Institutionalized Pollution Havens

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Abstract

This paper provides a lobby group theory based on Prat and Rustichini (*Econometrica* 2003) which suggests that the effect of foreign direct investment (FDI) on environmental policies is conditional on the structure of host countries' political institutions. In particular, FDI raises environmental policy stringency where the number of legislative units (such as the chambers of parliament or congress, government parties, the president, or the prime minister) are many, but reduces it where the legislative units are few. Our panel data evidence is fully consistent with this prediction. Pollution havens are thus more likely to occur in countries with institutional structures involving few legislative units. Finally, we show the empirical importance of endogenizing environmental policy in pollution haven hypothesis studies. Only when environmental policy is treated as endogenous does environmental policy stringency have a significant negative effect on FDI. This sheds new light on the existing literature on the pollution haven hypothesis.

Keywords: Pollution Haven Hypothesis, FDI, Environmental Policy, Political Economy, Political Institutions.

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I. Introduction

The assertion that countries with relatively weak environmental regulations will increasingly specialize in pollution intensive production has become the subject of a rapidly growing body of literature in recent years.[1] Commonly known as the Pollution Haven Hypothesis (PHH), the argument is often tested by examining the impact of environmental regulations on patterns of foreign direct investment (FDI) (see, e.g., List and Co 2001, Xing and Kolstad 2002). However, the literature contains very few investigations of the reverse relationship, i.e. the possible effects of FDI on environmental regulations - the only exception is Cole *et al*. (2006), to our knowledge.[2] This appears to be an important omission by the PHH literature since evidence suggests that foreign firms frequently lobby and bribe host country governments in order to influence policy to their advantage.[3] Furthermore, the sheer scale of FDI - in 2004 world FDI inflows were $648 billion, with the estimated stock of FDI equal to $9 trillion (UNCTAD 2005) - suggests that the potential lobbying power of foreign firms is significant, particularly in those countries most reliant on inward FDI.

If feedback does exist from FDI to regulations, a failure to take it into account will result in spurious econometric estimates. This paper therefore examines whether feedback does exist from FDI to regulations. In examining these feedback effects we draw upon a body of literature that emphasizes how political institutions such as presidential vs. parliamentary systems and electoral rules influence environmental and fiscal policy outcomes (see Persson *et*

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[1] See Taylor (2004) for an insightful discussion.

[2] Cole *et al*. (2006) study the environmental policy effects of FDI in the presence of corruption. They find that FDI raises (lowers) the stringency of environmental policy where the degree of corruption is low (high).

[3] Hellman *et al*. (2000) provide evidence of the corrupt practices of foreign investors in the transition economies and indicate that foreign firms are more likely to engage in lobbying and bribery than domestically owned firms. Kennedy (2005) documents the significant influence of foreign businesses on national economic policy in China and outlines how foreign firms are often assisted by their own governments when lobbying Chinese policy makers. Similarly, James and Ramstetter (2005) report that foreign owned firms in Indonesia and Thailand successfully lobbied the Indonesian and Thai governments for favorable economic policies. Finally, Gawande *et al*. (2004) provide evidence of lobbying by foreign firms in the US that resulted in reductions in US trade barriers.

al. 2000, Milesi-Feretti *et al*. 2002, and Fredriksson and Millimet 2004a, 2004b, 2006).[4] These studies suggest that economic policy, including environmental policy, is affected by the characteristics of host countries' political institutions. If so, then it appears important to investigate the impact of foreign firm lobbying on environmental regulations in the presence of different host countries' political structures. The political institution of particular interest in this paper is the number of legislative units (LUs) (or veto players). LUs are branches of government such as (dependent on the political system) the president, the prime minister, the chambers of parliament or congress, the government coalition parties or the majority party (see Tsebelis 1999, 2002; Keefer and Stasavage 2003).[5]

While the feedback effects of FDI on environmental regulations have received very little attention within the PHH literature, the impact of political institutions on these feedback effects has never previously been examined. A novel contribution of this paper is therefore to examine whether the effect of FDI on environmental regulations is influenced by the characteristics of a country's political institutions, and in particular by the number of legislative units of the government.

We start the analysis by developing a stylized lobbying theory using a single-principal, multi-agent model (a special case of Prat and Rustichini (2003), which has rarely been applied in the literature, to our knowledge) (as opposed to the multi-principal, single-agent model used by as in the single LU model by Grossman and Helpman 1994). This approach is particularly suited for the issue at hand. A firm lobby, formed by identical domestic and foreign firms, attempts to influence a government made up of n identical and independent LUs. The imperfectly competitive firms are engaged in quantity competition in a local market. The firm lobby offers all LUs prospective campaign contributions that are conditional only on the

[4] This literature is ignored by Cole *et al*. (2006).

pollution tax policy set by the LU itself. Each LU values campaign contributions, as well as aggregate social welfare, and independently selects its optimal tax policy (identical for all LUs in a symmetric equilibrium) after receiving the contribution offer from the lobby. Each LU's relative weight on aggregate social welfare may be regarded as a measure of LU honesty (see Schulze and Urspung 2001).

The model reveals that the arrival of a foreign subsidiary (equivalent to FDI) has two main effects on environmental policy. First, it has what we denote an "influence effect." By raising the lobbying effort of the firm lobby group (due to a greater aggregate output level of the lobby group members), FDI weakens the pollution tax policy. Second, FDI has a "welfare effect", which induces the government to raise the pollution tax. The intuition is that in an imperfectly competitive market with polluting firms, a welfare maximizing government sets a second-best tax policy which addresses both the pollution damage and the insufficient level of firm competition. Thus, the equilibrium tax policy is sub-optimally lax (below the first-best level) in order to raise output and consumer surplus (see Barnett 1980, Katsoulacos and Xepapadeas 1995). With greater product market competition due to FDI, the government's second-best pollution tax becomes stricter since the government's incentive to lower this tax declines.

The predictions that emerge are twofold; the effect of FDI on environmental policies is conditional on (i) the host country's set of LUs; and (alternatively) (ii) the host country's number of LUs *adjusted* by the LUs' degree of honesty, which we denote "aggregate honesty".[6] FDI has a positive (negative) effect on environmental policy stringency when the number of LUs are relatively many (few), and when "aggregate honesty" is high (low). This is

[5] Fredriksson and Millimet (2006) show that the dispersion of environmental policy outcomes is lower in bicameral systems.

[6] In equilibrium, the importance of the "welfare effect" relative to the "influence effect" depends on "aggregate honesty;" i.e. a composite variable made up by the number of LUs times their degree of honesty. Aggregate

due to the welfare effect dominating (being dominated by) the influence effect. Thus, the effect of FDI on environmental policy is institution- and specific and (and thus country-specific).

It follows that in economies with relatively few LUs and with low "aggregate honesty", pollution havens are more likely to become "institutionalized" due to FDI since the resulting weaker environmental policies contribute to greater pollution emissions, *ceteris paribus* (in addition to additional emissions due to the rise in output). This paper is the first to point out such a channel from FDI to environmental policy and emissions, via the structure of domestic political institutions.

Our empirical analysis, using a cross-country panel of data covering 33 countries, provides strong support for the main prediction of the model. The impact of FDI on environmental regulations is found to be statistically significant, and conditional upon the number of LUs. More specifically, FDI is found to reduce the stringency of regulations when the number of LUs is low, but to raise regulations when the number of LUs is relatively high. This finding is robust across a battery of sensitivity tests. We also find evidence that the "aggregate honesty" variable does play a similar role as the number of LUs by themselves, although the evidence is somewhat weaker.

Our empirical findings have significant implications for the existing PHH literature which typically assumes a unidirectional relationship between FDI and environmental regulations. If the activities of foreign firms themselves influence the stringency of regulations, then both regulations and FDI should be modeled simultaneously in empirical PHH studies. Failing to control for endogeneity between these two variables will result in spurious results. This may perhaps help explain the relative lack of evidence found for the PHH.

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honesty reflects the difficulty that a lobby group faces in its attempt to influence policy. We believe this paper is the first to take this combined perspective on institutional structure and policy maker corruptibility.

Indeed, we demonstrate that previously elusive PHH evidence is found once FDI and regulations are modeled simultaneously.[7] Strict environmental policies are now found to deter FDI, and the detected effects are significant both statistically and economically. This is a second main contribution of the present paper. Future empirical work on the PHH should consequently take into account the existence of feed-back effects demonstrated in this paper.

A small body of literature similarly suggests that trade and investment flows may endogenously determine regulations (Damania *et al*. 2003, Ederington and Minier 2003, Cole *et al*. 2006).[8] However, this literature has typically focused on US trade and investment flows, and US regulations. Moreover, it has ignored variations in political institutions across countries. This paper suggests a new mechanism though which FDI may influence regulations, and provides evidence of such endogeneity using cross-country data.

The paper is organized as follows. Section II sets up the model and derives the theoretical predictions and Section III presents the empirical analysis evaluating the theory, and Section IV utilizes the insights gained for PHH study. Section V concludes.

II. The Model

A small economy contains domestic producers, foreign producers, consumers, and at least one legislative unit (LU) of government. As in Grossman and Helpman (1996), a continuum of N^D identical domestic firms and N^F foreign subsidiaries are producing and competing (in quantities) in the local market which is imperfectly competitive, where $N^D + N^F = N$. The number of active firms in the market is taken as given, and (for simplicity) the market is assumed to be supplied exclusively by the N firms located within the

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[7] Additional reasons for the elusiveness PHH evidence are discussed by Ederington *et al*. (2005). In a study focusing on trade flows, Ederington *et al*. show that pollution abatement costs influence imports from developing countries, and in sectors with mobile (footloose) factors of production.

[8] Ederington and Minier (2003) argue that environmental regulations are affected by the level of imports, Fredriksson *et al*. (2003) discuss the environmental policy effects of corruption and the effect of environmental policy on FDI, and Damania *et al*. (2003) explore the effects of trade openness and corruption. While Cole *et*

jurisdiction's borders. High transportation costs (e.g.) are assumed to shield the N firms from the world market, and no trade takes place.[9]

Local production involves domestic pollution damage, s, which is controlled by the government with the help of an emissions tax, $t \in T \subset R_+$, per unit of pollution. Firm i's output is

given by q_i. The gross profit function of firm i (disregarding any political gifts) is given by

$$\pi_i = p(Q)q_i - e(q_i, w_i) - s_i t - F, \tag{1}$$

where $p(Q)$ is the inverse demand function, Q is consumption of the polluting good with price $p = a - Q$ (where a>0 reflects the local market size), $Q = \sum_i q_i = Nq_i$, $e(q_i, w_i) = cq_i + gw_i$ is the cost function, where w_i is abatement (following Katsoulacos and Xepapadeas 1995). The parameters c and g represent the marginal production and marginal abatement costs, respectively.[10] Total abatement costs are thus given by gw_i. F is the fixed cost of production. Following Katsoulacos and Xepapadeas (1995), the pollution damage function equals $s_i = vq_i + \beta w_i^{-\gamma}$, $s_i \geq 0$, which is increasing (and linear) in q_i and decreasing and concave in w_i. Thus, pollution abatement exhibits diminishing returns. This functional form is (in our view) tractable, and implies that marginal damage from pollution equals unity (because the population of consumers is normalized to unity, see below). Firms may reduce pollution damage both by abatement and output reduction. c, v, β, and γ are positive parameters.

al. (2006) investigate the effects of FDI on environmental policy in the presence of corruption, they do not test the pollution haven hypothesis.

[9] Thus, FDI serves as a substitute for trade in this model. Brainard (1997) shows that FDI is more likely to occur the higher are transportation costs and trade barriers. In our view the inclusion of an additional market complicates the analysis without improving upon our insights, and we thus ignore this aspect.

[10] Since our focus is on the political economy effects of FDI on environmental policy, we abstract from possible differences in marginal abatement costs between domestic and foreign firms. Thus, we (implicitly) assume that capital vintage, technology, and know-how are identical across firms.

The output and abatement levels that maximize profits satisfy the FOCs $\frac{\partial \pi_i}{\partial q_i} = a - Q - q_i - c - vt = 0$ and $\frac{\partial \pi_i}{\partial w_i} = -g - t\gamma\beta w_i^{-(\gamma+1)} = 0$. The implicit function theorem applied to the FOCs yields $dq_i/dt < 0$, and $dw_i/dt > 0$. In the Nash equilibrium, firm *i*'s output and abatement levels, given the pollution tax, *t*, equal $q_i = (a - c - vt)/(1 + N)$ and $w_i = (\beta\gamma t / g)^{1/1+\gamma}$, respectively. Foreign firms' profits are assumed fully repatriated to their home jurisdictions.

The population of consumers is normalized to unity. The utility of the representative consumer equals $U = u(Q) - s$, where $u(Q)$ is a concave, twice differentiable sub-utility function. The consumers' aggregate welfare equals (*x* is the integrating variable):

$$W^{CO}(t) = \int_0^Q p(x)dx - p(Q)Q + N(t-1)s(q,w), \tag{2}$$

i.e. the sum of consumer surplus, pollution tax revenues (equally redistributed to all consumers), less the damage from pollution, respectively.

The government consists of $n \geq 1$ independent and identical legislative units (LUs) with symmetrical power, indexed by *k*, which each independently sets its optimal pollution tax. The LUs are branches of government such as (dependent on the political system) the president, the prime minister, the chambers of parliament or congress, the government coalition parties or the majority party (in majority systems). Thus, rather than assuming one government unit as in much of the lobbying literature, we assume *n* LUs are all equally involved with policy making. While this assumption is a simplification, we believe this approach enables us to more accurately model real world policy-making and further advance of this type of model. It enables us to analyze the effects of FDI on environmental policies across countries with different number of LUs. As we will see below, the number of LUs is important for the relative influence of lobbying on policy outcomes.

A Three Stage Game

While in the first stage, all domestic and foreign firms active in the local economy join the firm lobby, the consumers are assumed unable to overcome free-riding problems (and are consequently not represented by a lobby group). The organized firm lobby offers a prospective contribution schedule $C^k(t^k)$ to each LU *k*. Thus, following Prat and Rustichini (2003) the promised contribution is made contingent *only* on the LUs' pollution tax policy choice, t^k, and the other LUs' policy choices do not matter for the size of the promised gift to LU *k*. In the second stage, each LU selects its optimal environmental policy, t^{k*}, and collects the corresponding political contribution from the firm lobby. We focus on a symmetric equilibrium, where each identical LU sets an identical pollution tax. Thus, the equilibrium tax equals $t^{k*} = t^*$. In the third stage, the firms set output and abatement levels.

The organized lobby contains a negligible number of individuals, and it thus ignores consumer surplus and tax revenues. The lobby's gross-of-contributions utility function is

$$V(t) \equiv (N^D + N^F)\pi. \tag{3}$$

Each LU *k* maximizes a weighed sum of political contributions and aggregate (gross-of-contributions) social welfare implied by its own pollution tax policy choice, and is thus given by

$$L^k(t^k) = C^k(t^k) + \alpha W^k(t^k), \tag{4}$$

where $\alpha > 0$ is the LU's (exogenous) weight on aggregate social welfare relative to contributions. Following, e.g., Schulze and Ursprung (2001), Damania *et al.* (2003), and Fredriksson and Millimet (2006) we interpret the weight α as a measure of LU honesty, i.e. the inverse of corruptibility.[11]

[11] Schulze and Ursprung (2001) argue that since in Grossman and Helpman's (1994) model the contributions are used to influence policy rather than elections, the framework reflects a corruptible government.

Since all foreign firm profits are repatriated, they are not part of LU k's aggregate social welfare function, which only includes the domestic firms' profits,

$$W^k(t^k) = W^{CO}(t^k) + N^D \pi(t^k). \qquad (5)$$

A pure strategy equilibrium is a subgame perfect equilibrium of the three-stage game in which all LUs and the lobby group employ pure strategies. For this case of a game played through agents (GPTA), a set of contribution schedules $\{C^{k*}\}_{k \in K}$, and a pollution tax $t^* = \{t^{k*}\}_{k \in K}$, is a pure-strategy equilibrium if for every LU k, and for every feasible contribution schedule, $t^{k*} \in \arg\max_{t^k \in T^k} [\alpha W^k(t^k) + C^k(t^k)]$, taking the offered schedules as given; and the lobby does not have a feasible strategy that yields a net payoff greater than the equilibrium net payoff.

The Political Equilibrium

Prat and Rustichini's (2003) Theorem 1 characterizes the pure strategy equilibrium for a GPTA with a finite set of actions. We assume here that their results apply to a situation with a continuous action choice set, and restrict attention to equilibria that lie in the interior of T. Theorem 1 of Prat and Rustichini (2003) implies that an equilibrium of the pollution tax policy determination game can be characterized as follows:

Theorem P-R: *A set* $(\{C^{k*}\}_{k \in K}, t^*)$ *of contributions and a pollution tax policy is a pure strategy equilibrium iff*

(C1) *for every* $k \in K$, t^{k*} *maximizes* $\alpha W^k(t^k) + C^{k*}(t^k)$ *on* T^k;

(C2) t^* *maximizes* $\left[V(t) - \sum_{k \in K} C^{k^*}(t^k) \right] + \left[\alpha \sum_{k \in K} W^k(t^k) + \sum_{k \in K} C^{k*}(t^k) \right]$ *on* T;

(C3) *for every* $k \in K$, $\alpha W^k(t^{k*}) + C^k(t^{k*}) = \max_{t^k \in T^k} \alpha W^k(t^k)$.

Condition (C1) states that each LU favors an environmental policy that maximizes her payoff, given the contribution schedule offered by the lobby group. Condition (C2) requires incentive compatibility. First, note that since all LUs are identical and are offered identical contribution schedules, they favor identical equilibrium tax policies, such that $t^{k*} = t^*$, and $V(t^{k*}) = V(t^*)$. Condition (C2) establishes that the equilibrium tax policy t^{k*} must maximize the joint welfare of the lobby (the first parenthesis) and the collective of LUs (the second parenthesis) (for now, we retain $\sum_k C^{k^*}(t^k)$ in (C2) in order to clarify the exposition). This suggests that the lobby may induce the collective of LUs to select any environmental policy, provided that it offers a sufficiently large sum of contributions. If the lobby seeks to persuade LU k to change her favored policy, it must at a minimum offer an increase in the political gift that fully compensates her for the associated utility loss. For t^{k*} to be an equilibrium, this additional compensation must be greater than the benefit of any alternative tax, t^k. Thus, at the equilibrium, $t^{k*} = t^*$, it cannot be possible for the lobby to induce an increase in the total surplus that may be divided between itself and the n LUs by reformulating the contribution schedules. Since $t^{k*} = t^*$ and $V(t^{k*}) = V(t^*)$, and by cancelling the $\sum_k C^{k^*}(t^k)$ terms, condition (C2) may be reformulated as:

(C2') $$t^{k*} \text{ maximizes } V(t^k) + \alpha \sum_{k \in K} W^k(t^k) \text{ on } T^k.$$

Thus, in the selection of the equilibrium pollution tax, the domestic firms' welfare is weighted relatively more heavily than the consumers' and the foreign firms' welfare. In particular, the domestic firms' weight equals $(1+\alpha)$. However, the weight on the lobby's welfare declines as the number of LUs rises, since the second term in (C2') becomes more influential as n increases (i.e. as the set K contains more LUs).

Condition (C3) states that each lobby group minimizes the costs involved with the implementation of the equilibrium policy, t^{k*}. For each LU k, the lobby scales back its offer until k is indifferent between the equilibrium policy, t^{k*}, and some alternative t^{k} associated with a zero contribution from the lobby. To find the (implicit) equilibrium characterization, we take the FOC of (C2').[12] After simple rearrangements, this yields

$$\alpha \frac{\partial W^{k}(t^{k*})}{\partial t^{k^{*}}} + \frac{1}{n} \frac{\partial V(t^{k*})}{\partial t^{k^{*}}} = 0, \tag{6}$$

since the LUs' weight on welfare is summed n times.

Expression (6) implicitly defines the equilibrium policy, t^{*}, since in the symmetric equilibrium the n identical LUs select identical pollution tax policies, t^{k*}, such that $t^{k*} = t^{*}$. Eqn. (6) suggests that in equilibrium each LU weighs aggregate social welfare against the lobby group's welfare. The latter component is adjusted by n, the number of LUs, suggesting that the lobby's relative influence is decreasing with the number of LUs. This is due to the associated increase in lobbying costs resulting from the greater number of required campaign contributions necessary to influence policy. As n grows, the lobby therefore scales back its contribution offers, resulting in the LUs implicitly placing a greater weight on social welfare. Essentially, as $n \to \infty$, the political market for contributions approaches perfect competition, the size of the contribution offers made declines to zero, and the LUs become a welfare maximizing collective.

To find an explicit expression for the equilibrium characterization we need to find the marginal effect of the pollution tax on the lobby group's welfare, given by (3), and on aggregate social welfare, given by (5). Substituting the resulting expressions into (6) (using the envelope theorem) yields

$$\underbrace{-Ns-\alpha N^{D}s}_{A}+\underbrace{\alpha n}_{B}N\underbrace{\left[s-\frac{vqN}{1+N}-(t-1)\left(\frac{v^{2}}{1+N}+\frac{(\beta\gamma)^{2}w^{-(1+\gamma)}}{g(1+\gamma)}\right)\right]}_{C}=0, \qquad (7)$$

where term A is the aggregate effect of the lobby group on the equilibrium tax (via lobbying and the government's consideration of lobby welfare), and term C is the government's consideration of consumer welfare. In this model, the pollution tax is subject to several downward pressures that contribute to reducing the tax below the welfare maximizing rate that would be selected in a perfectly competitive setting (the first-best pollution tax, which equals 1 since the population is normalized to 1). First, the lobby group offers contributions in return for a lower pollution tax. Second, with imperfect competition in the output market, the government lowers the pollution tax with an aim to raise consumer surplus (see Barnett 1980, Katsoulacos and Xepapadeas 1995). Since term A in (7) is unambiguously negative, term C must be positive.

In this paper, we propose a new perspective on lobby group influence, reflected by term B. In our view, the composite term αn reflects the "aggregate honesty" in the political process, because it amounts to the aggregate weight put on social welfare by the LUs deciding on environmental policy. The composite term thus mirrors the total level of resistance that the lobby group faces when attempting to influence policy. We henceforth denote αn by "aggregate honesty."

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[12] For completeness, in Appendix I we derive the equilibrium characterization using an approach that would be applicable also to the more general multi-principal, multi-agent model.

Next, we make the following assumption, which implies that t^* is set below marginal social damage from pollution:[13] **Assumption 1:** *In equilibrium*, $t^* = t^{k*} < 1$.

Assumption 1 simplifies the discussion below, without driving the results. We now show:

Proposition 1(*i*): *In the political equilibrium, the pollution tax increases* (*decreases*) *with the number of foreign firms if the number of legislative units is sufficiently high* (*low*).

Proposition 1(*ii*): *In the political equilibrium, the pollution tax increases* (*decreases*) *with the number of foreign firms if aggregate honesty is sufficiently high* (*low*).

Proof: (*i*) Differentiation of (7) yields

$$\frac{dt^*}{dN^F} = \frac{\overbrace{-s}^{A} + n\overbrace{\alpha\left(\beta w^{-\gamma} + \frac{vq(1+N(N-1))}{1+N} - \frac{(t^*-1)(\beta\gamma)^2 w^{-(1+\gamma)}}{g(1+\gamma)}\right)}^{B}}{-D}, \tag{8}$$

where D is the second-order condition of the equilibrium characterization (7), the solution to the government's maximization problem. A simple sufficient condition for D<0 is $(n - \alpha^{-1} - N^D N^{-1}) > 0$, see Appendix II. We assume D<0. Term *A* in the numerator of (8) is negative, and term *B* is positive under Assumption 1. With a positive denominator, -*D*, it follows that $\frac{dt^*}{dN^F} > (<) 0$, when $n > (<) \frac{s}{\alpha\left(\beta w^{-\gamma} + \frac{vq(1+N(N-1))}{1+N} - \frac{(t^*-1)(\beta\gamma)^2 w^{-(1+\gamma)}}{g(1+\gamma)}\right)}$.

Q.E.D.

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[13] Assumption 1 appears relatively weak. If we assumed that all firms' profits (i.e. also foreign firms') were included in aggregate social welfare, it would hold automatically.

(ii) Analogously to the proof of part (i), $\frac{dt^*}{dN^F} > (<) 0$, when

$$n\alpha > (<) \frac{s}{\beta w^{-\gamma} + \frac{vq(1+N(N-1))}{1+N} - \frac{(t^*-1)(\beta\gamma)^2 w^{-(1+\gamma)}}{g(1+\gamma)}} . \quad \textit{Q.E.D.}$$

The environmental policy impact of an additional foreign subsidiary (given the number of domestic firms) depends on the number of LUs. The net impact of FDI on the pollution tax is determined by two main effects. First, an increase in the number of foreign firms active in the domestic (output and political) markets increases the political pressure for a lower pollution tax. Since the firm lobby's output level increases, the stakes involved with pollution taxation increases for the lobby group. At a higher output level, a small change in the pollution tax has a greater impact on aggregate profits on the margin. This is an "influence effect" of FDI, which results in a weaker environmental policy (term A in (8)). Second, an increase in the total number of active firms raises the degree of product market competition.[14] This lessens the government's incentive to lower the pollution tax in order to keep domestic output, and thus consumer surplus, high. An increase in the output quantity also raises pollution, and it reduces the domestic firms' profits.; these effects also contribute to the government setting a higher tax. We denote the sum of these impacts a "welfare effect" of FDI which raises policy stringency (term B).

Where the number of LUs, n, is sufficiently low, the influence effect (term A) dominates and the additional foreign firm causes a decrease in environmental policy stringency. Where the number of LUs is sufficiently high, the welfare effect (term B) instead dominates and the additional foreign firm causes an increase in the pollution tax. The welfare effect dominates

[14] In an imperfectly competitive market with polluting firms, a welfare-maximizing government sets a second-best tax policy which addresses both the pollution damage and the insufficient level of firm competition

where the lobby's influence if relatively minor due to the presence of a large number of LUs. In such instances, influence activities are relatively costly due to a large number of political contributions required by the LUs, and the marginal effect of FDI on lobbying is consequently relatively minor. An analogous reasoning applies also to $n\alpha$, aggregate honesty.

From Proposition 1(*i*), it follows that FDI is more likely to create a pollution haven when the number of LUs is low.

Corollary 1: *In the political equilibrium, the pollution level is decreasing* (*increasing*) *in the number of foreign firms iff*

$$\frac{d(Ns)}{dN^F} = \underbrace{s}_{A} - N\left(\underbrace{\frac{vq}{1+N}}_{B} + \underbrace{\frac{v^2}{1+N}\frac{\partial t^*}{\partial N^F}}_{C} + \underbrace{\frac{\gamma\beta h^{-\frac{1}{1+\gamma}} t^{*-\frac{2\gamma+1}{1+\gamma}}}{1+\gamma}\frac{\partial t^*}{\partial N^F}}_{D} \right) < (>) 0. \quad (9)$$

Proof: Total differentiation of *Ns* yields (9). *Q.E.D.*

The intuition is as follows. The aggregate effect on pollution depends on the four terms in expression (9). Term *A* is the direct effect of an increase in the number of foreign firms. Term *B* is the decline in output per firm (and thus pollution) due to the higher degree of competition. Term *C* is the change in output per firm due to the tax change. From (8), $\partial t/\partial N^F > (<) 0$. Term *D* is the change in abatement due to the tax change. Assuming $\partial t/\partial N^F > 0$ (the number of LUs is sufficiently high) terms *C* and *D* may, together with term *B*, contribute to outweighing term *A*. In this case, the pollution level falls on the margin due to the investment, and a pollution haven is mitigated (environmental quality improves) by FDI. On the other hand, in the case $\partial t/\partial N^F < 0$ (the LUs are sufficiently few), only term *B* reduces

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(Barnett 1980, Katsoulacos and Xepapadeas 1995). Thus, the equilibrium tax policy is sub-optimally lax in order to raise output and consumer surplus.

pollution. FDI is more likely to create a pollution haven in this case. A similar analysis may be carried out also for aggregate honesty.

III. Empirical Analysis

Methodology

Our model proposes a clear relationship between FDI, the number of LUs and environmental policy. First, we assess the empirical support for Proposition 1(*i*) by estimating

$$ENVPOL_{it} = \alpha_i + \gamma_t + \beta' Z + \varepsilon_{it}, \tag{10}$$

where $ENVPOL_{it}$ denotes the stringency of environmental policy in country i in year t, α_i is a time-invariant country fixed effect, γ_t is a location-invariant time fixed effect, Z is our vector of independent variables, and ε_{it} is the error term. Eqn. (10) is estimated using a fixed effects specification (results from a random effects specification are available upon request).

Proposition 1(*i*) predicts that the effect of FDI on environmental regulations in country i is conditional on the number of LUs in country i. Specifically, FDI should have a positive effect on the stringency of environmental regulations when the number of LUs is high, but the impact should be negative when LUs are few. In order to empirically test this relationship, vector Z contains two alternative measures of inward FDI, two alternative measures of the number of LUs, and the interaction of FDI with the measure of LUs. Our model predicts that the estimated coefficient on FDI should be negative, while the coefficient on the interaction should be positive.

Eqn. (10) includes a number of control variables. *MANsh* represents the political pressure from manufacturing sector workers for weaker regulations with an aim to protect wages and jobs in the face of increased (foreign) competition. This is expected to have a negative impact on the stringency of environmental regulations. Since the literature suggests that lobby group size may have a non-monotonic effect, we include a quadratic term, $MANsh^2$ (see Potters and Sloof 1996). *MANsh* may alternatively capture the degree to which an economy consists of pollution intensive manufacturing. In this case *MANsh* may be positively signed, because the marginal pollution damage from domestic production rises.

The demand for environmental quality is expected to increase with income, and we thus include per capita income (*GDP*). In order to control for the greater exposure to industrial pollution by citizens in more urbanized countries, we include the urban population share (*URBsh*). Such political pressure should have a positive effect on regulatory stringency. However, following the literature on the environmental Kuznets curve (see, for example, Millimet *et al*. 2003), the marginal effect of both *GDP* and *URBsh* may be diminishing. Quadratic terms are therefore included. All explanatory variables are lagged by one year since the impact of the explanatory variables on environmental regulations may not be immediate.[15]

The direction of the hypothesized causality between *FDI* and *ENVPOL* in Eqn. (10) is the reverse of that assumed by the existing pollution haven literature. As a result, we control for potential endogeneity between *FDI* and *ENVPOL* by instrumenting *FDI* using three stage least squares (2SLS). To be suitable for use as an instrument, a variable must be correlated with *FDI*, but uncorrelated with ε_{it} in Eqn. (10). These requirements limit the choice of variables considerably. We use three instruments, two of which capture the degree of public infrastructure within the host country. The extent of public infrastructure is likely to influence potential investors' investment decisions (Wheeler and Mody 1992, Morrison and Schwartz 1996, Chandra and Thompson 2000). Our measures of infrastructure are the number of telephone mainlines (per 1000 people) and the number of television sets (per 1000 people). These variables capture the extent of a country's telecommunications network, electricity supplies, etc. Our third instrument is the economically active population, which captures the size and market of the host country. This reflects the empirical observation that small (large) countries tend to be more (less) open to both international trade and investment (see, e.g., Streeten 1993) and are therefore likely to have a greater (smaller) share of trade and FDI in GDP. Finally, the exogenous variables from Eqn. (10) are also included as instruments. The public infrastructure variables enter the first stage regression in lagged form, in order to minimize any possible causality moving from FDI to these variables.[16] A Sargan test of over-identifying restrictions is used to assess the validity of our instruments. Moreover, we also report F-tests of joint instrument significance. Finally, our sensitivity analysis investigates the robustness of our results to the choice of instruments by testing two alternative instruments.

In order to explore Proposition 1(*ii*), we use two alternative measures of aggregate honesty; the number of LUs multiplied by the degree of honesty.

Data Considerations

We have data for 13 OECD and 20 developing countries for the period 1982-1992. Table A1 in Appendix III provides all data sources and lists the countries included in the sample.

Although our theory discusses the policy effect of the number of foreign firms, empirical measures of this variable are, to the best of our knowledge, unavailable. We use two different measures of inward FDI, both scaled by aggregate GDP: (i) FDI stocks, and (ii) FDI flows (UNCTAD 2001). In our view, these two measures adequately capture the political effects discussed in the theory. While the FDI flow variable captures the effect on environmental regulation of new investments made, the FDI stock variable may better capture the overall effect of foreign investment. If there is a lag between the investment made and its political effects, the stock variable will also partially capture the effects of FDI flows. However, as already discussed, the explanatory variables are lagged to capture this political inertia.

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[15] The use of two and three year lags did not substantially change our results.

As a proxy for a country's environmental policies (*ENVPOL*) we use a measure of grams of lead-content per gallon of gasoline, previously utilized by, among others, Hilton and Levinson (1998) and Damania *et al*. (2003).[17] *ENVPOL* is created by multiplying the lead content in gasoline variable by –1. Thus, an increase in *ENVPOL* represents an increase in the stringency of regulations (i.e. a decrease in lead content). *ENVPOL* has multiple features that make it desirable as a measure of industry environmental regulations. Specifically, (i) the content of lead in gasoline is (almost) entirely a policy decision and is unlikely to be influenced by other factors; (ii) lead content in gasoline has both cross-section (including both developed and developing countries) and time-series coverage. No other alternative measures of regulations have this degree of coverage, to our knowledge; (iii) lead emissions are a particularly damaging local air pollutant with significant health implications, and the control of such emissions is therefore often an early environmental objective during a country's development;[18] (iv) lead-content of fuel has a statistically significant negative correlation with three other measures of industry environmental regulations (see Damania *et al*. 2003).[19]

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[16] Because the explanatory variables in our second stage regression (Eqn. (10)) are in lagged form, these also enter the first stage regressions in lagged form. This again minimizes any possible causal link from FDI.

[17] Lead content in gasoline is reported biannually. In order to obtain our reported results we assumed that lead contain remained constant over each two-year period. However, to test the sensitivity of our results to this assumption we also ran regressions in which each missing year of lead content data is assumed to be the average of the previous and the following year's lead content (e.g. 1985 lead content data is equal to the average of 1984 and 1986 lead content). Furthermore, we also ran regressions in which we only include the first reporting year (so the panel is effectively halved). The results were very similar across these three different samples. The key conclusions from our empirical analysis were the same.

[18] Since high lead content is considered by some to improve certain aspects of engine performance, it is possible that the demand for lead content in fuel could increase over time as consumers' income rose. However, in light of the known toxicity of lead it seems unlikely that such an effect would outweigh the environmental and health considerations.

[19] The first such measure considered by Damania *et al*. (2003) was constructed using forecasting techniques from Eliste and Fredriksson's (2002) single-year measure of environmental policy stringency and has a correlation of -0.78 with lead content in gasoline. This measure derived from UN Conference on Environment and Development (UNCED, 1992) country reports which cover numerous aspects of the environmental regulatory framework such as legislation, control mechanisms and enforcement. The second measure of environmental stringency is public expenditure on environmental R&D as a proportion of GDP. This variable is available for 1982-1992 for OECD countries only, and has a negative, statistically significant correlation of -0.38 with lead content. Thirdly, per capita membership of environmental organizations may be loosely correlated with the stringency of a country's environmental regulations, but panel data is only available for nine countries. It has a statistically significant correlation of -0.45 with lead content. We believe these

We use two alternative measures of the number of LUs within a country. The first measure, *CHECKS*, captures the number of checks and balances within government and is reported by the World Bank Database of Political Institutions, see Beck *et al*. (2001). *CHECKS* takes a minimum value of 1 if a country has no legislature, an unelected legislature, or a one-party legislature. The measure is incremented by one for each additional check or balance, e.g. for each chamber of the legislature, if a chief executive exists, and for every party in a governing coalition. Beck *et al*. (2001) and Keefer and Stasavage (2003) provide more information on *CHECKS*.

Our second measure of the number of LUs, *POLCON*, captures the number of political constraints within the legislature and is described in detail by Henisz (2000). Using data from political science databases, Henisz (2000) identifies the number of independent branches of government (executive, lower and upper legislative chambers) with veto power over policy change. The preferences of each of these branches and the *status quo* policy are then assumed to be independently and identically drawn from a uniform, uni-dimensional policy space. This initial measure is then adjusted in two ways in order to more accurately reflect the feasibility of policy change. Firstly, an adjustment is made according to the extent of alignment across branches of government using data on the party composition of the executive and legislative branches. A second adjustment is then made to capture the extent of preference heterogeneity within each legislative branch. While *CHECKS* fits the theory more closely, we believe *POLCON* may better reflect the actual number of LUs.

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measures to be inferior to lead content in gasoline as a measure of national environmental regulations due to their limited cross-country coverage, their potentially weak relationship with national environmental stringency and, in the case of the measure calculated using forecasting techniques, the reliance on a single-year measure of regulations. However, the fact that all three measures possess statistically significant correlations with lead content suggests that the latter variable captures national environmental regulations. See Damania *et al*. for details on the construction of these three alternative proxies for the stringency of environmental regulations, and Octel World Gasoline Survey for detailed information on the construction of the lead content variable.

Our two different aggregate honesty variables were created by multiplying a measure of honesty with *CHECKS* and *POLCON*, respectively, which resulted in AGG.HONESTY_1 and AGG.HONESTY_2. The 'government honesty' variable comes from the International Country Risk Guide used by Knack and Keefer (1995), and measures the extent to which "high government officials are likely to demand special payments". It takes the form of an index between 0 and 6, where 0 represents the least government honesty, and 6 the most honesty.

The control variables are defined in Appendix III. Table 1 provides summary statistics.

Results

Fixed effects (FE) 2SLS estimates of Eqn. (10), using both stock and flow measures of FDI and both *CHECKS* and *POLCON* as the measures of LUs, are reported in Table 2. [20] Comparable OLS results are provided in Appendix V, Table A3. As Table A3 indicates, Durbin-Wu-Hausman (DWH) exogeneity tests reject the null of OLS consistency, implying that our 2SLS estimates are preferred. Nevertheless, we report the OLS results for completeness. A Sargan test of over-identifying restrictions fails to reject the null that our 2SLS equations are properly specified. This suggests that our instruments are valid. An F-test also indicates that the instruments are jointly significant in the first stage estimations. Appendix IV, Table A2 reports these first-stage results.

The estimation results presented in Tables 2 provide clear support for the predictions of our theory. The impact of *FDI* on *ENVPOL* is found to be negative and statistically significant in three of the four models. Furthermore, the interaction of *FDI* with *CHECKS* and *POLCON* is found to be positive and statistically significant in all four models, implying that

[20] We found no evidence of first-order autocorrelation. A Hausman specification test indicated that the effects are correlated with the independent variables implying that the random effects (RE) results are inconsistent. For this reason, as well as for space considerations, we do not report the RE results (they are available from the authors upon request), although it is worth noting that they do support the findings of the FE specification.

the effect of *FDI* on *ENVPOL* is conditional upon the number of LUs. The F-test on the two FDI terms (which restricts their coefficients to zero) is highly significant in all models.

To gauge the magnitude of these impacts, Tables 2 reports the marginal effects of *FDI* on *ENVPOL*, calculated at the mean level of *CHECKS* or *POLCON*. Estimates are provided for a one unit increase in *FDI*, as well as for a one standard deviation increase in *FDI*. These marginal effects can be seen to vary in sign across models. For example, a one standard deviation increase in FDI stock (at the mean of *CHECKS*) will, according to model 1 in Table 2, result in an increase in *ENVPOL* of 0.44 (=(0.039 + (0.0073 x 2.99)) x 7.25), equivalent to a reduction in the lead content of gasoline of 0.44 grams. This reduction in lead content is equivalent to a decline of 0.45 of a standard deviation. Conversely, model 3 estimates that a one standard deviation increase in the FDI stock will result in a *decreas*e in *ENVPOL* of 0.10 (= (-0.057 + (0.10 x 0.43)) x 7.25), estimated at the mean of *POLCON,* equivalent to an increase in the lead content of gasoline of 0.10 grams. This rise in lead content is equivalent to an increase of 0.1 of a standard deviation.

Figures 1 and 2 illustrate how these marginal effects increase with the number of LUs measured by *CHECKS* and *POLCON*, respectively. Although the level of LUs at which the marginal effect becomes positive varies across models, by showing the marginal effects to increase with LUs across all models, these figures provide a significant degree of support for our theoretical prediction.

Turning to our control variables, *GDP* and GDP^2 are generally insignificant. In contrast, *URBsh* displays a negative relationship with *ENVPOL* that is increasing at the margin.[21] Across the four models, the minimum turning point levels of *URBsh* are between 50% and 54%, approximately the level of urbanisation in countries such as Ecuador and

[21] Both country fixed effects and time effects are consistent with prior expectations, with the latter indicating that *ENVPOL* has increased over time (i.e. lead content has decreased).

Morocco. Thus, for many countries in our sample, our estimates suggest that *ENVPOL* increases with the urban population share in accordance with our prior expectations. The sign of *MANsh* varies across models, although for three of our four models *MANsh* exhibits a negative relationship with *ENVPOL*, which is increasing at the margin.

Table 3 provides 2SLS results using our two measures of aggregate honesty, *AGG.HONESTY_1* and *AGG.HONESTY_2*, calculated using *CHECKS* and *POLCON* respectively. The results can be seen to be highly supportive of proposition (ii), i.e. *ENVPOL* increases (decreases) with *FDI* if aggregate honesty is sufficiently high (low). The coefficients on other control variables and the results of F-tests and Sargan tests are broadly similar to those in Table 2 and hence require little further comment. Figures 3 and 4 indicate that the marginal effect of *FDI* on *ENVPOL* increases with the levels of *AGG.HONESTY_1* and *AGG.HONESTY_2*, again supportive of our theoretical predictions.

Sensitivity Analysis

To examine the extent to which our results are being influenced by outliers we estimate *dfbetas*. *Dfbetas* measure the difference between each regression coefficient when the *i*th observation is included and excluded, the difference being scaled by the estimated standard error of the coefficient. According to Bollen and Jackman (1990), an observation needs attention if |dfbeta| > 1, suggesting that the observation shifted the estimated coefficient by one standard error, at least. We find no *dfbetas* exceeding 1, or even 0.5, across all independent variables, those within our first stage regressions included. It thus appears that outliers do not exert undue influence on our coefficient estimates.

To further illustrate the robustness of our results, Tables 4 and 5 present sensitivity analyses of the results in Tables 2 and 3, respectively, by examining a number of different specifications of Eqn. (10). In each table, models (1) to (4) use FDI stocks and models (5) to (8) use FDI flows. Models (1) and (2) drop the *URBsh* and *MANsh* variables, using *CHECKS* and *POLCON* respectively, to ensure that these additional control variables are not unduly influencing our findings. Next, models (3) and (4) examine the sensitivity of our results to our chosen instruments, again using *CHECKS* and *POLCON*, respectively. In these models we drop the two public infrastructure variables and replace them with the rate of inflation, a variable shown to be a deterrent to inward FDI (see, e.g., Schneider and Frey 1985, Singh and Jun 1995, Chakrabarti 2001). Alongside the rate of inflation we use a new measure of the size of a country, namely the total population. Models (5) to (8) then repeat models (1) to (4) using FDI flows rather than stocks.

The sign and significance of the results in Tables 4 and 5 are highly consistent with those in Tables 2 and 3. Moreover, there is little evidence of sensitivity to the dropping of control variables or the use of alternative instruments.[22] Marginal effects calculated at the mean of *CHECKS* and *POLCON* again have differing signs. However, as in Figures 1 and 2, all marginal effects increase with the level of LUs.[23]

IV. Testing the Pollution Haven Hypothesis in the Presence of Endogeneity

This paper has found clear evidence to suggest that the stringency of a country's environmental regulations is influenced by both the stock and flow of inward foreign direct investment. Such a finding has significant implications for the wider PHH literature which, by testing whether regulations are a determinant of FDI, assumes causality moves uni-

[22] A Sargan test fails to reject the null that our equation is properly specified for both models, while an F-test confirms that the instruments are jointly significant in the first stage regressions. For reasons of space we do not report the first stage results for the models in Tables 4 and 5. They are available upon request. In unreported results we examined the extent to which the scaling of *FDI* by GDP influences our results. The sign and significance of our variables of interest remain very similar when scaling *FDI* by population or when using *FDI* without scaling. We note, however, that most empirical *FDI* papers scale FDI, most typically by GDP or population (for example, Singh and Jun 1995, Chakrabarti 2001, Portes and Rey 2005).

[23] Figures showing marginal effects increasing with *CHECKS* and *POLCON,* estimated using models (1) to (8) in Tables 4 and 5, are highly consistent with Figures 1 - 4 and are available upon request.

directionally from regulations to FDI. We no longer believe this to be the case. While Cole *et al*. (2006) also make a similar conclusion, they fail to take advantage of this insight. They do not perform any PHH tests, and thus do not show the wider implications of their particular results (which also ignore political institutions).

We thus go beyond Cole *et al.* and examine the extent to which *ENVPOL* may influence *FDI* by estimating Eqn. (11), specifying the determinants of *FDI*, including *ENVPOL,* jointly with Eqn. (10),

$$FDI_{it} = \lambda_i + \pi_t + ENVPOL_{it} + \beta' X + \varepsilon_{it}, \qquad (11)$$

where λ_i is a time-invariant country fixed effect, π_t is a location-invariant time fixed effect, X denotes a vector of control variables and other variables are as previously defined.

Table 5 reports the results. Models (1) and (3) estimate a single OLS equation consistent with the existing PHH literature, for FDI stocks and flows, respectively. Models (2) and (4) then utilize 2SLS to jointly estimate the determinants of *FDI* and *ENVPOL*, again for FDI stocks and flows, respectively. The results are striking. The two OLS models find *ENVPOL* to have no statistically significant impact on *FDI*, similar to most of the existing literature. However, once the two equations are estimated jointly, *ENVPOL* is found to have a negative, statistically significant impact on *FDI*, lending support for the PHH.[24] Thus, the stringency of a country's environmental regulations appears to act as a deterrent to inward FDI (as economic intuition predicts), an effect which would be missed if endogeneity between *ENVPOL* and *FDI* were not controlled for.

We also note that the detected effects appear economically significant. Model (2) in Table 5 suggests that a one unit increase (1.02 standard deviation) in *ENVPOL* causes a decrease in the level of FDI stock equal to 0.64 of a standard deviation; Model (4) reveals that the same size increase in *ENVPOL* leads to a decrease in the FDI flow equal to 0.89 of a standard deviation.

This finding is consistent with a small body of literature which suggests that US regulations may be endogenously determined by trade flows or bureaucratic corruption (Ederington and Minier 2003, Fredriksson *et al*. 2003, Levinson and Taylor 2004). However, here we show a different, political institution-related, mechanism through which regulations affect FDI and, for the first time, provide evidence of the implications of such endogeneity using cross-country FDI data.

V. Final Remarks

The empirical literature has frequently explored the pollution haven hypothesis, but has generally taken environmental policy as given. In particular, the possible feedback effect of foreign direct investment (FDI) on environmental regulations has largely been ignored. In this paper, we show theoretically and empirically that FDI affects the stringency of host country environmental regulations. Moreover, the effect is institution specific, i.e. conditional on domestic host country political institutions. Specifically, the number of legislative units, such as the chambers of parliament (uni- or bicameral) and the number of government parties, plays an important role for the environmental policy effects of FDI because they affect the success of industry lobbying. The level of 'aggregate honesty' within government is also shown to be important. It follows that the effect of FDI on local environmental quality is also conditional on domestic political institutions. In particular, pollution havens are more likely to occur in countries with institutional structures involving few legislative units.

Finally, in a standard test of the pollution haven hypothesis we show the importance of endogenizing environmental policy in this fashion. When environmental regulations are treated

[24] This finding is robust across a range of alternative specifications of the FDI equation and does not appear sensitive to the inclusion or exclusion of explanatory variables. Space limitations prevent us from reporting a

as exogenous, they have no significant impact on FDI, while if endogenous their effect is significant and economically important. We believe this paper makes several novel contributions to the literature. Our findings appear to have important implications for future tests of the pollution haven hypothesis.

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APPENDIX I

In this appendix, we derive the equilibrium policy in a way which would apply also for the general case of multiple lobbies, multiple LUs (we still have only one lobby here, however). Assuming that the lobby group uses differentiable contribution schedules, the FOC of LU *k*'s maximization of condition (C1) equals $\alpha \frac{\partial W^k(t^{k*})}{\partial t^k} + \frac{\partial C^{k*}(t^{k*})}{\partial t^k} = 0,$ which may be summed over all *k* to yield

$$\alpha \sum_{k \in K} \frac{\partial W^k(t_k^*)}{\partial t^k} + \sum_{k \in K} \frac{\partial C^{k*}(t^{k*})}{\partial t^k} = 0\,. \tag{A1}$$

The equilibrium tax policy also maximizes condition (C2'), implying

$$\frac{\partial V(t^{k*})}{\partial t^k} - \sum_{k \in K} \frac{\partial C^{k*}(t^{k*})}{\partial t^k} + \alpha \sum_{k \in K} \frac{\partial W^k(t^{k*})}{\partial t^k} + \sum_{k \in K} \frac{\partial C^{k*}(t^{k*})}{\partial t^k} = 0. \tag{A2}$$

Substituting (A1) into (A2), we find that the lobby group offers all LUs schedules that in the aggregate are locally truthful, such that $\frac{\partial V(t^{k*})}{\partial t^k} = \sum_{k \in K} \frac{\partial C^{k*}(t^{k*})}{\partial t^k}$, i.e. the lobby sets its schedules such that the utility change resulting from a small policy move is reflected by the sum of changes in the offered contribution schedules. Substituting the local truthfulness condition into (A1), and recalling that the set K is made up by n identical LUs, yield the political equilibrium characterization of the pollution tax policy set by LU *k*, expressed in (6).

APPENDIX II

The SOC of (7) equals

$$\underbrace{-(Ns+\alpha N^{D})\frac{\partial s}{\partial t}}_{A}+\alpha nN\left[\underbrace{\frac{\partial s}{\partial t}}_{B}\underbrace{-\frac{v^{2}}{1+N}-\frac{(\beta\gamma)^{2}w^{-(1+\gamma)}}{g(1+\gamma)}+(t-1)\left(\frac{(\beta\gamma)^{3}w^{-(\gamma+2)}}{g^{2}(1+\gamma)}\right)}_{C}\right]=0, \quad \text{(A3)}$$

where $\dfrac{\partial s}{\partial t}=-\dfrac{v^{2}}{1+N}-\dfrac{\beta\gamma^{2}w^{-\frac{(1+2\gamma)}{1+\gamma}}}{g(1+\gamma)}<0$. A sufficient condition for (A3) to be negative is $(n-\alpha^{-1}-N^{D}N^{-1})>0,$ since term C in (A3) is unambiguously negative under Assumption 1.

APPENDIX III

Table A1. Data Definitions and Sources

Variable	Definition	Source
ENVPOL	Lead content of gasoline, multiplied by –1 to form an index of environmental regulations	Octel's Worldwide Gasoline Survey (various years)
CHECKS	Checks and balances in government	World Bank Database of Political Institutions, see Beck *et al*. (2001) and Keefer and Stasavage (2003)
POLCON	Political constraints (version 5)	Henisz (2000)
AGG.HONESTY_1	'Government honesty' multiplied by *CHECKS*	International Country Risk Guide, Beck *et al*. (2001), and Keefer and Stasavage (2003)
AGG.HONESTY_2	'Government honesty' multiplied by *POLCON*	International Country Risk Guide and Henisz (2000)
FDI	Inward FDI stocks and flows, divided by aggregate GDP	UNCTAD FDI Database (2001)
GDP	Per capita income	World Development Indicators (2004)
URBsh	Share of the population living in urban areas	World Development Indicators (2004)
MANsh	Manufacturing value added as a share of GDP	World Development Indicators (2004)
PHONE	Telephone mainlines (per 1000 people)	World Development Indicators (2004)
TV	Television sets (per 1000 people)	World Development Indicators (2004)
INFLATION	Inflation rate	World Development Indicators (2004)
ECON.ACT.POP.	Economically active population	World Development Indicators (2004)
POP	Total population	World Development Indicators (2004)

Countries in sample: Argentina, Australia, Bangladesh, Belgium, Brazil, Canada, Chile, Colombia, Ecuador, Egypt, Ethiopia, France, Germany, Ghana, Greece, India, Italy, Japan, Kenya, South Korea, Mexico, Morocco, Mozambique, Netherlands, Nigeria, Pakistan, Philippines, Portugal, South Africa, Spain, Tanzania, Thailand, Venezuela.

APPENDIX IV

Table A2. First Stage FDI Equations. Dependent variable: FDI stock or flow

	(A1) **FDI STOCK** Used in Table 2, Model (1)	**(A2)** **FDI FLOW** Used in Table 2, Model (2)	**(A3)** **FDI STOCK** Used in Table 2, Model (3)	**(A4)** **FDI FLOW** Used in Table 2, Model (4)
$PHONE_{t-1}$	-0.035***	-0.0048***	-0.044***	-0.0049***
	(5.2)	(3.2)	(5.5)	(3.2)
TV_{t-1}	0.023***	0.0063***	0.026***	0.0061***
	(4.8)	(5.8)	(4.8)	(5.2)
ECON.ACT.POP.	-3.70e-08***	-5.55e-09***	-4.43e-08***	-5.01e-09***
	(7.6)	(4.0)	(8.9)	(3.6)
$CHECKS_{t-1}$	-0.16***	0.0046		
	(3.3)	(0.4)		
$POLCON_{t-1}$			0.64	0.17
			(0.7)	(0.9)
GDP_{t-1}	2.30***	0.21**	2.48***	0.24***
	(5.9)	(2.4)	(5.2)	(2.7)
GDP^2_{t-1}	-0.033***	-0.0033***	-0.035***	-0.0037***
	(6.5)	(2.8)	(5.7)	(3.1)
$URBsh_{t-1}$	-0.34***	0.035	-0.33***	0.050
	(3.7)	(1.0)	(3.4)	(1.4)
$URBsh^2_{t-1}$	0.0013	0.000061	0.00099	-0.00015
	(1.6)	(0.2)	(1.1)	(0.5)
$MANsh_{t-1}$	-1.063***	-.053	-1.24***	-0.052
	-(6.1)	(1.3)	(6.0)	(1.3)
$MANsh^2_{t-1}$	0.028***0	0.00090	0.028***	0.00097
	(6.9)	(0.9)	(5.9)	(1.0)
Observations	319	319	319	319
R^2	0.41	0.32	0.42	0.29
F-test on IVs	88.73	59.91	115.53	51.06
(*p* value)	(0.000)	(0.000)	(0.000)	(0.000)
Sargan test	3.64	2.90	4.73	2.87
(*p* value)	(0.16)	(0.23)	(0.11)	(0.24)

Notes: Absolute value of t-statistics in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. These first stage equations were used to estimate the instrumental variables models in Table 2.

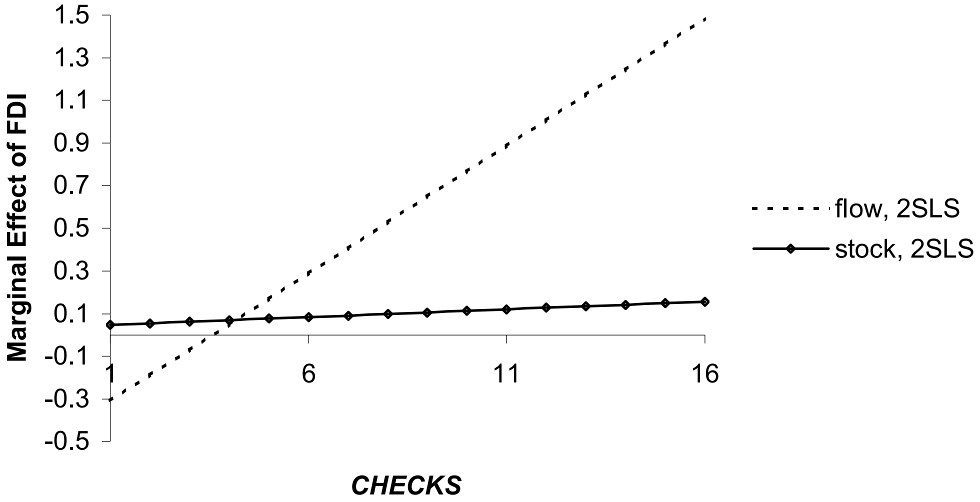
APPENDIX V

Table A3. OLS Results for FDI Stocks and Flows. Dependent variable: *ENVPOL* (environmental policy)

	(1) FDI STOCK FE, OLS	(2) FDI FLOW FE, OLS	(3) FDI STOCK FE, OLS	(4) FDI FLOW FE, OLS	(5) FDI STOCK FE, OLS	(6) FDI FLOW FE, OLS	(7) FDI STOCK FE, OLS	(8) FDI FLOW FE, OLS
$CHECKS_{t-1}$	-0.039**	-0.0080						
	(2.0)	(0.7)						
$(FDI*CHECKS)_{t-1}$	0.014***	0.050***						
$POLCON_{t-1}$			-0.87***	-0.26				
			(3.0)	(1.3)				
$(FDI*POLCON)_{t-1}$			0.085***	0.19**				
			(4.0)	(2.4)				
$AGG.HONESTY\_1_{t-1}$					-0.010***	-0.00024		
					(3.0)	(0.1)		
$(FDI*AGG.HONESTY\_1)_{t-1}$					0.0032***	0.0065**		
					(4.9)	(2.3)		
$AGG.HONESTY\_2_{t-1}$							-0.15***	-0.023
							(3.1)	(0.6)
$(FDI*AGG.HONESTY\_2)_{t-1}$							0.017***	0.025*
							(4.9)	(1.9)
FDI_{t-1}	-0.029**	-0.10**	-0.027**	-0.056**	-0.035***	-0.063	-0.028***	-0.050*
	(2.3)	(2.0)	(2.4)	(2.0)	(3.2)	(1.3)	(2.9)	(1.9)
Observations	319	319	319	319	319	319	319	319
R^2	0.40	0.39	0.37	0.37	0.40	0.38	0.37	0.36
DWH exog. test	9.87	8.13	8.48	9.56	8.88	8.12	9.88	9.36
(*p* value)	(0.001)	(0.004)	(0.003)	(0.002)	(0.003)	(0.004)	(0.001)	(0.002)
$\frac{\partial REGS}{\partial FDI}$	0.012	0.049	0.0099	0.024	0.011	0.031	0.010	0.010

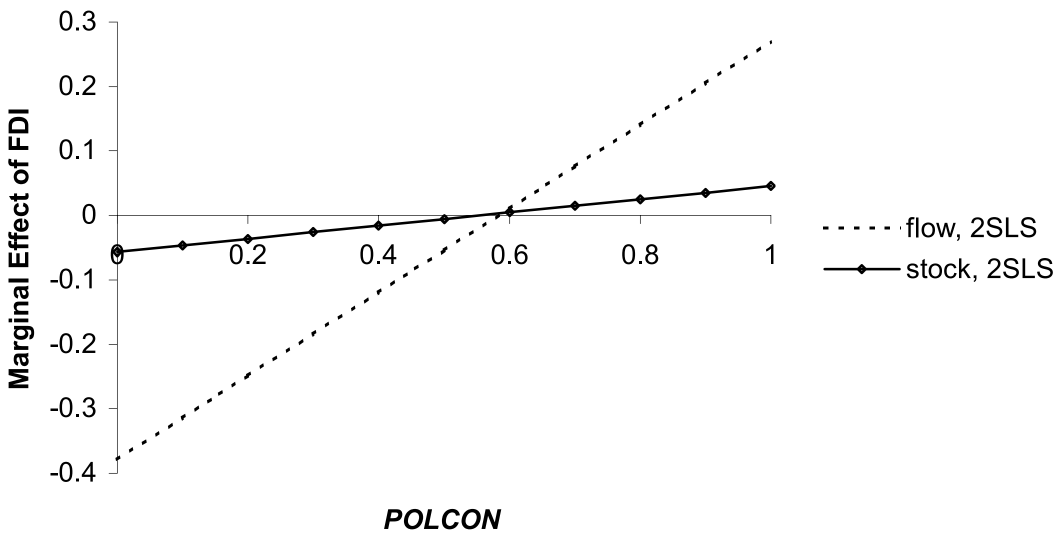
Notes: Absolute value of t-statistics in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. Marginal effects are calculated at the sample mean of *CHECKS, POLCON, AGG.HONESTY_1* and *AGG.HONESTY_2*. For reasons of space, other control variables (*GDP, MANsh, URBsh* and their quadratic terms) are not reported.

Figure 1. The Marginal Effect of *FDI* on *ENVPOL* Conditional on *CHECKS*



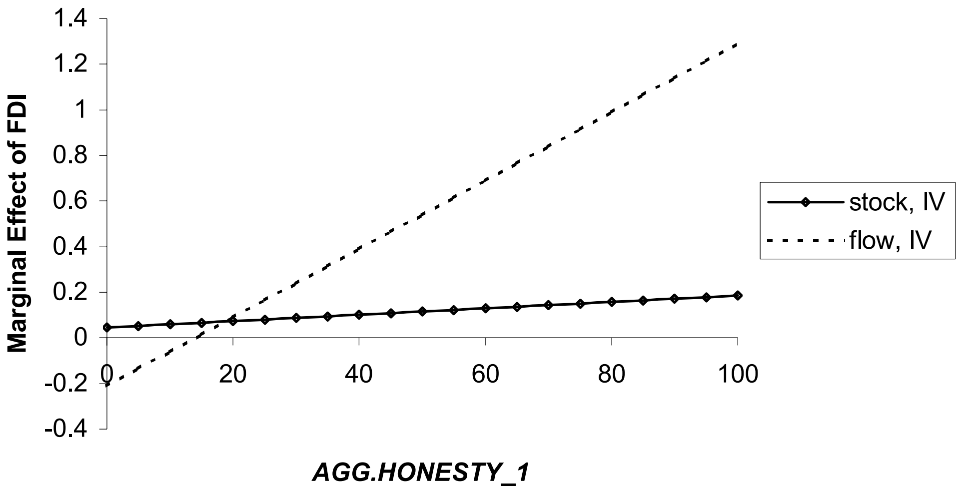
<u>Notes:</u> Marginal effects are calculated using Models (1) and (2), Table 2.

Figure 2. The Marginal Effect of *FDI* on *ENVPOL* Conditional on *POLCON*



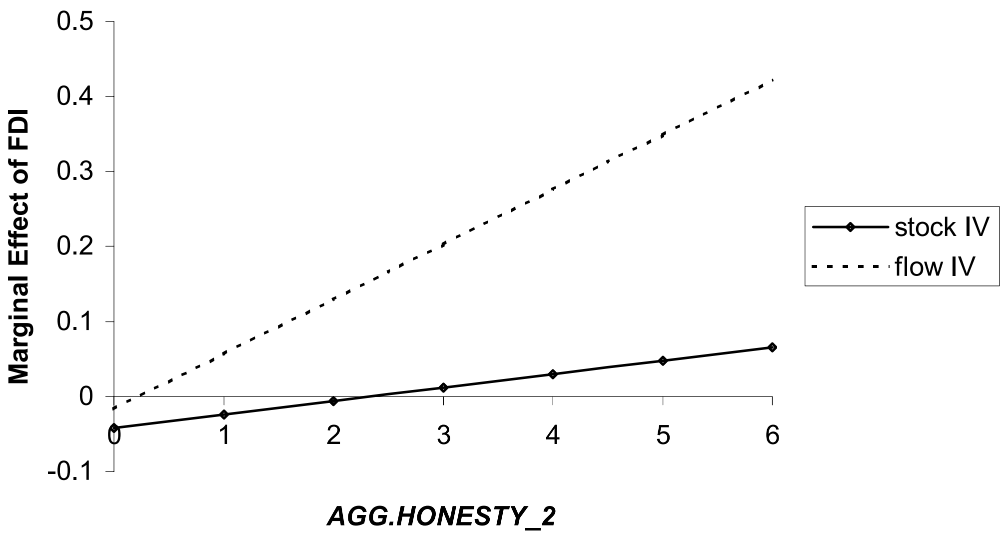
<u>Notes:</u> Marginal effects are calculated using Models (3) and (4), Table 2.

Figure 3. The Marginal Effect of *FDI* on *ENVPOL* Conditional on *AGG.HONESTY_1*



Notes: Marginal effects are calculated using Models (1) and (2), Table 3.

Figure 4. The Marginal Effect of *FDI* on *ENVPOL* Conditional on *AGG.HONESTY_2*



Notes: Marginal effects are calculated using Models (3) and (4), Table 3.

Table 1. Summary Statistics

	Mean	S.D.	Minimum	Maximum
CHECKS	2.99	2.0	1	16
POLCON	0.43	0.34	0	0.89
AGG.HONESTY_1	14.48	12.58	1	96
AGG.HONESTY_2	2.22	2.07	0	6.24
ENVPOL	-1.78	0.98	-3.98	0
FDI Stock	8.64	7.25	0.31	33.2
FDI Flow	0.82	0.95	0.01	7.92
GDP	7.83	9.65	0.085	41.35
URBsh (%)	55.28	25.30	11	97
MANsh (%)	19.61	7.15	3.61	34.56
TOTAL POP. (mn)	67.48	134.40	8.41	882.30
ECON. ACTIVE POP. (mn)	40.09	79.04	4.52	525.00
PHONE (per 1000 people)	148.09	168.02	1.10	564.95
TV (per 1000 people)	196.36	184.65	1.02	627.89
INFLATION	57.44	275.24	-9.81	3079.81

Table 2. Fixed Effects 2SLS Results for FDI Stocks and Flows using *CHECKS* and *POLCON* as Measures of Legislative Units. Dependent variable: *ENVPOL* (environmental policy)

	(1) FDI STOCK FE, 2SLS	(2) FDI FLOW FE, 2SLS	(3) FDI STOCK, FE, 2SLS	(4) FDI FLOW, FE, 2SLS
$CHECKS_{t-1}$	-0.0099	-0.062**		
	(0.5)	(2.3)		
$(FDI*CHECKS)_{t-1}$	0.0073**	0.12***		
	(2.1)	(3.6)		
$POLCON_{t-1}$			-1.33***	-0.77***
			(4.0)	(2.9)
$(FDI*POLCON_{t-1})$			0.10***	0.65***
			(3.6)	(2.9)
FDI_{t-1}	0.039	-0.43**	-0.057*	-0.38*
	(1.1)	(2.0)	(1.8)	(1.7)
$URBsh_{t-1}$	-0.15***	-0.13***	-0.21***	-0.18***
	(4.2)	(4.0)	(5.9)	(5.1)
$URBsh^2_{t-1}$	0.0014***	0.0012***	0.0021***	0.0017***
	(4.3)	(4.2)	(6.2)	(5.4)
GDP_{t-1}	-0.073	-0.029	-0.10	-0.05
	(0.9)	(0.4)	(1.2)	(0.7)
GDP^2_{t-1}	-0.00034	-0.0010	-0.000096	-0.00078
	(0.3)	(1.1)	(0.1)	(0.8)
$MANsh_{t-1}$	0.054	-.0071*	-0.096*	-0.063
	(0.8)	(1.7)	(1.7)	(1.4)
$MANsh^2_{t-1}$	-0.0024	0.00090	0.0017	0.0011
	(1.5)	(0.9)	(1.2)	(1.0)
Observations	319	319	319	319
R^2	0.36	0.35	0.35	0.32
F-test FDI	14.36	14.22	13.72	9.40
(*p* value)	(0.000)	(0.000)	(0.001)	(0.009)
F-test on IVs	88.73	59.91	115.53	51.06
(*p* value)	(0.000)	(0.000)	(0.000)	(0.000)
Sargan test	3.64	2.90	4.73	2.87
(*p* value)	(0.16)	(0.23)	(0.11)	(0.24)
$\frac{\partial REGS}{\partial FDI}$	0.061	-0.070	-0.013	-0.10
$\frac{\partial REGS}{\partial FDI} * s.d.$	0.44	-0.066	-0.10	-0.095

Notes: Absolute value of t-statistics in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. Marginal effects are calculated at the sample mean of *CHECKS*. s.d. = standard deviation of FDI.

Table 3. Fixed Effects 2SLS Results for FDI Stocks and Flows using *AGG.HONESTY* measures. Dependent variable: ENVPOL (environmental policy)

	(1) FDI STOCK FE, 2SLS	(2) FDI FLOW FE, 2SLS	(3) FDI STOCK FE, 2SLS	(4) FDI FLOW FE 2SLS
$AGG.HONESTY\_1_{t-1}$	-0.00086	-0.0075*		
	(0.0031)	(1.7)		
$(FDI*AGG.HONESTY\_1)_{t-1}$	0.0014***	0.015***		
	(2.6)	(2.8)		
$AGG.HONESTY\_2_{t-1}$			-0.23***	-0.076
			(3.4)	(1.5)
$(FDI*AGG.HONESTY\_2)_{t-1}$			0.018***	0.073*
			(3.5)	(1.8)
FDI_{t-1}	0.045	-0.21	-0.042	-0.016
	(1.4)	(1.1)	(1.4)	(0.7)
$URBsh_{t-1}$	-0.16***	-0.16***	-0.21***	-0.19***
	(5.2)	(4.9)	(6.2)	(5.5)
$URBsh^2_{t-1}$	0.0015***	0.0014***	0.0020***	0.0016***
	(5.4)	(4.9)	(6.2)	(5.2)
GDP_{t-1}	-0.084	-0.022	-0.089	-0.028
	(1.2)	(0.3)	(1.1)	(0.4)
GDP^2_{t-1}	-0.00014	-0.0011	-0.00036	-0.0011
	(0.14)	(1.1)	(-0.3)	(1.1)
$MANsh_{t-1}$	0.064	-0.035	-0.059	-0.035
	(1.2)	(0.9)	(1.1)	(0.8)
$MANsh^2_{t-1}$	-0.0025*	0.00013	0.00051	0.00018
	(1.9)	(0.14)	(0.4)	(0.2)
Observations	319	319	319	319
R^2	0.36	0.34	0.37	0.33
F-test FDI	14.68	8.62	12.32	3.64
(*p* value)	(0.001)	(0.01)	(0.002)	(0.16)
F-test on IVs	99.04	57.92	119.08	48.46
(*p* value)	(0.000)	(0.000)	(0.000)	(0.000)
Sargan test	0.13	0.030	0.14	0.15
(*p* value)	(0.71)	(0.86)	(0.70)	(0.70)
$\frac{\partial REGS}{\partial FDI}$	0.065	0.0072	-0.0020	0.15
$\frac{\partial REGS}{\partial FDI} * s.d.$	0.47	0.0068	-0.015	0.14

Notes: Absolute value of t-statistics in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. Marginal effects are calculated at the sample mean of *POLCON*. s.d. = standard deviation of FDI. The variables *AGG.HONESTY_1* and *AGG.HONESTY_2* are creating by multiplying a measure of government honesty with *CHECKS* and *POLCON*, respectively. For reasons of space, the first stage equations associated with these results are not reported but are available upon request.

Table 4. Sensitivity Analysis (All using 2SLS). Dependent variable: *ENVPOL* (environmental policy)

	(1) FDI STOCK	(2) FDI STOCK	(3) FDI STOCK Alt. IVs	(4) FDI STOCK Alt. IVs	(5) FDI FLOW	(6) FDI FLOW	(7) FDI FLOW Alt. IVs	(8) FDI FLOW Alt. IVs
$CHECKS_{t-1}$	-0.0031		-0.035		-0.038*		-0.042	
	(0.018)		(1.2)		(1.8)		(1.5)	
$FDI*CHECKS_{t-1}$	0.0069***		0.012***		0.12***		0.097***	
	(2.6)		(3.2)		(4.9)		(3.1)	
$POLCON_{t-1}$		-0.71***		-1.32***		-0.50**		-0.71***
		(2.8)		(3.7)		(2.3)		(2.9)
$FDI*POLCON_{t-1}$		0.065***		0.094***		0.64***		0.62***
		(2.9)		(3.4)		(3.5)		(3.1)
FDI_{t-1}	-0.0082	-0.060**	-0.0064	0.011	-0.56***	-0.49**	-0.66	-0.51
	(0.3)	(2.1)	(0.1)	(0.1)	(2.9)	(2.3)	(1.2)	(0.8)
$URBsh_{t-1}$			-0.14***	-0.19***			-0.13***	-0.18***
			(2.7)	(3.9)			(3.8)	(4.2)
$URBsh^2_{t-1}$			0.0013***	0.0020***			0.0013***	0.0017***
			(3.9)	(5.7)			(4.7)	(5.6)
GDP_{t-1}	0.078*	0.17***	-0.033	-0.14	0.089**	0.13***	0.030	-0.017
	(1.7)	(3.4)	(0.3)	(1.4)	(2.1)	(2.8)	(0.3)	(0.2)
GDP^2_{t-1}	-0.0022***	-0.0036***	-0.00089	0.00063	-0.0024***	-0.0030***	-0.0020	-0.0013
	(3.7)	(5.1)	(0.5)	(0.4)	(4.1)	(4.6)	(1.2)	(0.8)
$MANsh_{t-1}$			-0.022	-0.015			-0.092*	-0.077
			(0.2)	(0.2)			(1.6)	(1.3)
$MANsh^2_{t-1}$			-0.00063	-0.00019			0.0013	0.0015
			(0.2)	(0.1)			(1.0)	(1.0)
Observations	319	319	319	319	319	319	319	319
R^2	0.32	0.30	0.36	0.34	0.33	0.29	0.34	0.32
Sargan Test	2.07	2.16	0.001	1.52	1.96	1.89	1.90	1.61
(*p* value)	(0.15)	(0.16)	(0.97)	(0.22)	(0.16)	(0.17)	(0.17)	(0.21)
$\frac{\partial REGS}{\partial FDI}$	0.012	-0.032	0.029	0.051	-0.20	-0.21	-0.37	-0.24

Notes: Absolute value of t-statistics in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. Marginal effects are calculated at the sample means of *CHECKS* or *POLCON*. Models (1) and (2) estimate FDI stocks using only minimal control variables, using *CHECKS* and *POLCON*, respectively. Models (3) and (4) estimate FDI stocks using alternative instrumental variables, using *CHECKS* and *POLCON*, respectively. Models (5) to (8) repeat models (1) to (4) using FDI flows.

Table 5. Sensitivity Analysis (All using 2SLS). Dependent variable: *ENVPOL* (environmental policy)

	(1) FDI STOCK	(2) FDI STOCK	(3) FDI STOCK Alt. IVs	(4) FDI STOCK Alt. IVs	(5) FDI FLOW	(6) FDI FLOW	(7) FDI FLOW Alt. IVs	(8) FDI FLOW Alt. IVs
$AGG.HONESTY\_1_{t-1}$	0.0014		-0.012**		-0.0076*		-0.0088	
	(0.6)		(2.0)		(1.8)		(1.2)	
$(FDI^{*}$ $AGG.HONESTY\_1)_{t-1}$	0.0011***		0.0035***		0.014***		0.0096	
	(3.1)		(3.8)		(3.0)		(1.6)	
$AGG.HONESTY\_2_{t-1}$		-0.14**		-0.15**		-0.058		-0.10**
		(2.5)		(2.4)		(1.5)		(2.1)
$(FDI^{*}$ $AGG.HONESTY\_2)_{t-1}$		0.013***		0.013***		0.091**		0.089**
		(3.0)		(2.6)		(2.5)		(2.3)
FDI_{t-1}	0.029	-0.0095	-0.030	0.057	-0.047	0.35	0.54	0.54
	(1.2)	(0.3)	(0.3)	(0.6)	(0.2)	(1.6)	(0.7)	(0.7)
$URBsh_{t-1}$			-0.15***	-0.17***			-0.22***	-0.24***
			(3.1)	(3.6)			(3.8)	(4.4)
$URBsh^2_{t-1}$			0.0014***	0.0017***			0.0018***	0.0021***
			(4.5)	(5.2)			(4.0)	(4.4)
GDP_{t-1}	0.080*	0.13**	-0.023	-0.10	0.058	0.022	-0.14	-0.19
	(1.9)	(2.6)	(0.2)	(0.9)	(1.1)	(0.4)	(0.8)	(1.1)
GDP^2_{t-1}	-0.0022***	-0.0031***	-0.00098	0.00015	-0.0019***	-0.0012	0.00067	0.0014
	(3.8)	(4.3)	(0.5)	(0.08)	(2.6)	(1.6)	(0.3)	(0.5)
$MANsh_{t-1}$			-0.023	0.074			0.054	0.057
			(0.2)	(0.7)			(0.7)	(0.7)
$MANsh^2_{t-1}$			-0.00039	-0.0029			-0.0025	-0.0024
			(0.1)	(1.1)			(1.2)	(1.2)
Observations	319	319	319	319	319	319	319	319
R^2	0.32	0.32	0.37	0.36	0.33	0.33	0.36	0.36
Sargan Test	0.76	0.007	1.38	1.73	0.001	0.085	1.51	1.57
(*p* value)	(0.38)	(0.93)	(0.24)	(0.19)	(0.98)	(0.77)	(0.22)	(0.21)
$\frac{\partial REGS}{\partial FDI}$	0.045	0.019	0.021	0.086	0.15	0.55	0.68	0.74

Notes: Absolute value of t-statistics in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. Marginal effects are calculated at the sample means of *AGG.HONESTY_1* and *AGG.HONESTY_2*. Models (1) and (2) estimate FDI stocks using only minimal control variables, using *AGG.HONESTY_1* and *AGG.HONESTY_2*, respectively. Models (3) and (4) estimate FDI stocks using alternative instrumental variables, using *AGG.HONESTY_1* and *AGG.HONESTY_2*, respectively. Models (5) to (8) repeat models (1) to (4) using FDI flows.

Table 6. Testing the Pollution Haven Hypothesis. Fixed Effects estimates of FDI Stocks and Flows

	(1) FDI STOCK FE, OLS	(2) FDI STOCK FE, 2SLS	(3) FDI FLOW FE, OLS	(4) FDI FLOW FE, 2SLS
$ENVPOL_{t-1}$	0.063	-4.61***	0.064	-0.85***
	(0.5)	(4.6)	(1.6)	(4.0)
$CHECKS_{t-1}$	-0.21***	0.020	0.027	0.042
	(2.7)	(0.2)	(1.2)	(1.4)
$PHONE_{t-1}$	-0.040***	-0.015	-0.0046***	-0.0019
	(4.4)	(1.5)	(2.6)	(0.9)
TV_{t-1}	0.026***	0.032***	0.0029**	0.0066***
	(5.0)	(3.8)	(2.4)	(3.5)
ECON.ACT.POP.	-4.56E-08***	-4.76E-08***	-5.91E-09***	-6.35E-09***
	(8.1)	(5.2)	(4.6)	(3.7)
INFL	-0.0014**	0.0011	-0.00017	0.00018
	(2.1)	(1.3)	(1.3)	(0.8)
GDP_{t-1}	2.26***	0.86	0.45***	0.32***
	(4.3)	(1.6)	(4.3)	(2.7)
GDP^2_{t-1}	-0.034***	-0.022***	-0.0064***	-0.0061***
	(5.0)	(2.7)	(4.5)	(3.4)
$URBsh_{t-1}$	-0.40***	-0.94***	0.062	-0.043
	(3.7)	(6.0)	(1.5)	(0.9)
$URBsh^2_{t-1}$	0.0014	0.0061***	-0.00066*	0.00019
	(1.4)	(4.4)	(1.9)	(0.4)
$MANsh_{t-1}$	-1.08***	-0.83***	0.11**	-0.13*
	(4.6)	(3.3)	(2.0)	(1.9)
$MANsh^2_{t-1}$	0.024***	0.016***	0.0030**	0.0030*
	(4.5)	(2.7)	(2.4)	(1.9)
Observations	319	319	319	319
R^2	0.39	0.39	0.31	0.31

Notes: Absolute value of t-statistics in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level. Models (2) and (4) are estimated jointly with models (2) and (4) in Table 2. Replacing *CHECKS* with *POLCON* yields almost identical results.