THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

CARMA Larry James Lecture

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

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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:
  - James, L. R., & Brett, J. M. 1984. Mediators, moderators, and tests for mediation. *Journal of Applied Psychology,* 69: 307-321.
  - James, L. R., Mulaik, S. A., & Brett, J. M. 2006. A tale of two methods. *Organizational Research Methods,* 9: 233-244.
  - James, L. R. 2008. On the path to mediation. *Organizational Research Methods,* 11: 359-363.
  - James, L. R., Mulaik, S. A., & Brett, J.M. 1982. *Causal analysis: Assumptions, models, and data*. Beverly Hills, CA: Sage.

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…

- Aguinis, H. 1995. Statistical power problems with moderated multiple regression in management research. *Journal of Management*, 21: 1141-1158.
- Aguinis, H., & Stone-Romero, E. F. 1997. Methodological artifacts in moderated multiple regression and their effects on statistical power. *Journal of Applied Psychology*, 82: 192-206.
- Aguinis, H., & Pierce, C. A. 1998. Heterogeneity of error variance and the assessment of moderating effects of categorical variables: A conceptual review. *Organizational Research Methods*, 1: 296-314.

A Personal Journey…

- Articles available at www.hermanaguinis.com:

- Aguinis, H., Petersen, S. A., & Pierce, C. A. 1999. Appraisal of the homogeneity of error variance assumption and alternatives to multiple regression for estimating moderating effects of categorical variables. *Organizational Research Methods*, 2: 315-339.
- Aguinis, H., Boik, R. J., & Pierce, C. A. 2001. A generalized solution for approximating the power to detect effects of categorical moderator variables using multiple regression. *Organizational Research Methods*, 4: 291-323.
- Aguinis, H. 2004. *Regression analysis for categorical moderators*. NY: Guilford.

A Personal Journey…

- Articles available at www.hermanaguinis.com:

- Aguinis, H., Beaty, J. C., Boik, R. J., & Pierce, C. A. 2005. Effect size and power in assessing moderating effects of categorical variables using multiple regression: A 30-year review. *Journal of Applied Psychology*, 90: 94-107.
- Aguinis, H., Culpepper, S.A., & Pierce, C.A. 2010. Revival of test bias research in preemployment testing. *Journal of Applied Psychology*, 95: 648-680.
- Aguinis, H., Culpepper, S.A., & Pierce, C.A. in press. Differential prediction generalization in college admissions testing. *Journal of Educational Psychology*. doi: 10.1037/edu0000104

Most Recent Research

- ✓ Aguinis, H., Edwards, J. R., & Bradley, K. J. in press. Improving our understanding of moderation and mediation in strategic management research. *Organizational Research Methods*. doi: 10.1177/1094428115627498 **[included in 2017 ORM special issue on moderation and mediation]**

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

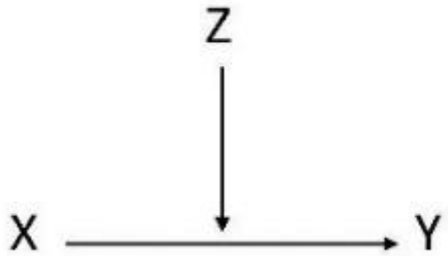
Literature Review: Houston, We Have 13 Problems…

- Search of articles published in *Strategic Management Journal* and *Organization Science* (January 2005 – December 2014)
- Manual review to identify articles using multiple regression to test moderation and mediation; N = 267

	Moderation	Mediation
SMJ	*126*	*24*
OS	*79*	*38*
Total	***205***	***62***

Moderation: The "When"

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



- 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)
  - $\hat{Y} = \beta_0 + \beta_1 X + \beta_2 Z + \beta_3 XZ$
  - β_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:

$$\rho_{XZ,XZ} = \frac{0 + (0.7)(0.7)}{0 + 1} = \mathbf{0.49}$$

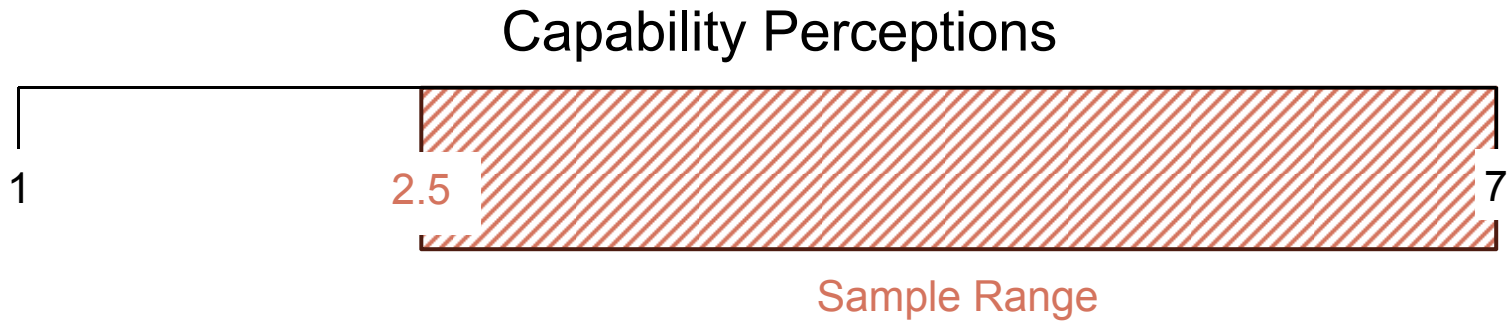
Solutions for Problem #1

- 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



- 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.

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

N = 100

$n_1 = 50$
$n_2 = 50$
$p = 0.5$

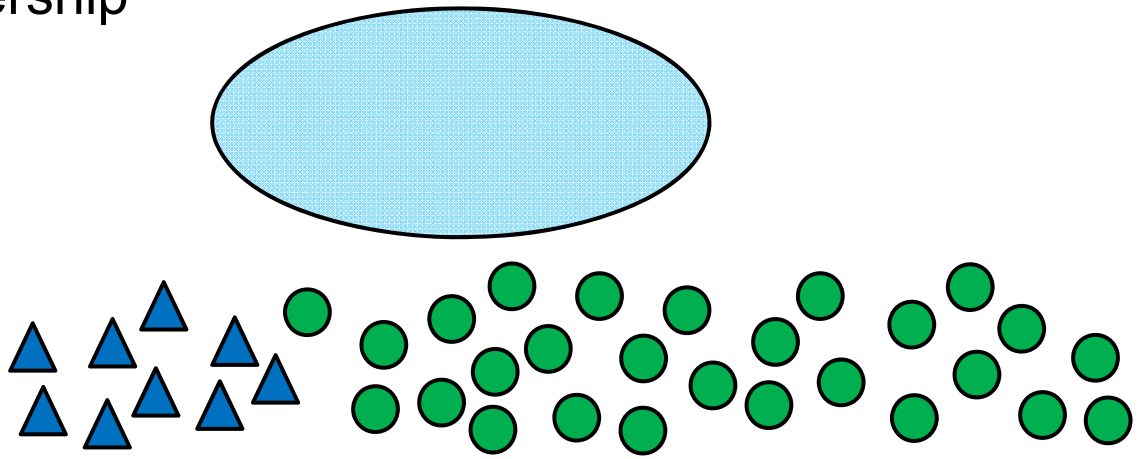
$$\frac{(100)(0.5)(1-0.5)}{100-1} = 0.2525$$

$n_1 = 20$
$n_2 = 80$
$p = 0.8$

$$\frac{(100)(0.8)(1-0.8)}{100-1} = 0.1616$$

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

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

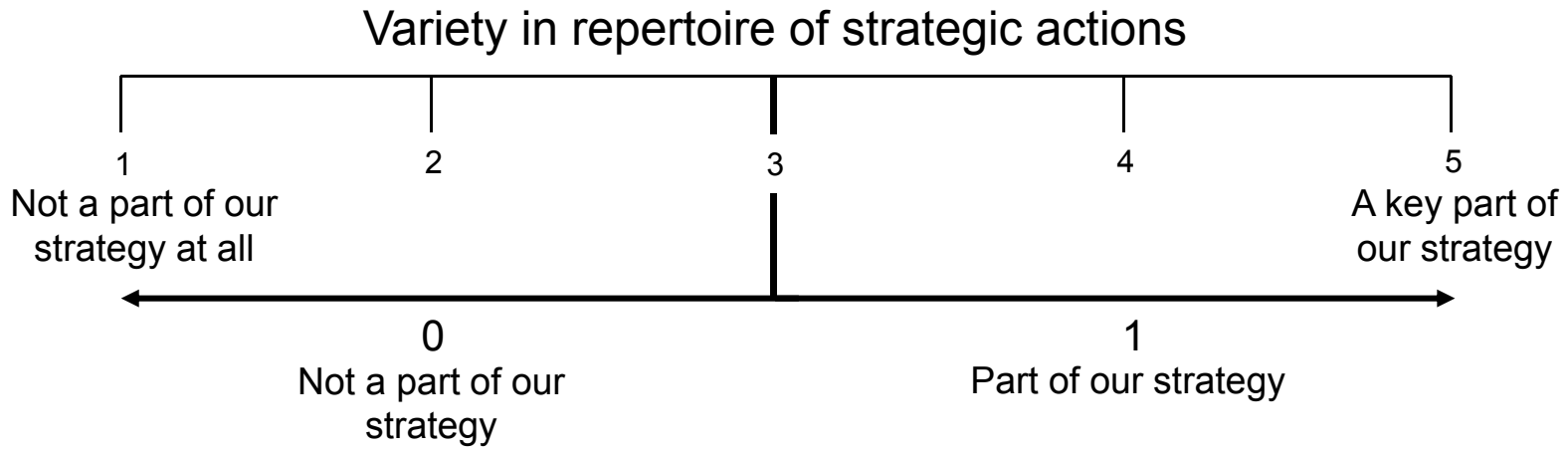
Solutions for Problem #4

- 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



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

Moderation: Problem #6

Correlation Between Product Term and its Components

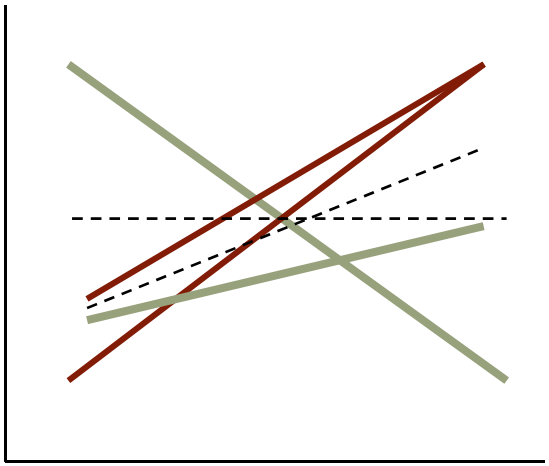
- 43.90% of articles discussed the issue of multicollinearity and used centering to "solve" this problem
- "*To reduce multicollinearity, we mean centered the independent and moderator variables before creating the interaction term*"
- Any apparent multicollinearity created by the correlation of XZ with 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

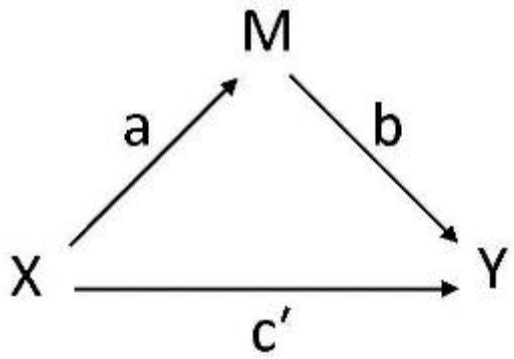
	Work Unit Performance	Work Unit Performance
	Model 1	Model 2
Informal Control Systems (ICS)	0.74*	-0.11
Task Interdependence (TI)		-0.11
ICS x TI		-1.12**

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



- 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: $ab \neq 0 \text{ and } c' = 0$
  - Partial mediation: $ab \neq 0 \text{ and } c' \neq 0$

Mediation: Test Procedure

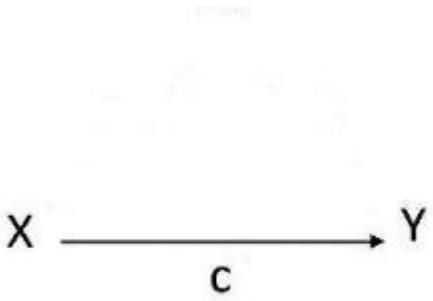
- Majority of mediation analyses rely on the causal-steps procedure (Baron & Kenny, 1986).
- Three regression equations:

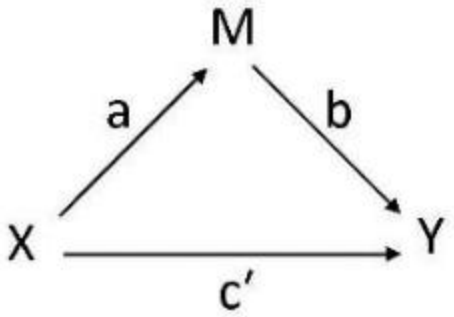
$$Y = cX + e_y$$
$$M = aX + e_z$$
$$Y = bM + c'X + e'_Y$$

- Mediation is present when:
  - c is significant → There is a total effect to be mediated
  - a is significant
  - b is significant → Establishes significant paths to and from mediator
  - 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:





$$Y = \boldsymbol{c}X + e_y$$

$$M = aX + e_z$$

$$Y = bM + \boldsymbol{c'}X + e'_Y$$

- 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) ≈ 0

Solutions for Problem #1

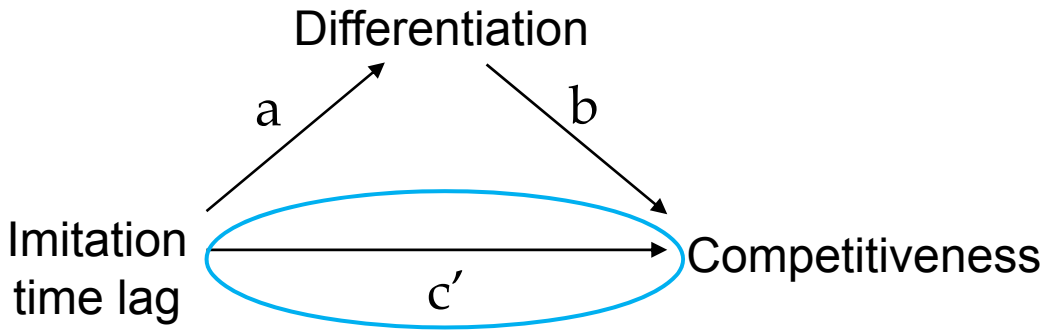
$$Y = cX + e_y$$
$$M = aX + e_z$$
$$Y = bM + c'X + e'_Y$$

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

Mediation: Problem #2

Testing the Direct Effect as a Condition for Mediation

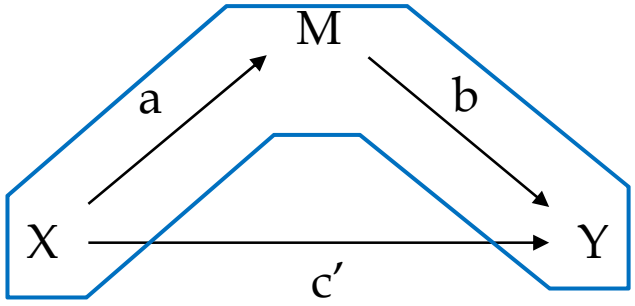
- 38.71% of articles required a test of the direct effect as a necessary step in showing mediation



- 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

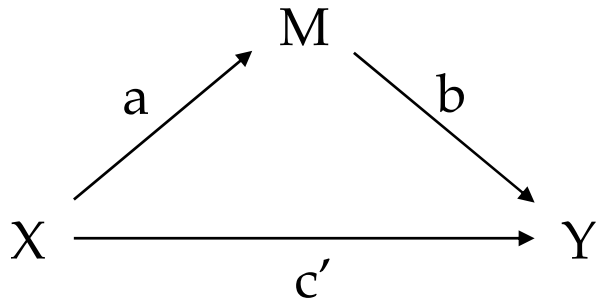


Mediation: Problem #3

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



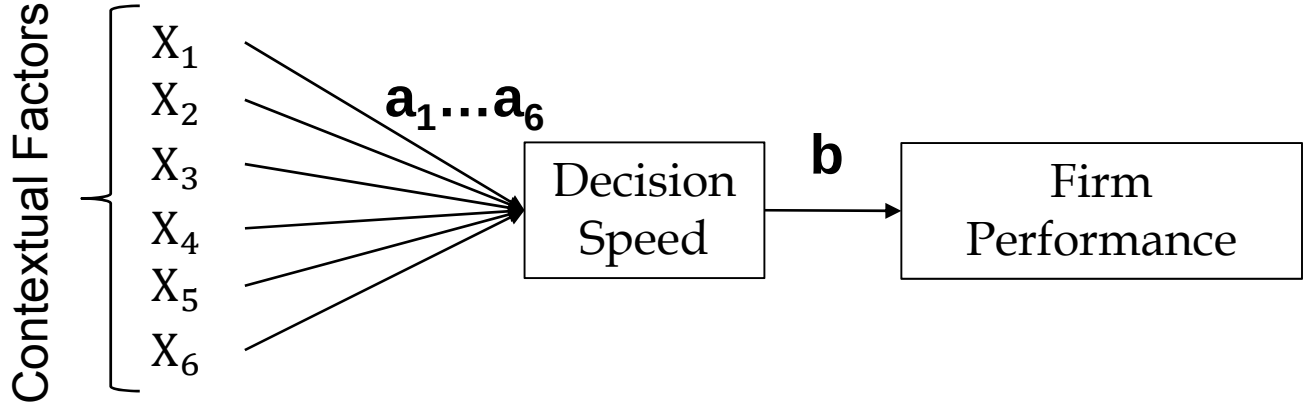
Solutions for Problem #3

- 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

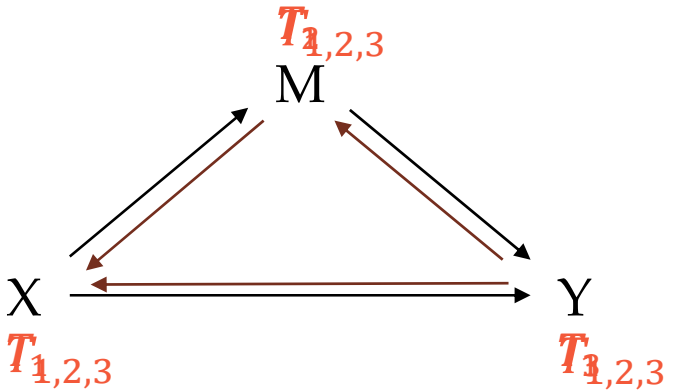
- The Sobel test is a common method of testing the mediated effect that is not appropriate to use
  - Product of the coefficients divided by the estimate of its standard error
  - Assumes the product of the coefficients is normally distributed
- Nonparametric testing procedures are available that do 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

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

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THANK YOU!!