What do we really know about the influence of environmental on financial performance?
A meta-regression analysis (MRA)
(Hang et al., 2015)

2015 MAER-Net Colloquium in Prague, Czech Republic

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- Motivation and research question
- Theoretical background
- Related literature and research gap
- Research design
- Empirical analysis
- Main results
- Limitations and discussion
- Conclusion and outlook

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Status quo

1) Hundreds of primary studies try to find a (generally) valid answer to the CEP-CFP conflict heaving a special focus:

   - **Primarily single country analyses**
   - **Investigation of single industry sectors**
   - **Employment of different variable definitions**
   - **Time varying effect**
   - **Omitted variable bias**

Research question

Do firms really profit from better CEP and which factors explain the heterogeneity of the CEP-CFP relation?

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Causal sequence	Direction		
	negative	neutral	positive
CEP → CFP	**Tradeoff hypothesis:** Financial returns from environmental activities do not compensate investments (Levitt, 1958)	**Supply and demand model:** Existence of an optimal investment in environmental issues (McWilliams & Siegel, 2001)	**Natural resource-based view:** Environmental responsibility creates a strategic advantage (Hart, 1995) **Extensions:** Instrumental stakeholder theory, social impact hypothesis
CEP ← CFP	**Managerial opportunism hypothesis:** Managers compensate their disappointment in bad times by better CEP (Weidenbaum & Vogt, 1987)		**Slack resources theory:** Slack resources are invested in environmental issues (March & Simon, 1958)
CEP ↔ CFP	**Virtuous circle:** Financial returns from enhanced intangible assets are reinvested (Waddock & Graves, 1997)		

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1) Albertini, E. 2013. **Does environmental management improve financial performance? A meta-analytical review**. Organization & Environment, 26(4): 431–457.

   - 52 Empirical primary studies
   - Univariate meta-analysis and subgroup analysis

2) Dixon-Fowler, H. R., Slater, D. J., Johnson, J. L., Ellstrand, A. E., & Romi, A. M. 2013. **Beyond "does it pay to be green?" A meta-analysis of moderators of the CEP–CFP relationship**. Journal of Business Ethics, 112(2): 353–366.

   - 39 Empirical primary studies
   - Univariate meta-analysis and subgroup analysis

3) Endrikat, J., Guenther, E., & Hoppe, H. 2014. **Making sense of conflicting empirical findings: A meta-analytic review of the relationship between corporate environmental and financial performance**. European Management Journal, 32(5): 735–751.

   - 149 Empirical primary studies
   - Univariate meta-analysis and subgroup analysis

4) Guenther, E., Hoppe, H., & Endrikat, J. 2012. **Corporate financial performance and corporate environmental performance: A perfect match?** Zeitschrift für Umweltpolitik und Umweltrecht, 34: 279–296.

   - 274 primary studies
   - Narrative review and vote counting

5) Horváthová, E. 2010. **Does environmental performance affect financial performance? A meta-analysis**. Ecological Economics, 70(1): 52–59.

   - 37 empirical primary studies
   - Ordered probit model

6) Murphy, C. J. 2002. **The profitable correlation between environmental and financial performance: a review of the research**. Prepared for Light Green Advisors, New York.

   - 20 primary studies
   - Narrative review

Key findings

- Consistent confirmation of a positive relation between CEP and CFP
- Studies contradict in terms of moderating effects

Major downsides

- Small study samples
- Concentration on single moderating factors
- Grey literature not integrated
- Inappropriate univariate statistical approaches

Value added

1) Integration of 142 empirical primary studies from 1978 trough 2015

2) Explicit inclusion of grey literature

3) General-to-specific approach in moderator analysis avoids data mining bias:

   - **Measurement differences**
   - **Regional differences**
   - **Industrial differences**
   - **Data characteristics**
   - **Publication characteristics**
   - **Estimation differences**
   - **Control variables**

4) Appropriate estimation technique addressing heteroskedasticity, unobserved heterogeneity, non-independence of multiple estimates from primary studies and outlier problems (Nelson & Kennedy, 2009)

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Synthesizing previous literature

- Unique sample **of 893 effect sizes** from **142 published and unpublished empirical studies** including more than **750,000 firm year observations**

- **Mixed-effects weighted least squares meta-regression analysis (MRA)** fitted by a general-to-specific approach which avoids a data mining bias (Carney, Gedajlovic, Heugens, van Essen, & van Oosterhout, 2011; Stanley & Doucouliagos, 2012) including precision-effect testing (PET) and funnel asymmetry testing (FAT)

- Alternative between-study variance estimation approaches (maximum likelihood estimator ML, bayes estimator BE) (Thompson & Sharpe, 1999), outlier analysis, sensitivity analysis concerning unpublished works as **robustness tests**

- Inclusion of **38 potentially relevant moderator variables** to test the **hypotheses**:

Measurement differences (*H1*), publication characteristics (*H2*), data characteristics (*H3*), regional differences (*H4*), industrial differences (*H5*), control variables (*H6*), and estimation differences (*H7*) moderate the relationship between CEP and CFP.

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Overview of our sample covering 893 effect sizes from 142 empirical primary studies from 1978 through 2015

Publishing type	
Published studies	**89.25%**
Grey literature	**10.75%**

Number of firms	
Minimum	**6**
Maximum	**3412**
Mean	**282.05**
Standard deviation	**393.77**

Observation period	
Before 1996	**23.29%**
Between 1996 and 2000	**17.03%**
Between 2001 and 2005	**28.33%**
After 2005	**31.35%**

Analyzed countries	
North America	**42.78%**
Europe	**27.21%**
Asia	**10.30%**
Australia	**6.38%**
South America	**4.23%**
Africa	**1.00%**

1) Fixed-effects meta-regression analysis (MRA):

Effect sizes vary randomly around population mean effect size due to a study-specific sample selection error $SE(r_i)$

$$r_{ij} = \boldsymbol{\beta_0} + \underbrace{\boldsymbol{\beta_1} SE(r_i)}_{} + \sum_{k=1}^{K} \boldsymbol{\gamma_k Z_{ik}} + \boldsymbol{\varepsilon_i}$$

$$\underbrace{}_{\textbf{PET}} \quad \underbrace{}_{\textbf{FAT}}$$

► Exploring the heterogeneity by a set of moderator variables Z

2) Fixed-effects weighted least squares meta-regression analysis (MRA):

$$\mathbf{t}_{ij} = \boldsymbol{\beta_1} + \boldsymbol{\beta_0} \left(\frac{1}{SE(r_{ij})} \right) + \sum_{k=1}^{K} \frac{\boldsymbol{\gamma_k Z_{ijk}}}{SE(r_{ij})} + \boldsymbol{\nu_{ij}}$$

► Considering heteroskedasticity due to different sample sizes

3) Mixed-effects weighted least squares meta-regression analysis (MRA):

In addition to the sample selection error, the individual true mean effect sizes vary around the overall population mean effect size by τ^2

$$t_i = \beta_1 + \beta_0\left(\frac{1}{SE(r_i)}\right) + \sum_{k=1}^{K}\frac{\gamma_k Z_{ik}}{SE(r_i)} + \underbrace{\eta_i + \nu_i}$$

Unobserved heterogeneity τ^2 estimated by the restricted maximum likelihood estimator (REML)

► Considering random-effects due to unobserved heterogeneity

Moderator variable code	Description	Mean	Standard deviation
(1) Measurement differences			
PROCESS-BASED	=1 if CEP is a process-based performance measure, 0 otherwise for outcome-based performance measures	0.432	0.496
MARKET-BASED	=1 if CFP is a market-based performance measure, 0 otherwise for accounting-based performance measures	0.308	0.462
PROACT	=1 if CEP measures proactive corporate activities, 0 otherwise	0.408	0.492
REACT	=1 if CEP measures reactive corporate activities, 0 otherwise	0.068	0.252
CAUSAL	Counts the lagged years between the measurement of CFP and CEP in the regression analysis by substituting the time of measurement of CEP from the time of measurement of CFP	0.319	0.835
(2) Publication characteristics			
NoAUTHOR	Counts the number of authors	2.262	1.061
CITE	Measures the number of citations on June 02, 2015 in Google Scholar	155.046	321.729

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| Moderator variable code	Description	Mean	Standard deviation
(3) Data characteristics			
MILLENIUM	=1 if the mean year of firm data in a primary study is from 2000 or later	0.643	0.479
DATERANGE	Measures the date range of primary data in years	4.361	3.314
NoFIRMS	Counts the number of firms on which a regression analysis is based on	282.047	393.765
1980s	=1 if the mean year of firm data in primary data is between 1980 and 1989, 0 otherwise	0.082	0.274
1990s	=1 if the mean year of firm data in a primary study is between 1990 and 1999, 0 otherwise	0.261	0.439
2000s	=1 if the mean year of firm data in a primary study is between 2000 and 2009, 0 otherwise	0.585	0.493
MLTNAT	=1 if the study employs data from more than one country, 0 otherwise	0.143	0.351
NoCOUNT	Counts the number of countries covered by the primary data	2.207	4.461
MLTSECT	=1 if the study employs data from more than one industry sector referring to two-digit SIC-codes, 0 otherwise	0.487	0.500
NoSECT	Counts the number of industry sectors covered by the primary data referring to two-digit SIC-codes	4.241	3.714
(4) Regional differences			
DVLP	=1 if the study investigates only data from developing countries, 0 otherwise	0.069	0.254
G8	=1 if the study investigates only data from countries that are members in the Group of Eight (G8), 0 otherwise	0.720	0.449
BRICS	=1 if the study investigates only data from BRICS countries, 0 otherwise	0.056	0.230
ASIA	=1 if the study investigates only data from Asia, 0 otherwise	0.059	0.236
EU	=1 if the study investigates only data from the EU, 0 otherwise	0.199	0.400
AFRICA	=1 if the study investigates only data from Africa, 0 otherwise	0.010	0.100
US	=1 if the study investigates only data from the US, 0 otherwise	0.340	0.474

Moderator variable code	Description	Mean	Standard deviation
(5) Industrial differences			
SMALL	=1 if the study investigates only data of small firms, 0 otherwise[2]	0.233	0.423
MANUF	=1 if the study investigates only data from the manufacturing industry, two-digit SIC-codes 20-39, 0 otherwise	0.389	0.488
SERV	=1 if the study investigates data from the two-digit SIC-codes 60-99, 0 otherwise	0.104	0.306
DIRT	=1 if the study investigates only data from dirty industries, two-digit SIC-codes 10-49, 0 otherwise	0.502	0.500
(6) Control variables			
RD	=1 if the study controls for intensity of research and development in the regression analysis, 0 otherwise	0.306	0.461
AD	=1 if the study controls for advertising intensity in the regression analysis, 0 otherwise	0.171	0.377
CAP	=1 if the study controls for capital intensity in the regression analysis, 0 otherwise	0.249	0.432
RISK	=1 if the study controls for financial risk in the regression analysis, 0 otherwise	0.462	0.499
GROW	=1 if the study controls for sales growth in the regression analysis, 0 otherwise	0.231	0.422
SIZE	=1 if the study controls for firm size in the regression analysis, 0 otherwise	0.766	0.424
IND	=1 if the study controls for industry effects in the regression analysis, 0 otherwise	0.296	0.457
(7) Estimation differences			
SMPL	=1 if the study applies a simple regression approach, 0 otherwise	0.321	0.467
HTRG	=1 if the study controls for unobserved heterogeneity in the statistical approach, 0 otherwise	0.197	0.398
ENDO	=1 if the study controls for endogeneity between CEP and CFP by lagged variables or an appropriate statistical technique, 0 otherwise	0.429	0.495

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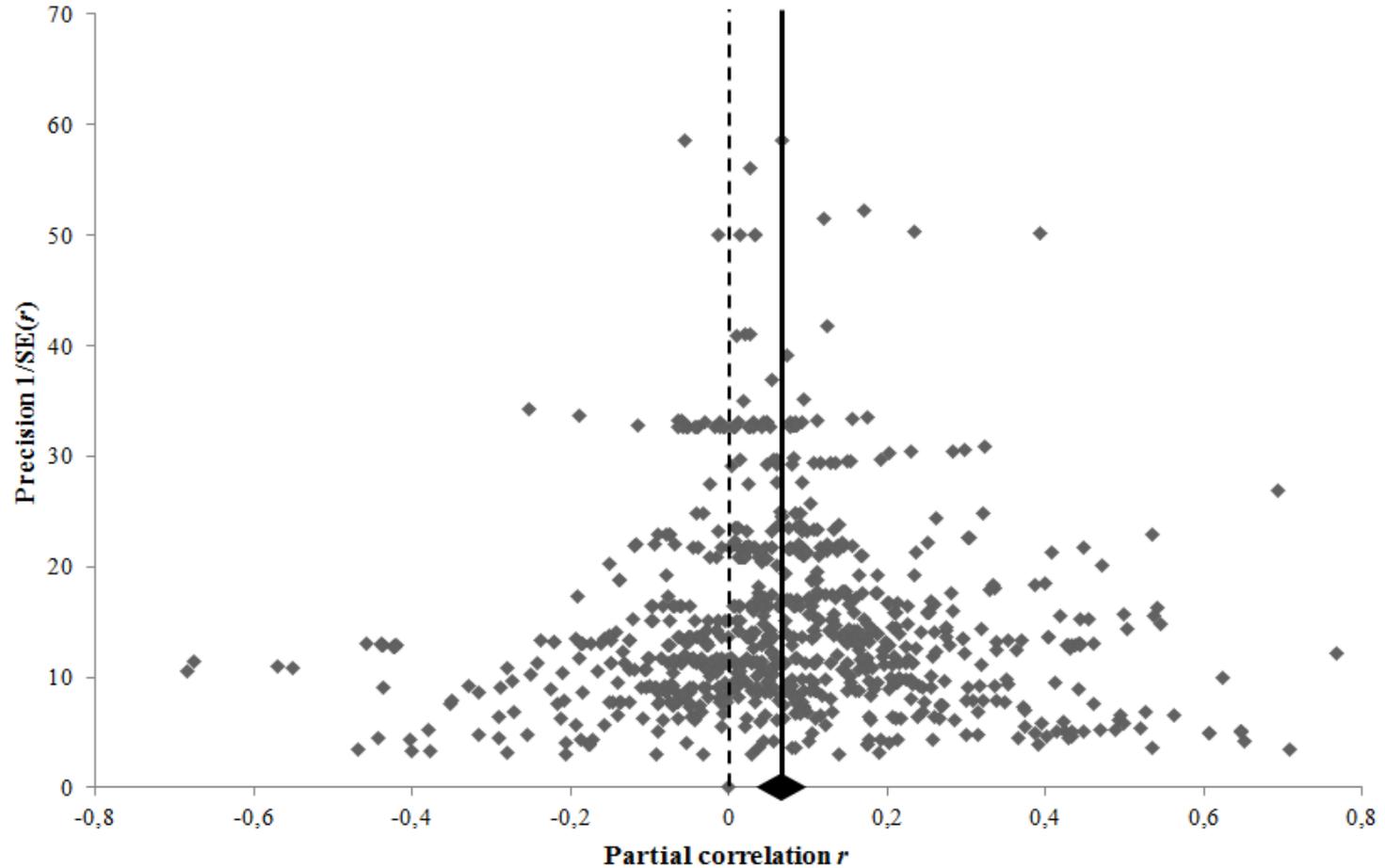
> ► **Absence of publication bias** confirmed by Egger's regression test (Egger et al., 1997)

Meta-regression analysis (MRA)

- The analysis confirms an overall **positive relation** between CEP and CFP.

- Our results indicate **strong evidence** for **regional and industrial moderating effects**. Economic performance, geographic location and industry standards affect the CEP-CFP relation.

- For **reactive investments** the overall positive relation between CEP and CFP is **significantly weaker.**

Robustness checks

The results are not sensitive to outliers, findings from unpublished articles and alternative estimations of the between-study variance τ^2 (ML, BE).

Robust findings

Moderator	p-value	Finding
(1) Measurement differences		
PROCESS-BASED	**< 1%**	**Outcome-based CEP** measures reveal a **higher effect** between CEP and CFP than process-based measures.
MARKET-BASED	**< 5%**	**Market-based CFP** measures reveal a **higher effect** between CEP and CFP than accounting based measures.
REACT	**< 1%**	**Reactive** environmental **activities underperform** with respect to CFP.
(2) Publication characteristics		
NoAUTHORS	**< 1%**	**Larger research teams** yield **higher effect size** estimates.
(3) Data charascteristics		
MILLENIUM	**< 1%**	The **effect** between CEP and CFP is **smaller after 2000** than before.
2000s	**< 1%**	The **effect** between CEP and CFP is larger **during the 2000s**.
MLTNAT	**< 1%**	**Multinational data** in primary studies reveal **higher effect size** estimates than single country analyses.
NoCOUNT	**< 1%**	The **growing number of analyzed countries** in primary studies lead to **smaller effect sizes**.
(4) Regional differences		
DVLP	**< 1%**	For **developing countries** the effect between CEP and CFP is **greater**.
BRICS	**< 1%**	The **effect** between CEP and CFP is **smaller in BRICS countries**.
ASIA	**< 1%**	In **Asia** the effect between CEP and CFP is **smaller**.
US	**< 1%**	The **effect** between CEP and CFP is **larger in the US**.
(6) Control variables		
CAP	**< 1%**	**Capital intensity** has a **strong indirect impact** on the CEP-CFP relation

Further findings

Moderator	*p*-value	Finding
(3) Data characteristics		
1980s	**< 5%**	The **effect** between CEP and CFP is **smaller during the 1980s**.
(5) Industrial differences		
SERV	**< 1%**	For the **service sector** the effect between CEP and CFP is **smaller**.
(6) Control variables		
SIZE	**< 1%**	**Firm size** has a **strong indirect impact** on the CEP-CFP relation

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There are **several issues to be critically considered** when conducting a meta-regression analysis (MRA) and interpreting its results. These aspects concern the underlying literature, the operationalization of moderators, dependencies in the data structure and endogeneity.

- Literature search procedure
- Dependent study samples
- Data dependency within studies
- Endogeneity problem
- Choice of moderators
- Operazionalization of moderators
- Biases

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1) The mixed-effects weighted least squares meta-regression analysis (MRA) is the **most appropriate approach** for synthesizing the findings of primary studies (in our case on the CEP-CFP relation).

    ► Multilevel methods, panel methods sepectively, would be possible

2) Based on the findings from the MRA, **new hypotheses can be derived** and tested especially for **macroeconomic factors**.

3) The answer to **the endogeneity problem** is still pending

4) For the integration of **additional moderators** further primary studies are needed.

5) It is important to consider the limitations when interpreting the results. However, they do not only appear in meta-analyses but they **restrict all literature overviews**.

Thank you very much for your attention!

Do you have any questions?

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