Methods for Integrating Moderation and Mediation: Moving Forward by Going Back to Basics

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Research that Examines
Moderation and Mediation

Many streams of research combine moderation and mediation. Examples:

- Job characteristics affect critical psychological states, which in turn affect motivation, and these links are moderated by growth needs strength.
- The interactive effect of expectancy, instrumentality, and valence on performance is mediated by motivation.

Moderation and mediation are combined whenever causal paths are contingent on some variable or an interaction effect is transmitted through an intervening variable.
Methods for Integrating Moderation and Mediation

Methods for integrating moderation and mediation can be traced to classic work by James and Brett (1984) and Baron and Kenny (1986).

Recent work has addressed models that combine moderation and mediation by combining path analysis with moderated regression (Edwards & Lambert, 2007; Preacher, Rucker, & Hayes, 2007).

Models considered in this work have been extended by Hayes (2013).
Current Status and Two Paths Forward

Much of the work on mediation, including work that integrates moderation, is limited to the basic three-variable model $X \rightarrow M \rightarrow Y$.

This model vastly understates the complexity of theoretical models that involve mediation.

Moreover, any path in a mediated model can be moderated by one or more variables.

To address this staggering variety of models, researchers can:

- Rely on methodological experts.
- Return to first principles.
Relying on Experts

Among the experts who continue to expand and extend models that combine moderation and mediation, the exemplar is Hayes (2013).

Hayes is the author of the PROCESS macro, which runs in SPSS and SAS.

PROCESS has become increasingly popular, and Hayes deserves credit for helping many researchers overcome the complexities of models with moderation and mediation.

Of course, researchers are limited by the models and tests built into PROCESS.
Returning to First Principles

- The prototype three-variable mediated model is a very simple path analytic model.

- Path analysis is the forerunner of SEM and has a long methodological history (Alwin & Hauser, 1975; Billings & Wroten, 1978; Duncan, 1966; Wright, 1934).

- Path analysis allow researchers to translate a model into a series of equations whose coefficients are the paths of the model.

- These coefficients can be used to derive the direct, indirect, and total effects of the model.
Translating a Theoretical Model Into Path Analysis

- We now turn to the conceptual logic for translating theoretical models into path models.
- This process is illustrated with a five-variable model but extends to larger models.
- Although illustrated with observed variables, this process applies to structural models with latent variables.
- For this illustration, we focus on a recursive model with one-way causation.
Begin With a Diagram

As a first step, translate your theoretical model into a diagram that connects the variables with arrows.

Your model will have two types of variables:

- Exogenous: Variables that only have arrows pointing from them.
- Endogenous: Variables that have arrows pointing to them and perhaps from them.

Relationships between exogenous variables are depicted by two-headed curved arrows.

Causal flow usually runs from left to right.
Starting the Model with Two Exogenous Variables

We begin with communication (COM) and role clarity (ROL) as two exogenous variables.
Adding a Covariance Between the Exogenous Variables

These variables are likely to covary. Because the variables are exogenous, we attribute this covariance to external factors.
Adding the First Endogenous Variable

We add coworker liking (LIK), which is the extent to which people have positive relationships with others at work.
Adding Paths to the First Exogenous Variable

Coworker liking is cast as an outcome of communication and role clarity, both of which can promote interpersonal harmony at work.
Adding a Second Endogenous Variable

We add trust (TRU), which refers to the belief that others can and will act on one’s behalf.
Adding Paths to the Second Endogenous Variable

We cast trust as an outcome of communication, role clarity, and liking.
Adding a Third Endogenous Variable

We add organizational citizenship behavior (OCB) as the final outcome of the model.
Adding Paths to the Third Endogenous Variable

We frame liking and trust as the proximal causes of OCB that transmit the effects of communication and role clarity.
We now have a model which posits that job conditions cause interpersonal relationships, which in turn cause OCB.
Numbering the Variables

Before adding symbols for correlations and path coefficients, we number the variables.
Adding Path Coefficients and the Covariance

We add the covariance and path coefficients using the symbols $c$ and $p$. For paths, the subscripts are the “to” and “from” variables.
Writing the Equations for the Path Model

With the path model in hand, we now write the corresponding structural equations. We have three endogenous variables and therefore have three equations:

- $LIK = p_{30} + p_{31}COM + p_{32}ROL + e_L$
- $TRU = p_{40} + p_{41}COM + p_{42}ROL + p_{43}LIK + e_T$
- $OCB = p_{50} + p_{53}LIK + p_{54}TRU + e_O$

Provided the usual assumptions are satisfied, these equations can be estimated using OLS regression. The same estimates would be obtained using SEM with observed variables.
Writing the Equations for the Path Model

We now manipulate the equations to derive the indirect and total effects. For this task, we can omit the intercepts and residuals.

When the right-hand variables are exclusively exogenous, the dependent variable has only direct effects associated with it. This condition applies to the equation for LIK:

- $LIK = p_{31} COM + p_{32} ROL$

As such, the effects of COM and ROL on LIK are direct effects, as represented by $p_{31}$ and $p_{32}$, which also signify their total effects.
Effects of Communication and Role Clarity on Liking

The path for COM is red, and the path for ROL is blue.
Writing the Equations for the Path Model

- When one or more of the right-hand variables is endogenous, we replace the variables with the equations that treat them as outcomes.

- The equation for TRU has LIK on the right side, which is an endogenous variable.
  - TRU = $p_{41} \text{COM} + p_{42} \text{ROL} + p_{43} \text{LIK}$

- Recall that the equation for LIK is:
  - LIK = $p_{31} \text{COM} + p_{32} \text{ROL}$
Writing the Equations for the Path Model

Substituting the equation for LIK into the equation for TRU yields:

\[ TRU = p_{41} \text{COM} + p_{42} \text{ROL} + p_{43}(p_{31} \text{COM} + p_{32} \text{ROL}) \]

Distribution and collecting like terms yields:

\[ TRU = (p_{41} + p_{43}p_{31}) \text{COM} + (p_{42} + p_{43}p_{32}) \text{ROL} \]

For COM, the direct effect on TRU is \( p_{41} \), and the indirect effect \( p_{43}p_{31} \). The total effect is the sum of the direct and indirect effects, which is \( p_{41} + p_{43}p_{31} \).

For ROL, the direct, indirect, and total effects of ROL are \( p_{42} \), \( p_{43}p_{32} \), and \( p_{42} + p_{43}p_{32} \).
Effects of Communication and Role Clarity on Trust

The paths unique to COM are red, the paths unique to ROL are blue, and the path shared by COM and ROL is purple.
Writing the Equations for the Path Model

Finally, the equation for OCB has LIK and TRU on the right side, which are endogenous.

- \( \text{OCB} = p_{53}\text{LIK} + p_{54}\text{TRU} \)

Recall the equation for TRU, which is:

- \( \text{TRU} = p_{41}\text{COM} + p_{42}\text{ROL} + p_{43}\text{LIK} \)

Substituting the equation for TRU into the equation for OCB yields:

- \( \text{OCB} = p_{53}\text{LIK} + p_{54}(p_{41}\text{COM} + p_{42}\text{ROL} + p_{43}\text{LIK}) \)

Distribution and collecting like terms yields:

- \( \text{OCB} = (p_{53} + p_{54}p_{43})\text{LIK} + p_{54}p_{41}\text{COM} + p_{54}p_{42}\text{ROL} \)
Writing the Equations for the Path Model

Distribution and collecting like terms yields:

\[ OCB = (p_{53} + p_{54}p_{43})\text{LIK} + p_{54}p_{41}\text{COM} + p_{54}p_{42}\text{ROL} \]

This equation shows that the effect of LIK on OCB has two components, \( p_{53} \) and \( p_{54}p_{43} \). \( p_{53} \) is the direct effect, \( p_{54}p_{43} \) is the indirect, and their sum, \( p_{53} + p_{54}p_{43} \), is the total effect.
Effects of Liking on OCB

The paths for LIK are green.
Writing the Equations for the Path Model

The OCB equation still has the endogenous variable LIK on the right side. Recall the equation for LIK:

- $\text{LIK} = p_{31}\text{COM} + p_{32}\text{ROL}$

We substitute the equation for LIK into the OCB equation:

- $\text{OCB} = (p_{53} + p_{54}p_{43})(p_{31}\text{COM} + p_{32}\text{ROL}) + p_{54}p_{41}\text{COM} + p_{54}p_{42}\text{ROL}$
Writing the Equations for the Path Model

Distribution and collecting like terms yields:

\[
OCB = (p_{53} p_{31} + p_{54} p_{41} + p_{54} p_{43} p_{31}) \text{COM} + \\
(p_{53} p_{32} + p_{54} p_{42} + p_{54} p_{43} p_{32}) \text{ROL}
\]

This equation shows that COM and ROL each have three indirect effects on OCB.

- The indirect effects for COM are \( p_{53} p_{31}, p_{54} p_{41}, \) and \( p_{54} p_{43} p_{31} \).
- The indirect effects for ROL are \( p_{53} p_{32}, p_{54} p_{42}, \) and \( p_{54} p_{43} p_{32} \).

Because COM and ROL have no direct effects on OCB, their total effects on OCB equal the sum of their indirect effects.
Effects of Communication and Role Clarity on Trust

The paths unique to COM are red, the paths unique to ROL are blue, and the paths shared by COM and ROL are purple.
Effect Analysis and Correlation

Decomposition

- The foregoing derivations constitute an effect analysis of the variables in the model.
- A full decomposition of the relationships among the variables would include spurious and unanalyzed components.
- The full set of components can be derived algebraically (Alwin & Hauser, 1975) and using tracing rules (Wright, 1934).
- These decompositions are very informative and yet have become a lost art in SEM.
Estimating the Path Model

We estimated the model using data Cable and Edwards (2004) with a sample size of 918.

The obtained estimates are as follows:

- $\text{LIK} = 1.57 + 0.32\text{COM} + 0.11\text{ROL}$
- $\text{TRU} = 0.15 + 0.28\text{COM} + 0.48\text{ROL} + 0.21\text{LIK}$
- $\text{OCB} = 2.90 + 0.11\text{LIK} + 0.14\text{TRU}$

All coefficients were statistically significant at $p < .05$.

$R^2$ estimates were .15, .43, and .11 for LIK, TRU, and OCB, respectively (all $p < .05$).
Assigning Path Coefficients and Correlations to the Model

The estimated path coefficients are assigned to the model below. The covariance between COM and ROL is also shown.
Computing and Testing Direct, Indirect, and Total Effects

- The direct effects of the model correspond to the coefficient estimates, which can be tested in the usual manner, provided the applicable assumptions are satisfied or accommodated.

- Indirect and total effects involve products of coefficients, which in general are not normally distributed.

- These quantities can be tested using nonparametric procedures, such as the bootstrap.
Overview of the Bootstrap

The bootstrap consists of the following steps:

- Create a large number (e.g., 1000) of bootstrap samples from the full sample by randomly drawing cases with replacement, with each bootstrap sample having the same number of cases as the full sample.

- Estimate the equations for the model with each bootstrap sample and save the coefficients. These coefficients can be multiplied and added to create bootstrap estimates of indirect and total effects.

- The bootstrap estimates can be used to construct sampling distributions and confidence intervals for the coefficients from the full sample.
Applying the Bootstrap in SPSS

Although not widely known, the bootstrap is programmed into the CNLR procedure, which can generate and save bootstrap coefficients.

The syntax for the REL equation is:

```plaintext
SET RNG=MT MTINDEX=54321 .
MODEL PROGRAM p30=1.574 p31=0.315 p32=0.107 .
COMPUTE PRED = p30 + p31*com + p32*rol .
CNLR rel
/OUTFILE='C:\RESEARCH\PRESENT\CARMA\ADMODMED\RELBOOT.SAV'
/BOOTSTRAP=1000 .
```
Applying the Bootstrap in SPSS

The syntax for the TRU equation is:

SET RNG=MT MTINDEX=54321.
MODEL PROGRAM p40=0.153 p41=0.279 p42=0.482 p43=0.211.
COMPUTE PRED = p40 + p41*com + p42*rol + p43*rel.
CNLR tru
/OUTFILE='C:\RESEARCH\PRESENT\CARMA\ADMODMED\TRUBOOT.SAV'
/BOOTSTRAP=1000.

The syntax for the OCB equation is:

SET RNG=MT MTINDEX=54321.
MODEL PROGRAM p50=2.900 p53=0.114 p54=0.143.
COMPUTE PRED = p50 + p53*rel + p54*tru.
CNLR ocb
/OUTFILE='C:\RESEARCH\PRESENT\CARMA\ADMODMED\OCBBBOOT.SAV'
/BOOTSTRAP=1000.
Applying the Bootstrap in SPSS

The coefficients saved in RELBOOT.SAV, TRUBOOT.SAV, and OCBBOOT.SAV can be exported into Excel files with this syntax:

```
GET FILE 'C:\RESEARCH\PRESENT\CARMA\ADMODMED\RELBOOT.SAV' .
SAVE TRANSLATE OUTFILE 'C:\RESEARCH\PRESENT\CARMA\ADMODMED\RELBOOT.XLS' REPLACE .

GET FILE 'C:\RESEARCH\PRESENT\CARMA\ADMODMED\TRUBOOT.SAV' .
SAVE TRANSLATE OUTFILE 'C:\RESEARCH\PRESENT\CARMA\ADMODMED\TRUBOOT.XLS' REPLACE .

GET FILE 'C:\RESEARCH\PRESENT\CARMA\ADMODMED\OCBBOOT.SAV' .
SAVE TRANSLATE OUTFILE 'C:\RESEARCH\PRESENT\CARMA\ADMODMED\OCBBOOT.XLS' REPLACE .
```
Results

Let’s take a look at those Excel files . . .

- RELBOOT.XLS
- LIKBOOT.XLS
- OCBBOOT.XLS
- MEDBOOT.XLS

For this illustration, the first three files have been copied into the fourth file.
Some Key Conclusions

- All direct, indirect, and total effects were positive and differed from zero.
- The total effect on LIK was larger for COM (.315) than for ROL (.107).
- The total effect on TRU was larger for ROL (.505) than for COM (.345), but the CI for their difference included 0 (-.024, .349).
- The total effects on OCB for COM and ROL were practically equal (.085 and .084) and did not statistically differ from one another.
We now add gender (GEN) as a moderator variable.*

*The bracket signifies that GEN moderates every path in the model.
Writing the Equations for the Path Model

The three equations for the model become:

\[ \text{LIK} = p_{30} + p_{31} \text{COM} + p_{32} \text{ROL} + p_{36} \text{GEN} + p_{37} \text{COMGEN} + p_{38} \text{ROLGEN} + e_L \]

\[ \text{TRU} = p_{40} + p_{41} \text{COM} + p_{42} \text{ROL} + p_{43} \text{LIK} + p_{46} \text{GEN} + p_{47} \text{COMGEN} + p_{48} \text{ROLGEN} + p_{49} \text{LIKGEN} + e_T \]

\[ \text{OCB} = p_{50} + p_{53} \text{LIK} + p_{54} \text{TRU} + p_{56} \text{GEN} + p_{510} \text{LIKGEN} + p_{511} \text{TRUGEN} + e_O \]

The interpretation of these equations is clarified by writing them in terms of simple paths, analogous to simple slopes.
Rearranging the Equations to Show Simple Paths

The simple path equation for LIK is:

- \( \text{LIK} = (p_{30} + p_{36} \text{GEN}) + (p_{31} + p_{37} \text{GEN}) \text{COM} + (p_{32} + p_{38} \text{GEN}) \text{ROL} + e_L \)

\( \text{GEN} \) is coded 0 = men, 1 = women. For men, we have:

- \( \text{LIK} = p_{30} + p_{31} \text{COM} + p_{32} \text{ROL} + e_L \)

For women, we have:

- \( \text{LIK} = (p_{30} + p_{36}) + (p_{31} + p_{37}) \text{COM} + (p_{32} + p_{38}) \text{ROL} + e_L \)
The simple path equation for TRU is:

- \[ TRU = (p_{40} + p_{46} \text{GEN}) + (p_{41} + p_{47} \text{GEN}) \text{COM} + (p_{42} + p_{48} \text{GEN}) \text{ROL} + (p_{43} + p_{49} \text{GEN}) \text{LIK} + e_T \]

For men, we have:

- \[ TRU = p_{40} + p_{41} \text{COM} + p_{42} \text{ROL} + p_{43} \text{LIK} + e_T \]

For women, we have:

- \[ TRU = (p_{40} + p_{46}) + (p_{41} + p_{47}) \text{COM} + (p_{42} + p_{48}) \text{ROL} + (p_{43} + p_{49}) \text{LIK} + e_T \]
Writing the Equations for the Path Model

Finally, the simple path equation for OCB is:

\[ OCB = (p_{50} + p_{56} \text{GEN}) + (p_{53} + p_{510} \text{GEN}) \text{LIK} + (p_{54} + p_{511} \text{GEN}) \text{TRU} + e_L \]

GEN is coded 0 = men, 1 = women. For men, we have:

\[ OCB = p_{50} + p_{53} \text{LIK} + p_{54} \text{TRU} + e_O \]

For women, we have:

\[ OCB = (p_{50} + p_{56}) + (p_{53} + p_{510}) \text{LIK} + (p_{54} + p_{511}) \text{TRU} + e_O \]
Job Conditions, Interpersonal Relationships, and OCB

The simple paths are now incorporated into the model. For brevity, we use $G$ to represent the moderator variable GEN.
Simple Paths for Men

The simple paths for men are shown below.
Simple Paths for Women

The simple paths for women are shown below.
Simple Slopes for Men and Women Relating LIK to OCB

The solid line is for men, and the dashed line is for women.
Simple Slopes for Men and Women Relating TRU to OCB

The solid line is for men, and the dashed line is for women.
Key Takeaways

- Methodological work on moderation and mediation should be seen as a starting point for developing your own models.
- There is no substitute for learning the fundamentals of path analysis, moderation, and the bootstrap.
- Becoming methodologically self-reliant is empowering, satisfying, and essential to your success as researcher.