# 6.2.2 Interaction Effects in Models with Latent Variables

The residual centering approach of Little et al. (2006) consists of three steps. In the first step, individual product terms are formed for each combination of the 3 indicators (w01-w03 and na01 - na03); then each of these product terms is regressed in a regression analysis to all first-order effect indicators (i.e. w01 etc.) and the residuals are stored in the data set as variables. These are finally used in the model as indicators of the latent product term variable. The R-syntax of all these procedures appears extensive and complicated at first glance; however, the individual elements are only repetitions with slight adjustments. It is not difficult to implement this approach with the necessary systematic approach.

Step 1: Multiply all first-order variables

wfcdata$pt11 <- wfcdata$w01 \* wfcdata$na01

wfcdata$pt12 <- wfcdata$w01 \* wfcdata$na02

wfcdata$pt13 <- wfcdata$w01 \* wfcdata$na03

wfcdata$pt21 <- wfcdata$w02 \* wfcdata$na01

wfcdata$pt22 <- wfcdata$w02 \* wfcdata$na02

wfcdata$pt23 <- wfcdata$w02 \* wfcdata$na03

wfcdata$pt31 <- wfcdata$w03 \* wfcdata$na01

wfcdata$pt32 <- wfcdata$w03 \* wfcdata$na02

wfcdata$pt33 <- wfcdata$w03 \* wfcdata$na03

The first index of each product term represents the first-order indicator used.

Step 2: Regression of each product term on all first-order effect indicators and storage in the data set

wfcdata$res11 <- resid(lm(pt11 ~ w01+w02+w03 + na01+na02+na03,   
 + data=wfcdata,na.action = na.exclude))

wfcdata$res12 <- resid(lm(pt12 ~ w01+w02+w03 + na01+na02+na03,

+ data=wfcdata,na.action = na.exclude))

wfcdata$res13 <- resid(lm(pt13 ~ w01+w02+w03 + na01+na02+na03,

+ data=wfcdata,na.action = na.exclude))

wfcdata$res21 <- resid(lm(pt21 ~ w01+w02+w03 + na01+na02+na03,

+ data=wfcdata,na.action = na.exclude))

wfcdata$res22 <- resid(lm(pt22 ~ w01+w02+w03 + na01+na02+na03,

+ data=wfcdata,na.action = na.exclude))

wfcdata$res23 <- resid(lm(pt23 ~ w01+w02+w03 + na01+na02+na03,

+ data=wfcdata,na.action = na.exclude))

wfcdata$res31 <- resid(lm(pt31 ~ w01+w02+w03 + na01+na02+na03,

+ data=wfcdata,na.action = na.exclude))

wfcdata$res32 <- resid(lm(pt32 ~ w01+w02+w03 + na01+na02+na03,

+ data=wfcdata,na.action = na.exclude))

wfcdata$res33 <- resid(lm(pt33 ~ w01+w02+w03 + na01+na02+na03,

+ data=wfcdata,na.action = na.exclude))

With this block, only the formed residual (e.g. "res11") and the product term used (e.g. "pt11") must be adapted as a dependent variable - the rest can be copied. For clarification both elements were underlined in the above code. The individual command lines use three still unknown functions. First, lm(Y ~ X) is used to regression ("linear model") the dependent variable Y to the independent variable X, "na.action=na.exclude" causes missing values on the side of the independent variable to be preserved in the residuals (otherwise we would have fewer cases in the product term variables than in the other model variables). Finally, the lm() function is enclosed in the re-sid() function, which extracts the residuals of the regression.

Once the product term variables have been formed, two tests should be performed to ensure that no errors have occurred. First, the averages of these indicators should all be exactly zero; second, the correlations with the first-order effect indicators should be zero and among the product term indicators substantial. The former is checked by

mean(wfcdata$res11,na.rm=TRUE)

For the latter, the correlation matrix of all variables is calculated:

modvar <- wfcdata[c("w01","w02","w03","na01","na02","na03",

+"res11","res12","res13","res21", Rest ausgelassen)]

round(cor(modvar,use="pair"),2)

There are many ways to generate correlation matrices, all of which are admittedly not very comfortable. Here a subdataset with the desired variables was created and the cor() function integrated into the round() function was applied to it.

Step 3: Specification of the model

Finally it goes to the model. This has two peculiarities: First, the covariances of the latent product term variables and the two first-order effect variables work-family conflict and negative affectivity are fixed at 0. Secondly, measurement error covariances are released between those product-term indicators in which virtually the same indicators are found: Since these consist of the same indicators, they should therefore also (be allowed to) correlate. The syntax shown below looks admittedly (again) elaborate - but with a bit of a system this is easily feasible.

intlat <- '

NAF =~ na01+na02+na03

WFC =~ w01+w02+w03

AZF =~ az01 + az02

PRTRM =~ res11+res12+res13+res21+res22+res23+res31+res32+res33

PRTRM ~~0\*WFC #The product term does not correlate with

PRTRM ~~0\*NAF #the first-order-effect-variables

#Error covariances of relevant product term indciators

res11~~res12

res12~~res13

res11~~res13

#res21, res22, res23

res21~~res22

res22~~res23

res21~~res23

#res31, res32, res33

res31~~res32

res32~~res33

res31~~res33

res11~~res21

res11~~res31

res21~~res31

#res12, res22, und res32

res12~~res22

res12~~res32

res22~~res32

#res13, res23, und res33

res13~~res23

res13~~res33

res23~~res33

#Structural model

AZF ~ WFC + NAF + PRTRM

'

fit <- sem(intlat, data=wfcdata, missing="fiml",estimator="mlr")

summary(fit)

In output, only the structural model is of primary interest here. The fit of the model should usually be acceptable if the measurement model of the latent variables (without product terms) is clearly fit. If not, the existing misfit is also strongly weighted by using the product terms. In the following output, many lines were shortened for the sake of economy. Central to the moderator effect is the effect of the latent product term, which is = -.30 here. Its z value is 3,054, which is only slightly higher than in the path models (z = 2.89). However, this does not always have to be the case. Especially for indicators with a higher measurement error or smaller samples, the difference between a model with a latent product term and a path model can be substantial and decisive.

Estimate Std.err Z-value P(>|z|)

Latent variables:

NAF =~

na01 1.000

na02 0.950 0.159 5.991 0.000

na03 0.739 0.123 5.986 0.000

WFC =~

w01 1.000

w02 1.002 0.071 14.151 0.000

w03 0.973 0.070 13.978 0.000

AZF =~

az01 1.000

az02 0.833 0.132 6.302 0.000

PRTRM =~

res11 1.000

res12 0.981 0.190 5.157 0.000

[...]

Regressions:

AZF ~

WFC -0.333 0.062 -5.371 0.000

NAF -0.155 0.111 -1.397 0.163

PRTRM -0.300 0.098 -3.054 0.002

Covariances:

WFC ~~

PRTRM 0.000

NAF ~~

PRTRM 0.000

res11 ~~

res12 0.138 0.068 2.020 0.043

[...]

Variances:

na01 0.559 0.083

na02 0.544 0.077

na03 0.547 0.060

w01 0.308 0.048

w02 0.427 0.058

w03 0.485 0.056

az01 0.108 0.124

az02 0.239 0.093

res11 0.658 0.131

res12 0.711 0.136

[...]

NAF 0.399 0.088

WFC 0.739 0.080

AZF 0.716 0.131

PRTRM 0.454 0.207