

Statistical and Econometric Methods for Transportation Data Analysis

Chapter 5 – Simultaneous-Equation Models

Example 5.2 (with 3SLS Extensions) Seemingly Unrelated Regression Estimation and 3SLS

A survey of 206 people was conducted on the campus of Purdue University in the Fall of 2007. One of the key questions of the survey was to find out how fast people drove on interstate highways with speed limits of 55 mph, 65 mph and 70 mph.

Your task is to first estimate a seemingly unrelated regression model to determine the normal driving speed of individuals in this data sample. The equation system:

$$\begin{aligned}Speed_{70} &= \beta_{70}Z + \alpha_{70}X + \varepsilon_{70} \\Speed_{65} &= \beta_{65}Z + \alpha_{65}X + \varepsilon_{65} \\Speed_{55} &= \beta_{55}Z + \alpha_{55}X + \varepsilon_{55}\end{aligned}$$

In these equations, $Speed_{70}$, $Speed_{65}$ and $Speed_{55}$ are the number of miles per hour respondents normally drive above the speed limit (with little traffic) for 70, 65, and 55 mph speed limits, respectively. These variables can take on positive values if respondents normally drive above the speed limit and negative values if they normally drive below it. Also in these equations, Z is a vector of driver and driver-household characteristics, X is a vector of vector of driver preferences and opinions, β s, α 's, are vectors of estimable parameters, and ε 's are disturbance terms.

Next, estimate the same modeling system using three-stage least squares (3SLS), that is:

$$\begin{aligned}Speed_{70} &= \lambda_{70-65}Speed_{65} + \beta_{70}Z + \alpha_{70}X + \varepsilon_{70} \\Speed_{65} &= \lambda_{65-70}Speed_{70} + \lambda_{65-55}Speed_{55} + \beta_{65}Z + \alpha_{65}X + \varepsilon_{65} \\Speed_{55} &= \lambda_{55-65}Speed_{65} + \beta_{55}Z + \alpha_{55}X + \varepsilon_{55}\end{aligned}$$

Then, provide a write up to include:

1. The results of your best model specification.
2. A discussion of the logical process that led you to the selection of your final specification (the theory behind the inclusion of your selected variables). Include t -statistics and justify the signs of your variables.

PURDUE

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A graduate class at Purdue University is undertaking a survey in an attempt to gain a better understanding of public opinions on a wide variety of subjects. We appreciate your time in completing this survey -- your responses will be strictly confidential.

Section A: Your Opinions and Preferences

- ① 1. On an interstate with a 70mph speed limit and little traffic, about how fast do you normally drive? _____ mph
- ② 2. On an interstate with a 65mph speed limit and little traffic, about how fast do you normally drive? _____ mph
- ③ 3. On an interstate with a 55mph speed limit and little traffic, about how fast do you normally drive? _____ mph
- ④ 4. About how many miles per year do you drive? _____ miles/yr
- ⑤ 5. How many vehicle accidents have you had (while driving) in the last 5 years? _____ years
- ⑥ 6. When braking quickly to avoid a collision do you usually?
1 Brake and steer 2 Brake only 3 Not sure/Depends on situation
- ⑦ 7. Do you have:
1 An engineering background 2 No engineering background
- ⑧ 8. When putting on socks and shoes do you normally:
1 Put both socks on then both shoes 2 One sock, one shoe 3 Not sure/Varies
- ⑨ 9. When waking up in the morning, what leg reaches the floor first from bed:
1 Right 2 Left 3 Both legs at the same time 4 Not sure/Varies
- ⑩ 10. Do you prefer to but online or in a store? 1 Online 2 Store 3 No preference
- ⑪ 11. Do you think Britney Spears should get full custody of her kids? 1 Yes 2 No 3 Don't care
- ⑫ 12. Do you prefer an automatic or manual transmission in your vehicle?
1 Automatic 2 Manual 3 No preference
- ⑬ 13. Do you sometimes smoke cigarettes? 1 Yes 2 No
- ⑭ 14. Do you prefer to text or talk on a cell phone? 1 Text 2 Talk 3 No preference
- ⑮ 15. At Purdue (West Lafayette), what is your favorite season?
1 Spring 2 Summer 3 Fall 4 Winter
- ⑯ 16. During severe winter weather (snow) do you use your car or bus? 1 Car 2 Bus 3 Not sure/Varies
- ⑰ 17. In money matters (investments, gambling, etc) do you consider yourself?
1 Conservative 2 Moderate 3 Risky 4 Don't know
- ⑱ 18. What is the first thing you drink in the morning?
1 Water 2 Juice 3 Milk 4 Soft drink 5 Coffee 6 Energy drink 7 Other
- ⑲ 19. Do you normally skip breakfast? 1 Yes 2 No

(Please Turn Over)

Section A: Continued

20. What drives your decision to accept a job offer?
1 Compensation 2 Career progression opportunities 3 Job location 4 Not sure
21. When showering, do you normally use: 1 Body wash 2 Bar soap 3 Unsure
22. While driving and using your cell phone, do you:
1 Use a headset 2 Use one hand on the phone - one hand on wheel 3 Other
4 Do not use phone while driving
23. When your car is the first in line at a traffic signal (dry road) and the light turns green do you normally:
1 accelerate briskly 2 accelerate moderately 3 accelerate slowly
24. What is the fastest that you (as a driver) have ever driven on an interstate, rural or urban road?
1 less than 70mph 2 70-79mph 3 80-89mph 4 90-99mph 5 100-109mph
6 110-119 mph 7 120-129mph 8 130-139mph 9 more than 140mph
-

Section B: Additional Questions About Yourself

25. Are you? 1 Female 2 Male
26. Are you? 1 Married 2 Single 3 Separated 4 Divorced 5 Other
27. What is your age? _____
28. Are you currently?
1 Not affiliated with Purdue 2 Purdue undergraduate 3 Purdue graduate
4 Purdue faculty 5 Purdue staff (other than RA/TA/faculty)
29. What is your highest completed level of education?
1 Some high school 2 High school diploma 3 Technical college degree (A.A.)
4 College degree 5 Post graduate degree
30. Please indicate your Race/Ethnicity
1 African American 2 American Indian 3 Asian 4 Caucasian
5 Hispanic/White 6 Hispanic/Non-white 7 Other 8 I would rather not answer
31. What is the approximate annual household income of the household you consider home?
1 no income 2 under \$10,000 3 \$10,000-\$19,999 4 \$20,000-\$29,999
5 \$30,000-\$39,999 6 \$40,000-\$49,999 7 \$50,000-\$74,999 8 \$75,000-\$100,000 9 Over \$100,000
32. Including yourself, how many people live in the household you consider home? _____
33. How many children, in the household you consider home, are under age 6? _____
34. How many children, in the household you consider home, are aged 6 to 16? _____
35. How many people living, in the household you consider home, work outside the home? _____
36. How many licensed and operable motor vehicles does your "home" household have? _____
37. Are you a licensed driver? 1 Yes 2 No
- 37a. If you are licensed to drive, how many years have you had a license? _____ years
38. Did you lie about your response to any of the previous questions on this survey? 1 Yes 2 No
-

40 STUDENT ID (Thank you)

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--> RESET
--> read;nvar=40;nobs=206;file=D:\old_drive_d\Book\Book2e-Data\Ex5-2.txt$
--> skip
--> create;ageL=x27-x38$
--> create;if(ageL>17)late=1$
--> create;if(x25=2)male=1$
--> create;if(x26=1)married=1$
--> create;if(x23=1)brisk=1$
--> create;mo70=x1-70$
--> create;mo65=x2-65$
--> create;mo55=x3-55$
--> dstat;rhs=mo70,mo65,mo55$

```

Descriptive Statistics
All results based on nonmissing observations.

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Variable      Mean      Std.Dev.   Minimum   Maximum   Cases Missing
=====

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All observations in current sample

Variable	Mean	Std.Dev.	Minimum	Maximum	Cases	Missing
MO70	5.45366	7.08727	-30.0000	20.0000	205	1
MO65	5.69024	7.15568	-25.0000	25.0000	205	1
MO55	6.24757	7.66951	-40.0000	25.0000	206	0

```

--> reject;x1=-999$
--> reject;x2=-999$
--> reject;x3=-999$
--> reject;x27=-999$
--> reject;x38=-999$
--> reject;x25=-999$
--> reject;x37=2$
--> Sure;lhs=mo70,mo65,mo55
    ;eq1=one,x27,x32,late,brisk,x24
    ;eq2=one,male,x27,x32,late,brisk,x24
    ;eq3=one,x33,late,brisk,x24$

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*****
* NOTE: Deleted      3 observations with missing data. N is now    191 *
*****

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Criterion function for GLS is log-likelihood.

Iteration	0, GLS	=	-1587.460
Iteration	1, GLS	=	-1585.073
Iteration	2, GLS	=	-1585.073
Iteration	3, GLS	=	-1585.073

GLS has converged.

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+-----+
Estimates for equation: MO70
Generalized least squares regression
Model was estimated Sep 13, 2012 at 09:31:08AM
LHS=MO70      Mean          =    5.748691
              Standard deviation =    6.822539
WTS=none     Number of observs. =         191
Model size   Parameters      =          6
              Degrees of freedom =         185
Residuals   Sum of squares   =    7071.643
              Standard error of e =    6.182645
Fit          R-squared       =    .1744634
              Adjusted R-squared =    .1521516
Model test   F[ 5, 185] (prob) =    7.82 (.0000)
Diagnostic   Log likelihood   =   -615.9227
              Restricted(b=0)   =   -637.2802
              Chi-sq [ 5] (prob) =   42.72 (.0000)
Info criter. LogAmemiya Prd. Crt. =    3.674423
              Akaike Info. Criter. =    3.674402
Not using OLS or no constant. Rsqd & F may be < 0.
Log|W|      8.0840 Log-Likelihood =   -1585.0730
Durbin-Watson 1.549 Autocorrelation =    .2255
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Variable	Coefficient	Standard Error	b/St.Er.	P[Z >z]	Mean of X
Constant	1.03937387	1.57273427	.661	.5087	
X27	-.02485828	.02481934	-1.002	.3166	31.4136126
X32	.12286014	.20565573	.597	.5502	2.83246073
LATE	-1.00489400	.90224677	-1.114	.2654	.45549738
BRISK	-.06583367	1.15896419	-.057	.9547	.18848168
X24	1.29620039	.21742426	5.962	.0000	4.32984293

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+-----+
Estimates for equation: MO65
Generalized least squares regression
Model was estimated Sep 13, 2012 at 09:31:08AM
LHS=MO65      Mean          =    5.850785
              Standard deviation =    7.007514
WTS=none     Number of observs. =         191
Model size   Parameters      =          7
              Degrees of freedom =         184
Residuals   Sum of squares   =    7614.406
              Standard error of e =    6.432934
Fit          R-squared       =    .1528310
              Adjusted R-squared =    .1252059
Model test   F[ 6, 184] (prob) =    5.53 (.0000)
Diagnostic   Log likelihood   =   -622.9848
              Restricted(b=0)   =   -642.3897
              Chi-sq [ 6] (prob) =   38.81 (.0000)
Info criter. LogAmemiya Prd. Crt. =    3.758855
              Akaike Info. Criter. =    3.758822
Not using OLS or no constant. Rsqd & F may be < 0.
Log|W|      8.0840 Log-Likelihood =   -1585.0730
Durbin-Watson 1.522 Autocorrelation =    .2390
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Variable	Coefficient	Standard Error	b/St.Er.	P[Z >z]	Mean of X
Constant	2.77846956	1.50616043	1.845	.0651	
MALE	-.08593715	.36576014	-.235	.8142	.62827225
X27	-.01630271	.02089760	-.780	.4353	31.4136126
X32	-.16336038	.17645812	-.926	.3546	2.83246073
LATE	-2.06350679	.93873401	-2.198	.0279	.45549738
BRISK	-.22663173	1.20641004	-.188	.8510	.18848168
X24	1.17412675	.22757164	5.159	.0000	4.32984293

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Estimates for equation: MO55
Generalized least squares regression
Model was estimated Sep 13, 2012 at 09:31:08AM
LHS=MO55      Mean          = 6.649215
              Standard deviation = 6.953037
WTS=none     Number of observs. = 191
Model size   Parameters      = 5
              Degrees of freedom = 186
Residuals   Sum of squares   = 7682.128
              Standard error of e = 6.426645
Fit          R-squared       = .1411856
              Adjusted R-squared = .1227165
Model test   F[ 4, 186] (prob) = 7.64 (.0000)
Diagnostic   Log likelihood   = -623.8304
              Restricted(b=0)   = -640.8991
              Chi-sq [ 4] (prob) = 34.14 (.0000)
Info criter. LogAmemiya Prd. Crt. = 3.746746
              Akaike Info. Criter. = 3.746735
Not using OLS or no constant. Rsqd & F may be < 0.
Log|W|      8.0840 Log-Likelihood = -1585.0730
Durbin-Watson 1.598 Autocorrelation = .2012
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Variable	Coefficient	Standard Error	b/St.Er.	P[Z >z]	Mean of X
Constant	3.29385084	1.17903549	2.794	.0052	
X33	-.01507763	.41775487	-.036	.9712	.22513089
LATE	-2.57853632	.94018290	-2.743	.0061	.45549738
BRISK	.51618891	1.20400057	.429	.6681	.18848168
X24	1.02451353	.22509710	4.551	.0000	4.32984293

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--> 3sls;lhs=mo70,mo65,mo55
;eq1=one,mo65,x27,x32,late,brisk,x24
;eq2=one,mo70,mo55,male,x27,x32,late,brisk,x24
;eq3=one,mo65,x33,late,brisk,x24
;Inst= male,married,late,brisk,x4,x5,x24,x27,x28,x29,x31,x32,x34,x35,x37$

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*****
* NOTE: Deleted 26 observations with missing data. N is now 168 *
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Criterion function is max(abs(%chg in b(i))).
Iteration 0, 3SLS = 1.000000
Iteration 1, 3SLS = 6.239083
Iteration 2, 3SLS = .9998302

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Estimates for equation: MO70
InstVar/GLS least squares regression
Model was estimated Sep 13, 2012 at 09:40:38AM
LHS=MO70      Mean          =    5.821429
              Standard deviation =    6.869460
WTS=none     Number of observs. =         168
Model size   Parameters      =          7
              Degrees of freedom =         161
Residuals    Sum of squares   =   1393.693
              Standard error of e =    2.942190
Fit          R-squared       =    .8154607
              Adjusted R-squared =    .8085834
Model test   F[ 6, 161] (prob) = 118.57 (.0000)
Diagnostic   Log likelihood   =   -416.1046
              Restricted(b=0)   =   -561.6305
              Chi-sq [ 6] (prob) = 291.05 (.0000)
Info criter. LogAmemiya Prd. Crt. = 2.199130
              Akaike Info. Criter. = 2.199082
Not using OLS or no constant. Rsqd & F may be < 0.
Durbin-Watson 1.655 Autocorrelation =    .1723
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Variable	Coefficient	Standard Error	b/St.Er.	P[Z >z]	Mean of X
Constant	-1.42182312	1.01987119	-1.394	.1633	
MO65	1.07969977	.07140781	15.120	.0000	5.89583333
X27	-.01269818	.01974662	-.643	.5202	31.7976190
X32	.22939908	.15877944	1.445	.1485	2.76785714
LATE	.95744540	.46918529	2.041	.0413	.47023810
BRISK	.60038783	.60306851	.996	.3195	.18452381
X24	.01939998	.13720854	.141	.8876	4.39880952

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Estimates for equation: MO65
InstVar/GLS least squares regression
Model was estimated Sep 13, 2012 at 09:40:38AM
LHS=MO65      Mean          =    5.895833
              Standard deviation =    6.998472
WTS=none     Number of observs. =         168
Model size   Parameters      =          9
              Degrees of freedom =         159
Residuals    Sum of squares   =    745.1716
              Standard error of e =    2.164859
Fit          R-squared       =    .9037401
              Adjusted R-squared =    .8988968
Model test   F[ 8, 159] (prob) = 186.60 (.0000)
Diagnostic   Log likelihood   =   -363.5123
              Restricted(b=0)   =   -564.7564
              Chi-sq [ 8] (prob) = 402.49 (.0000)
Info criter. LogAmemiya Prd. Crt. = 1.596896
              Akaike Info. Criter. = 1.596793
Not using OLS or no constant. Rsqd & F may be < 0.
Durbin-Watson 1.949 Autocorrelation =    .0255
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Variable	Coefficient	Standard Error	b/St.Er.	P[Z >z]	Mean of X
Constant	.18583962	.64708195	.287	.7740	
MO70	.58726659	.00062856	934.310	.0000	5.82142857
MO55	.39836223	.00064488	617.730	.0000	6.67261905
MALE	.314238D-07	.00096143	.000	1.0000	.63690476
X27	.00745723	.01159661	.643	.5202	31.7976190
X32	-.13471812	.09324695	-1.445	.1485	2.76785714
LATE	-.16141096	.33534949	-.481	.6303	.47023810
BRISK	-.77759065	.43730921	-1.778	.0754	.18452381
X24	-.00266262	.07984093	-.033	.9734	4.39880952

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Estimates for equation: MO55
InstVar/GLS least squares regression
Model was estimated Sep 13, 2012 at 09:40:38AM
LHS=MO55      Mean           = 6.672619
              Standard deviation = 7.063864
WTS=none     Number of observs. = 168
Model size   Parameters      = 6
              Degrees of freedom = 162
Residuals   Sum of squares   = 1743.601
              Standard error of e = 3.280696
Fit          R-squared       = .7830097
              Adjusted R-squared = .7763125
Model test  F[ 5, 162] (prob) = 116.92 (.0000)
Diagnostic  Log likelihood   = -434.9201
              Restricted(b=0)   = -566.3189
              Chi-sq [ 5] (prob) = 262.80 (.0000)
Info criter. LogAmemiya Prd. Crt. = 2.411203
              Akaike Info. Criter. = 2.411172
Not using OLS or no constant. Rsqd & F may be < 0.
Durbin-Watson 2.095 Autocorrelation = -.0476

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Variable	Coefficient	Standard Error	b/St.Er.	P[Z >z]	Mean of X
Constant	1.62954296	.66000782	2.469	.0136	
MO65	.91858220	.10526509	8.726	.0000	5.89583333
X33	-.316446D-05	.00461107	-.001	.9995	.23214286
LATE	-1.00628109	.53398234	-1.884	.0595	.47023810
BRISK	1.06687592	.67796081	1.574	.1156	.18452381
X24	-.02191570	.17154825	-.128	.8983	4.39880952