Meta-Analysis:
Overview and Introduction

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with thanks to Jacques Poot

Systematic Reviews

If science is the accumulation and refinement of knowledge and information, then we need guidelines and methods for **reliable and valid reviews, integrations, and syntheses** of studies examining similar research questions

Wolf (1986)

What is Meta-Analysis?

"Meta-analysis refers to the **statistical analysis** of a large collection of results from individual studies for the purpose of **integrating** the findings. It connotes a **rigorous alternative** to the casual, narrative discussions of research studies that typify our attempt to make sense of the rapidly expanding research literature."

Gene V Glass (1976) "Primary, secondary, and meta-analysis of research", *Educational Researcher* 5: 3-8.

Why meta-analysis? - 1

- Rarely do 'single experiments or studies provide sufficiently definitive answers upon which to base policy' (Hedges & Olkin 1982)

- Combining estimates increases statistical power
- Particularly useful in small sample contexts

- Calculation of stylised facts, e.g. for simulation models
- Less subjective and more transparent than narrative literature review

- Systematic tool to help to design the next study
- Can save costs when results are "transferable"

Why meta-analysis? - 2

- Competition of ideas
  - Meta-analysis provides a method of plausible inference when there is conflicting evidence
  - Policy makers needs to understand reasons for conflicting evidence
- Better understanding of the process of knowledge generation and dissemination
  - Meta-analysis can assist in identifying and quantifying selection and publication bias
- New knowledge gained from modelling the full distribution of comparable estimates (explaining observable heterogeneity)
  - The only way to make sense of the "flood of findings"
- Fully transparent and replicable synthesis of previous findings

The first meta-analysis

Karl Pearson
1857-1936

REPORT ON CERTAIN ENTERIC FEVER INOCULATION STATISTICS.

PROVIDED BY LIEUTENANT-COLONEL R. J. S. SIMPSON, C.M.G., R.A.M.C.

BY KARL PEARSON, F.R.S.,
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The following table gives the results of calculating the correlation coefficients of the tables in Appendix B:

INOCULATION AGAINST ENTERIC FEVER:

Correlation between Immunity and Inoculation.

I.	Hospital Staffs	+	0.373	±	0.021
II.	Ladysmith Garrison	+	0.445	±	0.017
III.	Methuen's Column	+	0.191	±	0.026
IV.	Single Regiments	+	0.021	±	0.053
V.	Army in India	+	0.100	±	0.013
	Mean value	+	0.226		

Correlation between Mortality and Inoculation.

VI.	Hospital Staffs	+	0.307	±	0.128
VII.	Ladysmith Garrison	−	0.010	±	0.081
VIII.	Single Regiments	+	0.300	±	0.093
IX.	Special Hospitals	+	0.119	±	0.022
X.	Various military Hospitals ...	+	0.194	±	0.022
XI.	Army in India	+	0.248	±	0.030
	Mean value	+	0.193		

British Medical Journal vol. 3, 1904, pp. 1243-1246.

Modern meta-analysis

Gene Glass

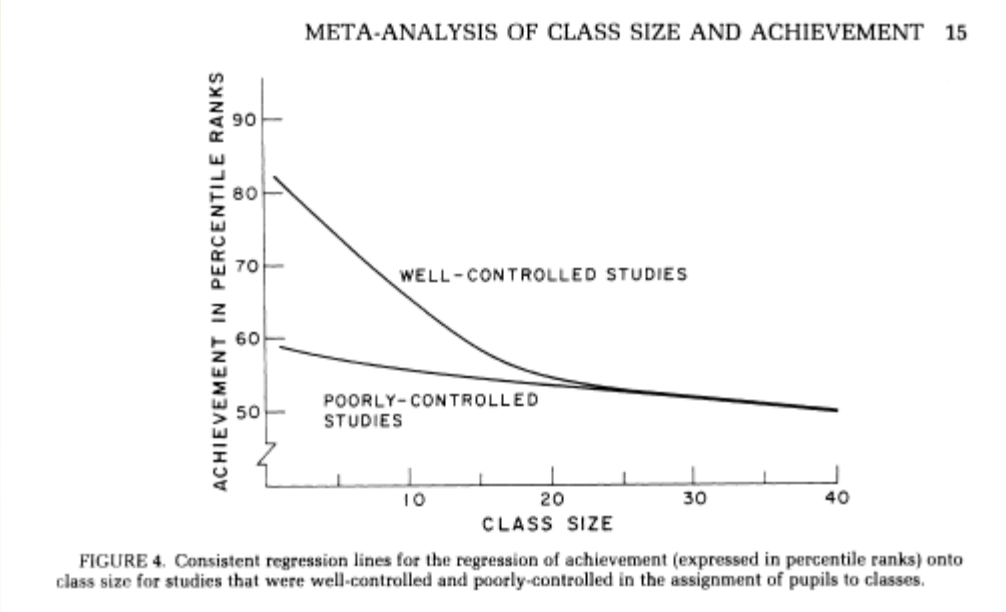


FIGURE 4. Consistent regression lines for the regression of achievement (expressed in percentile ranks) onto class size for studies that were well-controlled and poorly-controlled in the assignment of pupils to classes.

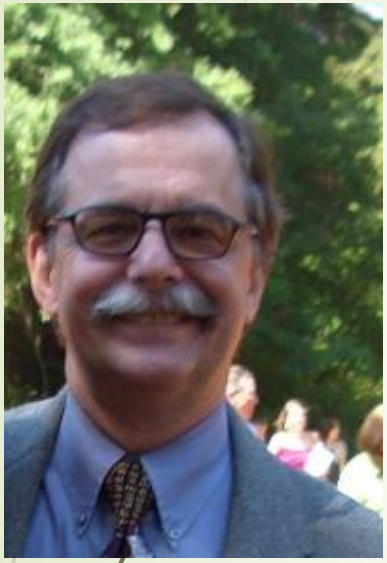
Example: Glass, G.V. and Smith M.L. (1979) Meta-analysis of research on class size and achievement *Educational Evaluation and Policy Analysis* 1(1): 2-16

Effect size: $\Delta_{S-L} = \frac{\bar{X}_S - \bar{X}_L}{\hat{\sigma}}$

Data: 77 studies (1902-1972; 900,000 pupils) from about a dozen countries yielded 725 Δ_{S-L}

Conclusion: "There is little doubt that, other things equal, more is learned in smaller classes"

Meta-analysis in economics



Tom Stanley

Stanley, T.D. and Jarrell, S.B. (1989) Meta-regression analysis: a quantitative method of literature surveys. *Journal of Economic Surveys* 3: 54-67.

Stanley, T.D. (2001) Wheat from Chaff: Meta-analysis as quantitative literature review. *Journal of Economic Perspectives* 15(3): 131-150.

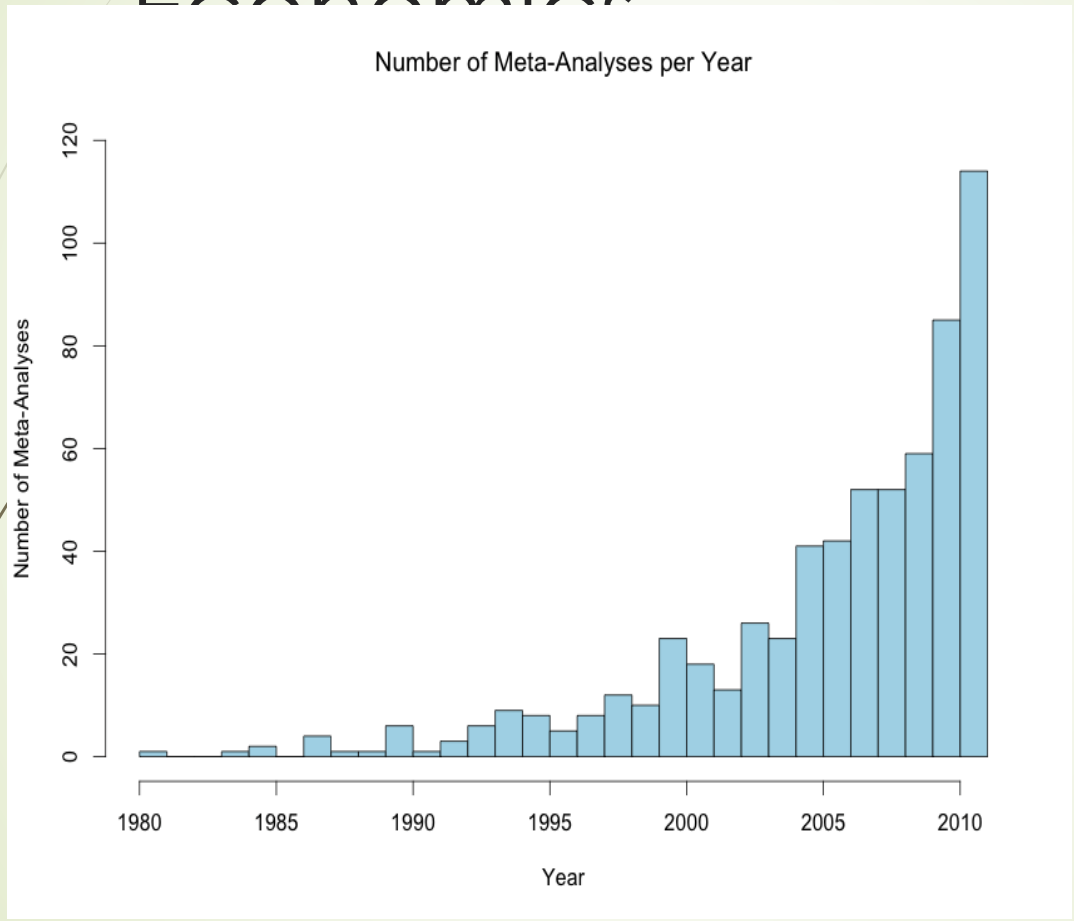
…

Stanley, T.D. and Doucouliagos, H. (2012) *Meta-Regression Analysis in Economics and Business*. Oxford: Routledge.

The meta-analysis "industry"

- History: see Chalmers I, Hedges LV and Cooper H (2002) A brief history of research synthesis. *Evaluation and the Health Professions* 25(1): 12-37.
- Classic Manual: Hedges LV and Olkin I (1985) *Statistical Methods for Meta-Analysis*. New York: Academic Press.
- Systematic review
  - Cochrane collaboration (medical research; www.cochrane.org.nz)
  - Campbell collaboration (education, crime and justice, social welfare; www.campbellcollaboration.org)
  - International Initiative for Impact Evaluation - 3ie (development; www.3ieimpact.org)
- Meta-analysis in economics
  - MAER-net, http://www.hendrix.edu/maer-network/

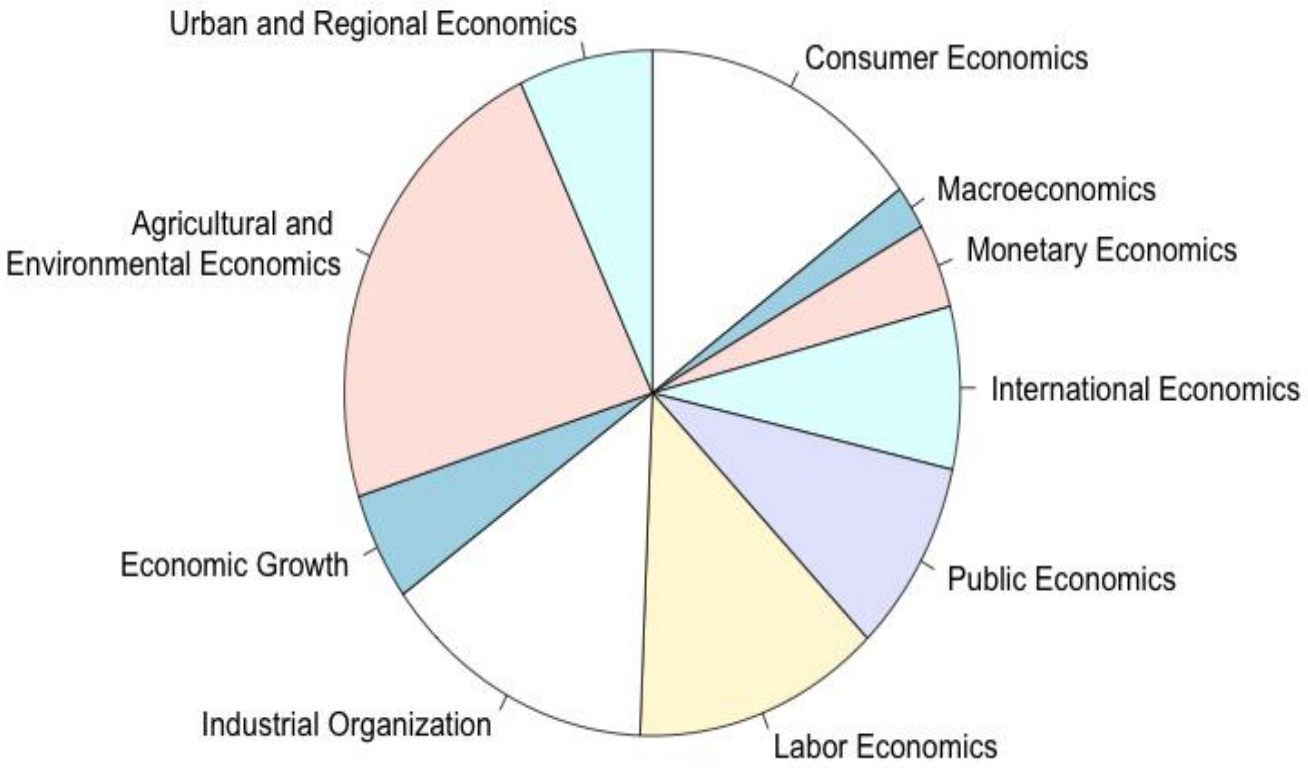
Meta-Meta-Analysis in Economics



2012)

Starting with: Nelson JP (1980) Airports and property values: A survey of recent evidence. *Journal of Transport Economics and Policy* 14(1): 37-52.

Meta-analyses in economics by field



The meta-analysis "recipe"

0. Define study objective
1. Collect and select studies
2. Define an effect size
3. Code effect sizes and relevant covariates
4. Calculate descriptive statistics
5. Run meta-regression models and investigate biases
6. Run diagnostics and robustness checks
7. Report results; see Stanley TD et al. (2013) Meta-analysis of economics research reporting guidelines. *Journal of Economic Surveys* 27(2): 390-394.

Documents & Effect Sizes

Size of MA data sets in economics					
sample n=619 (1980-2011)					
	mean	std. Dev.	median	min	max
# documents used	65.6	82.0	39.0	1	832.0
total # effect sizes	293.6	457.0	128.0	6	4286.0
# effect sizes/document	5.9	8.2	2.9	1	63.6

[*Source*: Florax and Poot (2013)]

Common Effect Sizes

- Regression coefficients with a common metric
- Elasticities
- Family of *t* and related statistics (*r*, *z*)
- Nonmarket value estimates
- Other effect sizes are relatively less commonly used

Choose Moderator Variables

- Standard errors, and sample size
- Other measures of study quality/robustness
- Specification variables (functional forms, types of regressors, data definitions)
- Study/sample characteristics
- Etc.

More on creating the data for meta-regression analysis

- Obtain studies that report the required effect sizes
  - Consider foreign language publications?
- Transform related estimates to effect sizes where possible
- Code all relevant study characteristics
  - Use theory to decide what matters
  - Contact authors if needed
  - Obtain relevant contextual information external to the study
- Have co-authors verify the coding
- Creating the dataset is the most costly part of meta-analysis!

Heterogeneity, heteroscedasticity and bias

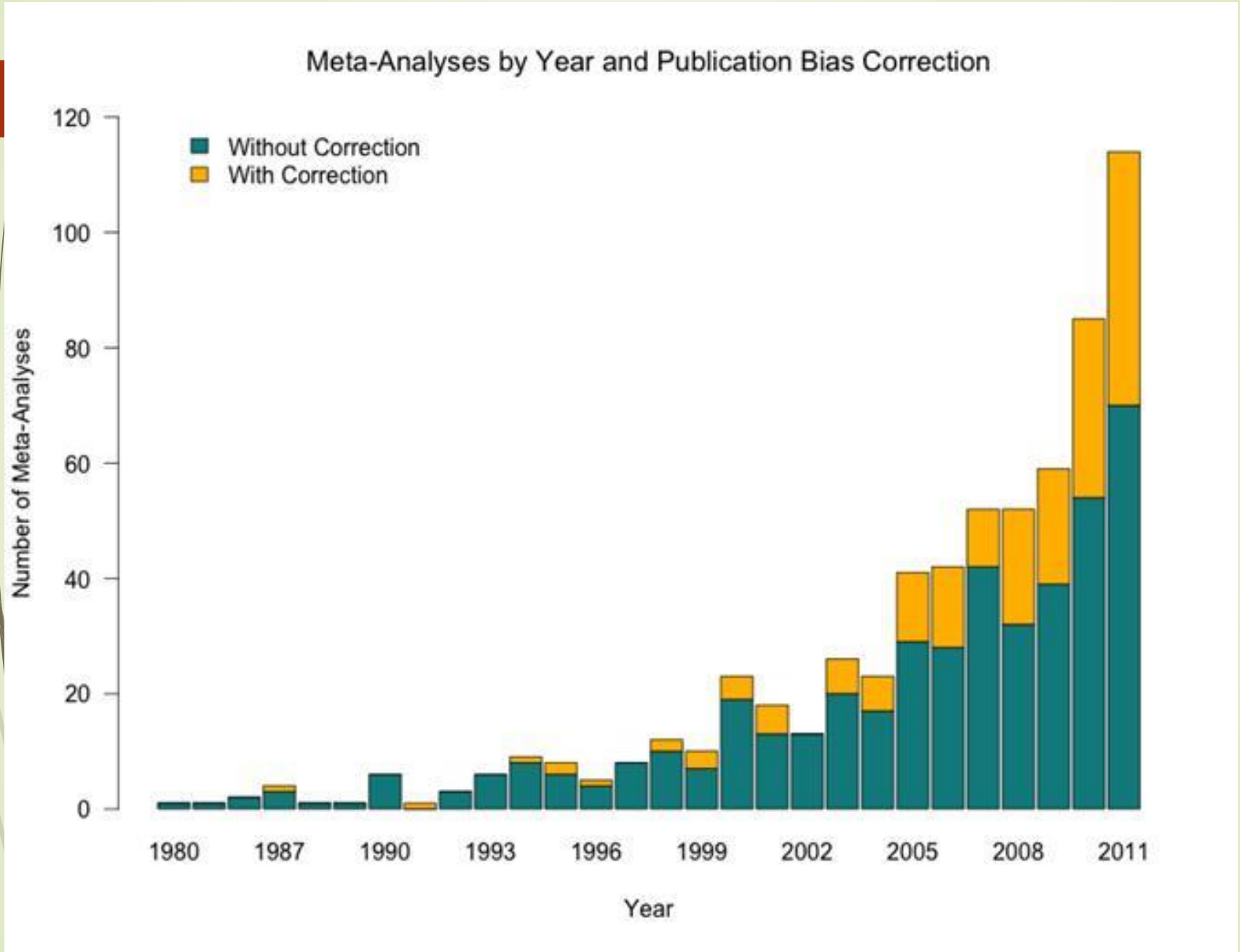
- In economics, β will most likely differ between studies (heterogeneity). If so, we need to model this variation.
- Moreover, y and X vary *across* studies in sample size, definition of variables and selection of variables.
- Researchers also report various results of y and X variation *within* studies. Some of these results *must* be biased.
- Meta-sample selection also generates bias

The on-going big issues in meta-analysis

- Heterogeneity of effect sizes
- Heterogeneity of precision
- Statistical versus economic significance
- (Non)-experimental design and causality
- Clusters
- Selection bias and quality control
- Publication bias

The problem of publication (or "file drawer“) bias

- A set of collected effect sizes is unlikely to be a random sample of conducted studies
- If hypothesis tests don’t reject $\beta = 0$, results are often not written up
- In each written paper, researchers only report a selected set of "preferred" specifications
- Journals favour publishing statistically significant findings and particularly large effect sizes
- Estimated standard errors may also be underestimated due to the wrong assumptions about the DGP in the primary study


Meta-Analyses by Year and Publication Bias Correction
Without Correction
With Correction
Number of Meta-Analyses
0
20
40
60
80
100
120
1980
1987
1990
1993
1996
1999
2002
2005
2008
2011
Year

Summing up…

- Meta-analysis can be either part of a new primary study (replacing or supplementing the narrative review therein) or the main focus of research in a new study
- Meta-analysis is applicable to both experimental and non-experimental / observational contexts; but each have developed their own techniques
- There are different techniques : look for robust results across techniques
- Good meta-analysis must account for heterogeneity, selection/publication bias, the difference between "within study" and "between study" variability, quality variation, and dependence
- Finally: given the "flood of findings" in the 21st century, further theory development specific to economic research is expected; and applications will continue to grow!

To Do

- Modeling selection bias and 'genuine effect'
- Modeling sources of heterogeneity
- Choosing appropriate estimator
- Addressing multicollinearity and overfitting

We will address these issue using a dataset on R&D and firm productivity