Introduction to Meta-Analysis
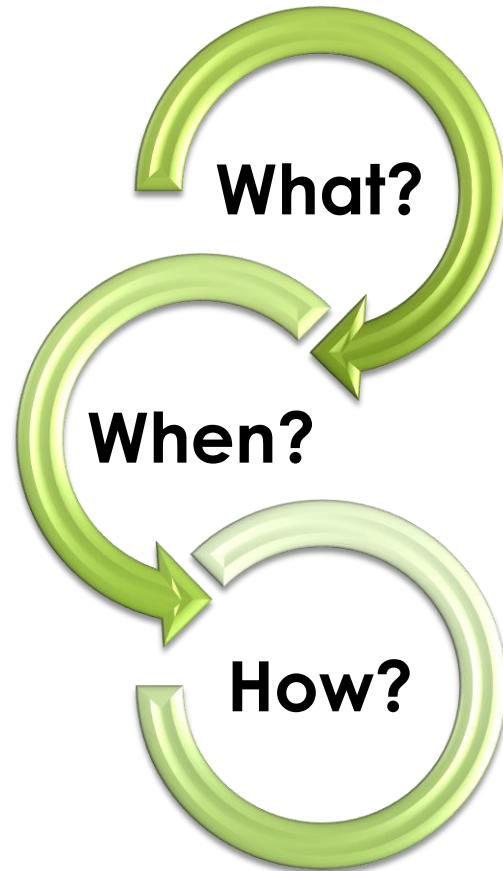
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Meta-Analysis ?

What?

When?

How?

What is a meta-analysis?

The first clear and official use of the term 'meta-analysis' only dates back to the 1970s, when statistician Gene Glass came up with it in his call for improved ways to sum up the results of a field of studies.

▶ Originally developed in medical/clinical research

  ▶ Now used in various fields including economics, finance, sociology and engineering

▶ **Meta-analysis** is an optional component of a systematic review

▶ **Meta-analysis** refers to a statistical procedure for combining data and results from multiple studies

  ▶ Combining and analysing data from **more than one study** at a time

▶ Unlike **narrative reviews**, which is more subjective, **meta-analysis** applies objective formulae to establish **statistical significance** across studies that might otherwise seem to have conflicting results

  ▶ It increases the validity of any observed difference and increases the reliability of the information

  ▶ The results of a meta-analysis can improve precision of estimates of a particular effect, answer questions not posed in individual studies, settle controversies arising from conflicting studies and generate new hypotheses

Meta-analysis

Julien I.E. Hoffman, in Basic Biostatistics for Medical and Biomedical Practitioners (Second Edition), 2019

Introduction

Meta-analysis is a set of techniques used to combine the results of a number of different reports to create a single, more precise estimate of an effect (Ferrer, 1998). The aims of meta-analysis are to increase statistical power and improve estimates of size of effect. There must be a valid reason to combine the studies. Although the frequency with which meta-analysis is used is increasing, meta-analysis has its

Meta-analysis of Clinical Trials

Junfeng Sun, ... Charles Natanson, in Principles and Practice of Clinical Research (Fourth Edition), 2018

Abstract

Meta-analysis has become a popular approach for summarizing a large number of clinical trials and resolving discrepancies raised by these trials. In this chapter, we introduce the general procedures for

Meta Analysis

J. Sánchez-MecaF. Marín-Martínez, in International Encyclopedia of Education (Third Edition), 2010

Calculating an Average Effect Size

The statistical analyses in a meta-analysis are guided by a statistical model that must be previously assumed. The main task of the statistical model is to establish the properties of the effect-size population from which the individual effect-size estimates have been selected. To accomplish the first purpose in a meta-analysis, that is,

Michael W. Wiederman, Katherine M. Nicolai, in The Psychology and Sociology of Wrongful Convictions, 2018

Meta-analysis is frequently referred to as a statistical form of literature review. Specifically, the process entails standardizing the results of each study so that the individual results can be combined or summed across studies. Each individual study involved different samples, different measures, and different forms of statistical comparison. Of course there will be some overlap in these areas across the studies, but it's highly unlikely that even any two studies involved the same measures, or were analyzed or compared in the same way. Meta-analysis involves converting all the different statistical results into one form of effect size (how large the finding was).

Examples

Medical

- Reddy, R.K., Charles, W.N., Sklavounos, A., Dutt, A., Seed, P.T. and Khajuria, A., 2021. **The effect of smoking on COVID-19 severity: A systematic review and meta-analysis**. *Journal of Medical Virology*, 93(2), pp.1045-1056.
- Pranata, R., Huang, I., Lim, M.A., Wahjoepramono, E.J. and July, J., 2020. **Impact of cerebrovascular and cardiovascular diseases on mortality and severity of COVID-19– systematic review, meta-analysis, and meta-regression**. *Journal of Stroke and Cerebrovascular Diseases*, 29(8), p.104949.

Psychology

- Sin, N.L. and Lyubomirsky, S., 2009. **Enhancing well-being and alleviating depressive symptoms with positive psychology interventions: A practice-friendly meta-analysis**. *Journal of clinical psychology*, 65(5), pp.467-487.
- Donaldson, S.I., Lee, J.Y. and Donaldson, S.I., 2019. **Evaluating positive psychology interventions at work: A systematic review and meta-analysis**. *International Journal of Applied Positive Psychology*, 4(3), pp.113-134.

Economics

- Nunkoo, R., Seetanah, B., Jaffur, Z.R.K., Moraghen, P.G.W. and Sannassee, R.V., 2020. **Tourism and economic growth: A meta-regression analysis**. *Journal of Travel Research*, 59(3), pp.404-423.
- Kastratović, R., 2020. **The impact of foreign direct investment on host country exports: A meta-analysis**. *The World Economy*, 43(12), pp.3142-3183.
- Fidrmuc, J. and Lind, R., 2020. **Macroeconomic impact of Basel III: Evidence from a meta-analysis**. *Journal of Banking & Finance*, 112, p.105359.

Education

- Bernard, R.M., Abrami, P.C., Lou, Y., Borokhovski, E., Wade, A., Wozney, L., Wallet, P.A., Fiset, M. and Huang, B., 2004. **How does distance education compare with classroom instruction? A meta-analysis of the empirical literature**. *Review of educational research*, 74(3), pp.379-439.
- Allen, M., Bourhis, J., Burrell, N. and Mabry, E., 2002. **Comparing student satisfaction with distance education to traditional classrooms in higher education: A meta-analysis**. *The American Journal of Distance Education*, 16(2), pp.83-97.

Management

- Blut, M., Frennea, C.M., Mittal, V. and Mothersbaugh, D.L., 2015. **How procedural, financial and relational switching costs affect customer satisfaction, repurchase intentions, and repurchase behavior: A meta-analysis**. *International Journal of Research in Marketing*, 32(2), pp.226-229.
- Carrillat, F.A., Jaramillo, F. and Mulki, J.P., 2009. **Examining the impact of service quality: a meta-analysis of empirical evidence**. *Journal of Marketing Theory and Practice*, 17(2), pp.95-110.
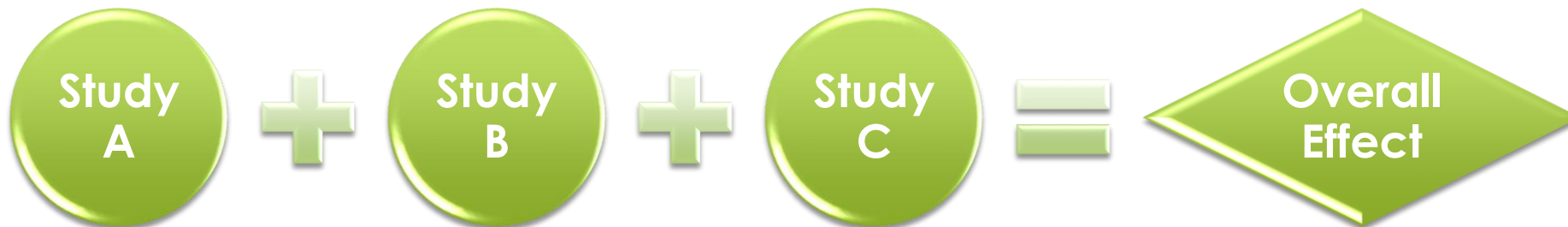
Why perform a meta-analysis ?

▶ Assess the strength of evidence (Confirming overall effect direction)

▶ Combine the results quantitatively (Obtaining an overall estimate of the effect)

Study A + **Study B** + **Study C** = **Overall Effect**

Why perform a meta-analysis ?

- Investigate heterogeneity
  - To explain the differences in the results
  - To identify general trends across the studies
  - To identify patterns of publication selection
- Use of sub-group analysis
  - In terms of specific sample
  - In terms of age group
  - In terms of gender
  - In terms of region
  - In terms of level of development
  - In terms of types of publication
  - In terms of methodology/techniques employed
- Use of meta-regression techniques

When does it make sense to perform a meta-analysis

- When there are **more than one study** addressing the **same question** or investigating the **same topic**

- When more than one study has estimated **an effect**

- When the **differences in the study characteristics** are likely to affect the effect (or when investigating specific differences)

- When the **effect** has been **measured and reported in similar ways** (or when the data are available)

How?

1. • Formulate the problem
2. • Do a literature search
3. • Decide an inclusion criteria
4. • Collect data & calculate effect size
5. • Do preliminary tests & meta-analysis
6. • Examine sources of heterogeneity using sub-group analysis or regression-based techniques

Example

Nunkoo, R., Seetanah, B., Khan Jaffur, Z.R., Moraghen, P.G.W. and Sannassee, R.V., 2020. **Tourism and economic growth: A meta-regression analysis**. *Journal of Travel Research*, *59*(3), pp.404-423.

Tourism and Economic Growth: A Meta-regression Analysis

Robin Nunkoo[1,2,3,4] [iD], Boopen Seetanah[5],
Zameelah Rifkha Khan Jaffur[5],
Paul George Warren Moraghen[5],
and Raja Vinesh Sannassee[5]

Abstract
Numerous studies have focused on delineating the relationship between tourism and economic growth. In this article, we present the results of a rigorous meta-regression analysis based on 545 estimates drawn from 113 studies that empirically tested the tourism-led growth hypothesis (TLGH). The results suggest the presence of publication bias in the literature on this topic, where the majority of studies report positive and statistically significant estimates. Findings provide support for the TLGH, but they also suggest that the estimates are sensitive to a number of factors that are related to country data, specification, and estimation characteristics, and time span. Such sensitivities suggest that greater emphasis should be placed on reporting estimates of the relationship between tourism and economic growth across a variety of methodological characteristics and specification and estimation choices. The implications of the results for theory development are also discussed.

Keywords
economic growth, tourism-led growth hypothesis, meta-regression analysis, publication bias, methodology

Step 1: Formulate problem

▶ Research question:

Tourism	➡	Economic Growth

▶ Conflicting results – positive/negative/inconclusive

▶ Weighted overall effect – summarise the literature

▶ Identify factors behind variations

Step 2: Literature search

- To examine the relationship between tourism and economic growth

- Keywords:
  - "tourism", "economic growth"
  - "Effect" of "tourism" on "economic growth"
  - The "tourism-economic growth" "nexus"
  - "Tourism-led growth hypothesis"

- Published/Unpublished articles
  - Journal articles, working papers, book chapters, notes, theses etc
  - English and other languages

Step 3: Decide an inclusion criteria

- Whether the study includes enough information for analysis (i.e. standard error/t-statistic in addition to point estimate)

    - Size of the effect (point estimate/regression coefficient)

    - Direction of the effect (positive/negative)

    - Precision of the effect (significant/not significant)

- Study design

- Time frame

- Sample size

- Publication type (Published/Unpublished)

Step 4: Collect data

Index	Study Name	Publication Year	Country(ies) Studied	Data Type (Panel/Time Series/Cross-Secional)	Estimation Methods	Point Estimates	t-statistics	S.E
1	Durbarry (2004)	2004	Mauritius	time series	Engle and Yoo ECM - cointegration	0.7754	6.599	0.1175
1	Fayissa et al. (2008)	2008	30 SSA	panel	GMM	0.0249	3.074074	0.0081
2	Fayissa et al. (2008)	2008	30 SSA	panel	GMM	0.0256	3.160494	0.0081
3	Fayissa et al. (2008)	2008	30 SSA	panel	fixed effect	0.0378	4.447059	0.0085
4	Fayissa et al. (2008)	2008	30 SSA	panel	random effect	0.0388	3.88	0.01

Labels (annotations):
- Study Number/ID → Index
- Author(s)' Names/Study Name → Study Name
- Year of publication → Publication Year
- Sample of countries investigated → Country(ies) Studied
- Data Type → Data Type
- Techniques → Estimation Methods
- Regression coefficient → Point Estimates
- Precision of estimates → t-statistics, S.E
- Standard error → S.E

Step 4: How to collect data

- Fayissa2008.pdf

Step 4: Calculate effect size

▶ An effect size is usually a standardized measure of the magnitude of observed effect

▶ Examples:

  ▶ Point estimates (Regression coefficients)

  ▶ Correlation coefficient (partial/semi partial)

  ▶ Standardized regression coefficient

  ▶ t-statistics

  ▶ Relative risk

  ▶ Odds ratio

▶ Further details can be found from:

  ▶ Card, N.A., 2015. *Applied meta-analysis for social science research*. Guilford Publications

  ▶ Ellis, P.D., 2010. The essential guide to effect sizes: Statistical power, meta-analysis, and the interpretation of research results. Cambridge university press

  ▶ Borenstein, M., Hedges, L.V., Higgins, J.P. and Rothstein, H.R., 2021. Introduction to meta-analysis. John Wiley & Sons.

Step 5: Preliminary tests

- Elimination of outliers
  - Remove respective study/studies from sample
- Publication selection bias tests
  - Funnel plot (Type I publication bias) → direction of effect
  - Galbraith plot (Type II publication bias) → significance of effect
  - Funnel asymmetry test (FAT)
- To check whether publication bias detected will affect analysis
  - Rosenthal Fail Safe N; Fisher Fail-Safe N; Orwin Fail-Safe N
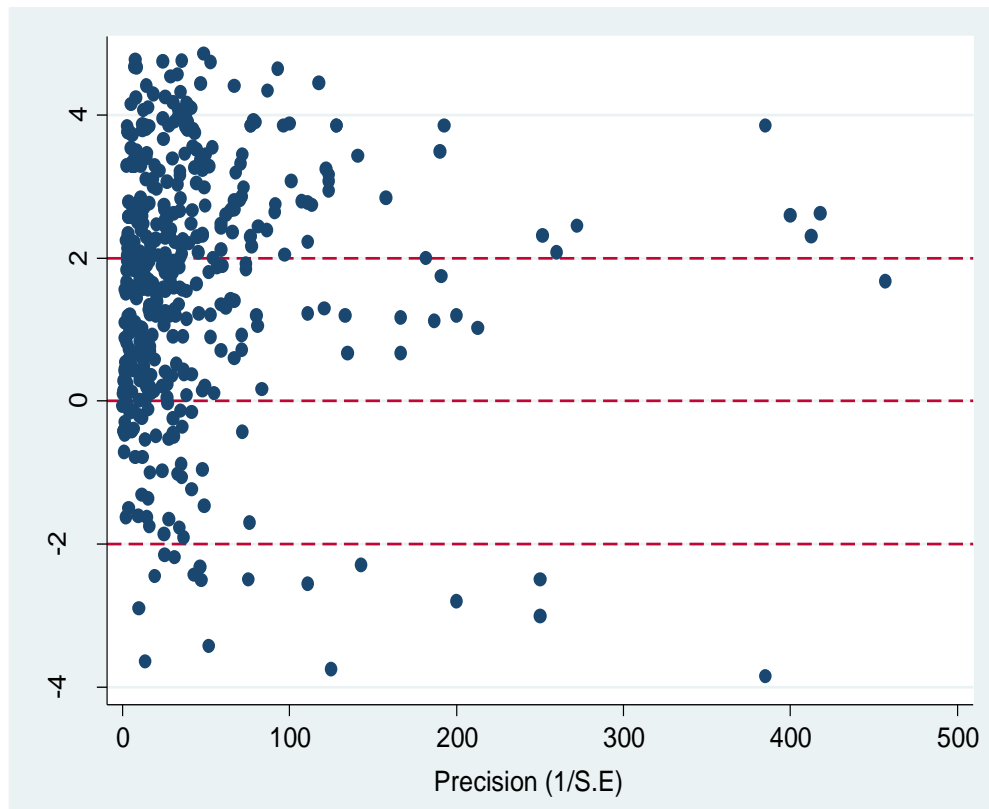
Step 5: Type I Publication Bias

Funnel Plot
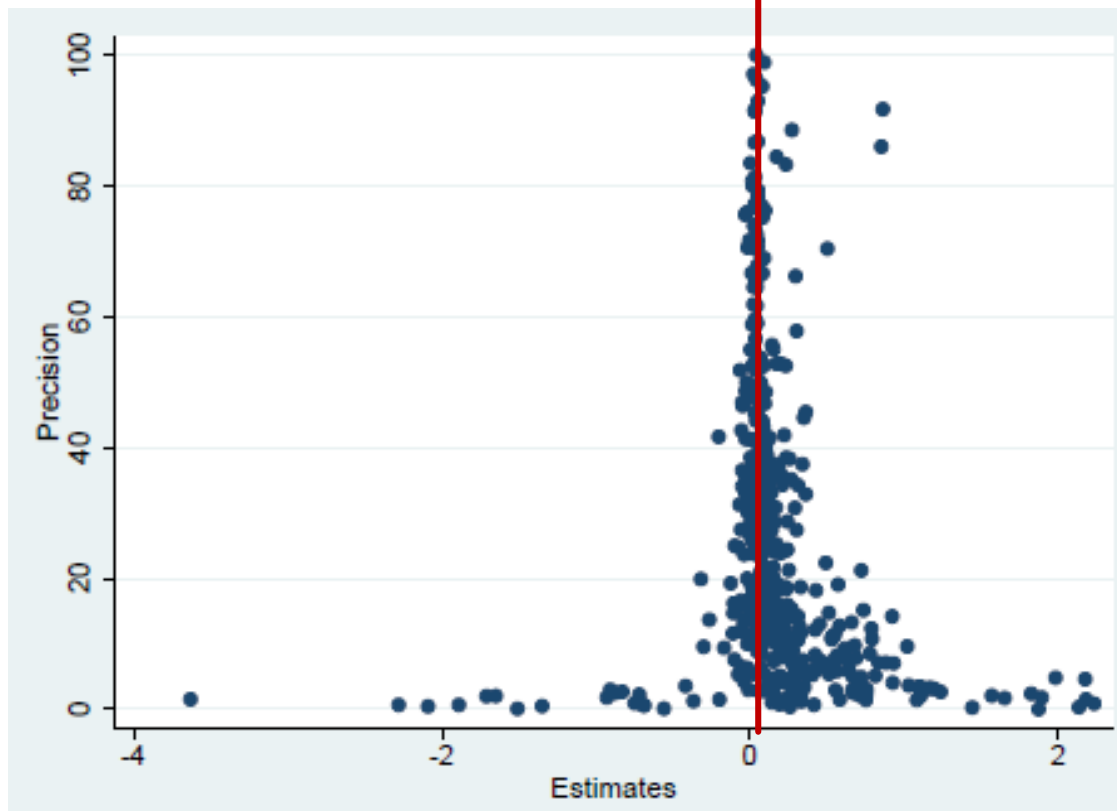
- Asymmetric Funnel Plot usually indicates presence of publication bias

- More observations are on the positive side

- Studies reporting a positive effect are likely to be published

Step 5: Type II Publication Bias

Galbraith Plot

Precision (1/S.E)

- All of the *t*-values are not within the two-sided critical values of the 5% significance level
- Published empirical studies more likely to report significant results

- **Rosenthal Fail Safe N**: Publication bias has limited influence on meta regression results has failsafe N=136661.

Step 5: Meta-analysis

- Fixed effect/Random effect models

- Calculate a summary statistic for each study

- Calculate the overall effect

  - Usually weighted average of these summary statistic

- Forest plot → graphically displays results of a meta-analysis
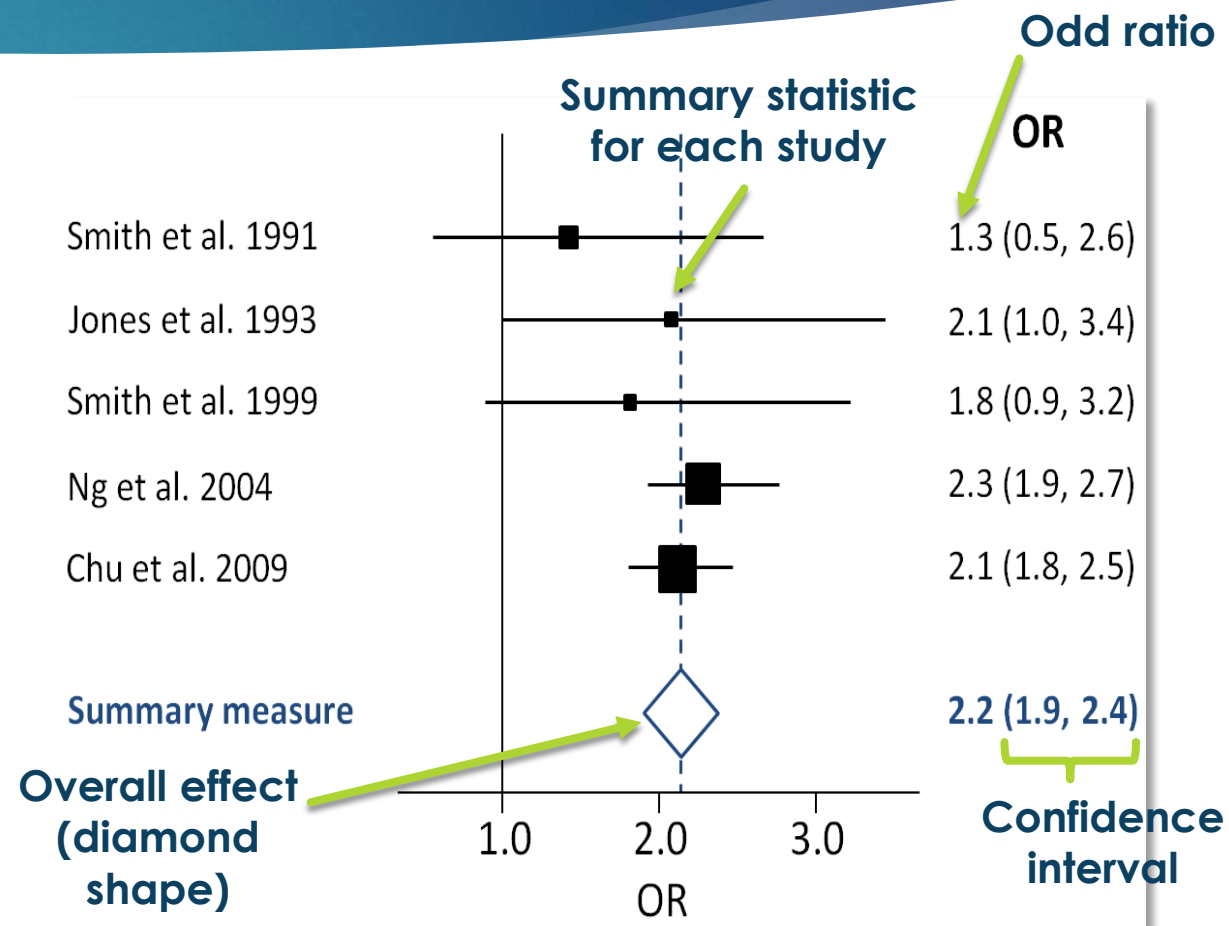
Step 5: Fixed effect and Random Effect Models

Fixed effect

▶ Assumptions

  ▶ One true effect size underlies all studies in analysis

  ▶ Differences among studies are purely random error (i.e. due to chance)

▶ Heterogeneity

  ▶ Ignored

▶ Confidence interval

  ▶ Narrower

Random effect

▶ Assumptions

  ▶ Study effect is from a distribution of study effects

▶ Heterogeneity

  ▶ Incorporated

  ▶ Within study variance

  ▶ Between study variance

▶ Confidence interval

  ▶ Wider

Step 5: Forest plot

- randomeffectresult.pdf

- forestplot.pdf

Thank you!