

A Free Environmental Lunch?

The Impact of Environmental Management Systems
on Energy Efficiency

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Cost of Convenience?



Environmental Management

Important sustainability practice in business

69%

Europe

62%

Asia-Pacific

44%

North America

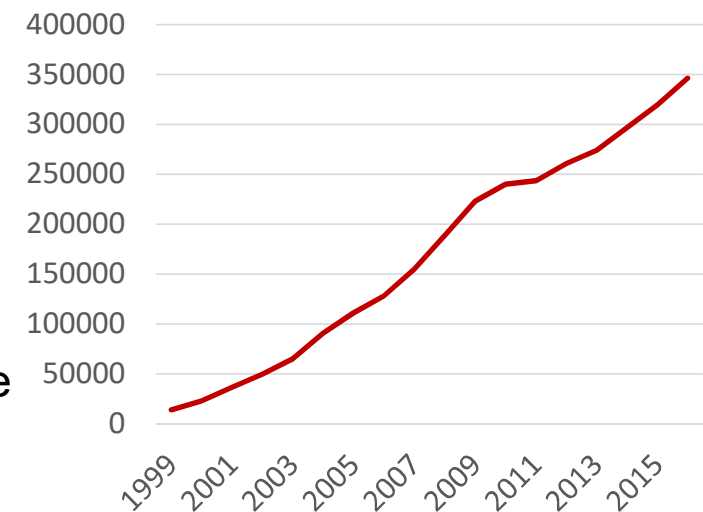
Environmental policy statements ratio
Christiansen and García (2004)

Environmental Management System (EMS)

ISO 14001

- An **framework** for the effective development of environmental management (Delmas, 2001)
- Based on the principle of **continuous improvement** and internal assessment (Bansal & Hunter, 2003)
- Enhancement of reputation and environmental performance

Cumulative number of certified facilities (ISO14001)



Survey-based Previous Literature

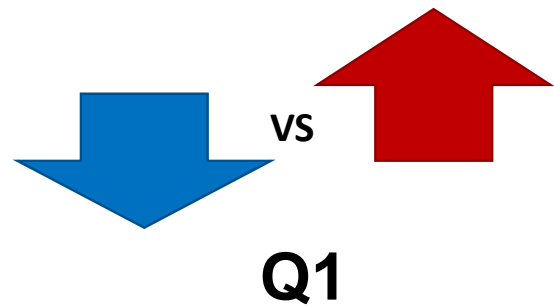
Author	Sample	Method	Measure	Effect
Alemagi et al. (2006)	Cameroon	Survey	% of positive report on environmental benefits	Positive
Castka and Prajogo (2013)	New Zealand	Survey	5-point Likert scale on reduction in energy and material use	Positive
Djekic et al. (2014)	Serbia	Survey	5-point Likert scale on reduction in energy use	Positive
Martín-Peña et al. (2014)	Spain	Survey	7-point Likert scale on reduction in water, energy, and material use	Positive
Radonjic and Tominc (2006)	Slovenia	Survey	% of positive report on energy consumption reduction	Positive

Conflicting Views

Domain	Operations <i>Management</i>	Environmental <i>Engineering</i>
Argument	EMS <i>increases</i> energy efficiency	Environmental management <i>decreases</i> energy efficiency
Reason	Effective management of input resources, including energy	More energy is required for environmental management
Method	Survey	Simulation and engineering experiment
Authors	Boiral et al. (2018)	Plappally and Lienhard (2012) Lannelongue and González-Benito (2012)

Purpose of Study

Research questions



How?

Q2

Solution?

Q3

Q1

Does EMS adoption **increase** or **decrease** energy efficiency?

Multiple-goals in EMS

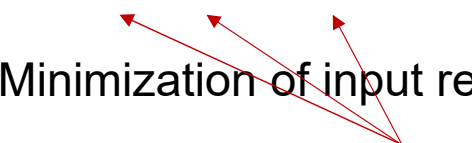
Multiple-goals and the ramification

- Multiple goals are often negatively correlated^[1]
- Managerial opportunism, where managers allow for adverse impacts and superficial actions, can occur.^[2]

Energy enables pollution control and prevention

- Monitoring activities and related compliance systems typify EMS and require energy (ISO14001 Clause 4.5.1)

Multiple goals in EMS

- Reduction of pollution
 - Air, water, waste, ...
 - Minimization of input resources
 - Raw material, energy, ...
 - Risk management
 - Environmental risk, safety, ...
- 

[1] Ethiraj and Levinthal (2009), Meyer (2002); [2] Lannelongue and González-Benito (2012)

Environment > Energy

Growing attention to energy management, but not enough

- Companies do not focus on energy as an integrated part of environmental management^{[1][2]}
- Why? split incentives, principal-agent relationships, and information imperfections^[3]

Relatively high attention to environmental measures

- In contrast, other environmental indicators (e.g., pollution-related) are well perceived.
- The risk of any hazard from environmental impact associated with the indicators is high.

H1. Environmental management systems decrease energy efficiency

[1] Amundsen (2000); [2] Thollander (2010), Dobes (2013); [3] Jaffe and Stavins (1994), Shi et al. (2008), Painuly et al. (2003), Sardianou (2008)

Data

Data Sources

- **Yearly panel data** (secondary) of South Korean plants from multiple sources:
 - Open Data Portal
 - ENV-INFO SYSTEM
- **Plant-level ISO 14001 adoption data** from the Korea Accreditation Board
- Time span: **2001-2014** | # of observation: **13,816** | # of plants: **1,768**

Level of analysis: **Plant**

Dependent variable

- Energy efficiency (OECD, 2014): $\text{Produced value} / \text{Energy consumption}$

Econometric Approach

- DID (Difference in differences) and Fixed-effects approach

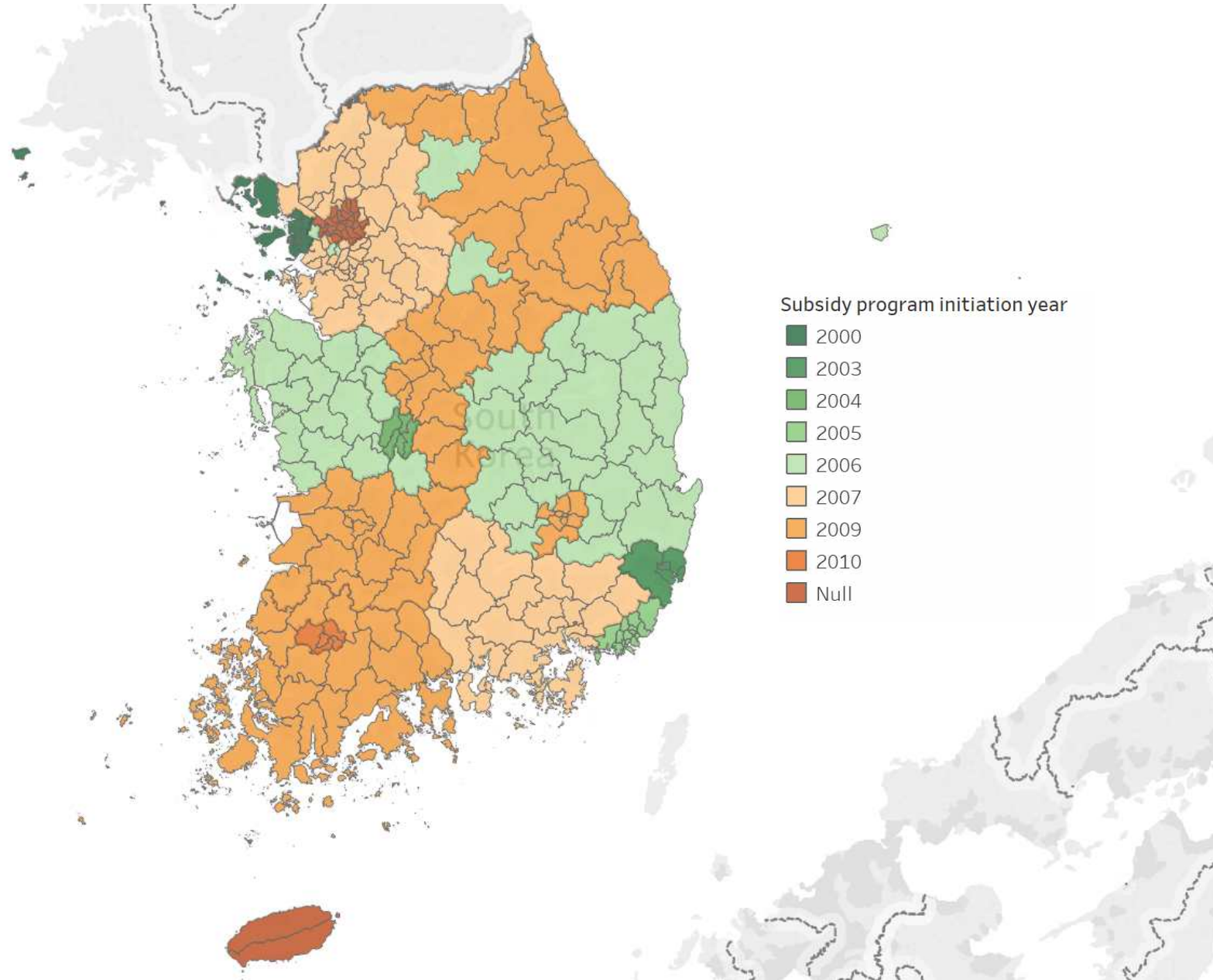
$$y_{it} = \beta_0 + \beta_{ISO14001} ISO14001_{it} + \underbrace{B_X X_{it}}_{\text{Dynamic control}} + \underbrace{\zeta_i}_{\text{Plant FE}} + \underbrace{\eta_t}_{\text{Year FE}} + \varepsilon_{it}$$

(plant age, renovation, sales, region change, heating days, cooling days, manager change, manager experience, manager number)

- Selection bias! → Panel IV approach

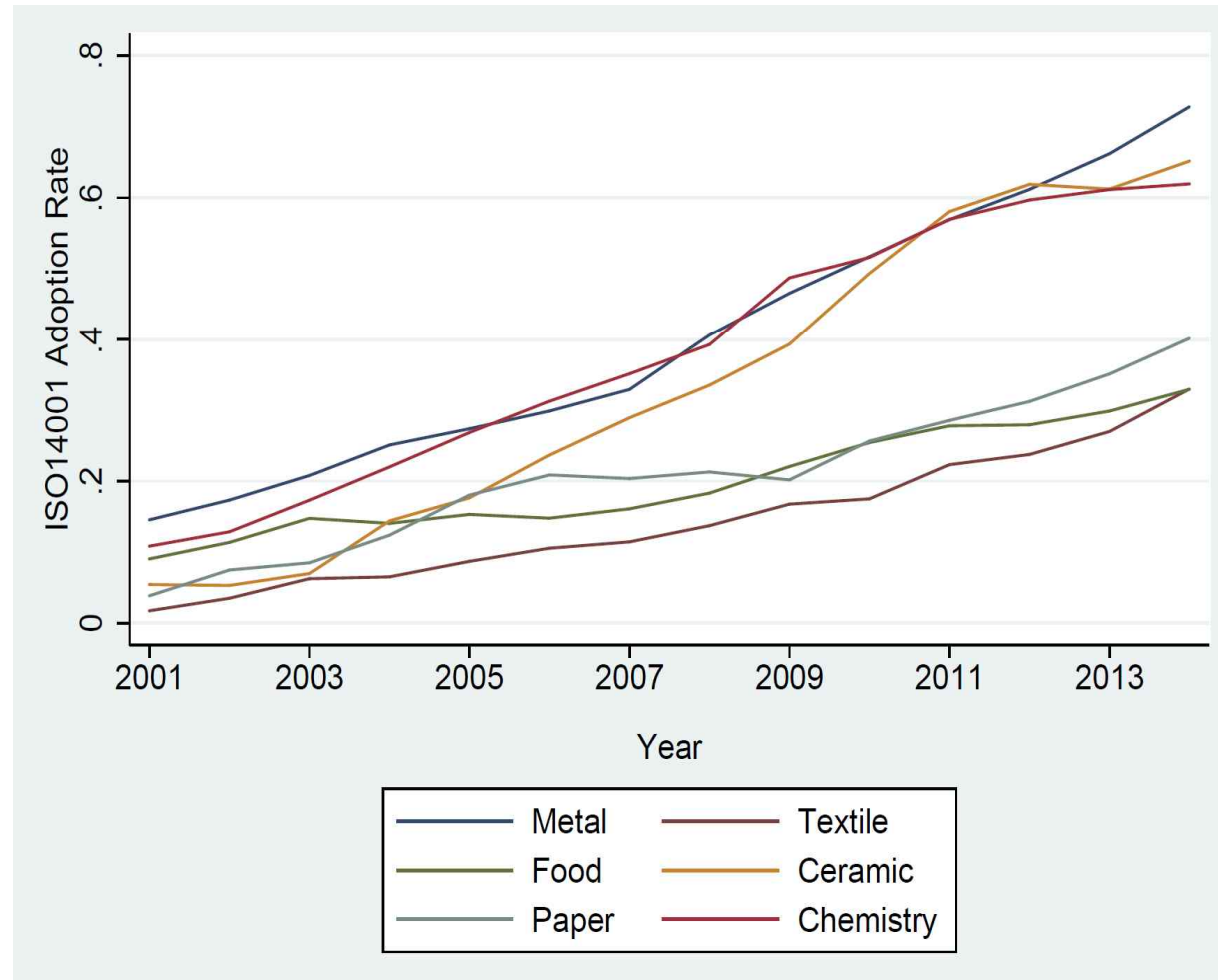
Subsidy Program Initiation Year

- Varies by regions



Sectoral Adoption Rate

- Adoptee age vs. Non-adoptee



Results for Q1

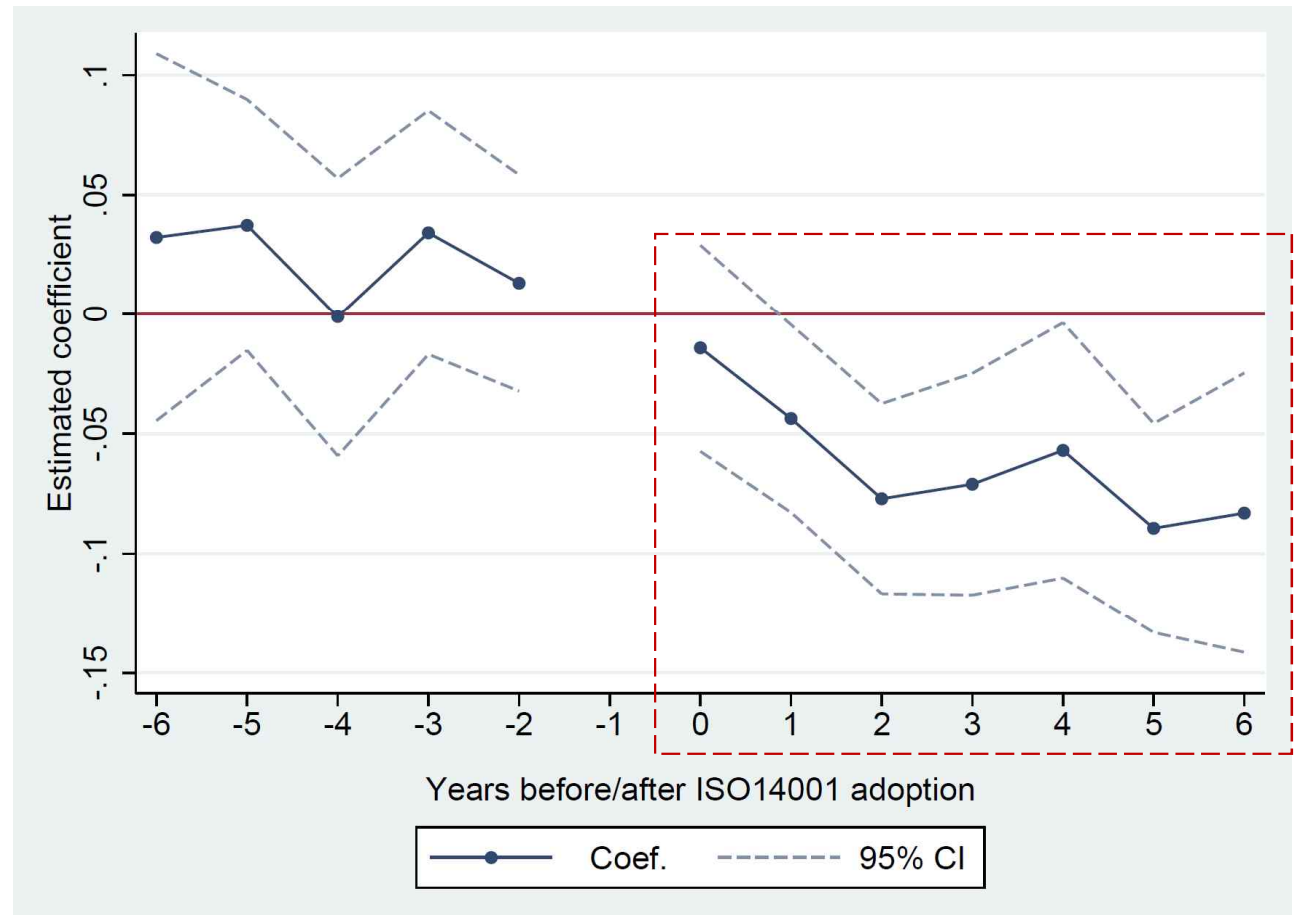
- Negative impact of EMS

Regression Results for the Impact of ISO 14001 on Energy Efficiency

Dependent variable:	Full sample		Adopter sample		2SLS	
					First stage	Second stage
	(1.1) <i>Log EE</i>	(1.2) <i>Log EE</i>	(1.3) <i>Log EE</i>	(1.4) <i>Log EE</i>	(1.5) <i>ISO14001</i>	(1.6) <i>Log EE</i>
<i>ISO14001</i>	-0.035* (0.020)	-0.046*** (0.018)	-0.048* (0.028)	-0.038** (0.019)		-0.167** (0.074)
<i>Log Sales</i>		0.320*** (0.011)		0.323*** (0.014)	0.001 (0.001)	0.321*** (0.008)
<i>Heating Days</i>		-0.000 (0.000)		-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
<i>Cooling Days</i>		-0.000 (0.000)		-0.000* (0.000)	0.000 (0.000)	-0.000 (0.000)
<i>Log Plant Age</i>		-0.020		-0.032	0.034***	-0.015

Yearly Effect

- ISO14001 x
Adoption age dummy var.



Environmental management systems decrease energy efficiency by 5%

Q2

If EMS adoption **decreases** energy efficiency,
what are the mechanisms?

First Mechanism of the Adverse Effects

Mechanism 1. Increase in facility scale

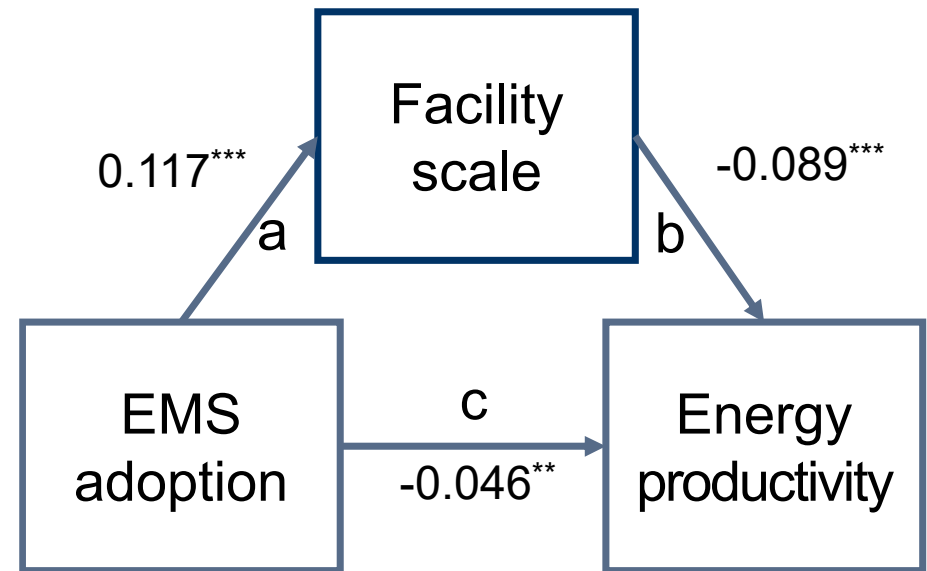
- Monitoring and controlling environmental outputs require additional facilities^[1]
- Newly introduced facility inevitably consumes extra energy, which lowers energy efficiency

H2a. The increase in facility scale due to the adoption of EMS decreases energy efficiency

[1] Amundsen (2000); [2] Thollander (2010), Dobes (2013); [3] Jaffe and Stavins (1994), Shi et al. (2008), Painuly et al. (2003), Sardianou (2008)

Mediation Model Approach

- Estimating the indirect effect (i.e., $a \times b$)
 - GSEM results: -0.010 ($p < 0.01$)
- Estimating the total effect (i.e., $a \times b + c$)
 - GSEM results: -0.056 ($p < 0.05$)



Note: *** $p < .01$, ** $p < .05$; Sobel test passed; sector fixed effects included instead of plant fixed effects

The increase in facility scale due to EMS decreases energy efficiency by 1% (H2a Supported)

Second Mechanism of the Adverse Effects

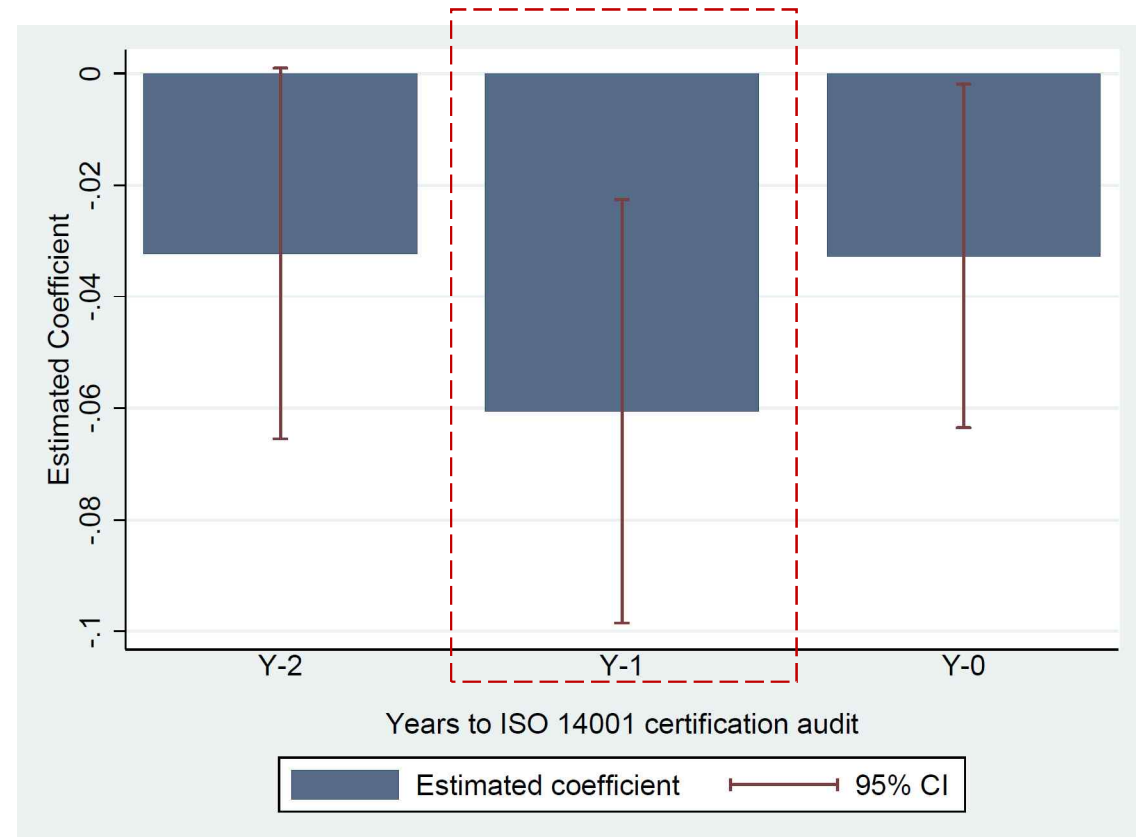
Mechanism 2. Intensified level of environmental management

- EMS intensifies the level of environmental management (EM)
- Such environmental management requires more energy to be operated

H2b. Increases in the level of EM due to the adoption of EMS decrease energy efficiency

EM Level Changes via Recertification

- Institutional setting
 - 3-year cycle of *recertification*
 - Increase in commitment before recertification
 - Estimating the effect of remaining year dummy variable
- Significantly negative effect at Y_{3K-1}



Note: Plant FE, Year FE, and control variables are included in the test

Increases in the level of EM due to EMS decrease energy efficiency (H2b Supported)

Q3

How can firms mitigate the unintended effect caused by EMS adoption?

How to Mitigate the Negative EMS Impact

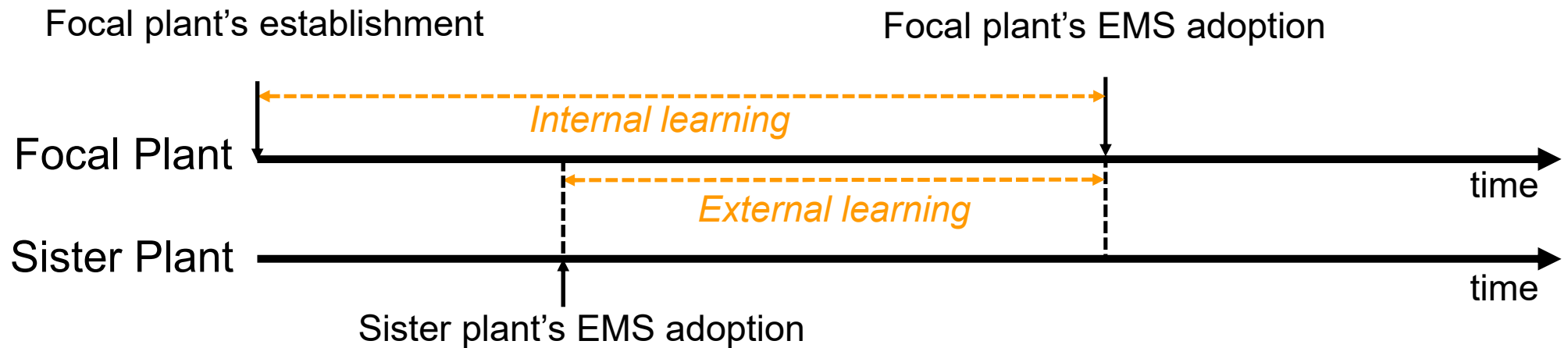
Role of organizational learning

- **Learning-by-doing** enables EMS adopters to achieve greater benefits^[1]
- Operations management practices are shared between plants within a firm^[2]

H3. Learning mitigates decreases in energy efficiency caused by the adoption of EMS

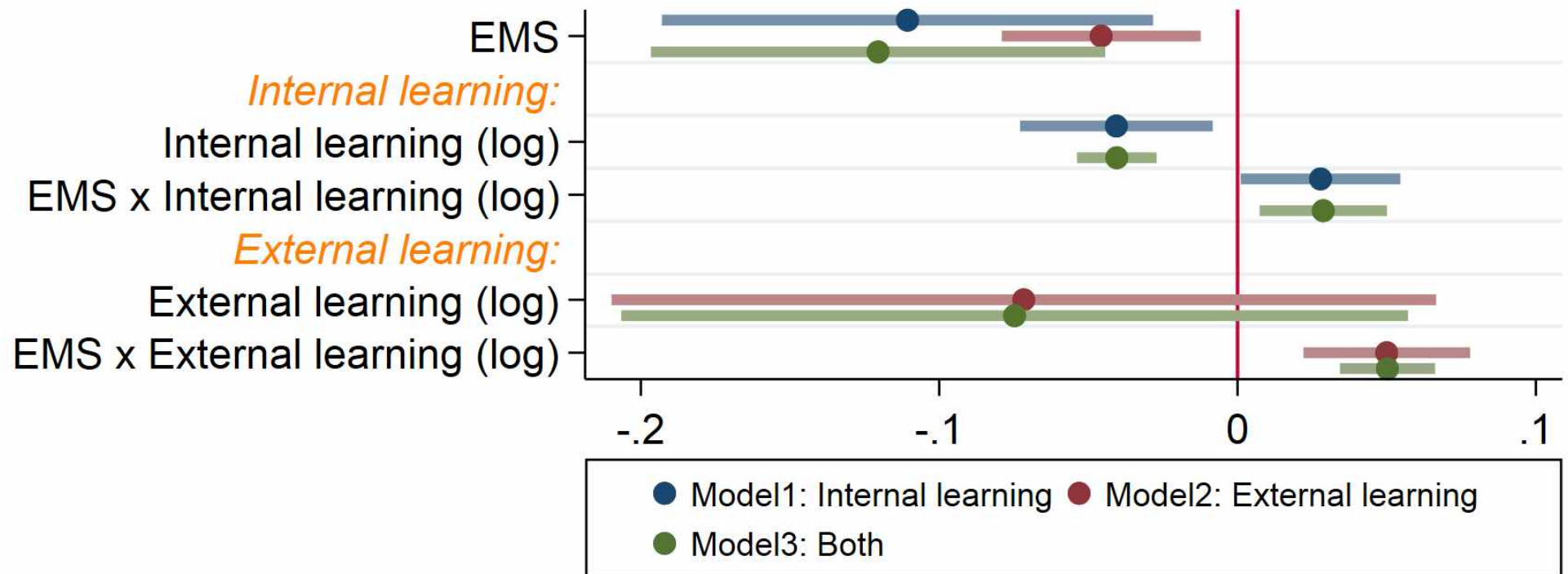
[1] Russo (2009); [2] Bloom et al. (2018).

Operationalization of Learning



Note. The operationalization of learning follows Argote (2013) and Russo (2009)

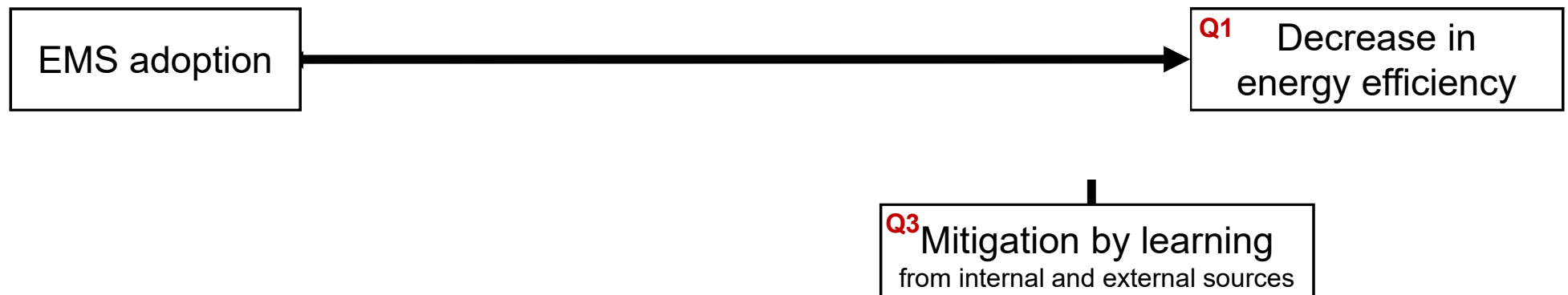
Results for Q3



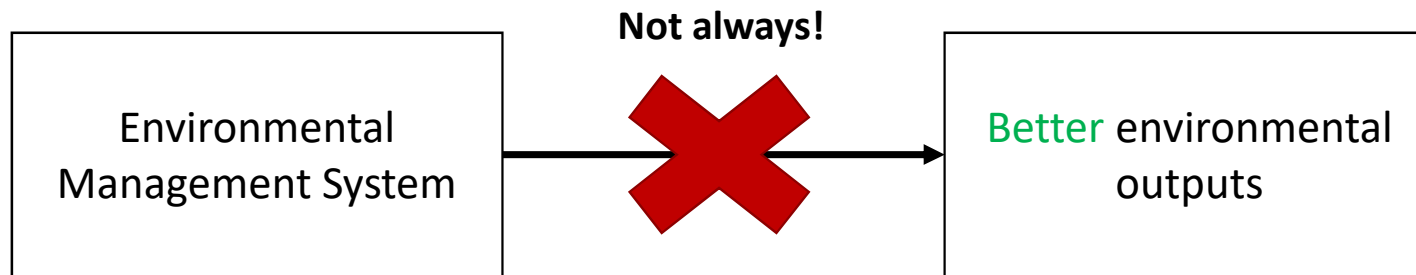
Note: Plant FE, Year FE and control variables are included in the test
Lines cover 95% CI; Dots indicate the estimated mean parameter values

Learning mitigates decreases in energy efficiency caused by EMS (H3 Supported)

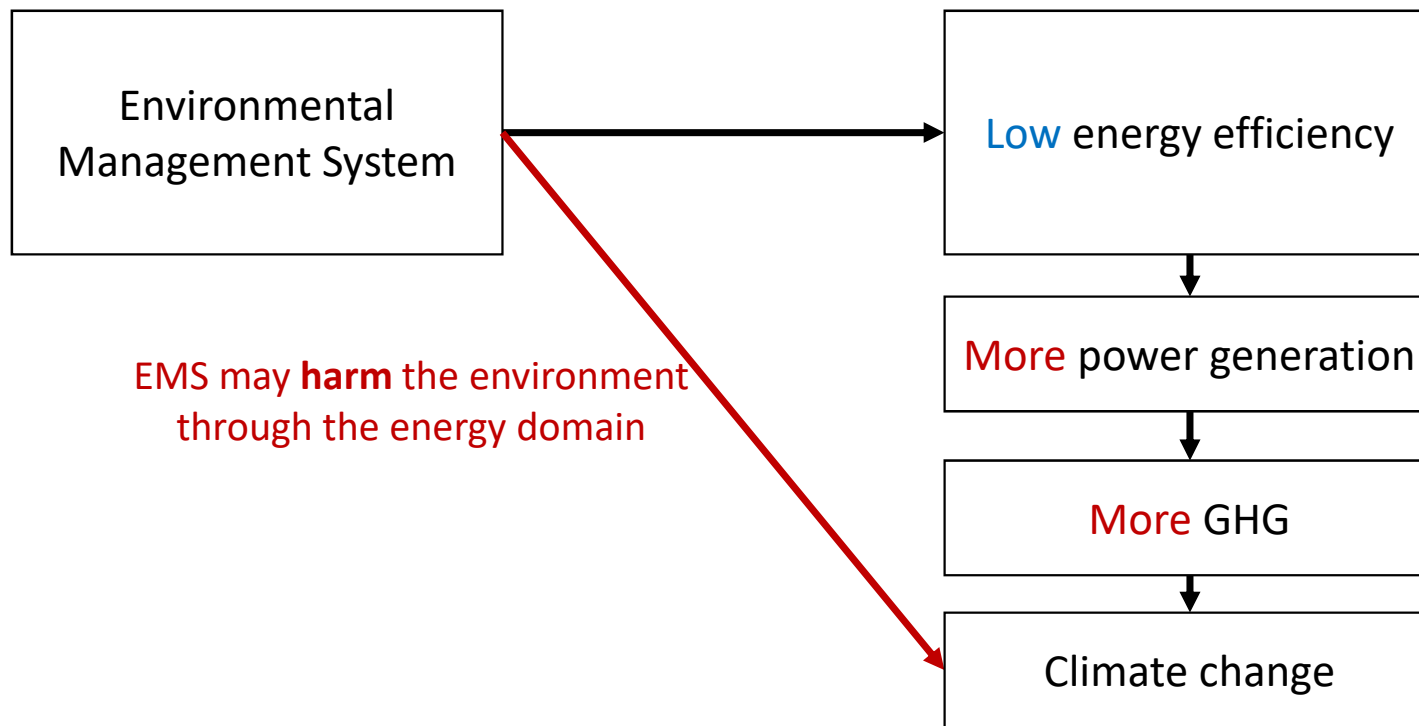
Summary



Implications



Implications



Q: We should **NOT** adopt
Environmental Management System?

A: Wrong question!
Find a way to deal with the negative impact

1

Complementary
standards

2

Knowledge
management

3

Incentive system for
knowledge sharing

Contribution

- First study to use *secondary plant-level data* in examining the impact of EMS on energy efficiency.
- *Addresses discrepancy* between the sustainable operations management and environmental engineering literature.
- Shows the *negative impact of EMS adoption* on energy efficiency and identifies its *underlying mechanisms*.
- Suggests that organizational *learning can mitigate* the negative impact.

Thank you