ISO 14001 Adoption and Firm Efficiency: Evidence from the South Korean Manufacturing Industry

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Introduction

Overview of ISO 14001:

- In 1996, International Organization for Standardization(ISO) developed the voluntary environmental program, ISO14001, which aims to improve environmental management system (EMS). Despite the costly nature and non-legal requirements for the adoption, implementation of this program has grown fast recently (Fig.1).
- ISO 14001 does not target specific emission level but focuses on improvement of management process. It is not a country or industry specific standard but a worldwide standard that covers various regions and industries. Third-party audit is required for the certification.

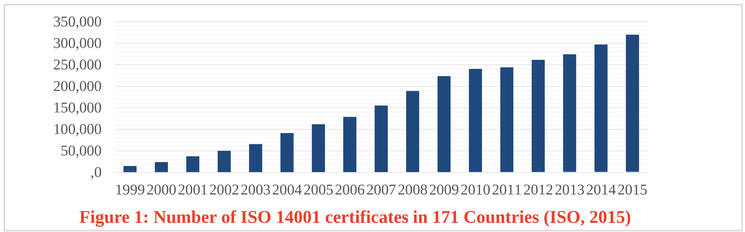

Figure 1: Number of ISO 14001 certificates in 171 Countries (ISO, 2015)

Efficiency improvement:

- ISO (2015) suggests efficiency improvement as one of key expected outcomes. By involving managers and employees in the process of EMS from plan to review stages, ISO 14001 encourages them to be aware of the environmental management system and their responsibility. In addition, firms can find outdated routines and inefficient resource usages by ISO guidelines.
- Some case studies have reported efficiency improvement not only as a primary motivation of ISO14001 adoption but also as a beneficial outcome.

ISO 14001 in Korea:

- Total 5436 certificates and 127 Accreditation bodies in Korea (KAB, 2014)
- The Korean manufacturing industry accounts for a large share of the Korean economy (over 30% of GDP), and it is a high polluting industry (40% in total CO2 emission). Thus, over 80% of ISO 14001 certificates are in manufacturing industry, and the number of certified manufacturing firms has increased continuously (Fig. 2).

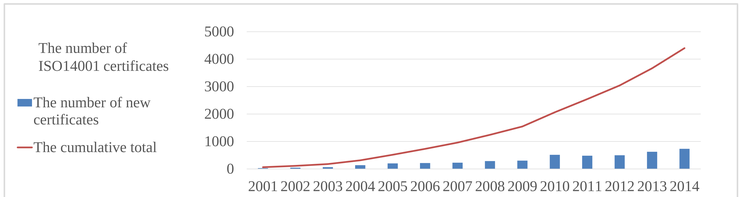

Figure 2: Evolution of ISO 14001 certificates in Korean Manufacturing industry (KAB, 2014)

Objective

- We examine the impact of the ISO14001 standard adoption on firm inefficiency in the Korean manufacturing industry.
- To measure the individual firms' inefficiency, we use a stochastic frontier approach with three different distributions of inefficiency.
- An instrumental variable approach is employed for the consistent parameter estimation.

Methods

DATA:

- Unbalanced panel data of manufacturing firms in South Korea for the period 2001-2014
- ISO14001 certification data from Korean Accreditation Board database
- Financial data and firm level information from Financial Supervisory Service

The Model:

- A stochastic frontier production model with a trans-log function:

$$(1)\ lnY_{it} = \alpha + \beta_1 lnL_{it} + \beta_2 lnK_{it} + \beta_3 lnI_{it} + \beta_4 lnL_{it}^2 + \beta_5 lnK_{it}^2 + \beta_6 lnI_{it}^2 + \beta_7 lnL_{it} lnK_{it} + \beta_8 lnL_{it} lnI_{it} + \beta_9 lnK_{it} lnI_{it} + Year_{it} + KSIC_{it} + V_{it} - U_{it}$$

where Y_{it} represents the observed output, total sales of firm i at time t. K_{it},L_{it}, and I_{it} represent inputs used in production; labor cost, fixed assets, and intermediate inputs of firm i at time t, respectively. $Year_{it}$ is year dummy, $KSIC_{it}$ represents industry dummy based on the two-digit KSIC. U_{it} and V_{it} are error terms which capture the deviations from the production frontier. V_{it} represents statistical noise and is drawn i.i.d. according to $N(0, \sigma_v^2)$. U_{it} is a non-negative random variable measuring technical inefficiency. It is also assumed to be i.i.d. random variable following the non-negative truncations of the distribution, $N(\mu_{it}, \delta_u^2)$, for the Model (1) and (2). In addition, we consider the half-normal distribution at the Model (3) and the exponential distribution at the Model (4).

- A firm i's inefficiency at year t is defined by:

$$(2)\ U_{it} = \alpha_0 + \alpha_1 ISO14001_{it} + \alpha_2 Size_{it} + \alpha_3 Age_{it} + \alpha_4 Export_{it} + \alpha_5 R\&D_{it} + \alpha_6 Herfindahl_{it} + \theta_j + \lambda_t + \varepsilon_{it}$$

where $ISO14001_{it}$ is the firm i's ISO14001 adoption status dummy at year t. *Size* is the log of the number of employees, *Age* is the log of the number of years since a firm has been established, *Export* iss the ratio of export sales to total sales, *R&D* is the ratio of R&D expenditure to total sales, and *Herfindahl* represents the market concentration at the two-digit KSIC. To control unobserved variation across industries and years, industry fixed effect, θ_j, and year fixed effect, λ_t are included.

  - Model (1): one stage estimation using the equation (1) and (2).

Identification Issue:

- Reverse causality and unobservable factors which are correlated with both ISO14001 and inefficiency.
- Instrumental Variable: the ratio of the number of certified firms to the total number of firms in the industry. This instrument is highly correlated with an individual firm's ISO14001 adoption decision because the adoption ratio affects the marginal cost, information asymmetry, and imitating behavior. However, the adoption rate should not be directly correlated with an individual firm's technical efficiency.

Estimation Procedure:

- Two stage estimation: first, technical inefficiency is estimated from the frontier function, the equation (1). Then, the effect of ISO14001 adoption on technical inefficiency is examined using equation (2) with an instrumental variable.
- The following distributions of U_{it} are considered for the two-stage estimation model:
  - Model (2): the distribution of U_{it} is assumed to be truncated normal
  - Model (3): the distribution of U_{it} is assumed to be half normal
  - Model (4): the distribution U_{it} is assumed to be exponential

Results

Table 1. Stochastic Frontier

Variable	Model (1)	Model (2)	Variable	Model (1)	Model (2)
Constant	1.567	5.911***	$(lnK)^2$	0.0202***	0.00813***
	(1.496)	(0.4461)		(0.00481)	(0.00131)
log(L)	0.705***	0.426***	$(lnI)^2$	0.0712***	0.0664***
	(0.221)	(0.0428)		(0.00728)	(0.000641)
log(I)	0.608***	0.495***	log(L)log(I)	-0.188***	-0.125***
	(0.205)	(0.0288)		(0.0496)	(0.00218)
log(K)	-0.234*	-0.123***	log(L)log(K)	-0.0510	0.0118***
	(0.127)	(0.0314)		(0.0374)	(0.00272)
$(lnL)^2$	0.125***	0.0601***	log(I)log(K)	0.0222	-0.0170***
	(0.0458)	(0.00206)		(0.0371)	(0.00167)

Note: Model (1) and (2) have 5,245 firms and 30,006 observations.

Table 2. Inefficiency Model

Variable	Model (1)	Model (2)		Model (3)		Model (4)	
		First Stage	Second Stage	First Stage	Second Stage	First Stage	Second Stage
ISO14001	8.288		-1.24e-05		-0.0836*		-0.138***
	(6.129)		(0.000620)		(0.0447)		(0.0372)
Peer Pressure		0.815***		0.657***		0.694***	
		(0.0370)		(0.0438)		(0.0400)	
Export Ratio	-0.00594	0.000155	-1.27e-06	0.00086***	1.81e-05	0.000698***	-5.40e-05
	(0.0151)	(0.000131)	(9.33e-07)	(0.000148)	(7.60e-05)	(0.000135)	(6.81e-05)
RD Ratio	0.0713**	-0.0027***	4.04e-07	0.000791	0.00144	3.31e-05	0.000728
	(0.0358)	(0.000988)	(6.05e-06)	(0.00117)	(0.00128)	(0.00107)	(0.000647)
Age	0.758***	-0.0382***	0.00039***	-0.0530***	-0.0498***	-0.0297***	-0.0248***
	(0.184)	(0.00824)	(7.04e-05)	(0.00993)	(0.00958)	(0.00934)	(0.00629)
Size	0.270	0.0237***	8.71e-05*	0.0447***	-0.000400	0.0551***	0.00335
	(0.317)	(0.00511)	(4.68e-05)	(0.00592)	(0.00441)	(0.00569)	(0.00351)
Herfindahl	-7.599	-0.0981***	-4.29e-05	-0.0704**	0.0531**	-0.131***	-0.114***
Index	(6.882)	(0.0260)	(0.000247)	(0.0313)	(0.0240)	(0.0294)	(0.0190)

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, Cragg-Donald Wald F statistics in Model(2), (3), and (4) are larger than the Stock-Yogo weak ID test critical values at 10% maximal IV size, 16.38.

Conclusion

- This paper provides empirical evidence that the ISO14001 standard promotes a firm's efficiency. The model with an instrumental variable reports that the adoption of ISO14001 improves the firm efficiency, by 8~14% depending on the models.
- Our results show that environmentally responsible strategy would not weaken but strengthen corporate competitiveness.
- For example, the expected outcome from efficiency improvement by ISO 14001 adoption is high enough to compensate the related cost in the case of Small and medium firms in Korea; the average cost of ISO 14001 adoption is 14,740 thousand won, but the increase in the expected sales improvement is around 8% of the average sales, 2,094 million won (IIT in Korea, Vol.14 No.30)

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