Standardized parameter estimates for the structural model are presented in Figure 7.7. As shown, both risk perceptions ($\beta = -.43$, $p < .01$) and willingness to participate in health and safety programs ($\beta = .34$, $p < .01$) were predicted by perceived health and safety climate. Risk perceptions ($\beta = .45$; $p < .01$) but not willingness to participate ($\beta = .18$, ns) were predicted by respondents' accident history.

Deleting the nonsignificant path from the model did not result in a significant change to model fit, [$\chi^2_{\text{difference}}(1) = 1.70$, ns].

CHAPTER 8 *Concluding Comments*

In previous chapters, we considered the logic and mechanics of structural equation modeling with specific reference to the three most common versions of structural equation models: confirmatory factor analysis, observed variable path analysis, and latent variable path analysis. In this final chapter, I introduce two useful extensions to the procedures discussed thus far.

Single Indicator Latent Variables

As a general rule, one should strive for at least two or three indicators (observed variables) for every latent variable. Following this guideline generally will steer you clear of the shoals of underidentified models. In some cases, this rule must be violated because of either lack of available data or lack of forethought.

Unfortunately, we are sometimes stuck with only one indicator for a construct. Two solutions to this dilemma are possible. First, one can divide the scale items to form multiple indicators, as was done in the previous chapter. The second solution is to declare a latent variable with only one indicator. This is bound to leave us with an identification problem (trying to estimate both a unique and a common factor loading as well as the variance for one construct using only one indicator). The solution is to FIx the common (LY) and unique (TE) factor loadings at predetermined values and to estimate only the variance of the latent variable.

Specifically, we fixed the common factor loading (in the LY matrix) to be equal to the product of the reliability (alpha) and the standard deviation. If you understand reliability to measure the proportion of true score variance in a scale, this procedure essentially says X% of the variance in the observed score is true score variance. The unique factor loading (the diagonal element in the TE matrix) was fixed at a value equal to 1 – reliability × variance of the observed score. Again, this is simply an estimate of the percentage of error variance, which is all that is represented by the unique factor loading.

The one remaining case is when your single indicator is not a scale and you do not have any estimate of reliability for the variable. Fixing the factor loadings usually provides a workable solution to this problem. In this case, you only have to fix the common factor loading to equal 1 and the unique factor loading to equal 0 (assuming perfect reliability in the single item) to duplicate the procedure described above.

Simplifying Complex Models

If you recall the example of latent variable path analysis given above, you will remember that the LISREL code is rather complex. In formulating a model this way, you must keep track of the forms of all eight LISREL matrices at the same time. Moreover, you must keep track of the status (fixed, free) of every element in those matrices.

There is a way to reduce the cognitive complexity of latent variable models. Essentially, the procedure is to ignore the *X*-variable side of the LISREL model and to use only the *Y* side. As an illustration, below are two alternate model statements. Both describe exactly the same model and are mathematically equivalent (more important, they result in the same output).

```
MO NX = 7 NK = 3 NY = 5 NE = 2 PH = ST PS = DI,FR BE = FU,FI
     GA = FU,FI
MO NY = 12 NE = 5 PS = SY,FI BE = FU,FI TE = SY,FI
```

Note that both model statements reference 12 observed variables and five latent variables. The major differences are that I have eliminated all reference to the *X* variable matrices (LX, PH, TD) in the second statement, reducing my model to only four matrices (LY, BE, TE, and

PS). Also note that I have changed the specification of the PS matrix to be symmetrical and fixed rather than diagonal and free. This will allow me to estimate the correlations between the three exogenous variables (previously represented in the PH matrix). Thus, the PS matrix will now look like this:

	Eta1	Eta2	Eta3	Eta4	Eta5
Eta1	Free				
Eta2	Fixed	Free			
Eta3	Fixed	Fixed	Free		
Eta4	Fixed	Fixed	Free	Free	
Eta5	Fixed	Fixed	Free	Free	Free

The lines of code that would follow the second model statement would free the diagonal elements for all latent variables (variances) and free the covariances between the last three latent variables (which are the exogenous variables). The code is as follows.

```
FR PS(1,1) PS(2,2) PS(3,3) PS(4,4) PS(5,5)
FR PS(5,4) PS(5,3) PS(4,3)
```

The only difference this modification seems to make in the actual analyses (aside from the reduced demands on short-term memory) is that LISREL will report R^2 values for the exogenous variables, and these values will always be zero. This is because you do not predict any of the variance in three of the latent variables. Despite this minor difference, fit indices and parameter estimates will be exactly the same either way you set up the model.

Final Comments

Despite my somewhat tongue-in-cheek attitude, I have developed a great deal of respect for the power of LISREL to address increasingly complex research questions. In the foregoing, I have tried to illustrate some of the main types of questions that can be asked and answered using LISREL.

It is important to note that I have focused on the mechanics rather than the mathematical derivation or logical rigor of LISREL analyses.

Although this approach suited my goals in writing a researcher's guide, please be aware that I have glossed over many of the fine points of using LISREL. I leave you with the task of exploring these issues in more depth and the suggestion that the reference list following this chapter provides a good starting point for this exploration.

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