Regression without measurement error using `proc calis`

```
/* calculus2.sas */
options linesize=79 pagesize=500 noovp formdlim='_';
title 'Calculus 2: Regression with no measurement error';
title2 'Using proc calis: Limit output with ODS exclude';

data math;
     infile 'calculus.data'  firstobs=2;
     input id hscalc hsengl hsgpa test grade;

/* Exclude some output you really don't want to see.
   The (persist) option means keep doing it.      */
ods exclude
     Calis.ModelSpec.LINEQSEqInit               (persist)
     Calis.ModelSpec.LINEQSVarExogInit          (persist)
     Calis.ModelSpec.LINEQSCovExogInit          (persist)
     Calis.ML.SqMultCorr                        (persist)
     Calis.StandardizedResults.LINEQSEqStd      (persist)
     Calis.StandardizedResults.LINEQSVarExogStd (persist)
     Calis.StandardizedResults.LINEQSCovExogStd (persist)
     ;

proc calis cov ; /* Analyze the covariance matrix (Default is corr) */
     title3 'Reduced model with beta1 = beta2 = beta';
     var grade hsgpa test; /* Declare observed vars */
     lineqs                /* Simultaneous equations, separated by commas */
          grade = beta hsgpa + beta test + epsilon;
     std                   /* Variances (not standard deviations) */
          hsgpa = phi11,
          test  = phi22,
          epsilon = psi;
     cov                   /* Covariances */
          hsgpa test = phi12; /* Unmentioned pairs get covariance zero */
     bounds 0.0 < phi11,
            0.0 < phi22,
            0.0 < psi;
     /* Setting bounds is optional, but recommended. SAS will complain
        loudly if you hit a boundary, making it easier to notice if
        the numerical search for the MLE leaves the parameter space. */

proc calis cov ; /* Analyze the covariance matrix (Default is corr) */
     title3 'Full model (Saturated)';
     var grade hsgpa test; /* Declare observed vars */
     lineqs                /* Simultaneous equations, separated by commas */
          grade = beta1 hsgpa + beta2 test + epsilon;
     std                   /* Variances (not standard deviations) */
          hsgpa = phi11,
          test  = phi22,
          epsilon = psi;
     cov                   /* Covariances */
          hsgpa test = phi12; /* Unmentioned pairs get covariance zero */
     bounds 0.0 < phi11,
            0.0 < phi22,
            0.0 < psi;

proc reg;
     title3 'Ordinary regression for comparison with saturated model';
     model grade = hsgpa test;
```

The CALIS Procedure
Covariance Structure Analysis: Model and Initial Values

Modeling Information

Data Set	WORK.MATH
N Records Read	287
N Records Used	287
N Obs	287
Model Type	LINEQS
Analysis	Covariances

Variables in the Model

Endogenous	Manifest	grade
	Latent	
Exogenous	Manifest	hsgpa test
	Latent	
	Error	epsilon

Number of Endogenous Variables = 1
Number of Exogenous Variables = 3

The CALIS Procedure
Covariance Structure Analysis: Descriptive Statistics

Simple Statistics

Variable	Mean	Std Dev
grade	60.98955	17.73355
hsgpa	80.98293	5.97063
test	8.81533	3.56910

The CALIS Procedure
Covariance Structure Analysis: Optimization

Initial Estimation Methods

1	Observed Moments of Variables
2	McDonald Method

Optimization Start
Parameter Estimates

N	Parameter	Estimate	Gradient	Lower Bound	Upper Bound
1	beta	1.43813	0.00524	.	.
2	phi11	35.64841	7.9818E-19	0	.
3	phi22	12.73851	2.4787E-18	0	.
4	psi	185.81825	-1.213E-18	0	.
5	phi12	7.24928	-5.15E-18	.	.

Value of Objective Function = 0.0005028133

Calculus 2: Regression with no measurement error 4
Using proc calis: Limit output with ODS exclude
Reduced model with beta1 = beta2 = beta

The CALIS Procedure
Covariance Structure Analysis: Optimization

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	0.0005028133
Max Abs Gradient Element	0.0052381077	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	4	0	0.0004825	0.000020	1.091E-7	0	1.000

Optimization Results

Iterations	1	Function Calls	7
Jacobian Calls	3	Active Constraints	0
Objective Function	0.0004825446	Max Abs Gradient Element	1.0907832E-7
Lambda	0	Actual Over Pred Change	1
Radius	0.0127338107		

Convergence criterion (ABSGCONV=0.00001) satisfied.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Summary

Modeling Info	N Observations	287
	N Variables	3
	N Moments	6
	N Parameters	5
	N Active Constraints	0
	Baseline Model Function Value	0.6496
	Baseline Model Chi-Square	185.7968
	Baseline Model Chi-Square DF	3
	Pr > Baseline Model Chi-Square	<.0001
Absolute Index	Fit Function	0.0005
	Chi-Square	0.1380
	Chi-Square DF	1
	Pr > Chi-Square	0.7103
	Z-Test of Wilson & Hilferty	-0.5537
	Hoelter Critical N	7961
	Root Mean Square Residual (RMSR)	0.4368
	Standardized RMSR (SRMSR)	0.0057
	Goodness of Fit Index (GFI)	0.9997
Parsimony Index	Adjusted GFI (AGFI)	0.9981
	Parsimonious GFI	0.3332
	RMSEA Estimate	0.0000
	RMSEA Lower 90% Confidence Limit	0.0000
	RMSEA Upper 90% Confidence Limit	0.1134
	Probability of Close Fit	0.7941
	ECVI Estimate	0.0359
	ECVI Lower 90% Confidence Limit	0.0390
	ECVI Upper 90% Confidence Limit	0.0520
	Akaike Information Criterion	10.1380
	Bozdogan CAIC	33.4354
	Schwarz Bayesian Criterion	28.4354
	McDonald Centrality	1.0015
Incremental Index	Bentler Comparative Fit Index	1.0000
	Bentler-Bonett NFI	0.9993
	Bentler-Bonett Non-normed Index	1.0141
	Bollen Normed Index Rho1	0.9978
	Bollen Non-normed Index Delta2	1.0047
	James et al. Parsimonious NFI	0.3331

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Linear Equations

grade	=	1.4304*hsgpa	+ 1.4304*test	+ 1.0000 epsilon
Std Err		0.1016 beta	0.1016 beta	
t Value		14.0724	14.0724	

Estimates for Variances of Exogenous Variables

Variable Type	Variable	Parameter	Estimate	Standard Error	t Value
Observed	hsgpa	phi11	35.64841	2.98107	11.95826
	test	phi22	12.73851	1.06525	11.95826
Error	epsilon	psi	185.81825	15.53890	11.95826

Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate	Standard Error	t Value
hsgpa	test	phi12	7.24928	1.33099	5.44653

The CALIS Procedure
Covariance Structure Analysis: Model and Initial Values

Modeling Information

Data Set	WORK.MATH
N Records Read	287
N Records Used	287
N Obs	287
Model Type	LINEQS
Analysis	Covariances

Variables in the Model

Endogenous	Manifest	grade
	Latent	
Exogenous	Manifest	hsgpa test
	Latent	
	Error	epsilon

Number of Endogenous Variables = 1
Number of Exogenous Variables = 3

The CALIS Procedure
Covariance Structure Analysis: Descriptive Statistics

Simple Statistics

Variable	Mean	Std Dev
grade	60.98955	17.73355
hsgpa	80.98293	5.97063
test	8.81533	3.56910

The CALIS Procedure
Covariance Structure Analysis: Optimization

Initial Estimation Methods

1 Observed Moments of Variables
2 McDonald Method
3 Two-Stage Least Squares

Optimization Start
Parameter Estimates

N	Parameter	Estimate	Gradient	Lower Bound	Upper Bound
1	beta1	1.46805	1.2908E-17	.	.
2	beta2	1.34956	1.4041E-17	.	.
3	phi11	35.64841	1.0173E-18	0	.
4	phi22	12.73851	2.8469E-18	0	.
5	psi	185.72484	-1.02E-19	0	.
6	phi12	7.24928	-5.582E-18	.	.

Value of Objective Function = 0

The CALIS Procedure
Covariance Structure Analysis: Optimization

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	1.404108E-17	Radius	1

Optimization Results

Iterations	0	Function Calls	4
Jacobian Calls	1	Active Constraints	0
Objective Function	0	Max Abs Gradient Element	1.404108E-17
Lambda	0	Actual Over Pred Change	0
Radius	1		

Convergence criterion (ABSGCONV=0.00001) satisfied.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Summary

Modeling Info	N Observations	287
	N Variables	3
	N Moments	6
	N Parameters	6
	N Active Constraints	0
	Baseline Model Function Value	0.6496
	Baseline Model Chi-Square	185.7968
	Baseline Model Chi-Square DF	3
	Pr > Baseline Model Chi-Square	<.0001
Absolute Index	Fit Function	0.0000
	Chi-Square	0.0000
	Chi-Square DF	0
	Pr > Chi-Square	.
	Z-Test of Wilson & Hilferty	.
	Hoelter Critical N	.
	Root Mean Square Residual (RMSR)	0.0000
	Standardized RMSR (SRMSR)	0.0000
	Goodness of Fit Index (GFI)	1.0000
Parsimony Index	Adjusted GFI (AGFI)	.
	Parsimonious GFI	0.0000
	RMSEA Estimate	.
	Probability of Close Fit	.
	ECVI Estimate	0.0426
	ECVI Lower 90% Confidence Limit	.
	ECVI Upper 90% Confidence Limit	.
	Akaike Information Criterion	12.0000
	Bozdogan CAIC	39.9569
	Schwarz Bayesian Criterion	33.9569
	McDonald Centrality	1.0000
Incremental Index	Bentler Comparative Fit Index	1.0000
	Bentler-Bonett NFI	1.0000
	Bentler-Bonett Non-normed Index	.
	Bollen Normed Index Rho1	.
	Bollen Non-normed Index Delta2	1.0000
	James et al. Parsimonious NFI	0.0000

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Linear Equations

grade	=	1.4680*hsgpa	+	1.3496*test	+	1.0000 epsilon
Std Err		0.1435 beta1		0.2401 beta2		
t Value		10.2283		5.6207		

Estimates for Variances of Exogenous Variables

Variable Type	Variable	Parameter	Estimate	Standard Error	t Value
Observed	hsgpa	phi11	35.64841	2.98107	11.95826
	test	phi22	12.73851	1.06525	11.95826
Error	epsilon	psi	185.72484	15.53109	11.95826

Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate	Standard Error	t Value
hsgpa	test	phi12	7.24928	1.33099	5.44653

The REG Procedure
Model: MODEL1
Dependent Variable: grade

Number of Observations Read	287
Number of Observations Used	287

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	36824	18412	98.44	<.0001
Error	284	53117	187.03276		
Corrected Total	286	89941			

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-69.79413	11.15172	-6.26	<.0001
hsgpa	1	1.46805	0.14403	10.19	<.0001
test	1	1.34956	0.24095	5.60	<.0001