of Iterations	110	
Optimization Method	Newton-Raphson	
AIC	15529	
Schwarz Criterion	15818	
Seed for Monte Carlo Integration	850810001	
Number of Draws	20	

Algorithm converged.

The SAS System 11:40 Monday, December 6, 2010 2

The QLIM Procedure

Parameter Estimates

Parameter	DF	Estimate	Standard Error	Approx t Value	Approx Pr > |t|
KAcr.Intercept	1	-1.532772	0.068303	-22.44	<.0001
KAcr.TwoLTB	1	0.499629	0.078106	6.40	<.0001

KAcr.TwoLTacl	1	-0.400926	0.239754	-1.67	0.0945
KAcr.CommLU	1	0.303326	0.112506	2.70	0.0070
KAcr.Indiana	1	-0.749011	0.085528	-8.76	<.0001
_Limit2.KAcr	1	1.123681	0.099931	11.24	<.0001
BCcr.Intercept	1	-1.019192	0.084192	-12.11	<.0001
BCcr.OneLTB	1	0.163937	0.064400	2.55	0.0109
BCcr.TwoLTB	1	0.487907	0.060767	8.03	<.0001
BCcr.TwoLTacl	1	-0.970522	0.185893	-5.22	<.0001
BCcr.ResidLU	1	0.092299	0.046405	1.99	0.0467
BCcr.CommLU	1	0.414642	0.077032	5.38	<.0001
BCcr.SchlChLU	1	0.473987	0.212056	2.24	0.0254
BCcr.AADT	1	0.162685	0.029823	5.46	<.0001
BCcr.INDOTrd	1	0.494408	0.081471	6.07	<.0001
BCcr.RXRmaj	1	0.447423	0.255185	1.75	0.0795
BCcr.Indiana	1	-0.822445	0.070141	-11.73	<.0001
BCcr.UTB	1	0.257606	0.082826	3.11	0.0019
_Limit2.BCcr	1	0.772219	0.029936	25.80	<.0001
_Limit3.BCcr	1	1.365527	0.049716	27.47	<.0001
_Limit4.BCcr	1	1.777770	0.073358	24.23	<.0001
_Limit5.BCcr	1	2.289772	0.128536	17.81	<.0001
PDOcr.Intercept	1	0.961046	0.179793	5.35	<.0001
PDOcr.TwoLTB	1	0.305307	0.050850	6.00	<.0001
PDOcr.TwoLTacl	1	-0.961801	0.152820	-6.29	<.0001
PDOcr.DrvwMaj36	1	-0.458395	0.161286	-2.84	0.0045
PDOcr.CommLU	1	0.463906	0.070169	6.61	<.0001
PDOcr.AADT	1	0.265663	0.026551	10.01	<.0001
PDOcr.Speed60	1	-0.090939	0.054084	-1.68	0.0927
PDOcr.ang75a90	1	-0.203401	0.040635	-5.01	<.0001
PDOcr.OneRTB	1	0.222421	0.052181	4.26	<.0001
PDOcr.TwoRTB	1	0.295875	0.054147	5.46	<.0001
PDOcr.INDOTrd	1	0.710077	0.072569	9.78	<.0001
PDOcr.AnyRTtpr	1	-0.261534	0.051428	-5.09	<.0001
PDOcr.Indiana	1	-2.298051	0.170642	-13.47	<.0001
_Limit2.PDOcr	1	0.823946	0.026096	31.57	<.0001
_Limit3.PDOcr	1	1.375727	0.035443	38.82	<.0001
_Limit4.PDOcr	1	1.796672	0.042935	41.85	<.0001
_Limit5.PDOcr	1	2.186852	0.051239	42.68	<.0001
_Limit6.PDOcr	1	2.431034	0.057541	42.25	<.0001
_Limit7.PDOcr	1	2.577459	0.062066	41.53	<.0001
_Rho.KAcr.BCcr	1	0.320684	0.038905	8.24	<.0001
_Rho.KAcr.PDOcr	1	0.222309	0.034848	6.38	<.0001
_Rho.BCcr.PDOcr	1	0.382542	0.021492	17.80	<.0001

Model with Data from Indiana

The SAS System 11:51 Monday, December 6, 2010 1

The QLIM Procedure

Discrete Response Profile of KAcr

Index	Value	Frequency	Percent
1	0	4321	97.32
2	1	113	2.55
3	2	6	0.14

Discrete Response Profile of BCcr

Index	Value	Frequency	Percent
1	0	3929	88.49
2	1	370	8.33
3	2	95	2.14

4	3	34	0.77
5	4	9	0.20
6	5	3	0.07

Discrete Response Profile of PDOcr

Index	Value	Frequency	Percent
1	0	3544	79.82
2	1	615	13.85
3	2	169	3.81
4	3	55	1.24
5	4	27	0.61
6	5	5	0.11
7	6	7	0.16
8	7	18	0.41

Model Fit Summary

Number of Endogenous Variables	3	
Endogenous Variable	KAcr BCcr PDOcr	
Number of Observations	4440	
Missing Values	16	
Log Likelihood	-5218	(40 parameters/d.o.f.)
Maximum Absolute Gradient	0.02693	
Number of Iterations	91	
Optimization Method	Newton-Raphson	
AIC	10516	
Schwarz Criterion	10772	
Seed for Monte Carlo Integration	562742001	
Number of Draws	20	

Algorithm converged.

The QLIM Procedure

Parameter Estimates

Parameter	DF	Estimate	Standard Error	Approx t Value	Pr > |t|
KAcr.Intercept	1	-2.310513	0.079251	-29.15	<.0001
KAcr.TwoLTB	1	0.530686	0.092132	5.76	<.0001
KAcr.TwoLTacl	1	-0.452587	0.239856	-1.89	0.0592
KAcr.CommLU	1	0.450437	0.124620	3.61	0.0003
_Limit2.KAcr	1	1.114564	0.124729	8.94	<.0001
BCcr.Intercept	1	-1.989949	0.083046	-23.96	<.0001
BCcr.OneLTB	1	0.340248	0.091134	3.73	0.0002
BCcr.TwoLTB	1	0.599290	0.083658	7.16	<.0001
BCcr.TwoLTacl	1	-1.050739	0.191178	-5.50	<.0001
BCcr.ResidLU	1	0.164570	0.053380	3.08	0.0020
BCcr.CommLU	1	0.407336	0.089267	4.56	<.0001
BCcr.SchlChLU	1	0.474213	0.210338	2.25	0.0242
BCcr.AADT	1	0.161565	0.035183	4.59	<.0001
BCcr.INDOTrd	1	0.452974	0.059608	7.60	<.0001
BCcr.RXRmaj	1	0.418475	0.251469	1.66	0.0961
_Limit2.BCcr	1	0.721591	0.035530	20.31	<.0001
_Limit3.BCcr	1	1.239702	0.058475	21.20	<.0001
_Limit4.BCcr	1	1.768024	0.101232	17.47	<.0001
_Limit5.BCcr	1	2.235643	0.176023	12.70	<.0001
PDOcr.Intercept	1	-1.412597	0.086803	-16.27	<.0001
PDOcr.TwoLTB	1	0.301936	0.059307	5.09	<.0001
PDOcr.TwoLTacl	1	-0.942845	0.154422	-6.11	<.0001
PDOcr.DrvwMaj36	1	-0.419144	0.161415	-2.60	0.0094

PDOcr.CommLU	1	0.353380	0.081775	4.32 <.0001
PDOcr.AADT	1	0.276996	0.031607	8.76 <.0001
PDOcr.Speed60	1	-0.072487	0.055029	-1.32 0.1878
PDOcr.ang75a90	1	-0.127382	0.048019	-2.65 0.0080
PDOcr.OneRTB	1	0.267070	0.063999	4.17 <.0001
PDOcr.TwoRTB	1	0.293962	0.069839	4.21 <.0001
PDOcr.INDOTrd	1	0.514137	0.055716	9.23 <.0001
PDOcr.AnyRTtpr	1	-0.265162	0.054787	-4.84 <.0001
_Limit2.PDOcr	1	0.749892	0.028049	26.74 <.0001
_Limit3.PDOcr	1	1.226168	0.042198	29.06 <.0001
_Limit4.PDOcr	1	1.539036	0.055228	27.87 <.0001
_Limit5.PDOcr	1	1.810990	0.070831	25.57 <.0001
_Limit6.PDOcr	1	1.883891	0.075988	24.79 <.0001
_Limit7.PDOcr	1	2.010157	0.086160	23.33 <.0001
_Rho.KAcr.BCcr	1	0.345502	0.045620	7.57 <.0001
_Rho.KAcr.PDOcr	1	0.284848	0.043965	6.48 <.0001
_Rho.BCcr.PDOcr	1	0.454917	0.025953	17.53 <.0001

Model with Data from Michigan

The SAS System 11:59 Monday, December 6, 2010 1

The QLIM Procedure

Discrete Response Profile of KAcr

Index	Value	Frequency	Percent
1	0	735	92.34
2	1	57	7.16
3	2	4	0.50

Discrete Response Profile of BCcr

Index	Value	Frequency	Percent
1	0	491	61.68
2	1	206	25.88
3	2	73	9.17
4	3	11	1.38
5	4	11	1.38
6	5	4	0.50

Discrete Response Profile of PDOcr

Index	Value	Frequency	Percent
1	0	40	5.03
2	1	228	28.64
3	2	186	23.37
4	3	129	16.21
5	4	89	11.18
6	5	46	5.78
7	6	17	2.14
8	7	61	7.66

Model Fit Summary

Number of Endogenous Variables 3

Endogenous Variable KAcr BCcr PDOcr
Number of Observations 796
Log Likelihood -2390 (33 parameters/d.o.f.)
Maximum Absolute Gradient 0.00214
Number of Iterations 53
Optimization Method Newton-Raphson
AIC 4845
Schwarz Criterion 5000
Seed for Monte Carlo Integration 25357001
Number of Draws 20

Algorithm converged.

The QLIM Procedure

Parameter Estimates

Parameter	DF	Estimate	Standard Error	Approx t Value	Pr > |t|
KAcr.Intercept	1	-1.479642	0.077775	-19.02	<.0001
KAcr.TwoLTB	1	0.337508	0.159056	2.12	0.0338
KAcr.CommLU	1	-0.237245	0.276366	-0.86	0.3906
_Limit2.KAcr	1	1.158050	0.169599	6.83	<.0001
BCcr.Intercept	1	-0.657018	0.152898	-4.30	<.0001
BCcr.OneLTB	1	0.062864	0.118850	0.53	0.5969
BCcr.TwoLTB	1	0.417394	0.120050	3.48	0.0005
BCcr.ResidLU	1	-0.291746	0.104145	-2.80	0.0051
BCcr.CommLU	1	0.459217	0.164838	2.79	0.0053
BCcr.AADT	1	0.055554	0.066853	0.83	0.4060
BCcr.INDOTrd	1	-0.004919	0.164371	-0.03	0.9761
BCcr.UTB	1	0.439550	0.100356	4.38	<.0001
_Limit2.BCcr	1	0.908072	0.056412	16.10	<.0001
_Limit3.BCcr	1	1.648324	0.092973	17.73	<.0001
_Limit4.BCcr	1	1.902131	0.113205	16.80	<.0001
_Limit5.BCcr	1	2.452004	0.189114	12.97	<.0001
PDOcr.Intercept	1	1.217551	0.140719	8.65	<.0001
PDOcr.TwoLTB	1	0.257347	0.113963	2.26	0.0239
PDOcr.CommLU	1	1.052969	0.152110	6.92	<.0001
PDOcr.AADT	1	0.213673	0.056658	3.77	0.0002
PDOcr.ang75a90	1	-0.476507	0.083532	-5.70	<.0001
PDOcr.OneRTB	1	0.089933	0.095067	0.95	0.3441
PDOcr.TwoRTB	1	0.347384	0.094759	3.67	0.0002
PDOcr.INDOTrd	1	0.528275	0.142851	3.70	0.0002
_Limit2.PDOcr	1	1.249140	0.075727	16.50	<.0001
_Limit3.PDOcr	1	1.893322	0.081632	23.19	<.0001
_Limit4.PDOcr	1	2.383576	0.086378	27.59	<.0001
_Limit5.PDOcr	1	2.833897	0.092719	30.56	<.0001
_Limit6.PDOcr	1	3.169115	0.099770	31.76	<.0001
_Limit7.PDOcr	1	3.332841	0.104321	31.95	<.0001
_Rho.KAcr.BCcr	1	0.162806	0.075163	2.17	0.0303
_Rho.KAcr.PDOcr	1	0.049904	0.063290	0.79	0.4304
_Rho.BCcr.PDOcr	1	0.122767	0.043313	2.83	0.0046

Likelihood Ratio Test for Parameter Transferability between Indiana and Michigan Data

The likelihood ratio test (LRT) is:

$$X^2 = -2 \times [LL(\beta_T) - LL(\beta_a) - LL(\beta_b)]$$

where, α and b the Indiana and Michigan models, respectively, between which the transferability of parameters is tested, $LL(\beta_T)$ the log likelihood at convergence of the model estimated with the intersection data from both States (T), $LL(\beta_\alpha)$ the log likelihood of convergence of the model using Indiana data (α), and $LL(\beta_b)$ the log likelihood of convergence of the model using Michigan data (b). This X^2 test statistic is χ^2 distributed with degrees of freedom equal to the summation of the number of estimated parameters in both Indiana and Michigan models (α and b) minus the number of estimated parameters in the full model (T). Table 1 below summarizes the LRT for the developed models. At a 0.90 level of confidence, the tests showed that there is evidence to reject the hypothesis of equality across the two data segments (the null hypothesis is rejected by a very large margin). N is the number of observations, $LL(\beta)$ the log likelihood at convergence, *d.o.f.* the degrees of freedom, χ^2 the chi-squared statistic, $LL(\beta)$ *d.o.f.* the test's *d.o.f.*, χ^2 *critical* the critical value of the chi-squared of the test with $LL(\beta)$ *d.o.f.* at a 0.90 level of confidence, and H_0 is the null hypothesis that the parameters are transferable.

Table 1. Likelihood ratio test for parameter transferability between Indiana and Michigan data (at 0.90 level of confidence)

	N	*LL(β)*	*d.o.f.*	χ^2	*LL(β) d.o.f.*	χ^2 *critical*	*Conclusion*
Indiana Intersections	4440	-5218	40				
Michigan Intersections	796	-2390	33	226	29	39.0875	Reject H_0
Joint model (All Intersections)	5232	-7721	44				

Note: $X^2 = -2 \times [LL(\beta_T) - LL(\beta_a) - LL(\beta_b)] = -2 \times [-7721 - (-5218) - (-2390)] = 226$; $d.o.f. = (40 + 33) - 44 = 29$.

Joint Model with Data from Both Indiana and Michigan (only BC crashes)

The SAS System 21:17 Monday, December 6, 2010 1

The QLIM Procedure

Discrete Response Profile of BCcr

Index	Value	Frequency	Percent
1	0	4416	84.40
2	1	576	11.01
3	2	168	3.21
4	3	45	0.86
5	4	20	0.38
6	5	7	0.13

Model Fit Summary

Number of Endogenous Variables	1	
Endogenous Variable	BCcr	
Number of Observations	5232	
Missing Values	17	
Log Likelihood	-2797	(14 parameters/d.o.f.)
Maximum Absolute Gradient	7.77521E-6	
Number of Iterations	49	
Optimization Method	Newton-Raphson	
AIC	5623	

Schwarz Criterion 5714

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	343.53	2 * (LogL - LogL0)
Upper Bound of R (U)	5938.1	- 2 * LogL0
Aldrich-Nelson	0.0616	R / (R+N)
Cragg-Uhler 1	0.0636	1 - exp(-R/N)
Cragg-Uhler 2	0.0937	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.0654	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.0601	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.0579	R / U
Veall-Zimmermann	0.1159	(R * (U+N)) / (U * (R+N))
McKelvey-Zavoina	0.105	

N = # of observations, K = # of regressors

Algorithm converged.

Parameter Estimates

Parameter	DF	Standard Estimate	Approx Error	t Value	Pr > |t|
Intercept	1	-1.574595	0.057261	-27.50	<.0001
TwoLTB	1	0.199208	0.058346	3.41	0.0006
ResidLU	1	-0.005477	0.047314	-0.12	0.9078
CommLU	1	0.384058	0.073476	5.23	<.0001
OneUTB	1	1.115989	0.156680	7.12	<.0001
TwoUTB	1	0.851868	0.097192	8.76	<.0001
ang75a90	1	0.024603	0.046067	0.53	0.5933
MedGT80	1	-0.216518	0.091838	-2.36	0.0184
AADT	1	0.202906	0.030264	6.70	<.0001
TwoRTB	1	0.064537	0.059338	1.09	0.2768
_Limit2	1	0.732849	0.028641	25.59	<.0001
_Limit3	1	1.292188	0.048121	26.85	<.0001
_Limit4	1	1.683086	0.071396	23.57	<.0001
_Limit5	1	2.174297	0.126540	17.18	<.0001

Model with Data from Indiana (only BC crashes)

The SAS System 21:11 Monday, December 6, 2010 1

The QLIM Procedure

Discrete Response Profile of BCcr

Index	Value	Frequency	Percent
1	0	3929	88.49
2	1	370	8.33
3	2	95	2.14
4	3	34	0.77
5	4	9	0.20
6	5	3	0.07

Model Fit Summary

Number of Endogenous Variables	1	
Endogenous Variable	BCcr	
Number of Observations	4440	
Missing Values	16	
Log Likelihood	-1943	(12 parameters/d.o.f.)
Maximum Absolute Gradient	0.0001407	
Number of Iterations	45	
Optimization Method	Newton-Raphson	
AIC		3910
Schwarz Criterion	3987	

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	130.93	2 * (LogL - LogL0)
Upper Bound of R (U)	4016.8	- 2 * LogL0
Aldrich-Nelson	0.0286	R / (R+N)
Cragg-Uhler 1	0.0291	1 - exp(-R/N)
Cragg-Uhler 2	0.0488	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.0295	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.0241	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.0326	R / U
Veall-Zimmermann	0.0603	(R * (U+N)) / (U * (R+N))
McKelvey-Zavoina	0.073	

N = # of observations, K = # of regressors

Algorithm converged.

Parameter Estimates

Parameter	DF	Standard Estimate	Approx Error	t Value	Pr > |t|
Intercept	1	-1.714869	0.066048	-25.96	<.0001
TwoLTB	1	0.307801	0.068637	4.48	<.0001
ResidLU	1	0.152590	0.054754	2.79	0.0053
CommLU	1	0.386819	0.085765	4.51	<.0001
ang75a90	1	-0.025037	0.057043	-0.44	0.6607
MedGT80	1	-0.284257	0.216649	-1.31	0.1895
AADT	1	0.152154	0.036042	4.22	<.0001
TwoRTB	1	0.092789	0.069157	1.34	0.1797
_Limit2	1	0.681845	0.033705	20.23	<.0001
_Limit3	1	1.158634	0.055746	20.78	<.0001
_Limit4	1	1.647860	0.096779	17.03	<.0001
_Limit5	1	2.092132	0.173268	12.07	<.0001

Model with Data from Michigan (only BC crashes)

The SAS System 20:47 Monday, December 6, 2010 47

The QLIM Procedure

Discrete Response Profile of BCcr

Index	Value	Frequency	Percent
1	0	491	61.68
2	1	206	25.88
3	2	73	9.17
4	3	11	1.38
5	4	11	1.38
6	5	4	0.50

Model Fit Summary

Number of Endogenous Variables	1	
Endogenous Variable	BCcr	
Number of Observations	796	
Log Likelihood	-763.36868	(14 parameters/d.o.f.)
Maximum Absolute Gradient	2.82701E-6	
Number of Iterations	47	
Optimization Method	Newton-Raphson	
AIC		1555
Schwarz Criterion		1620

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	84.187	2 * (LogL - LogL0)
Upper Bound of R (U)	1610.9	- 2 * LogL0
Aldrich-Nelson	0.0956	R / (R+N)
Cragg-Uhler 1	0.1004	1 - exp(-R/N)
Cragg-Uhler 2	0.1156	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.1029	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.0693	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.0523	R / U
Veall-Zimmermann	0.1429	(R * (U+N)) / (U * (R+N))
McKelvey-Zavoina	0.1248	

N = # of observations, K = # of regressors

Algorithm converged.

Parameter Estimates

Parameter	DF	Estimate	Standard Error	Approx t Value	Pr > |t|
Intercept	1	-0.523690	0.143131	-3.66	0.0003
TwoLTB	1	0.598693	0.140961	4.25	<.0001
ResidLU	1	-0.377424	0.113042	-3.34	0.0008
CommLU	1	0.415902	0.163379	2.55	0.0109
OneUTB	1	0.705661	0.172727	4.09	<.0001
TwoUTB	1	0.617566	0.147084	4.20	<.0001
ang75a90	1	-0.332403	0.093959	-3.54	0.0004
MedGT80	1	-0.333454	0.108541	-3.07	0.0021
AADT	1	0.120755	0.068696	1.76	0.0788
TwoRTB	1	-0.224593	0.132963	-1.69	0.0912
_Limit2	1	0.928053	0.057682	16.09	<.0001
_Limit3	1	1.686093	0.095569	17.64	<.0001

_Limit4	1	1.946457	0.116332	16.73	<.0001
_Limit5	1	2.504467	0.192826	12.99	<.0001

Likelihood Ratio Test for Parameter Transferability between Indiana and Michigan Data (BC crashes only)

The likelihood ratio test (LRT) is:

$$X^2 = -2 \times [LL(\beta_T) - LL(\beta_a) - LL(\beta_b)]$$

where, α and b the Indiana and Michigan models, respectively, between which the transferability of parameters is tested, $LL(\beta_T)$ the log likelihood at convergence of the model estimated with the intersection data from both States (T), $LL(\beta_a)$ the log likelihood of convergence of the model using Indiana data (α), and $LL(\beta_b)$ the log likelihood of convergence of the model using Michigan data (b). This X^2 test statistic is χ^2 distributed with degrees of freedom equal to the summation of the number of estimated parameters in both Indiana and Michigan models (α and b) minus the number of estimated parameters in the full model (T). Table 1 below summarizes the LRT for the developed models. At a 0.90 level of confidence, the tests showed that there is evidence to reject the hypothesis of equality across the two data segments (the null hypothesis is rejected by a very large margin). N is the number of observations, $LL(\beta)$ the log likelihood at convergence, *d.o.f.* the degrees of freedom, χ^2 the chi-squared statistic, $LL(\beta)$ *d.o.f.* the test's *d.o.f.*, χ^2 *critical* the critical value of the chi-squared of the test with $LL(\beta)$ *d.o.f.* at a 0.90 level of confidence, and H_0 is the null hypothesis that the parameters are transferable.

Table 1. Likelihood ratio test for parameter transferability between Indiana and Michigan data (at 0.90 level of confidence)

	N	$LL(\beta)$	*d.o.f.*	χ^2	$LL(\beta)$ *d.o.f.*	χ^2 *critical*	*Conclusion*
Indiana Intersections	4440	-1943	12				
Michigan Intersections	796	-763.37	14	181.26	12	18.5493	Reject H_0
Joint model (All Intersections)	5232	-2797	14				

Note: $X^2 = -2 \times [LL(\beta_T) - LL(\beta_a) - LL(\beta_b)] = -2 \times [-2797 - (-1943) - (-763.37)] = 226$; $d.o.f. = (12 + 14) - 14 = 12$.

Joint Model with Data from Both Indiana and Michigan (only BC crashes)

The SAS System 21:56 Monday, December 6, 2010 1

The QLIM Procedure

Discrete Response Profile of BCcr

Index	Value	Frequency	Percent
1	0	4416	84.40
2	1	576	11.01
3	2	168	3.21
4	3	45	0.86
5	4	20	0.38
6	5	7	0.13

Model Fit Summary

Number of Endogenous Variables 1

Endogenous Variable	BCcr	
Number of Observations	5232	
Missing Values	17	
Log Likelihood	-2868	(10 parameters/d.o.f.)
Maximum Absolute Gradient	6.05807E-7	
Number of Iterations	21	
Optimization Method	Newton-Raphson	
AIC	5755	
Schwarz Criterion	5821	

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	202.88	2 * (LogL - LogL0)
Upper Bound of R (U)	5938.1	- 2 * LogL0
Aldrich-Nelson	0.0373	R / (R+N)
Cragg-Uhler 1	0.038	1 - exp(-R/N)
Cragg-Uhler 2	0.0561	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.0387	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.0349	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.0342	R / U
Veall-Zimmermann	0.0702	(R * (U+N)) / (U * (R+N))
McKelvey-Zavoina	0.0723	

N = # of observations, K = # of regressors

Algorithm converged.

Parameter Estimates

Parameter	DF	Standard Estimate	Error	Approx t Value	Pr > |t|
Intercept	1	-1.584436	0.053316	-29.72	<.0001
TwoLTB	1	0.101385	0.041687	2.43	0.0150
ResidLU	1	0.000646	0.046240	0.01	0.9888
CommLU	1	0.426151	0.071733	5.94	<.0001
ang75a90	1	0.055956	0.045353	1.23	0.2173
AADT	1	0.291685	0.026698	10.93	<.0001
_Limit2	1	0.706981	0.027637	25.58	<.0001
_Limit3	1	1.244859	0.046422	26.82	<.0001
_Limit4	1	1.617235	0.068490	23.61	<.0001
_Limit5	1	2.073887	0.119240	17.39	<.0001

Model with Data from Indiana (only BC crashes)

The SAS System 21:50 Monday, December 6, 2010 1

The QLIM Procedure

Discrete Response Profile of BCcr

Index	Value	Frequency	Percent
1	0	3929	88.49
2	1	370	8.33
3	2	95	2.14
4	3	34	0.77
5	4	9	0.20
6	5	3	0.07

Model Fit Summary

Number of Endogenous Variables	1	
Endogenous Variable	BCcr	
Number of Observations	4440	
Missing Values	16	
Log Likelihood	-1945	(10 parameters/d.o.f.)
Maximum Absolute Gradient	7.35801E-6	
Number of Iterations	20	
Optimization Method	Newton-Raphson	
AIC	3910	
Schwarz Criterion	3974	

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	127.16	2 * (LogL - LogL0)
Upper Bound of R (U)	4016.8	- 2 * LogL0
Aldrich-Nelson	0.0278	R / (R+N)
Cragg-Uhler 1	0.0282	1 - exp(-R/N)
Cragg-Uhler 2	0.0474	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.0287	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.0242	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.0317	R / U
Veall-Zimmermann	0.0586	(R * (U+N)) / (U * (R+N))
McKelvey-Zavoina	0.0698	

N = # of observations, K = # of regressors

Algorithm converged.

Parameter Estimates

Parameter	DF	Estimate	Standard Error	Approx t Value	Approx Pr > |t|
Intercept	1	-1.696782	0.062437	-27.18	<.0001
TwoLTB	1	0.368087	0.051755	7.11	<.0001
ResidLU	1	0.150059	0.054653	2.75	0.0060
CommLU	1	0.411158	0.084407	4.87	<.0001
ang75a90	1	-0.020811	0.056979	-0.37	0.7149
AADT	1	0.137062	0.033806	4.05	<.0001
_Limit2	1	0.681390	0.033690	20.23	<.0001
_Limit3	1	1.158517	0.055756	20.78	<.0001
_Limit4	1	1.648351	0.096854	17.02	<.0001
_Limit5	1	2.092832	0.173286	12.08	<.0001

Model with Data from Michigan (only BC crashes)

The SAS System 21:44 Monday, December 6, 2010 1

The QLIM Procedure

Discrete Response Profile of BCcr

	Index	Value	Frequency	Percent
1	0		491	61.68
2	1		206	25.88
3	2		73	9.17
4	3		11	1.38
5	4		11	1.38
6	5		4	0.50

Model Fit Summary

Number of Endogenous Variables	1	
Endogenous Variable	BCcr	
Number of Observations	796	
Log Likelihood	-777.46006	(10 parameters/d.o.f.)
Maximum Absolute Gradient	9.90268E-7	
Number of Iterations	18	
Optimization Method	Newton-Raphson	
AIC	1575	
Schwarz Criterion	1622	

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	56.004	2 * (LogL - LogL0)
Upper Bound of R (U)	1610.9	- 2 * LogL0
Aldrich-Nelson	0.0657	R / (R+N)
Cragg-Uhler 1	0.0679	1 - exp(-R/N)
Cragg-Uhler 2	0.0783	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.0691	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.0447	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)

McFadden's LRI 0.0348 R / U
Veall-Zimmermann 0.0982 (R * (U+N)) / (U * (R+N))
McKelvey-Zavoina 0.0859

N = # of observations, K = # of regressors

Algorithm converged.

Parameter Estimates

Parameter	DF	Standard Estimate	Error	Approx t Value	Pr > |t|
Intercept	1	-0.577494	0.133189	-4.34	<.0001
TwoLTB	1	0.431556	0.115924	3.72	0.0002
ResidLU	1	-0.254115	0.097388	-2.61	0.0091
CommLU	1	0.597484	0.154750	3.86	0.0001
ang75a90	1	-0.406254	0.091102	-4.46	<.0001
AADT	1	0.209800	0.060034	3.49	0.0005
_Limit2	1	0.904775	0.056218	16.09	<.0001
_Limit3	1	1.635022	0.092330	17.71	<.0001
_Limit4	1	1.882196	0.111916	16.82	<.0001
_Limit5	1	2.411939	0.184661	13.06	<.0001

Likelihood Ratio Test for Parameter Transferability between Indiana and Michigan Data (BC crashes only)

The likelihood ratio test (LRT) is:

$$X^2 = -2 \times [LL(\beta_T) - LL(\beta_a) - LL(\beta_b)]$$

where, α and b the Indiana and Michigan models, respectively, between which the transferability of parameters is tested, $LL(\beta_T)$ the log likelihood at convergence of the model estimated with the intersection data from both States (T), $LL(\beta_\alpha)$ the log likelihood of convergence of the model using Indiana data (α), and $LL(\beta_b)$ the log likelihood of convergence of the model using Michigan data (b). This X^2 test statistic is χ^2 distributed with degrees of freedom equal to the summation of the number of estimated parameters in both Indiana and Michigan models (α and b) minus the number of estimated parameters in the full model (T). Table 1 below summarizes the LRT for the developed models. At a 0.90 level of confidence, the tests showed that there is evidence to reject the hypothesis of equality across the two data segments (the null hypothesis is rejected by a very large margin). N is the number of observations, $LL(\beta)$ the log likelihood at convergence, *d.o.f.* the degrees of freedom, χ^2 the chi-squared statistic, $LL(\beta)$ *d.o.f.* the test's *d.o.f.*, χ^2 *critical* the critical value of the chi-squared of the test with $LL(\beta)$ *d.o.f.* at a 0.90 level of confidence, and H_0 is the null hypothesis that the parameters are transferable.

Table 1. Likelihood ratio test for parameter transferability between Indiana and Michigan data (at 0.90 level of confidence)

	N	*LL(β)*	*d.o.f.*	χ^2	*LL(β) d.o.f.*	χ^2 *critical*	*Conclusion*
Indiana Intersections	4440	-1945	10				
Michigan Intersections	796	-777.46	10	291.08	10	15.9872	Reject H_0
Joint model (All Intersections)	5232	-2868	10				

Note: $X^2 = -2 \times [LL(\beta_T) - LL(\beta_a) - LL(\beta_b)] = -2 \times [-2797 - (-1943) - (-763.37)] = 226$; $d.o.f. = (12 + 14) - 14 = 12$.

Table B-1 Crash statistics from the Michigan and Indiana datasets

Crashes by Severity Category for Michigan Intersections WITH U-Turns

Discrete Response Profile of KAcrUT

Value	Frequency	Percent
0	348	43.72
1	30	3.77
Total*	30 (0.079/int.)	

Discrete Response Profile of BCcrUT

Value	Frequency	Percent
0	208	26.13
1	105	13.19
2	45	5.65
3	8	1.01
4	8	1.01
5	4	0.50
Total*	271 (0.72/int.)	

Discrete Response Profile of PDOcrNUT

Value	Frequency	Percent
0	17	2.14
1	92	11.56
2	80	10.05
3	65	8.17
4	35	4.40
5	27	3.39
6	7	0.88
7	55	6.91
Total*	1149 (3.04/int.)	
TOTAL*	1450 (3.84/int.)	

Crashes by Severity Category for Michigan Intersections WITHOUT U-Turns

Discrete Response Profile of KAcrNUT

Value	Frequency	Percent
0	387	48.62
1	27	3.39
2	4	0.50
Total*	35 (0.084/int.)	

Discrete Response Profile of BCcrNUT

Value	Frequency	Percent
0	283	35.55
1	101	12.69
2	28	3.52
3	3	0.38
4	3	0.38
Total*	178 (0.43/int.)	

Discrete Response Profile of PDOcrNUT

Value	Frequency	Percent
0	23	2.89
1	136	17.09
2	106	13.32
3	64	8.04
4	54	6.78
5	19	2.39
6	10	1.26
7	6	0.75
Total*	953 (2.28/int.)	
TOTAL*	1166 (2.79/int.)	

*** Note that Total values represent number of crashes per intersection per year.**