Ecological Economics 102 (2014) 113–117

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

To shut down or to shift: Multinationals and environmental regulation

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ARTICLE INFO

Article history:
Received 20 October 2010
Received in revised form 4 February 2014
Accepted 24 March 2014
Available online xxxx

JEL classification:
F20
Q58

Keywords:
Environmental regulation
Foreign direct investment

ABSTRACT

According to the pollution haven effect mobile capital responds to environmental regulation by moving from countries with high regulation to countries with low regulation. Previous tests of the pollution haven effect focus on host country regulation effect. This study also examines the effect of home country regulation on foreign direct investment (FDI). Using a panel of 28 OECD countries for 1990–2000 to estimate host and home country environmental regulations' effect on FDI, this study finds that host regulation decreases FDI. In contrast, home environmental regulation increases FDI at low levels of home regulation and decreases FDI at high levels of home regulation.

1. Introduction

The *pollution haven effect* predicts that foreign direct investment (FDI) responds to environmental regulation by moving from countries with high regulation to those with low regulation. Previous literature has sometimes failed to adequately distinguish between the *pollution haven hypothesis* and the *pollution haven effect* (Taylor, 2004). The pollution haven hypothesis predicts that removal of trade barriers between high-income and low-income countries results in pollution-intensive production moving to low-income countries with relatively lax environmental regulation. A necessary condition for the pollution haven hypothesis is a strong pollution haven effect (Taylor, 2004). The pollution haven effect may be triggered by changes in either home country or host country regulation. Existing literature focuses on the host country effects, while the effect of home country environmental regulation on FDI has been virtually ignored. This paper considers both host and home country environmental regulation effects on FDI.

Host country regulation and home regulation have different effects on a multinational firm. Fig. 1 presents the effects of host regulation, which I separate into the pollution haven effect and the shutdown effect. In this paper, the pollution haven effect refers to the gradual shift of investment away from the host country in response to higher host regulation whereas the shutdown effect corresponds to levels of host regulation at which the multinational would shut down its affiliate in the host country. Assuming that the headquarters of the multinational are mobile and would only locate in countries with production facilities, a firm's responses to home country regulation are presented in Fig. 2. If home country regulation increases, then initially FDI will increase as more investment shifts abroad, i.e. the pollution haven effect. After home regulation gets high enough firms would shut down their production and headquarters at home so that all production takes place abroad, i.e. the shutdown effect.

I estimate home and host country environmental regulation effects on FDI using bilateral FDI data between 1990 and 2000 for 28 member countries of the Organisation for Economic Co-operation and Development (OECD). In accord with existing work, I find that host country regulation discourages FDI. However, FDI and home regulation have a quadratic relationship. At low levels of home regulation, an increase in home regulation increases foreign investment until the shutdown effect begins to dominate; then increasing home regulation decreases FDI.

2. Literature

Many studies have determined the effect of the host jurisdiction's environmental regulation on FDI.[1] In a literature review of environmental regulation and industry location, Brunnermeier and Levinson (2004) find that statistically significant pollution haven effects are prevalent among more recent studies using panel data techniques or instruments to control for endogeneity. Despite the extent of attention

[1] These studies include Bartik (1989, 1998), McConnell and Schwab (1990), Friedman et al. (1992), Henderson (1996), Levinson (1996), Mani et al. (1996), Becker and Henderson (2000), List and Co (2000), Keller and Levinson (2002), Xing and Kolstad (2002), Jeppesen et al. (2002), Frederiksson et al. (2003), List et al. (2003), Eskeland and Harrison (2003), Javorcik and Wei (2004), Dean et al. (2005), Henderson and Millimet (2007).

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http://dx.doi.org/10.1016/j.ecolecon.2014.03.013
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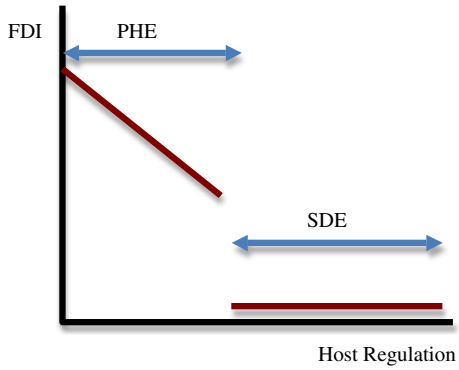

Fig. 1. Host regulation effects for an individual firm.

host regulation has received, no previous study has explicitly examined home jurisdiction's environmental regulation effects on outbound FDI in a cross-country setting.

A handful of studies have considered home country environmental regulation effects on foreign investment. In a theoretical study with simulated results Markusen (1997) analyzes the effects of environmental regulation on firms' location decisions. The firms can either be national (foreign or domestic) or multinational. He finds that, in general, higher environmental regulation tends to reduce the number of multinationals and increase the number of national firms. Markusen's main finding is related to the shutdown effect identified in this study. Eskeland and Harrison's (2003) theoretical model outlines why the effect of home country regulation on outbound FDI is ambiguous. In contrast to Eskeland and Harrison, Section 3 provides a simple framework that gives rise to a quadratic relationship between home country regulation and FDI.

Existing empirical literature on home country effects has used variation in industry-level regulation. Eskeland and Harrison's empirical results suggest that industry pollution abatement costs have no impact or a weak positive impact on U.S. outbound FDI into four developing countries. In a related study, when Cole and Elliott (2005) control for capital intensity alongside industry pollution abatement costs, they find that industries with higher pollution abatement costs have higher investment levels in Mexico and Brazil. This is evidence of the pollution haven effect in response to home regulation. Rather than relying on U.S. industry-level activity, I exploit variation in country-level environmental regulation for home and host countries by using bilateral FDI data.

Several studies have used firm-level analysis to determine home country environmental regulation effects. Employing U.S. firm-level data for 1966–1999, Hanna (2010) finds that the Clean Air Act Amendments increased foreign assets and foreign output, but that the more heavily regulated U.S. firms did not disproportionately increase foreign investment in developing countries. Her study focuses on U.S. firms alone and does not control for host country regulation. Evidence from China by Dean et al. (2005) suggests that FDI from OECD countries is attracted to provinces with higher environmental regulation, regardless of the dirtiness of the industry. However, highly-polluting industries from Hong Kong, Macao and Taiwan invest more in provinces with lower environmental regulation. This is further evidence that both host country regulation and home regulation should be explicitly considered. Closely matching Dean's result, Clark et al. (2000) find that U.S. firms in dirty industries are less likely to conduct offshore assembly in developing countries. Finally, Javorcik and Wei (2004) estimate a model explaining location decisions of 143 multinational firms in 25 transition economies. Allowing the effect of host country environmental regulation to vary with the dirtiness of the firm's industry, they find that host country environmental regulation does not impact location decisions. On the other hand, firms in cleaner industries are more likely to invest in these transition economies, consistent with the idea that home regulation affects investment decisions. In contrast to previous empirical literature, my study explicitly estimates both home country environmental regulation effect and the host country regulation effect on FDI.

3. Conceptual Framework

In the simplest models of multinational firms, each firm has a choice to be a domestic firm by only investing at home, a foreign firm by only investing abroad or a multinational firm by investing at home and abroad. Increasing environmental regulation in a country increases the operational costs in that country and multinationals can shift some or all of their production to another country. If operational costs abroad increase as a result of tighter environmental regulation then multinationals may shift some of their investment away from the host country but remain multinational—the pollution haven effect. Other multinationals may shut down foreign plants altogether and become a domestic firm—the shutdown effect. The pollution haven effect and the shutdown effect reduce FDI in response to higher regulation in the host country as shown on Fig. 1. For home country environmental regulation these two effects work in opposite directions as shown on Fig. 2. With increased home regulation, the pollution haven effect implies multinationals shift more of their investment abroad but remain multinational, thereby increasing FDI. Assuming that headquarters are mobile, some multinationals may shut down domestic plants and become foreign firms resulting in a decrease in FDI—the shutdown effect. If high home country environmental regulation causes the firm to only afford one plant, it may choose to build a domestic plant instead because of ties to the home country. In either case, the impact of shutdown effect on FDI would be negative for home regulation. The sign of home environmental regulation effect on FDI depends on the level of home country regulation. In aggregate, this implies a quadratic relationship between home regulation and FDI depicted on Fig. 3. This simple framework yields two

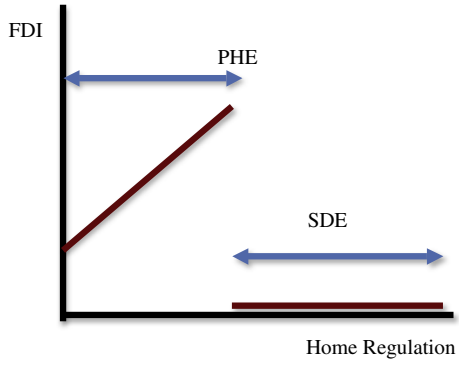

Fig. 2. Home regulation effects for an individual firm.

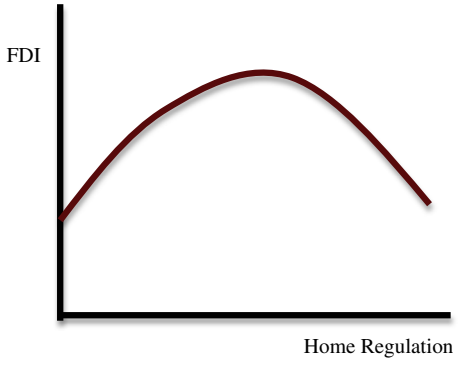

Fig. 3. Home regulation effects in aggregate.

testable hypotheses; that host regulation decreases FDI and that home regulation may increase or decrease FDI depending on the level of environmental regulation.

4. Empirical Model

The effect of environmental regulation on FDI from country i to country j in year t is estimated using the following gravity model of FDI in a log–log form:

$$\mathrm{Ln}\left(FDI_{ijt}\right) = \beta_1 \mathrm{Ln}\left(Reg_{jt}\right) + \beta_2 \mathrm{Ln}(Reg_{it}) + \beta_3 [\mathrm{Ln}, (Reg_{it})]_2 + \beta_4 X_{1it} + \beta_5 X_{2jt} + \beta_6 X_{3ij} + Trend_t + \varepsilon_{ijt} \quad (1)$$

All variables except for trend terms and dummy variables are logged because FDI data are highly skewed and a log–log model provides better-behaved residuals (Blonigen and Davies, 2004). The variables of interest are host country environmental regulation (Reg_{jt}), home regulation (Reg_{it}) and home regulation squared. The quadratic form allows the home country effect to vary with the size of regulation. X_{1it}, X_{2jt} and X_{3ij} are covariates that control for home country, host country and country-pair characteristics, respectively. Both X_{1it} and X_{2jt} include GDP per capita, population, trade costs and skill level. X_{2jt} also controls for host country investment costs and corruption. X_{3ij} is time-invariant and includes distance between the two countries and the common official language dummy. *Trend* allows for a linear and a quadratic trend term, and ε is the error term. I estimate the model using ordinary least squares.

The expected effect of host country environmental regulation on FDI is negative as both the pollution haven effect and the shutdown effect are negative. On the other hand, the effect of home environmental regulation on FDI is expected to be concave because the pollution haven effect and the shutdown effect work in opposite directions with the negative shutdown effect dominating at higher levels of home country regulation.

Large economies are expected to have higher levels of inbound and outbound FDI, implying a positive coefficient on host and home GDP. It is also expected that countries with higher per capita income send out and receive more FDI. Hence, when holding GDP constant, increasing home or host population would decrease FDI. Higher trade costs would increase horizontally-motivated FDI. Horizontal FDI is driven by multinationals trying to jump tariffs. On the other hand, vertical FDI is motivated by cheap inputs abroad and involves importing the final goods back home. Trade costs would thus decrease vertical FDI. The net effect of trade costs on FDI depends on the relative importance of horizontal and vertical FDI.

Countries with highly skilled workers may be better able to attract headquarters for multinational firms. So, home skill level is expected to have a positive effect on FDI. The effect of host country skill is theoretically ambiguous. Horizontal FDI would likely require highly skilled workers, whereas vertical FDI would tend to go to lower-skilled lower-wage countries. The net effect of host skill therefore depends on the relative importance of the two types of FDI. High host-country investment costs and corruption lower the expected return to multinationals and thus decrease FDI into those countries. Distance between countries, a proxy for transportation costs, is expected to reduce FDI. Finally, country pairs with a common official language are predicted to engage in more FDI.

5. Data

Much of the existing pollution haven literature focuses on FDI from rich to poor countries. My study includes only the OECD countries. The vast majority of the world's FDI activity takes place between these relatively rich countries. Furthermore, there is sufficient variation in FDI, income and environmental regulation in OECD countries for the pollution haven effect to emerge.

Table 1
Descriptive statistics.

Variable	Obs	Mean	Std. dev.	Min	Max
Ln(FDI Stock)	2685	6.5	2.6	(2.3)	12.5
-Ln(Host SO_2 Intensity)	1900	7.0	1.2	4.3	9.5
-Ln(Home SO_2 Intensity)	1900	7.0	1.1	3.6	9.5
Ln(Home SO_2 Intensity)^2	1900	49.8	16.2	13.2	90.7
-Ln(Host NOx Intensity)	2178	6.7	1.2	4.8	11.9
-Ln(Home NOx Intensity)	2178	6.5	1.1	4.7	11.9
Ln(Home NOx Intensity)^2	2178	44.1	17.4	22.0	140.9
-Ln(Host CO_2 Intensity)	2685	7.5	0.6	5.8	8.6
-Ln(Home CO_2 Intensity)	2685	7.6	0.5	5.8	8.6
Ln(Home CO_2 Intensity)^2	2685	58.4	8.0	33.2	74.6
-Ln(Host GHG Intensity)	2575	7.4	0.7	5.7	8.7
-Ln(Home GHG Intensity)	2575	7.5	0.6	5.7	8.7
Ln(Home GHG Intensity)^2	2575	56.0	9.1	32.4	75.7
-Ln(Host PM <2.5)	1025	8.5	1.6	6.0	13.9
-Ln(Home PM <2.5)	1025	8.4	1.5	4.9	13.9
Ln(Home PM < 2.5 Intensity)^2	1025	72.2	30.2	23.7	192.6
Ln(Home GDP)	2685	12.9	1.5	8.7	16.1
Ln(Home Population)	2685	16.8	1.3	12.4	19.5
Ln(Home Trade/GDP)	2685	4.0	0.5	2.8	5.0
Ln(Home Skill)	2685	2.2	0.2	1.5	2.5
Ln(Host GDP)	2685	13.1	1.4	10.5	16.1
Ln(Host Population)	2685	17.1	1.2	15.3	19.5
Ln(Host Trade/GDP)	2685	4.0	0.5	2.8	5.0
Ln(Host Skill)	2685	2.2	0.2	1.5	2.5
Ln(Host Investment Costs)	2685	4.1	0.2	3.6	4.4
Ln (Host Corruption)	2685	0.7	0.7	(1.6)	1.9
Ln(Distance)	2685	7.7	1.1	5.3	9.9
Common Official Language	2685	0.1	0.3	0	1

Bilateral FDI stock and flow for OECD countries are measured in millions of U.S. dollars and come from SourceOECD (2006). The results presented in this paper use inbound FDI data reported by the host country. Measuring stringency of environmental regulation across countries has been a challenge. Rather than one comprehensive measure of regulation, I use five different emissions-based environmental regulation indicators measured by the inverse of emissions intensity of GDP. If the countries' industrial composition and technology were the same, then environmental standards would be reflected by the emissions intensity of GDP (emissions over GDP).[2] Higher emission intensity would imply lower regulation. For countries with dirty industries (or technology), this regulation measure will be low relative to countries with similar standards but cleaner industries. However, the opposite is true about countries with clean industries. This reduces variation in the environmental regulation variable and it may adversely affect the possibility of detecting the pollution haven effect.[3] Emission data come from United Nations GEO Data Portal online and include sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon dioxide (CO_2), green house gases (GHG), and particulate matter smaller than 2.5 microns (PM25). There are other emission data available through this source but the omitted pollutants are closely related to the transportation sector, agricultural sector or residential wastewater.

GDP per capita, population, and trade costs come from World Development Indices 2004. To control for trade costs I include openness to trade measured by imports plus exports divided by GDP. This is a commonly used proxy for trade costs—higher openness to trade implies lower trade costs. Skill variable is the average years of schooling for

[2] Ln(Reg) = Ln(GDP / Emissions) = −Ln(Emission Intensity)

[3] Suppose there are four countries: a country with clean industries and high regulation (clean-high), a country with dirty industries and high regulation (dirty-high), a country with clean industries and low regulation (clean-low) and a country with dirty industries and low environmental regulation (dirty-low). If the true environmental regulation was known then clean-high and dirty-high would be assigned the same high value and clean-low and dirty-low would both be assigned a low value for regulation. With the proposed measure above, clean-high will receive a high measure, dirty-low will receive a low measure, while dirty-high and clean-low would receive something between the two.

Table 2
Bilateral FDI stock, OLS regressions.

	(1)	(2)	(3)	(4)	(5)
Variables	SO_2	NOx	CO_2	GHG	PM25
Ln(Host Reg)	−0.829***	−0.368***	−0.736***	−1.068***	−0.086
	(0.065)	(0.027)	(0.122)	(0.098)	(0.075)
Ln(Home Reg)	0.799**	0.568**	7.261***	4.317***	1.731***
	(0.319)	(0.255)	(1.196)	(1.147)	(0.236)
Ln(Home Reg)^2	−0.051**	−0.056***	−0.443***	−0.281***	−0.082***
	(0.022)	(0.016)	(0.076)	(0.074)	(0.012)
Ln(Home GDP)	2.724***	3.181***	1.959***	2.514***	2.642***
	(0.151)	(0.124)	(0.157)	(0.145)	(0.135)
Ln(Home Population)	−1.429***	−1.879***	−0.732***	−1.350***	−1.409***
	(0.154)	(0.119)	(0.165)	(0.149)	(0.142)
Ln(Home Trade/GDP)	1.884***	1.968***	1.286***	1.130***	1.359***
	(0.116)	(0.108)	(0.099)	(0.103)	(0.175)
Ln(Home Skill)	1.715***	1.360***	2.297***	1.687***	0.766
	(0.192)	(0.189)	(0.229)	(0.217)	(0.495)
Ln(Host GDP)	2.510***	0.829***	1.312***	1.801***	1.121***
	(0.222)	(0.147)	(0.157)	(0.151)	(0.243)
Ln(Host Population)	−1.462***	0.512***	−0.254	−0.905***	0.124
	(0.242)	(0.147)	(0.176)	(0.170)	(0.231)
Ln(Host Trade/GDP)	1.690***	1.236***	0.530***	0.144	1.083***
	(0.143)	(0.131)	(0.112)	(0.117)	(0.242)
Ln(Host Skill)	−0.140	0.284	−0.562***	−0.412**	−0.620
	(0.196)	(0.188)	(0.191)	(0.172)	(0.592)
Ln(Host Investment Costs)	−0.049	−1.378***	−0.705**	−0.778***	−1.757**
	(0.350)	(0.288)	(0.285)	(0.281)	(0.713)
Ln(Host Corruption)	−0.289***	−0.716***	−0.577***	−0.395***	−0.427***
	(0.083)	(0.071)	(0.072)	(0.074)	(0.149)
Ln(Distance)	−0.561***	−0.510***	−0.793***	−0.853***	−0.643***
	(0.040)	(0.035)	(0.034)	(0.035)	(0.046)
Common Official Language	1.543***	1.656***	1.485***	1.377***	1.357***
	(0.097)	(0.083)	(0.084)	(0.084)	(0.139)
Trend	0.615***	0.417***	0.210**	0.243**	0.280*
	(0.112)	(0.102)	(0.103)	(0.101)	(0.145)
Trend^2	−0.020***	−0.014***	−0.007**	−0.007**	−0.010**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Constant	−27.561***	−30.629***	−46.516***	−19.767***	−28.029***
	(2.955)	(2.593)	(6.235)	(6.027)	(4.663)
Observations	1900	2178	2685	2575	1025
R-squared	0.743	0.734	0.719	0.733	0.790

Standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

individuals over age 25. These data are reported every five years between 1980 and 2000 by Barro and Lee (1996). I use linear interpolation for intermittent years. Investment costs are measured as the inverse of a composite index comprising of operations risk index, political risk index, remittance and repatriation factor index. These indices are developed by Business Environment Risk Intelligence S.A.[4] The corruption measure used is the Corruption Perceptions Index published by Transparency International. The common language dummy and distance variables come from Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) available online at www.cepii.fr. Descriptive statistics are provided in Table 1.

6. Results

As expected, I find that host country environmental regulation decreases FDI. Home country regulation is included to detect the aggregate pollution haven and shut down effects embedded in the quadratic relationship discussed in Section 3 and depicted in Fig. 3. The results in Table 2 do in fact confirm the predicted home country relationship. For each of the five environmental regulation measures I find that an increase in home country regulation at low levels of home regulation increases FDI but at high levels of home regulation decreases FDI. Not only do the predicted relationships confirm concavity, the estimated coefficients' quadratic relationships have the inflection points within the sample ranges of home regulation.[5] This matches the prediction in Fig. 3 that the pollution haven effect of increased home regulation driving more investment abroad is at some point overwhelmed by the shutdown effect and decreasing foreign investment. Therefore, these results provide evidence of pollution haven and shutdown effects necessary for the existence of pollution haven hypothesis.

The estimated coefficients of the covariates are with predicted signs and statistically significant. Larger home and host economies are engaged in more FDI. As home population increases income per capita decreases and FDI decreases. Home countries more open to trade (with lower trade costs) and with higher skilled workers engage in more FDI.

The host country population effect on FDI is not robust across specifications. Therefore, income per capita does not necessarily increase FDI into OECD countries. For this sample lower-skilled host countries tend to attract more FDI consistent with vertical FDI. As expected, host country investment costs and corruption both significantly reduce FDI. Distance between countries lowers FDI while common official language increases FDI. Overall, the estimated equations explain between 70 and 80% of the variation in log of FDI and match theoretical expectations outlined in Section 4.

[4] For more information see http://www.beri.com.

[5] Inflection point for home environmental regulation function (minimum, maximum) by column in Table 2: SO_2 7.79 (3.6, 9.5), NOx 5.06 (4.7, 11.9), CO_2 8.20 (5.8, 8.6), GHG 7.67 (5.7, 8.7), PM25 10.53 (4.9, 13.9)

These results are robust to a number of modifications. Substituting the dependent variable, FDI flow in lieu of FDI stock, did not change our main findings. Including log of GDP squared as an independent variable or replacing the quadratic trend terms with year fixed effects also provided qualitatively similar results. Allowing for a quadratic form of host regulation produced three different shapes of estimated host–country–regulation relationships.[6] The remaining coefficients, including home regulation coefficients, remained qualitatively unchanged. Since theory does not provide a good reason to include host regulation variable in the quadratic form, this paper models it linearly.

A caveat of my empirical model is that environmental regulation is treated as exogenous. Instrumenting for host environmental regulation improves the chances of detecting the pollution haven effect (Brunnermeier and Levinson, 2004). Therefore, correcting for the potentially endogenous relationship between FDI and environmental regulation should only strengthen these results. While total FDI may have an effect on environmental regulation, the data used here are unlikely to suffer from endogeneity because FDI to or from just one country should not have much of an impact on the country's regulation, particularly for OECD countries involved in bilateral FDI with many countries.

To distinguish between rich and poor country effects I estimated separate regressions for FDI taking place between rich countries only and FDI going from rich countries to poor countries (rich-poor). The poor countries in this sample are the Czech Republic, Hungary, the Republic of Korea, Mexico, Poland, the Slovak Republic and Turkey. Both sets of results are similar to those presented in the paper. Although, for each subsample one of the estimated home-country parabolas reversed from concave to convex. Furthermore, the rich–poor sample size was insufficient to identify statistically significant regulation effects.

7. Conclusion

A necessary condition for the pollution haven hypothesis is the presence of a large pollution haven effect. This paper outlines the potential effects of environmental regulation on mobile capital and estimates the effects of host and home country environmental regulation on FDI. If the home country increases its environmental regulation then the pollution haven effect implies that more investment would be shifted abroad—an increase in FDI. However, in an extreme case the multinational would shut down home operations and become a foreign firm— the shutdown effect. When home country regulation increases the pollution haven effect and the shutdown effect work in opposite directions. I find that an increase in home country environmental regulation increases FDI at low levels of regulation but decreases FDI at high levels of regulation, suggesting that home environmental regulation may be driving investment from home countries. On the other hand, an increase in host country regulation results in both a negative pollution haven effect and a negative shutdown effect. The empirical results show evidence that FDI decreases when host country environmental regulation increases. Despite including only the relatively rich OECD countries, this paper provides evidence of significant pollution haven effects.

Acknowledgments

I thank Ron Davies, Glen Waddell, Bruce Blonigen, Trudy Cameron, Doug Dalenberg and the participants of WEAI 2008 session for their comments. Any errors or omissions are the responsibility of the author.

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[6] For host regulation, four of the regressions find a convex relationship (three statistically significant). For SO_2 and GHG the inflection points of the quadratic relationship fall outside the host regulation sample range, so that the implied relationship is negative. For CO_2 the estimated host–country relationship was estimated concave with the inflection point within the sample.