The R Statistical Computing Environment
Basics and Beyond
Structural-Equation Models in R: Exercises

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Data from a paper by Wheaton, Muthén, Alwin, and Summers ("Assessing reliability and stability in panel models," *Sociological Methodology*, 1977: 84-136) have become a staple for developing examples of latent-variable structural-equation models. The model shown in Figure , which uses the Wheaton et al. data, is from the LISREL 7 manual (by Jöreskog and Sörbom).The variables in the model include scales to measure "anomia" and "powerlessness" (both conceived as indicators of a more general, latent variable, "alienation"); "education," measured as years of schooling, and the socio-economic index score ("SEI") of the respondent's occupation (both conceived as indicators of the respondent's socio-economic status, or "SES"). Anomia and powerlessness were measured both in 1967 and 1971; education and SEI were measured only in 1967. Wheaton et al.'s data were a sample comprising 932 respondents drawn from a rural region of Illinois.

The variance-covariance matrix of the observed variables is as follows:

	Anomia67	*Powerless67*	*Anomia71*	*Powerless71*	*Education*	*SEI*
Anomia67	11.834					
Powerless67	6.947	9.364				
Anomia71	6.819	5.091	12.532			
Powerless71	4.783	5.028	7.495	9.986		
Education	−3.839	−3.889	−3.841	−3.625	9.610	
SEI	−21.899	−18.831	−21.748	−18.775	35.522	450.288

The covariance matrix is in the file `S-Wheaton.txt` on the workshop web site, and may be read, e.g., using

```
S.Wheaton <- readMoments(file=file.choose(),
    names=c('Anomia67','Powerless67','Anomia71','Powerless71','Education','SEI') )
```

1. Write out the equations for the structural submodel and the measurement submodel of the SEM in Figure .

2. Comment briefly on the specification of the model.

3. Figuring out whether this model is identified is not simple, but the model is identified. It is simple, however, to check that the number of unknown parameters in the model is not greater than the number of variances and covariances among the observed variables. Perform this check, and, given that the model is identified, determine whether it is just-identified or overidentified.

   (a) *Hints*: In counting the parameters make sure that you include the variances of the measurement errors, the variances of the structural disturbances, and the variance of the latent exogenous variable; you should find that there are *4* fewer parameters than observable variances and covariances.

4. Use the `sem` function to fit the model to the data and briefly comment on the results.

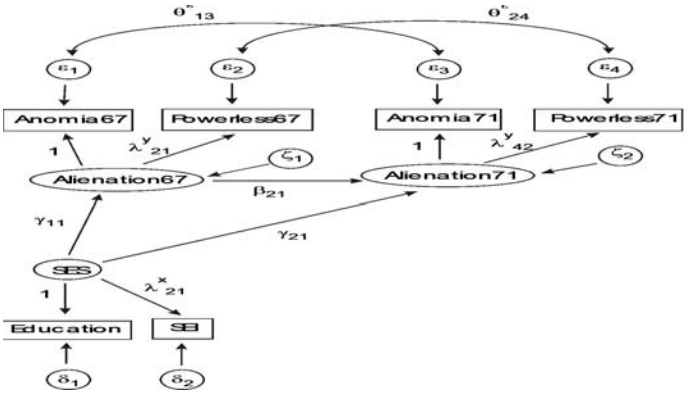

Figure 1: A latent-variable SEM for the Wheaton et. al. alienation data.

(a) *Hints*: Be careful to include among the parameters to be estimated: the structural parameters; the variances of the measurement errors; those measurement-error covariances that are part of the model; the variances of the structural disturbances; and the variance of the latent exogenous variable.

5. Fit a version of the model in which the measurement-submodel parameters for Alienation are the same in 1967 and 1971. That is, impose the equality constraints $\lambda_{11}^{y} = \lambda_{32}^{y}$, $\theta_{11}^{\varepsilon} = \theta_{33}^{\varepsilon}$, and $\theta_{22}^{\varepsilon} = \theta_{44}^{\varepsilon}$. Check the equality constraints by performing a likelihood-ratio test comparing this version of the model with the previous version. What conclusions do you draw?