Does ISO14001 raise firms' awareness of environmental protection? The case of Vietnam

Bin Ni[1*], Hanae Tamechika[2], Tsunehiro Otsuki[3] and Keiichiro Honda[4]

[1] Department of International Economics, Faculty of Economics, Hosei University, Tokyo, Japan, [2] Graduate School of Economics, Nagoya City University, Nagoya, Japan, [3] Osaka School of International Public Policy, Osaka University, Osaka, Japan, and [4] Faculty of Administrative Studies, Prefectural University of Kumamoto, Kumamoto, Japan

[*]Corresponding author. Email: jiadaniel@hotmail.com

ONLINE APPENDIX

Table A1. Categorization of manufacturing sectors

Variables	Definition
a_mnf	Dummy variable: 1 if firm is manufacture of food products industry, manufacture of beverages industry, or manufacture of tobacco products industry; 0 otherwise.
b_mnf	Dummy variable: 1 if firm is manufacture of textiles, manufacture of wearing apparel, or manufacture of leather and related products; 0 otherwise.
c_mnf	Dummy variable: 1 if firm is manufacture of coke and refined petroleum products, manufacture of chemicals and chemical products, manufacture of pharmaceuticals, medicinal chemical and botanical products, or manufacture of rubber and plastics products; 0 otherwise.
d_mnf	Dummy variable: 1 if firm is manufacture of other non-metallic mineral products, manufacture of basic metals, manufacture of fabricated metal products, except machinery and equipment, or manufacture of other fabricated metal products; metalworking service activities; 0 otherwise.
e_mnf	Dummy variable: 1 if firm is manufacture of computer, electronic and optical products, manufacture of electrical equipment, manufacture of machinery and equipment n.e.c, manufacture of motor vehicles; trailers and semitrailers, or manufacture of other transport equipment; 0 otherwise.
f_mnf	Dummy variable: 1 if firm is manufacture of wood and products of wood and cork except furniture, manufacture of paper and paper products, printing and reproduction of recorded media, manufacture of furniture, other manufacturing, or repair and installation of machinery and equipment; 0 otherwise.

Table A2. Summary statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max
Air	3043	34.925	22.605	0	50.000
Liquid	13043	46.514	12.105	0	50.000
Solid	17420	47.776	9.772	0	50.000
Salary	202068	5.820	1.531	0.270	10.640
Turnover	202126	8.220	1.866	0.732	13.394
TFP	202126	0.485	0.143	0.000	0.727
ISO14001	22672	0.742	0.262	0	1
Emsystem	22696	0.325	0.468	0	1
Environstandard	22708	0.315	0.464	0	1
Cleanmanufacture	22762	0.403	0.491	0	1
Wastedept	22728	0.328	0.328	0	1
Cost_environ	131584	0.361	1.244	0	14.440
Cap_lab	204168	101.598	1342.982	0	527071.750
Labour	204168	79.960	464.112	1	64751
FDI	55433	15.087	35.241	0	100

Propensity score matching

Next, we use propensity score matching (PSM) to confirm our findings. The purpose of our estimation is to determine the average treatment effect on the treated sample (ATT), which, in this study, is the performance difference between ISO14001 adopters and non-adopters. While accurate measurements need random experimental settings, the counterfactual phenomenon is usually unobserved. In this case, Rosenbaum and Rubin (1983) propose using a propensity score, which we can do here to match adopters with non-adopters. We use the first-stage equation introduced in section 4.1 to predict the likelihood of a firm adopting ISO14001.

The challenge is that firms do not report the year they acquired ISO14001. Thus, we use the information for 2006 (one year before our first year of observation) to calculate firms' propensity score for ISO14001 adoption in year 2007.[1] Then, we match them with firms in the same year, that have similar propensity but do not adopt ISO14001. If the performance indicators in these two groups are significantly different, then we can make the judgment that ISO14001 has potentially led firms to improve. To proceed, we further assume that by controlling the covariates, we can make the error term uncorrelated with firms' decisions with regard to ISO14001 adoption.[2]

Our treatment sample (ISO14001 = 1) varies in size from 825 in 2007 to 1201 in 2009. The average value of each control variable for the treated group is higher than that for the control group. For example, the average TFP for the treated group is 0.56, compared with

[1] We repeat the same practice for the other years as well.
[2] In reality, this assumption can be violated. For example, a policy shock in an industry might encourage firms to apply for ISO accreditation; an opposite scenario can also be considered.

0.49 for the control group. The estimation results are consistent with the statistical intuition. Table A3a reports the results using nearest one-to-one matching. The ATT estimates are all significant, except for the share of treated solid waste. This indicates that firms' overall performance tends to improve significantly following the adoption of ISO14001.

Table A3a. Results using propensity score matching

	(1)	(2)	(3)	(4)	(5)	(6)
	Logarithm of			Share of treated …		
Variables	real salary	real turnover	TFP	liquid waste	air waste	solid waste
Method	Nearest	Nearest	Nearest	Nearest	Nearest	Nearest
ATT	1.127***	1.319***	0.0559***	1.812**	13.24***	0.470
	(0.101)	(0.121)	(0.00635)	(0.848)	(3.024)	(0.699)
Observations	4,007	3,987	4,253	2,021	536	2,591

Notes: Standard errors are in parentheses. *** p<0.01, ** p<0.05. (One-tail significance test is conducted.) One-to-one matching is applied.

The results of the balancing test are presented in table A3b.

Table A3b. Results of balancing test (PS test)

		Mean		% reduct		t-test		V(T)/ V(C)
Variable	U / M[a]	Treated	Control	%bias	bias	t	p>t	
FDI2006	U	47.049	22.921	53.8		10.57	0.000	1.37*
	M	54.517	57.961	-7.7	85.7	-0.75	0.455	1
Capital labor	U	314.82	142.45	25.4		6.51	0.000	3.77*
ratio 2006	M	364.18	389.48	-3.7	85.3	-0.34	0.737	0.88
a_mnf	U	0.18421	0.2027	-4.7		-0.86	0.387	.
	M	0.16744	0.13023	9.4	-101.2	1.08	0.279	.
b_mnf	U	0.11842	0.12471	-1.9		-0.36	0.721	.
	M	0.11163	0.17209	-18.5	-862.2	-1.8	0.073	.
c_mnf	U	0.20263	0.11249	24.9		5.23	0.000	.
	M	0.2	0.24186	-11.6	53.6	-1.05	0.297	.
d_mnf	U	0.18684	0.24941	-15.2		-2.73	0.006	.
	M	0.18605	0.12093	15.8	-4.1	1.88	0.061	.
e_mnf	U	0.22105	0.08507	38.4		8.75	0.000	.
	M	0.26512	0.25581	2.6	93.2	0.22	0.827	.
f_mnf	U	0.08684	0.22563	-38.9		-6.35	0.000	.
	M	0.06977	0.07907	-2.6	93.3	-0.37	0.714	.
Labor2006	U	919.89	251.06	44.5		14.17	0.000	8.53*
	M	855.97	898.15	-2.8	93.7	-0.23	0.822	0.64*
Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.105	248.73	0	27.5	25.4	82.0*	2.82*	100
Matched	0.014	8.52	0.384	8.3	7.7	28.3*	0.98	33

Notes: [a] U: unmatched, M: matched. * p<0.1 level of significance.

We also conduct balance tests (for matched firms) to check for differences in average

covariates between the treated and control groups to see if there remain any significant differences between the two groups after propensity score matching. The results of the t-test for the major covariates (*FDI, capital_labor ratio, Labor*) do not reject the null hypothesis that the mean of the treated group is equal to that of the control group for the matched pairs, meaning the models balance the covariates well. Also can be seen from figures A1a–A1c, the propensity score after matching is almost the same for the treated and control group, which verifies the validity of the covariates that we choose. Further evidence is found in that the standardized bias is substantially reduced after the matching. Based on the discussion of Caliendo and Kopeining (2008), a standardized bias below 5 per cent is enough to justify the balance.

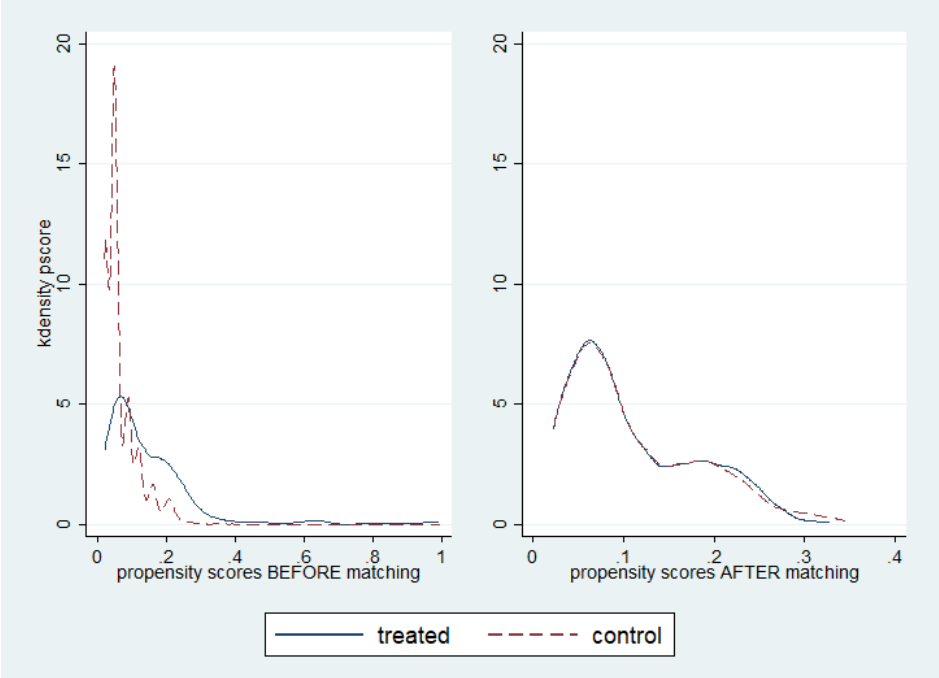

Figure A1a. Propensity score before and after matching (salary)

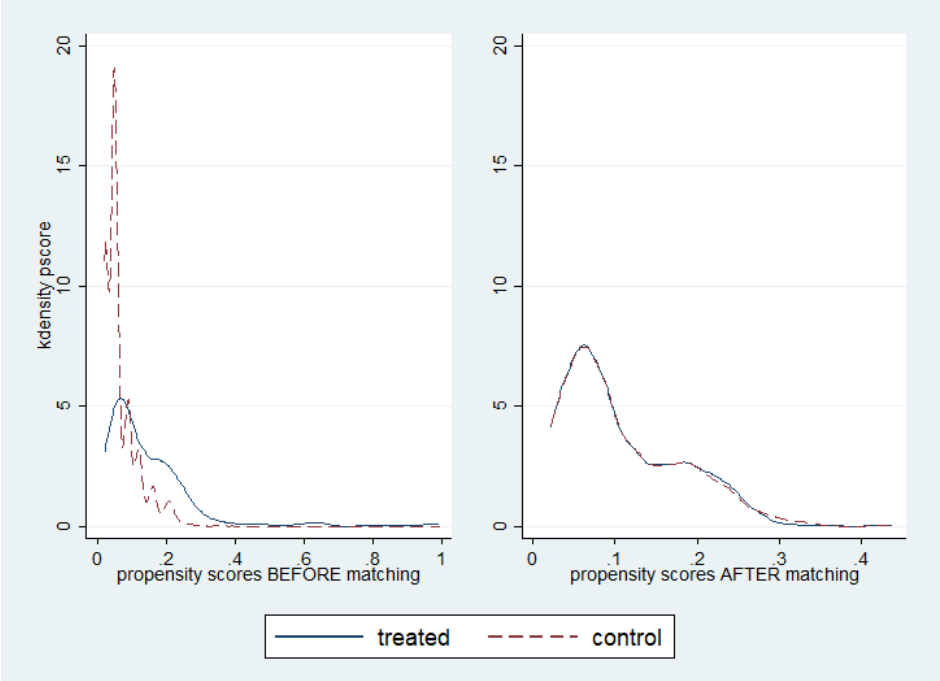

Figure A1b. Propensity score before and after matching (turnover)

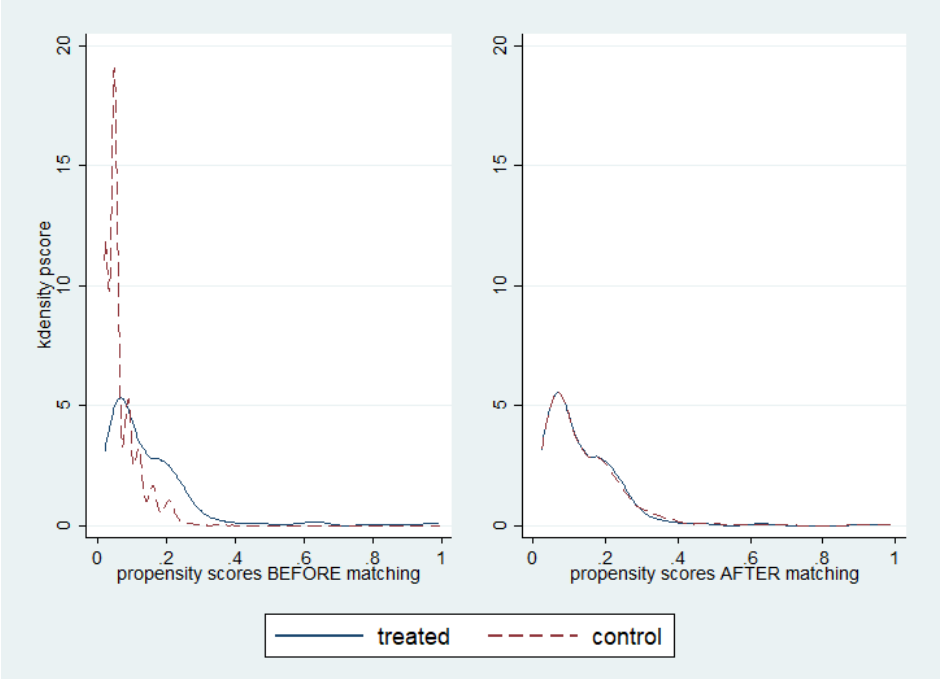

Figure A1c. Propensity score before and after matching (productivity)

Despite strong evidence that ISO14001 improves firms' competitiveness and raises their awareness of the need for environmental protection, the estimation might still suffer from bias owing to data limitations, as previously explained. More accurate results could be achieved if more detailed information on the background of ISO14001 adoption was available, for example, why firms in some industries or areas have a greater tendency to acquire ISO accreditation, especially in the context of Vietnam. Thus, there is room for future research on whether the impact of ISO adoption is temporary.

Other robustness checks

To ensure the robustness of our results, several issues need further clarification. Since ISO14001 accreditation is valid for three years, a firm might lose its accredited status during the study's 2007–2009 time frame. If they fail to renew their certificate, then our estimation results would be biased when we count these firms as ISO14001-adopters. In order to allay this concern, we limit the sample to those firms that did not change their ISO14001 status, or that acquired the ISO14001 certification during 2008–2009. Despite such changes, ISO14001 is still positive and significant in all specifications, which is consistent with our baseline estimation results. Besides, the TFP calculation using Levinsohn and Petrin's method is also used, which yields similar results in all cases. The results are excluded but are available upon request.

References

Caiendo M and Kopeining S (2008) Some practical guidance for the implementation of propensity score matching. *Journal of Economic Surveys* **22**(1), 31–72.

Rosenbaum PR and Rubin DB (1983) The central role of the propensity score in observational studies for causal effects. *Biometrika* **70**(1), 41–55.