CARMA Larry James Lecture

The When and Why of Effects: Moderation and Mediation in Strategic Management Research

Herman Aguinis
Avram Tucker Distinguished Scholar
George Washington U. School of Business
The Urgency of Methods Training

• Research methodology is now more important than ever
• Retractions, ethical violations, data fabrication, hypothesizing after results are known (HARKing), p-hacking, questionable research practices
• Current debate about the credibility and trustworthiness of results and conclusions based on management research
• This debate is methodological in nature
  • How we do our work
  • How we do research
• Our modest contribution: Best-practice recommendations articles on regression, multilevel modeling, meta-analysis, outliers, control variables, and other issues (see www.hermanaguinis.com/pubs.html)
The Urgency of Methods Training

• At its core, issues about the credibility and trustworthiness of our research are about methodological issues:
  • How we conceptualize a study
  • How we design a study
  • How we measure variables
  • How we analyze our data
  • How we report results and describe implications
Honoring Professor Larry James

- Numerous contributions to methodological advancements:
  - Unmeasured variables
  - Using structural equation modeling to test causal models
  - Meta-analysis and validity generalization
  - Multilevel theory
  - Within-group agreement
  - Indirect measurement systems
  - Conditional reasoning
  - Moderation and mediation
- “he wanted his research to have practical value to organizations and the individuals that comprised them” (LeBreton & Mulaik, 2015, *American Psychologist*, 2015).
Honoring Professor Larry James

- Moderation and mediation:
CARMA Webcast (2004)

• 2004 webcast on measurement error and moderation in meta-analysis
CARMA Webcast (2004)

• Not trying to camouflage as a zebra
• Digital cameras were not that good 12 years ago
Why Should we Care about Moderation and Mediation?

- Yet another methodological topic? Is this really necessary?
- Yes, not just a “mere methodological” issue or “quibbles of stats geeks”
- Central to theory building and testing
- Central to understanding management and organizations
- Critical for understanding when and why organizational practices are effective
- Directly related to how we do research with implications for replicability, trustworthiness, and credibility of our results and conclusions
A Personal Journey…

• Articles available at www.hermanaguinis.com:
• A journey that began more than 20 years ago…

A Personal Journey…

• Articles available at www.hermanaguinis.com:


A Personal Journey…

• Articles available at www.hermanaguinis.com:

Most Recent Research


Improving Our Understanding of Moderation and Mediation in Strategic Management Research

Herman Aguinis  Jeffrey R. Edwards
and Kyle J. Bradley
Overview of Today’s Presentation

• Review of articles that assessed the possible presence of moderation and mediation in SMJ and OS from 2005 to 2014
• Describe 13 problems we uncovered
• Offer solutions for each of the problems
• Solutions and problems are applicable to strategic management studies, organizational behavior, human resource management, entrepreneurship, information systems, industrial and organizational psychology, and other social and behavioral sciences
• Caveat: Will not be able to cover all issues in detail
• Please see articles listed in previous slides
Literature Review: Houston, We Have 13 Problems...

- Manual review to identify articles using multiple regression to test moderation and mediation; N = 267

<table>
<thead>
<tr>
<th></th>
<th>Moderation</th>
<th>Mediation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMJ</td>
<td>126</td>
<td>24</td>
</tr>
<tr>
<td>OS</td>
<td>79</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>205</td>
<td>62</td>
</tr>
</tbody>
</table>
Moderation: The “When”

- Moderator variables (also called interactions) influence the nature (e.g., magnitude and/or direction) of a relation/effect:

\[
Y = \beta_0 + \beta_1 X + \beta_2 Z + \beta_3 XZ
\]

- The traditional data-analytic approach for categorical moderators (e.g., industry type) is subgrouping analysis
- Moderated multiple regression is typically used to study continuous moderators (e.g., firm resources)
  - \( \hat{Y} = \beta_0 + \beta_1 X + \beta_2 Z + \beta_3 XZ \)
  - \( \beta_3 \) offers information on the presence and magnitude of the moderating effect
Moderation: Problem #1

Lack of Attention to Measurement Error

- 62.44% of articles did not mention measurement error at all
- Impact of measurement error depends on where it occurs
  - Measurement error in independent (X) and moderator (Z) variables introduces bias in unstandardized coefficient estimates
  
- Measurement error in outcome variables (Y) does not bias coefficient estimates, attenuates estimates of explained variance

- Example: moderating effect of capabilities to deal with gas deregulation on the relation between managerial domain-specific experience and opportunity interpretation:

\[
\rho_{xz,xz} = \frac{0 + (0.7)(0.7)}{0 + 1} = 0.49
\]
Solutions for Problem #1

• Do not assume reliable measurement—this is typically a false assumption
• Use measures that have high reliability
• Do not assume measurement error is zero and report the reliabilities of the measures (including the interaction term)
• This is especially important for situations when a hypothesized moderating effect is not found
  • If reliability of the predictors is low, an existing moderating effect is likely underestimated and may even go undetected (i.e., false negative)
Moderation: Problem #2

Variable Distributions Are Assumed to Include the Full Range of Possible Values

- 34.15% of articles seemed to include scores that did not span the full possible range

![Capability Perceptions](image)

- When sample variance is less than population variance, the statistical power for detecting moderating effects is diminished
- Even if a moderating effect is statistically significant, range restriction can reduce the observed effect size
Solutions for Problem #2

- Attempt to capture the full range of scores of ALL variables included in the analysis
- If this is not feasible, provide the estimated population variance to rule out range restriction as a plausible alternative explanation for the obtained results (i.e., non-significant and/or small moderating effects)
Moderation: Problem #3

Unequal Sample Size Across Moderator-Based Categories

- 20% of articles had unequal sample sizes across moderator subgroups (this issue applies to categorical moderators).
- This issue is akin to range restriction issues in continuous moderator variables.

\[ S_Z^2 = \frac{\sum(Z_i - \bar{Z})}{N - 1} = \frac{Np(1 - p)}{N - 1} \]

\[ \begin{align*}
  n_1 &= 50 \\
  n_2 &= 50 \\
  p &= 0.5 \\
  N &= 100
\end{align*} \]

\[ \frac{(100)(0.5)(1 - 0.5)}{100 - 1} = 0.2525 \]

\[ \begin{align*}
  n_1 &= 20 \\
  n_2 &= 80 \\
  p &= 0.8 \\
  N &= 100
\end{align*} \]

\[ \frac{(100)(0.8)(1 - 0.8)}{100 - 1} = 0.1616 \]
Solutions for Problem #3

• Oversample from the smaller group
  • Increases power at the cost of representativeness
  • Y: international entry, X: media coverage, Z: type of ownership

Foreign Firms International Entry

Owned by individuals

Owned by other firms
Moderation: Problem #4

*Insufficient Statistical Power*

- 43.41% of articles did not mention statistical power and seem underpowered
- For the 205 articles combined, the median N was 227.5
  - Sample size is an important determinant of statistical power
- This is too small to yield statistical power of .80 or higher to detect the typical moderating effect size
- Many moderating effects have likely gone undetected
Solutions for Problem #4

• Statistical power is largely ignored
• Power can be increased by:
  • Conducting studies with larger sample sizes
  • Conducting research in settings that control for extraneous variables
• At the very least, statistical power must be computed and reported and ruled out as the “culprit” for non-significant effects
Moderation: Problem #5
Artificial Dichotomization of Continuous Moderators

- 10.24% of articles used artificial dichotomization to create a “categorical” moderator variable
- Artificial dichotomization occurs when researchers categorize continuous variables into groups (e.g., median split)
- Results in a loss of information

Variety in repertoire of strategic actions

1  2  3  4  5
Not a part of our strategy at all
Not a part of our strategy
Part of our strategy
A key part of our strategy
Solutions for Problem #5

- Artificial dichotomization:
  - Discards information
  - Reduces statistical power to detect moderating effects
  - Attenuates the size of the moderating effect
- Use of artificial dichotomization should be discontinued
43.90% of articles discussed the issue of multicollinearity and used centering to “solve” this problem.

“*To reduce multicollinearity, we mean centered the independent and moderator variables before creating the interaction term*”

Any apparent multicollinearity created by the correlation of XZ with X and Z does not cause problems for tests of moderation

\[
\hat{Y} = \beta_0 + \beta_1 X + (\beta_2 Z + \beta_3 XZ)
\]

Centering predictor and moderator variables does facilitate interpretation of the X and Z coefficients (i.e., the slope of each variable when the other equals zero).

In the presence of an XZ interaction, first-order effects can be interpreted as an average across the full range of values of the other predictor.
Solutions for Problem #6

- Mean centering is useful for interpreting lower-order coefficients as the average across values of the other predictor.
- When the interaction is ordinal, interpreting first-order effects may be informative.
- However, this is not true for disordinal interactions.
- Results regarding interaction effects remain unchanged if predictors are centered or not.
Moderation: Problem #7
Interpreting First-Order Effects Based on Models Excluding Product Terms

- 42.93% of articles interpreted lower order effects before introducing interaction terms
- X does not have a single unique effect but a range of effects that varies according to the level of Z.
- It is not meaningful to hypothesize or test a single effect for a predictor when that predictor interacts with a moderator variable

<table>
<thead>
<tr>
<th></th>
<th>Work Unit Performance</th>
<th>Work Unit Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>Model 2</td>
<td></td>
</tr>
<tr>
<td>Informal Control Systems (ICS)</td>
<td>0.74*</td>
<td>-0.11</td>
</tr>
<tr>
<td>Task Interdependence (TI)</td>
<td>-0.11</td>
<td>-0.11</td>
</tr>
<tr>
<td>ICS x TI</td>
<td>-1.12**</td>
<td></td>
</tr>
</tbody>
</table>
Solutions for Problem #7

• Conclusions should be drawn from the full model that includes the interaction term
• Researchers should use simple slopes to test meaningful levels of the moderator variables
Mediation: The “Why”

- Mediator variables transmit the effect of the antecedent on the outcome, either in part or whole

\[ M \]
\[ \overset{a}{\longrightarrow} X \]
\[ \overset{b}{\longrightarrow} Y \]
\[ \overset{c'}{\longrightarrow} \]

- Indirect effect represents the part of the effect of X on Y that is mediated by M
- The magnitude of the indirect effect is represented by the product of the paths a and b
  - Full mediation: \( ab \neq 0 \) and \( c' = 0 \)
  - Partial mediation: \( ab \neq 0 \) and \( c' \neq 0 \)
Mediation: Test Procedure

• Majority of mediation analyses rely on the causal-steps procedure (Baron & Kenny, 1986).
• Three regression equations:

\[
Y = cX + e_y
\]
\[
M = aX + e_z
\]
\[
Y = bM + c'X + e'_Y
\]

• Mediation is present when:
  • \(c\) is significant → There is a total effect to be mediated
  • \(a\) is significant → Establishes significant paths to and from mediator
  • \(b\) is significant
  • \(c'\) is not significant → Shows full mediation (not required for partial mediation)
Mediation: Test Procedure

• Much confusion is about the role of the X-Y relation (c and c’) in the mediation test procedure:

\[ Y = cX + e_Y \]
\[ M = aX + e_z \]
\[ Y = bM + c'X + e'_Y \]

• Mediating effect: product between a and b or ab
• 2016: 30th-year anniversary of the publication of Baron and Kenny (1986)... a good time to debunk some myths!
Mediation: Problem #1
Requiring a Significant Total Effect Between the Antecedent and the Outcome

• 51.61% of articles required a significant total X-Y relation as a first step in the mediation test
• If the direct effect $c$ is significant and positive
• And the indirect effect $ab$ is significant and negative…
• The total X-Y effect could be zero: $c = c' + (-ab) \approx 0$
Solutions for Problem #1

- We should focus on the paths that constitute the mediating effect
- These are necessary and sufficient to establish mediation

\[
Y = cX + e_y \\
M = aX + e_z \\
Y = bM + c'X + e'_y
\]
Mediation: Problem #2

*Testing the Direct Effect as a Condition for Mediation*

- 38.71% of articles required a test of the direct effect as a necessary step in showing mediation

![Diagram](image)

- Testing $c'$ was included in the original causal-steps procedure
- This need not be considered when determining whether differentiation mediated the effect of imitation time lag on competitiveness
- This step can cause researchers to overlook meaningful mediating processes
Solutions for Problem #2

- Future research should conclude that mediation exists when the indirect effect is supported.
- Past research has dismissed significant indirect effects when the direct effect remained significant in the final step.

![Diagram showing mediation effect with variables X, M, and Y, and paths a, b, and c']
Mediation: Problem #3

Including a Direct Effect Without Conceptual Justification

- 37.10% of articles tested for a direct effect without providing justification

- If the theory under investigation predicts complete mediation, then researchers should test a model that specifies complete rather than partial mediation

- Omitting path $c'$ when complete mediation is hypothesized upholds the principle of parsimony and yields an estimate of path $b$ that is consistent with the specified model
Solutions for Problem #3

• Models should be fully aligned with theory
• If the theory predicts mediation, full mediation should be used as the baseline
• Consequences of omitting the c’ path can be assessed by testing the fit of the model using a chi-square statistic with one degree of freedom
• Compares the complete mediation model with the partial mediation model using the chi-square test
Mediation: Problem #4

Disregarding the Magnitude of the Indirect Effect

- 77.42% of articles did not examine the mediating effect itself ($ab$)
- Evaluating the size of the mediating effect is critical for understanding alternative mediating mechanisms

- Although they may all be statistically significant, we do not know their relative importance without comparing the mediating effects
Solutions for Problem #4

- The Sobel test is a common method of testing the mediated effect that is not appropriate to use
  - Product of the coefficients divided by the estimate of its standard error
  - Assumes the product of the coefficients is normally distributed
- Nonparametric testing procedures are available that do not rely on assumptions of normality
  - Percentile-based confidence intervals derived using the bootstrap (e.g., Gottfredson & Aguinis, in press, JOB)
  - Method of choice for future research using mediation
Mediation: Problem #5

Testing Mediation With Cross-Sectional Data

• 58.06% of articles used cross-sectional data to investigate models that are inherently causal in nature
• Testing mediational models with cross-sectional data can produce biased estimates

• Experimental design is the best choice but…
• Sequential data can ameliorate biases
• Ideally, all three variables would be measured on each occasion
Solutions for Problem #5

• Mediated models contain causal paths that imply the passage of time
• Future research should:
  • When possible, implement an experimental design to provide evidence of mediation (Eden, Stone-Romero, & Rothstein, 2015, HRMR)
  • Use longitudinal data for assessing mediation
  • Gather panel data to rule out alternative causal flows
Mediation: Problem #6
*Lack of Attention to Measurement Error*

- 88.71% of articles did not address issues related to measurement error in predictors
- There is a belief that variables are measured objectively and error-free given reporting requirements and standards for publicly traded corporations (Dalton & Aguinis, 2013, ORM)
- Measurement error in X and M can bias path estimates upward or downward
- Statistical tests of these paths can be either too liberal or too conservative either of which would lead to incorrect conclusions
- In mediation tests using regression, measurement error is effectively disregarded
Solutions for Problem #6

• Researchers should create and use more reliable measures
• *Some* effects of measurement error can be offset by using structural equation modeling (SEM) with latent variables
  • Increasingly prevalent
  • Not a magic cure for issues with poor quality measures
  • Only corrects for certain sources of measurement error
Conclusions

• Moderation and mediation are critical for theory advancement as well as practical applications
• If we understand moderation, we know about the “when:” conditions under which certain relations and effects exist or not, and conditions under which the size of relations and effects become larger or smaller
• If we understand mediation, we know about the “why:” intervening mechanisms between variables and reasons for relations and effects
• Our literature review uncovered 13 pervasive problems that are not just “methodological nuances.” These problems show that in many cases the WRONG words have been included in the Results, Implications for Theory, and Implications for Practice sections of SMJ and OS articles
Conclusions

- Our review revealed that numerous substantive conclusions regarding the possible presence or absence of **moderating effects** are likely incorrect:
  - Moderating effect of headquarters embeddedness on the relation between subsidiary embeddedness and headquarters value-added
  - Moderating effect of a firm’s resources and capabilities to deal with natural gas deregulation on the relation between managerial domain-specific experience and opportunity interpretation (i.e., ranging from threat to opportunity)
  - Moderating effect of type of firm ownership on the relationship between media coverage and subsequent entry of foreign firms
Conclusions

- Our review revealed that numerous substantive conclusions regarding the possible presence or absence of **mediating effects** are likely incorrect:
  - Mediating effect of competitive advantage in the relation between resource value and firm performance
  - Mediating effect of decision speed in the relation between six organizational and environmental factors and firm performance
  - Mediating effect of differentiation in the relation between imitation time lag and competitiveness
Conclusions

• Fortunately, each of the 13 problems has solutions
• Clearly, some are easier and more cost-effective to implement than others

Improving Our Understanding of Moderation and Mediation in Strategic Management Research

Herman Aguinis  Jeffrey R. Edwards and Kyle J. Bradley
Conclusions

• Our recommendations will be useful for authors, methods courses instructors, and also journal reviewers and editors who evaluate manuscripts reporting moderation and mediation tests
• Articles are available at www.hermanaguinis.com
• Feel free to contact me if you have any questions
THANK YOU!!