MIMIC models

The term MIMIC stands for Multiple Indicators and Multiple Causes. The simplest form of a MIMIC model involves a single unobserved latent variable "caused" by several observed *x*-variables and indicated by several observed *y*-variables. The model equations are

$$\mathbf{y} = \boldsymbol{\lambda}\eta + \boldsymbol{\varepsilon},$$
$$\eta = \boldsymbol{\gamma}^{'}\mathbf{x} + \boldsymbol{\zeta},$$

where $y^{'} = \left(y_1, y_2, ..., y_p\right)$ are indicators of the latent variable η, and $\mathbf{x}^{'} = \left(x_1, x_2, ..., x_q\right)$ are the "causes' of η. From the LISREL point of view one can regard the first equation as the measurement model for η and the second as the structural equation for η. The ε's and ζ are assumed to be mutually uncorrelated. The first equations also says that the *y*'s are congeneric measures of η and the second equation indicates that η is linear in the *x*'s plus a random disturbance term. The model can also be viewed as a multivariate regression model with two specific constraints:

- The regression matrix must have rank 1.
- The residual covariance matrix must satisfy the congeneric measurement model.

This can be seen by substituting the second equation into the first, yielding

$$\mathbf{y} = \boldsymbol{\lambda}\boldsymbol{\gamma}^{'}\mathbf{x} + \boldsymbol{\lambda}\boldsymbol{\zeta} + \boldsymbol{\varepsilon},$$
$$= \boldsymbol{\Pi}\mathbf{x} + \boldsymbol{\zeta}\mathbf{z},$$

which shows that $\boldsymbol{\Pi} = \boldsymbol{\lambda}\boldsymbol{\gamma}^{'}$ and $Cov(\mathbf{z}) = \boldsymbol{\lambda}\boldsymbol{\lambda}^{'}\psi + \boldsymbol{\Theta}_{\varepsilon}$, where $\psi = Var\left(\zeta\right)$ and $\boldsymbol{\Theta}_{\varepsilon}$ is the diagonal covariance matrix of $\boldsymbol{\varepsilon}$.

The equations above correspond to the equations shown below

$$\boldsymbol{\eta} = \mathbf{B}\boldsymbol{\eta} + \boldsymbol{\Gamma}\boldsymbol{\varepsilon} + \boldsymbol{\zeta}$$
$$\mathbf{y} = \boldsymbol{\Lambda}_y\boldsymbol{\xi} + \boldsymbol{\delta}$$

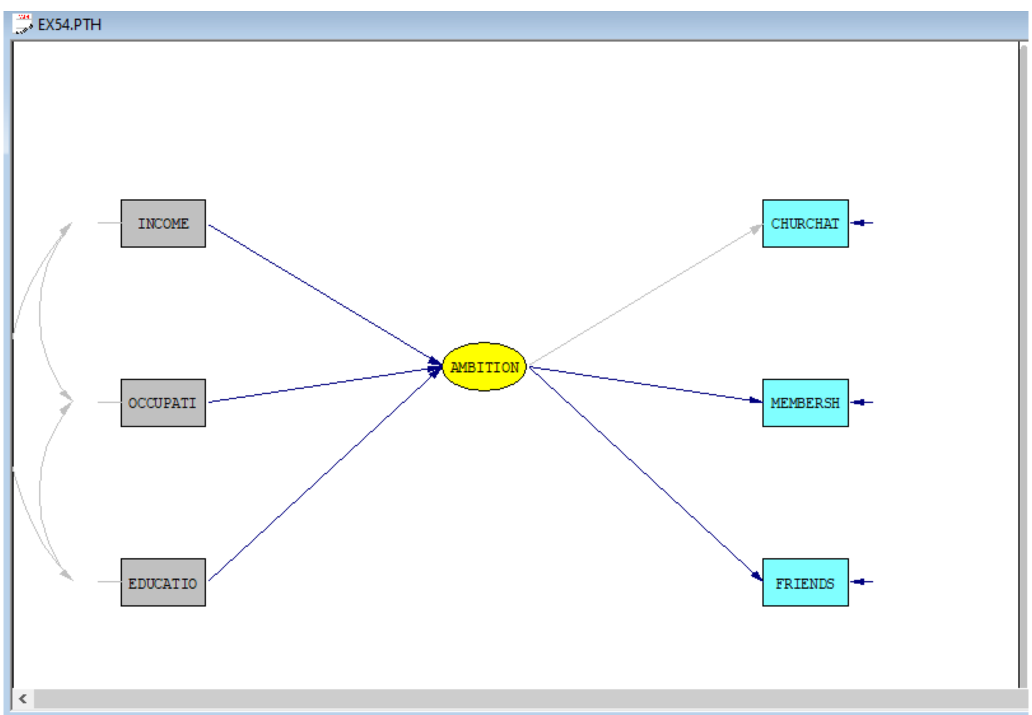
with $\mathbf{x} \equiv \xi$, i.e., $\mathbf{\Lambda}_x = \mathbf{I}$ and $\mathbf{\Theta}_\delta = \mathbf{0}$. The latter specification is handled by the FI option which also implies that $\mathbf{\Phi} = Cov(\xi)$ will be estimated by $\mathbf{S}_{xx}$, the same covariance matrix of $\mathbf{x}$.

In a study of the relationship (Hodge & Treiman (1968)) between social status and social participation in a sample of 530 women, six social status variables were measures. Their names and correlations are given in the table below.

Table: Correlations for variables in MIMIC model

	x_1	x_2	x_3	y_1	y_2	y_3
Income	1.000					
Occupation	0.304	1.000				
Education	0.305	0.344	1.000			
Church attendance	0.100	0.156	0.158	1.000		
Memberships	0.284	0.192	0.324	0.360	1.000	
Friends seen	0.176	0.136	0.226	0.210	0.265	1.000

All variables are standardized. A path diagram is given below.



The y's may be viewed as independent indicators of a latent variable η (social participation) which is caused by the x's. Thus,

$$\eta = \gamma_1 x_1 + \gamma_2 x_2 + \gamma_3 x_3 + \zeta,$$
$$y_1 = \lambda_1 \eta + \varepsilon_1,\ y_2 = \lambda_2 \eta + \varepsilon_2,\ y_3 = \lambda_3 \eta + \varepsilon_3.$$

From a substantive viewpoint, it may be helpful to view the x's as determining

$$\xi = \gamma_1 x_1 + \gamma_2 x_2 + \gamma_3 x_3 = \textit{social status},$$

which in turn determines

$$\eta = \xi + \varepsilon = \textit{social participation.}$$

The LISREL command file for the analysis is (**EX54.LIS** in the **LISREL Examples** folder):

```
Social Status and Participation
DA NI=6 NO=530 MA=KM
LA
INCOME OCCUPATION EDUCATION CHURCHAT MEMBERSH FRIENDS
KM FI=EX54.COR
SE
4 5 6 1 2 3
MO NY=3 NE=1 NX=3 FI LY=FR
LE
AMBITION
FI LY(1)
VA 1 LY(1)
OU SE TV
```

Although the overall fit of the model is not too bad (χ^2 = 12.5 with 6 degrees of freedom), most of the relationships in the model are poorly determined as revealed by the low squared multiple correlation. The t-values reveal that occupation may not be a significant determinant of social participation, although income and education are.

```
  LISREL Estimates (Maximum Likelihood)

         LAMBDA-Y

            AMBITION
            --------
 CHURCHAT      1.000

 MEMBERSH      1.579
             (0.235)
               6.718

  FRIENDS      0.862
```

(0.143)
6.035

GAMMA

	INCOME	OCCUPATI	EDUCATIO
AMBITION	0.108	0.045	0.155
	(0.028)	(0.026)	(0.031)
	3.821	1.728	4.938

Covariance Matrix of ETA and KSI

	AMBITION	INCOME	OCCUPATI	EDUCATIO
AMBITION	0.217			
INCOME	0.169	1.000		
OCCUPATI	0.132	0.304	1.000	
EDUCATIO	0.204	0.305	0.344	1.000

PHI

	INCOME	OCCUPATI	EDUCATIO
INCOME	1.000		
OCCUPATI	0.304	1.000	
EDUCATIO	0.305	0.344	1.000

PSI

AMBITION
0.161
(0.037)
4.353