International Review of Business Research Papers
Vol. 4 No.2 March 2008 Pp.176-202

Dirty Industry Migration Globally and to China— an Empirical Study

Haitian Lu* and Hong Huang**

This work empirically tests the hypothesis of foreign dirty industry migration ("DIM") to China. Based on the two primary vehicles of DIM, namely direct DIM through foreign investment and indirect DIM through international trade, and applying the open sources of data from the U.S. Census Bureau and China Statistics Yearbook from 1995 to 2006, the author identifies the sectors that show evidence of DIM, and estimates the aggregate environmental impact of both direct and indirect DIM on China. The conclusion of this work has policy implications for the sustainable development of both China and other developing countries that emulate China's development strategies.

Field of Research: Dirty Industry Migration, Environmental Stringency, Pollution, China

1. Introduction

On February 8, 1992, an article titled "Let Them Eat Pollution" was published in *The Economist*, which leaked an internal memo by Lawrence Summers, the World Bank's chief economist at the time. He suggested, on the basis of his economic analysis, that the World Bank should consider encouraging the migration of pollution intensive industries to developing countries.[1] This, of course, aroused significant unrest and controversy among economic theorists, environmentalists and the general public. The term "Dirty Industry Migration" (hereinafter DIM), in a narrow sense, refers to the hypothesis that free trade and investment without an adequate consideration on environmental factors drives pollution-intensive industries to migrate to countries with laxer environmental regulations or to the "pollution havens".

---

*Dr. Haitian LU, School of Accounting and Finance, the Hong Kong Polytechnic University
E-mail: afhtlu@inet.polyu.edu.hk
*Hong Huang, School of Accounting and Finance, the Hong Kong Polytechnic University
E-mail: afrhh@inet.polyu.edu.hk

According to the classical trade theories based on comparative advantage, countries will generally produce and export goods manufactured with factors that are abundant within the country and will import those for which factors of production are scarce. On this basis, economic theorists, policymakers from both industrialized and industrializing nations, spokesmen for international agencies and private corporations all tend to assume that highly polluting industries would gradually move from industrialized countries with scarce environmental factor endowments to countries where such factors are be abundant (Low & Yeats, 1992).

China is the largest developing country in the world with a population over 1.3 billion. Like other developing economies, China has taken an open attitude towards international trade and investment. In 2002, China has surpassed the U.S. and became the world's largest foreign direct investment ("FDI") recipient. Since 2004 it has become the world's 3rd largest trading country in both import and export.[2] In the meantime, China had a notorious record for mass industrialization at the cost of environmental protection. In a sense, China has the potential of becoming a "pollution haven" as Summers suggested. Furthermore, as China's international influence increases with its expanding economic power, many other developing countries tend to emulate China in their economic and social policies. Hence a clear understanding on China's attitude towards DIM not only has policy implications for the country itself, but also for other developing countries which are seeking similar development strategies to that of China.

This work is an empirical study on the DIM situation in China. The key questions this work is going to address are: Is DIM to China a reality or an ungrounded fear? If there is DIM from industrialized country to China, in which sector and how is that achieved? How to estimate the environmental impact of the sectoral foreign DIM on the host state? The following of this work is organized as follows. Part II is a literature review and evaluation on the previous empirical studies of DIM and related topics with a focus on their methodologies. Part III is a description on the methodology and data for testing the DIM in China, followed by the discussion and analysis on the research findings. Part IV is the conclusion and suggestions for future research.

2. DIM Globally and in China — Literature Review

The empirical research on DIM draws much lesson from the approaches that were applied in testing the related hypothesis, such as the pollution haven or race to the bottom (Walter, 1982; Cropper & Oates, 1992; Wheeler, 2000). Despite the broad diversity in the approaches of literature, these approaches generally aim at identifying the correlation between the industrial migratory behavior and the stringency in environmental standards in the host or home country (OECD, 2002).

2.1 Firm Level Empirical Studies

Empirical studies at firm's level generally fall into two major approaches. One approach is to compare the major indicators of a company's economic activity level with those of its environmental cost. The result varies from industry to industry. For example, in the U.S. paper and pulp, refined petroleum and steeling industry, lower productivity and growth rate were found as a result of the stringency of environmental regulation (Gray & Shadbegian, 1993). But for most other industries, such trend is not remarkable (Repetto, 1995). The result also varies from country to country. For example, a study based on Japanese companies discovered higher economic performance as a result of the environmental pressures (Yoichi Nishijima, 1993). But for companies of other countries the trends are not consistent.

In contrast, the other approach more directly studies the migrating activity by individual firms and evaluates the environmental motives behind their locational choice. The general presupposition of this approach is that industrial firms seek investment where they can exploit a comparative advantage. Environmental costs, due to tightened pollution controls, can affect this advantage negatively (UNCTAD, 1995). Using primarily case study, this approach proves to be successful in finding cases that support the DIM hypothesis. Examples of both governments failing to enforce environmental legislations and firms acknowledging that environmentals were a factor—were found in Costa Rica, Mexico, India, Indonesia, Papua New Guinea and the Philippines (WWF, 1999). Jha et. al (1999) find that in China, many foreign firms have located their plants for highly polluting industries such as pesticides and asbestos (Jha, Markandya and Vossenaar, 1999). Other instances of industrial flight of heavily polluting sectors have been found, for example, in the case of asbestos tile and benzidine dye manufacturing facilities relocating to Mexico and Romania from U.S. and Canada (Berrie, 1992; Suttles, 2002; Cairncross, 1990; Castleman, 1979), wood finishing firms to Mexico from California (GAO, 1990), wet processing in the tanning industry from Europe to Brazil (WWF,1999; Odegard, 1999; Knutsen, 1999; Hesselberg, 1999), and iron and steel industry from EU to China, Brazil and the Republic of Korea (Barton, 1999).

Despite these important findings, this approach was challenged to have suffered from selection bias—primarily because firms that have actually shifted are documented (Eskeland & Harrison, 1997; Mani, Pargal and Hug, 1997). Some authors have characterized this as being marginal and not showing up in aggregate trade and investment statistics (Nordström & Vaughan, 1999). Other studies tend to believe that given the proportionately low business costs for environmental compliance, corporations would be reluctant to resettle due to the high costs involved in relocating (Esty & Geradin, 1998; Knodgen, 1979). By comparison, there are other determinants for location that mark a higher priority for corporations. These may include the availability of cheap labour (Esty & Geradin, 1998; Knodgen, 1979); natural resource endowments of the host country (Low, 1993), presence of industrial base (Mani & Wheeler, 1998), market size, availability

to raw materials (Wheeler & Mody, 1992), and concerns about liability or consumer pressures in home countries (Esty & Geradin, 1998).

2.2 Industry Level Empirical Studies

At industry's level, there are generally two approaches for empirical research on DIM: international trade approach and international investment approach. Each approach has yielded mixed results.

2.2.1 International Trade Approach

The international trade approach mainly examines the export performance of Pollution Intensive Industries ("PII") of different countries at the international market. The underlying hypothesis is that if a country's environmental standard is higher than others, then its market share of PII export in the global market will decrease. Based on this hypothesis, Tobey (1990) uses a UNCTAD survey to rank 23 countries on a scale of 1 (most tolerant) to 7 (most strict) for stringency of environmental regulation. He then regresses net exports of each country's PII on their factor inputs (land, labour, capital, and natural resources) and on stringency of environmental regulation. In no case does he find that stringency of environmental regulation was a statistically significant determinant of net exports.

World Bank researchers Low and Yeats test whether developing countries have gained a comparative advantage in producing pollution intensive industrial products ("PIIP") during the period 1965-1988 (Low & Yeats, 1992). Their model relies on the calculation of Revealed Comparative Advantage ("RCA"), defined as the share of an industry in a country's total exports, relative to that industry's share of total world exports of manufactures. They look at the RCAs of 109 countries for PIIPs. They observe the decreases in PIIPs' RCAs in the developed world and increases in Eastern Europe, Latin America, and West Asia. Sorsa (1994) also finds similar trends that over the last 20 years, the export of PIIPs from developing countries are increasing in while those from developed countries are decreasing (Sorsa, 1994).

At regional level, the research of Grossman and Krueger (1993) is widely cited during debates around the passage of North America Free Trade Agreement ("NAFTA"). Grossman and Krueger test whether pollution abatement costs in U.S. industries affected imports from Mexico. That is, they ask whether dirtier U.S. industries relied more heavily on imports from Mexico, as would be expected if Mexico was functioning as a pollution haven relative to the U.S. They find traditional economic determinants of trade and investment, such as factor prices and tariffs, to be very important. In contrast, they find the impact of cross-industry differences in pollution abatement costs on U.S. imports from Mexico to be small and statistically insignificant (Grossman & Krueger, 1993).

Another study by Abimanyu (1996) focuses on the trade between the U.S, Japan, Australia, and the Association of Southeast Asian Nations ("ASEAN"). It also uses an RCA model to find that dirty industry expansion was faster in developing countries than developed ones. However, it concludes that differences in environmental standards between developing and developed countries were not a significant cause of the movement of dirty industries (Abimayu, 1996). Results along the same line are found by Hettige, Mani and Wheeler (1998). They find that from 1960 to 1995, pollution-intensive output as a percentage of total manufacturing has fallen consistently in the OECD countries and risen steadily in the developing world. Moreover, the periods of rapid increase in net exports of pollution-intensive products from developing countries coincided with periods of rapid increase in the cost of pollution abatement in the OECD economies—a typical "pollution haven" effect (Hettige, Mani & Wheeler, 1998).

Using different variables, Lucas, Wheeler, and Hettige (1992) look at the trade liberalization and the toxic intensity of manufacturing in 80 countries between 1960 and 1988 (Lucas, Wheeler & Hettige, 1992). Analyzing aggregate toxic releases per unit of output, they identify metals, cement, pulp and paper, and chemicals as the dirtiest industries. They find that the dirty (toxic-intensive) industries grew faster in the developing countries as a whole, but this growth was concentrated in relatively closed, fast growing economies, rather than in the countries that were most open to trade. Regional work by Birdsall and Wheeler (1993) on Latin America generates similar results (Birdsall & Wheeler, 1993). However, the work of Lucas et al. is criticized by Rock (1996) for their classification of dirty industries and their narrow definition of openness. Rock finds that a measure of the toxic intensity of GDP (toxic pollution loads per dollar of GDP) for a country as a whole is positively correlated with measures of openness to trade during 1973-1985. That is, the more open is a country's trade policy, the greater is the pollution intensity of GDP.

Despite these findings, these authors also suggest several countervailing factors which serve to undermine the "pollution haven" hypothesis: first, the consumption / production ratios for dirty-sector products in the developing world have remained close to unity throughout the period. It implies that most of the dirty-sector development story is strictly domestic. Second, a significant part of the increase in dirty-sector production share in the developing regions seems due to a highly income-elastic demand for basic industrial products. With continued income growth, this elasticity has declined. Third, some portion of the international adjustment has probably been due to the energy price shock and the persistence of energy subsidies in many developing countries. These subsidies have been on the wane for a decade. Finally and ultimately, it seems clear that environmental regulation increases continuously with income. According to them, any tendency towards formation of a "pollution haven" seemed to be self-limiting, because economic growth brings countervailing pressure to bear on polluters through increased regulation (Rock, 1996).

2.2.2 International Investment Approach

The international investment approach mainly examines the pollution haven hypothesis by tracing the FDI flow and the stringency of environmental standards. The underlying hypothesis is that lower environmental standards are more attractive to pollution-intensive FDI. The findings of this approach vary, and they are sensitive to the measures chosen to proxy stringency of environmental regulation and pollution intensity. For example, Smarzynska and Wei (2001) measure the stringency of environmental regulation and pollution-intensity by participation in international treaties and an emissions index. They find dirty projects are more likely to locate in areas with low stringency. However, this result is not robust to alternative measures such as actual standards and an abatement index.

Other scholars (Adam 1997, Repetto 1995; Lucas et al 1992; Eskeland & Harrison 1997; Warhurst & Bridge, 1997) correlate U.S. outward FDI with environmental standards. Most of them find no support for pollution haven hypothesis (Adams, 1997; Repetto, 1995; Lucas et al, 1992; Eskeland & Harrison, 1997; Warhurst & Bridge, 1997). One study by Xing & Kolstad (1997) does find the predicted effect that there is a rise in the flows of FDI in dirty industries to developing countries. However its robustness has been questioned because the authors use Sulphur Dioxide emissions alone as a proxy for environmental regulation in a large model of locational choice and fail to separate the effects of environmental regulation from other variables (Nordström & Vaughan, 1999; Jha & Vossenaar, 1999; Low & Yeats, 1992; Low, 1993). Focused on the home country environmental standards, Eskeland & Harrison (1998) look at the patterns of U.S. foreign investment in Mexico, Venezuela, Morocco, and Cote d'Ivoire between 1982 and 1994, and examine whether they are influenced by U.S. pollution abatement costs. This study also finds traditional economic variables to be important, but rejects the hypothesis that the pattern of U.S. foreign investment in any of the recipient countries is skewed toward industries with high costs of pollution abatement.

2.3 Evaluation on the Existing Empirical Studies

To summarize the mixed empirical findings, it seems clear that the migration of dirty industries globally is a fact, but whether the environmental factor being their primary incentive to migrate is a debatable issue. While much can be learned from previous studies, I identify at least three important limitations to the body of work reviewed in the previous section. These are the limitations that this work tries to overcome in the empirical model in the context of China. The most obvious limitation is the imprecise measurement of certain variables, such as environmental stringency. When studying DIM in a specific country's context, quantitative international comparisons require that complex information about national policy, such as the degree of stringency of environmental regulation or openness to trade, must be represented by numerical variables. However, it is difficult to quantify the optimum or most efficient level of environmental protection for each country

(Neumayer, 2001). Comparing environmental laws is also problematic due to the high number of variables involved. This gives rise to inevitable problems of subjectivism and arbitrariness. Furthermore, it is questionable whether the environmental stringency is an absolute or relative criterion. An undeniable fact is every country is gradually increasing rather than decreasing their environmental stringency, therefore merely examining the correlation between a single country's environmental standard and its DIM pattern may not provide convincing explanation, but rather we should probably look at the change in the gap of inter-country environmental standards as the proxy for environmental stringency. In any case, it is not clear how to apply the results of an analysis of many countries over long time periods to the effects of a specific nation's scenario, such as China.

The second limitation is on the research scope. No previous research has explicitly made the distinction between direct and indirect DIM. Consequently, their research focuses on either trade and environment, or investment and environment. No research has ever evaluated their aggregated effect on a specific country in their research on DIM. Even for the studies that focus on the DIM through FDI, they tend to focus narrowly on the number of plant relocation and green field investments in the host country. In fact, it is the total scale of migrated dirty production in a country that should be measured, not the number of new plants. Expansion of old plants and opening of new ones both have the effect of increasing production. These factors need to be taken into account for a comprehensive study on the DIM.

The third limitation is the lack of solid DIM empirical study on China. Most previous empirical research tends to study the patterns of international trade and investment and their correlation with environmental stringency from the capital exporting country perspective. One of the important reasons is the comprehensiveness of data and statistics in these countries, especially in the environment field, which makes solid empirical studies possible. In contrast, a comprehensive trade, investment, and environment statistical system in align with international standards has not been established in China until recently. This makes empirical studies especially those involve historical time series and cross-sectional international comparison extremely difficult. Actually the reliable data constrain is a common problem for most developing country-sourced empirical studies.

3. Empirical Study on Dirty Industry Migration in China

Bearing in mind the strength and limitations of previous studies, this paper designs a straightforward empirical model to test the DIM hypothesis in the context of China, the key empirical question is: Is there empirical evidence of DIM from industrialized countries to China? If yes, in which sector(s)?

3.1 Methodology for Testing the Existence of DIM in China

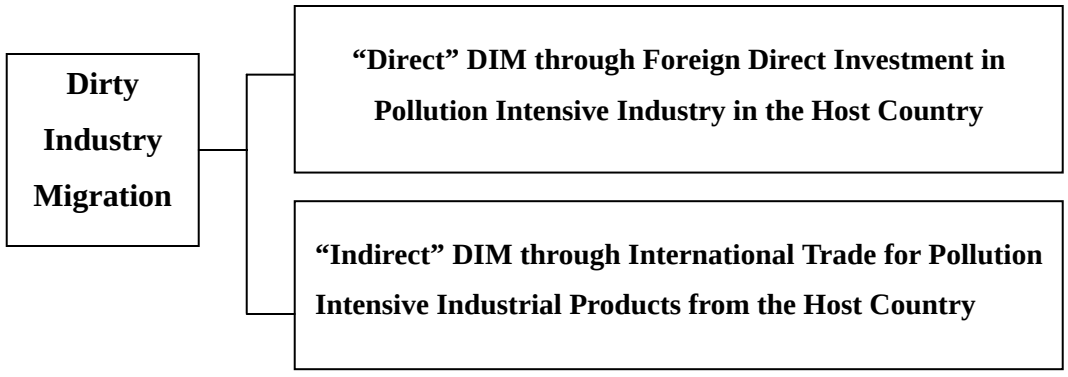
3.1.1 Distinction between "Direct" and "Indirect" Dirty Industry Migration

The distinction between "direct" DIM and "indirect" DIM is made here to untangle some confusion in the understanding of "migration" (see

Chart 1). Traditionally people tend to understand the DIM as referring only to the plant relocation of dirty production plants from one country to the other. However, in the author's opinion, the migration of dirty industries can be achieved directly, i.e. MNCs *directly* invest abroad to relocate their production overseas so as to fleeing from the high environmental regulations in their home country. Such direct DIM can take the form of greenfield investment in pollution intensive industries ("PII") in the host state, [3] or financing on the expansion of existing production facilities, or acquiring the corporations in PII in the host state, etc. Alternatively, the migration of dirty industries can be achieved indirectly. Namely, through the closure of dirty production or other forms of exit from the dirty industry in their home countries, PIIs in the home state tend to import such products from producers in other countries in substitution. In other words, the total demand for Pollution Intensive Industrial Products ("PIIP") did not decrease but only the market share being filled by other countries. A commonality in both "direct" and "indirect" DIM is that in both scenarios pollutions arising out of dirty production relocate from the home to the host countries.

The significance of making the distinction between direct and indirect DIM is to rectify a common deficiency with past literature on DIM. Previous researchers tend to focus on either DIM through FDI or DIM through international trade, yet very few researchers have attempted to combine the two for the assessment of DIM. In effect it is the aggregate environmental impact of both foreign trade and investment that gives a comprehensive picture of DIM in a particular country. Following this logic, in this part two empirical studies are conducted, one on the direct and the other on indirect DIM in China. Based on the aggregate empirical results of the two studies, I am going to draw a preliminary conclusion on whether there is evidence of DIM in China.

Chart 1 Distinction between "direct" and "indirect" Dirty Industry Migration



As discussed above, there exists both direct DIM through foreign investment and indirect DIM through international trade. For this reason, my empirical model consists of two parallel studies. One model is based on the proportion of foreign funded dirty production in the total foreign funded industrial production in China. The purpose of this study is to examine whether foreign investors have a general preference towards pollution intensive industries in China. The other model is based on the change in the composition of the bilateral commodities trade between China and U.S. The purpose of this study is to examine whether there is evidence of indirect DIM from the U.S. to China. The results of both researches will be studied together in order to draw a conclusion on the DIM in China.

3.1.2 Identify "Dirty" Industries

Various definitions have been used for pollution intensive industries in the empirical literature.[4] As there appears to be no definitive criteria yet adopted to define pollution intensive industries, I follow the "Pollution Abatement Costs and Expenditures: 1999" issued by the U.S. Census Bureau in November 2002.[5] The report is produced based on a most recent U.S. national industrial pollution abatement costs and expenditures survey in 1999. The Pollution abatement Capital Expenditures ("PACE") in the report is defined to include "installation and retrofit that occurred during 1999 for separately identifiable methods, techniques, or process technologies installed exclusively for the purpose of removing pollutants after their creation, from air emissions, water discharges, and/or solid waste or expenditures for technologies that reduce or eliminate the creation of pollutants. Include the total expenditures for pollution abatement." The Pollution abatement operating costs ("PAOC") is defined as "annual costs for operating and maintaining all pollution abatement technology. Include all costs of materials and fuels, salaries and wages, leasing and contract work and services for pollution abatement."[6]

The report surveyed the PACE and PAOC of industries up to 6-digit NAICS. It therefore it provides a good reference on the pollution intensity of various industries in the U.S. and world wide. For the purpose of this study, I select all the twenty 3-digit NAICS manufacturing industries (NAICS 311 to 337, excluding 339 Miscellaneous Manufacturing) and calculate their individual pollution intensity. The pollution intensity is calculated by adding the PACE and PAOC of a specific industry and divided by the Total Value of Shipments ("TVS") of that industry. (See Table 2 on "Pollution Intensity of NAICS-3 Manufacturing Industries") The TVS is chosen as the coverage variable since it is available for all manufacturing industries and is correlated well enough with operating costs. Based on my calculation, a ranking on the pollution intensity of major manufacturing industries is shown in Table 1:

Table 1 Ranking of the Pollution Intensity of NAICS-3 Manufacturing Industries

[Unit: Million US$]

Classification	NAICS Code	Sector	Value of shipments	PACE	PAOC	Pollution Intensity*
HPII	331	Primary metal mfg	158,101.80	605.7	1,543.90	1.360%
	324	Petroleum & coal products mfg	168,096.20	488.1	1,697.90	1.300%
	322	Paper mfg	157,491.00	611.9	945.60	0.989%
	325	Chemical mfg	419,673.90	990.9	2,808.00	0.905%
	327	Nonmetallic mineral product mfg	97,498.40	232.6	281.50	0.527%
	311	Food mfg	429,053.50	369.9	924.30	0.302%
	316	Leather & allied product mfg	9,673.20	7.3	19.60	0.278%
	332	Fabricated metal product mfg	256,899.50	283.3	405.30	0.268%
	313	Textile mills	54,854.20	37.1	105.00	0.259%
	321	Wood product mfg	97,583.40	82.1	134.90	0.222%
PII	326	Plastics & rubber products mfg	172,396.90	102.6	164.70	0.155%
	323	Printing & related support activities	102,403.70	35.2	80.30	0.113%
	335	Electrical equipment, appliance, & component mfg	119,792.20	33.7	97.00	0.109%
	337	Furniture & related product mfg	72,751.90	35	39.10	0.102%
	334	Computer & electronic product mfg	463,651.60	138	325.40	0.100%
Clean Industry	333	Machinery mfg	277,117.40	163.3	97.70	0.094%
	336	Transportation equipment mfg	675,121.90	134.7	454.40	0.087%
	312	Beverage & tobacco product mfg	107,437.00	17.1	66.10	0.077%
	339	Miscellaneous mfg	108,238.10	11.5	42.80	0.050%
	314	Textile product mills	32,641.60	7.2	4.90	0.037%

Source: U.S. Census Bureau, "Pollution Abatement Costs and Expenditures: 1999" (2002) <http://www.census.gov/prod/2002pubs/ma200-99.pdf>

*Pollution intensity (calculated by the author in %) = (PACE + PAOC) / Value of Shipments

In this work, I define industries which have pollution intensity over 0.2% as high pollution intensive industry ("HPII"), those between 0.1% and 0.2% as pollution intensive industry ("PIIs"), and those below 0.1% as "clean" manufacturing industry. The migration of HPIIs and PIIs are the focus of study.

3.3.3 Empirical Study on Direct DIM in China

3.3.3.1 Methodology and Findings

To test the foreign investor's industrial preference in China, the author selects a set of time series data from National Statistics Yearbooks published by the National Bureau of Statistics ("NBS") of China.[7] This set of data covers the economic indicators of foreign invested enterprises ("FIEs") in China for a 10 year's period from 1996 to 2005.[8] In China, the definition of FIEs refers to the enterprises in which foreign investors contribute at least 25% of the registered capital of the enterprise.[9] Among the economic indicators of FIEs the author selects the "Total Assets of FIEs" as the variable because it best reflects the overall scale of foreign funded dirty production in China.

The author's approach is to first identify the annual increase in the total asset of the FIEs in each PII, and divide them by the total increased FIE's asset of that year. By this calculation, it shows that for the 10 year-period from 1996 to 2005, 5 out of 10 HPIIs[10] and all 5 PIIs[11] have increased their respective shares in the total assets of FIEs. Despite this finding, this result is still insufficient to prove that foreign investors have a preference over China's PIIs. Some scholars argue that an increase in the presence of dirty industry in developing countries could simply be an indication of growth and industrialization in developing countries (Low, 1993), a rise in demand for such products in those countries (Jha, Markandya, & Vossenaar, 1999), or the countries' possession of higher natural resource endowments (Low & Yeats, 1992). In response to these challenges, the author further studies the industrial distribution trend of the asset of domestic (non-foreign owned) enterprises ("DE"). The industrial distribution trend of FIE assets represents the preference of foreign investments, and the industrial distribution trend of DE assets represents that of domestic investors, which is a good reflection on China's normal industrialization process, the demand for such products, and the country's possession of various endowments. Therefore, by comparing the shares of an industry's yearly increased FIE assets and DE assets in their respective total yearly increased assets, the author's presumption is that if the share of an industry's FIE asset in all FIE asset is higher than the share of that industry's DE asset in all the assets of DE, then it indicates that foreign investors have a preference in that industry. The comparison result is shown in Table 2.

Table 2 Comparison between the % of yearly increased FIE / DE assets in industry *i* in the total yearly increased FIE / DE assets from 1996 to 2005

Industries	Mean of the % of yearly increased FIE asset in industry i in the total yearly increased FIE assets	Mean of the % of yearly increased asset of DE in industry i in the total yearly increased DE asset	Mean Difference	Standard Deviation	T-Statistics
Smelting and pressing of ferrous metals	2.17	8.07	-5.9	0.046	-3.620
Smelting and pressing of nonferrous metals	1.13	3.2	-2.07	0.023	-2.555
Petroleum & coal products mfg	2.43	2.36	0.07	0.050	0.381
Paper mfg	3.81	1.61	2.2	0.029	2.149 [b]
Chemical mfg	5.71	6.2	-0.49	0.029	-0.481
Nonmetallic mineral product mfg	2.78	3.81	-1.03	0.021	-1.402
Food mfg	2.25	1.21	1.03	0.017	1.730 [c]
Leather & allied product mfg	1.31	0.44	0.87	0.010	2.493 [b]
Fabricated metal product mfg	2.81	1.5	1.31	0.021	1.761 [c]
Textile mills	3.27	2.88	0.39	0.021	0.530
Wood product mfg	0.62	0.62	0.00	0.008	0.008
Plastics & rubber products mfg	4.43	1.91	2.52	0.02	3.620 [a]
Printing & related support activities	1.02	0.65	0.37	0.014	0.769
Electrical equipment, appliance, & component	6.62	4.14	2.48	0.034	2.035 [b]
Furniture & related product	0.86	0.28	0.57	0.004	4.303 [a]
Computer & electronic product mfg	23.11	4.15	18.96	0.047	11.319 [a]

Source: China Statistics Yearbook 1995 to 2006, available at: http://www.stats.gov.cn/tjsj/ndsj/

Note: Mean difference > 0 indicates FIE has a preference over domestic enterprise on that industry.
[a] Denotes underlying mean differences is statistically significant at the 1% level.
[b] Denotes underlying mean differences is statistically significant at the 5% level.
[c] Denotes underlying mean differences is statistically significant at the 10% level.

The results in Table 3 indicate that four out of ten HPIIs[12] and four out of five PIIs [13] have demonstrated statistically significant foreign-over-domestic investment preference. In other words, in these industries, there is evidence of direct DIM.

3.3.3.2 A Further Discussion on the FDI-based Research Findings

So far the author applies the set of data from the NBS to evaluate the scale and distribution of foreign funded dirty production in China. A critical question then arises: To what extent are such statistics reliable and reflecting the actual situation? If there are factors which undermine the data accuracy, what are they and how will they affect the author's conclusion based on data analysis? This question has to be dealt with as there is a common perception that a Communist government like that in China's is prone to make use of official data for propaganda purposes, therefore its statistics are processed rather than original. For this argument the author feels necessary to make some comments.

Previous researches tend to use western-based statistics for international research. Very few researches on DIM based their arguments on data produced by developing countries. There are compelling reasons why the author needs to apply the statistics of China NBS. The most obvious reason is that no other country or international organization is capable of conducting such a comprehensive sector specific foreign funded project survey on China, especially the author applies the total assets of FIE in PII rather than the actual FDI inflows as the proxy for the scale of foreign funded dirty production in China. The uniqueness of this set of data determines that there are little comparable data that the author can apply for cross-references. Considering that China's industrial and foreign investment policies have been relatively coherent since 1995, the comprehensiveness and specificity of this set of data determine that it is a true reflection of the foreign presence in China's PII.

Previous suspicions from overseas scholars on the reliability of China's foreign investment data generally fall under two categories: the alleged "fabrication of official statistics" and the FDI "round-tripping". In response to these suspicions the author analyzes their robustness and possible impacts on the conclusion of DIM in China. The alleged "fabrication of official statistics" is a general argument raised by scholars. They suspect the proliferation of official data and the astonishing speed with which the NBS releases its statistical data to the public.[14] In many cases, public confidence on its official statistics has been dented by official revelations of exaggerated reports or false figures.[15]

The author admits the existence of such phenomenon. The central planning sets production targets for lower governments to fulfill, and this creates pressures for provincial authorities / enterprises to make false reports. In relation to foreign investment data, another incentive for the fabrication of data is that, in China the ability to attract FDI is taken as one of the governors' "Official Record" (Zheng Ji) that may boost his political fortunes. Consequently, higher officials tend to distribute and impose such tasks on lower officials and the latter, in case not being able to attract enough foreign investments, tends to declare inflated statistics to the upper level authorities. However, for any responsible scholar, if seriously looking at China's statistics, it may be found that it is not possible for the central statistical authorities to deliberately and systematically fabricate statistical information for the following reasons:

First, it is technically and politically difficult for any government to systematically manufacture false economic and social statistics on a large scale. The deliberate falsification of official statistics would entail the mammoth administrative complications of keeping two separate set of books (one for the public and one for restricted use) all the way from the central down to local levels. Second, in relation to the author's research on DIM, data like foreign trade and foreign investment cannot be easily falsified as they involve foreign countries and such data can be cross-referenced with that of other countries. It is also dangerous to tamper with growth figures. To inflate a higher percentage increase for this year would make it more difficult to do it again in the following year, as growth is a cumulative process based on the powerful compound interest rate principle.

Finally, some statistics such as wages, prices, household incomes, and inflation rates, if falsified, can be easily checked out by the people based on their own personal experience. Faking such data then serves no purpose except to discredit all the other official materials. In short, the official mendacity is simply impossible because of the abovementioned reasons. An authoritarian government, instead of falsifying numbers, could have easily withheld unfavorable information, or just published selective items in a misleading context. In fact, as the Chinese government is getting more technocratic, it demands more accurate statistics for better macroeconomic management. The remarkable evidence is the revision of China's *Statistics Law* in June 2000 in order to punish those who make use of their position to distort statistics for political or financial gains.

Despite that the reliability is no longer a central issue for Chinese official statistics today. It does not imply that the statistics are automatically accurate. In fact, in China the problem is more of "people cheating the government" rather than "government cheating the people" (Wong & Ren, 2000). In other words, fabrication of data tends to come from below: i.e. enterprises and local governments, who manipulate statistics for ulterior motives. To cope with these abuses, the China NBS has to from time to time run additional surveys or dispatch officials to check on the suspected data sources. This is for the purpose of, to the largest extent, "squeezing the water"[16] and restoring the data to their original face.

Acknowledging the distortive effect of statistics manipulation from below, it deserves discussion how it will affect the author's FDI-based empirical result on DIM. On the one hand, if local officials have overstated the FIE assets and the central government failed to deflate these figures, then the DIM problem *in total scale* may be not as serious as anticipated but the change of each PII's share in the total scale of foreign funded dirty production is unclear. On the other hand, dirty industries are often large investments with high sunk cost (i.e. capital intensive). As a result, local governors often regard the settle down of these industries as a quick way to build their official record. For these reasons they tend to strive for such projects regardless their negative impact on environment. To balance these factors, we cannot preclude the possibility that after properly deflate the inflated data collected from local authorities, the central government finally come out with a by and large accurate set of statistics, as the NBS claimed. In that case, this paper's empirical result based on the foreign investment data is not much affected.

The other strong argument which challenged China's foreign investment data is the "round-tripping"—funds originated from the China disguised as foreign capital and repatriated to China. If this argument is true, it will certainly affect our conclusion in that, to the extent that a portion of foreign investment in PIIs is artificial, they really should not be counted as DIM but rather as domestic investment in PII. The author acknowledges the distortion effect of "round-tripping" on China's foreign investment. First of all, the favorable tax treatment that foreign investors enjoy used to be a primary incentive for round-tripping. Foreign-funded manufacturing enterprises in the Mainland enjoy a tax-free holiday for two years after their first profitable year, then a 50% discount on taxes for a further three years. Profit consideration will therefore make round-tripping a tempting practice. Secondly, although China has been imposing foreign exchange control, capital flight could not be completely curbed. Thus it is quite possible that some of the funds flowing back to China would be disguised as foreign capital.[17] A large proportion of China's FDI inflows come from Hong Kong or overseas tax havens and this reinforces the notion of round-tripping. The following table shows that Hong Kong's changing share in China's FDI inflows from 1990 to 2001.

Table 3 Hong Kong's Share in China's FDI Inflows

1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
54%	55%	68%	63%	58%	53%	49%	46%	41%	41%	38%	36%

Source: Bank of China Statistics 2003

It is noticed that the share has been declining since 1992 and the decline continued after 1997 when it was handed over to China. Meanwhile, inflows from overseas tax havens such as the British Virgin Islands ("BVI"), Bermuda and Cayman Islands have been on the rise and make up for Hong Kong's decline. A rational explanation is that after the hand-over, some capital was concerned enough to abandon Hong Kong for these overseas tax havens. By the end of 2005,

it was reported that Hong Kong, BVI and Cayman Islands ranked 1st, 2nd and 8th in China's ten largest sources of FDI inflows, totaling US$289.19 billion or 47.89% of the total utilized foreign capital of that year, adding further evidence of round tripping.

Having confirmed the existence of "round-tripping", the question is then, to what extent round tripping accounts for China's FDI inflows? In other words, how serious is the problem of exaggeration? Unfortunately, there is neither official statistics nor consensus. Hong Kong and overseas tax havens encourage free flows of capital and it is impossible to trace the capital's real origins. A 2002 report by International Finance Corporation ("IFC") of the World Bank put the estimates that the round-tripped capital accounts for between 30-50% of the total China's inward FDI in the year 2000. The market's general assessment is that the ratio has declined from 30% to around 10-20% in recent years. Considering the fact that Hong Kong's share has been on a steady decline, China's capital flight has also been on a steady decline due to improved supervision, and the progressive development of national treatment of foreign and domestic enterprises under China's WTO commitments, the author is inclined to the latter estimate.

To what extent the round-tripping affects this paper's empirical result on DIM really depends on how much of the round-tripped capital was actually invested in pollution intensive industries. In examining this issue, the author holds the opinion that the round-tripping problem does not affect much on our estimated scale of foreign funded dirty industries in China. Even more, it increases the share of foreign funded PII relative to the total foreign invested industries in China. There are two primary reasons for that: First, the nature of dirty industries has determined that "round-tripping" activities are unlikely to occur in this field. This is mainly because the capital intensive character of "dirty" industries determines that such investment often involves huge capital. China's stringent control over foreign exchange transaction makes the "round-tripping" process not only risky but also costly.[18] In other words, it is very difficult to transfer overseas a large amount of capital required for PII investment. If one's objective is to take the advantage of China's tax holidays in PII, then the "round-tripping" is the last resort one may consider as the cost of round-tripping may easily outweigh the proposed tax benefits. For this reason the "round tripping" is not a common practice in pollution intensive industries, unless for special purposes.

Second, even if huge amount of Chinese capital is transferred overseas, it may not consider investing in China's dirty industries because Chinese laws provided that certain capital and pollution intensive industries are prohibited or restricted from foreign investment, either because of their strategic importance to China's economy or of their potential impact on China's natural resources, people's health and the environment. This further undermines the necessity of using "round-tripped" capital to invest in PIIs. To summarize, for the abovementioned reasons, pollution intensive industries in China might be a field with few round-tripped capital involvement. As a result, the existence of round-tripping phenomenon in China's

FDI data does not affect much on our empirical result. Furthermore, since the scale of foreign invested dirty industries is not much affected by round-tripping, the author may even boldly postulate that the more round-tripped capital involved in China's inward foreign investment, after deduction of round-tripping capitals the higher is the share of foreign capital in PII relative to the total true FDI in China.

3.3.4 Empirical Study on the Indirect DIM between China and U.S.

The author selects the Sino-U.S. bilateral trade as a case for the indirect DIM study for several reasons. First, U.S. is the largest industrialized country and China is the largest industrializing country. The Sino-U.S. trade makes an excellent case to study the characters of international trade between developed and developing countries, which is the primary vehicle of indirect DIM. Second, U.S. is both China's most important trading partner and the largest export market for China's industrial products. According to the latest U.S. statistics, China's trade surplus with U.S. has reached US$230 billion in 2006 (increased from US$28 billion in 2001).[19] Washington is seriously concerned over China's enormous trade surplus with U.S. and the surplus has fueled accusations in Washington over unfair trade practices by China, including efforts to hold the RMB artificially low to boost exports. For these reasons, it would be particularly useful to study whether there is the trend of indirect DIM from U.S. to China. In other words, whether there is evidence that U.S. producers in "dirty" industries have gradually lowered their production and at the same time purchased more pollution intensive industrial products ("PIIPs") from China.

The author selects a set of Sino-U.S. international trade data which covers an 11-year period from 1995 to 2006 (same period with the foreign investment based empirical study) from the U.S. Census Bureau.[20] Based on the previous classification of HPII and PII, the author calculated the share of the industrial products of each HPII / PII in the annual total export from China to U.S. and in the annual total export from U.S. to China. The matching of the HPII / PII and their respective industrial products under U.S. SITC is shown in Table 4.

Table 4 the Matching of HPII / PII under NAICS and PIIP under SITC

NAICS Code	SITC Code for Commodity Grouping
Primary metal mfg (331)	Nonferrous Metal (Iron and Steel) (SITC 67 and 68)
Petroleum & coal products mfg (324)	Mineral fuels, lubricants and related materials (SITC 3)
Paper mfg (322)	Paper, paperboard, and articles of paper pulp, paper or paper board (SITC 64)
Chemical mfg (325)	Chemicals and related products (SITC 5)
Nonmetallic mineral product mfg (327)	Nonmetallic mineral manufactures (SITC 66)

NAICS Code	SITC Code for Commodity Grouping
Food mfg (311)	Food and live animals (SITC 0)
Leather & allied product mfg (316)	Leather, leather manufactures, n.e.s., and dressed furskins (SITC 61)
Fabricated metal product mfg (332)	Manufactures of metals (SITC 9)
Textile mills (313)	Textile yarn, fabrics, made-up articles, n.e.s., and related products (SITC 65)
Wood product mfg (321)	Cork and wood manufactures other than furniture (SITC 63)
Plastics & rubber products mfg (326)	Rubber manufactures (SITC 62)
Printing & related support activities (323)	Office machines and automatic data processing machines (SITC 75)
Electrical equipment, appliance, & component mfg, Computer & electronic product mfg (335 & 334)	Machinery and transport equipment (SITC 7)
Furniture & related product mfg (337)	Furniture and parts thereof; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings (SITC 82)

Source: NAICS codes from U.S. Census Bureau, <http://www.census.gov/epcd/naics02/naicod02.htm>, SITC codes from U.S. Census Bureau, International Trade Statistics, <http://censtats.census.gov/sitc/sitc.shtml> (PII-PIIP matched by the author)

The calculation shows that during the period 1995 to 2006, most PIIPs of China have increased their respective share in China's export to U.S.[21] As for U.S. export to China, the trend is not consistent: four out of ten HPIIs increased their shares in the U.S. export to China,[22] while six have decreased.[23] Thus, if the author's hypothesis of indirect DIM from U.S. to China is to be supported, then special attention shall be paid to those industries that have increased their revealed comparative advantage in China's export to U.S. against U.S. export to China. For this reason a further calculation and comparison is conducted based on the growth rate of each sector in the composition of China's export to U.S. and U.S.'s export to China from 1996 to 2006. The result is shown in Table 6.

Table 5 Comparison between the growth rate of industry *i* in the composition of China's export to U.S. and in the composition of U.S.' export to China from 1996 to 2006

Industries	Mean Composition Growth Rate (China export to U.S.)	Mean Composition Growth Rate (U.S. export to China)	Mean Difference	Standard Deviation	T-Statistics
Smelting and pressing of ferrous and non-ferrous metals	15.02%	17.9%	-2.88%	0.854	-0.107

Industries	Mean Composition Growth Rate (China export to U.S.)	Mean Composition Growth Rate (U.S. export to China)	Mean Difference	Standard Deviation	T-Statistics
Petroleum & coal products mfg	3.03%	14.71%	-11.68%	1.076	-0.343
Paper mfg	2.12%	-7.93%	10.05%	0.141	2.255 [b]
Chemical mfg	1.02%	-1.74%	2.76%	0.160	0.548
Nonmetallic mineral product mfg	-1.95%	3.87%	-5.82%	0.274	-0.673
Food mfg	0.12%	-5.25%	5.37%	0.269	0.631
Leather & allied product mfg	5.91%	9.95%	-4.04%	0.362	-0.353
Fabricated metal product mfg	4.68%	-1.6%	6.28%	0.188	1.058
Textile mills	1.23%	8.41%	-7.18%	0.152	-1.492
Wood product	6.56%	4.7%	1.86%	0.331	0.178
Plastics & rubber products mfg	12.03%	19.44%	-7.42%	0.280	-0.838
Printing & related support activities	9.72%	12.92%	-3.2%	0.480	-0.210
Furniture & related product mfg	9.88%	4.19%	5.7%	0.248	0.727
Machinery and transport equipment	5.41%	0.28%	5.13%	0.116	1.398 [c]

Source: U.S. Census Bureau International Trade Statistics, <http://www.census.gov/foreign-trade/statistics/country/index.html>
Note: Mean Difference > 0 indicates industry I grows faster in the composition of China's export to U.S. than U.S.' export to China during the period 1996 to 2006.
[a] Denotes underlying mean differences is statistically significant at the 1% level.
[b] Denotes underlying mean differences is statistically significant at the 5% level.
[c] Denotes underlying mean differences is statistically significant at the 10% level.

By this comparison, two sectors are identified as demonstrating a statistically significant trend of indirect DIM. They are Paper manufacturing which is an HPII and the Machinery and transport equipment which is a PII.

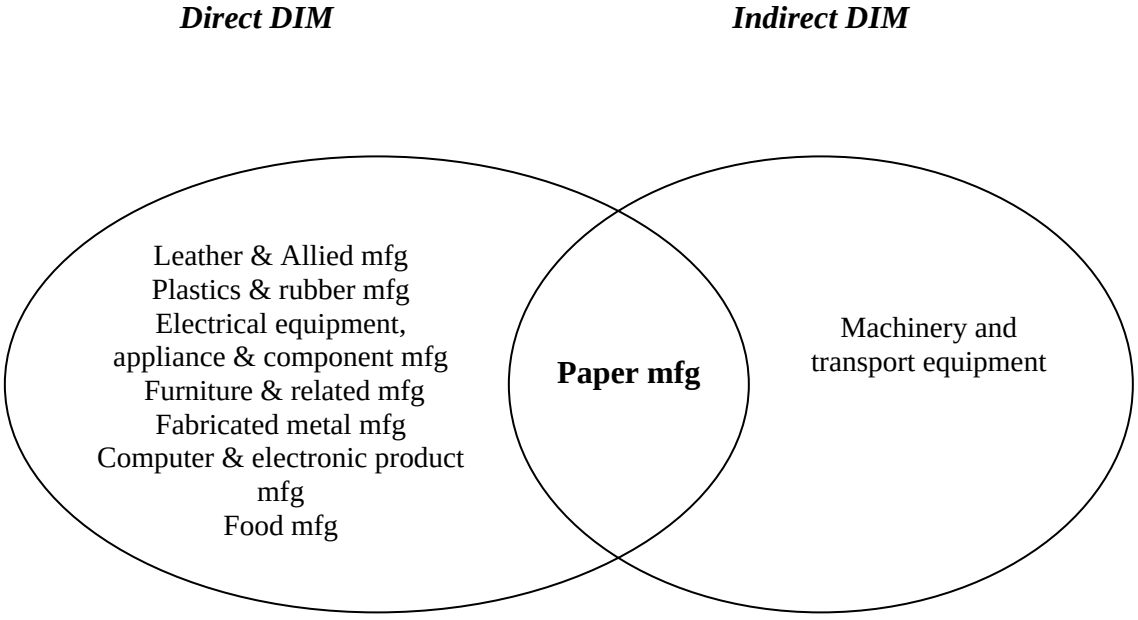
3.3.5 Combined Assessment on Direct and Indirect DIM

The combined empirical result of both direct and indirect DIM is shown in Chart 2. Eight sectors shows evidence of direct DIM and two sectors shows evidence of indirect DIM. Notably in Paper manufacturing sector, the evidence of both direct and indirect DIM is statistically significant. In the paper manufacturing industry, the

foreign investment has an annual average of 225% preference over domestic investment and such preference is on a steady growth in recent years. In respect of the Sino-U.S. bilateral trade of paper and paper board products, the proportion has steadily increased from 0.52% in 1995 to 0.63% in 2006 in China's export to U.S. and decreased from 2.08% to 0.8% in U.S. export to China.

The identification of these industries, especially the paper manufacturing industries in which evidence for both direct and indirect DIM are apparent, has policy implications. For example, if China is to legislate or use policy tools to regulate the DIM, then these industries would be the priority of the regulator's attention. It would be helpful to have a thorough examination on the existing trade and investment patterns and policies that apply to these industries and see whether they have taken an adequate consideration of environmental issues. At the same time, the environmental laws, regulations and sectoral standards in these industries also required a general survey to see whether they are understood, fair, and adequate.

Chart 2 Summary of Empirical Findings on the Direct and Indirect DIM in China

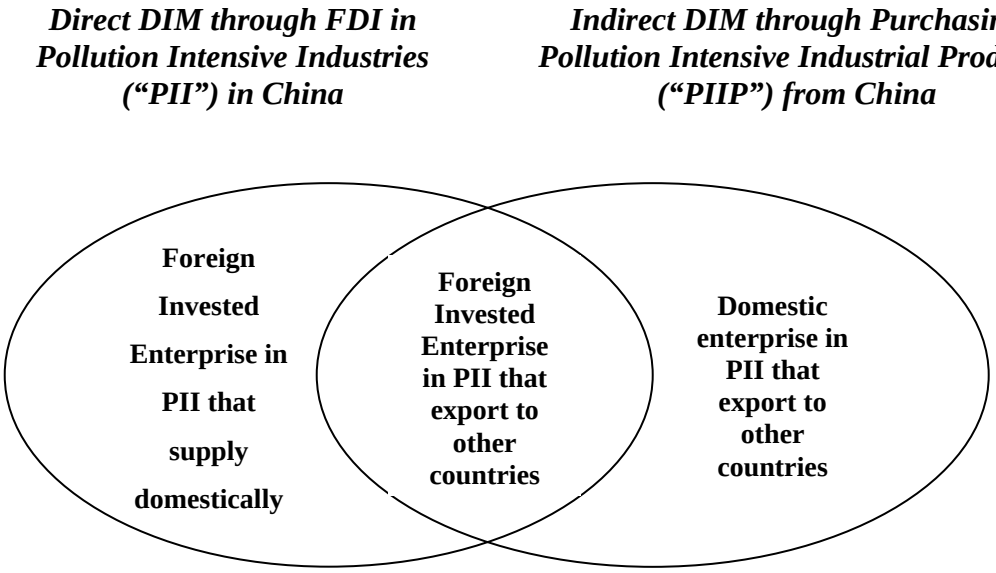


3.3.6 The Calculation of Aggregate Impact of DIM in China

Based on the author's analysis, the extent of DIM situation in China shall be the aggregate impact of both direct DIM through foreign investment in PII and indirect DIM through international trade in PIIP. However, their environmental aggregate impact on China is not simply the sum of the two. It is because many FIE in PII in

China are at the same time involved in the international trade of PIIPs. In that case since pollution is generated in the same production process, there is an overlap between direct DIM and indirect DIM. Therefore, the author predicts that the environmental impact of DIM on China is higher than that of direct or indirect DIM whichever is higher, but less than the aggregation of the two. It is in fact the aggregated environmental impact of three components: namely "FIEs in PII that supply domestically", "FIEs in PII that export to other countries" "DEs in PII that export to other countries". Such proposition is illustrated in Chart 3 below.

Chart 3 Aggregate Environmental Impact of Direct and indirect DIM in China



4. Conclusion

This work empirically tests the existence of DIM in China. Based on the two primary vehicles of DIM, namely direct DIM through foreign investment and indirect DIM through international trade, the author conducts two parallel empirical studies and estimates the aggregate environmental impact of DIM on China. To summarize the findings, the author is of the opinion that a large scale of DIM may not occur in China. In other words, evidence neither show that foreign investors have a general preference over China's PIIs nor that China specializes solely on PIIPs in its exports. Despite this, the author does find evidence of either direct or indirect DIM in specific industries. Notably in the paper manufacturing industry the evidence of both direct and indirect DIM is significant. Such an observation should attract sufficient attention and due regulation. The empirical testing model designed by this research is original. It could be applied to any capital-importing country for the examination on the trend of direct DIM, and be applied between any two countries to examine the extent of indirect DIM from one to the other (subject to

data availability). Furthermore, by adopting different characteristics of industries, this model could be applied to test the trend in the global migratory patterns of, for example, labor-intensive industry, technology-intensive industry, and so on.

Despite this, there are several important limitations on this empirical model. Firstly, this research adopts the U.S. PACE standard of 1999 for the determination of PIIs and mainly adopts a 3-digit NAICS for sectoral examination. It must be stressed that by using different criteria of PII and adopting more detailed industrial classification up to 6-digit, the empirical result will vary, as there is possibility that a parent sector does not show the trend of DIM but its subsidiary sector does. Second, although our model addresses the question whether there is evidence of DIM from industrialized countries to China, we did not empirically address a further, and perhaps more important question: To what extent China's sectoral environmental stringency affects the patterns of DIM which has been observed? In other words, although the author identifies the trend of DIM in certain industries, the driving forces of migration in these industries differ, of which the sectoral environmental stringency may or may not be the primary incentive for their migration. These factors deserve more intensive study,

Finally, a related exploratory question that may interest the future researchers is: Other than the evidence of DIM from industrialized countries to China, is there a tendency of DIM from China to even less developed countries? If yes, what are their driving factors? These questions are justified because trade statistics also show the volume of China's import of PIIP increases together with export in order to meet the country's huge demand for industrial products.[24] Moreover, there is evidence that China's domestic enterprises, especially state-owned-enterprises, are becoming increasingly active in outward FDI in PIIs. Following the rationale of this research, it would be an interesting topic to study the more comprehensive global pattern of DIM.

Endnotes

[1] In urging the World Bank to encourage the migration of dirty industries to Less Developed Countries ("LDC"), Summers argued that worldwide welfare will be maximized by locating dirty industries in LDCs because: (1) the income lost through health-impairing pollution will be lower in countries with lower wage levels; (2) many under-populated LDCs are under-polluted (as compared to Los Angeles or Mexico City); and (3) the demand for a clean environment for aesthetic and health reasons will be greater in wealthy countries than in poor countries. *The Economist*, (8 Febuary 1992), p.66.

[2] World Trade Organization ("WTO") statistics, <http://stat.wto.org> Accessed 10 June 2006.

[3] A Greenfield Investment is the investment in a manufacturing plant, office, or other physical company-related structure or group of structures in an area where no previous facilities exist.
Source: <http://en.wikipedia.org/wiki/Greenfield_investment> Accessed 28 February 2007.

[4]In defining "pollution intensive", a conventional approach in the literature has been to identify pollution-intensive sectors as those which have incurred a certain high level of pollution abatement cost per unit of output. According to the Economic Committee of Asian and Pacific Economic Cooperation ("APEC"), dirty industries, or what they call "environmentally sensitive industries" are those industries that incurred pollution abatement and control expenditures of approximately 1% or more of the value of their total sales. APEC, Survey on Trade-Related Environmental Measures and

Environmental-Related Trade Measures in APEC (1998) Wellington, New Zealand. Tobey (1990) defines pollution intensive industry as one where pollution abatement costs in the United States were 1.85% or more of the total costs (Tobey, 1990). Levinson (1996) defines "high pollution intensity" as those pollution abatement capital expenditures as a percentage of total new capital expenditures exceeding 5%.

[5]U.S. Census Bureau, "Pollution Abatement Costs and Expenditures: 1999" (2002) <http://www.census.gov/prod/2002pubs/ma200-99.pdf> Accessed 10 Jan 2006.

[6] Id, at A-10, Appendix A.

[7]The electronic version of the original data is available from the website of NBS at <http://www.stats.gov.cn/tjsj/ndsj/> Accessed 20 February 2007.

[8] Before 1995 such consistent data was not available, and since China's 2006 National Statistics Yearbook has not yet been published, the 2005 statistics is not available.

[9] Foreign investment in China statistics includes investment from Hong Kong and Taiwan.

[10] Namely, primary metal manufacturing, leather & allied product manufacturing, fabricated metal product manufacturing, textile mills, wood product manufacturing.

[11] Namely, plastics & rubber products manufacturing, printing & related support activities, electrical equipment, appliance, & component manufacturing, furniture & related product manufacturing, computer & electronic product manufacturing

[12] These four HPII are paper manufacturing; food manufacturing; leather & allied product manufacturing; and fabricated metal product manufacturing.

[13]These PIIs are plastics & rubber products manufacturing; electrical equipment, appliance & component manufacturing; furniture & related product manufacturing; and computer & electronic product manufacturing.

[14] It was alleged that in China, the national yearbook containing the last-year data, for instance, is normally published in the third quarter of this year. Even more remarkable, such key economic performance indicators as industrial output, imports and exports and ("CPI") Consumer Price Index of the current month are normally released in the middle of the following month. It is perhaps quicker than anywhere in the world.

[15] For instance, in early 1998 Premier Zhu Rongji declared his intention to see 8% growth for China. At the end of 1998, most provinces returned with more than 8% GDP growth figures for the year. NBS eventually had to readjust some provincial figures downward to arrive at a 7.8% growth for China for 1998. See Anonymous, "Numbers Lie: Premier Uncovers Lies", *Asia Weekly* (27 March 2000). The same problem has repeated itself. In 1999 China's GDP growth was 7.1%, with 10 provinces reporting more than 10% growth. Hence there is the need for NBS to readjust the numbers. See Anonymous, "Beijing has HK$546 b chasm in key data", *South China Morning Post* (29 February 2000).

[16] See Anonymous, "Are China's statistical figures on economy reliable?", *People's Daily* (22 July 2002).

[17] China's capital flight is a rather complex issue. No accurate estimate could possibly be made. Economists usually use the Net Error and Omission under China's Balance of Payments account as a reference to the size of the flight. From 1997 to 2000, the amounts were US$17bn, US$16.5bn, US$14.8bn and US$11.9bn respectively (in a downtrend). Although not all of it is capital flight, the consensus remains that a large proportion is and part of it should find its way back into China. Source: China State Administration of Foreign Exchange (SAFE) <http://www.safe.gov.cn> Accessed 5 May 2004.

[18] The major forms that round tripping can take include under-invoicing exports, over-invoicing imports, and overseas affiliates of Chinese companies borrowing funds or raising capital in the stock market and reinvesting them in China, etc.

[19]U.S. Census Bureau International Trade Statistics, <http://www.census.gov/foreign-trade/statistics/country/index.html> Accessed 1 March 2007.

[20] U.S. Census Bureau, International Trade Statistics, <http://censtats.census.gov/sitc/sitc.shtml> Accessed 8 March 2007.

[21] Except mineral fuels, lubricants and related materials; nonmetallic mineral manufactures.

[22] The 4 HPII that increase their shares in U.S. export to China are Iron and Steel; Mineral fuels, lubricants and related materials; Leather and leather manufactures; Textile yarn, fabrics, made-up articles, n.e.s., and related products.

[23] The 6 HPII that decrease their shares in U.S. export to China are Mineral fuels, lubricants and related materials; Paper manufacturing; Chemicals and related products; Food and live animals; Manufactures of metals; Wood product manufacturing.

[24] For example, based on the idea of embodied effluent trade (EET) introduced by Lee & Roland-Holst (1997), Chai (2002) compares the pollution content of exports (Ex) and imports (Em) of China during the period 1980-82 and 1996-98, and find that despite China's import is becoming cleaner in 1996-98 than in 1980-82, it is still more than 60% more pollution intensive than its export counterpart. This implies that "in a long-term situation of relatively balanced bilateral trade, import trade has had a beneficial effect on China's environment, as it enabled China to transfer a significant amount of environmental cost to other countries."

References

Abimayu, A. 1996, “Impact of Free Trade on Industrial Pollution: Do Pollution Havens Exist?”, *ASEAN Economic Bulletin*, vol.13, no.1.

Adams, J. 1997, “Environmental Policy and Competitiveness in A Globalized Economy: Conceptual Issues and A Review of Empirical Evidences” in OECD, Globalization and Environment: Preliminary Perspectives, OECD, Paris, pp.53-100.

Barton, J.R. 1999, “Environmental Regulations, Globalization of Production and Technological Change in the Iron and Steel Sector”, Paper Presented at Conference on Environmental Regulations, Globalization of Production and Technological Change, University of East Anglia.

Berrie, P.J. 1992, “Controlling the Export of Hazardous Industries: A Look at the United States Asbestos Industry”, *Transnational Law & Contemperoary Problems*, no.2, p.274.

Birdsall, N. & Wheeler, D. 1993, “Trade Policy and Industrial Pollution in Latin America: Where Are The Pollution Havens?” *Journal of Environment and Development*, vol.2, Winter.

Cairncross, F. 8 September 1990, “Cleaning Up”, *The Economist* 24.

Castleman, B.I. 1979, “The Export of Hazardous Factories to Developing Nations”, *International Journal of Health Services*, no.9, p.572.

Chai, J.C.H. 2002, “Trade and Environment: Evidence from China’s Manufacturing Sector”, *Sustainable Development*, no.10, pp.25-35.

Cropper, M. & Oates, W. 1992, “Environmental Economics: A Survey”, *Journal of Economic Literature*, no.30, p.675.

Eskeland, G.S. & Harrison 1997, “Moving to Greener Pasture? Multinationals and the Pollution-Haven Hypothesis”, Policy Research Working Paper 1744, The World Bank, Washington D.C.

Esty & Geradin, D. 1998, “Environmental Protection and International Competitiveness: A Conceptual Framework”, *Journal of. World Trade*, no. 5, pp.19-20.

General Accounting Office (“GAO”) 1990, Report on the Furniture Finishing Industry”, Washington D.C.

Gray, W.B. & Shadbegian, R.J. 1993, *Environmental Regulation and Manufacturing Productivity at the Plant Level*, National Bureau of Economic Research, Cambridge, MA.

Grossman, G. & Krueger, A. 1993, "Environmental Impacts of a North American Free Trade Agreement" in Garber, P. (Ed.), The Mexico-US Free Trade Agreement, MIT Press, Cambridge, MA.

Hesselberg, J. 1999, "International Competitiveness: The Tanning Industry in Poland, the Czech Republic, Brazil and Mexico", F.I.L Working Papers, no. 15, University of Oslo.

Hettige, H., Mani, M. & Wheeler, D. 1998, "Industrial Pollution in Economic Development: Kuznets Revisited", World Bank Development Research Group Working Paper, no. 1876, p.244.

Jha, V., Markandya, A. and Vossenaar, R. 1999, *Reconciling Trade and the Environment: Lessons From Case Studies in Developing Countries*, Elgar, Cheltenham, UK.

Knodgen, G. 1979, "Environment and Industrial Sitting: Results of an Empirical Survey of Investment by Western German Industry in Developing Countries", *Zeitschrift fur Umweltpolitik*, no, 2.

Knutsen, H.G 1999, "Leather Tanning, Environmental Regulations and Competitiveness in Europe: A Comparative Study of Germany, Italy and Portugal", F.I.L Working Papers, no. 17, University of Oslo.

Lee, H. & Roland-Holst, D.W. 1997, "Trade and the Environment", in Francois, J.F. & Reinert, K.A. (Eds.), Applied Methods for Trade Policy Analysis: A Handbook, Cambridge University Press, Cambridge, pp.517-550.

Levinson, A. 1996, "Environmental Regulations and Manufacturer's Location Choices: Evidence from the Census of Manufacturing", *Journal of Public Economics*, vol.61, no. 1, pp. 5-29.

Low, P. & Yeats, A. 1992, "Do 'Dirty' Industries Migrate?", in Low, P., International Trade and the Environment, World Bank Discussion Paper no. 159, The World Bank, Washington DC, p. 2.

Low, P. 1993, "The International Location of Polluting Industries and the Harmonization of Environmental Standards", in Munoz, H. & Rosenberg, R. (Eds), Difficult Liaison – Trade and the Environment in the Americas, Transaction Publishers, New Brunswick, USA, p.21.

Lucas, R.E.B., Wheeler, D. & Hettige, H. 1992, "*Economic Development, Environmental Regulation and the International Migration of Toxic Industrial Pollution, 1960-1988*" in Low, P. (Ed.), International Trade and the Environment, The World Bank, Washington D.C.

Mabey, N. & McNally, R. 1999, *Foreign Direct Investment and the Environment: From Pollution Haven to Sustainable Development,* WWF, Surrey, UK.

Mani, M., Pargal, S. & Hug, M. 1997, "Does Environmental Regulation Matter? Determinants of the Location of New Manufacturing Plants in India 1994", Policy Research Working Paper 1718, The World Bank, Washington D.C.

Neumayer, E. 2001, "Pollution Havens: An Analysis of Policy Options for Dealing with an Elusive Phenomenon" *Journal of Environment & Development*, vol.10, no.2, pp.147-177.

Nordström, H. & Vaughan, S. 1999. *Trade and Environment: Special Studies 4*, World Trade Organization, Geneva.

Odegard, J.T. 1999, "Leather Tanning in Brazil", F.I.L Working Papers, no.19, University of Oslo.

OECD 2002, "Environmental Issues in Policy-based Competition for Investment: A Literature Review", <http://www.olis.oecd.org/olis/2001doc.nsf/LinkTo/env-epoc-gsp(2001)11-final> Accessed 27 December 2006.

Repetto, R. 1995, "Jobs, Competitiveness, and Environmental Regulation: What Are the Real Issues?" World Resources Institute Research Report, Washington D.C.

Rock, M. 1996, "Pollution Intensity of GDP and Trade Policy: Can the World Bank Be Wrong?", *World Development,* vol.24, no. 3, pp.471-479.

Smarzynska, B. & Wei, S. 2001, "Pollution Havens and the Location of Foreign Direct investment: Dirty Secret or Popular Myth?", International Trade Team – Development Economics Research Group, The World Bank. Washington D.C.

Sorsa, P. 1994, "Competitiveness and Environmental Standards: Some Exploratory Results", Policy Research Working Paper 1249, The World Bank, Washington D.C.

Suttles, J.T. 2002, "Transmigration of Hazardous Industry: the Global Race to the Bottom, Environmental Justice, and the Asbestos Industry", *Tulane Environmental Law Journal*, no. 16, pp.25-29.

Tobey, J.A. 1990, "The Effects of Domestic Environmental Policies on Pattern of World Trade: An Empirical Test", *Kyklos*, vol.43, no.2, World Bank Series Studies 191.

UNCTAD 1995, *Environment: International Competitiveness and Development: Lessons from Empirical Studies,* UNCTAD Trade and Development Board, Ad Hoc Working Group on Trade, Environment and Development, Geneva.

Walter, I. 1982, "Environmentally Induced Industrial Relocation in Developing Countries", in Rubin, J.S. & Graham, R. T. (Eds). Environment and Trade, Allanheld, Osmum and Co., Totowa NJ, pp.67-101.

Warhurst, A. & Bridge, G. 1997, "Economic Liberalization, Innovation, and Technology Transfer: opportunities for cleaner production in the minerals industry", *Natural Resources Forum*, vol.21 no.1, pp.1-12.

Wheeler, D. & Mody, A. 1992, "International Investment Location Decisions: The Case of US Firms", *Journal of International Economics*, no.33, pp.57-76.

Wheeler, D. 2000, "Racing to the Bottom? Foreign investment and Air Quality in Developing Countries", Development Research Group World Bank, <http://econ.worldbank.org/files/1340_wps2524.pdf> Accessed 13 February 2007.

Wong, J. & Ren, C.F. 2000, "Understanding China's Statistical System", *East Asian Institute Working Paper*, no. 75.

World Wildlife Fund 1999, *Foreign Investment in the Asia Pacific Mining Sector: National Policies, Economic Liberalisation and Environmental and Social Effects*, WWF, Gland, Switzerland.

Xing, Y. & Kolstad, C. 1995, "Do Lax Environmental Regulations Attract Foreign Investments?", Working Papers in Economics, University of California, Santa Barbara.

Yoichi Nishijima 1993, "Internalization of Environmental Costs and Industry Competitiveness", OECD Workshop on Environmental Policies and Industrial Competitiveness.