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Are foreign investors attracted to weak environmental regulations? Evaluating the evidence from China[☆]

Judith M. Dean[a,*,1], Mary E. Lovely[b], Hua Wang[c]

[a] U.S. International Trade Commission, United States
[b] Department of Economics, Syracuse University, United States
[c] Development Research Group, The World Bank, United States

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ABSTRACT

At the center of the pollution haven debate is the claim that foreign investors from industrial countries are attracted to weak environment regulations in developing countries. Some recent location choice studies have found evidence of this attraction, but only for inward FDI in industrial countries. The few studies of inward FDI in developing countries have been hampered by weak measures of environmental stringency and by insufficient data to estimate variation in firm response by pollution intensity. This paper tests for pollution haven behavior by estimating the determinants of location choice for equity joint ventures (EJVs) in China. Beginning with a theoretical framework of firm production and abatement decisions, we derive and estimate a location choice model using data on a sample of EJV projects, Chinese effective levies on water pollution, and Chinese industrial pollution intensity. Results show EJVs in highly-polluting industries funded through Hong Kong, Macao, and Taiwan are attracted by weak environmental standards. In contrast, EJVs funded from non-ethnically Chinese sources are not significantly attracted by weak standards, regardless of the pollution intensity of the industry. These findings are consistent with pollution haven behavior, but not by investors from high income countries and only in industries that are highly polluting. Further investigation into differences in technology between industrial and developing country investors might shed new light on this debate.

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1. Introduction

> "While studies based on U.S. data provide us with some of the most convincing evidence for a regulatory impact on economic activity – i.e. a pollution haven effect – convincing evidence for or against the pollution haven hypothesis must employ international data" M. Scott Taylor (2004).

One of the most contentious issues debated today is whether inter-country differences in environmental regulations are turning poor countries into "pollution havens." The main argument is that stringent environmental standards in industrial countries lead to the relocation of dirty goods production away from high income countries toward developing countries, where standards are relatively weak.[2] A convincing test of the pollution-haven hypothesis (PHH) would surely examine foreign direct investment (FDI) outflows from industrial countries to all host countries. In lieu of such a formidable endeavor, researchers have searched for evidence of what Taylor (2004) calls a "pollution haven effect," the deterrence of exports or capital inflows by tighter environmental regulation. Existence of a pollution haven effect is necessary, but not sufficient, for the PHH to hold. While higher environmental costs must affect trade and investment flows for pollution havens to appear, these cost effects may be outweighed by other factors determining international flows.

Early empirical studies do find FDI in pollution-intensive industries, but find little evidence that it had been influenced by relative environmental standards or had flowed relatively faster into

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* Corresponding author. Tel.: +1 202 205 3051.
E-mail addresses: Judith.Dean@usitc.gov (J.M. Dean), melovely@maxwell.syr.edu (M.E. Lovely), hwang1@worldbank.org (H. Wang).

[1] The views in this paper are those of the authors. They do not necessarily represent the views of the U.S. International Trade Commission or any of its individual Commissioners.

[2] A corollary is that developing countries may purposely undervalue environmental damage to attract more FDI. While these views assume that relatively weaker environmentalstandards in developing countries are inappropriate, such standards may reflectoptimal policy responses to differences in marginal costs and benefits (Dean, 2001).

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developing countries.[3] More recently, Eskeland and Harrison (2003) examine the pattern of industrial country FDI across industries within Mexico, Venezuela, Morocco, and Cote d'Ivoire, but find little evidence to support PHH. Javorcik and Wei (2004) analyze the investment choices of multinational firms locating across Eastern Europe and the former Soviet Union. Although they find some evidence that FDI is deterred by tight standards, their results are not robust to alternative proxies for environmental stringency. In contrast, studies focusing on the location of investment in the United States find evidence consistent with the PHH. Keller and Levinson (2002), List and Co (2000), and List et al. (2004) all find that regulatory costs deter investment in relatively stringent U.S. states. These U.S. studies argue that lack of evidence for PHH in earlier studies may be due to a failure to account for endogeneity and measurement error.

This paper tests for evidence of pollution haven behavior by foreign investors in China, incorporating the methodological insights of these recent studies. Building upon Copeland and Taylor's (2003) firm production and abatement model, we derive a model of FDI location choice in the presence of inter-provincial differences in environmental stringency, amended to include agglomeration and factor abundance. We assemble a new dataset of 2886 manufacturing equity joint venture (EJV) projects in China,[4] across 28 3-digit ISIC industries during 1993–1996, and estimate this model using conditional and nested logit. These data permit us to examine differences in investors' responses based on source and pollution intensity.[5] We use data on actual collected water pollution levies to construct a measure of provincial environmental stringency, drawing on annual Chinese environmental and economic censuses. This detailed information on the levy system allows us to address endogeneity concerns directly.

Turning the spotlight on investment flows into a low-standard, developing country is essential. The U.S. is a high standard, industrial country and it receives the vast majority of its capital inflows from other industrial countries. Thus, the behavior observed in the U.S. may not characterize FDI flows into developing countries, the focus of concern in the pollution haven debate (Blonigen and Wang, 2005). China provides an advantageous site for such an investigation. Significant Chinese trade and investment liberalization in 1992 spurred vast FDI inflows from many source countries (Broadman and Sun, 1997; Shuguang et al., 1998) and made China the single largest recipient of FDI flows to the developing world in 1995 (UNCTAD, 1996). China's national price-based, well-developed water pollution control system makes it unique among developing countries with severe pollution problems.[6] The enormity and scope of FDI flows to China reduce the likelihood that environmental costs are the driving force behind them. However, environmental stringency varies dramatically across Chinese provinces. Thus, if reductions in compliance costs matter to investors, PH behavior will be evident in their location choice across China.

Our analysis addresses three important issues raised in the recent literature. First, the impact of regulatory costs varies across industries by pollution intensity (Copeland and Taylor, 1994; Taylor, 2004). Attempts to find such differential effects have been hampered by lack of detail on investment flows or by small sample sizes. Our large sample of projects and our disaggregated Chinese industrial emissions intensity data allow us to test for differences in firm response by pollution intensity.[7] Second, poor proxies for environmental stringency can lead to measurement error and endogeneity bias (Keller and Levinson, 2002). Lack of data on environmental policy in developing or transition economies has led researchers to use either indirect measures of stringency (e.g., signing an international environmental treaty) or outcome measures (e.g. pollution abatement costs). Using Chinese collected pollution levies and official water pollution-tax formula, we are able to measure provincial environmental stringency and control for endogeneity arising from industrial concentration.[8] Third, omission of corruption and other location-specific attributes can lead to a spurious relationship between FDI and environmental stringency (Javorcik and Wei, 2004; Fredriksson et al., 2003; Keller and Levinson, 2002). Careful modeling of firm production and abatement decisions, inclusion of location fixed effects, and corrections for the effects of state ownership allow us to reduce the possibility of omitted variable bias.[9]

Results suggest important links between the investor's source country, the pollution intensity of the industry, and PH behavior. For the sample of projects from non-ethnically Chinese (non-ECE) source countries, we find no significant evidence of pollution haven behavior, regardless of the pollution intensity of the industry. However, projects in highly polluting industries from ethnically Chinese (ECE) sources are significantly deterred by pollution taxes. These findings provide evidence of PH behavior by foreign investors in China, but not by investors from high income countries and only in industries that are highly polluting. The results also point to a new direction for inquiry in the PHH debate: investigating whether differences in technology between industrial and developing country investors might be a critical factor in explaining PH behavior.

2. FDI and environmental stringency in China

The distribution of foreign investment within China is highly uneven, as it is in most host countries.[10] Henley et al. (1999) report that 80% of cumulative FDI inflows is located in one of China's ten eastern provinces. This distribution clearly reflects the influence of special incentive programs[11] and the policy of gradual opening pursued before new guidelines were issued in 1992.[12] However, as Huang (2003) notes, in comparison to other countries at similar stages of development, FDI inflows to China are remarkable for their wide distribution among industries and provinces.[13]

The pattern of clustering of investors from different source countries is distinctive.[14] According to Henley et al. (1999), between 1985 and 1996, 66.4% of FDI into China came from ECE sources: Hong Kong, Macao, and Taiwan. While dispersed throughout China, FDI from these sources, especially from Hong Kong, concentrated in the southern coastal provinces.[15] Much of this investment involved labor-intensive processing of

[3] See surveys of the literature by Dean (1992, 2001) and Copeland and Taylor (2004).

[4] In their investigation of FDI inflows to China, Amiti and Javorcik (2008) use more recent data that provide information on the number of foreign firms by province and by industry. These data are not publicly available.

[5] The current study is a revised version of Dean et al. (2005).

[6] In 2006, China's freshwater lakes and 40% its 7 major rivers were heavily polluted (SEPA, 2007).

[7] Adapting the framework in Dean et al. (2002a,b, 2004, 2005), Di (2007) provides some firm level evidence of a PH effect for investors in dirty industries. Unlike Dean et al., Di covers only 4 industries, uses US abatement costs to proxy pollution intensity, and does not test for differential responses by source country.

[8] Di uses only a single year of levy data, and, ignoring the official pollution tax formula, incorporates it incorrectly.

[9] Di acknowledges omitted variable problems, but does not introduce appropriate corrections.

[10] For evidence of FDI clustering, see Ondrich and Wasylenko (1993) and Head and Mayer (2004).

[11] China began accepting FDI in 1979, and established 4 SEZs in 2 provinces in 1980. Although 14 coastal cities received FDI incentives in 1984, by 1986 most of these were available anywhere in China to foreign enterprises that produced for export or brought advanced technology (Head and Ries, 1996).

[12] See Tseng and Zebregs (2002). In 1992 China removed a number of sectoral and regional FDI restrictions and decentralized approval (Lardy, 1994). New 1995 rules "encouraged" investment using new technology or equipment for pollution control, and "prohibited" highly polluting processes (Henley et al., 1999).

[13] In the 1995 Industrial Census, no industry received more than 10% of total FDI. While interior regions received only 13% of cumulative FDI from 1992 to 1998, that exceeded all FDI inflows to India during the same period.

[14] In Chinese official publications ECE (non-ECE) FDI is designated as "Chinese" ("Foreign") FDI.

[15] ECE investors may also have family or business interests which influence their location choice.

imported inputs for re-export. The remaining 33.6% of FDI came from non-ECE sources: mainly OECD countries, with the largest shares from the US (8%) from Japan (8%). Much of this investment was by transnational corporations to produce goods for the Chinese market.

We compiled data for a sample of EJV investments undertaken during 1993–1996 using project descriptions available from the Chinese Ministry of Foreign Trade and Economic Cooperation (various years).[16] The full sample includes 3854 projects, or 3.4% of the total EJV projects entered into during this period, valued at $2.4 billion, or roughly 1% of the value of all EJV inflows into China in the period. While complete data showing FDI by province, type and year are not available, we were able to obtain the provincial distribution of total EJV projects for 1993–95.[17] The simple correlation between the provincial distributions of sample EJV projects and total EJV projects (summed over 1993–95) is 0.90, suggesting that our sample is fairly representative of the overall distribution of EJVs across provinces.

Table 1 and Fig. 1 show the distribution of the 2886 manufacturing EJVs in the sample across provinces, by source and by 2-digit ISIC industrial sector, respectively. Provinces are grouped into five regions: coastal, northeast, central, southwest, and northwest.[18] While the patterns of investment differ, Table 1 shows that both ECE and non-ECE partners engage in EJVs in all provinces. Investment in the southern coastal region is predominantly ECE, while investment in the northern coastal region is split more equally between sources. Fig. 1 suggests that industrial concentration is generally low, with most provinces receiving investment in a wide range of sectors. The most pronounced specialization occurs in the northwest region, where natural-resource based activities dominate.

Fig. 2 shows the distribution of sample EJVs across ISIC 3-digit industries by source and pollution intensity. Since about two-thirds of total FDI in this time period is of ECE origin, it is not surprising that ECE FDI accounts for about 60–70% of the FDI in most sectors. However, the pattern of investment across industries is very similar for ECE and non-ECE FDI, with only a few sectors where one source is dominant.[19] The average water pollution intensity of Chinese industries is measured as chemical oxygen demand (COD) emissions (kg) per 1000 yuan real output.[20] COD emissions are highly correlated with other water pollutants and account for the majority of Chinese pollution tax revenues (Wang and Wheeler, 2005). Most ECE and non-ECE projects are concentrated in the least polluting industries. While a higher share of non-ECE EJVs are in industries with very low and very high pollution intensity, the simple correlation between the distributions is 0.90.[21]

The water pollution levy system is the most fully developed mechanism in the Chinese pollution control regime.[22] The discharge levy faced by a polluter depends on the pollutant, volume of emissions, and concentration. Because concentration standards are set jointly at the national and provincial level, they vary across provinces and, hence, may influence location choice. If the pollutant concentration of a firm's wastewater exceeds the local concentration standard, a levy is applied.[23] The tax rate for each pollutant is set at the national level and does not vary by industry. For each plant, a potential levy is calculated for each pollutant, and the actual levy imposed is the greatest of these potential levies.

Dasgupta et al. (1997) conclude from plant-level data that these fines are typically consistent with the form dictated by regulatory statutes. Thus, we combine the regulatory formula and data on total collected levies and wastewater to create a measure of *de facto* provincial stringency—the average collected levy per ton of wastewater.[24] Conditional on the emissions intensity of provincial output, this measure is a function only of the stringency of provincial *de facto* regulation. Provinces that commonly reduce the levy below its *de jure* level will receive fewer tax revenues, and, all else equal, will have lower measured stringency. Table 2 shows period average data on collected levies, wastewater effluent intensity, and the share of wastewater meeting the provincial standard for each province.

Table 1
Equity joint venture sample, by province, 1993–1996.

Province	Number of projects	Projects from ECE sources (%)	Average Utilized FDI * ($10,000)	Average Utilized FDI* (%)
Coastal				
Beijing	248	50.4	55,358.7	8.1
Fujian	95	91.6	30,247.2	4.4
Guangdong	325	77.8	91,830.7	13.4
Hainan	19	68.4	6495.6	1.0
Hebei	99	52.5	22,430.3	3.3
Jiangsu	565	55.6	16,2205.0	23.7
Shandong	400	57.3	73,166.0	10.7
Shanghai	114	47.4	44,075.3	6.4
Tianjin	68	25.0	25,944.6	3.8
Zhejiang	176	61.9	34,860.3	5.1
Northeast				
Heilongjiang	62	61.3	8339.0	1.2
Jilin	76	55.3	9593.8	1.4
Liaoning	166	38.0	37,875.8	5.5
Inland				
Anhui	34	55.9	5200.6	0.8
Henan	85	76.5	8357.3	1.2
Hubei	41	41.5	7461.8	1.1
Hunan	110	72.7	26,248.5	3.8
Jiangxi	76	85.5	8284.1	1.2
Shanxi	8	25.0	1822.4	0.3
Southwest				
Guangxi	36	72.2	9858.3	1.4
Guizhou	6	50.0	437.0	0.1
Sichuan	21	57.1	5301.9	0.8
Yunnan	8	62.5	1064.1	0.2
Northwest				
Gansu	0		0	0.0
Inner Mongolia	11	72.7	1812.0	0.3
Ningxia	3	66.7	365.7	0.1
Qinghai	2	50.0	150.5	0.0
Shaanxi	27	37.0	5734.8	0.8
Tibet	0		0	0.0
Xinjiang	5	40.0	526.3	0.1
Total	2886	100	685,047.0	100

*Period averages. Values are in $10,000 (1990). Source: Ministry of Foreign Trade and Economic Cooperation (various years), and author calculations. See text discussion and Appendix A for more details.

[16] EJVs are LLCs incorporated in China, in which foreign investors hold equity. See Fung (1997).
[17] The number of total EJV projects (approved contracts), by province and year, were taken from the provincial reports in the Local Economic Relations and Trade chapter of the *Almanac*.
[18] These regional groups are similar to Demurger et al. (2002), with their coastal and metro groups combined.
[19] The tobacco industry is monopolized by the Chinese government and heavily regulated.
[20] COD measures the oxygen consumed by chemical breakdown of organic and inorganic matter in water. A comparison of 1995 COD intensities for China (Dean and Lovely, 2008) and 1987 biological oxygen demand intensities (BOD) for the US (Hettige et al., 1995) shows a high correlation. In both countries paper is the most water-polluting, with food/beverages a distant second, followed by chemicals, non-ferrous metals and leather. The remaining industries have relatively low water-pollution intensities.
[21] Chinese data for ISIC 33 (wood products and furniture) are missing. About 3.9% (2.4%) of the ECE (non-ECE) EJVs are in this sector. Since estimates for the US are relatively low (Hettige et al. (1995), we classify these EJVs in the low-polluting group.
[22] Chinese air pollution regulation was not as well developed in the mid-1990s and disaggregated air levies were not available for analysis. However, U.S. and Chinese industries show similar rankings for air pollution intensity.
[23] In 1993, a fee on all wastewater was imposed by the national government.
[24] We thank David Wheeler and the World Bank staff for access to these data.

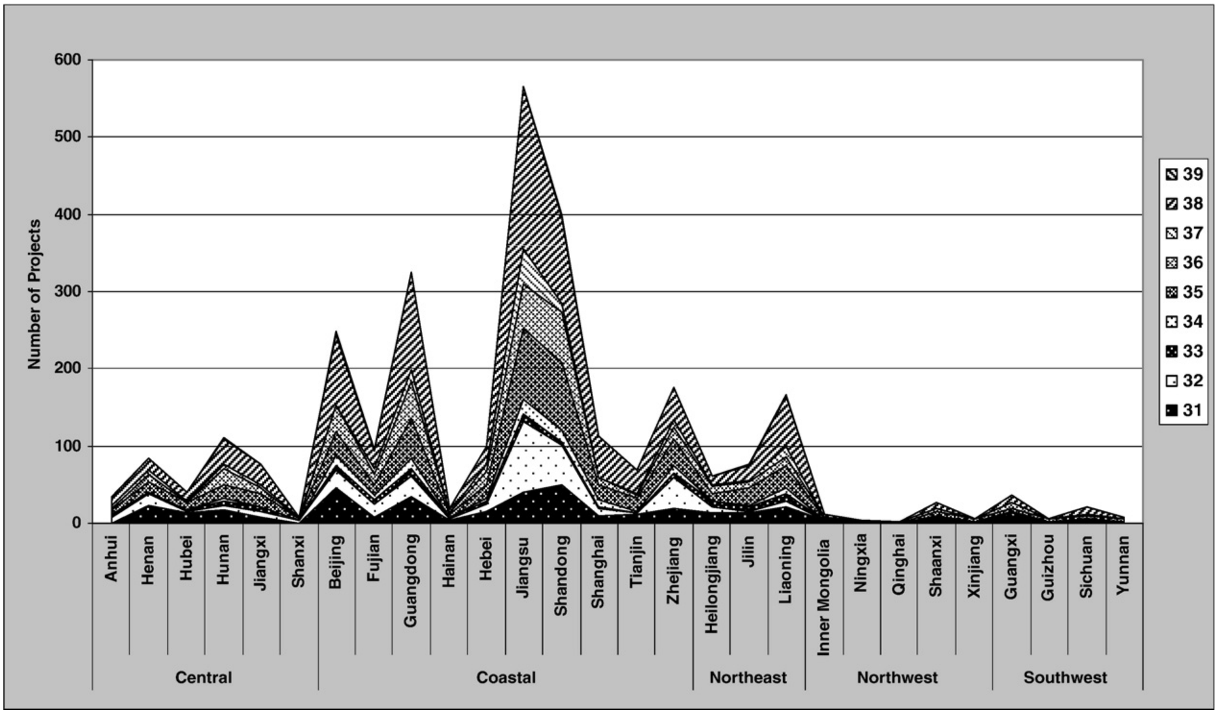

Fig. 1. Distribution of EJV sample by province and industry, 1993–1996.

Evidence from previous studies suggests that FDI in China has concentrated in higher income provinces (*e.g.* Cheng and Kwan, 2000) and that these provinces have *more* stringent environmental regulation (Dean, 2002; Wang and Wheeler, 2003). The maps in Fig. 3 show the average water pollution levy and the share of sample EJVs across provinces. In 1993 and 1996, the sample EJVs clustered on the coast, with a few inland and almost none in the west. In 1993, there was wide variation in the levies, with the highest rates along the coast. By 1996 much of the map had darkened, indicating an increase in the levies across most parts of the country. These maps suggest a positive unconditional

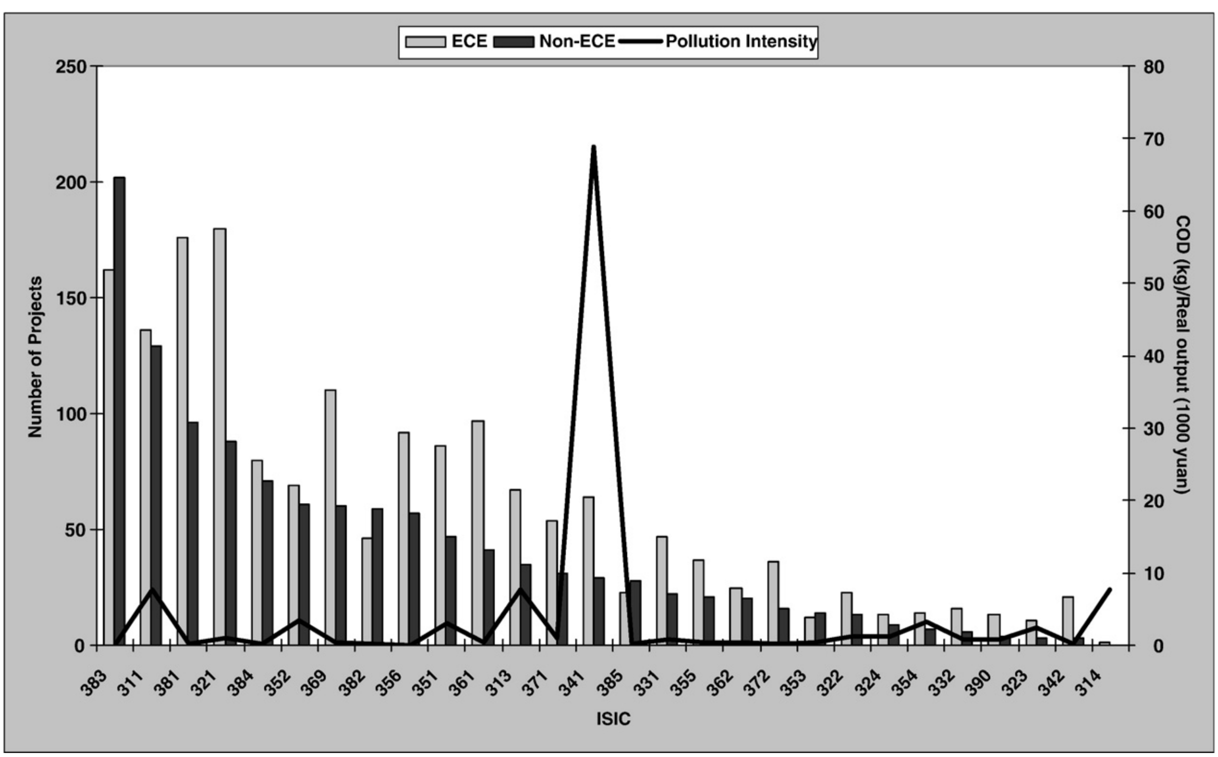

Fig. 2. Distribution of EJV sample by industry, source and pollution intensity 1993–1996.

Table 2
Provincial characteristics: period averages (1993–1996).

Province	Cons. p.c. (yuan)	Water levy (yuan/ton wastewater)	Effluent intensity (COD/000 tons wastewater)	Share of wastewater meeting standard	Domestic entrepr. (000s)	Cum. real FDI ($ billion)	Skilled labor (%)	Unskilled labor (%)	Highways (km/km^2 area)	Inland waterway (km/km^2 area)	Telephones per 000 people	SEZ or OCC	Indus. output from SOE (%)
Coastal													
Beijing	2972	0.09	0.20	0.66	9.4	1986.7	33	14	0.72	0.000	129.02	1	51
Fujian	2522	0.08	0.33	0.42	14.3	4347.0	8	28	0.37	0.031	37.76	1	23
Guangdong	3104	0.11	0.25	0.55	29.2	13862.7	12	22	0.42	0.059	68.98	1	25
Hainan	1928	0.09	0.59	0.45	1.5	1297.1	12	25	0.40	0.009	32.21	1	53
Hebei	1458	0.05	0.29	0.69	22.7	543.2	9	22	0.27	0.000	20.62	1	38
Jiangsu	2197	0.06	0.20	0.68	40.5	4069.9	13	21	0.25	0.233	39.49	1	23
Shandong	1662	0.10	0.94	0.48	26.5	2814.5	10	24	0.33	0.012	20.36	1	30
Shanghai	5869	0.06	0.12	0.77	11.9	3422.1	30	14	0.57	0.317	125.54	1	46
Tianjin	3018	0.12	0.36	0.70	9.1	1002.4	23	16	0.34	0.007	79.39	1	41
Zhejiang	2478	0.10	0.26	0.70	36.5	1198.8	9	22	0.34	0.106	47.78	1	19
Northeast													
Heilongjiang	2394	0.06	0.32	0.53	18.9	419.5	15	18	0.10	0.000	31.87	0	72
Jilin	2027	0.06	0.58	0.53	13.2	321.4	18	17	0.15	0.006	37.09	0	65
Liaoning	2573	0.08	0.24	0.67	29.0	2004.3	14	16	0.29	0.004	41.71	1	49
Inland													
Anhui	1426	0.08	0.36	0.49	24.1	338.4	7	30	0.24	0.040	14.05	0	41
Henan	1183	0.06	0.52	0.48	23.6	431.8	9	24	0.29	0.007	11.53	0	40
Hubei	1745	0.04	0.22	0.60	23.4	674.8	11	25	0.26	0.042	19.97	0	49
Hunan	1587	0.05	0.21	0.57	25.6	460.8	9	21	0.27	0.047	16.39	0	48
Jiangxi	1338	0.04	0.23	0.49	18.4	283.5	8	26	0.20	0.029	12.96	0	50
Shanxi	1430	0.06	0.23	0.49	11.5	103.7	12	20	0.21	0.001	18.61	0	49
Southwest													
Guangxi	1452	0.07	0.62	0.45	12.9	910.0	8	22	0.17	0.019	11.94	1	50
Guizhou	1070	0.03	0.21	0.41	7.7	88.1	6	35	0.18	0.010	6.71	0	71
Sichuan	1408	0.04	0.23	0.46	41.3	735.8	7	25	0.18	0.014	10.75	0	44
Yunnan	1379	0.09	0.51	0.31	7.9	109.0	5	35	0.18	0.004	9.14	0	73
Northwest													
Gansu	1118	0.05	0.13	0.47	7.2	44.3	10	40	0.08	0.013	15.41	0	72
Inner Mongolia	1511	0.05	0.97	0.40	9.9	77.5	13	23	0.04	0.001	22.76	0	68
Ningxia	1430	0.04	0.43	0.44	1.8	10.7	11	35	0.16	0.008	23.13	0	74
Qinghai	1539	0.02	0.08	0.51	1.6	4.8	11	44	0.02	0.000	18.11	0	83
Shaanxi	1274	0.07	0.19	0.65	13.3	480.2	12	26	0.19	0.005	16.36	0	61
Tibet	1127	na	na	na	0.3	2.0	3	70	0.02	0.000	9.94	0	80
Xinjiang	1852	0.12	0.74	0.37	6.9	66.4	14	25	0.02	0.000	22.16	0	71

Source: Environmental data from a World Bank dataset, compiled from *Chinese Environmental Yearbook*, various years. Other provincial data from *China Statistical Yearbook*, various years, and calculations by authors. See Appendix A for more details. Cumulative real FDI (1980 dollars) from Coughlin and Segev (2000).

relationship between the average provincial levies and the share of EJV projects locating in a province. They also suggest that any empirical analysis must account for regional clustering.

3. Modeling foreign investor behavior

Given the global surge in FDI into China following its 1992 trade and foreign investment liberalization, we take the decision to invest in China as exogenous. We consider a multinational firm that wants to invest one unit of capital somewhere in China. The firm's objective is to choose the host province that yields the highest profit. Profit depends, among other factors, on the cost of emissions. A provincial pollution policy is defined as the schedule of fines the firm faces for wastewater disposal, given its emissions intensity. Since Chinese provincial fine schedules exempt below-threshold emissions intensity, the cost of emissions to the firm depends on the firm's emissions intensity choice. We treat foreign firms as price takers with respect to provincial pollution policy at the time of their location decision. The firm can obtain information on the fine schedule, as well as the average rate that has been levied by inspectors in each province. This information is incorporated directly into our approach.

3.1. Production, emissions, and profits

We consider a firm that jointly produces two outputs, good X and polluted wastewater emissions Z, using variable inputs of unskilled labor, L, skilled labor, H, and a vector of intermediate (locally-provided) services, s. The capital input is embodied in the original investment and is fixed in the short run. We assume that the firm can abate the concentration of pollutants in its wastewater, so emission intensity is a choice for the firm. Accordingly, the firm can allocate an endogenous fraction, θ, of its inputs to abatement activity. This implies that abatement and production use factors in the same proportion. If $\theta = 0$, there is no abatement and, by choice of units, each unit of output generates one unit of pollution. The joint production technology for firm i operating in industry j is:

$$X_{ij} = \left(1-\theta_{ij}\right)G^j\left(L_{ij}, H_{ij}, I_{ij}(s)\right), Z_{ij} = \varphi^{ij}\left(\theta_{ij}\right)G^j\left(L_{ij}, H_{ij}, I_{ij}(s)\right). \quad (1)$$

The function $I(s)$ aggregates local service varieties into an intermediate input for the foreign firm. We assume that G is increasing and concave, and $0 \le \theta \le 1$, $\phi(0) = 1, \phi(1) = 0$.

To derive an estimating equation, we follow Copeland and Taylor (2003) and assume that the relation between abatement activity and emissions takes a constant elasticity form, $\phi^{ij}(\theta) = (1-\theta)^{1/\alpha_{ij}}$, where $0 \le \alpha_{ij} \le 1$. This function captures the efficiency with which the firm's abatement inputs reduce emissions; the larger α_{ij} is, the less efficient is the firm in abating pollution. Abatement efficiency may vary across industries because industrial production processes differ, with some processes resulting in large volumes of emissions (*e.g.* paper and

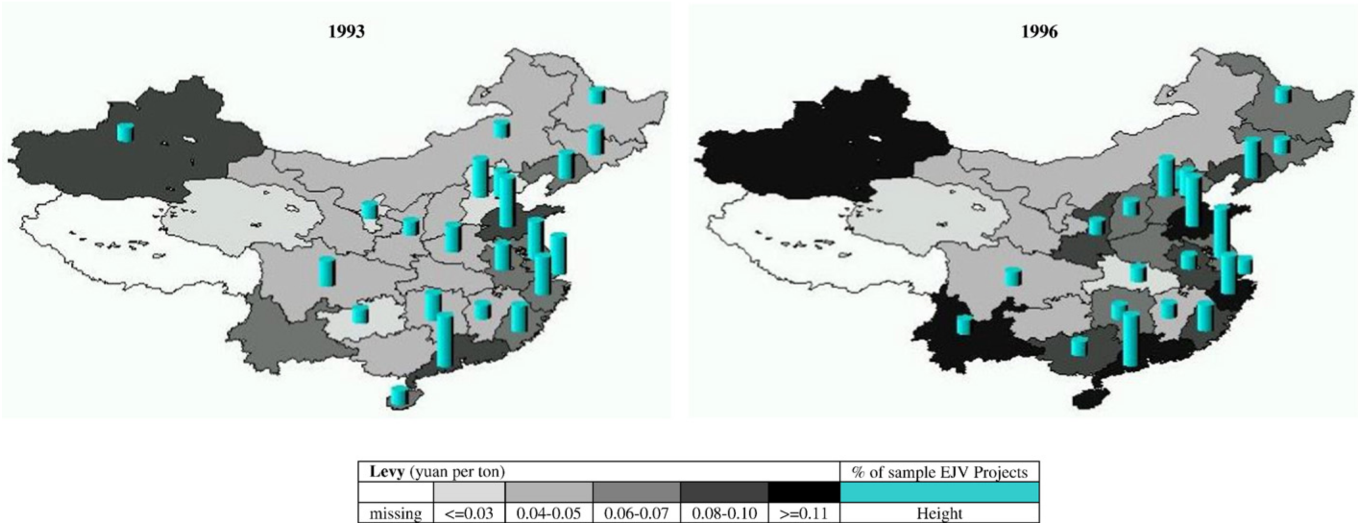

Fig. 3. Source: EJV distribution constructed from the sample EJV data. Average provincial pollution levy constructed from World Bank dataset, compiled from *Chinese Environmental Yearbook*, various years. See Appendix A for more details.

paper products). Additionally, abatement efficiency will vary among firms within an industry if investors from different source countries use different production technologies.[25] Using this form for abatement technology, we can eliminate θ and invert the joint production technology to obtain a net production function in which emissions are treated as an input:

$$X_{ij} = Z_{ij}^{\alpha_{ij}}\left[G^j\left(L_{ij}, H_{ij}, I_{ij}(s)\right)\right]^{(1-\alpha_{ij})}. \quad (2)$$

Let factor prices be given by the vector $\mathbf{w}=(\tau, u, h, \tilde{p}_s)$, where τ is the marginal tax rate for emissions, u the wage for unskilled labor, h the wage for skilled labor, and $\tilde{p}_s$ a price index for locally-provided services. All factor prices vary across provinces, including the marginal emissions tax rate. We assume that the firm adjusts its emissions by altering the effluent concentration of its wastewater. Using the structure of the Chinese levy system, the fine for non-compliant firms in province k is[26]

$$F_{ijk} = R\left(\frac{E_{ij} - E_k}{E_k}\right)W_{ij}, \quad (3)$$

where F_{ijk} is the total fine levied on firm i in industry j if it locates in province k. Here, R is the national tax rate on the discharge factor (given in brackets), E_{ij} is the effluent concentration in firm i's wastewater, E_k is the allowable concentration standard set by province k, and W_{ij} is firm i's wastewater. For firms exceeding the standard, the marginal levy on emissions from Eq. (3), denoted by τ_k, is $\tau_k=R/E_k$, which varies by province. Under this levy system, the total fine paid by a non-compliant firm operating in province k can be expressed as $F_{ij}=(\tau_k E_{ij}-R)W_{ij}=\tau_k Z_{ij}-RX_{ij}$. Therefore, the cost function for a firm operating in province k with the production function (2) is $C^{ij}(\mathbf{w}_k, R, X_{ij})$.

Let the producer price for a unit of X_j be denoted by p_j. For any non-compliant firm, the maximum profit that can be earned in province x is the solution to:

$$\pi_{ijk}\left(p_j, \mathbf{w}_k, R\right) = \max p_j X_{ij} - C^{ij}\left(\mathbf{w}_k, R, X_{ij}\right). \quad (4)$$

A firm will choose the investment location that offers the highest feasible profit given local factor prices.

3.2. Pollution taxes and profits

Using Eq. (4), we can explore how cross-province differences in the emissions concentration standard influence the maximum profit that an investor can earn in that province, *ceteris paribus*. A stricter provincial concentration standard implies a higher marginal levy rate, which enters the profit function through τ_k. Variable cost is non-decreasing in factor prices and profits are non-increasing in cost.[27] Therefore, profits are non-increasing in τ_k. Using the Envelope Theorem, the impact of a higher pollution tax on profit reflects the firm's optimal level of emissions: $\partial\pi_{ijk}(p_j, \mathbf{w}_k, R)/\partial\tau_k=-Z_{ijk}$. Because the decline in profit from a higher pollution tax is the emissions level itself, it follows that firms that are large polluters will be more sensitive to variation in pollution taxes when choosing a location for investment.

From Eq. (2) and noting that the firm chooses emissions such that the value of the marginal product of emissions equals the pollution tax, the firm's chosen pollution intensity (PI), defined as emissions per unit value of output, can be expressed as $PI_{ijk}=Z_{ijk}/P_jX_{ijk}=\alpha_{ij}/\tau_k$. Thus, a firm's pollution intensity is increasing in its abatement parameter α_{ij} and the response to pollution taxes should vary in accordance with the firm's pollution intensity. These observations lead to the following hypothesis, which we test using provincial variation in pollution levies.

Hypothesis. A stricter environmental standard, all else equal, decreases profits. This profit effect is larger (i) for firms in industries that are more pollution intensive in production; and (ii) within industries, for firms whose capital investment embodies less efficient abatement technology.

To test (i) we allow the responsiveness of firms to pollution taxes to differ by the pollution intensity of their industry. We test (ii) by allowing the responsiveness of firms to pollution taxes to differ by source group, controlling for the pollution intensity of the investor's industry.

[25] Evidence suggests that most innovation in pollution control equipment has occurred in OECD countries (Lanjouw and Mody, 1996) and that firms tend to purchase pollution control equipment from domestic suppliers (Popp, 2006).

[26] For further details on the Chinese levy system, see Wang and Wheeler (2005).

[27] See Varian (1992).

4. Econometric method

4.1. Econometric model and estimation

While the exact functional form of the profit function in Eq. (4) is unknown, we assume that potential profit is a multiplicative function of its arguments and, thus, linear in logs.[28] Decomposing Eq. (4) and distinguishing the levy τ_k, other variables that are observable at the provincial level, $\mathbf{V_K}$, and variables observable at the regional level, $\mathbf{V_R}$, profits for firm i can be expressed as[29]:

$$\ln\pi_{ik} = a_0 + a_1 \ln\tau_k + \mathbf{b}'\mathbf{V_K} + \mathbf{c}'\mathbf{V_R}. \tag{5}$$

Clearly provincial characteristics, such as investment incentives and transport costs, influence the location decision. Following Head and Ries (1996) and Cheng and Kwan (2000), we add incentives as a proportionate shift factor to the profit function. We also introduce variables that capture transportation and telecommunications costs. Finally, we relax the assumption that firms receive the same price in every province. The literature indicates that some firms, particularly those with partners based in the US and Japan, produce for the local market, so we introduce measures of local income and market size.

Assuming that potential profits are subject to shocks to local conditions (ξ_{ik}) that are specific to firm-province pairs, and that ξ_{ik} follows a Type I Extreme Value distribution, the probability, P_{ij}, that investor i chooses province k where k is a member of choice set K is given by

$$P_{ik} = \frac{\exp(\ln\pi_{ik})}{\sum_{k\in K}\exp(\ln\pi_{ik})}, \tag{6}$$

where we represent $\ln\pi_{ij}$ by Eq. (5). Eq. (6) is estimated using data on 2886 manufacturing EJVs undertaken during 1993–1996 across 28 provinces and 27 3-digit ISIC industries. Baseline results are obtained using conditional logit. To test hypothesis (i), we allow the pollution levy parameter to vary by industrial pollution intensity. To test hypothesis (ii), we estimate Eq. (6) for ECE and non-ECE subsamples, separately.[30] Because Malaysia, Indonesia, and the Philippines have large ethnically Chinese populations, the few projects from these countries are included in the ECE subsample.[31]

Given investors' geographic links to coastal provinces, clustering of prior investment and natural resources, and the gradual nature of the opening process from the coast inward, the assumption of independence of irrelevant alternatives may not hold for China.[32] To allow for correlation among provinces in the same geographic region, we estimate a nested logit model. This allows for dependence among the unobservable aspects of profitability among provinces in a given region. The location choice becomes a two-level nested decision—choosing a region in China, and then a specific province within that region. We estimate the nested logit model using full information maximum likelihood estimation.

4.2. Data description

Summary data for provincial characteristics are shown in Table 2, with definitions and sources provided in the Appendix A. Although wages by skill level are not available, a distribution of the labor force by education categories is available for each province from the 1990 Population Census and a 1% sample of the population performed in 1995.[33] Since inter-provincial labor mobility is low, we assume that relative labor supplies determine relative wages in each province. Defining unskilled labor as those who are illiterate or have less than primary level education and skilled labor as those with senior secondary education or beyond, we calculate the percentage of unskilled and skilled labor relative to the percentage of semi-skilled labor (those with primary and junior secondary level education).

The profit function also depends on the price of locally produced intermediate services. Head and Ries (1996) argue that agglomeration in China is the result of localization economies from concentrations of intermediate service providers. Adopting their framework, we assume the market for local services is monopolistically competitive and that foreign firms use a composite of these services. The equilibrium number of intermediate suppliers then depends on the final-good price, the number of foreign firms to which they may sell, and the number of domestic firms who may undertake the costly upgrading necessary to serve foreign firms. This framework can be used to derive a price index for locally-provided service intermediates, which is a function of previous foreign investment and the number of potential local intermediate service suppliers. Previous foreign investment is measured as the real value of provincial cumulative FDI, from 1983 to the year before the project is undertaken. Availability of potential intermediate service suppliers is measured by the number of domestic enterprises.

As in other studies, we include several measures of infrastructure. Transport infrastructure is proxied by the length of roads and inland waterways (both adjusted for provincial size), while telecommunications are proxied by the number of urban telephone subscribers relative to population. FDI incentives are included using a dummy that takes a value of one if there is a special economic zone (SEZ) or open coastal city (OCC) in the province. This variable does not vary during the 1993–1996 period.

Using the data on COD-intensity of Chinese industrial output, we create three dummy variable indicators of water pollution intensity (PI). About 60% of the EJV projects in the sample are in industries designated as low polluters, with a PI of less than 1 kg per thousand yuan output (1990 yuan). Another 24% of the sample are in industries with $1<\text{PI}<3.5$, and are classified as medium polluters. The final 16% are in industries with $\text{PI}>7$, and are denoted high polluters. This classification scheme is motivated by low within-group variation, but high between-group variation in PI.

4.3. Addressing environmental stringency and endogeneity

Environmental stringency may itself be endogenous, thus blurring the relationship between stringency and FDI location choice. One source of endogeneity might be two-way causality. Foreign investors might negotiate pollution levies with local authorities prior to choosing where to invest. This would imply that the levy itself is a function of the location choice of the firm. As the OECD (2005) states, there is evidence that local Environmental Protection Boards (EPBs) often negotiate the levels of fees with firms. In addition, EPBs are often impeded from fully enforcing environmental regulations, when local leaders believe the non-compliant enterprises are important for the local economy.

However, the OECD study notes that negotiations between the EPBs and firms take place *after* the EPBs issue notices to collect discharge fees. Thus, such negotiations occur *after* location, production, and emissions decisions have been made by the firm and following an inspection by local authorities (Wang and Wheeler, 2005). In addition, recent evidence shows that state-owned enterprises (SOEs) have more bargaining power than other firms and that this has led to significantly lower environmental levies for SOEs relative to foreign-invested and Chinese private firms (Wang et al., 2003; Wang and Jin, 2006; Wang and Wheeler, 2005). This evidence suggests that two-way causality is

[28] The cost function is commonly assumed to be generalized Cobb-Douglas (e.g. Head and Mayer, 2004).

[29] The subscript j is suppressed for clarity.

[30] There is no source for 12% of projects in 1996, 17% in 1995, 10% in 1994, and 3% in 1993. Since most FDI inflows at this time were ECE, these projects were designated ECE. Our results are not sensitive to this assumption.

[31] Omission of these Southeast Asian projects from the analysis did not affect our results.

[32] This clustering may also differ systematically for ECE and non-ECE investors—an outcome consistent with the foreign-investor information disadvantage stressed by List et al. (2004) in their interpretation of results for the US.

[33] We interpolate between these years to develop a time series.

unlikely to be a problem when it comes to a foreign investor's location choice. While enforcement does vary across provinces, evidence from Wang and Wheeler (2005) shows that better enforcement does significantly increase average collected *plant-level* water pollution levies. Thus, our collected levy variable should correctly signal *de facto* stringency, due to tighter regulations, better enforcement or both.

But the influence of SOEs points to the importance of controlling for corruption and a second possible source of endogeneity—omitted variable bias. Fredriksson et al. (2003) and Javorcik and Wei (2004) argue that corruption may imply lower environmental charges, but may also imply a less attractive location in which to invest. Thus, if corruption is omitted, low levies may not attract FDI even if the PHH is true. A similar bias may arise if income is omitted. Higher incomes may imply more stringent environmental regulations, but may also imply a larger local market and better infrastructure. If these variables are omitted, high levies might not deter FDI, even if PHH were true.

The use of a lag should prevent any contemporaneous correlation between the levy and the error term. However, in light of the evidence on bargaining power of SOEs, we proxy corruption using controls for state ownership. Since large reductions in state ownership may signal a commitment to liberalization and less potential for corruption, we include growth in the share of provincial output from SOEs as a location choice determinant. In addition, since the appeal of higher incomes and investment incentives may be reduced if commerce is heavily concentrated in SOEs, we interact both incentives and consumption per capita with the degree to which the economy is *non*-state-owned. As a final defense against omitted variable bias, we introduce regional and provincial fixed effects to capture other province-specific features that might impact FDI location choice. With a short time-series, these fixed effects reduce our ability to estimate the influence of provincial characteristics that change slowly over time, but they greatly reduce the scope for correlation between the error term and the levy.

A third source of endogeneity is measurement error in the proxy for environmental stringency. To see this, suppose that of the N firms located in a province, firms 1 to n emit wastewater up to standard and, thus, do not pay a fine. Using Eq. (3) and the definition of τ, the average provincial collected levy is:

$$\frac{TL_{kt}}{W_{kt}} = \tau_k \cdot \left[\sum_{i=n+1}^{N} w_{it}(E_{it} - E_{kt}) \right] \tag{7}$$

where TL_{kt} are total collected levies and $w_{it} = W_{it}/W_{kt}$. As Eq. (7) indicates, the average collected levy in province k is the product of (i) the marginal pollution tax, which reflects provincial policy only, and (ii) the weighted average deviation of firm effluent intensity from the provincial standard, which reflects industrial composition in the province as well as the tax. A more stringent provincial standard (a decrease in E_{kt}) will always imply a higher average collected levy, *cet. par.* However, a higher share of pollution-intensive industries could raise E_{it}, and therefore the average collected levy, even if E_{kt} is constant.

Table 2 provides some evidence that this is important. The average collected levy in both Zhejiang and Xinjiang is 0.12 yuan per ton of wastewater—one of the highest in China. Zhejiang has a relatively low average effluent intensity (0.36 tons COD per thousand tons wastewater) and 70% of its wastewater met its concentration standard. In contrast, Xinjiang has one of the highest average effluent intensities (0.74) and only 37% of its wastewater met its concentration standard. For this reason, in addition to the regional and provincial fixed effects, we control for the average provincial effluent intensity in Eq. (6) as a proxy for the bracketed term in Eq. (7).

5. Results

We estimate Eq. (6) using conditional logit and nested logit methods. In both approaches, we estimate the model for the full sample and for each of the source-specific subsamples, ECE and non-ECE. As suggested by our theory, we allow the effect of regulation to vary by the pollution intensity of the industry in which the investment occurs.

5.1. No evidence of a pollution haven effect on average

Table 3 reports the conditional logit results for the full sample. Model (1) incorporates regional fixed effects to control for unobserved correlates of environmental stringency. Average collected levy and average effluent intensity are lagged one year to represent predetermined information, available to an investor at the time of the location decision. The estimated coefficient for the average levy in model (1) is very small and insignificant. Therefore, ignoring the variation in pollution intensity across industries, we find no support for a pollution-haven effect in our full sample. We do find strong regional effects, however, indicating that EJVs are much less likely to locate in the southwest and northwest and much more likely to locate in the coastal and northeast regions, relative to the central (omitted) region.

We expect all investors to be attracted to provinces with large stocks of FDI (agglomeration) and potential suppliers (local firms), as well as special incentives and good infrastructure. These priors are supported by the full sample.[34] Estimates in model (1) also indicate a strong attraction to provinces with relatively abundant skilled workers, and provinces where state-ownership is shrinking rapidly. We also expect that firms seeking to sell into the local market will be attracted to areas that have rich and growing local markets, as measured by provincial consumption per capita and real provincial GDP growth. EJVs appear to be attracted to fast-growing markets, but high incomes have no significant impact in model (1).

Model (2) of Table 3 allows for province-specific effects that deviate from those captured by the regional dummies, providing an additional defense against omitted variable bias.[35] Notably, the estimated average levy coefficient now is negative, but it remains insignificant. Thus, inclusion of provincial fixed effects does not change the lack of support for a PH effect in the full sample. For most of the other explanatory variables, the results in model (2) mirror those in model (1). However, there are a few exceptions. The estimated coefficient for average effluent intensity is now negative and significant, and for consumption per capita is now positive and significant. Thus, investors are indeed attracted to cleaner provinces with higher incomes. Model (2) also suggests a much stronger attraction to rapid growth, incentives, and abundant semi-skilled labor. While model (2) does render local firms and agglomeration insignificant, there is little variation in these variables over this short time period.

5.2. The pollution intensity of the industry matters

Hypothesis (i) suggests that the attraction of low levies will be stronger for highly polluting industries. In model (3) of Table 3, the PI dummy indicators are interacted with the average levy and average effluent intensity to test whether these groups respond differently to pollution standards. We find that the pollution levy is not a significant deterrent for firms in industries with low pollution intensity. The estimated coefficient for firms in medium pollution intensity industries is negative, but also not significant. However, investors in highly polluting industries are significantly less likely to choose a province with a high levy. This finding is consistent with haven-

[34] The estimated coefficient for telephone coverage is negative and significant, but may simply be a poor proxy for telecommunications infrastructure. Other authors have found similar results using various measures of telephones.

[35] For each region with n provinces, $(n-1)$ provincial fixed effects are introduced (though not shown in Table 2).

Table 3
EJV provincial location choice: conditional logit, full sample[1,2].

	(1)		(2)		(3)		(4)	
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
Provincial variables (in logs)								
Levy[3]	0.01	0.10	−0.06	−0.45				
Av. effluent intensity[3]	0.09	1.27	−0.43**	−3.44				
Levy[3]*low polluter					0.13	1.04	0.03	0.24
Levy[3]*medium polluter					−0.11	−0.75	−0.18	−1.07
Levy[3]*high polluter					−0.38*	−2.48	−0.42**	−2.59
Av. EI[3]*low polluter					−0.02	−0.21	−0.46**	−4.01
Av. EI[3]*medium polluter					0.15	1.68	−0.31*	−2.36
Av. EI[3]*high polluter					0.27**	2.87	−0.11	−0.90
Local firms	0.46**	6.77	0.25	1.31	0.45**	6.73	0.28	1.48
Agglomeration	0.35**	8.91	−0.02	−0.17	0.35**	8.94	−0.02	−0.22
Ratio skilled labor	1.26**	8.45	−2.44**	−5.36	1.27**	8.54	−2.38**	−5.24
Ratio unskilled labor	−1.17**	−3.51	−1.81**	−4.94	−1.15**	−3.46	−1.78**	−4.88
Weighted SEZ or OCC[4,5]	1.19**	4.54	2.44**	2.74	1.21**	4.65	2.50**	2.80
Weighted consumption P.C.[5]	0.11	0.48	1.78**	4.56	0.12	0.53	1.79**	4.59
Real provincial growth[4,6]	1.27**	2.82	2.26**	3.56	1.19**	2.69	2.21**	3.51
Change in state ownership	−2.10**	−2.81	−1.85**	−2.12	−2.12**	−2.84	−1.97*	−2.27
Telephones	−1.38**	−10.84			−1.39**	−10.96		
Roads	0.31**	3.41			0.32**	3.44		
Inland navigable waterways	0.12**	7.11			0.12**	7.09		
Regional fixed effects								
Coast	0.38*	2.10	3.02**	3.83	0.39*	2.14	3.00**	3.79
Northeast	0.36*	2.36	−0.80	−1.55	0.39**	2.53	−0.80	−1.56
Southwest	−1.28**	−7.98	−1.66**	−3.28	−1.29**	−8.11	−1.70**	−3.36
Northwest	−0.33	−1.61	−0.04	−0.07	−0.34	−1.66	−0.05	−0.09
Provincial fixed effects[7]	No		Yes		No		Yes	
Obs	80,808		80,808		80,808		80,808	
Log likelihood	−7862.65		−7795.52		−7856.85		−7789.34	
LR test	2286.71**		3642.45**		2319.69**		3654.81**	

[1]**, *, and † indicate significance at the 1%, 5%, and 10% levels, respectively. [2]Gansu and Tibet excluded since no foreign investment located there during the time period. [3]Variable is lagged one year. [4]Variable not in logs. [5]Weighted by (1 − share of industrial output from SOEs). [6]Three-year moving average. For each region with *n* provinces, $(n-1)$ provincial fixed effects are introduced.

Table 4
EJV provincial location choice: conditional logit, ECE and non-ECE samples[1,2].

	ECE sample				Non-ECE sample			
	(3)		(4)		(3)		(4)	
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
Provincial variables (in logs)								
Levy[3]*low polluter	0.15	0.90	0.10	0.57	0.04	0.19	0.02	0.07
Levy[3]*medium polluter	−0.15	−0.77	−0.17	−0.83	−0.13	−0.55	−0.12	−0.41
Levy[3]*high polluter	−0.54**	−2.84	−0.54**	−2.69	−0.18	−0.72	−0.19	−0.65
Av. EI[3]*low polluter	0.04	0.43	−0.47**	−3.14	−0.04	−0.34	−0.31	−1.71†
Av. EI[3]*medium polluter	0.17	1.38	−0.38*	−2.19	0.18	1.32	−0.10	−0.48
Av. EI[3]*high polluter	0.24†	1.91	−0.20	−1.21	0.32*	2.35	0.09	0.46
Local firms	0.35**	4.53	0.37	1.48	0.67**	4.57	0.31	0.99
Agglomeration	0.47**	10.16	−0.09	−0.67	0.08	1.12	−0.06	−0.32
Ratio skilled labor	0.46**	2.61	−3.60**	−5.91	2.77**	9.90	−0.27	−0.36
Ratio unskilled labor	−1.33**	−3.46	−2.40**	−5.33	−1.06†	−1.72	−0.73	−1.09
Weighted SEZ or OCC[4,5]	0.57†	1.67	2.06†	1.77	2.07**	4.97	1.95	1.35
Weighted consumption p.c.[5]	0.08	0.27	1.59**	3.19	0.84*	2.22	3.35**	4.88
Real Provincial Growth[4,6]	0.93†	1.66	2.52**	3.07	1.62*	2.24	1.09	1.06
Change in state ownership	−2.41*	−2.36	−2.90**	−2.51	−2.74*	−2.22	−1.72	−1.22
Telephones	−1.17**	−7.51			−2.22**	−9.62		
Roads	0.30*	2.43			0.52**	3.56		
Inland navigable waterways	0.18**	7.59			0.06*	2.37		
Regional fixed effects								
Coast	0.47*	1.96	4.80**	4.64	0.57†	1.93	0.50	0.39
Northeast	0.15	0.72	−0.86	−1.30	1.09**	4.31	−0.44	−0.50
Southwest	−1.41**	−7.49	−1.54**	−2.42	−1.00**	−3.46	−1.26	−1.44
Northwest	−0.43†	−1.59	0.19	0.23	0.05	0.17	−0.86	−1.08
Provincial fixed effects[7]	No		Yes		No		Yes	
Obs	47,964		47,964		32,844		32,844	
Log likelihood	−4658.07		−4592.50		−3101.31		−3066.65	
LR test	1343.27**		2231.13**		1023.23**		1684.05**	

[1]**, *, and † indicate significance at the 1%, 5%, and 10% levels, respectively. [2]Gansu and Tibet excluded since no foreign investment located there during the time period. [3]Variable is lagged one year. [4]Variable not in logs. [5]Weighted by (1 − share of industrial output from SOEs). [6]Three-year moving average. [7]For each region with n provinces, $(n-1)$ provincial fixed effects are introduced.

seeking behavior, but also supports the view that such behavior is conditioned by pollution intensity.[36]

These results are robust to the inclusion of provincial fixed effects. In model (4), we find significant PH behavior among investors in highly polluting industries but not among investors in industries with low or medium pollution intensity. As before, inclusion of provincial fixed effects controls for provincial characteristics correlated with effluent intensity and consumption per capita. All three types of polluters are attracted to cleaner provinces and provinces with higher incomes.

5.3. The source country of the investor matters

Hypothesis (ii) suggests that the attraction of weak environmental regulations depends on the technological sophistication of the firm within a given industry. There is some evidence from firm surveys that non-ECE investors transfer more advanced technology in their Chinese investments than do investors from ECE countries.[37] Our hypothesis is that the levy will have a stronger deterrent impact on ECE firm location decisions than on non-ECE firms, all else equal. To investigate this, we estimate models (3) and (4) for the 1713 (1173) projects funded by ECE (non-ECE) investors, separately.[38]

Model (3) in Table 4 shows the results for the split sample. Higher standards do not affect the location decision for ECE investors in low or medium polluting industries, but are a negative and significant deterrent for investors in highly polluting industries. Higher standards have no significant impact on location choice for non-ECE investors, regardless of pollution intensity. Importantly, these results are robust to the inclusion of provincial fixed effects, as shown in model (4). As with the full sample, the inclusion of fixed effects indicates that both investors groups are attracted to cleaner, higher income provinces. We conclude that ECE investors are deterred by more stringent pollution standards, but only when investing in pollution intensive activities. In contrast, non-ECE investors do not engage in significant pollution-haven seeking behavior within China.[39]

5.4. The investment decision is nested

It is possible that the decision to locate EJVs in China is a nested one. Strong regional effects in the conditional logits suggest a nested decision, and Hausman tests rejected the null hypothesis of the independence of irrelevant alternatives. Thus, we estimate a nested logit specification. The investor is assumed to first choose the region in which to invest and then the province within that region.[40] We include regional averages of consumption per capita, population, and real income growth as determinants of regional choice.

Table 5
EJV provincial location choice: nested logit, by source[12].

	Full sample		ECE		Non-ECE	
	(1)		(2)		(3)	
	Coeff	z	Coeff	z	Coeff	z
Provincial variables (in logs)						
Levy[3]*low polluter	0.08	0.67	0.02	0.11	−0.01	−0.05
Levy[3]*medium polluter	−0.15	−0.97	−0.11	−0.56	−0.15	−0.58
Levy[3]*high polluter	−0.37*	−2.14	−0.53**	−2.51	−0.15	−0.55
Av. EI[3]*low polluter	0.15**	2.52	0.21**	2.81	0.21*	2.41
Av. EI[3]*medium polluter	0.23**	3.49	0.29**	3.20	0.27**	2.59
Av. EI[3]*high polluter	0.33**	4.96	0.42**	5.08	0.35**	3.03
Local firms	0.56**	7.11	0.46**	5.12	0.66**	4.01
Agglomeration	0.34**	9.89	0.44**	10.72	0.09	1.34
Ratio skilled labor	1.38**	11.80	0.65**	4.35	2.77**	11.37
Ratio unskilled labor	−0.71**	−2.73	−0.74*	−2.31	−1.29*	−2.26
Weighted SEZ or OCC[4,5]	1.43**	4.82	0.62	1.46	2.06**	4.65
Weighted consumption p.c.[5]	0.05	0.13	0.18	0.41	1.37*	2.32
Real provincial growth[6]	1.63**	3.34	1.16†	1.79	2.41**	3.07
Change in state ownership[4]	−2.23**	−2.56	−1.97†	−1.88	−1.42	−0.89
Telephones	−1.21**	−7.03	−1.06**	−5.13	−2.26**	−7.83
Roads	0.32**	3.39	0.36**	2.95	0.55**	3.93
Inland navigable waterways	0.11**	6.72	0.17**	7.55	0.07**	2.70
Regional variables						
Average consumption p.c.	0.48	1.40	0.30	0.75	−0.51	−0.52
Average population	0.02	1.12	0.01	0.57	−0.04	−1.32
Average annual real growth[6]	3.73**	4.01	5.65**	4.77	1.17	0.82
IV parameters						
Coast	1.38**	8.95	1.63**	6.85	1.51**	3.60
Northeast	0.72**	3.17	1.04**	4.03	1.11**	3.51
Inland	0.80**	2.84	1.24**	3.79	1.26**	2.63
Southwest	1.66**	6.85	2.00**	5.99	1.54**	4.05
Northwest	0.69*	2.06	0.87*	2.19	1.49**	3.02
Obs	80,808		47,964		32,844	
Log likelihood	−7848.62		−4648.31		−3102.07	
LR test	3536.24**		2119.50**		1613.21**	
LR test: IV parameters = 1	64.94**		143.91**		26.20**	

[1] **, *, and † indicate significance at the 1%, 5%, and 10% levels, respectively.
[2] Gansu and Tibet excluded since no foreign investment located there during the time period.
[3] Variable is lagged one year.
[4] Not in logs.
[5] Weighted by (1 − share of industrial output from SOEs).
[6] Three-year moving average. Not in logs.

Table 5 presents the nested logit results for the full sample and both subsamples, incorporating pollution intensity. If the investor's decision is not nested, then the estimated inclusive value (IV) parameters should be equal to one. The last row of Table 5 shows that this null hypothesis is rejected for the full sample and each of the source sub-samples. As further verification of the nested logit specification, the IV parameters for both sub-samples are within the range consistent with the maintained assumption of stochastic profit maximization.[41] Results for the full sample (model 1) show that investors are attracted to regions with high annual real income growth. While this holds true for ECE investors, non-ECE investors' decisions are not significantly influenced by any of these regional attributes.

The results in Table 5 confirm that the levy plays no significant role in determining the choice of province for investors in low pollution intensity industries. The estimated levy effect is negative for nvestors in industries of medium pollution intensity, but these coefficients are never statistically significant. However, there is a negative and significant response to the levy by investors in highly polluting industries for the full sample. When the sample is split by source, it is clear that this result is

[36] Wald tests indicated no significant difference between the responses of low- and medium-intensity polluters, but a significant difference between the response of high-intensity polluters and those of other two groups.

[37] Survey data on EJVs in China (Brandt and Zhu, undated) indicated that during 1987–1993, 35% (5%) of EJVs with Hong Kong investors were required to transfer advanced technology (a patent) from a foreign parent, in contrast to 76% (29%) of EJVs with developed country investors. Similarly 6% of EJVs from Hong Kong were required to manufacture certain components or final products in China, in contrast to 42% of EJVs with developed country investors. We thank Susan Zhu for making this information available.

[38] Because the South Asian projects may reflect round-tripping concerns, the models were rerun omitting these projects. The results were unaffected. We thank K.C. Fung for bringing this to our attention.

[39] Dean and Lovely (2008) show that water and air pollution intensities are not highly correlated across industries. Thus, non-ECE firms still might be deterred by air pollution regulations, if air pollution was more stringently regulated or more costly to abate. We have no evidence regarding the latter, but we know Chinese air regulations were less well developed, and collected levies from water pollution exceeded those from air pollution (Wang and Wheeler, 2005). This suggests that, *de facto*, water pollution was more stringently regulated than air pollution.

[40] Modeling the choice to locate in China at all would require a three-tiered nest and national measures of stringency (which are not available). Since existing research stresses the importance of non-environmental motivations for investing in China in the 1990s, we believe omitting the prior decision does not bias our results.

[41] See Ondrich and Wasylenko (1993) and Kling and Herriges (1995).

Table 6
Elasticity of unconditional probabilities with respect to change in selected own province characteristics.

Province characteristics	Elasticities					
	Guangdong		Henan		Inner Mongolia	
	ECE	Non-ECE	ECE	Non-ECE	ECE	Non-ECE
Pollution levy (high polluter)	−0.48	−0.14	−0.54	−0.16	−0.52	−0.16
# Local firms	0.41	0.63	0.47	0.69	0.45	0.70
Agglomeration	0.40	0.09	0.45	0.09	0.43	0.10
Skilled labor	0.58	2.66	0.66	2.88	0.64	2.94
Unskilled labor	−0.67	−1.24	−0.76	−1.34	−0.73	−1.37
Incentives[1,2]	0.42	1.48				
Consumption per capita[1]	0.16	1.32	0.18	1.43	0.18	1.46
Real provincial growth	1.04	2.31	1.28	2.50	1.14	2.55
SOE growth	−1.74	−1.36	−2.01	−1.47	−1.94	−1.50
Inland navigable waterways/area	0.15	0.07	0.17	0.07	0.17	0.07
Roads/area	0.32	0.53	0.37	0.57	0.36	0.58

[1] Incentives and consumption per capita are weighted by the share of output from non-SOEs.
[2] Of these three provinces, only Guangdong had any SEZs or had Open Coastal Cities between 1993 and 1996.

driven by the ECE sample.[42] Non-ECE investors are negatively but not significantly influenced by the levy, regardless of the pollution intensity of the industry. Thus, the nested logit analysis supports the conclusion that only ECE investment in highly polluting industries is significantly deterred by stringent pollution regulation.

To compare the effects of environmental stringency relative to other determinants of FDI location choice, we compute the elasticities of the unconditional probability of locating in three provinces (Table 6). These elasticities are based on the nested logit coefficients in Table 5 and the unconditional probabilities evaluated at the means of the provincial variables. Guangdong is a relatively high income province with high average pollution levies, a high level of agglomeration, a high percentage of wastewater meeting the provincial standard, and a relatively low average effluent concentration. Henan and Inner Mongolia are moderate and low income provinces, respectively, with progressively lower levies and less agglomeration, higher average effluent concentrations, and lower percentages of wastewater meeting the provincial standard.

The first row of Table 6 shows that while both ECE and non-ECE investors in highly-polluting industries have an inelastic response to changes in the own province average levy, the ECE investors' elasticities are about three times larger than those of non-ECE investors. A one percent increase in Guangdong's average levy decreases the likelihood of locating there by 0.48% for ECE investors, but only 0.14% for non-ECE investors. The impact of a one percent change in Henan's or Mongolia's levy on the likelihood that ECE investors will locate there is somewhat higher than for Guangdong, indicating a greater sensitivity to marginal changes in levies in low stringency areas.

In all three provinces, ECE investors show a large, elastic response to an increase in the local growth rate and to the rate of decline in state ownership. A one percent faster reduction in state ownership increases the probability that an ECE investor locates in Guangdong by 1.7%, while a one percent increase in the provincial growth rate increases the probability by 1%. These elasticities are even larger for Inner Mongolia and Henan, where state ownership is high and diminishing slowly, and where income growth is slower. ECE FDI is more attracted by an increase (decrease) in the relative supply of skilled (unskilled) labor in all three provinces than by reductions in the average pollution levy. These results suggest that educating the work force and increasing privatization are potentially more useful tools for attracting ECE FDI than reducing environmental stringency.

Non-ECE FDI also shows an elastic response to changes in state ownership, and a relatively large inelastic response to changes in the number of local suppliers. In contrast to ECE investment, non-ECE FDI is highly responsive to changes in the abundance of skilled labor and to increased real provincial income growth. A one percent increase in the ratio of skilled labor raises the likelihood of choosing Guangdong by 2.66%, while a one percent faster real growth rate raises it by 2.31%. For Henan and Inner Mongolia, where real incomes are lower and skilled labor is relatively scarce, these elasticities are larger. These comparatively large elasticities might reflect the greater specialization of non-ECE investors in high-skill-intensive goods, and their orientation toward the domestic market.

6. Conclusion

Because it is host to the largest share of FDI to the developing world and because environmental stringency varies among its provinces, China is an excellent setting for an investigation of the pollution haven effect. We have created and analyzed a new compilation of foreign EJVs into China during 1993–1996, categorized by industry, source country, and province. These data exhibit wide dispersion in FDI across industries and provinces. Our evidence from conditional and nested logit analysis indicates that ECE-sourced FDI in highly polluting industries is significantly deterred from provinces with relatively stringent pollution regulation. In contrast, FDI from non-ECE countries is not deterred, regardless of pollution intensity. These findings suggest that there are important links between the investor's source country, the pollution intensity of the industry, and PH behavior. While we find evidence of PH behavior by foreign investors in China, it is not by investors from high income countries and it is only in industries that are highly polluting.

One explanation for these findings may be technology differences. Profit-maximizing behavior implies that PH behavior is conditioned by technology. As Bhagwati (2004) has argued, richer countries have higher environmental standards, which have induced innovation and production of environment-friendly technology (Lanjouw and Mody, 1996), so that FDI from these countries often employs newer, cleaner technology even in locations where standards are relatively weak.[43] In contrast, entrepreneurs in poorer countries with lower standards typically use older, less "green" technologies and may import them as second-hand machinery.[44] If regulatory costs are non-negligible, we might expect them to affect decisions of investors from poorer rather than richer countries.

We do not have any direct evidence on the levels of technology used by investors in our sample. However, the non-ECE group is dominated by investors from the US, EU, and Japan, while the ECE group is

[42] Wald tests showed no significant difference between the coefficients for low and medium polluters, but significant differences between high polluters and the other two groups.

[43] Empirical evidence supports this claim (Pearson 2000 pp. 319-320). Firms may do this because dirtier techniques: are costly (older less efficient equipment); reduce the ability to export if goods do not meet the latest quality/environmental standards; increase financial risk from publicity of poor environmental performance.

[44] See a number of papers in Blackman (2006).

dominated by investors from Hong Kong, Taiwan, and Macao. To the extent that these developing economies are characterized by relatively weak environmental standards or relatively limited access to green technologies, our results would be consistent with alternative technology-based explanations of PH behavior. Concern should then be focused on expanding access to abatement technology and lowering the cost of its adoption in developing countries.

Given recent advances in the incorporation of firm heterogeneity into models of offshore production, it seems particularly promising to explore the possibility that firm TFP is correlated with abatement efficiency. If so, and if the lowest productivity level needed to become a multinational varies by source country, due to differences in distance or other cost factors, then these costs factors may provide a partial explanation for the differential behavior we uncover in our sample. Understanding the nature and strength of these and other differences is for future research.

Appendix A. Data definitions and sources

Variable	Definition	Source
EJV project data	Province, value $10,000 (1990), source, industry	*Almanac of China's Foreign Economic Relations and Trade*, various years
EJV source classification	ECE = Macao, Taiwan, Hong Kong, S. Asian countries Non-ECE = all other countries	Coded by authors
EJV industry classification	ISIC revision 2, 3-digit industries	Coded by authors
Average levy	Total collected water pollution levies/wastewater (yuan/ton)	World Bank dataset compiled from *Chinese Environmental Yearbook*, various years
Average effluent intensity	COD (kg)/000 tons wastewater	World Bank dataset compiled from *Chinese Environmental Yearbook*, various years
Industry pollution intensity	COD (kg)/output (thousand 1990 RMB yuan), by ISIC classification	World Bank dataset compiled from *Chinese Environmental Yearbook*, various years
Skilled labor	Percent of population who have a senior secondary school education level or above	*China Statistical Yearbook*, various years, and calculations by authors
Unskilled labor	Percent of population who are either illiterate or have less than primarily level education	*China Statistical Yearbook*, various years, and calculations by authors
Semi-skilled labor	Percent of population who have primary or junior secondary education level	*China Statistical Yearbook*, various years, and calculations by authors
Cumulative FDI value	Cumulative value of real contracted FDI, from 1983 until $t-1$ (in 1980 prices), $million.	Coughlin and Segev (2000)
Number of domestic enterprises	[Number of industrial enterprises − (number of non-ECE industrial enterprises) − (number of ECE industrial enterprises)], township level and above. (000s)	*China Statistical Yearbook*, various years, and calculations by authors.
Telephones	Number of year-end urban subscribers/population, lagged one year	*China Statistical Yearbook*, various years
Incentive	Dummy variable for a province with either SEZ or Open Coastal City (as of 1996)	Constructed by authors.

Appendix A (*continued*)

Variable	Definition	Source
Roads	Highways (km)/land area (km^2)	*China Statistical Yearbook*, various years
Railroads	Railway (km)/land area (km^2)	*China Statistical Yearbook*, various years
Consumption p.c.	Consumption (1000 yuan)/ population	*China Statistical Yearbook*, various years
Growth rate of real GDP	Percentage change in annual real industrial output (1990 yuan), lagged one year	World Bank dataset compiled from *China Statistical Yearbook, various years*
Change in state ownership	Difference between share of industrial output from SOEs in year t and $t-1$.	World Bank dataset compiled from *China Statistical Yearbook, various years*, and author calculations.

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