Single-Factor model for simulated data

```
/* fac1.sas */
options linesize=79 pagesize=1000 noovp formdlim='_';
title 'One factor, three observed variables';
title2 'Generate random data within SAS';
data chance;
     /******* Set parameters here ********/
     n = 500;
     L1 = 1 ; L2 = 1 ; L3 = -1;
     ev1 = 1 ; ev2 = 1 ; ev3 = 1;
     /* With these settings, should get absolute values of loadings equal
        to 1/sqrt(2) = 0.707, and psi1=psi2=psi3= 1/2. */
     iseed = 51493; /* Seed for random number generator */
     /************************************************************/
     /* Random number generation */
     do i = 1 to n;
        kuhsee = rannor(iseed);
        e1 = sqrt(ev1)*rannor(iseed);
        e2 = sqrt(ev2)*rannor(iseed);
        e3 = sqrt(ev3)*rannor(iseed);
        X1 =  5 + L1*kuhsee + e1;
        X2 = 10 + L2*kuhsee + e2;
        X3 = 15 + L3*kuhsee + e3;
        output;
     end;
     keep x1 x2 x3;

proc calis vardef=n pcorr; /* Print correlation matrix */
     title3 'Default starting values';
     var x1 x2 x3;          /* Manafest vars are in the data set */
     lineqs                 /* Simultaneous equations, separated by commas */
          x1 = lambda1 F + delta1,
          x2 = lambda2 F + delta2,
          x3 = lambda3 F + delta3;
     std                    /* Variances (not standard deviations) */
          F  = 1,
          delta1-delta3 = psi1-psi3;
     bounds 0.0 < psi1-psi3;    /* Variances are positive */

/* Now try to make SAS find the second maximum by starting with the first
   two loadings negative */

proc calis vardef=n pcorr; /* Print correlation matrix */
     title3 'My starting values for loadings';
     var x1 x2 x3;          /* Manafest vars are in the data set */
     lineqs                 /* Simultaneous equations, separated by commas */
          x1 = lambda1 (-.8) F + delta1,
          x2 = lambda2 (-.8) F + delta2,
          x3 = lambda3 (.8)  F + delta3;
     std                    /* Variances (not standard deviations) */
          F  = 1,
          delta1-delta3 = psi1-psi3;
     bounds 0.0 < psi1-psi3;    /* Variances are positive */
```

```
/* We can make the model identified by just constraining one of the loadings
to be positive -- say lambda3. But using bounds below DOES NOT WORK. It
yields lambda3-hat = 0 and the other two positive. */

proc calis vardef=n pcorr; /* Print correlation matrix */
     title3 'Bounds to constrain one of the loadings';
     var x1 x2 x3;          /* Manafest vars are in the data set */
     lineqs                 /* Simultaneous equations, separated by commas */
          x1 = lambda1  F + delta1,
          x2 = lambda2  F + delta2,
          x3 = lambda3  F + delta3;
     std                    /* Variances (not standard deviations) */
          F  = 1,
          delta1-delta3 = psi1-psi3;
     bounds 0.0 < psi1-psi3,    /* Variances are positive */
            0.0 < lambda3;      /* Constrain one loading to be positive */
```

The CALIS Procedure
Covariance Structure Analysis: Pattern and Initial Values

LINEQS Model Statement

		Matrix	Rows	Columns	------Matrix Type-------	
Term 1	1	_SEL_	3	7	SELECTION	
	2	_BETA_	7	7	EQSBETA	IMINUSINV
	3	_GAMMA_	7	4	EQSGAMMA	
	4	_PHI_	4	4	SYMMETRIC	

The 3 Endogenous Variables

Manifest	X1	X2	X3
Latent			

The 4 Exogenous Variables

Manifest				
Latent	F			
Error	delta1	delta2	delta3	

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Observations	500	Model Terms	1
Variables	3	Model Matrices	4
Informations	6	Parameters	6

Variable	Mean	Std Dev
X1	5.02167	1.45535
X2	9.98415	1.42812
X3	15.00440	1.56078

Correlations

	X1	X2	X3
X1	1.0000	0.5130	-0.5521
X2	0.5130	1.0000	-0.5495
X3	-0.5521	-0.5495	1.0000

Determinant 0.441361 Ln -0.817892

NOTE: Some initial estimates computed by instrumental variable method.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Vector of Initial Estimates

	Parameter	Estimate	Type
1	lambda1	0.71787	Matrix Entry: _GAMMA_[1:1]
2	lambda2	0.71456	Matrix Entry: _GAMMA_[2:1]
3	lambda3	-0.76903	Matrix Entry: _GAMMA_[3:1]
4	psi1	0.48466	Matrix Entry: _PHI_[2:2]
5	psi2	0.48941	Matrix Entry: _PHI_[3:3]
6	psi3	0.40859	Matrix Entry: _PHI_[4:4]

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
Max Abs Gradient Element	5.066403E-16	Radius	1

Optimization Results

Iterations	0	Function Calls	2
Jacobian Calls	1	Active Constraints	0
Objective Function	0	Max Abs Gradient Element	5.066403E-16
Lambda	0	Actual Over Pred Change	0
Radius	1		

ABSGCONV convergence criterion satisfied.

Predicted Model Matrix

	X1	X2	X3
X1	1.0000	0.5130	-0.5521
X2	0.5130	1.0000	-0.5495
X3	-0.5521	-0.5495	1.0000

Determinant 0.441361 Ln -0.817892

One factor, three observed variables 6
Generate random data within SAS
Default starting values 21:55 Monday, April 3, 2006

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)	0.0000
Parsimonious GFI (Mulaik, 1989)	0.0000
Chi-Square	0.0000
Chi-Square DF	0
Pr > Chi-Square	<.0001
Independence Model Chi-Square	408.13
Independence Model Chi-Square DF	3
RMSEA Estimate	0.0000
RMSEA 90% Lower Confidence Limit	.
RMSEA 90% Upper Confidence Limit	.
ECVI Estimate	0.0242
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	.

Default starting values

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Estimates

```
X1      =   0.7179*F        +  1.0000 delta1
Std Err     0.0454 lambda1
t Value    15.8200
X2      =   0.7146*F        +  1.0000 delta2
Std Err     0.0454 lambda2
t Value    15.7489
X3      =  -0.7690*F        +  1.0000 delta3
Std Err     0.0455 lambda3
t Value   -16.9140
```

Variances of Exogenous Variables

Variable	Parameter	Estimate	Standard Error	t Value
F		1.00000		
delta1	psi1	0.48466	0.04604	10.53
delta2	psi2	0.48941	0.04600	10.64
delta3	psi3	0.40859	0.04712	8.67

My starting values for loadings

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Estimates

```
X1      =  -0.7179*F        +  1.0000 delta1
Std Err     0.0454 lambda1
t Value   -15.8200
X2      =  -0.7146*F        +  1.0000 delta2
Std Err     0.0454 lambda2
t Value   -15.7489
X3      =   0.7690*F        +  1.0000 delta3
Std Err     0.0455 lambda3
t Value    16.9140
```

Variances of Exogenous Variables

Variable	Parameter	Estimate	Standard Error	t Value
F		1.00000		
delta1	psi1	0.48466	0.04604	10.53
delta2	psi2	0.48941	0.04600	10.64
delta3	psi3	0.40859	0.04712	8.67