The CALIS Procedure
Covariance Structure Analysis: Model and Initial Values

Modeling Information	
Maximum Likelihood Estimation	
Data Set	SASDATA.HSB2
N Records Read	200
N Records Used	200
N Obs	200
Model Type	PATH
Analysis	Covariances

Variables in the Model		
Endogenous	**Manifest**	math science
	Latent	
Exogenous	**Manifest**	read write
	Latent	
Number of Endogenous Variables = 2 **Number of Exogenous Variables = 2**		

Endogenous variables are dependent variables - or variables which have arrows going into them.

Exogenous variables are independent variables - or variables which have NO arrows going into them

Initial Estimates for PATH List				
Path			**Parameter**	**Estimate**
read	**===>**	**science**	_Parm1	.
read	**===>**	**math**	_Parm2	.
write	**===>**	**science**	_Parm3	.
write	**===>**	**math**	_Parm4	.
math	**===>**	**science**	_Parm5	.

This section shows you what parameters SAS will calculate based on your model.

We have a parameter for each path

and we will have a parameter for each box - a measure of error or variation

Initial Estimates for Variance Parameters			
Variance Type	**Variable**	**Parameter**	**Estimate**
Exogenous	**read**	_Add1	.
	write	_Add2	.
Error	**math**	_Add3	.
	science	_Add4	.
NOTE: Parameters with prefix '_Add' are added by PROC CALIS.			

The CALIS Procedure
Covariance Structure Analysis: Model and Initial Values

Initial Estimates for Covariances Among Exogenous Variables			
Var1	**Var2**	**Parameter**	**Estimate**
write	**read**	_Add5	.
NOTE: Parameters with prefix '_Add' are added by PROC CALIS.			

This is the last parameter - a measure of the association/ relationship/or variation shared between the 2 independent variables: WRITE and READ

The CALIS Procedure
Covariance Structure Analysis: Descriptive Statistics

Simple Statistics			
Variable		**Mean**	**Std Dev**
read	reading score	52.23000	10.25294
write	writing score	52.77500	9.47859
math	math score	52.64500	9.36845
science	science score	51.85000	9.90089

Analysis results starts off with a description of the data - means and standard deviations

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**
1	**_Parm1**	0.30153	-3.824E-16
2	**_Parm2**	0.41695	3.3406E-16
3	**_Parm3**	0.20653	1.9742E-16
4	**_Parm4**	0.34112	3.3406E-16
5	**_Parm5**	0.31901	-7.271E-16
6	**_Add1**	105.12271	-7.704E-34
7	**_Add2**	89.84359	0
8	**_Add3**	42.54028	-5.953E-18
9	**_Add4**	49.01931	5.2937E-18
10	**_Add5**	57.99673	2.6963E-33
Value of Objective Function = 0			

The CALIS Procedure
Covariance Structure Analysis: Optimization

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	10
Functions (Observations)	10

Optimization Start			
Active Constraints	0	**Objective Function**	0
Max Abs Gradient Element	7.270939E-16	**Radius**	1

Optimization Results			
Iterations	0	**Function Calls**	4
Jacobian Calls	1	**Active Constraints**	0
Objective Function	0	**Max Abs Gradient Element**	7.270939E-16
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	
Chi-Square	0.0000
Chi-Square DF	0
Pr > Chi-Square	.
Hoelter Critical N	.
Standardized RMR (SRMR)	0.0000
Adjusted GFI (AGFI)	.
RMSEA Estimate	.
Bentler Comparative Fit Index	1.0000

FIT statistics - this is not very helpful with this sample data. Most popular FIT statistics for SEM are: SRMSR, AGFI, RMSEA, and CFI

GOALS:
1) chi-square statistic - you want it to be non-significant - so a p-value > 0.05

2) the SMRSR and RMSEA you want these to be small values - aim for less than 0.05

3) AGFI and Bentler's CFI, the larger the better - goal is close to 1.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

PATH List

Path			Parameter	Estimate	Standard Error	t Value	Pr > |t|
read	===>	science	_Parm1	0.30153	0.06816	4.4238	<.0001
read	===>	math	_Parm2	0.41695	0.05620	7.4191	<.0001
write	===>	science	_Parm3	0.20653	0.07023	2.9407	0.0033
write	===>	math	_Parm4	0.34112	0.06079	5.6114	<.0001
math	===>	science	_Parm5	0.31901	0.07610	4.1922	<.0001

The first set of results are in the units of measure for each variable. In this example they are all percentages - so no worries. For your own data - be aware!!

Variance Parameters

Variance Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Exogenous	read	_Add1	105.12271	10.53865	9.9750	<.0001
	write	_Add2	89.84359	9.00690	9.9750	<.0001
Error	math	_Add3	42.54028	4.26470	9.9750	<.0001
	science	_Add4	49.01931	4.91423	9.9750	<.0001

Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
write	read	_Add5	57.99673	8.02265	7.2291	<.0001

Squared Multiple Correlations

Variable	Error Variance	Total Variance	R-Square
math	42.54028	87.76781	0.5153
science	49.01931	98.02764	0.4999

The R-square hear tells you how much of the overall variation in MATH is explained by ALL the other variables in the path model - so 51.5%

SCIENCE can be explained by ~50%

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Stability Coefficient of Reciprocal Causation = 0
Stability Coefficient < 1
Total and Indirect Effects Converge

In order for the indirect effects results (seen later in this output) to be of value, you want this test to read that the stability coefficient is <1

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Effects of read			
Effect / Std Error / t Value / p Value			
	Total	Direct	Indirect
science	0.4345 0.0629 6.9046 <.0001	0.3015 0.0682 4.4238 <.0001	0.1330 0.0364 3.6499 0.000262

Remember that there were 2 paths from READ to SCIENCE - the direct path and an indirect path through MATH. Both effects are listed here.

First check if the effect is significant - essentially different from 0, in both the direct and indirect this is the case.

We have a direct effect of 0.30 and an indirect effect of 0.13. Together the overall effect of READ on SCIENCE is 0.43

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Effects of write			
Effect / Std Error / t Value / p Value			
	Total	Direct	Indirect
science	0.3153 0.0681 4.6323 <.0001	0.2065 0.0702 2.9407 0.003274	0.1088 0.0324 3.3585 0.000784

Interpret as above

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Standardized Results for PATH List

Path			Parameter	Estimate	Standard Error	t Value	Pr > |t|
read	===>	science	_Parm1	0.31225	0.06919	4.5128	<.0001
read	===>	math	_Parm2	0.45631	0.05793	7.8769	<.0001
write	===>	science	_Parm3	0.19772	0.06676	2.9618	0.0031
write	===>	math	_Parm4	0.34513	0.05977	5.7739	<.0001
math	===>	science	_Parm5	0.30185	0.07073	4.2679	<.0001

These are the standardized effects - in STD units

The first thing we will note when reading these results, is whether the effect is significant or not. Again - different from 0 and having an effect on the outcome variable SCIENCE in this case. Interpretation is similar to that of a correlation coefficient - ranges from -1 to 1.

Standardized Results for Variance Parameters

Variance Type	Variable	Parameter	Estimate	Standard Error	t Value	Pr > |t|
Exogenous	read	_Add1	1.00000			
	write	_Add2	1.00000			
Error	math	_Add3	0.48469	0.04933	9.8257	<.0001
	science	_Add4	0.50006	0.05013	9.9755	<.0001

These are estimates of the error of each independent variable

Standardized Results for Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate	Standard Error	t Value	Pr > |t|
write	read	_Add5	0.59678	0.04564	13.0752	<.0001

This is the covariance of the variation shared between the 2 independent variables

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Standardized Effects of read			
Effect / Std Error / t Value / p Value			
	Total	Direct	Indirect
science	0.4500 0.0613 7.3450 <.0001	0.3123 0.0692 4.5128 <.0001	0.1377 0.0369 3.7366 0.000186

Same as above - only these are the standardized effects

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Standardized Effects of write			
Effect / Std Error / t Value / p Value			
	Total	Direct	Indirect
science	0.3019 0.0637 4.7392 <.0001	0.1977 0.0668 2.9618 0.003059	0.1042 0.0305 3.4152 0.000637

Same as above - only these are the standardized effects