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Do the manufacturing industries in Taiwan transfer their polluting production	via foreign
direct investment?	

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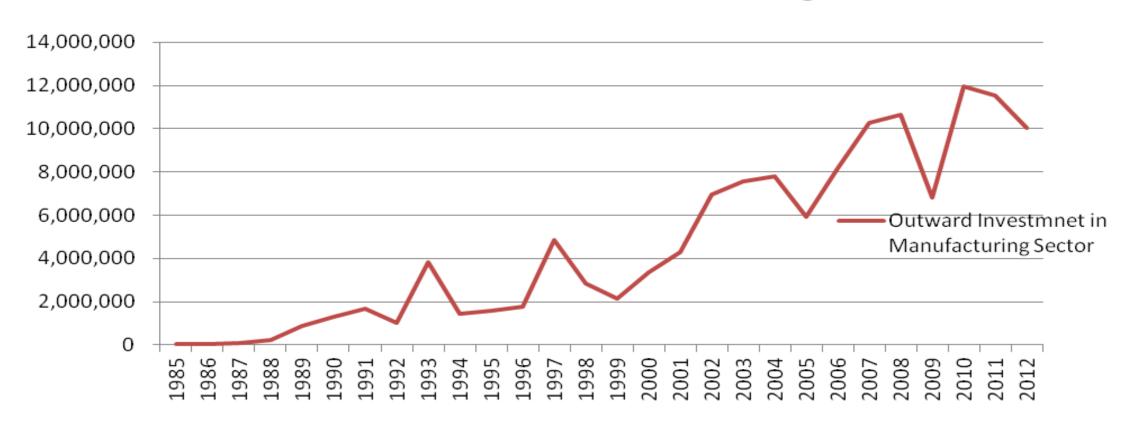
Do the manufacturing industries in Taiwan transfer their polluting production via foreign direct investment?

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Overview

- The relationships between economic growth, environmental pollution, and foreign direct investment (FDI) have a prominent place among the debates of the effects of globalization.
- According to statistics on approved outward investment by the Investment Commission in the Ministry of Economic Affairs (MOEA), Taiwan, the outward investment of Taiwanese manufacturing industries appears a significant surge in both cases and amounts since 1987.

Outward Investmnet in Manufacturing Sector



- The government initially enacted several environment statutes since the middle 1970s (e.g. Water Pollution Control Act and the Waste Disposal Act in 1974; Air Pollution Control Act in 1975; Noise Control Act in 1983).
- However, economic growth remained the primary national target for Taiwan in the 1980s (statutes had been revised slightly and the supervision did not sufficiently implement the environmental statutes).
- As both environmental regulations and their enforcement have been enhanced from the early-1990s.
- The main purpose of this study is to examine whether the stricter environmental stringency accounts for partial variations of the outward investments of Taiwanese manufacturing industries.

Data & Model

- Data Sources:
- Annual surveys on outward foreign direct investment and manufacturing operations conducted by the Ministry of Economic Affairs (MOEA), in Taiwan.
- World Bank, International Monetary Fund, and World Economic Forum.
- This study applies the firm-level data in manufacturing sectors from the year 2000 to 2003 of the period, including 1751 observations.
- Regression Model

$$FDI_{ikt} = \alpha_0 + \alpha_1 SIZE_{it} + \alpha_2 RD_{it} + \alpha_3 KL_{it} + \alpha_4 LABOR_{it} + \alpha_5 ENV_{it} + \alpha_6 PINDU_{it}$$

$$+ \alpha_7 PINDU_{it} ENV_{it} + \alpha_8 GDP_{kt} + \alpha_9 DWAGE_{kt} + \alpha_{10} LABOR_{it} DWAGE_{kt} + \alpha_{11} STRING_{kt} + \alpha_{12} ENV_{it} STRING_{kt} + \alpha_{13} PINDU_{it} ENV_{it} STRING_{kt} + \varepsilon_{itk}$$

Empirical Results

Unbalanced panel data analys control for the hetero			•	Variable Definition and Basic Statistics						
Indep. Variables	Model (1)	Model (2)	Model (3)	Variables	Definition	Means	S.D.	Min	Max	
SIZE (α_1)	0.3227*** (7.67)	0. 3217*** (7.61)	0.3241*** (8.13)	FDI	logarithm of foreign investment in fixed assets	200,431.6	122,746.3	0.3	3.80e+07	
RDS (α_2)	0.0209** (2.63)	0.0229** (3.17)	0.0225** (2.83)	SIZE	(1000NT\$) logarithm of sales (1000NT\$)	1,451,186	4,537,740	3770	1.05e+08	
$KL~(\alpha_3)$	0.2256*** (11.97) 0.2897***	0.2263*** (11.58) 0.2882**	0.2260*** (11.76) 0.2825**	RD	logarithm of R&D expenditure (1000NT\$)	38374.61	187921.1	0	4102630	
LABOR (α_4) ENV (α_5)	(3.49) 0.0275*** (5.00)	(3.27) 0.0690 (1.65)	(3.11) 0.0848 (0.86)	KL	logarithm of net value of fixed assets to total employment ratio	2,522.12	3,448.956	0	39,371.36	
$PINDU (\alpha_6)$	-0.3217* (-2.00) -0.0620**	-0.3054* (-1.86) -0.1967**	-0.2858 (-1.78) -0.4410**	LABOR	logarithm of number of employees	233.0809	424.0526	30	9,373	
$PINDU*ENV(\alpha_7)$ $GDP(\alpha_8)$	(-3.07) 0.0149 (0.37)	(-2.49) 0.0264 (0.59)	(-3.30) 0.0269 (0.46)	ENV	logarithm of environmental protection expenditure	2,526.918	16,240.83	0	358,427	
DWAGE (α_9) LABOR*DWAGE (α_{10})	0.4132 (1.14) 0.0331 (0.60)	0.0401 (0.11) 0.0394 (0.77)	0.0924 (0.19) 0.0413 (0.75)	PINDU	(1000NT\$) =1 if firm in Taiwan belongs to polluting industries; =0, otherwise.	0.1646	0.3709	0	1	
$CO2~(STRING)~(\alpha_{11})$	0.0278 (1.32)	(0.77)	(0.70)	GDP	logarithm of host country's GDP (USD)	1.98e+12	2.63e+12	3.12e+10	1.10e+13	
ENV*CO2 (α_{12}) PINDU*ENV*CO2 (α_{13})	-0.0027** (-2.78) 0.0096***			DWAGE	wage differential between Taiwan and host country	0.8537	0.8536	-2.0889	2.7073	
$CPI(STRING)$ (α_{11})	(13.50)	-0.4164		(1000 USD / per month) Indexes for overall environmental stringency of host country (STRING):						
ENV*CPI (α_{12})		(-1.18) -0.0397 (-1.19)		CPI	logarithm of corruption perceptions index (index for	4.0559	1.5761	1.9	9.4	
$PINDU*ENV*CPI~(\alpha_{13})$		0.1298* (2.05)			host country's corruption					
GDPperca (STRING) (α_{11})			-0.1014 (-0.53) -0.0083	CO2	the emission of carbon dioxide in the host country	4.1308	5.3219	0.74	20.66	
ENV*GDPperca (α_{12})			(-0.66) 0.0496**	-	(tons / per capita)					
$PINDU*ENV*GDP$ perca (α_{13})	1751		(2.91)		logarithm of GDP per capita based on purchasing	8219.456	11940.32	2623.038	40618.68	
Number of Observations R-squared	1751 0.2339	0.2489	0. 2338	GDPperca	power parity (in constant 2005 international dollars)					

Note: *, **, *** indicate significance at the 10%, 5%, and 1%.

Dependant variable: logarithm of foreign investment in fixed assets

Values in parentheses are t-values

All the models adjust the errors for the correlation within host country

Note: The statistics of firm's characteristics are based on the 1751 observations applied in our models and before they are taken logarithm. The statistics of host country's characteristics are based on the 11 countries' data during the covered years and before taken logarithm.

- Larger size of a firm in Taiwan significantly and positively correlates to the higher FDI, which support the conceptual framework of the proximity-concentration trade-off between multinational sales and trade.
- Higher R&D expenditure correspond to higher FDI, which supports the view point of intangible asset theory.
- The positive coefficients of *KL* and *LABOR* are consistent with the conclusions made by previous studies that the increasing outward FDI of Taiwanese manufacturing sector was induced by increasing production costs.
- Positive direct effect (alpha 5) and negative value of indirect effect (alpha 12) suggest that non-polluting firm's FDI behavior consists with the statement of pollution haven hypothesis.
- On the contrary, polluting firms (PINDU=1) have a negative direct effect (alpha5 + alpha7) and a positive indirect effect (alpha12+ alpha13), which does not consist with the statement of pollution haven hypothesis.
- The potential explanation for the controdition to Pollution Haven Hypothesis is that the pollution haven effect is stronger in the early stage and diminishes over time while stricter environmental regulations are implemented.
- The data we apply covers the period of the early 2000s while both environmental regulations and their enforcement had been enhanced since the early-1990s. That implies the polluting firms, which could not stand for the stricter environmental regulations, may have left the market in the early stage.
- This result may fit one possible version of Porter's hypothesis that environmental regulation may have a positive effect on the international competitiveness of domestic firms.

Multinomial Logit Aanalysis

- To avoid the misspecification induced by measurement error of environmental stringency and the aggregate variables of host country, we adopt Multinomial Logit (MNL) model as a check of assertion concluded from the unbalanced panel data analyses.
- Given firm's direct investment in China is the baseline, the log-odds ratio indicates the relative probability of firms' investing in country *j*.

$$\ln\left[\frac{P_{ij}}{P_{i0}}\right] = X_i'(\beta_j - \beta_0) = X_i'\beta_j$$

Result

	j=1(United States)		j=2 (Hong Kong)		j=3 (J	(apan	j=4 (Malaysia)	
SIZE	0.4576***	0.4399***	0.2223***	0.2248***	0.0166	0.0531***	-0.0182**	-0.0556***
	(8.66)	(8.11)	(10.25)	(9.78)	(1.10)	(6.5)	(-2.02)	(-3.27)
RDS	0.1521***	0.1527***	0.1294***	0.1295***	0.1530***	0.1535***	0.0256***	0.0259***
	(18.10)	(17.16)	(22.68)	(22.93)	(16.42)	(19.23)	(17.77)	(16.07)
KL	0.1124***	0.0997***	-0.0509***	-0.0487***	-0.0654***	-0.0427*	0.2414***	0.2185***
	(6.44)	(6.68)	(-4.88)	(-4.82)	(-2.96)	(-1.8)	(13.51)	(11.94)
LABOR	-0.3778***	-0.3432***	-0.4269***	-0.4329***	-0.0594**	-0.1399***	-0.1167***	-0.0484**
	(-6.46)	(-5.15)	(-15.57)	(-14.47)	(-2.43)	(-5.24)	(-6.90)	(-2.43)
ENV	-0.0735***	-0.0869***	0.0360***	0.0378***	0.0823***	0.1027***	0.0071***	-0.0183**
	(-10.03)	(-19.55)	(11.51)	(12.99)	(13.68)	(17.97)	(2.67)	(-7.42)
$PINDU^*$		0.0407***		-0.0040		-0.0769***		0.0690***
ENV		(3.84)		(-0.81)		(-17.81)		(57.69)
Constant	-7.8332***	-7.6706***	-4.2392***	-4.2612***	-6.0097***	-6.2859	-4.1152***	-3.7757**
	(-4.43)	(-4.33)	(-2.63)	(-2.63)	(-4.43)	(-4.55)	(-2.57)	(-2.41)
	j=5 (Singapore)		j=6 (Thailand)		j=7(Indonesia)		j=8 (Philippines)	
SIZE	-0.2858***	-0.2469***	-0.0801***	-0.0617***	0.1010***	-0.0887**	0.1702***	0.2556***
	(-16.76)	(-16.73)	(-4.98)	(-3.36)	(12.07)	(-2.27)	(12.98)	(11.8)
RDS	-0.0218***	-0.0222***	-0.0490***	-0.0491***	-0.0563***	-0.0532***	-0.1367***	-0.1408**
	(-6.53)	(-5.31)	(-20.16)	(-18.82)	(-13.96)	(-12.10)	(-21.51)	(-20.3)
KL	0.8052***	0.8326***	0.1400***	0.1486***	0.1542***	0.0764**	0.1945***	0.2367***
	(18.25)	(17.63)	(7.60)	(9.38)	(5.39)	(2.10)	(6.21)	(7.82)
LABOR	0.6204***	0.5523***	-0.1220***	-0.1527***	-0.6563***	-0.3889***	-0.0008	-0.1301**
	(22.88)	(20.87)	(-6.94)	(-6.94)	(-14.32)	(-5.13)	(-0.03)	(-5.15)
ENV	-0.2603***	-0.2130***	0.0888***	0.0979***	0.0688***	-0.0768***	0.1366***	0.1683***
	(-93.78)	(-62.59)	(23.25)	(44.2)	(6.17)	(-7.57)	(19.68)	(28.95)
	-	-3.3805***		-0.0293***		0.2754***		-0.0974**
$PINDU^*$		(0 63)		(-6.54)		(58.8)		(-11.99)
		(-8.62)				· · · · · · · · · · · · · · · · · · ·		
PINDU* ENV Constant	-8.8336***	(-8.62) -9.21***	-2.6436*	-2.8059*	-2.4850	-0.6872	-7.2572***	-8.0798**

Note: *, **, *** indicate significance at the 10%, 5%, and 1%.

Dependant variable: logarithm of foreign investment in fixed assets Values in parentheses are z-values

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All the models include time fixed effect and adjust the errors for the correlation within host country

• Summary: (1) polluting firms' behaviors are counter-PHH in four (i.e. Hong Kong, Japan, Malaysia, and Thailand) countries. (2) non-polluting firms are more like the pollution haven seekers than polluting firms in two (i.e. United States and Philippines) of the four countries where polluting firms' behavior support PHH.

Conclusion

- (1) Polluting firms undergoing more environmental protection expenditure tend to invest more in countries with stricter environmental regulations.
- (2) Non- polluting firms are more likely to be pollution haven seekers than polluting firms are.
- (3) The results imply environmental protection expenditure may induce a counter effect against pollution haven effect (PHE) to manufacturing firms. For firms with higher levels of environmental protection expenditure (e.g. polluting firms), PHE is smaller than the counter effect such that the phenomenon against PHH occurs.
- (4) The findings in our study also provide one possible version of Porter's hypothesis. The activities of pollution abatement required to meet the standards of environmental regulations may enable manufacturing firms with more knowledge and capability to comply with stricter environmental regulations in other countries.