Scientific Software International

# Structural equation model for the role behavior of farm managers

## Contents



## 1. Introduction

This example is based on data from Warren, White and Fuller (1974) who reported on a study focusing on the studying of managerial behavior of farm managers. The data are a random sample of 98 managers from Iowa.

The observed data are the following four characteristics:

- KNOWLEDG: Knowledge of economic phases of management directed toward profit-making in a business and product knowledge
- VALORIEN: Tendency to rationally evaluate means to an economic end
- ROLSATIS: Gratification obtained by the manager from performing the managerial role
- TRAINING: amount of formal education

The role behavior of a manager (ROLBEHAV) was assumed to be linearly related to these 4 variables. The variable ROLBEHAV was measured with a set of 24 questions covering 5 functions of planning, organizing, controlling, coordinating and directing. For a detailed discussion of the construction of the variables, please refer to the *Multivariate Analysis with LISREL* text.

As the raw data is not available, the analysis is based on the covariance matrix of the variables at hand.

## 2. OLS estimation

In the first model, we use the syntax

```
Observed Variables: ROLBEHAV  KNOWLEDG  VALORIEN  ROLSATIS  TRAINING
Covariance Matrix:
0.0209
0.0177  0.0520
0.0245  0.0280  0.1212
0.0046  0.0044 -0.0063  0.0901
0.0187  0.0192  0.0353 -0.0066  0.0946
Sample Size: 98
Regress ROLBEHAV on KNOWLEDG  VALORIEN  ROLSATIS  TRAINING
```

to obtain the ordinary least squares estimates, ignoring measurement errors in the *x*-variables:

```
Estimated Equations

 ROLBEHAV = 0.230*KNOWLEDG + 0.120*VALORIEN + 0.0562*ROLSATIS + 0.110*TRAINING + Error, R² = 0.446
 Standerr  (0.0534)         (0.0355)         (0.0375)          (0.0391)
 Z-values   4.316            3.370            1.501             2.814
 P-values   0.000            0.001            0.133             0.005

 Error Variance = 0.0116
```

Now consider the case where we assume to know the values of the reliabilities of the *x*-variables. We assume these to be 0.60, 0.64, 0.81, and 1.00 respectively.

Under this assumption, we can calculate the error variance for each as $1-reliability(x)*\text{var}(x)$. We obtain the error variances 0.0208, 0.0436, 0.0171, and 0.000 for the four *x*-variables. Subtracting these values from the diagonal elements in the covariance matrix

| | ROLBEHAV | KNOWLEDG | VALORIEN | ROLSATIS | TRAINING |
|---|---|---|---|---|---|
| ROLBEHAV | 0.021 | | | | |
| KNOWLEDG | 0.018 | 0.052 | | | |
| VALORIEN | 0.025 | 0.028 | 0.121 | | |
| ROLSATIS | 0.005 | 0.004 | -0.006 | 0.090 | |
| TRAINING | 0.019 | 0.019 | 0.035 | -0.007 | 0.095 |

produces the adjusted covariance matrix

| | ROLBEHAV | KNOWLEDG | VALORIEN | ROLSATIS | TRAINING |
|---|---|---|---|---|---|
| ROLBEHAV | 0.021 | | | | |
| KNOWLEDG | 0.018 | 0.031 | | | |
| VALORIEN | 0.025 | 0.028 | 0.078 | | |
| ROLSATIS | 0.005 | 0.004 | -0.006 | 0.073 | |
| TRAINING | 0.019 | 0.019 | 0.035 | -0.007 | 0.095 |

We use the following syntax and the adjusted covariance matrix to fit the next model.

```
Observed Variables: ROLBEHAV  KNOWLEDG  VALORIEN  ROLSATIS  TRAINING
Covariance Matrix:
0.0209
0.0177  0.0312
0.0245  0.0280  0.0776
0.0046  0.0044 -0.0063  0.0730
0.0187  0.0192  0.0353 -0.0066  0.0946
Sample Size: 98
Regress ROLBEHAV on KNOWLEDG  VALORIEN  ROLSATIS  TRAINING
```

The maximum likelihood estimates for this analysis are as follows:

```
 Estimated Equations

 ROLBEHAV = 0.380*KNOWLEDG + 0.152*VALORIEN + 0.0594*ROLSATIS + 0.0677*TRAINING + Error, R² =
0.575
 Standerr  (0.0693)         (0.0448)         (0.0370)          (0.0354)
 Z-values   5.487            3.401            1.606             1.910
 P-values   0.000            0.001            0.108             0.056

 Error Variance = 0.00889
```

We note considerable differences in both estimates and standard errors. It is clear that the measurement error in one variables can impact the regression coefficient of another variable. However, we assumed to know the reliabilities here. These error variances cannot be estimated using the covariance matrix if there is only one measure *x* for each explanatory variable.

## 3. Split-halves

Rock et. al. (1977) proposed splitting each of the measures randomly into two parallel halves to estimate the effect of measurement error in the observed variables. The covariance matrix of these split-halves for the current data are given in the table below. The number in parentheses represents the number of items in each half.

| | | $y_1$ | $y_2$ | $x_{11}$ | $x_{12}$ | $x_{21}$ | $x_{22}$ | $x_{31}$ | $x_{32}$ | $x_4$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $y_1$ | (12) | 0.0271 | | | | | | | | |
| $y_2$ | (12) | 0.0172 | 0.0222 | | | | | | | |
| $x_{11}$ | (13) | 0.0219 | 0.0193 | 0.0876 | | | | | | |
| $x_{12}$ | (13) | 0.0164 | 0.0130 | 0.0317 | 0.0568 | | | | | |
| $x_{21}$ | (15) | 0.0284 | 0.0294 | 0.0383 | 0.0151 | 0.1826 | | | | |
| $x_{22}$ | (15) | 0.0217 | 0.0185 | 0.356 | 0.0230 | 0.0774 | 0.1473 | | | |
| $x_{31}$ | (5) | 0.0083 | 0.0011 | -0.0001 | 0.0055 | -0.0087 | -0.0069 | 0.1137 | | |
| $x_{32}$ | (6) | 0.0074 | 0.0015 | 0.0035 | 0.0089 | -0.0007 | -0.0088 | 0.0722 | 0.1024 | |
| $x_4$ | | 0.0180 | 0.0194 | 0.0203 | 0.0182 | 0.563 | 0.0142 | -0.0056 | -0.0077 | 0.946 |

This covariance matrix is available in the file **rock.cm**. This can be used to estimate the true regression equation

$$\eta = \gamma_1 \xi_1 + \gamma_2 \xi_2 + \gamma_3 \xi_3 + \gamma_4 \xi_4 + \zeta$$

with the measurement models

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \eta + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}$$

$$\begin{bmatrix} x_{11} \\ x_{12} \\ x_{21} \\ x_{22} \\ x_{31} \\ x_{32} \\ x_4 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1.2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \end{bmatrix} + \begin{bmatrix} \delta_{11} \\ \delta_{12} \\ \delta_{21} \\ \delta_{22} \\ \delta_{31} \\ \delta_{32} \\ 0 \end{bmatrix}$$

Note the inclusion of the value ‘1.2” in the last equation. This reflects that $x_{32}$ has 6 values, while $x_{31}$ only has 5 (see table above).

In these equations, the latent variables are

$\eta$ : role behavior

$\xi_1$ : knowledge

$\xi_2$ : value orientation

$\xi_3$ : role satisfaction

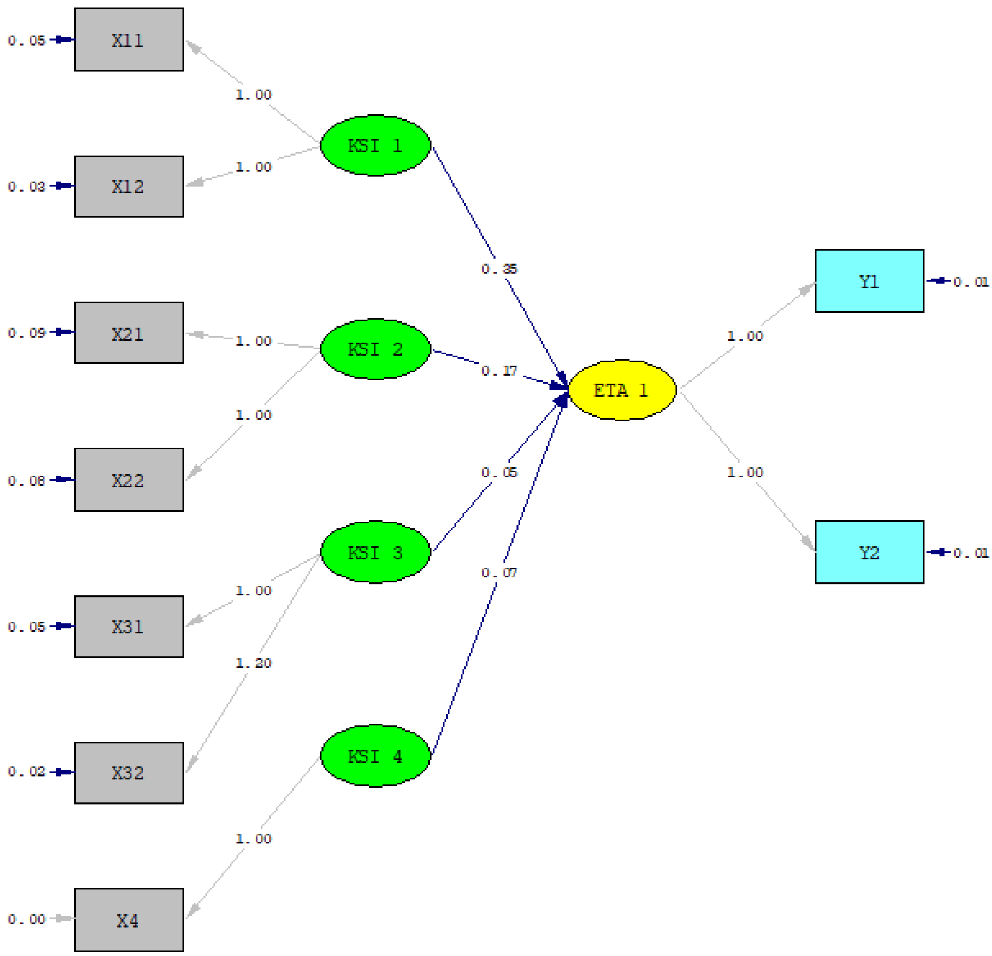
$\xi_4$ : past training

while $y_1$ and $y_2$ represent split-half measures of role behavior, $x_{11}$ and $x_{12}$ split-halves for knowledge, $x_{21}$ and $x_{22}$ split-halves for value orientation, and $x_{31}$ and $x_{32}$ the same for role satisfaction. The variable $x_4 = \xi_4$ is a measure of past training.

To fit this model, we use the syntax file

rolebehavior3b.lis

```
Role Behavior of Farm Managers, Part B
DA NI=9 NO=98
CM=rock.cm
LA
Y1 Y2 X11 X12 X21 X22 X31 X32 X4
MO NY=2 NE=1 NX=7 NK=4
FI TD 7
VA 1 LY 1 LY 2 LX 1 1 LX 2 1 LX 3 2 LX 4 2 LX 5 3 LX 7 4
VA 1.2 LX 6 3
OU SE AD=OFF
```




The path diagram for this analysis is shown above. From the output we obtain the following results for the $\gamma$ 's and their standard errors:

```
    GAMMA

              KSI 1       KSI 2       KSI 3       KSI 4
           --------    --------    --------    --------
   ETA 1      0.350       0.168       0.045       0.071
            (0.132)     (0.079)     (0.053)     (0.044)
              2.652       2.135       0.848       1.611
```

If these are compared with the results of the OLS estimates, we note considerable bias in the OLS estimates, although the standard errors associated with the OLS estimates are smaller.

From the goodness of fit measures reported

```
                        Goodness-of-Fit Statistics

Degrees of Freedom for (C1)-(C2)                     22
Maximum Likelihood Ratio Chi-Square (C1)             27.244 (P = 0.2021)
Browne's (1984) ADF Chi-Square (C2_NT)               25.615 (P = 0.2686)
```

that the current model fits the data reasonably well. Using the estimates of the true and error score variances for each observed measure, the reliabilities of the composite measures can now be computed. The reliability estimates are obtained as

| $y$ | $x_1$ | $x_2$ | $x_3$ |
|---|---|---|---|
| 0.82 | 0.60 | 0.64 | 0.81 |