Little Path Analysis Example with SAS

This is the same “Little Path” example we did with R.

```
/* path0.sas */
options linesize=79 noovp formdlim='_';
title 'STA2201s06 Little Path Example';

data path;
     infile 'littlepath.dat.txt';
     input X Y1 Y2;

proc calis  cov vardef=n;
   /*   Analyze the covariance matrix (Default is corr) and divide by n
        rather than (n-1) in covariance matrix, to get pure MLEs  */
     title2 'Reduced (restricted) Model: gamma2=0';
     var X Y1 Y2;    /* Declare which variables are observed */
     lineqs              /* Simultaneous equations, separated by commas */
          Y1  = gamma1 X + e1,
          Y2  = beta Y1  + e2;
     std                  /* Variances (not standard deviations) */
          X  = phi,       /* Optional starting values in parentheses */
          e1 = psi1,
          e2 = psi2;
     bounds 0.0 < phi,
            0.0 < psi1,
            0.0 < psi2;

proc calis  cov vardef=n pcorr pcoves;
        /* cov:      Analyze the covariance matrix (Default is corr)
           vardef=n  Divide by n rather than (n-1) in covariance matrix,
                     to get pure MLEs
           pcorr:    Prints correlation (or covariance) matrices of
                     observed variables -- both sample and predicted
           pcoves:   Prints estimated asymptotic covariance matrix of
                     estimates, and also the estimated information matrix.
*/
     title2 'Full (unrestricted) Model: with gamma2 (saturated)';
     var X Y1 Y2;    /* Declare which variables are observed */
     lineqs              /* Simultaneous equations, separated by commas */
          Y1  = gamma1 X + e1,
          Y2 =  gamma2 X + beta Y1 + e2;
     std                  /* Variances (not standard deviations) */
          X  = phi,       /* Optional starting values in parentheses */
          e1 = psi1,
          e2 = psi2;
     bounds 0.0 < phi,
            0.0 < psi1,
      0.0 < psi2;
```

path0.lst

```
                    STA2201s06 Little Path Example                        1
                 Reduced (restricted) Model: gamma2=0
                                      15:52 Tuesday, February 14, 2006

                          The CALIS Procedure
          Covariance Structure Analysis: Pattern and Initial Values

                        LINEQS Model Statement


                      Matrix      Rows    Columns    ------Matrix Type-------

Term 1            1   _SEL_          3          5    SELECTION
                  2   _BETA_         5          5    EQSBETA        IMINUSINV
                  3   _GAMMA_        5          3    EQSGAMMA
                  4   _PHI_          3          3    SYMMETRIC


                          The 2 Endogenous Variables

    Manifest        Y1  Y2
    Latent


                          The 3 Exogenous Variables

    Manifest        X
    Latent
    Error           e1  e2
```

```
                    STA2201s06 Little Path Example                        2
                 Reduced (restricted) Model: gamma2=0
                                      15:52 Tuesday, February 14, 2006

                          The CALIS Procedure
          Covariance Structure Analysis: Pattern and Initial Values

             Manifest Variable Equations with Initial Estimates


                 Y1      =        .*X      +  1.0000 e1
                                    gamma1
                 Y2      =        .*Y1     +  1.0000 e2
                                    beta


                      Variances of Exogenous Variables

                      Variable Parameter      Estimate

                      X        phi                    .
                      e1       psi1                   .
                      e2       psi2                   .
```

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Observations	10000	Model Terms	1
Variables	3	Model Matrices	4
Informations	6	Parameters	5

Variable	Mean	Std Dev
X	0.00932	1.74652
Y1	-0.00494	2.62215
Y2	-0.01536	5.72564

Set Covariances of Exogenous Manifest Variables

X

NOTE: Some initial estimates computed by two-stage LS method.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Vector of Initial Estimates

	Parameter	Estimate	Type
1	beta	2.01159	Matrix Entry: _BETA_[2:1]
2	gamma1	0.99182	Matrix Entry: _GAMMA_[1:1]
3	phi	3.05032	Matrix Entry: _PHI_[1:1]
4	psi1	3.87504	Matrix Entry: _PHI_[2:2]
5	psi2	4.90811	Matrix Entry: _PHI_[3:3]

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	5
Functions (Observations)	6
Lower Bounds	3
Upper Bounds	0

Optimization Start

Active Constraints	0	Objective Function	8.9651124E-6
Max Abs Gradient Element	0.0053209368	Radius	1

Iter	Rest arts	Func Calls	Act Con	Objective Function	Obj Fun Change	Max Abs Gradient Element	Lambda	Actual Over Pred Change
1	0	2	0	3.91249E-6	5.053E-6	1.029E-6	0	1.000

Optimization Results

Iterations	1	Function Calls	3
Jacobian Calls	2	Active Constraints	0
Objective Function	3.9124927E-6	Max Abs Gradient Element	1.0294436E-6
Lambda	0	Actual Over Pred Change	1.0000000008
Radius	0.0063577479		

ABSGCONV convergence criterion satisfied.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	0.0000
Goodness of Fit Index (GFI)	1.0000
GFI Adjusted for Degrees of Freedom (AGFI)	1.0000
Root Mean Square Residual (RMR)	0.0023
Parsimonious GFI (Mulaik, 1989)	0.3333
Chi-Square	0.0391
Chi-Square DF	1
Pr > Chi-Square	0.8432
Independence Model Chi-Square	24722
Independence Model Chi-Square DF	3
RMSEA Estimate	0.0000
RMSEA 90% Lower Confidence Limit	.
RMSEA 90% Upper Confidence Limit	0.0152
ECVI Estimate	0.0010
ECVI 90% Lower Confidence Limit	.
ECVI 90% Upper Confidence Limit	0.0013
Probability of Close Fit	1.0000
Bentler's Comparative Fit Index	1.0000
Normal Theory Reweighted LS Chi-Square	0.0391
Akaike's Information Criterion	-1.9609
Bozdogan's (1987) CAIC	-10.1712
Schwarz's Bayesian Criterion	-9.1712
McDonald's (1989) Centrality	1.0000
Bentler & Bonett's (1980) Non-normed Index	1.0001
Bentler & Bonett's (1980) NFI	1.0000
James, Mulaik, & Brett (1982) Parsimonious NFI	0.3333
Z-Test of Wilson & Hilferty (1931)	-0.9298
Bollen (1986) Normed Index Rho1	1.0000
Bollen (1988) Non-normed Index Delta2	1.0000
Hoelter's (1983) Critical N	981846

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Estimates

```
Y1      =   0.9918*X        +  1.0000 e1
Std Err     0.0113 gamma1
t Value    87.9923
Y2      =   2.0135*Y1       +  1.0000 e2
Std Err    0.00845 beta
t Value      238.3
```

Variances of Exogenous Variables

Variable	Parameter	Estimate	Standard Error	t Value
X	phi	3.05032	0.04314	70.71
e1	psi1	3.87504	0.05480	70.71
e2	psi2	4.90811	0.06941	70.71

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Standardized Estimates

```
Y1      =   0.6606*X      +  0.7507 e1
                gamma1
Y2      =   0.9221*Y1     +  0.3869 e2
                beta
```

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	Y1	3.87504	6.87565	0.4364
2	Y2	4.90811	32.78296	0.8503

The CALIS Procedure
Covariance Structure Analysis: Pattern and Initial Values

LINEQS Model Statement

		Matrix	Rows	Columns	------Matrix Type-------	
Term 1	1	_SEL_	3	5	SELECTION	
	2	_BETA_	5	5	EQSBETA	IMINUSINV
	3	_GAMMA_	5	3	EQSGAMMA	
	4	_PHI_	3	3	SYMMETRIC	

The 2 Endogenous Variables

Manifest	Y1	Y2
Latent		

The 3 Exogenous Variables

Manifest	X	
Latent		
Error	e1	e2

The CALIS Procedure
Covariance Structure Analysis: Pattern and Initial Values

Manifest Variable Equations with Initial Estimates

```
Y1      =        .*X      +  1.0000 e1
                  gamma1
Y2      =        .*Y1     +       .*X      +  1.0000 e2
                  beta              gamma2
```

Variances of Exogenous Variables

Variable	Parameter	Estimate
X	phi	.
e1	psi1	.
e2	psi2	.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Observations	10000	Model Terms	1
Variables	3	Model Matrices	4
Informations	6	Parameters	6

Variable	Mean	Std Dev
X	0.00932	1.74652
Y1	-0.00494	2.62215
Y2	-0.01536	5.72564

Covariances

	X	Y1	Y2
X	3.050318741	3.02536023	6.08578666
Y1	3.025360230	6.87564866	13.84404912
Y2	6.085786659	13.84404912	32.78293586

Determinant 58.013878 Ln 4.060682

Set Covariances of Exogenous Manifest Variables

X

NOTE: Some initial estimates computed by two-stage LS method.

NOTE: Some initial estimates computed by McDonald's method.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Vector of Initial Estimates

	Parameter	Estimate	Type
1	beta	2.01496	Matrix Entry: _BETA_[2:1]
2	gamma1	0.99182	Matrix Entry: _GAMMA_[1:1]
3	gamma2	-0.01000	Matrix Entry: _GAMMA_[2:1]
4	phi	3.05032	Matrix Entry: _PHI_[1:1]
5	psi1	3.87504	Matrix Entry: _PHI_[2:2]
6	psi2	4.90820	Matrix Entry: _PHI_[3:3]

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	6
Functions (Observations)	6
Lower Bounds	3
Upper Bounds	0

Optimization Start

Active Constraints	0	Objective Function	0.0000275483
Max Abs Gradient Element	0.008275348	Radius	1

Iter	Rest arts	Func Calls	Act Con	Objective Function	Obj Fun Change	Max Abs Gradient Element	Lambda	Actual Over Pred Change
1	0	2	0	3.7945E-10	0.000028	5.613E-6	0	1.000

Optimization Results

Iterations	1	Function Calls	3
Jacobian Calls	2	Active Constraints	0
Objective Function	3.794494E-10	Max Abs Gradient Element	5.6126417E-6
Lambda	0	Actual Over Pred Change	1
Radius	0.0148453255		

ABSGCONV convergence criterion satisfied.

Approximate Covariance Matrix of Parameter Estimates

	beta	gamma1	gamma2
beta	0.0001266745	-6.07152E-19	-0.000125638
gamma1	-6.07152E-19	0.00012705	9.281881E-19
gamma2	-0.000125638	9.281881E-19	0.0002855338
phi	-1.03624E-18	2.657779E-19	1.346138E-18
psi1	-2.31246E-18	-5.68922E-19	3.919255E-18
psi2	3.388002E-19	5.54319E-19	-3.36028E-19

Approximate Covariance Matrix of Parameter Estimates

	phi	psi1	psi2
beta	-1.03624E-18	-2.31246E-18	3.388002E-19
gamma1	2.657779E-19	-5.68922E-19	5.54319E-19
gamma2	1.346138E-18	3.919255E-18	-3.36028E-19
phi	0.001861075	1.380867E-18	2.347034E-34
psi1	1.380867E-18	0.0030034916	4.016529E-18
psi2	2.347034E-34	4.016529E-18	0.004818565

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Factor sigm = 0.00020002

Determinant = 6.97577E-20

Matrix has Only Positive Eigenvalues

Approximate Correlation Matrix of Parameter Estimates

	beta	gamma1	gamma2
beta	1	-4.78592E-15	-0.660613803
gamma1	-4.78592E-15	1	4.873264E-15
gamma2	-0.660613803	4.873264E-15	1
phi	-2.13419E-15	5.465747E-16	1.846626E-15
psi1	-3.74901E-15	-9.20984E-16	4.232155E-15
psi2	4.336509E-16	7.084571E-16	-2.86476E-16

Approximate Correlation Matrix of Parameter Estimates

	phi	psi1	psi2
beta	-2.13419E-15	-3.74901E-15	4.336509E-16
gamma1	5.465747E-16	-9.20984E-16	7.084571E-16
gamma2	1.846626E-15	4.232155E-15	-2.86476E-16
phi	1	5.840591E-16	7.83752E-32
psi1	5.840591E-16	1	1.055793E-15
psi2	7.83752E-32	1.055793E-15	1

Determinant = 0.563589403

Matrix has Only Positive Eigenvalues

Information (Cross Product Jacobian) Matrix

	beta	gamma1	gamma2
beta	2.8016993311	-7.88861E-31	1.2327781932
gamma1	-7.88861E-31	1.5743407018	-3.18935E-15
gamma2	1.2327781932	-3.18935E-15	1.2429483236
phi	9.860761E-32	-7.525E-17	1.110223E-16
psi1	-1.11022E-16	-7.33979E-16	4.930381E-32
psi2	0	-2.22045E-16	0

Information (Cross Product Jacobian) Matrix

	phi	psi1	psi2
beta	9.860761E-32	-1.11022E-16	0
gamma1	-7.525E-17	-7.33979E-16	-2.22045E-16
gamma2	1.110223E-16	4.930381E-32	0
phi	0.1074755197	-4.94123E-17	0
psi1	-4.94123E-17	0.066595826	-5.55112E-17
psi2	0	-5.55112E-17	0.0415102844

Predicted Model Matrix

	X	Y1	Y2
X	3.050318741	3.02536023	6.08578666
Y1	3.025360230	6.87564866	13.84404912
Y2	6.085786659	13.84404912	32.78307107

Determinant 58.015477 Ln 4.060710

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	0.0000
Goodness of Fit Index (GFI)	1.0000
GFI Adjusted for Degrees of Freedom (AGFI)	.
Root Mean Square Residual (RMR)	0.0001
Parsimonious GFI (Mulaik, 1989)	0.0000
Chi-Square	0.0000
Chi-Square DF	0
Pr > Chi-Square	<.0001
Independence Model Chi-Square	24722
Independence Model Chi-Square DF	3
RMSEA Estimate	0.0000
RMSEA 90% Lower Confidence Limit	.
RMSEA 90% Upper Confidence Limit	.
ECVI Estimate	0.0012
ECVI 90% Lower Confidence Limit	.
ECVI 90% Upper Confidence Limit	.
Probability of Close Fit	.
Bentler's Comparative Fit Index	1.0000
Normal Theory Reweighted LS Chi-Square	0.0000
Akaike's Information Criterion	0.0000
Bozdogan's (1987) CAIC	0.0000
Schwarz's Bayesian Criterion	0.0000
McDonald's (1989) Centrality	1.0000
Bentler & Bonett's (1980) Non-normed Index	.
Bentler & Bonett's (1980) NFI	1.0000
James, Mulaik, & Brett (1982) Parsimonious NFI	0.0000
Z-Test of Wilson & Hilferty (1931)	.
Bollen (1986) Normed Index Rho1	.
Bollen (1988) Non-normed Index Delta2	1.0000
Hoelter's (1983) Critical N	.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Estimates

```
Y1      =   0.9918*X        +  1.0000 e1
Std Err     0.0113 gamma1
t Value    87.9923
Y2      =   2.0150*Y1       +-0.00334*X        +  1.0000 e2
Std Err     0.0113 beta        0.0169 gamma2
t Value      179.0           -0.1978
```

Variances of Exogenous Variables

Variable	Parameter	Estimate	Standard Error	t Value
X	phi	3.05032	0.04314	70.71
e1	psi1	3.87504	0.05480	70.71
e2	psi2	4.90820	0.06942	70.71

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Standardized Estimates

```
Y1      =   0.6606*X      +  0.7507 e1
                gamma1
Y2      =   0.9228*Y1     +-0.00102*X      +  0.3869 e2
                beta             gamma2
```

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	Y1	3.87504	6.87565	0.4364
2	Y2	4.90820	32.78307	0.8503