



Measurement models: Ability and aspiration

Broadly speaking, there are two basic problems that are important in the social and behavioral sciences. The first problem is concerned with the measurement properties – validities and reliabilities – of the measurement instruments. The second problem concerns the causal relationships among the variables and their relative explanatory power.

Most theories and models in the social and behavioral sciences are formulated in terms of theoretical or hypothetical concepts, or constructs, or latent variables, which are not directly measurable or observable. However, often a number of indicators or symptoms of these variables can be used to represent the latent variables more or less well. The purpose of a measurement model is to describe how well the observed indicators serve as a measurement model instrument for the latent variables. The key concepts here are measurement, reliability, and validity. Measurement models often suggest ways in which the observed measurements can be improved.

Measurement models are important in the social and behavioral sciences when one tries to measure such abstractions as people's behavior, attitudes, feelings and motivations. Most measures employed for such purposes contain sizable measurement errors and the measurement models allow us to take these errors into account.

Calsyn & Kenny (1977) presented the correlation matrix given in Table 1, based on 556 white eighth-grade students. The measures are:

x_1 = self-concept of ability (S-C ABIL)

x_2 = perceived parental evaluation (PPAREVAL)

x_3 = perceived teacher evaluation (PTEAEVAL)

x_4 = perceived friend's evaluation (PFRIEVAL)

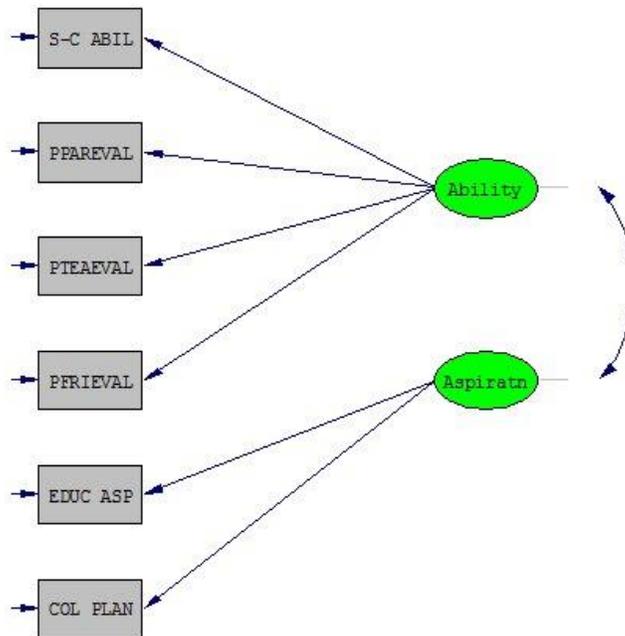
x_5 = educational aspiration (EDUC ASP)

x_6 = college plans (COL PLAN)

Table: Correlations among ability and aspiration measures

	x_1	x_2	x_3	x_4	x_5	x_6
S-C ABIL	1.00					
PPAREVAL	0.73	1.00				
PTEAEVAL	0.70	0.68	1.00			
PFRIEVAL	0.58	0.61	0.57	1.00		
EDUC ASP	0.46	0.43	0.40	0.37	1.00	
COL PLAN	0.56	0.52	0.48	0.41	0.72	1.00

We analyze a model in which x_1 , x_2 , x_3 , and x_4 are assumed to be indicators of “ability” and x_5 and x_6 are assumed to be indicators of “aspiration”. We are primarily interested in estimating the correlation between true ability and true aspiration. The path diagram for this example is given below. To distinguish latent variables from observed variables in the path diagram, the former are enclosed in ovals and the latter in rectangles.



In this example we illustrate the use of an external data file. The data file contains the correlation matrix of the variables. The name of the file is **EX4.COR**, and contents are as follows:

```

1.00
0.73 1.00
0.70 0.68 1.00
0.58 0.61 0.57 1.00
0.46 0.43 0.40 0.37 1.00
0.56 0.52 0.48 0.41 0.72 1.00

```

The input file illustrates, in particular, how to specify the model by paths instead of by relationships (**EX4A.SPL** in the **Simplis Examples** folder):

```

EX4A.SPL
Ability and Aspiration
Observed Variables
'S-C ABIL' PPAREVAL PTEAEVAL PFRIEVAL 'EDUC ASP' 'COL PLAN'
Correlation Matrix From File: EX4.COR
Sample Size: 556
Latent Variables: Ability Aspiratn
Paths
  Ability -> 'S-C ABIL' PPAREVAL PTEAEVAL PFRIEVAL
  Aspiratn -> 'EDUC ASP' 'COL PLAN'
Print Residuals
Path Diagram
End of Problem

```

Lines 2 and 3 define the observed variables as before. Line 4 specifies that the correlation matrix is to be read from the file **EX4.COR** rather than from the input file. Line 5 gives the sample size. This model involves latent (unobservable) variables as well as observed variables, so a distinction must be made between these two kinds of variables in the input file. The latent variables are defined in line 6. In LISREL documentation we name latent variables using capitalized words to distinguish them from observed variables whose names will be entirely in capitals. The model is specified in terms of paths. The first line of the paths section (line 8) specifies that there is a path from Ability to each of the variables from S-C ABIL to PFRIEVAL. This implies 4 paths. The next line (line 9) specifies that there is a path from Aspiration to both EDUC ASP and COL PLAN. This means 2 more paths. The line `Print Residuals` is a request to print certain matrices of residuals.

The output file reveals the following results.

Measurement Equations

```

S-C ABIL = 0.863*Ability, Errorvar.= 0.255 , R2 = 0.745
Standerr (0.0351) (0.0234)
Z-values 24.561 10.907
P-values 0.000 0.000

```

```

PPAREVAL = 0.849*Ability, Errorvar.= 0.279 , R2 = 0.721
Standerr (0.0355) (0.0241)
Z-values 23.958 11.549

```

P-values	0.000	0.000
PTEAEVAL = 0.805*Ability, Errorvar.= 0.352 , R ² = 0.648		
Standerr	(0.0364)	(0.0269)
Z-values	22.115	13.070
P-values	0.000	0.000
PFRIEVAL = 0.695*Ability, Errorvar.= 0.517 , R ² = 0.483		
Standerr	(0.0386)	(0.0347)
Z-values	17.996	14.877
P-values	0.000	0.000
EDUC ASP = 0.775*Aspiratn, Errorvar.= 0.399 , R ² = 0.601		
Standerr	(0.0404)	(0.0382)
Z-values	19.206	10.453
P-values	0.000	0.000
COL PLAN = 0.929*Aspiratn, Errorvar.= 0.137 , R ² = 0.863		
Standerr	(0.0394)	(0.0435)
Z-values	23.571	3.151
P-values	0.000	0.002

Correlation Matrix of Independent Variables

	Ability	Aspiratn
	-----	-----
Ability	1.000	
Aspiratn	0.666 (0.031) 21.547	1.000

The latent variables are standardized by default unless some other unit of measurement is specified by the user. Since the observed variables are also standardized in this example, this means that the factor loadings which appear in front of each latent variable above are *standardized* factor loading or standardized validity coefficients (see Bollen, 1989a).

The correlation between Ability and Aspiration is estimated as .67 with a standard error of 0.03 and *t*-value of 21.53. The high *t*-value indicates that the correlation is non-zero. In another context, it may be more interesting to test whether the correlation is 1. This can be done by forming an approximate confidence interval for the true correlation using the standard error. In this case, the confidence interval will be (.604,.728). Since this interval does not include the value 1, we conclude that the correlation is less than 1. This is not a rigorous test, but it gives a crude method of testing whether a uni-dimensional model rather than a two-dimensional model would be sufficient to account for the intercorrelations among the observed variables.

The correlation between Ability and Aspiration is a disattenuated correlation in the sense that the effects of measurement errors in the observed variables have been eliminated. The disattenuated correlation of .67

between Ability and Aspiration may be compared with the attenuated correlations between the observed ability and aspiration measures, which range between .37 and .56. Thus the disattenuated correlation is higher.

For measurement relations, there is an error term on each observed variable as indicated by the one-way arrows on the left side of the path diagram. These error terms represent *errors in variables* rather than *errors in equations* as the error terms in the previous examples. The error terms are usually interpreted as measurement errors (or observational errors) in the observed variables, although they may also contain specific systematic components. The estimated error variance is given along with each measurement relationship. In this context, R^2 is usually interpreted as the reliability of the observed measure on the left. It is seen that S C ABIL is the most reliable of the indicators of Ability and COL PLAN is the most reliable indicator of Aspiration. Since the model fits the data well, we may also interpret the loadings in front of the latent variables as validity coefficients and interpret S C ABIL as the most valid indicator of Ability and COL PLAN as the most valid indicator of Aspiration.

The fit of the model is quite good as evidenced by the chi-square of 9.26 with 8 degrees of freedom. The fit may be further examined by inspecting the sections in the output file labeled FITTED COVARIANCE MATRIX, FITTED RESIDUALS, and STANDARIZED RESIDUALS. These look as follows.

Fitted Covariance Matrix

	S-C ABIL	PPAREVAL	PTEAEVAL	PFRIEVAL	EDUC ASP	COL PLAN
	-----	-----	-----	-----	-----	-----
S-C ABIL	1.000					
PPAREVAL	0.733	1.000				
PTEAEVAL	0.695	0.684	1.000			
PFRIEVAL	0.600	0.591	0.560	1.000		
EDUC ASP	0.446	0.439	0.416	0.359	1.000	
COL PLAN	0.534	0.526	0.498	0.430	0.720	1.000

Fitted Residuals

	S-C ABIL	PPAREVAL	PTEAEVAL	PFRIEVAL	EDUC ASP	COL PLAN
	-----	-----	-----	-----	-----	-----
S-C ABIL	0.000					
PPAREVAL	-0.003	0.000				
PTEAEVAL	0.005	-0.004	0.000			
PFRIEVAL	-0.020	0.019	0.010	0.000		
EDUC ASP	0.014	-0.009	-0.016	0.011	0.000	
COL PLAN	0.026	-0.006	-0.018	-0.020	0.000	0.000

Standardized Residuals

	S-C ABIL	PPAREVAL	PTEAEVAL	PFRIEVAL	EDUC ASP	COL PLAN
	-----	-----	-----	-----	-----	-----
S-C ABIL	0.000					
PPAREVAL	-0.072	0.000				
PTEAEVAL	0.098	-0.108	0.000			
PFRIEVAL	-0.663	0.487	0.234	0.000		
EDUC ASP	0.781	-0.265	-0.432	2.180	0.000	
COL PLAN	1.422	-0.120	-0.388	-1.708	0.000	0.000

If the line

Print Residuals

is not included in the input file, the information about the residuals is only given in summarized form as follows:

Summary Statistics for Fitted Residuals

Smallest Fitted Residual = -0.020
 Median Fitted Residual = 0.000
 Largest Fitted Residual = 0.026

Stemleaf Plot

```
- 2|00
- 1|86
- 0|96430000000
  0|5
  1|0149
  2|6
```

Summary Statistics for Standardized Residuals

Smallest Standardized Residual = -1.708
 Median Standardized Residual = 0.000
 Largest Standardized Residual = 2.180

Stemleaf Plot

```
- 1|7
- 0|74431110000000
  0|1258
  1|4
  2|2
```