

UNIVERSITÄT HOHENHEIM  
Fakultät Wirtschafts- und Sozialwissenschaften  
Lehrstuhl für Außenwirtschaft  
Prof. Gabriel Felbermayr, Ph.D.

# Empirical Evidence on the Pollution Haven Hypothesis

Seminararbeit im Rahmen des  
Außenwirtschaftlichen Seminars

WS 2008 / 2009

Stefan Gassner  
mail@stefan-gassner.de  
Matr. Nr.: 355645  
9. Fachsemester  
Diplom Wirtschaftswissenschaften

Stuttgart-Hohenheim, den 20. Dezember 2008

# Contents

<b>1</b>	<b>Introduction</b>	<b>3</b>
<b>2</b>	<b>The Pollution Haven Hypothesis</b>	<b>4</b>
2.1	The possible impact-patterns of trade on the environment . . . . .	4
2.2	Pollution Haven Models . . . . .	4
<b>3</b>	<b>From theory to estimation</b>	<b>5</b>
3.1	Theory: A model to test the Pollution Haven Hypothesis . . . . .	5
3.1.1	Examining trade flows . . . . .	6
3.1.2	Examining (foreign) direct investment . . . . .	8
3.2	Estimation: Measuring the variables . . . . .	9
3.2.1	Environmental stringency $E_{it}, E_k$ . . . . .	9
3.2.2	Pollution-intensity of an industry, $D_j$ . . . . .	13
3.2.3	Strength of institutions of a country . . . . .	14
3.2.4	Other variables . . . . .	14
<b>4</b>	<b>Empirical Evidence on the Pollution Haven Hypothesis</b>	<b>15</b>
4.1	Previous findings . . . . .	15
4.2	Findings, based on extended theory . . . . .	16
4.3	Findings, based on extended estimation methods . . . . .	20
4.4	Robustness checks . . . . .	25
<b>5</b>	<b>Conclusion</b>	<b>26</b>

# 1 Introduction

If the 1990s were the decade of computer and internet-technology, the late 2000s can surely be described as the years of “green thinking”. Not only are former Vice-Presidents of the United States shooting alarming global-warming movies or organising around-the-world music events to save our planet. Also the increasing number of companies providing “green” services for their products (e.g. “carbon offsets”) . It seems that using environmental protection for marketing purposes is fashionable.

Despite these efforts there is little change in consumption patterns. Paper and chemical products are consumed more than ever. People in developed countries cry for higher environmental regulation but do not want to change their consumption patterns. Trade may be providing both: A cleaner environment at home and the same affluent supply of goods at the same time, by importing pollution-intensive products. This “not in my backyard” thinking of the first world may lead to the constitution of pollution-havens in third world countries.

The following examines contemporary economic literature for empirical evidence on the Pollution-Haven Hypothesis. The initial research question of this paper is formulated as follows: Does a highly regulated country increasingly import polluting goods and is its pollution-intensive industry relocating to “brownier” countries?

As this will actually answer the question, if there is empirical evidence on the Pollution Haven Hypothesis, it will be argued later that one may need to split and rephrase the research question: “Does the U.S. increasingly import goods that face high pollution abatement costs in the U.S.?” and “Does environmental policy in transition economies further foreign direct investment of U.S.’ pollution-intensive industries?”. To find answers, this paper will first introduce the Pollution Haven Hypothesis (PHH). Secondly, three contemporary articles on this topic will be put under scrutiny. Namely those of Levinson and Taylor (2008), Ederington et al. (2005) and Javorcik and Wei (2004). To do so, the common structure of these articles will be adopted for this paper as well. First, the theory they are based on will be compared, then the different estimation approaches are examined. Finally, their results will be checked against previous findings on the topic, and their new findings are discussed.

## 2 The Pollution Haven Hypothesis

### 2.1 The possible impact-patterns of trade on the environment

The public debate about the impact of trade on the environment is controversial. On the one hand people fear that trade will change the environment for the worse. If trade or FDI patterns change due to differences in environmental regulation, and if lax environmental regulation leads to a comparative advantage, a “race to the bottom” may occur, in which all countries compete for more net exports and higher FDI by lowering their standards (Boyce, 2004, p 105). On the other hand economists claim if environmental externalities are internalized by say capped pollution permits, both developed and developing countries will gain from trade, despite the increase in pollution (Copeland and Taylor, 2003, p 145).

According to Copeland and Taylor (2003, pp 3-4) there are three impacts of trade on the environment: A scale (or volume) effect, a technique effect and a composition effect. The scale effect assumes that freer trade leads to more production. Since higher production is linked to more pollution, trade may be harmful for the environment. The technique effect states that efficient production equals cleaner production, thus it may reduce the (negative) impact of trade on the environment (this may be especially true if capped pollution permits encourage innovation, see Porter and van der Linde (1995)). Since not all countries can specialise in “green” production, it is important to examine, which countries are more likely to specialise in pollution-intensive exports. This is the composition of output effect, that is argued in the Pollution Haven Hypothesis (PHH).

### 2.2 Pollution Haven Models

Instead of reducing the consumption of pollution-intensive products or increasing abatement policies, rich countries can have both: a clean environment and the consumption of pollution-intensive goods, by simply importing those from other countries with laxer environmental regulation. Copeland and Taylor (Copeland and Taylor, 2003, p 143) describe such “pollution havens” as follows:

[...] A region or country with a concentration of pollution-intensive activity that has been induced by pollution policy that is weak relative to its trading partners.

The models are generally based on the following assumptions: Firstly, they suggest that the location of production of pollution-heavy goods is based on environmental costs. Secondly, they assume that environmental protection is a normal good and therefore environmental policy is influenced by the income level of a country (Copeland and Taylor, 2003, p 144). Since the distribution of income levels across the world is unequal, so is the level of environmental protection. It is argued that countries with higher income levels have stricter environmental laws and are therefore “greener” than their developing counterparts. Thirdly, pollution havens also exist due to differences in institutions and differences in the environments’ carrying capacity.

The task of this paper is to examine, if these propositions hold empirically. Does a highly regulated country increasingly import polluting goods and is its pollution-intensive industry relocating to browner countries?

### **3 From theory to estimation**

The theoretical argumentation that trade may induce the formation of pollution havens may be straightforward. Brunnermeier and Levinson (2004, p 7) quote the outcome of an opinion survey, conducted in 1999: Some 67 percent found that lax environmental regulation in developing countries threaten U.S. jobs as well as the environment in the originating countries, because the lower environmental standards abroad motivate U.S. companies to relocate.

However, there has been little empirical evidence that environmental regulations actually affect trade patterns. Does this mean that environmental policies do not affect imports from other countries or the individual company’s decision of international plant location? Are the underlying assumptions and instruments just not able to identify the effect?

This chapter first derives general models of how to describe the impact of environmental stringency on an industry. It then finds estimates for the input variables.

#### **3.1 Theory: A model to test the Pollution Haven Hypothesis**

In order to find empirical evidence for the PHH, researchers typically start with adjusting the traditional Heckscher-Ohlin model of international trade for differences in

environmental regulations. The underlying regression model can be described as follows:

$$Indic_{it} = \beta F_{it} + b_1 E_{it} + b_2 \tau_{it} + \epsilon_{it} \quad (1)$$

with

$Indic_{it}$  some indicator of economic activity, like net imports or FDI in an industry  $i$  at time  $t$ .

$F_{it}$  factor intensity variables of industry  $i$  at time  $t$ . Measuring intensity of human and physical capital employed.

$E_{it}$  stringency of environmental regulation in industry  $i$  at time  $t$ .

$\tau_{it}$  trade barriers in industry  $i$  at time  $t$ .

$\epsilon_{it}$  random error term.

The existing literature can be divided along the indicator  $Indic_{it}$  used: First, those examining international trade flows of a sector or industry. Second, those examining foreign direct investment on a sector, industry or firm basis.

### 3.1.1 Examining trade flows

Levinson and Taylor (2008, p 225 - 230) developed an equation linking industry net imports to domestic and foreign measures of regulations, factor costs and tariffs.

As it was assumed by previous empirical work, Levinson and Taylor divide the U.S. economy into sectors (on the 3-digit SIC code) and those in turn into industries (the 4-digit code). Production of a sector requires sector-specific labour and capital, respectively. It creates pollution as a co-output. In order to be able to rank industries according to their pollution intensity and abatement efforts, the authors constitute a Cobb-Douglas function linking pollution emitted and other input factors.

Assuming that input factor costs are constant across countries and time, trade occurs only because of environmental regulation differences. The Heckscher-Ohlin model then predicts that countries relatively well endowed with environmental resources will export pollution-intensive products (Rauscher, 2005, p 1408).

Levinson and Taylor (2008, p 225 - 230) derive the following pattern of trade. Products of industry  $i$  are produced at home if the following condition holds:

$$\left( \frac{C^F}{C^{F*}} \right) \leq \left( \frac{\tau^*}{\tau} \right)^{\frac{\alpha(i)}{1-\alpha(i)}} \quad (2)$$

with

$C^F$  marginal input factor costs, an asterisk is stating foreign costs.

$\tau$  marginal cost of emission, an asterisk is stating foreign costs.

$\alpha(i)$  weight of abatement importance in industry  $i$  [0;1]

This states that *ceteris paribus* more pollution intensive products are imported into a country if environmental regulations in the exporting country are laxer - the classical definition of the PHH.

Both articles, Levinson and Taylor (2008, p 231) and Ederington et al. (2005, p 93), see problems in the regression model as shown in equation (1). For example unobserved heterogeneity and endogeneity<sup>1</sup>. The former means that it is very likely that industry specific factors other than the observed ones are correlated with net imports. This will lead to complications in interpreting the results. For example, if an unobserved comparative advantage leads to high exports of a pollution intensive product, then pollution in that country will be high and so will regulation become over time. A cross-section comparison will mistakenly find that high regulation is correlated with high exports (Brunnermeier and Levinson, 2004, p 12).

To overcome this issue, the studies use panel data to include country and industry fixed effects into the regression. Hence equation 1 turns into the following:

$$M_{it} = a_i + a_t + b_1 E_{it} + b_2 \tau_{it} + \beta F_{it}^n + \epsilon_{it} \quad (3)$$

with

$M_{it}$  net imports in industry  $i$  at time  $t$ , scaled by total industry shipments for example.

$E_{it}$  stringency of environmental regulation in industry  $i$  at time  $t$ .

$\tau_{it}$  trade barriers (average ad-valorem tariffs) in industry  $i$  at time  $t$ . Measured by dividing duties paid by total import volume, for example.

$F_{it}$  factor intensity variables of industry  $i$  at time  $t$ . Measuring intensity of human and physical capital employed.

$a_i, a_t$  industry and time specific fixed effects.

$\epsilon_{it}$  random error term.

The researchers then look at changes in net imports, rather than the absolute value, so that constant unobservable specific effects can be neglected.

---

<sup>1</sup>For empirical evidence on these presumptions, see the following chapters

The other issue with the regression model mentioned above is endogeneity of environmental policy. Modelling environmental regulation as an exogenous variable may hold in a short-term analysis, in the long run it is to be expected that policy makers incorporate effects on trade and FDI into environmental laws. If greater production leads to greater income, which leads to greater demand for environmental quality, then environmental stringency could be a function of trade (Brunnermeier and Levinson, 2004, p 12). To overcome this problem, the authors search for instruments to measure  $E_{it}$  that are not correlated with the error term  $\epsilon_{it}$  in equation (3) (see below).

### 3.1.2 Examining (foreign) direct investment

The paper of Javorcik and Wei (2004) is different in its approach. It examines foreign direct investment (FDI) inflows rather than net imports. Therefore, equation (1) is adjusted to reflect the investment decision:

$$Prob[FDI_{jk} = 1] = X_j\Gamma_j + H_k\Phi_k + Z_{jk}\Pi + \beta E_k + \gamma D_j E_k + \varphi D_j + \epsilon_{jk} \quad (4)$$

with

$FDI_{jk}$  a boolean variable with the value 1 if firm j has undertaken FDI in country k or is planing to, and 0 otherwise.

$X_j$  a vector describing (fixed) characteristics of firm j.

$H_k$  a vector describing (fixed) characteristics of host country k, other than environmental standards.

$Z_{jk}$  a vector describing the relationship between the host country k and the home country of firm j.

$D_j$  index of pollution intensity of firm j [0;2].

$E_k$  stringency of environmental regulation in host country k[0;2].

$\beta$  volume effect: a negative value implies that stronger environmental protection in host country k tends to discourage inward FDI.

$\gamma$  composition effect: a negative value implies more pollution-intensive firms would locate in country k with weaker environmental stringency than home.

$\Gamma_j, \Phi_k, \Pi$  vectors of parameters with corresponding dimensions.

$\epsilon_{jk}$  normally distributed error term.

In this case, if the pollution haven hypothesis holds, the study would find  $\beta < 0$  and/or  $\gamma < 0$ . The model incorporates unobserved country and investor characteristics by using fixed effects regressions. Javorcik and Wei (2004, p 4) solve the possible impact of endogeneity by the simple assumption that may be true for the sample countries they examined: Most efforts to make environmental laws more stringent are being undertaken in order to comply to EU standards (so that the states will be able to become members of the EU). Since the EU standards are set exogenously, the potential problem of endogeneity of standard-setting is mitigated.

There is one major difference between equations (4) and (3) other than the dependent variable. Equation (4) also claims that there is an explanatory variable  $D_j$  that is an index for the pollution intensity of a firm. Incorporating this variable allows them, after specifying an instrument of how to measure the intensity, to test whether the pollution-intensity of a company has any impact on its propensity to relocate to a country with less stringent environmental laws.

## 3.2 Estimation: Measuring the variables

Having set a theoretical framework, it is important to have a closer look at how the literature derives suitable instruments to measure the variables used in the models.

### 3.2.1 Environmental stringency $E_{it}$ , $E_k$

The models presented before may seem to be straightforward. However, getting the input variables might not be. The question arises, for example, how the environmental stringency of a country in a sector or industry could be measured. It is quite obvious that an approximation for this is needed: Environmental regulation may be a whole set of different means; magnitude and enforcement may vary across industries and sectors. Since the (environmental) stringency and the pollution-intensity cannot be measured directly, the research question whether a highly regulated country is increasingly importing polluting goods and if its pollution-intensive industry is relocating to “brownier” countries cannot be answered. Instead we need to use an indirect approach. The literature provides several measures, the most commonly used is the abatement costs that a sector or industry face. As a matter of fact, the only country to survey companies for the used form of abatement costs is the United States, limiting researchers to trade

and FDI flows with the U.S. Hence, the first part of the research question needs to be rephrased to “does the U.S. increasingly import goods that face high pollution abatement costs in the U.S.”?

Typically, previous research has taken environmental stringency as an exogenous variable. Some researchers claim that this may be a reason why little evidence for the PHH has been found in the past. Hence, it is worthwhile examining this possibility.

### **Environmental stringency as an exogenous variable**

Levinson and Taylor (2008, p 230) base their variable  $E_{it}$  on Pollution Abatement Operation Costs (PAC) as reported by the U.S. Census Bureau<sup>2</sup>. Only operation costs are used since environmental capital expenditures are hard to differentiate from other capital expenditures and skewed by high investments.

Ederington et al. (2005, p 93) use a similar approach, also based on pollution abatement costs, to derive  $E_{it}$ . In contrast to Levinson, they study individual industries rather than whole sectors. And instead of scaling their instrument by sector value added, they state abatement cost as a portion of total material costs. However, it is also noted in their study that the latter alteration does not affect the study’s results.

Since there was a change in SIC Code compositions in 1987, Levinson and Taylor (2008, p 238) decided not to include later years, whereas Ederington et al. (2005, p 93) used the NBER Database to allocate later data to 1972 SIC Codes. The former approach may be more accurate but the latter is more up to date.

Javorcik and Wei (2004) use a different set of instruments to measure the impact of environmental standards  $E_k$  on an industry. Most importantly they take the strength of enforcement of the set standards into account, as described later.

To measure the strength of environmental standards, the article uses four indicators, complementing each other. First, the host country’s participation in international environmental protection treaties. Second, the quality of Air and Water Ambient and

---

<sup>2</sup>“The data collected includes capital expenditures and operating costs by type of media, and the percentage that is attributed to hazardous materials. Types of pollutants include air, water and solid waste. The survey also collects data on disposal and recycling expenditures and costs, pollution prevention, site cleanup, habitat protection, environmental monitoring and testing, administrative environmental programs, permits, fees, penalties and fines. ” (The U.S. Census Bureau, 2006)

<b>Levinson and Taylor (2008)</b>	<b>Ederington et al. (2005)</b>	<b>Javorcik and Wei (2004)</b>
Economic activity in the U.S.	Economic activity in the U.S.	Economic activity in transition economies
Net imports, scaled by value added	Net imports, scaled by total material costs	Foreign direct investment (FDI)
Exogenous and endogenous environmental policy	Exogenous environmental policy	Exogenous environmental policy
Pollution Abatement Costs and Expenditures (Operating costs only)	Pollution Abatement Costs and Expenditures (Operating costs only)	Four complementing indicators: Participation in environmental treaties, the EBRD index, the ESI index and a proxy for actual reductions in emissions
U.S. sectors	U.S. industries within a sector	firms within an industry
Timeframe: 1977 to 1986	Timeframe: 1977 to 1992	Timeframe: 1989 to 1994

Table 1: Research designs of the studies examined (source: own design)

Emission Standards rating (EBRD index). Third, the Environmental Sustainability Index (ESI of 2001) is used as a measure for the country's overall progress towards environmental sustainability. Fourth, two variables to include actual efforts to reduce both, lead and  $CO_2$  emissions (relative to GDP growth) (Javorcik and Wei, 2004, pp 7-9).

This approach may be somewhat more direct as using pollution abatement costs. But it is also more subjective, regarding the selection of the treaties for example. ESI data was only collected in 2001, but the sample ends in 1995, creating a time lag. Moreover this methodology uses cross-sectional data and not panel data like the other articles. As it is argued later, this may explain why this approach creates mixed results.

### **Environmental stringency as an endogenous variable**

As shown above, there may be reason to see environmental stringency as an endogenous variable. Looking for suitable instruments to filter this effect out, Levinson and Taylor (2008, p234-237) adopt a fixed-effects instrumental variables approach for the used

panel data. The instrument should not be correlated to the error term in equation (3), since any variations in foreign regulation or other costs are left in the error term.

Standard theory of regulation assumes that the stringency of regulation is related to income levels of affected parties, the current level of pollution and tastes. These characteristics differ from region to region rather than from sector to sector (Levinson and Taylor, 2008, p235). To transform regional into sector characteristics, two facts are kept in mind. First, much of U.S. environmental regulation is set by states. Second, the distribution of manufacturing industries in a sector varies from state to state. Thus, differences between state pollution abatement costs are to be expected.

Defining  $E_{it}$  as the pollution costs faced by sector  $i$ , the paper takes the weighted average of state characteristics, based on a sector's value added in each state at the beginning of the sample period as a proxy. Hence, all changes in the future come from changes in state characteristics alone. To make sure, that the used measure is highly correlated with the abatement costs and not correlated with the error term in equation (3), a small industry assumption is made (Levinson and Taylor, 2008, p 235):

Sector-specific shocks to costs, tariffs, foreign pollution regulation, etc., that alter home sector production are not large enough to induce a change in the stringency of environmental policy in the states in which the sector resides.

This leaves exogenous variation of environmental regulation only. Two state characteristics are examined: Sector external shocks and variations in per-capita income. The article assumes that if more than one sector (other than sector  $i$ ) experience a shock (like a foreign cost rise), this will also have an impact on abatement costs in sector  $i$ . The instrument derived therefore allows observation of which sectors locate to a state with high pollution caused by other sectors, as shown in figure (5)

$$E_{it}^A = \frac{\sum_{s=1}^{48} \left( \sum_{j \neq i}^{48} P_{j,s,t} \right) V_{i,s,77}}{V_{i,77}} \quad (5)$$

$s$  state (48 U.S. states are examined).

$j, i$  denotes industries  $i$  and  $j$ .

$V_{i,s,77}$  The value added by industry  $i$  in state  $s$  in the baseyear 1977.

$P$  describes the type of pollutant.

Furthermore, the authors expect changes in income per capita to have an effect on the demand for a clean environment. Once again an instrument is derived that uses

weighted average of the income per capita, based on the value added in each state in the base year:

$$E_{it}^B = \frac{\sum_{s=1}^{48} (\text{Incomepercapita}_{s,t}) V_{i,s,77}}{V_{i,77}} \quad (6)$$

In order to avoid problems with the assumptions underlying the instruments, Levinson and Taylor (2008, p 237) decide to eliminate those sectors which represent more than 3% of a state's output (so that the small-industry assumption holds). As stated by Ederington et al. (2005, p 92), geographic proximity may have an impact on industry composition and therefore trade flows. Thus, states that border either Mexico or Canada are omitted when trade with those countries is observed, so that changes in a sector's composition based on geographic location is not measured by the instrument.

### 3.2.2 Pollution-intensity of an industry, $D_j$

Since Javorcik and Wei (2004, p 3) also examine whether the pollution-intensity of a firm is a decisive factor for its location, a further measurement needs to be derived: the pollution-intensity index  $D_j$ . To do so, they use two measures: One is based on the Toxics Release Inventory (TRI) data <sup>3</sup> and is a more direct measure of pollution-intensity as the second measure used: PAC. Both assume that all firms of an industry are equally pollution-intensive and that international subsidiaries are as pollution-intensive as their U.S. counterparts.

The first measure states a median level for each industry's toxic chemical pollution, normalized by the average shipping volume of the industry. Reducing possible problems with outliers, the data was converted into a pollution intensity index (with a value ranging between 0 and 2). The index will be 0 if emissions in all four categories (air, land, water and underground) are in the lowest 33 percentiles, the value 2 if emissions in any category are in the top 33 percentiles, and 1 otherwise. A problem with this index, as noted by the authors, is that the amount of pollutants emitted does not say anything about their toxicity. However, other studies have found that there is no significant variation in ranks based on total emissions and toxicity risks on the aggregate level.

The second measure is PAC, as it is used in other studies. However, in contrast to Levinson and Taylor (2008) and Ederington et al. (2005), Javorcik and Wei (2004) do

---

<sup>3</sup>as collected by the U.S. Environmental Protection Agency.

not only use Operating Costs but also Capital Expenditures to calculate their index. This may bias the findings, as noted above. The index also uses the 0 to 2 scale: it is 0 if the normalized value was below the 33rd percentile and 2 if it was above the 66th percentile.

The way how both measures are derived may skew the results of the study. Keeping this in mind, the second part of the initial research question needs to be rephrased to “Does environmental policy in transition economies further foreign direct investment of U.S. pollution-intensive industries?”.

### **3.2.3 Strength of institutions of a country**

Having rigid environmental policies in place and not being able or willing to enforce them, may have the same impact on economic activity as not having a policy at all. Only Javorcik and Wei (2004, p 2) adopt this argument in their theoretical approach. To adjust their findings for a country’s level of corruption, they need to use a composite measure, since most indices are “based on subjective perceptions from surveys of firms or individuals” (Javorcik and Wei, 2004, p 9). On top of that, not enough data is available for the examined transition economies. The authors derive their measure based on the Global Competitiveness Report 1997 (GCR) and the World Development Report 1997 (WDR). To check for robustness, a further measure, the Neumann Corruption Index is used, a more objective and “harder” index than the other, they argue.

Secondly, Javorcik and Wei (2004, pp 11-12) try to measure the level of democracy. This is based on two indicators, political rights and civil liberties (as used in earlier literature on democracy, collected by Freedom House).

Thirdly, the environmental stringency measures based on participation in treaties and the EBRD index are multiplied with the number of active environmental NGO per million people in country  $k$  to take enforcement into account.

### **3.2.4 Other variables**

For clarification and plausibility tests, further variables are included in the research designs of all three authors. Only if the estimation and findings hold for these variables, can the results for environmental stringency be seen as robust.

For example, Javorcik and Wei (2004, p 11) include a whole set of further variables such as, market size (measured by GDP), corporate tax rates, openness to trade, distance

between home and host country, GDP per capita at home relative to GDP in the host country.

## 4 Empirical Evidence on the Pollution Haven Hypothesis

Previous studies have had difficulties in finding empirical evidence for the existence of the PHH. Also, some studies find evidence for larger and more significant pollution haven effects for *green* industries. This is somewhat similar to Porter's hypothesis, which sees a link between more stringent regulation leading to cost-saving innovation and therefore to an export-acceleration over time, based on competitive advantage (Porter and van der Linde, 1995).

This obvious contradiction with both, previous economic theory and public opinion is the starting point for more research. Since the "old" generation of papers, mainly written in the 1990s were based on cross-sections of data and a rather simplistic regression model, the "new" generation of the early 2000s tries to incorporate large panel data and regression models that may be more realistic.

The general approach of the "new generation" papers is to first have a look at the "old" models and to test them with the new data. Second, they try to introduce either new theory or new estimation approaches. Third, they test their newly introduced explanation for why there has been little evidence for the PHH in the past with the new data sets. This paper will also follow this approach.

### 4.1 Previous findings

Copeland and Taylor (2003, pp 253 - 257) find changes of pollution due to changes in trade to be very small. This also reflects the outcome of other authors' findings. The oldest dates back to 1973 when Walter found that the U.S. is exporting relatively pollution intensive products (The pollution measure for U.S. exports is 15% higher than that of U.S. imports). Xu reports in 1995 some 80% of the pollution-intensive goods are exported by OECD countries (all cited by Copeland and Taylor (2003, pp 255 - 256)). Examining FDI rather than trade, Dean finds no PHH support either (see Brunnermeier and Levinson (2004, p 7)).

Based on equation (1), all of these approaches have certain similarities. First, mostly non-panel-data is used (some are based on expert interviews or company surveys). Second, environmental policy is handled exogenously. Newer approaches claim to improve on both ends, theoretical framework and empirical methodology.

## 4.2 Findings, based on extended theory

Some researchers find that the theory used by others understates the effect of the PHH. Therefore they suggest changes to equation (1). In the following, the presumptions dealing with new theoretical explanations are analysed and tested empirically.

### **“Omitting the enforcement of environmental regulation”**

Given that a country’s weakness in public institutions may deter FDI, Javorcik and Wei (2004, p 2) state that even if a country has lax environmental laws and a higher level of corruption for example, it may not be as attractive for FDI as a country with marginally higher environmental stringency but less corruption. It seems reasonable to believe that lax environmental regulation and corruption occur together, understating the PHH effect in the results of previous studies.

A second argument put forward is that the level of democracy may have a similar impact on attracting FDI. While a more democratic country may attract more FDI, it may also have a higher level of environmental-protection laws, once again a reason why previous studies may not have found evidence for the PHH.

Indeed, when adjusting for corruption and democracy, the findings of Javorcik and Wei (2004, p 13) seem to correspond better with the PHH. When using participation in international treaties as the proxy for environmental standards in host country  $k$ , the results show a negative value for  $\beta$ . In three out of six regressions this finding is statistically significant, only if the corruption index is used. Hence, this argument may explain why little evidence for the PHH was found in the past.

### **“Separation of research issues”**

Previous research separately examined, if FDI in general is attracted to lower-standards countries and if polluting industries are more likely to undertake FDI, respectively. In contrast Javorcik and Wei (2004, p 3) try to answer the question whether dirty indus-

tries are relatively more attracted to locations with weak standards.

The authors find that firms in *less* polluting industries tend to undertake *more* FDI in transition economies (these findings are similar to those of Levinson and Taylor (2008, pp 240 - 242)). Javorcik and Wei (2004, p 13) give two possible explanations for the finding that contradicts with the PHH. First, the region is over saturated with pollution-intensive industries. Second, foreign investors may be deterred to acquire a foreign company by concerns about unresolved liability for past pollution. Proof for this is, however, not provided in the study.

Adjusting the results for enforcement by NGOs, the findings present a stronger volume effect ( $\beta$ ) that is negative and statistically significant in 3 out of 4 cases. This indicates that indeed, countries with higher standards attract less FDI. As it was the case in the first regressions, no evidence could be found for the composition effect  $\gamma$ .

These results were based on the participation in international environmental treaties. In the following Javorcik and Wei (2004, pp 15-16) check their finding with using different measures for environmental stringency. Neither the EBRD, nor the ESI, nor the actual efforts to reduce emissions support the PHH. To the contrary, those measures also find that cleaner industries are more likely to invest in transition economies.

When the abatement cost index is used to characterise the “brownness” of a firm, the tests show mixed results and no robust support for the PHH. The study cannot find a link between the pollution-intensity and the eagerness to invest abroad.

### **“Unobserved heterogeneity”**

In a first regression, Levinson and Taylor (2008, pp 240 - 242) find that the 20 sectors with the lowest pollution abatement cost spent 0.12% of their value added on abatement, whereas the 20 sectors with the highest abatement cost spent 4.8%. Interestingly enough, when net imports from Canada and Mexico are divided, the results show higher net imports from Mexico in those sectors with *lower* abatement costs (although not significant). Furthermore, the U.S. imports more goods with *high* abatement costs from Canada (the supposedly “greener” country). The results in the top half of table 2 repeats the findings of previous studies based on cross-section data.

This leads to the hypothesis that there might be unobserved factors, other than environmental regulation that affect trade flows between countries. For example, Canada might have rather capital intensive industries that happen to be pollution intensive as

well. Copeland and Taylor (2003, p 257) claim that one of the reasons for not finding large PHH effects is the simultaneity of capital-intensity and environmental-intensity.

	<b>Mexico</b>	<b>Canada</b>
The 20 sectors with the lowest average PAC per U.S.\$ of value added	-0.00021	-0.00535*
The 20 sectors with the highest average PAC per U.S.\$ of value added	-0.00159	0.04693
The 20 sectors with the lowest change in PAC per US\$ of value added	-0.00017	-0.00345
The 20 sectors with the highest change in PAC per U.S.\$ of value added	-0.00103	0.02662

Table 2: *(Change in) Average Net imports / value added. Asterisk denotes significance at the 5% level. Source: (Levinson and Taylor, 2008, p 241)*

Assuming that those country specific factors are rather time-invariant, a second regression is made. Based on equation (1) and examining changes in net imports and changes in abatement costs rather than absolute values, it shows a link between net imports and abatement costs: Sectors in which the abatement costs have increased the most, show also increased changes in net imports, both from Canada and Mexico (results reported in the bottom half of table (2)). On top of that, when holding the sector compositions on 1976 levels, the results also show a positive correlation for both, Mexico and Canada (Levinson and Taylor, 2008, p 241).

As equation (3) suggests, fixed effects could leverage the problems arising out of unobserved heterogeneity. Accounting for fixed effects, a positive statistically significant relationship between increased PAC and increased net imports could be found for both, Mexico and Canada. Also, the effects are of a comparable magnitude, when compared with the relative volume of imports. Hence, when including fixed effects, statistically significant evidence for the PHH can be found (see first row of table 3).

The bottom row of table 3 makes the economic implication of the pollution haven hypothesis quite clear. Whilst it may not be significant for the average industry's trade volume, it is for sectors facing the highest increase in PAC. Some 26% of the increase in

	<b>Mexico</b>	<b>Canada</b>
Correlation between change in net imports and PAOC per U.S.\$ of value added	0.064*	0.529*
For the average industry		
When accounting for fixed effects	+ 6m US\$	+ 53m US\$
as percentage of increase in trade volume	4%	8%
For the average of the 20 industries facing the highest increase in PAC		
When accounting for fixed effects	+ 37m US\$	+ 302m US\$
as percentage of increase in trade volume	26%	51%

Table 3: *Change in net imports due to increased PAC. Asterisk denotes significance at the 5% level. Source: (Levinson and Taylor, 2008, p 252)*

the trade volume with Mexico and 51% of Canada’s respectively, can be explained with the increase in pollution abatement costs. Thus, unobserved heterogeneity understates the effect of the PHH in previous research.

**“Environmental policy is incorporated as an exogenous variable”**

The models described, handle environmental policy exogenously. The PHH suggests that if a country lowers its environmental standards it might gain a new source of comparative advantage. If the model does not consider those endogenous effects, net imports and  $E_{it}$  may seem to be weakly correlated even if “environmental regulations are a major source of comparative disadvantage” (Ederington and Minier, 2003, p 139). This may be especially true in the long run.

For example, environmental policy could be seen as a second-best trade barrier that promotes exports and is not regulated by international treaties (Brunnermeier and Levinson, 2004, p 7).

The underlying assumptions for second-best models are that “ (i) countries use domestic regulations as a means of manipulating trade flows; and (ii) trade flows are in fact responsive to regulatory choices” (Ederington and Minier, 2003, p 139). Testing if environmental policy is a second-best trade barrier, Ederington and Minier (2003, p 146) found empirical support that environmental policy should be modelled endogenously: An industry with pollution abatement costs 1 percentage point higher than other in-

dustries have *ceteris paribus* a net import ratio over 30 percentage points higher.

As shown in the previous chapter, Levinson and Taylor (2008) use two instruments to leverage for endogeneity of environmental stringency. Introducing an analysis basing the regression on two-stage least squares for these, Levinson and Taylor (2008, p 246) find an economic impact of PAC increases, even for the average industry of table 3: 9% of trade with Mexico and 13% of trade with Canada could be explained with increased abatement costs. Since the findings hold throughout all robustness checks, the effect of the PHH is understated in previous research.

### 4.3 Findings, based on extended estimation methods

Rather than improving the regression models itself, some authors see the way the data is composed or which proxies are used to obtain the input variables to be problematic. These suggestions are stated and tested in the following.

#### **“Using abatement cost to proxy environmental stringency”**

Assuming that industries with high pollution abatement costs are also the high polluting industries may not be correct. All of the studies examined take final products into account only. Intermediate products are not incorporated into the models. If a rather clean product uses rather “brown” inputs, ignoring intermediate inputs will understate the pollution content of imports, because only the final product industry’s abatement costs are captured. PAC only considers new investment, leaving no information about the capital stock. If the PHH causes some industries to disinvest, the data poses even more bias (Levinson and Taylor, 2008, p 238).

Moreover, pollution abatement costs are derived from a survey, therefore it is very likely that these costs also contain data, that has little to do with pollution abatement, since it may be very difficult for firms to distinguish how much of the cost of a change in production could be accounted to pollution reduction. The data is only available in the United States and bears issues like the aggregation bias mentioned later.

Even though there is some reason in using PAC as a proxy. Since it has been collected over a considerable time, it allows panel regressions and it is quite easy to obtain. Using other measures for environmental stringency, like the participation in international

environmental treaties, the EBRD, the ESI or the actual efforts to reduce emissions, Javorcik and Wei (2004, pp 13-23) cannot find better support for the PHH.

Pollution abatement cost may be a second-best solution to measure environmental stringency but other measures seem to be even less reliable.

**“Environmental costs are only a small fraction of total costs”**

For most industries abatement costs were found to average around 1% of total material costs and hence may not have a big impact on trade patterns (Ederington et al., 2005, p 97). However, the impact may be small, but “it seems unlikely that more stringent regulations would have no effect whatsoever” (Levinson and Taylor, 2008, p 224). It can be argued, that especially for the most regulated industries the ratio between environmental costs and total production cost may be significant enough to consider relocation.

This hypothesis is tested by Ederington et al. (2005, p 97). They compute the average environmental costs for each industry between 1978 and 1992. Then, the average cost is compared with the current cost in any given year and put into equation (3). Hence if the hypothesis holds, they expect the correlation between net imports of a pollution-intensive industry and above-average environmental costs to be positive.

However, the correlation between above-average environmental costs and net imports (-31.12 (16.76)) is found to be negative at the 90% significance-level. This states that net imports in more pollution-intensive industries are not as susceptible to change in environmental costs as in other industries.

Looking for an explanation, Ederington et al. (2005, p 97) test a further hypothesis: They expect pollution-intensive industries to be less mobile than others. And indeed the effect appears to be smaller (-3.60 (18.42)), but the correlation is still negative and not significant at all. Thus, this argument does not provide a sufficient explanation, why previous studies were not able to find stronger evidence for the PHH.

**“Share of trade between industrialised countries is too big”**

In a globalised economy, trade patterns have changed. Most trade now occurs between industrialised countries, rather than between industrialised and developing countries. One explanation for this is intra-industry trade, which describes trade flows between

the same industry of two different countries. These countries are similar in their levels of environmental regulation and per-capita-income. Therefore, when looking at net imports from all countries of the world, the share of trade with industrialised countries could be too big to find evidence for the PHH. It may be important to compare net imports from countries with distinguishable levels of environmental protection laws. Ederington et al. (2005, p 94) follow this and divide trade flows into those occurring with countries with low and with high environmental standards. Another test is done by dividing trade flows into those with high-income and those with low-income (OECD and non-OECD members, respectively) trading partners. Assuming that the categorisation holds throughout the examined time period, it is expected that an increase in U.S. abatement costs will have a more significant impact on trade with low-income and low-standards countries.

The results in table 4 clearly show that, while an increase in U.S. abatement costs leads to an (not-statistically significant) effect on trade with other OECD countries, it will increase net imports from developing countries on a statistically significant level. Ederington et al. (2005, p 95) also show that the abatement-cost elasticity of trade with non-OECD countries is approximately five times greater than the one for all the countries. Similar effects could be found for the high and low-standard country samples, although they are not statistically significant. Thus, the share of trade between industrialised countries understates the effect of the PHH.

Javorcik and Wei (2004) examine FDI in transition countries, namely 25 economies in

	<i>OECD</i>	<i>Non- OECD</i>	<i>High environ- mental stan- dards</i>	<i>Low environ- mental stan- dards</i>	<i>All coun- tries</i>
U.S. abatement costs	-0.22 (0.15)	0.25 (0.10)*	-0.23 (0.15)	0.11 (0.07)	0.20 (0.27)

Table 4: *The effect of an increase in U.S. abatement costs on net imports from Non-OECD countries is significantly larger than from other countries. Asterisk denotes statistical significance at the 5% level. Source: (Ederington et al., 2005, p 94).*

Eastern Europe, rather than industries or sectors in developed countries. The sample

therefore includes countries that have remarkable differences in environmental policies and per-capita-income. Although they share the same history, similar cultures and all have a relatively high human capital endowment. Previous studies, as cited by Javorcik and Wei (2004, p 2), have found that FDI also correlates with the experience a company has gained in the region before. Since these countries opened to trade at the same time, this factor may not have an impact on the sample. This approach seems to improve the research design, however the study is not able to find evidence for the PHH. To the contrary, it finds results similar to the “old” generation models.

Overall the argument that trade between industrialised countries covers the PHH effect cannot be ruled out. But evidence in favour of the argument is only weakly shown by the studies examined.

#### **“An aggregation bias”**

It is very unlikely that the industries composing a sector are homogeneous in their attributes (and not only in their abatement-intensity). It is also likely that the effects of more stringent regulation may vary from industry to industry. This means for example that, if the PPH were true, then the most polluting industries would move from a highly-regulated country to a less regulated one. Therefore the sector-wide abatement costs in the first country would decrease due to a new composition of the sector, while net imports increase and environmental policy remains unchanged. Levinson and Taylor (2008, p 232) claim that if not accounting for this bias, previous studies have also captured the effect of a “trade on measured pollution costs”.

Holding the composition of industries constant on the 1974 level, Levinson and Taylor (2008, p 233) find evidence that U.S. manufacturing has indeed shifted toward less polluting industries. Using sector or industry aggregates of PAC therefore understates the actual rise in environmental stringency, because the underlying industries have become “greener” over time.

Different in their approach, Javorcik and Wei (2004, p 12) use a firm-level data set derived from a survey of some 1,405 firms, rather than sector or industry aggregations. Allowing control for individual decisive factors for the investment (like a firm’s size, R&D intensity and previous experience with the region), this may generate better results by avoiding industry average effects. The findings now show support for the PHH.

### **“Immobile industries are less susceptible to change”**

Previous research assumed that industries are homogeneously reacting to changes in environmental regulation. This is very unlikely. Industries may vary in their susceptibility to changes in comparative advantage or the composition of costs. Some industries might be less flexible when it comes to selecting plant locations. This could be especially true, if potential gains from relocation are short-term. Even more so if fixed moving-costs, transportation costs, or the importance of agglomeration economies are high, Ederington et al. (2005, p 94) argue. For some pollution-intensive industries it may be completely impossible to relocate, such as the oil, coal or gas industries.

Ederington et al. (2005, p 94) claim three hypotheses. Firstly, an increase in abatement costs will have a greater effect on net imports in industries with low transportation costs. Secondly, an increase in abatement costs will have a greater effect on net imports in industries with low plant set-up costs. Thirdly, an increase in abatement costs will have a larger effect on net imports in industries with small external economies.

To test this the authors explore the importance of transportation costs, plant fixed costs and agglomeration economies or network economies. They derive a transportation cost measure for each industry by using distance independent freight costs. To account for fixed plant costs they use data on real capital structures of an industry. The effect of external economies on an industry is measured by an index of geographic concentration.

The study calculated interactive terms for the three immobility measures by first examining industries in which transportation costs, plant fixed costs and agglomeration economies have an above average importance. It then computed the interaction terms of the “footlooseness index” with environmental costs for an industry with median importance to all the three measures (see table 5).

Although, only for plant fixed costs the effects are significant on the 5% level, the results shown in table 5 still claim a negative correlation between net imports adjusted for transportation, plant fixed costs and environmental costs. The results on agglomeration economies are more mixed and just show a negative correlation with abatement costs for industries with above average importance for agglomeration economies.

Nevertheless, the overall results imply that an increase in abatement costs of 1 percentage point would decrease net imports by 0.96 percentage points for a median level industry. For less mobile industries (the top 20th percentile of all three measures), the

same increase would only lead to a decrease in net imports of 0.20 percentage points and for more mobile industries (the bottom 20th percentile) a 1 percent increase in environmental costs result in a decrease of 1.5 percentage points in net imports.

This shows that there are differences amongst industries. Thus, by not looking at more footloose industries the effect of the PHH is understated in previous research.

	<i>transportation costs</i>	<i>plant fixed costs</i>	<i>agglomeration economies</i>
Environmental cost	-12.31 (7.89)	-5.39 (1.37)*	2.84 (3.10)

Table 5: *Results for an industry with a median level of all three immobility levels. Asterisk denotes statistical significance at the 5% level. Source: (Ederington et al., 2005, p 96)*

#### 4.4 Robustness checks

Javorcik and Wei (2004, pp 14-21) conducted several checks on their results. For example, they re-ran the regressions by, only considering U.S. firms, using the Neumann index to measure corruption, replacing country specific variables with fixed effects, and using firm fixed effects instead of firm specific variables. But none of these showed any new or other results. It may be noted that the other variables they incorporated in their research design not always showed the predicted direction of correlation, and are not significant for most of the regressions. Therefore, this may question the research design as a whole.

Ederington et al. (2005) test their findings by including tariffs, human and physical capital variables. In most regressions, the correlations for both, tariffs and human capital are as expected (and also significant). However, the results on physical capital are not statistically significant. Yet this research design can be seen as stable.

To check their findings, Levinson and Taylor (2008, pp 246-249) re-ran all of their regressions, dropping each single assumption made (like the small industry assumption). They find the same results as previously, all of them significant and some even supporting the PHH more. They do not include other variables, however their findings can be considered robust.

## 5 Conclusion

In conclusion, both research questions, “does the U.S. increasingly import goods that face high pollution abatement costs in the U.S?” and “does environmental policy in transition economies further foreign direct investment of U.S.’ pollution-intensive industries?” cannot be answered. Neither by the older studies nor by the newer approaches.

Javorcik and Wei (2004) are unable to find more than weak support for both, that the environmental stringency of a country has impact on the inflow of FDI and that pollution-intensive industries are more likely to undertake FDI. Moreover, the study shows that cleaner rather than dirtier industries are eager to undertake FDI. These findings may be partially due to the shown problems in their approach, such as not using panel data.

Ederington et al. (2005) find empirical evidence for two out of the three hypotheses, explaining why so little empirical evidence on the PHH was found in the past. The amount of trade with low-income countries and the geographic mobility of industries have not been accounted for enough in previous research designs. However, using pollution abatement cost may not be a valid proxy for worldwide environmental stringency. Levinson and Taylor (2008) may provide the strongest explanations why it is so hard to find empirical evidence to answer the research questions: Unobserved heterogeneity, endogeneity of regulation and an aggregation bias. But not all of their findings are significant. Furthermore, not all aspects seemed to be considered, such as including intermediate products.

Given the mixed findings of all studies this topic is still one that needs more research to find more compelling empirical evidence.

## References

- Boyce, J. (2004). Green and brown? globalization and the environment. *Oxford Review of Economic Policy*, 20(1):pp105 – 128.
- Brunnermeier, S. B. and Levinson, A. (2004). Examining the evidence on environmental regulations and industry location. *Journal of Environment and Development*, 13(1):p6 – 41.
- Copeland, B. and Taylor, S. (2003). *Trade and the Environment*. Princeton University Press.
- Ederington, J., Levinson, A., and Minier, J. (2005). Footloose and pollution-free. *The Review of Economics and Statistics*, 87(1):pp92 – 99.
- Ederington, J. and Minier, J. (2003). Is environmental policy a secondary trade barrier? an empirical analysis. *The Canadian Journal of Economics*, 36(1):137 – 154.
- Javorcik, B. S. and Wei, S.-J. (2004). Pollution havens and foreign direct investment: Dirty secret or popular myth. *Contributions to Economic Analysis & Policy*, 3(2):Article 8.
- Levinson, A. and Taylor, S. (2008). Unmasking the pollution haven effect. *International Economic Review*, 49(1):pp223 – 254.
- Porter, M. E. and van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, 9(4):pp97 – 118.
- Rauscher, M. (2005). *International Trade, Foreign Investment, and the Environment*, volume 3 of *Handbook of Environmental Economics (Editors: Mäler, K. G. and Vincent, J.)*. Elsevier (North-Holland Handbooks in Economics).
- The U.S. Census Bureau (2006). Pollution abatement costs and expenditures survey.