INDIRECT COMPLIANCE COST, POLLUTION HAVEN EFFECT, AND EXPORT FLOWS IN ASEAN-5

By

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ABSTRACT

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Low Kok Tong

The environmental issues in Southeast Asia have received growing while the desire for economic growth in the Association of Southeast Asian Nations (ASEAN) continues to lead governments to open their economy for trade and investment. The trade composition profile of ASEAN-5 and its high involvement in international production fragmentation making the region actually an important case to study when investigating pollution haven hypothesis. This study aims to investigate the relationship between indirect environmental compliance cost and export flows of ASEAN-5 to their major trading partners. Since relative economic sizes and geographical proximity may be important to determine export flows, this research will use gravity model of international trade as a basic framework and apply sectoral panel data analysis, specifically mixed-effects linear regression via maximum likelihood (Mixed-ML) analysis, for the period of year 2006 - 2014. As a result, This study finds significant evidence that indicate indirect environmental compliance costs will have influence over exports flows for both the dirty and clean industry. Therefore, the regulators are encouraged to raise the indirect compliance costs against dirty industries through empowering local community in assessing pollution information of dirty industries.

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APPROVAL SHEET

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SUBMISSION OF DISSERTATION

It is hereby certified that **(Low Kok Tong)** (ID No: **(15ABM06686)**) has completed this dissertation entitled "INDIRECT COMPLIANCE COST, POLLUTION HAVEN EFFECT, AND EXPORT FLOWS IN ASEAN-5 " under the supervision of Dr. Wong Chin Yoong (Supervisor) from the Department of Economics, Faculty of Business and Finance , and Dr. Eng Yoke Kee (Co-Supervisor) from the Department of Economics , Faculty of Business and Finance .

I understand that the University will upload softcopy of my dissertation in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

(Low Kok Tong)

DECLARATION

I Low Kok Tong hereby declare that the dissertation is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

(LOW KOK TONG)

Date 25 June 2018

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AFTA	ASEAN Free Trade Area
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
CO_2	Carbon Dioxide
EAC	Environmental Assimilative Capacity
FDI	Foreign direct investment
FEM	Fixed Effect Model
GDP	Gross domestic products
GMIT	Gravity Model of International Trade
HOV	Hecksher-Ohlin Vanek Model
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
PACE	Pollution Abatement Costs and Expenditures
PHH	Pollution Haven Hypothesis

REM	Random Effect Model
UNEP	United Nations Environment Programme

CHAPTER 1

INTRODUCTION

1.1 Background of the study

1.1.1 The environment issues in Southeast Asia

Countries in Southeast Asia, particularly in ASEAN-5 countries[1], have been delivering impressive economic performance over the last 30 years. GDP per capita improved from absolute poverty to relatively decent life for majority while some people were becoming very rich. Industrialization was undertaken with the aids of the foreign direct investment (FDI) and exports were growing drastically (Jomo, 2001). Urbanization was taking place in full swing where infrastructure and high rise building were mushrooming during 1950 to 2010 (Philip & McGee, 2003) and migrations from rural area were obvious.

Nevertheless, the economic progress in the Southeast Asia is accompanied by several unintended consequences, especially the environmental issues (Iwami, 2001; Shively & Smith , 2013). Environmental issues in Southeast Asia have become increasingly notable and received great attention from public, researchers and environmental activist around the world. These environmental issues include air pollution and climate change, river pollution and contaminated water supplies, vulnerability to natural disasters, and waste disposal.

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[1] ASEAN-5 refers to the five founding countries of Association of Southeast Asian Nations (ASEAN) namely Indonesia, Malaysia, the Philippines and Singapore and Thailand. ASEAN-5 is the main sample group in this research.

Southeast Asia has among the worst air pollution in the world, besides East Asia and India (Lee et al., 2016). In 2000, Southeast Asian countries contributed 12% of the world's greenhouse gas emissions (Asian Development Bank [ADB], 2009). Although their emission level is relatively low compared with China and US, it actually has increased 27% from 1990 levels (ADB, 2009) and is expected to overtake US and China's emission by 2030, if no remedy is taken (Lee, Sethupathi, Lee, Bhatia, and Mohamed, 2013).

Indonesia is one of the biggest emitters of carbon dioxide (CO_2) in the world, contributing about 60% of the region's emission in 2000 (Bennet and Oshikoya, 2011). "Land use change" emission due to burning activity is one of the major contributors for the country's emission. Burning activities are regularly initiated by small-scale farmers or agro-industrial companies to clear land of trees for agricultural purposes as it is the cheapest and most convenient method of land clearance (Lee et al., 2016). The hazes generated from these burning activities have been more often in Indonesia and spread across many countries in the region, particularly in Malaysia, Singapore, Thailand, and Brunei, resulting in serious health and safety concerns. Public institutions were closed and people were advised to stay at home. It was also causing economic loss when the hazes escalated and led cities and air flight to shut down (Lee et al., 2016). These burning activities which have generated substantial amount of CO_2 are contributing significantly to global climate change.

Marilao River in Philippine and Citarum River in Indonesia are one of the most polluted rivers in Asia. Industrial wastes were discharged into Marilao River which is a source of drinking water and agricultural usage for the millions of residents living within its basin, while Citarum River was contaminated by heavy metals that come from industrial activities along the river such as mining and processing metal ores, finishing and plating of metal and the manufacture of metal object (Roosmini, Hadisantosa, Salami, & Rachmawati, 2009). In Thailand, agro-food industrial has been found as the source of water pollution and harming aquatic animal population resulted from increasing untreated waste water were dumped into rivers (Wattanapinyo & Mol, 2013).

Deforestation is also a severe environmental problem for Southeast Asia, in particular Indonesia and Malaysia. In Indonesia, legal timber supplies from natural forests declined from 17 million m^3 in 1995 to less than eight million m^3 in 2000, and the most natural rainforest would be degraded by 2032 (United Nations Environment Programme [UNEP], 2007). The main causes of deforestation are illegal logging and the rapid proliferation of oil palm plantation. Illegal logging are wantonly taking place in 37 of the 41 national parks of Indonesia, especially in Gunung Palung, Kutai, Danau Sentarum, Gunung Leuser and Tanjung Puting (UNEP, 2007). Meanwhile, the conversion of forest land to palm oil production in palm oil industry significantly contributes to deforestation.

The list of instances can go on. Worse still, environmental degradation can contribute to climate change. ADB (2009) admonishes that climate change in Southeast Asia, if not addressed adequately, will be worsened and could seriously impede the sustainable development and poverty elimination efforts in the region thus far. Southeast Asia region itself may suffer for climate change more than the world average, ADB's 2009 forecast model suggests that annual mean temperature is estimated to increase 4.8°C on average by 2100 from 1990. Meanwhile, mean sea level will rises in a projected level about 3 - 16 cm by 2030 and 7 - 50 cm by 2070 (Roosmini et al, 2009).

As a consequence of climate change, Thailand experienced its worst drought in 20 years in 2010, due to the water level of the Mekong River, a trans-boundary river in Southeast Asia, dropped to its lowest level in 50 years. This was severely affected Thailand rice production and also created heavy burden for government to assist those afflicted residents (Marks, 2011).

Heat waves, tropical cyclones and recorded floods which cause severe damage to human life and economic have been more frequently occurring in the region. For instance, the Philippines has been attacked by Southern Leyte Mudslide in 2006 that caused 1100 lives were lost while Bopha typhoon that attacked Mindanao, Philippines in December 2012 affected more than 213,000 people in the country (ADB, 2009).

1.1.2 In search of the origin

While relatively low environmental awareness is clearly contribute to the environmental issues in Southeast Asia, the aggressively ongoing economic development is believed to have intense impact over the environment. A typical pattern of economic growth and environmental quality would be manifested in two stages. The early stage of economic growth usually cause an increase in environmental degradation related to natural resource exploitation.

The second stage of environmental degradation will takes place when the economy is in the process of industralization and urbanization. Therefore, it is reasonable to expect a positive relationship between economic growth and pollution level in which an increases in economic activities will causes the pollution level to be higher. Nevertheless, Copeland and Taylor (2003) points out that the scale of growth will lead the pollution to increase, but a strong policy response and the source of economic growth (composition effects) can reverse the scale effects.

In light of this, the appropriate way to investigate the environmental issues in the Southeast Asian countries would be observing both the environmental standards and the source of economic growth. Therefore, the following subsection attempts to study the environmental issues in ASEAN-5 countries, which is Indonesia, Malaysia, Philippines, Thailand and Singapore as they are the main country sample of this study. ASEAN-5 countries were selected out of other Southeast Asian countries as they are largest 5 economies and actively achieving economic growth with distinct environmental policies. The following discussion would mainly focuses on these five countries from two aspects: (I) the environmental standard and enforcement; (II) trade openness, CO_2 emission trend and the trade composition.

I. The environmental standard and enforcement

In this subsection, there are three main aspects wish to be highlighted when studying environmental standard in ASEAN-5 countries: (1) The environmental standard in general view; (2) The environmental regulation framework; (3) Factors that compel ASEAN-5 countries to adopt certain level of environmental standard.

(i) Environmental standards overview

It is indeed a fact that the environmental standard between countries are far from being harmonized. Table 1.1 presents the environmental performance index (EPI) of 20 countries with different income level[2] and indicating two useful information. First, among ASEAN-5 countries, Indonesia, Malaysia, Philippines and Thailand had EPI below 60 which was below average. Comparing with their major trading partners, China, Hong Kong, Korea, Japan and US[3], there was clear discrepancies in environmental standards with Hong Kong, Japan and US, but at about same level with Korea and China.

Singapore was distinctive among ASEAN-5 countries and demonstrated high environmental standards. However, it is meaningful to remain Singapore in the sample to check the results are consistent between countries with different level of environmental standards.

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[2] EPI measures the environmental health and ecosystem vitality of a country, thus it also indicates the country's environmental regulation stringency and enforcement.

[3] China, Hong Kong, Korea, Japan and US, were chosen as they are the top five single largest importers for ASEAN-5 countries.

Table 1.1: Comparison of Environmental Standards, 2014

Country	EPI[2]	GDP per capita[1]	Country	EPI	GDP per capita[1]
Australia	82.40	61,925.5	Malaysia	59.31	11,307.7
Singapore	81.78	56,284.6	Mexico	55.03	10,325.6
Germany	80.47	47,821.9	Thailand	52.83	5,977.4
United Kingdom	77.35	46,332.0	Indonesia	44.36	3,491.9
Canada	73.14	50,235.4	Philippines	44.02	2,872.5
Japan	72.35	36,194.4	China	43.00	7,590.0
France	71.05	42696.8	Vietnam	38.17	2,052.3
United States	67.52	54,629.5	India	31.23	1,581.5
South Korea	63.79	27,970.5	Myanmar	27.44	1,203.8
Taiwan	62.18		Bangladesh	25.61	1086.8

Source: World Development Indicators, Environmental Performance Index Report 2014
Note: [1]Data are in current U.S. Dollar
[2]Environmental Performance Index (0, weakest; 100 strongest)

Second, the table shows that the countries which adopting higher environmental standard (EPI above 70) were, in general, the countries with high income level, include Australia, United Kingdom, Germany and Canada. In contrast, the countries with lower environmental standard (EPI below 60) are usually poorer, such as Bangladesh, Myanmar, India and Vietnam.

There is logical view supporting this observation; that is high income nations have higher capability and demand over better environmental quality, while poor or developing countries may struggling for basic needs where environmental quality become secondary importance. These countries have the tendency to emphasize on eradicate poverty or pursuing economic growth at the expense of environmental quality through implementing weaker environmental regulation.

One can also easily links this view to Environmental Kuznet Curve (EKC) which posits that income growth will leads pollution level to increase at the early stage but further increase in income level will be accompanied by a decline in pollution level at later stage. This view implies that the environmental quality is a luxury.

Nevertheless, World Bank (2012) argued that “green growth” is affordable for both developed and developing countries as many green policies are able to sustain themselves financially once externalities are priced. Meanwhile, there is also a growing literature that cast doubt on its empirical validity over EKC (see examples Stern, 2004; Dinda, 2004; and Stern, 2014). Dasgupta, Laplante, Wang and Wheeler (2002) stated that the curve is actually flattering and shifting to the left.

These arguments being mentioned here is to show that there is no inevitable relation between national income and pollution level, however, many policy makers still suggest the notion of “grow dirty and clean up later” which emphasizes satisfying human need is an urgency task and environmental issues can be solved later when the countries become wealthier (World Bank, 2012; Arcas, 2013)[4].

On the other hand, the people, especially the lowest income group, may also resisting the implementation of stringent environmental regulation as their livelihood often benefits from environmental exploitation. More importantly, they may not have better or equal alternative for income if their original livelihood is being banned or restricted by environmental regulation (Ananta, Fadillah, Yunani, Adliansyah, & Adhinata, 2013). Combine these two reasons, governments in developing world have higher tendency to embrace weaker environmental regulation in order to achieve a more rapidly growing income.

Note that a weak environmental standards does not mean that environmental regulations are absent or they are not following international standard, but it can be the lack of governance and weak enforcement of the law and regulation. Sometimes, weak enforcement can be due to the policy makers, even the leaders of environmental department, have no strong believe in environmental protection (Tan, 2004).

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[4] Environmental crisis usually has longer time scale and may not palpable before it become into reality (Heal, 2005). The long time scale explains the reason why people are championing the idea of “grow dirty and clean up later” and neglect irreversible damage.

Hence, environmental assimilative capacity (EAC) which refers to the ability of a country to absorb or tolerate pollutants has been introduced. Blackhurst (1977) states that EAC is not only determined by physical ability of water, air, and land to absorb waste disposal, but also influenced by the level of pollution the society is willing to compromise.

(ii) Environmental policies of ASEAN-5 and its issues

Generally, stipulated environmental protection laws and regulations of ASEAN-5 countries are reasonably well established and literally covering all related areas, include energy usage, air pollution, waste management, land and biodiversity preservation and etc. However, a more comprehensive view of environmental regime, according to Esty and Porter (2001), should also includes stringency of standards, regulatory structure, regulatory enforcement, environmental institution, subsidies, and information.

While Singapore has the relatively stringent environmental regulations and governance, and thus delivers high environmental performance (Lye, 2010), the environmental policies in other ASEAN countries are difficult to be fully enforced. It is not only due to they are prioritizing economic growth (Elliot 2012), but also being challenged by the political issues, weak coordination between agencies, as well as society’s resistance (Xi & Yang, 2012; Tan, 2004).

On the regulator side, as most of the ASEAN nations are in a political structure where certain degree of autonomy is given to state governments, unconcerted actions in environmental regulation enforcement between federal and state governments offer opportunities for interest groups to continue exploit the environment uncontrollably and resulted in high rate of deforestation, forest fire, and illegal logging in the region. The weak coordination between ministries, departments and related government institutions also prevent effective enforcement of environmental policy (Tan, 2004).

In addition, although ASEAN has committed to establish a mechanism to protect the region's environment and sustainability of natural resources as early as 1997 (ASEAN Secretariat, 2009), the regional cooperation is still weak to effectively addressing the transboundary pollution issues as the ASEAN has mutual understanding to not interfere with other member's national policies (Kalirajan, Uz Zaman, & Wijesekere, 2015) and effective channels of communication from policy makers to stakeholders have not established (Elliot, 2012).

In some cases, although regulators insist on full enforcement of environmental regulation, firms and the public could also trying to shy away from enforcement (Xi & Yang, 2012), making the costs of enforcement become exceedingly high. One of the examples would be the Malaysian Solid Waste and Public Cleansing Management Act 2007. Recent statistic shows that only 17% of Malaysians have taken up recycling, despite years of law implementation and extensive awareness campaigns have been conducted (Fazleena, 2016).

The resistance to law enforcement can be formidable and violent for the case of illegal logging in Indonesia. The illegal logging companies have hired large number of security guards with military background and heavy weapons to confront those forest and wildlife law enforcement staffs whose receives little training in patrolling or combat skills, making the enforcement task to be extremely dangerous (UNEP, 2007).

II. ASEAN-5 trade openness, CO^2 emission and trade composition

(i) Trade openness

Export-led growth strategy has been an important economic policy for ASEAN-5 countries to achieve economic growth. ASEAN-5 countries, at different timing and extent, have liberalized their trade and investment regime since early 1960s (Sally & Sen, 2005).

Singapore was the earliest and ardent supporter of free trade and remained completely open for trade since 1960s (Hill 2014). As of February 2016, Singapore recorded most number in free trade agreements (FTAs) among Asian countries where 29 FTAs have been signed or under negotiation (see table 1.2). Singapore's trade numbers have been always at three to four times of its GDP size since 1980s (see figure 1.1) and its export-oriented strategy has led the economy to achieve high income nation status in thirty years (Thangavelu & Toh, 2005).

Malaysia, Indonesia, Thailand and Philippines and Thailand were later in 1980s started major trade and investment liberalization one after another. Malaysia had been aggressively inviting FDI during 1980s as the country perceived the positive role of FDI could played in importing capital and technologies (Hill, 2014). Hence, in order to attract FDI, Malaysia adopted higher trade openness at the same time in which the trade to GDP ratio, as shown in figure 1.1, were more than 100 percent.

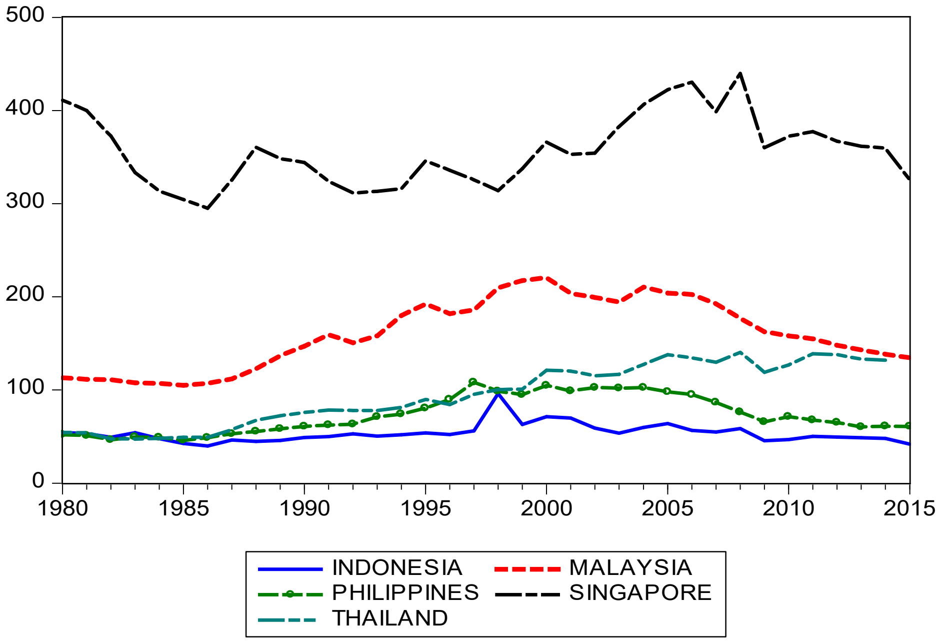
Thailand was not as open as its neighbours, Singapore and Malaysia, and the average tariff was higher with greater tariff dispersion and protection for domestic service sectors were considerable (Sally & Sen, 2005). However, Thailand ranked third in the number of FTAs among Asian Countries with 22 FTAs (see Table 1.2), following the Singapore and India. FTAs have recently become the focus of Thailand trade policy and receive much attention from policy makers (Sally & Sen, 2005).

Compare to Singapore, Malaysia and Thailand, Indonesia's trade liberalization process appears to be reactive to current economic and political situation with little sense of strategy. Indonesia would only liberalized the trade and foreign investment regime when the economy was performing poorly and restricted FDI when economy was booming (Organisation for Economic Co-operation and Development [OECD], 2014; Hill, 2014).

However, Indonesia's trade policies have changed from high protection to relatively open in a comparatively short period, although there were higher non-tariff barriers particularly on agriculture products, textiles and steel (Sally & Sen, 2005). According to world bank database, the weighted mean applied tariff were reduced drastically from 5.5% in 2002 to 2.49% in 2010 and remained at the lower level tariff in following years.

In Philippines, import-substitution strategy has been long implemented since 1950s due to balance of payment crisis and the powerful lobby for import restriction from domestic industrial sectors and the policy have largely remained until 1980s. The tariff reform program was initiated in 1981 and average tariff rate declined from 42 percent in 1980 to 28 percent in 1985 (Dohner & Ponciano, 1989). Trade openness of Philippines were in the range of 52% and 102% during 1980 to 2014 (refer to figure 1.1),

Figure 1.1: ASEAN-5's Trade to GDP ratio (in %), 1980-2015



Note: The graph is calculated and drawn based on the data from World Development Indicators database.

Table 1.2: ASEAN-5 Free Trade Agreement Status, 2015

Countries	Under negotiation	Signed but not yet In Effect	Signed and In Effect	TOTAL
Indonesia	7	1	9	17
Malaysia	6	1	14	21
Philippines	3	0	7	10
Singapore	8	1	20	29
Thailand	9	0	13	22

Source: Asian Regional Integration Center website

(ii) Aggregate trends in trade and CO_2 emission level

Figure 1.2 - 1.6 illustrate the general trends of gross domestic products (GDP), exports and CO_2 emission in ASEAN-5 countries during 1989 to 2011. Generally, the CO_2 emission in Indonesia, Malaysia, and Thailand increase in tandem with GDP growth throughout the whole time period, implying their sources of economic growth may be polluting. Exports, at the same time, also increased throughout the years, making the GDP-CO_2-exports patterns in these three countries seem to be consistent with the hypothesis of increasing exports can lead to economic growth and raise CO_2 emission level[5].

Singapore, however, presents completely contrary trends in which the CO_2 emission level was gradually declining while GDP and exports were increasing (see Figure 1.5). This can be explained by Singapore's specific country characteristics. Singapore is geographically lack of natural resources, leads the country to move away from resource-based sectors, which usually are polluting, since the earlier stage of development.

Meanwhile, Singapore has transformed their economy structure since 1980s, from manufacturing to high value added industries, particular ICT and financial service industries and other high technology manufacturing when their workforce was losing advantage of low wage labor when other

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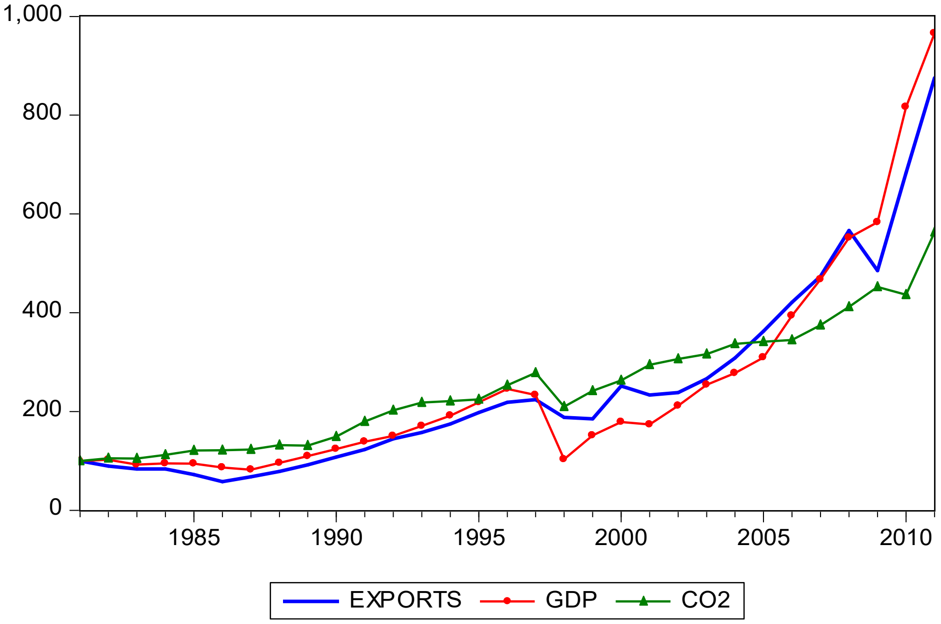
[5] Based on graph analysis, the relationship between Thailand's exports and GDP were relatively weak, compare with other ASEAN-5 countries while GDP-CO2 trends moved closely with each other. This implies Thailand's CO2 emission level may cause by economic growth but less affected by exports.

Southeast Asian countries presented a more attractive wage rate for foreign investors (Cahyadi, Kursten, Weiss & Yang, 2004). In addition, the country also adopts a more stringent environmental regulation (see Table 1.1), and thus the economic growth in Singapore did not pollute their environment.

After 2005, Philippines's CO_2 emission increasing rate was much slower than GDP and exports growth rate, indicating the source of growth in Philippines may be relatively clean. However, this may be due to the physical environmental assimilative capacities are relatively higher than GDP growth rate, and trade composition in Philippines are creating other type of pollution, such as soil and water pollution (more discussion in section I (iii)).

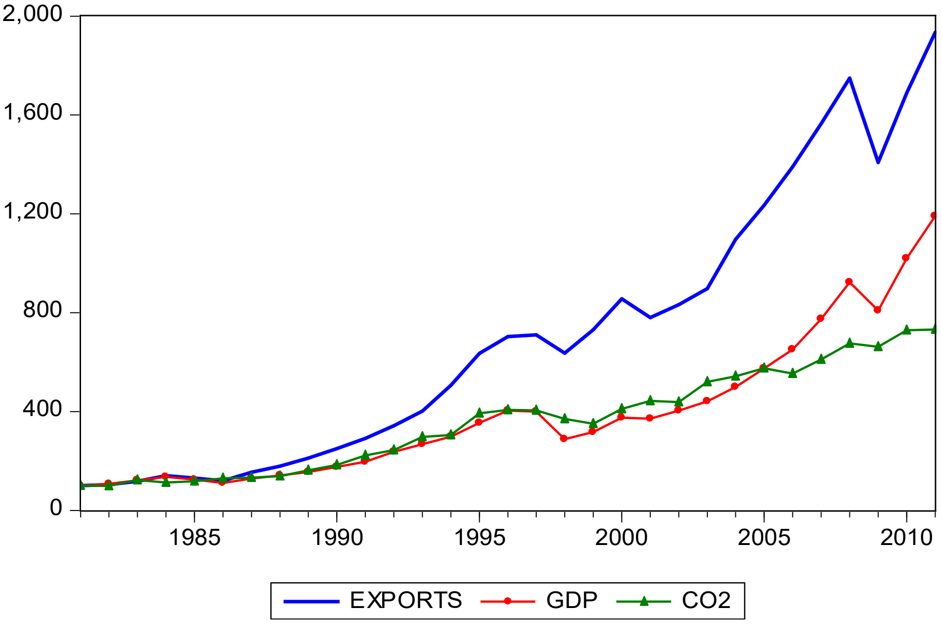
While all ASEAN-5 countries are, more or less, open to global market, Singapore shows decreasing trend in CO_2 emission. Interestingly, the other four ASEAN countries also see a slower increased in CO_2 emission after 2005 while the GDP and exports were continue to increase. This raises two questions: can the environmental problem of ASEAN-5 countries be attributed to growing exports? Or composition of export is a more important factors? And the remaining discussion in this section will be trying to answer these questions.

Figure 1.2: Indonesia's Export, GDP and CO$_2$ Emission Pattern, 1981-2011



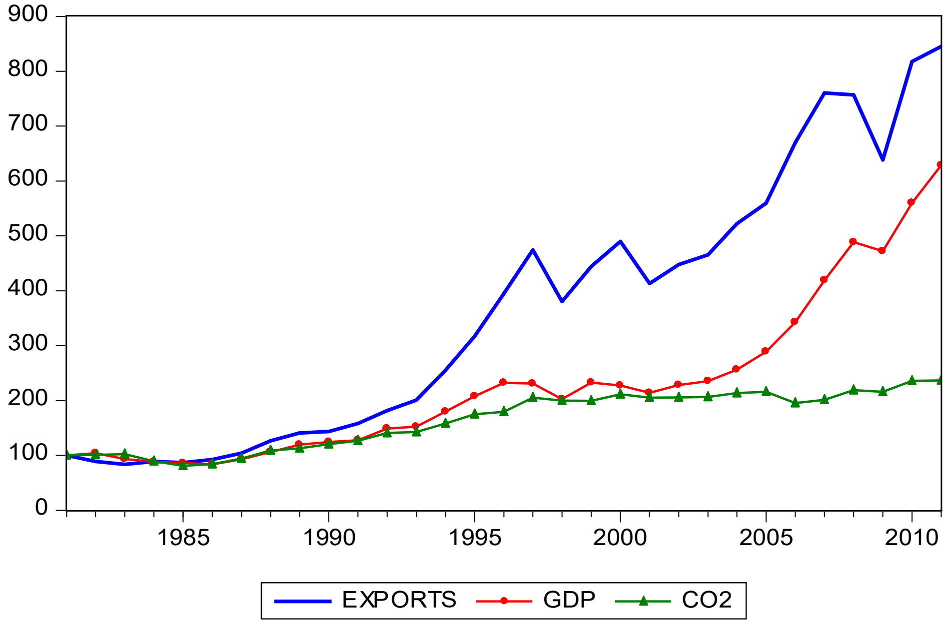
Source: World development Indicator database
Note: X-axis represent year; Y-axis represents index

Figure 1.3: Malaysia's Export, GDP and CO$_2$ Emission Pattern, 1981-2011



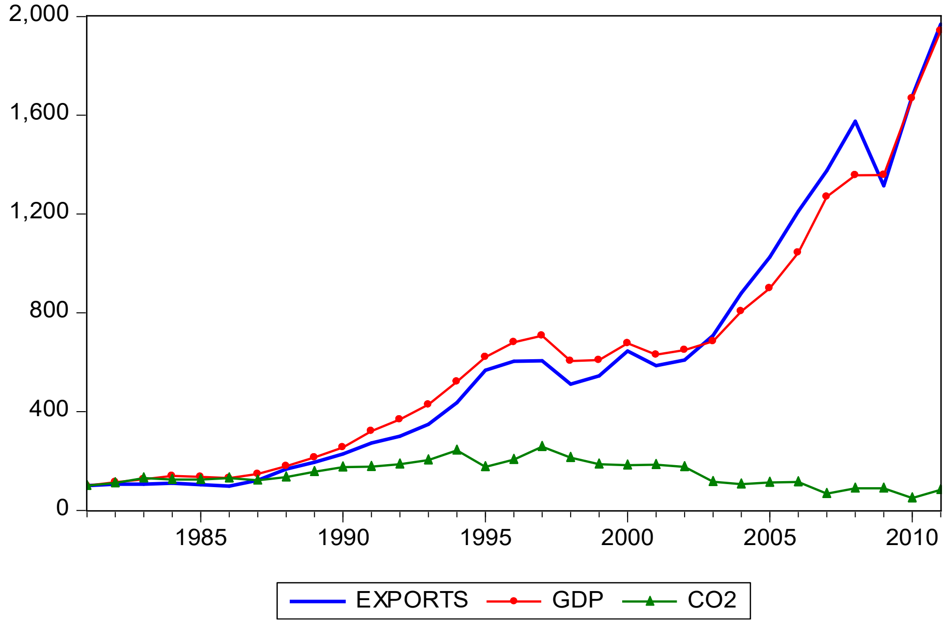
Source: World development Indicator database
Note: X-axis represent year; Y-axis represents index

Figure 1.4: Philippines's Export, GDP and CO2 Emission Pattern, 1981-2011



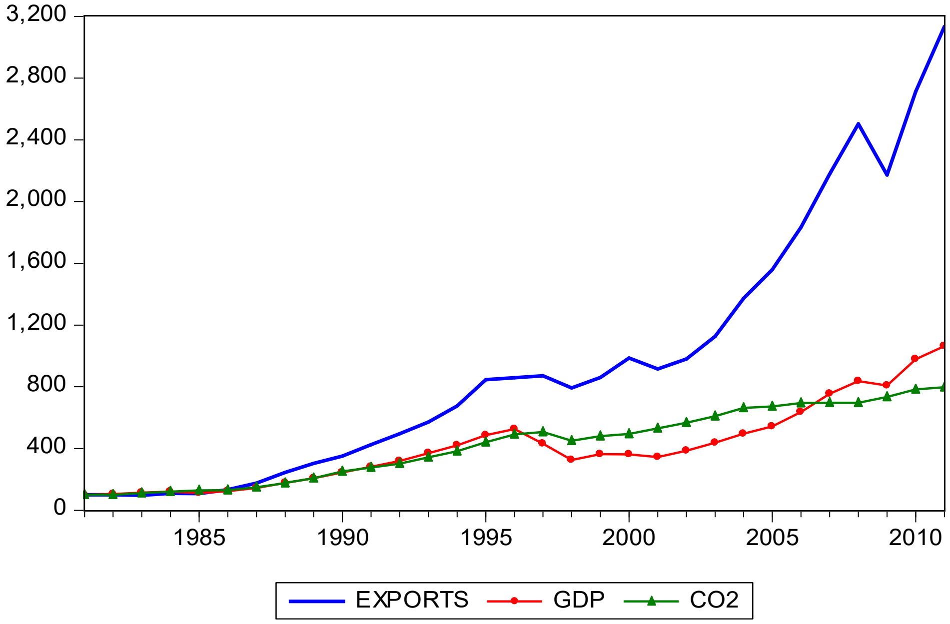
Source: World development Indicator database
Note: X-axis represent year; Y-axis represents index

Figure 1.5: Singapore's Export, GDP and CO2 Emission Pattern, 1981-2011



Source: World development Indicator database
Note: X-axis represent year; Y-axis represents index

Figure 1.6: Thailand's Export, GDP and CO2 Emission Pattern, 1981-2011



Source: World development Indicator database
Note: X-axis represent year; Y-axis represents index

(iii) Composition of trade

While the last subsection examines solely on CO_2 emission data to reflect pollution level, it is important to note that different sector may causes different type of pollution, either on land, air or water, at various intensity. Generally, the lower stage the industries are in the economic sector, the higher pollution the industry would be generated during production.

Production in primary sector, such as mining and raw materials processing industries, would be most polluting in which environmental degradation occurs directly in the way of natural resources depletion, and then soil contamination and water pollution.

Industries in secondary sector which mainly refer to manufacturing sector are, in principal, less polluting than primary sector. However, secondary manufacturing that associated with natural resources, chemicals and metals could have high pollution intensity (see Table 1.3). Lastly, tertiary sector generates least pollution in the process of production as the sector only involves the supplying of services, such as financial services, consultation, legal services and etc[6].

Table 1.3: Top 10 Most Polluting Industries Ranked by Various Authors

Mulatu et al (2010)	Hettige et al (1995)	Chung (2013)
Industrial chemical	Fertilizers	Cement, lime and plaster
Drugs and medicines	Industrial Chemicals	Clay building materials
Iron and steel	Iron and steel	Pulp, paper and paperboard
Non-ferrous metal	Fabricated metal products	Starches products
Rubber and plastic products	Plastic products	Textiles
Paper, paper products	Textiles	Iron and steel
Non-metalic mineral products	Non-ferrous metal	Man-made Fiber
Wood products and furniture	Wood products	Basic chemical
Metal products	Paper and paperboard	Ceramic products
Textiles, apparel and leather	Petroleum refineries	Glass and glass products

The major exports of ASEAN-5 countries, as shown in Table 1.4, are mostly the industries either in primary sector or secondary sector that close to primary sector which are high pollution intensity, including petroleum, palm oil, machinery, electrics and electronics (E&E) sectors. While petroleum exploration and production process can cause negative environmental impact to soils, surface and groundwater, and ecosystem (Kharaka and Dorsey, 2005), and oil palm plantation can cause deforestation, the E&E sectors can be classified as clean industry according to table 1.3[7].

Indonesia, Malaysia, Philippines and Thailand are clearly involved extensively in exports of the industries which are likely to undermine local environment. For Singapore, however, the export composition does not explain its relatively clean export-GDP-CO_2 emission pattern in which the major exports of the country in 2010 and 2015 were petroleum and related products, and transportation and freight respectively. This may owing to the

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[6] However, there are service industries can generate pollution such as transportation. Colvile, Hutchinson, Mindell & Warren (2001) pointed out that the air pollution issues including acid deposition, stratospheric ozone depletion and climate change can be partly attributed to the emissions generated from road, air, rail and water transportation.

[7] The E&E sector can also bring environmental problems such as soil and water contamination, resource depletion, energy use and waste when these sectors continue to expand in scale of production (Ibitz, 2012). The type of E&E product is also an important factor for understanding the impact of the sector on the environment.

greenhouse gas emission of international transportation and freight services industries have been largely overlooked in data collection (Anca, Hummels, Puzzello, & Avetisyan, 2013) as these services are mobile.

Table 1.4: ASEAN-5 Top 5 Major Export Products and Services

2015			2010*		
	Value	Share		Value	Share
Indonesia					
Petroleum, gas and coal	31,525.10	20.97	Petroleum, gas and coal	60,269.80	29.62
Palm oil and its fraction	15,385.30	10.23	Palm oil and its fraction	17,261.20	8.48
Natural rubber	3,564.10	2.37	Natural rubber	11,416.10	5.61
Copper ore	3,277.20	2.18	Copper ore	4,700.40	2.31
Jewelry	2,839.70	1.89	Gold	1,887.30	0.93
Malaysia					
E&E products	64,560.80	35.60	E&E products	58,028.54	39.10
Petroleum & LNG	29,664.71	15.40	Petroleum & LNG	22,718.94	15.40
Chemicals	12,809.00	7.10	Palm oil	11,243.32	7.60
Palm oil	9,324.50	5.10	Chemicals	9,477.84	6.40
Machinery	8,395.30	4.60	Machinery	4,994.45	3.40
Philippines					
Electronic products	28,915.22	49.30	Electronic products	31,079.48	60.47
Machinery & Trans	5,099.74	8.70	Agro-based products	2,917.49	5.68
Agro-based products	3,512.10	5.99	Machinery & Trans	2,571.92	5.00
Mineral products	2,796.95	4.77	Mineral products	1,869.85	3.64
Wood manufactures	2,791.30	4.76	Garments	1,701.50	3.31
Singapore					
Transportation	45,930.61	15.27	Petroleum & its products	37,495.42	12.94
Freight	6,838.09	12.25	Transportation	37,312.00	12.88
Petroleum & its products	35,614.72	11.84	Electrical Machinery	36,965.81	12.76
Electrical Machinery	24,601.69	8.18	Freight	29,291.43	10.11
Financial	9,694.26	6.55	Oil Bunkers	20,369.55	7.03
Thailand					
Machinery	89,564.00	44.76	Machinery	72,106.08	42.60
Manufactured goods	43,958.86	21.97	Manufactured goods	57,335.35	33.87
Food	25,297.35	12.64	Food	20,977.96	12.39
Chemicals	19,393.24	9.69	Chemicals	14,848.57	8.77
Crude materials	8,536.98	4.27	Crude materials	9,757.26	5.76

Note: *Indonesia using 2011 data
Value: values are in million USD; Share (%): share of export to total exports in percentage.
E&E products: Electrics and Electronics products
Source: Ministry of Trade of Indonesia, MATRADE, Philippines Statistics Authority, Singapore Department of Statistics, Bank of Thailand

1.1.3 Is ASEAN-5 a pollution haven?

Countries have good reasons to embrace free trade such as achieve economic growth through seizing comparative advantage from factor endowment, and taking advantage of economies of scale in international market.

Gaining economies of scale could mean an increase in economic activities in a country that lead to more industrial production, busier transportation and resources consumption. This would naturally undermine the environment in which pollution are generated as a by-product of economic activities (Copeland & Taylor, 2003).

Furthermore, if low environmental standard or high environmental assimilative capacity has been a comparative advantage of a country, then it is likely to produce high pollution commodities for export and import commodities which is less polluting (Grossman & Krueger, 1991).

In light of this, pollution haven hypothesis (PHH) suggests that free trade between nations with different levels of environmental standards would encourage production and export of pollution-intensive sectors in the nations where regulations are lax and thereby become "pollution haven" of nations with high environmental standards (d'Arge & Kneese, 1972; Broner, Paula & Vasco, 2015).

Developing countries are likely to be a potential "pollution haven" as they have displayed greater concern on achieving economic growth over environmental preservation which they believe can be solved later when they become richer (World Bank, 2012). This become more relevant when Southeast Asia countries have integrated in the international production networks and continue to open up their economy in terms of FDI and trade to expand the current production network (Taguchi & Lar, 2015).

What have been elaborated thus far can be summarized into three facts: (1) ASEAN-5 countries are, to certain extent, export-oriented; (2) There is clear discrepancy in environmental standards between ASEAN-5 countries and its trading partners, China, HK, Japan, US, and Korea; (3) The trade composition of most ASEAN-5 countries tend to be polluting industries. Judging from above observations, it is reliable to claim that ASEAN-5 and its trade composition have demonstrated signs that are consistent with PHH and therefore worth conduct empirical investigation.

1.2 Problem Statement

As in section 1.1.1 suggested, the environmental issues of ASEAN-5 countries is motivation of this study to investigate on whether the active export activities are attributed to the factor of environmental issues in the region. With the differences in environmental regulation, ASEAN-5 countries could be the pollution haven for its trading partners. And To understand whether ASEAN-5 countries are pollution haven, empirical study is needed to detect pollution haven effect.

Although there are voluminous studies have been working on searching pollution haven effect, the evidence of the hypothesis remain tenuous (Javorcik & Wei, 2004) and makes the search for evidence appears to be a challenging task. The most common conclusion drawn by early studies in pollution haven hypothesis is that the costs arising from environmental policy have little or no effect on trade or investment flows (Copeland & Taylor, 2004).

Controlling pollution in the process of production is found to be a negligible cost factor for most private firms. For large scale polluters, average control cost per unit could even be reduced due to the fact that abatement is subject to scale economies. These studies suggest that relative pollution control costs between two nations do not give firms a strong motivation to move production offshore or determining comparative advantage (Broner, Paula, & Vasco, 2015).

The more recent literature have made progress in searching pollution haven effect by explicitly addressing industry characteristics and firm heterogeneous issues. Mobility, productivity and agglomeration economies effect are also considered as important issues which may affect trade and investment flows (Ederington, Levinson, & Minier, 2003; Copeland and Taylor, 2004; Wagner & Timmins, 2008; Greenstone, List, and Syverson, 2012).

What have not been emphasized in the past literature is taking account for indirect compliance cost in compliance costs. Indirect compliance costs refer to the costs with respect to regulatory transaction or process costs and opportunity costs. Many empirical studies of pollution haven hypothesis have largely focused on direct compliance costs arise from environmental regulation which usually use pollution abatement costs and capital expenditure data as a proxy.

Nevertheless, Anderson and Kagan (2000) argued that the indirect compliance costs could be a more forceful factor than environmental regulation per se. In addition, ‘De facto’ costs of compliance would incur against firms when the chance that noncompliance will be detected and sanctioned.

‘De facto’ costs of compliance can also be referred as liability law. Hussien (2004) explained that polluters are subject to liability law and monetary compensation shall be made if they are found guilty to responsible for harmful pollution to affected pollutees. Liability laws are costly and capable to lead private firms to reach socially optimal level of pollution.

The indirect compliance costs can be higher than environmental control costs because the challenges from the concern of regulators and public tend to be greater compared to merely paying additional operation costs or capital expenses to abate pollution. Firms have to make extra efforts to deal and negotiate exceptions and flexibility of regulatory requirement when they have to increase pollution arise from production expansion. Higher legal costs will be incurred if there is conflict with the regulators.

Meanwhile, Anderson and Kagan (2000) suggested that the weak empirical evidence of pollution haven that focused on examining between advance and developing countries could be astray from actual direction as those studies were considering only direct abatement cost and neglected the regulatory process costs or transaction costs.

Clearly, there is an important research gap to be filled that full environmental costs have to be internalised to capture the tendency of certain resource and pollution intensive industries to establish production in areas of low environmental standards.

An empirical model which can capture this effect is, therefore, worth to explore and develop. In summary, there are three research questions need to be addressed in this study:

1. Is ASEAN-5 economies the pollution haven for their major trading partners ?

2. How significant the indirect compliance costs as an environmental cost?

3. Does environmental cost impacts differently on industries which have different industry characteristic?

1.3 Research Objectives

Generally, the main objective of this research is to develop a measurement for indirect environmental compliance costs and examine the effect of more comprehensive environmental costs between ASEAN-5 countries and their major trading partners (China, Hong Kong, Japan, South Korea and U.S.) on ASEAN-5 export flows at industry level. By taking both direct costs and indirect cost, as well as specific characteristic of the industries, this study attempts to search for the evidence of pollution haven effect.

1.3.1. Specific Objectives

The study has the specific goals in accessing, that is to:

1. estimate the relationship between environmental compliance cost difference and trade flows in ASEAN-5.

2. construct an index to capture the indirect compliance cost and estimate the magnitude of indirect compliance costs as an environmental cost.

3. estimate the relationship between environmental compliance cost and exports flows of industries with various characteristics, particularly in agglomeration effect.

1.4 Significance of the study

The contribution of this study to the literature are three folds; First, most of the studies analyze the trade and environment relationship on US-Mexico, US-China, or Europe region but there are less studies concerning specifically on the Southeast Asia region. However, based on trade composition profile of ASEAN-5 and its high involvement in international production fragmentation, the region is actually an important case to study when investigating pollution haven hypothesis.

Second, this study is one of the few research examining the impact of environmental regulation stringency on trade flows, considering institutional costs (indirect compliance costs) such as adversarial legalism, corruption, process costs arising from environmental regulation. This shows that a proper measurement of environmental costs that include both costs imposed directly from regulators and indirectly from institutional environment is important for understanding pollution haven effect puzzle. This is mainly due to institutional costs can influence competitiveness of an industry. The results will provide fresh view to the existing findings that shows environmental costs are low and insignificant to affect trade and investments flows.

Third, the results of this study could be instructive for trade and investment policy making process as the central importance of environmental sustainability to process of economic development are frequently emphasized by economists. The study suggests, to ensure the effectiveness of environmental regulation, policy makers may have to make the direct environmental control policies are consistent with the institutional environment.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The awareness of environmental protection is mounting around the world. The concerns in relation to trade and environment began in the early 1970s when the leading advanced countries had introduced the environmental laws and triggered worries about increase in environmental costs can undermine the existing competitive advantage of industrial sector, which in turn influencing the trade amounts.

The attention towards trade and environment had turned weak in 1980s but it revived in the early of 1990s when United Nations Conference on Environment and Development (UNCED), the Uruguay round of the Generalized Agreements on Tariffs and Trade (GATT), and the North American Free Trade Agreement (NAFTA) brought the topic back into negotiations (Brunnermeier & Levinson, 2004).

Nevertheless, this new wave of research interests were concern more about the impact of freer trade on the environmental quality, including scale effect, Environmental Kuznets Curve, and pollution haven hypothesis. This chapter will starts with reviewing theoretical works of pollution haven hypothesis and then discussing the major findings of existing empirical works.

2.1 Theories of pollution haven hypothesis

The field of international trade achieved one important conclusion is that the welfare for two countries will be maximized if commodities can be exchanged between two countries freely in international market. Tariffs which would distort the relative costs and prices between two countries are undesirable. As a result, the world tariffs have been reducing for last decades until environmental issues have been revealed and environmental control has been called by the public (d'Arge & Kneese, 1972).

Since the tariff no longer a main hindrance for international trade, the impact of environmental regulation appears to be a more apparent block that hinder international trade (Arcas, 2013). Environmental control measurements are, like tariffs, will distorts the international market and thus affecting the world output and welfare (d'Arge & Kneese, 1972). Meanwhile, the uncoordinated regulations would make existing link between world commodity prices and factor prices across trading countries become invalid (McGuire, 1981).

The early studies pertinent to free trade and environment was started in 1970s and many of these studies have worked on developing theoretical framework to explicitly explain the relationship between environmental regulation and ramification from comparative advantage and trade pattern amid reducing trade barriers. These studies were interested in answering the question whether a country with higher environmental regulation stringency will lead the affected industries to lose comparative advantage, which in turn alters the trade pattern, gains from trade (the gain from trade analysis was take into account the social welfare, see Siebert, 1977), balance of payments and income (See for example: Siebert, 1985; Pethig, 1976; McGuire, 1981; and Blackhurst, 1977).

This branch of early studies used conventional trade theory as analysis framework and regarded the "environment[8]" as a third factor of production based on the standard two factor of production -- labor and capital model. There are two industries which are polluting-intensive industry and non-polluting industry. In a condition where environmental policy is absent, the welfare gain from trade are improved or reduced relying on whether the country is specialize in pollution intensive or non-polluting industry (Siebert, 1977).

When environmental policy is implemented, it is assumed that part of the firm's resources will be allocated to comply with the policy. In a three factors of production model (environment, labor and capital), there are two way of analysis can be inferred: (1) the change in relative prices and (2) differences in production technologies.

When resources are devoted for environmental control, Siebert (1977) estimated the cost of production in pollution-intensive industry would increase. As a result, the relative prices between pollution-intensive and non-polluting industries for two trading countries will change due to the environmental regulation. A country will specialize in pollution-intensive industry if the relatively price of pollution industry in the country is higher than its counterpart (Siebert, 1974).

In the model of Pethig (1975), comparative differences in production technology would determine the comparative advantages between two countries which in turn the trade pattern. A country specializes and exports on the production of labor-intensive good if its labor production technique is more effective than the trading partner country.

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[8] The environment as a factor of production is referring to the resources that used for pollution abatement purposes to prevent pollutants from entering the environment. It could also be assumed as a technology that used in reducing pollutants during the production process.

The more important, however, Pethig (1975) predicted that implementing environmental policy can diminishing or jeopardizing the original comparative advantage. Consequently, the country with less restrictive environmental control will export and specialize on the production in environment intensive commodity. For factor of production, similar trend would occur where regulated industry will move out from the strict regulation country to less regulated country (McGuire 1981).

Once the new specialization pattern is formed, the original welfare from trade, national income, balance of payment and environmental quality will be changed. Siebert (1977) estimated that national income will decline with better environmental quality due to resources used in abatement activities being taken away from production, causing the output of pollution-intensive sector to decline. Nevertheless, pollutants are reduced and welfare gain from environmental policy is expected if the marginal social costs of producing commodity are greater than the marginal benefits.

d'Arge and Kneese (1972) expected that when a country unilaterally implements environmental control measurements, such move will cause the change in term of trade. As a result, new equilibrium level of domestic expenditure and income is formed and it subsequently adjusted to the change in demand. The multiplier-type repercussion which further altering the level of income and employment will continue if full employment is not achieved. If barriers to trade or other actions were not taken to remedy the income and balance of trade, second adjustment arising from balance of payments disequilibrium would occur. If the balance of payments was in deficit, a negative adjustment in term of trade is expected.

On the other hand, one important concept which is environmental assimilative capacities (EAC) was introduced by d'Arge and Kneese (1972) and Siebert (1985). They suggested that the country with relatively large EAC should, other things being equal, produces pollution-intensive commodities for export and import if both trading countries have identical production, pollution and abatement techniques. They would, at the same time, consume relatively more commodities with higher residuals yield in consumption.

Nevertheless, Pethig (1975) pointed out that the application of EAC into comparative advantage model is not explicitly rationalized within general equilibrium. Pethig (1975) derived a function which shows that the ecological system will only collapse if the the emission level exceeds certain high level. In addition, if the environmental quality was ensured by policy makers through environmental control, no country will have welfare loss from trade as EAC is equal to the sum of local and foreign emission level. However, the environmental standards between the two countries with same environmental quality do not equally strict and harmonizing their environmental policies is not encouraged.

The works of developing theoretical framework were perpetuated until early 1990s, but this newer branch of literature has shifted the analysis focus to the impact of trade on environmental quality (like pollution emission level and the consumption rate of natural resources), instead of comparative advantage and trade welfare analysis (include environment as part of the welfare). These literature (see examples: Grossman & Krueger, 1991; Copeland & Taylor, 1994; and Antweiler, Copeland, & Taylor, 2001) prefer to apply scale, composition, and technique effect to explain the impact of free trade on environment quality, and they found that the country with lower environmental standard or income, has higher tendency to specialize in dirty industry when come to free trade.

The scale, composition and technique effect work in one mechanism and influencing each other other. Grossman and Krueger (1991) explained that free trade can affect environment through scale effect in which some pollutants are natural byproduct of economic activities and pollutant emission tends to grow with expanded trade-induced economic activities. However, firms can improve environment quality through adopting cleaner technologies and society can demand for better environment if free trade lead to an increase in income level (Technique effect)[9]. Composition effect, on the other hand, will degrade the environment if the source of comparative advantage of a country were derived from pollution-intensive sectors or through adopting lower environmental standards.

Although the terminologies of scale, technique, and composition effect have been introduced by several researchers included Grossman and Krueger (1991), explicit model-based definition of these effects have yet to be fully developed. Copeland and Taylor (1994) took a first step toward developing theoretical model on top of the terminologies by constructing a simple static two-country general equilibrium model with a continuum of goods differentiated by their pollution intensity that creates incentive to trade[10].

As a result, the model inferred that the pollution level will rise in the lax regulated country and decline in the tight regulated country. The two countries may have an increase in real income when they open up economy for trade, however, as dirty goods can be produced in relatively lower cost in South where environmental regulation is lax, free trade encourages dirty good production to shift to South and clean good production to North[11].

Their model also predicted that when rich countries become more affluent, world pollution will increase, but if poor countries get richer, world pollution will decline. They explained that when growth occurs in the rich countries, the factor prices before and after trade become wider. As the

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[9] Grossman and Krueger (1991) pointed out technique effect would occur in two ways: First, local economy may benefited from technologies transfer as foreign producers are usually using cleaner production technology. Second, if trade liberalization can increases income level, it is likely that the environmental awareness of people will increase followed by higher income level and demand for stricter environmental regulations.

[10] There were three key assumptions have established in the model. First, it adopted a North-South framework which assumed the countries between two regions had clear divergences in income; Second, to establish a link between income level and the environmental policy, the model assumed governments were responsive to the demand of citizens; Third, industries were differed in their pollution intensities to capture the effect of different environmental policy on trade patterns.

[11] In free trade, the composition effects always dominates scale and technique effects as the differences in relative factor supplies give rise to the re-adjustment of pollution demand and supply. Therefore, the South is allowed to raise the gain from trade by accepting increasing pollution when trade opportunities appeared (Copeland and Taylor, 1994).

intensity of the overall world composition effect is determined by the gap between posttrade factor prices, it may cause the techniques difference among countries become greater and pollution deteriorates in poor country due to specialization of dirty industries. However, the world pollution will decline when the growth is happened in the poor country as the world composition turned better due to the gap between posttrade factor prices are relatively narrow when factor supply ratios approaching to each other.

Antweiler, Copeland, and Taylor (2001) also studied on same mechanism, but they presented separate estimates of scale, composition, and technique elasticities and provided a methodology for summing up these effects to examine the impact of reduced trade barriers on the environment. As a result, the model predicted that if two countries which differ only in their trade friction of polluting goods export, the country with lower trade frictions will have higher pollution.

To study on PHH, Antweiler, Copeland, and Taylor (2001) allowed income differences and factor abundance differences to jointly determine trade patterns in the model, and investigated whether trade-induced composition effect is better explained by factor abundance hypothesis or PHH[12]. The model found results consistent with PHH: high income country is likely to move toward better environmental standard, and specializes in clean good if all countries are given same relative factor endowments and only differ in per capita incomes. Meanwhile, if a country has factor abundance in dirty industry, all else constant, the country have higher tendency to export dirty goods.

The early studies in 1970s are more interested in developing theoretical framework. However, as early theoretical studies provide limited guidance regarding how to weigh various confounding effects and forces caused by environmental policy, Taylor (2004) stated that it has caused some later

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[12] Conventional factor endowment theory posits that countries export goods which has factor abundance, however, a more stringent environmental regulation can influence the original comparative advantage, thus both factors are expected to be important in determining comparative advantage (Antweiler, Copeland, and Taylor, 2001)

empirical works on PHH confused with two different concepts.

The first concept was “pollution haven effect” which demonstrates how the changes in environmental policy would cause the changes in trade pattern between two countries. In other words, pollution haven effect captures how the strengthening of environmental regulation could lift production costs and dampen the export of related goods. The second concept was the “Pollution Haven Hypothesis”. It predicts, when trade are liberalized, the pollution-intensive industries will relocate from countries with strict pollution policies to countries with lax pollution policies.

These two concepts are similar in the sense that the differences in environmental regulation between countries are considered. However, Taylor (2004) pointed out that the empirical evidence of pollution haven effect is usually links the changes in trade or investment flows across industries with the variation in environmental control costs arise from environmental regulation. Meanwhile, empirical evidence for PHH are then comes from the investigation on whether differences in environmental regulation stringency across form a trade pattern that consistent with PHH definition.

Many existing econometric literature are actually studying pollution haven effect and only few are working on PHH. However, the evidence of pollution haven effect is necessary, but not sufficient, to prove the validity of PHH. If an empirical researcher find pollution haven effect is significant in for trade and flows, then the results could be a suggestive evidence for PHH (Taylor, 2004).

Besides distinguishing pollution haven effect from PHH, Taylor (2004) further unbundling PHH into five units which are country characteristic, environmental regulation, production costs, trade or investment flows, and pollution, price and income. Each of these units are linked in sequence in a logical chain via four channels and one feedback effect. It is useful to study each of the channels link country characteristic to pollution level. By doing so, researchers are able to review and investigate the inevitability and strength of each of the PHH logical chain, so that the significance of conclusion can be strengthen.

2.2 Empirical works of pollution haven hypothesis

2.2.1 Effect on Trade pattern, emission and industry location: the old literature

The most common method of trade and environment literature is studying the effect of regulatory differences on output measures or trade pattern, such as production, net exports, and emissions. This method is based on the logic that the country which imposes a more stringent environmental regulations than other countries, is expected to experience a deterioration of its comparative advantage in pollution-intensive industries and eventually reflects in trade flows (Van Beers & van den Bergh, 1997). Heckscher-Ohlin model of international trade which is popular in testing sources of international comparative advantage has been used by early empirical studies (for instance, Kalt, 1988; and Tobey, 1990) to study whether environmental policy would affect the competitiveness of U.S. industries by including environmental variable into the model.

Tobey (1990) used UNCTAD index to proxy environmental standard across countries and examined how it would affect the net exports of five polluting sectors in 23 countries. By controlling other factors such as labor, land, minerals, and capital endowments at country level, the research found that the differences in environmental regulation between trade countries were not statistically significant for international trade patterns in these industries.

Furthermore, the Heckscher-Ohlin Vanek (HOV) model with environmental stringency was extended to allow for non-homothetic preferences (NHP) and scale economies or product differentiation (EOS). The two different methods were conducted for all three specifications; One method included a qualitative variable which used to reflect environmental measurement stringency. The second were concerning the signs of the estimated error terms while the environmental measurement variable was not included in the estimated equation. The results of this extensive HOV model showed that variables were not found significant in any of the five OLS regression.

Grossman and Krueger (1991) conducted empirical study based on trade and environment theory of scale, composition and technique terminology. To test on technique effect, they used a cross-country sample of income level and two pollutants measures of urban areas located in 42 countries to explore the relationship between economic growth and air quality. Meanwhile, geographic characteristics of different cities and common global time trend in the levels of pollution has also been included in the estimation as explanatory variables.

After holding these explanatory variables constant, they found that the two air pollutants, sulphur dioxide and dark matter, move parallel with the increased in per capita GDP at low levels, but decreased at the income level beyond USD4,000 and USD5,000. On the concern about NAFTA and Mexico’s maquiladora sector, they set up another test to examine the determinants of the industry pattern of the U.S. imports from Mexico.

The estimation found no significant positive relationship between environmental control costs which measured by pollution abatement costs as a fraction of value added, in the US manufacturing industry and the size of Mexico’s maquiladora sector. Therefore, Grossman and Krueger (1991) suggested that environmental advocacy groups may overlooked some potential benefits of trade liberalization between US and Mexico.

Finally, to investigate composition effect, the study used the results from a computable general equilibrium model to study the possible compositional effect of a NAFTA on pollution in Mexico. The researchers found that the composition effect created by further U.S.- Mexico trade was more likely to be affected by factor endowments than by differences in pollution abatement costs.

While some researchers applied Heckscher-Ohlin model in their empirical studies, van Beers and van den Bergh (1997) applied another popular trade model, gravity model of trade, to capture trade pattern in different environmental standard across countries. This model was useful especially when the research took into account bilateral trade flows among 21 countries. The literature used OECD economic indicator as environmental variable and examined the bilateral trade flows for all, pollution-intensive, and non-resource based polluting sectors in 1992.

The results showed stringency of environmental regulation was significantly negative to bilateral trade flows for all sectors and insignificant effect on bilateral trade flow for pollution-intensive sectors. To specifically investigate on bilateral trade flows rather than at aggregate level, the researchers regressed an estimation treating non-resource based bilateral trade as independent variable. They found a significant negative effect on exports of 'dirty' non-resource based sectors that consistent with the results of aggregate model. Such results was within the expectation of the researchers as most of the OECD sample comprises of industrial products which were rather ‘footloose’.

Until the late 90s, many of the early studies relied on cross-sectional data to test PHH but the most common findings of these studies was that environmental standard divergence across countries or regions have insignificant effect on trade flows (Copeland & Taylor, 1994; Cherniwchan, Copeland & Taylor, 2016). It would be rather arbitrary to accept these conclusions as cross-section data inherently neglected unobserved heterogeneity and variation over time. In light of this, many researchers started to apply panel data thereafter as it enables them to compare the data of different countries or regions within certain time period while encountering other econometric issues, such as unobserved time-invariant variables, by applying regional fixed effects (Brunnermeier & Levinson, 2004).

Antweiler, Copeland, and Taylor (2001) adopted panel data to study the effect of trade liberalization on SO2 concentration of 293 observation sites in 40 countries during 1971 to 1996. Similar with the work of Grossman and Krueger (1991), they considered those variables representing scale, composition and technique effect and the overall results were clearly supporting the theory.

The study found scale and technique effect in which the results showed that the scale of economic activity in these 40 countries had a positive and significant relationship with SO_2 concentrations while the per capita income level had a significant and strong negative relationship with SO_2 concentrations. However, the composition effect was inclined toward factor endowment hypothesis, but not pollution haven hypothesis where capital-to-labor ratios had positive and significant relationship with pollution concentration. The magnitude of such effect was large where 1% increases in a nation’s capital-to-labor ratio will led the pollution to increase by 1%.

Examining the change in trade pattern is a study about understanding whether environmental policies could affect country comparative advantage and in turn lead to the change in trade composition under trade liberalization. It can operate in such a way that one country specializes in clean industries and another specializes in dirty industries in response to comparative advantage arising from environmental regulation, without the happening of industry migration from overseas. Therefore, trade pattern does not clearly tell whether a firm is motivated to relocate their production abroad due to environmental standard variation across countries. In view of this, a branch of literature is studying the effect of environmental regulation on FDI flows and firm location.

Early studies used new plants data to analyze the factors affecting the location decision as new plants are not as constrained by sunk costs and therefore more sensitive to even small divergence in regulatory stringency between countries (Levinson, 1996). Bartik (1988) and Levinson (1996) use cross-section conditional logit model and similar set of control variables (corporate tax, unionization and wages) to study the effect of environmental regulations an plant site choice. They found little evidence to show regulation stringency can significantly affect plant site decision although their results are not directly comparable, because they have used different samples of new plants and different measures of environmental stringency.

2.2.2 Testing on industry characteristic and firm heterogeneity: the newer literature

The newer literature have recogized that ignoring industry characteristics and firm heterogeneity may be reason for difficulties in searching pollution haven effect. While the impact of environmental regulation on location should be stronger for pollution intensive industry (Wossink, 2010), Ederington, Levinson, and Minier (2003) argued that some industries which were less geographically mobile[13], and have high transportation costs, could not be able to relocate their production easily and tend to be insensitive to differences in regulatory stringency between countries. Ryan (2012) pointed out that industries with high sunk costs of entry can be more concentrated with lower production when there is shift in the costs of entry and investment to comply with environmental regulation.

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[13] An industry can be less mobile when it is technical difficulties of the industry (Levinson, 1996),or highly concentrated in specific region and enjoying agglomeration effect (Wagner and Timmins, 2009).

Moreover, environment regulations may create different impacts on firms when they are heterogeneous at size distribution or mass of firms (Konishi & Nori, 2015), and relative size of more productive firms (Kreickemeier & Richter, 2014). Levinson (1996) expected the plants of large firms would be more footloose than smaller firms as they may have larger economies of scale which allow them to constantly searching for better site. Greenstone, List, and Syverson (2012) found environmental regulations have led less productive firms to exit the industry. As a result, Industry becomes more concentrated but delivering lower average productivity of firms due to higher cost of environmental regulations.

Wagner and Timmins (2009) emphasized that industry agglomeration is affecting investment location choice. They argued that, when pollution-intensive industries are agglomerated and generating environmental problems, pollution haven effect will be confounded by the agglomeration in an estimation if policy makers strengthening environmental standards to encounter the environmental problems. Consequently, researchers tend to observe that a country with strict environmental regulation is, at the same time, receiving dirty FDI, and refuting PHH.

Currently, there are sufficient number of empirical literature considering industry characteristics and firm heterogeneous into their models and more meaningful results have been achieved in understanding pollution haven effects. Ederington, Levinson, and Minier (2003) examined the relationship of pollution abatement costs and US net imports by by 4-digit SIC code between 1978 - 1992 by taking account the effects of plant fixed costs, transportation costs and geographic concentration. The most meaningful finding in the research is that those industries with highest pollution abatement costs were also appear to be the least footloose, and therefore less sensitive with environmental costs which incurred by stricter environmental regulation.

Wagner and Timmins (2009) used panel data on Germany manufacturing sector outward FDI flows and account for stock of inward FDI as a proxy for agglomeration. They found a more stringent environmental regulation was statistically significant in preventing FDI of chemical industry but there were no evidence of pollution haven effect for other two pollution-intensive industries (primary metals and paper industries) under examination.

Mulatu et al. (2010) argued that the impact of environmental regulation is expected to be heterogeneous for both spatially and across industry. In light of this, they integrated two area of economics, economic geography and environmental economics, and analyzed the effect of environmental regulation on the industry location of 16 manufacturing industries from 13 European countries. Their empirical results suggested that the pollution haven effect was not only exist, the relative strength of the effects had the same magnitude as compare to other determinants of industry location.

Chung (2014) attempted to disentangle confounders from pollution haven effect through controlling the time period of data and apply difference-in-differences (DID) type identification strategy to control for country- and industry-specific unobserved heterogeneity. The literature examined the South Korean FDI outflows of 121 industries between 2000 - 2007 and found the pollution intensive industries are motivated to invest more in countries with relatively lenient environmental regulation. They obtained the same conclusion from data for both total amount of investment and the number of new foreign affiliates, as well as for import data. However, the results will vary when the estimation were conducted at a more aggregated level, or not controlling unobserved heterogeneity adequately.

On the impact of environmental regulation over comparative advantage, Broner, Paula and Vasco (2015) treated pollution intensity as a technological characteristics of industries to test whether environmental regulation stringency determine the comparative advantage in polluting industry. They found evidence that environmental regulation is an important source of comparative advantage in which less stringent environmental regulation have led the countries to import more from U.S. polluting industries than in other industries.

Other latest literature, for example, Shapiro (2016) examined the relationship between trade costs with respect to environmental regulation and the CO_2 emission from shipping. The results indicate that the benefits of international trade outweighed trade's environmental costs by a factor of 161. Azam (2016) tested the suitability of spatial effects in trade model with environmental variable using the basis of augmented gravity model. The results indicate that the spatial error model is appropriate for their sample data and shows that environmental standards are positively correlated with trade.

2.2.3 Summary and discussion on existing empirical works

As Table 2.1 and 2.2 shown, the empirical results tend to not supporting the suggestion of pollution haven hypothesis, meaning the lenient environmental regulation is not statistical significant in attracting pollution-intensive industries to invest or specialize in a country.

Nevertheless, several improvements can be observed in search of evidence for pollution haven hypothesis. The first improvement would be the researchers have applied panel data instead of cross-sectional data as it enables them to observe the differences among countries characteristics and time period simultaneously when the environmental issues usually take place over a long period.

The second improvement would be emphasizing the importance of industry characteristics. The literature which considering industry characteristics and firm heterogeneous have obtained different results that showing environmental regulation is important factor for pollution-intensive industries' FDI and trade (see Table 2.2).

The measurement of environmental costs is an area which should be further discussed. Table 2.1 to 2.2 show that the methods to measure environmental variables of existing literature are far from reaching consensus. The literature which observing environmental regulation differences among countries is using different dataset such as OECD environmental indicators, UNCTAD index and GREEN index. However, researcher argues that different industry is bearing different burden from environmental regulation in which the environmental costs of pollution-intensive industry is expected to be higher (Anderson & Kagan, 2000). As such, industry-level pollution abatement costs data have been frequently used to measure environmental regulation stringency or environmental costs itself. However, it is not able to compare across large country data (Chung, 2014).

Table 2.1: Effect on Trade Pattern, Emission and Industry Location

Authors	Empirical Approach	Dataset	Dependent Variable	Environmental variable	Main Finding
Bartik (1988)	cross-section, conditional logit approach	US Fortune 500 companies, 1972 to 1978	location of manufacturing branch plants	State air pollution spending, and State water pollution spending	No statistically significant relationship between environmental regulation and the business location.
Tobey (1990)	Cross-Section	5 polluting sectors in 23 countries, 1975	Net export	UNCTAD index	Differences in regulatory stringency were not statistically significant for international trade patterns of these observed industries.
Grossman and Kreuger (1991)	Cross-sectional, OLS	U.S. imports from Mexico, by 3-digit industry, 1987	Imports	U.S. PAOC/Value added, by sector	PAOC coefficient were either statistically insignificant, or negative and statistically significant in different industries.

Levinson (1996)	Cross-section, conditional logit	New manufacturing plant location in US, 1982-1987	New plant location	Conservation Foundation, Free Index, Green Index, Aggregate Abatement Costs, Industry Abatement Costs.	All environmental coefficients were negative, but only few were statistically significant
Henderson (1996)	Panel, fixed effect tobit and conditional Poisson	5 pollution industries in US counties, 1977-1987	Number of plants	County ambient ozone attainment status	Environmental requirements were more stringent in the counties that fail to attain NAAQS than other counties that already met the NAAQS standard
Van Beers and Van Den Bergh (1997)	Cross-section, gravity model	21 countries, for all, pollution-intensive, nonresource-based polluting sectors, 1992	bilateral trade	Index compiled from 1992 OECD envrionmental indicators	The results showed stringency of environmental regulation was significantly negative to bilateral trade flows for all sectors and insignificant effect on bilateral trade flow for pollution-intensive sectors.
Antweiler, Copeland, and Taylor (2001)	Panel Data	40 countries, for 293 observation sites, during 1970 to 1996	SO2 concerntration		Positive composition effect was found from capital-to-labor ratios and pollution.
Javorcik and Wei (2004)	Cross-section	25 economies in Eastern Europe and former Soviet Union, 1995	Investment flows at firm level data	International treaties, quality of air and water ambient, emission standards, environmental sustainability index	No evidence supporting the view that dirty FDI had strong motivation to invest in a state with lax environmental regulation.

Table 2.2: Recent literature: Industry Characteristic and Firm Heterogeneous

Authors	Empirical Approach	Dataset	Dependent Variable	Environmental variable	Findings
Wagner and Timmins (2009)	Dynamic panel	24 German manufacturing industries	Germany outward FDI in 163 destination country	Executive Opinion Survey	Strict environmental regulation was statistically significant in preventing FDI of chemical industry
Mulatu et al (2010)	Panel data	13 countries in Europe and 16 industries, 1990 - 1994	Average share of industry	Environmental Sustainability Index	Pollution haven effect is exist and the relative strength had the same magnitude as compare to other determinants of industry location.
Chung (2014)	Panel data	121 industries in Korea, 2000 -2007	Korean FDI outflows	Global competitiveness report	Pollution intensive industries are motivated to invest more in countries with relatively lenient environmental regulation.
Broner, Paula and Vasco (2015)	Panel data	85 manufacturing industries in U.S., 1989-2005	101 Country's relative import shares into U.S.	grams of lead content per liter of gasoline	the effect of environmental regulation on the pattern of trade is relevant and as important as traditional factors of comparative advantage.
Shapiro (2016)	Cross-section , Panel data	Bilateral trade of 128 countries for 14 sectors, 2007.	CO2 emission from trade	Trade's environmental costs	The benefits of international trade outweighed trade's environmental costs by a factor of 161.

2.3 Measuring environmental regulatory cost

Many empirical studies prefer to use pollution abatement costs and expenditures (PACE) data to measure the cost of complying environmental regulation or the environmental regulation stringency and its impact on economic activities (see examples: Tobey, 1990; Ederington, Levinson, & Minier, 2003; Manderson & Kneller, 2012, and Keller & Levinson, 2002).

The data are usually obtained from "US Pollution Abatement Costs and Expenditures survey" that conducted annually by the US Census Bureau through asking the plants to report their expenditures on capital and operations in relation to environmental regulation, including depreciation, labor, energy, materials, and other inputs.

PACE data have been widely employed in trade and environmental literature could be based on two rationales: (1) Environmental regulation stringency must has an impact on the cost of production, before it can influence FDI flows and trade pattern; (2) Industry with different level of pollution intensity is bearing different burden from environmental regulation. Therefore, PACE is used as a proxy for environment stringency, or to understand the significance of environmental cost with respect to total cost of production.

Nevertheless, PACE data are not able make comparison in large country sample as only few countries are providing this data (Chung, 2014). In addition, PACE data often lead to a conclusion that the environmental cost is insignificant to support pollution haven effect (Copeland & Taylor, 2004; Ederington, Levinson, & Minier, 2003) due to presence of omitted variables and measurement error (Levinson & Taylor, 2008), and Broner, Paula and Vasco (2015) argued that PACE data do not fully capture the capital costs of complying with environmental regulation.

Anderson and Kagan (2000) stressed that the indirect costs for complying environmental regulation could be a greater influential factor than environmental regulation per se and they studied the FDI trend of U.S. dirty and clean FDI between 1977 to 1996 for evidence related to indirect regulatory and legal costs.

The data trend showed that Europe and several countries with relatively high environmental standards but coordinated regulatory and legal systems had above-average rate or decreasing at a below average shares of dirty FDI. On contrary, countries with low environmental standard but less efficient and stable legal systems, had a decreasing share of dirty FDI. They proposed that dirty FDI flows is believed to be determined by a common factor other than environmental regulation, and they conjectured that high regulatory process costs are likely to be the answer.

Such an argument can obtain theoretical support in Cheung (1969) which stated that cost minimization decision in production process is not only about choosing the lowest-cost production combination, but also considering the set of arrangements with the lowest transaction costs. The transaction costs, based on his view, would be the effectiveness of law enforcement, or the corruptibility of courts and other costs of transaction in the marketplace.

Besides, some other literature also argued that firms may not make investment decision by considering explicit costs only, and linked the productivity lost due to complying environmental regulation as an opportunity costs[14] that indicating the costs of environmental control[15]

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[14] OECD (2014) defines opportunity costs are the costs that diverted to regulatory compliance and away from preferred uses.

[15] The concept of Indirect Compliance Cost in Anderson and Kagan (2000) is very similar to the concept of institutional cost and transaction cost in Institution Economics field. As this is the very important idea for this study, Anderson and Kagan (2000) definition of Indirect Compliance Cost has been employed. Other literature such as Yang (2013) mentioned opportunity cost as implicit cost of environmental control, and it could be catagorized as Indirect Compliance Cost as well. However, such a definition is not as comprehensive as Anderson and Kagan (2000) and difficult to measure. This is another reason that this study applied the later concept in the empirical model.

(Yang, 2013[16]; Aiken et al., 2009).

Despite its importance, direct data for measuring indirect compliance costs are not readily available. Nevertheless, Global Competitive Report, while measuring the competitiveness of a country through a set of indexes, has provided useful data in relation to the indirect compliance cost. In this annual report, institutions have been considered as one of the 12 categories of factors of competitiveness that determine the level of productivity of a country. Institution is a quality of competitiveness which is determined by the efficiency of a legal and administrative framework in an economy and the interaction between individuals, firms and the governments (World Economic Forum, 2015).

Ease of Doing Business Report conducted by World Bank Group is also capturing similar information. The doing business index measures the regulatory quality and efficiency of an economy in which 11 areas of business regulation, such as starting a business, dealing with construction permits, getting credit and etc, are being examined (World Bank, 2016). Despite both reports provide information about institutions, global competitiveness index would be a more appropriate data to be used in this study if following the definition of indirect compliance costs in Anderson and Kagan (2000) in which efficiency of legal framework in settling disputes, irregular payment and bribes and other institution qualities have been captured into indicator sets (refer Table 2.3).

Global Competitiveness report and Ease of Doing Business report rate and rank the regulatory efficiency of more than 100 countries over the world with standardized methods allow direct comparison across countries and suitable for panel data analysis. However, indexes have the downsides of

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[16] Yang (2013) applied alternative data envelopment analysis (DEA) based approach to measure opportunity cost of environmental regulation (OCER) and the economic impact of environmental regulations (EIER), by using Taiwan port industry as a case study. The study applied a panel dataset which included the period of 2001 - 2007, and made labor, fixed assets, and annual expenses as inputs and total revenue as the output in port operation. However, the study found that the port industry has a greater problem on production inefficiency rather than opportunity costs owing to environmental regulation.

inviting simplistic policy conclusion and selecting inappropriate indicators and weights (Balzaravicience & Pilinkiene, 2012).

Table 2.3: Comparison of Two Indicator Sets

Global Competitiveness Index (Pillar Institution)	Ease of doing business
Property rights	starting a business
Intellectual property protection	Dealing with construction permits
Division of public funds	Getting electricity
Public trust in politicians	Registering property
Irregular payments and bribes	Getting credit
Judicial independence	Protecting minority investors
Favoritism in decisions of government officials	Paying taxes
Wastefulness of government spending	Trading across borders
Burden of government regulation	Enforcing contracts
Efficiency of legal framework in settling disputes	Resolving insolvency
Efficiency of legal framework in challenging regulations	Labor market regulation
Transparency of government policy making	
Business costs of terrorism	
Business costs of crime and violence	
Organized crime	
Reliability of police services	
Ethical behavior of firms	
Strength of auditing and reporting standards	
Efficacy of corporate boards	
Protection of minority shareholders' interests	
Strength of investor protection	

Source: Global Competitiveness Report 2015-2016, Ease of Doing Business Report 2016

2.4 Gravity Model

Gravity model of international trade (GMIT) in one of the widely used trade models over the last thirty years to explain international trade flows. It suggests that the trade volume between two countries is influenced by the relative economy size (usually measured by GDP) and the geographical distance between the two trading countries (Bergstrand, 1985).

GMIT cannot be explained by existing economic thought on international trade, including Ricardian model and HO theory as it is inspired by a well-known physics law, i.e. ‘Law of Universal Gravitation’ (Stay & Kulkarni, 2016). Usually, the GMIT has been applied to a basic frictionless model to estimate statistically the bilateral trade flows under free trade circumstance (Deardoff, 1998). Nevertheless, GMIT is strongly supported by empirical evidence in which the explanatory power of both the economic sizes and distance variables are stable across times, countries and even the various econometric methods (Chaney, 2013).

Sohn (2001) found that Korea’s bilateral trade patterns are well explained by basic gravity model, suggesting that close the economies which are larger and closer to Korea is the more desirable trade destination to promote bilateral trade. When more countries sample involved, Inmaculada & Felicitas (2002) found random effect gravity model shows better results than fixed effect model in assessing Mercosur-European Union trade which included a sample of 20 countries.

In a more recent study, Stay and Kulkarni (2016) employed gravity model to test the volume of international trade flows of the United Kingdom and the 14 trading partners. They found empirical evidence for the model even the simplest form of GMIT where UK has been trading more with countries with similar economic size and close proximity, such as France, Italy and Germany.

2.5 Conclusion

The literature of pollution haven hypothesis have been vast and experienced several changes or improvement over time. The earliest studies in 1970s are interested in developing theoretical framework on top of conventional trade theory. They focus on observing the alteration in comparative advantage due to environmental regulation differences across countries. The analysis of theoretical works have subsequently shifted to understanding the impact of free trade on environmental quality or pollution level. These literature use the scale, composition and technique effect terminologies as a main analysis framework.

The empirical works were only active since 1980s and they can be divided into two main branches. The first branch was studying the effect of regulatory differences on output measures or trade pattern, such as production, net exports, and emissions. The second branch was observing the effect of environmental regulation on FDI flows and firm location. These empirical studies literature are failed to find important or consistent evidence across industries and countries that support pollution haven hypothesis. Latest empirical literature provide some meaningful results indicating that environmental regulation is statistically significant in determining trade and investment flows, after taking several industry characteristics such as agglomeration, mobility and pollution intensity into consideration.

Measurement of environmental cost has been a challenge for researchers in which indirect compliance costs have been overlooked by existing literature. This is especially important when usual measurement such as pollution abatement costs are not successful in examining pollution haven hypothesis. Hence, there is clearly research gap to be filled and this study attempts to contribute to the literature by looking into account the importance of indirect compliance costs.

CHAPTER 3

METHODOLOGY

3.0 Introduction

The characteristics of ASEAN-5, such as openness to trade, the trade compositions, relatively lax environmental regulation, coupled with its environmental issues, appear to be an appropriate research object for pollution haven hypothesis empirical model[17]. This chapter aims to provide the empirical methods to analyse whether the environmental standard differences between ASEAN-5 and its major trading partners have the impact toward sectoral export patterns in ASEAN-5 countries.

Since geographical distribution may be important for investors, this research will use gravity model of trade as basic framework. The gravity model of trade is an established trade model which achieves numerous empirical success in explaining trade flows among two countries. Meanwhile, this study uses panel data analysis, specifically the multilevel mixed-effects linear regression via maximum likelihood (Mixed-ML), to provide understanding of the variability in industry exports and environmental costs data with regard to unobservable variation in region-related characteristics within ASEAN-5 countries.

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[17] This view is supported by Javorcik and Wei (2004) who suggest transition countries are suitable region for studying PHH as these countries appeared to be large variation in environmental standards.

3.1 Theoretical framework

The gravity model is an empirical model which explains trade between two countries or regions. The earliest formulation of the gravity trade model was borrowing laws from physics. Many different researchers include Tinbergen, Pöyhönen and Linneman, have separately worked on the law and use gravity model to understand international trade flows, by explaining attractive force between economic volumes of two different countries.

In 1687, Newton proposed the 'Law of Universal Gravitation' which suggests that two celestial bodies are subjected to an attractive force, relying positively on the product of their masses and negatively on the square of their distance. Jan Tinbergen, in 1962, applied such law to international trade flows and used GDP and population to measure the 'mass' and distance between two location to explain the trade pattern between two countries. Since then, the empirical model has been applied to a wide range of area including migration, tourism, as well as foreign direct investment (Martinez-Zaroso & Nowak-Lehmann, 2003).

Weak theoretical foundation was a criticism for gravity model. However, Anderson and other researchers, since 1979, have developed the gravity equation from various trade models, including Ricardian, Heckscher-Ohlin, and increasing returns to scale models. Currently, the gravity model of international trade flows is an established trade model for evaluating the impact of a variety of policy issues, include regional trading groups (Evenett & Keller, 2002; Serlenga & Shin, 2007).

The general gravity law for international trade and social interaction may be expressed in roughly the same notation:

$$F_{ij} = G\frac{M_i^{\alpha} M_j^{\beta}}{D_{ij}^{\theta}} \tag{3.1}$$

where

F_{ij} :The ‘flow’ from origin *i* to destination *j*. Alternatively, this also represents total volume of interaction between *i* and *j* in both direction.

$M_1 M_2$:The relevant economic sizes of the two locations. In international trade model, they are usually the gross domestic product (GDP) or gross national income (GNI) of each location.

D_{ij}^2 :The distance between the two locations.

G :A gravitational constant depending on the units of measurement for mass and force.

Note that the Newton Law (3.1) indicates if $\alpha = \beta = 1$ and $\theta = 2$. This formula explains, all else equal, large ‘flows’ (such as trade flows) will occur when GDPs of two countries are high but with short distance. Similarly, trade flows are expected to be lower if distance between two countries are long (Stay and Kulkarni, 2016).

Given the multiplicative nature of the gravity model, the equation (3.2) can take natural logs and obtain a linear relationship as:

$$\ln(F_{ij}) = \alpha \ln M_i + \beta \ln M_j + \theta \ln D_{ij} + \rho \ln R_j + \mu_{ij} \qquad (3.2)$$

where:

F_{ij} :Commodities exports between country *i* and *j*

M_i : Economic Mass *i*

M_j : Economic Mass *j*

R_j : Constant across country

D_{ij} : Distance between country *i* and *j*

ln : Log linear form

3.2 Model specification

The econometric specification in this study is based on the standard gravity model as in (3.2). In order to modify the gravity model to fit with the research objectives, this study augments the original model by including environmental variables, as well as other variables representing polluting industry characteristic:

$$\ln EXPORT_{icjt} = \alpha + \beta_1 \ln GDP_{ct} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{ct} + \beta_4 \ln POP_{jt} + \beta_5 \ln DIST_{ij} \\ + \beta_6 DCOST_{cjt} + \beta_7 INDCOST_{cjt} + \beta_8 \ln AGG_{jt} + \sum \gamma_t TIME_t + e_{cj} \qquad (3.3)$$

where:

$EXPORT_{icjt}$: Exports of industry i from importing country c to exporting country j at time t

GDP_{ct} : Gross Domestic Product of importing country c at time t

GDP_{jt} : Gross Domestic Product of exporting country j at time t

POP_{ct} : Population of importing country c at time t

POP_{jt} : Population of exporting country j at time t

$DIST_{cj}$: Distance between country c and j

$DCOST_{cjt}$: Direct environmental cost differences between of importing country c and export country j at time t

$INDCOST_{cjt}$: Indirect compliance cost differences between of importing country c and export country j at time t

AGG_{ijt} : Agglomeration effect of industry i in exporting country j at time t

$TIME_t$: Time dummies in order to control the effect of common global events

3.2.1 Expected sign of the variables

Gross Domestic Products (GDP)

GDP represents the economic size for two trading countries from the aspect of production capacity and markets. Generally, regardless the type of industry, the GDP of exporters (ASEAN-5 countries) and importers (trading partners), respectively, are expected to be significantly positive with trade flows. The higher the exporter's GDP, the higher the amount of trade can be observed as larger country implies greater production capacity to increase exports and meet market demand. As a same force on opposite side, higher importer's GDP will lead to higher demand for imports (thus, exporters will have higher exports) as the expenditure capabilities are greater when the economic size of a country is large (Evenett & Keller, 2002; Stay & Kulkarni, 2016).

Population

A country with large population represents a large market and demand to absorb the local production capability and therefore less motivation to engage in trade. However, they may export when they achieve high level of production. Therefore, if the population of exporters are large, the volume of exports are likely to be higher; Nevertheless, if the population of importers are large, exporters tend to receive less demand from them and lower exports volume can be observed. (Bikker, 2010). As such, the expected sign of coefficient for β_3 is positive while β_4 is negative.

Distance

Distance is a "resistance" force in the gravity model of trade. It impedes trade between two countries in which transportation and transaction costs are likely to be higher as the distance increase. Hence, the expected sign of β_5 will be negative. Meanwhile, Stay and Kulkarni (2016) state that distance is more than merely representing the transportation cost in which the frequency of personal contact between nations can have direct relationship to trade volume. The cost of business person making direct contacts with neighboring country is lower than the country from the other continental, and more personal contacts can facilitate businesses and trade flows.

Direct Environmental costs

Environmental control cost variable is envisaged to have different impact to industry with various pollution intensity. Generally, direct environmental costs will have negative relationship with the volume of exports as increasing production cost implies lower productivity and less exports regardless the type of industry. Pollution-intensive industry may be more sensitive to direct environmental costs, therefore, if a country has lower environmental costs and become comparative advantage, then the country tend to produce high pollution commodities for exports (Grossman & Krueger, 1991). However, higher environmental costs in a country, on the other hand, may encourage the development of clean industry and clean commodities production for exports will increase[18]. In sum, the expected sign for β_6 would be negative for all industry and dirty industry group, and positive for clean industry group.

Indirect environmental compliance costs

Indirect environmental compliance costs β_7 is expected to have negative sign. Unlike direct environmental cost, higher indirect environmental compliance cost implies higher cost of doing business and unfavorable for all type of industry. However, since pollution-intensive industries are direct target for regulators to insist on full environmental regulatory compliance, a higher indirect environmental compliance costs is likely to reduce polluting commodities exports. Hence, pollution-intensive industries may have higher value of β_7.

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[18] Porter Hypothesis which suggests that environmental regulation, when properly designed, can establish an environment that motivates innovation and technological improvements within polluting industries (Porter and van der Linde, 1995). However, this study envisages that strict environmental regulation leads the country to form new comparative advantage upon clean industries and larger amount of clean commodities exports can be noticed.

Agglomeration effect

Southeast Asia region has integrated in a sophisticated international production networks that extended to the whole world and vertical FDI has been an important driver to facilitate the industrial development of production fragmentation. This has shifted the trade patterns in Southeast Asia region from North-South trade to intra-industry trade (Kimura, 2008), implying FDI inflows are important factor to determine trade pattern in the region.

Accumulated FDI inflows can create agglomeration economies which generate increasing returns and growth within clustering area, owing to positive spillover effect include reduced transport costs and localized information flows. If an industry is benefited from such positive spillover effect, the production and exports will increase and less affected by environmental cost (Cole, Elliott, & Okubo, 2010). Therefore, the expected sign between agglomeration effect and exports flow is positive.

3.2.2 Hypothesis statement

Objective 1: testing on pollution haven effect

$H_0: \beta_6 = \beta_7 = 0$

H_1: At least one beta is not equal to zero

Objective 2: testing on indirect compliance cost

$H_0: \beta_7 = 0$

$H_1: \beta_7 \neq 0$

Objective 3: testing on industry characteristics

$H_0: \beta_8 = 0$

$H_1: \beta_8 \neq 0$

3.3 Model estimation

This study uses panel data analysis to estimate the gravity model. As Southeast Asia region has been integrated deeply with global production fragmentation chain, time series data with only one country sample may not offers comprehensive picture for “pollution heaven effect” in the region. However, it is well known that cross-section OLS estimation does not considers heterogeneous characteristics related to the bilateral trade relationship and variation over time (Brunnermeier & Levinson, 2004; Serlenga & Shin (2007).

In this study, the unobserved heterogeneity may emanate from the industry or country characteristics that are likely to correlated with the environmental control costs, and the level of polluting goods production and exports (Brunnermeier & Levinson, 2004). For example, if a country has an unobserved comparative advantage in manufacturing polluting good, it will produce more and increases the pollution level, at the same time, it also imposes strict regulations and result in higher environmental control cost. Meanwhile, time factor is important in which environmental issues may have longer time frame to be observed.

A panel data approach will be more appropriate as it takes account of heterogeneity by including country pair ‘individual’ effects. Baltagi (2013) states several advantages of using panel data, including (1) More information data and variability, implying more degrees of freedom and more efficiency; (2) Able to study the dynamic of adjustment while cross-sectional distribution that look relatively stable can conceal a multitude of change; (3) Able to examine of more complicated behavioural models, including study of time-invariant variables.

In light of this, the panel model with two-way fixed effect proposed by Serlenga and Shin (2007) can be expressed as follow:

$$y_{cjt} = \alpha_{cj} + \theta + \beta_1 X_{cjt} + \beta_2 X_{jt} + \beta_3 X_{ct} + \beta_4 Z_{jt} + u_{hft} \qquad (c, j = 1, \ldots, N, h \neq f, t = 1, ..T) \tag{3.4}$$

Where y_{cjt} is the dependent variable which would be industry exports from country *c* to country *j* at time *t*. X_{cjt} are those explanatory variables with three dimension variation, for example, the environmental regulation differences between exporting and importing countries at time *t*. X_{ct} and X_{jt} are explanatory variables that varying with time *t* in importing country *c* or exporting country *j*; however, Z_{cj} are explanatory variables that offer difference between importing country *c* and exporting country *j* but do not vary over time. α_{cj} is a country-pair specific individual effect that might be correlated with some or all of the explanatory variables, $\theta_t s$ are time-specific effects apply to all individual sample such as business cycle that suppose to be adjusted; u_{cjt} are disturbance terms which are assumed to be *i.i.d.* with zero mean and constant variance across all c*, j, t*.

Consider the panel model is using two-way error component disturbances, then:

$$u_{ijt} = \mu_i + v_{ij} + \varepsilon i_{jt}, \tag{3.5}$$

where μ_i denotes the unobservable individual effect, and v_{it} denotes the remainder stochastic disturbance term. ε_{it} is a zero mean idiosyncratic random disturbance uncorrelated across cross-section units and over time periods.

3.3.1 Multilevel Mixed-effects Linear Model

In the OLS model, it is assumed that unobservable individual effect is absent. However, given the characteristic of the data set used in this study are multilevel in structure, a richer estimation model is needed to allow slope parameters to vary over individual or time. A multilevel regression model concerns a sample with a hierarchical structure. The sample of this study can be described as a multistage sample in which exports data of 20 industries can be clustered within 25 trading combinations between ASEAN-5 countries and their trading partners (see Diagram 3.1).

The multilevel mixed-effect linear regression (MMLR) is selected in this study as it has several advantages: (1) MMLR can explicitly address individual change across time; (2) MMLR is more flexible in terms of repeated measures; and (3) MMLM can be used for estimate higher-level model which have repeated observations within individuals within cluster.

The third advantage is especially important as the data structure in this study has three level. An MMLR model which encompasses both fixed effects and random effects is favorable to consider the issues involved hierarchical data clustering (Baltagi, 2013). It can flexibly models the means, variances and covariance of the data and provides understanding of the variability in industry exports and environmental costs data with regard to unobservable variation in region-related characteristics within ASEAN-5 countries.

Considers the following unbalanced panel data regression model:

$$y_{ijt} = x'_{ijt}\beta + u_{ijt}, \qquad i = 1,...,M, \quad j = 1,...,N_i \quad t = 1,...,T_i \tag{3.6}$$

Where y_{ijt} could denote the output of the jth country in the ith industry for the tth time period. x_{ijt} denotes a vector of k nonstochastic inputs. The disturbance of (1) is given by

$$u_{ijt} = \mu_i + v_{ij} + \varepsilon_{ijt}, \qquad i = 1,...,M, \quad j = 1,...,N_i \quad t = 1,...,T_i \tag{3.7}$$

Where μ_i denotes the ith unobservable country specific effect which is assumed to be *i.i.d.* $(0, \sigma_\mu^2), v_{ij}$ denotes the nested effect of the jth industry within the ith country which is assumed to be *i.i.d.* $(0, \sigma_\mu^2)$ and ε_{ij} denotes the remainder disturbance which is also assumed to be *i.i.d.* $(0, \sigma_\varepsilon^2)$. The $\mu_i's, v_{ij}'s$ and $\varepsilon_{ijt}'s$ are independent of each other and among themselves. The model makes each succesive component of the error term to be nested within the preceding components and allows for unequal number of industries data and time periods across industries.

Moreover, this study uses Mixed-ML estimation to take advantage of a more efficient estimation of the parameters of the model for the conditional mean. The three level Mixed-ML model can be expressed as:

$$y_{jk} = X_{jk}\beta + Z_{jk}^{(3)}u_k^{(3)} + Z_{jk}^{(2)}u_{jk}^{(2)} + \varepsilon_{jk} \tag{3.8}$$

In this model, $i = 1,....,n_{jk}$ is the first-level observations which nested within $j = 1,....,M_k$ second-level groups. And the second-level groups are, meantime, nested within $k = 1,....,M$ which are the third-level groups. Group j,k consists of n_{jk} observations, so $y_{jk}, x_{jk},$ and ε_{jk} each have row dimension n_{jk}. $Z_{jk}^{(3)}$ is the $n_{jk} \times q_3$ design matrix for the third-level random effects $u_k^{(3)}$, and $Z_{jk}^{(2)}$ is the $n_{jk} \times q_2$ design matrix for the second-level random effects $u_{jk}^{(2)}$.

Furthermore, assume that

$$u_k^{(3)} \sim N(0, \Sigma_3); \quad u_{jk}^{(2)} \sim N(0, \Sigma_2); \quad \varepsilon_{jk} \sim \mathrm{N}(0, \sigma_\varepsilon^2 I)$$

And that $u_k^{(3)}, u_{jk}^{(2)}$, and ε_{jk} are independent.

Diagram 3.1: Level of data

3.3.2 Static Linear Panel Models

OLS model may expose to random-effect estimators biased if individual effects are not zero and failed to capture. However, static linear panel models examine individual-specific effects, time effects, or both, to address the potentially unobserved heterogeneity or individual effect in a estimation. The estimation using Static Linear Panel models is conducted to perform the sensitivity analysis as compare with Multilevel Mixed-effects Linear Model.

I. Pooled ordinary least square (POLS)

If the individual effect does not exist, POLS produce efficient and consistent parameters estimates. Recall equation (3.6)

$$Y_{it} = \alpha + X'_{it}\beta + u_{it} \qquad (i = 1. \ldots, N ; t = 1, \ldots, T),$$

The disturbance term μ_{it} can be represented as:

$$u_{it} = \mu_i + \lambda_t + v_{it} \qquad (i = 1, ..., N; t = 1, ..., T), \tag{3.7}$$

where μ_i denotes the unobservable individual effect, λ_t is the unobservable time effect, v_{it} denotes the remainder stochastic disturbance term. If individual effect does not exist, then $\mu_i + \lambda_t = 0$.

II. Fixed effects model (FE)

In FE model, the equation can be expressed as follow:

$$Y_{it} = (\alpha + \mu_i + \lambda_t) + X'_{it}\beta + v_{it} \tag{3.8}$$

where $\alpha + \mu_i + \lambda_t$ represents different intercepts for each firm. Since an individual specific effect is time invariant and being treated as part of the intercept, individual effect is allowed to be correlated with other regressors and not violating OLS assumption of exogeneity. The FE model is estimated by least squares dummy variable (LSDV) regression and within effect estimation methods.

III. Random effects model (RE)

In RE model, Greene (2002) states the unobserved individual heterogeneity in disturbance term can be regarded to be uncorrelated with the included variables, and formulated as:

$$Y_{it} = \alpha + X'_{it}\beta + (\mu_i + \lambda_t + v_{it}) \tag{3.9}$$

Random effect model assumes that individual effects and regressor are not correlated. The difference among individuals lies in their individual specific errors, but not their intercepts, and hence RE model is also known as error component model. However, the regression with a compound disturbance may not be efficiently and consistently estimated by ordinary least squares, then generalized least square (GLS) would be the alternative approach for

RE model.

IV. Selecting the best panel model

In order to select the best method among the three models, and to detect heterogeneity problem, this study will use Poolability F test to examine the pooled OLS and FE model while Breusch-Pagan LM is used to test between Pooled OLS and RE model. Subequently, Hausemen tests would be performed to examine the FE model and RE model if there is heterogeneity.

i. Poolability tests

The question of whether to pool data is fundamental when using panel data. Poolability tests enable researcher to select the panel model to be estimated within the framework of fixed-effect models as it respond to three questions: (1) are there individual effects? or is it desirable to estimate by pooled OLS? (2) are there time effects outweigh the individual effects? (3) are the coefficients β constant across individuals?

These tests compare two simple principle: restricted and unrestricted models. The restricted model is a behavioural equation with the same parameters over time and across regions while the unrestricted model has parameters that may change over time or across region in the same behaviroural equation (Baltagi, 2013). Hence, the null model of poolability test is the OLS model (restricted) as below:

$$Y_{it} = \alpha + X'_{it}\beta + u_{it} \tag{3.10}$$

and its alternative model with *iid* (0, σ2) errors (unrestricted) is:

$$Y_{it} = \alpha + X'_{it}\beta + u_i + v_{it} \tag{3.11}$$

The null hypothesis may be written as: $H_0 : \mu_i = 0$, i = 1, . . . , N.

The traditional restriction-test statistic is:

$$F = \frac{(ESS_R - ESS_U)/(N-1)}{ESS_U/((T-1)N-K)} \tag{3.12}$$

where ESSR denotes the residual sum of squares under the null hypothesis, ESSU the residual sum of squares under the alternative.

ii. Breusch-Pagan Lagrange-multiplier (LM) test

The null hypothesis in the LM test is that variances across entities is zero, implying no significant difference across units and no panel effect. The Breusch-Pagan LM test statistic (simple form) is:

$$LM = LM_1 + LM_2$$

$$LM_1 = \frac{NT}{2(T-1)}\left\{1 - \frac{\hat{u}'(I_N \otimes J_T)\tilde{u}}{\tilde{u}'\tilde{u}}\right\}^2,$$

$$LM_2 = \frac{NT}{2(T-1)}\left\{1 - \frac{\hat{u}'(J_N \otimes I_T)\tilde{u}}{\tilde{u}'\tilde{u}}\right\}^2, \tag{3.13}$$

By using LM1 alone can test for the existence of individual effects $\sigma_\mu^2 \neq 0$ or use LM2 to test for time effects $\sigma_\lambda^2 \neq 0$. Both terms are distributed as $\chi^2(1)$, therefore the statistic LM is distributed as $\chi^2(2)$, in all cases under $H_0 : \sigma_\lambda^2 = \sigma_\mu^2 = 0$

iii. Hausemen tests

The Hausemen tests solve the hypothesis problem in which the estimator under null hypothesis is efficient but inconsistent under the alternative, while the other estimator is consistent under both hypothesis. For panel data, FE estimator is consistent in both the RE model and FE model. However, the RE (GLS) estimator is not able to use in FE model while it is efficient by construction in the RE model.

The Hauseman test statistic is:

$$m = q'(\operatorname{var} q)^{-1} q, \tag{3.14}$$

where $\operatorname{var} q = \operatorname{var} \tilde{\beta} - \operatorname{var} \hat{\beta}$ follows from the known properties of both estimators under the null hypothesis. The statistic m is distributed as $\chi 2$ under the null hypothesis, with degrees of freedom corresponding to the dimension of β.

Consider the regression model shown in (3.5) but with a two-way error component disturbances as (3.7). While individual and time effect error term (λ_t) are believed to be unobervable, to diagnose whether the remainder stochastic disturbance term (v_{it}) is well behaved, this study will perform Wooldridge autocorrelation test by constructing an auxiliary regression. In addition, since country data is likely to have similarity or connection among individual sample in which the other factor of country *i* is not independent from country *j*; hence, this study uses Pesaran cross-section dependence test to diagnose the problem.

3.4 Data Description

The characteristic of ASEAN-5 appear to be an appropriate research objects for pollution haven hypothesis empirical model[19] and therefore, they are selected for this study. On the other hand, the trading partners, China, Hong Kong, Korea, Japan and US, are chosen as they are the top five single largest importers for ASEAN-5 countries with comprehensive data (see table 3.1). Import data of intra-ASEAN trade is not considered in this study as most of the countries in the region are sharing high geographical and economic similarity for the study of pollution haven hypothesis. All of the data are collected for the time period of 2006 to 2014 and the empirical test

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[19] Singapore which is a advance country with high environmental standards are clearly distinct from other ASEAN-5 countries. However, this study applies the research procedure in Elliott & Shimamoto (2008) and included Singapore into the empirical research to see if the results is consistent.

is conducted by econometrics software Stata 12.

Table 3.1 List of Countries

Time coverage	Export countries	Import countries
2006 -2014	Indonesia	China
	Malaysia	Hong Kong
	Philippines	Korea
	Singapore	Japan
	Thailand	United States

The exports data are obtained from the ASEAN secretariat statistical (ASEANstats) website. These trade data is collected at industry level, covering the period of 2006 to 2014, and disaggregated into 20 industries according to 2-digit classification (section) of the Harmonized System (HS). In addition, these industries data are also divided into dirty and clean industry groups based on their pollution intensity (see table 3.2 and table 3.3). This procedure, according to Mulatu et al. (2010), can prevent the disadvantage of lack of variability in industry and country characteristic.

Table 3.2: List of Industry

HS Code	Industry	Pollution intensity
03	Fish and crustaceans, molluscs, and other aquatic invertebrates	Dirty
15	Agriculture, Hunting and Forestry	Dirty
26	Ores, Slag and Ash	Dirty
27	Mineral fuels, mineral oils and products of their distilation	Dirty
25	Salt; Suplphur; Earths and Stone; Plastering Materials, Lime and Cement	Dirty
28	Inorganic Chemicals; Organic or Inorganic Compounds of Precious Metals	Dirty
29	Organic Chemicals	Clean
30	Pharmaceutical products	Clean
39	Plastic and articles thereof	Dirty
40	Rubber and articles thereof	Dirty
44	Wood and articles of wood; wood charcoal	Dirty
48	Paper and Paperboard; Articles of Paper Pulp, Of Paper or Of Paperboard	Dirty
59	Impregnated Coated, Covered or Laminated Textile Fabrics	Dirty
69	Ceramic Products	Dirty
72	Iron, Steel, Copper, Alluminium, Lead and Tin	Dirty
84	Nuclear reactors, boilers, machinery and mechanical appliances	Clean

85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers	Clean
87	Vehichles other than railway or tramway rolling-stock; parts and accessories	Clean
90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; parts and accessories	Clean
94	Furniture, bedding, mattresses, mattress supports, cushions and similar stuffed furnishing; lamps and lighting fittings	Clean

Table 3.3: List of Top 10 Polluting Industries

Reference	Industries	Pollution intensity
Hettige et. al. (1995)	Fertilizers	966.6
	Industrial Chemicals	609.77
	Iron and steel	349.9
	Fabricated metal products	212.82
	Plastic products	175.56
	Textiles	154.38
	Non-ferrous metal	151.22
	Wood products	144.69
	Paper and paperboard	122.87
	Petroleum refineries	78.63
Mulatu et. al. (2010)	Industrial chemical	5.4826
	Drugs and medicines	5.4826
	Iron and steel	4.1136
	Non-ferrous metal	4.1136
	Rubber and plastic products	1.4784
	Paper, paer products	1.1395
	Wood products and furniture	0.9499
	Metal products	0.8901
	Non-metalic mineral products	0.6575
	Textiles, apparel and leather	0.6337
Chung (2014)	Cement, lime and plaster	0.196
	Clay building materials	0.177
	Pulp, paper and paperboard	0.103
	Starches and strach products	0.099
	Textiles	0.092
	Iron and steel	0.084
	Man-made Fiber	0.081
	Basic chemical	0.077
	ceramic products	0.074
	Glass and glass products	0.067

Specifically, this study uses three references to define dirty and clean industry. The three references are: (1) Hettige, Martin, Singh, and Wheeler (1995) which applied exponential acute human toxic intensity index to measure pollution intensity of a industry according four digit ISIC codes and description; (2) Mulatu et. al. (2010) which used toxic release inventory (TRI) data compiled by US Environmental Protection Agency; and (3) Chung (2014) which measured pollution intensity through energy use per output data.

In this study, an industry is classified as dirty industry when it is measured as top 10 polluting industries in Hettige et. al (1995), Mulatu et. al. (2010) and Chung (2014). The advantage of this approach is that these three references cover different methods and time periods (1995, 2010, and 2014) and thus able to ensure the industry, when defined as dirty or clean industry, is consistent in term of both method and time aspect.

Gross Domestic Products and population data are obtained from the World Bank Development Database. These two data are originally expressed in current USD at market prices and in millions respectively. Meanwhile, the proximity measurement used in this test is the log of the distance between the two major cities of the respective countries. The cities are usually the capitals of the two countries. These data are calculated through Great Circle distance in miles using the latitude and longitude of the two points in equation.

The number of ISO14001 certification has been used to proxy direct environmental control cost and the data are acquired from ISO organization website. ISO 14001 is a certification awarded to a firm if it is able to prove compliance with the international standard of environmental managment systems. The most common data has been applied to measure environmental compliance cost is pollution abatement costs and expenditure, however, this data is not available for many the countries, particularly in developing countries.

ISO 14001 could be the best alternative available as a firm, to obtain the certification, has to make substantial improvement and re-structure the management system and production process which incur higher environmental cost[20]. It therefore can represent environmental compliance costs level in a industry and country. In addition, ISO 14001 data is an international standard that applies to all industries and all countries, hence it is a comparable and objective measure of environmental compliance cost (Xi & Yang, 2012). However, given ISO 14001 is intended for use by an organization seeking to manage its environmental responsibility, it does not represent the compulsory regulatory costs. But it is still applicable as a country or industry with relatively small registration number of ISO 14001 can suggest a weaker environmental awareness and therefore lower direct environmental costs.

There is no direct data for indirect environmental compliance costs thus far. Nevertheless, Global Competitive Report provides useful information in relation to the cost. The report rates and ranks the competitiveness of 140 countries over the world with standardized methods, and considers institution system of a country as one of the main pillars of competitiveness, hence it allows direct comparison across countries (Chung, 2014).

There is a list of indicators reflecting the competitiveness of an institution system, among them, five indicators which are ‘irregular payments and bribes’, ‘burden of government regulation’, ‘efficiency of legal framework in settling disputes’, and ‘efficiency of legal framework in challenging regulations’ have been selected based on the definition of indirect compliance costs stated in Anderson and Kagan (2000). Subsequently, this study conducts principal component analysis to compress the data of these five indicators into a single set of values which useful for the estimation, without much loss of information.

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[20] According to ISO website, ISO 14001 specifies the requirements for an environmental management system that an organization is required to fulfilled without exclusion to achieve the environmental objective and obligation.

With respect to agglomeration data, this study follows Wagner and Timmins (2009) in using the total stock of inward FDI as a proxy for agglomeration or congestion externalities. There are several indexes have been developed to measure agglomeration in an economy, however, the fundamental advantage of using stock of inward FDI as proxy is that the data are available for a large cross-section of countries.

CHAPTER 4

EMPIRICAL RESULTS AND FINDING

4.0 Introduction

The purpose of this chapter is to estimate the causal relationship between indirect compliance cost and ASEAN-5's export at different level of pollution intensity by using multilevel mixed-effects linear regression via maximum likelihood (Mixed-ML), and Multilevel mixed-effects linear regression via restricted maximum likelihood Mixed-REML). This empirical test was conducted through three series of testing. First one was based on aggregate model which observing the export of all industry without separating the industries by pollution intensity while the second and third series were dirty industry and clean industry respectively.

All three series have five specification include Mixed-ML and Mixed-REML and the comparison model include Pooled Ordinary Least Square (POLS), Fixed Effect Model (FEM) and Random Effect Model. Meanwhile, these specifications are using the same data set and covers same time periods, variables of gravity model include GDP, population, and distance are used as control variables for the estimation.

4.1 Descriptive statistic

This study used a panel dataset including ASEAN-5 countries' export at industry level for the year 2006-2014. Tables 4.1, 4.2, and 4.3 present a summary of statistic for all variables in three industry groups. Generally, the values of inter-countries standard deviation are higher than the time factor for most of the variables. Some of the differences between same variables are substantial, indicating that the variation between countries are more significant than the time changes (Wooldridge, 2012).

The standard deviation of export variables (lnexport) among ASEAN-5 countries are 2.6914 for all industry group. It is quite large compare with the standard deviation of other variables, and it ranged from a minimum of 9.0722 to a maximum of 23.7504. The standard deviation figure of export variable of dirty and clean industries are approximate to each other with a mean value between of 17.3959 to 18.6278.

Both Direct environmental cost (dcostcj) and Indirect compliance cost (indcostcj) are the first two largest standard deviation compare to other variables at the value of 0.6762 and 3.9201 respectively. The value of these two variables are measured in ratio form. The higher the value, the higher the costs of direct and indirect environmental cost in a country over its trading partner. High standard deviation figure indicating the environmental costs within ASEAN-5 countries are large. It may due to the sample has two extreme country groups which is likely to be Singapore and Philippines in which they present two extremely distinct environmental regulation system.

Agglomeration effect variable (Aggj) has the standard deviation of 0.1810 which is also quite varying in which the range are from a minimum of -0.0042 to a maximum of 0.4789.

Table 4.1: Summary Statistic for All Industry

Variable		Mean	Std. Dev	Min	Max	Observations
lnexport	overall	17.8288	2.7549	4.6250	24.0698	N = 4422
	between		2.6914	9.0722	23.7504	n = 500
	within		0.6774	11.5248	23.9894	T-bar = 8.844
lngdpc	overall	28.5901	1.4784	25.9887	30.4886	N = 4500
	between		1.4635	26.1885	30.3606	n = 500
	within		0.2185	27.8235	29.1567	T = 9
lngdpj	overall	26.4255	0.4998	25.5290	27.5453	N = 4500
	between		0.4226	26.0118	27.2055	n = 500
	within		0.2675	25.8420	26.7992	T = 9
lnpopc	overall	18.5424	1.7621	15.7408	21.0339	N = 4500
	between		1.7636	15.7673	21.0141	n = 500
	within		0.0150	18.5076	18.5740	T = 9
lnpopj	overall	17.6497	1.3079	15.2974	19.3546	N = 4500
	between		1.3083	15.4283	19.3028	n = 500
	within		0.0434	17.5189	17.7362	T = 9
lndistcj	overall	8.4166	0.7055	7.0175	9.6912	N = 4500
	between		0.7061	7.0175	9.6912	n = 500
	within		1.05E-15	8.4166	8.4166	T = 9
dcostcj	overall	0.3933	0.7539	0.0032	5.2159	N = 4500
	between		0.6762	0.1150	2.8408	n = 500
	within		0.3345	-1.1837	2.7683	T = 9
indcostcj	overall	2.9638	6.9000	0.2259	73.1240	N = 4500
	between		3.9201	0.3650	16.6754	n = 500
	within		5.6806	-10.6915	59.4124	T = 9
aggj	overall	0.2301	0.1851	-0.0960	0.5170	N = 4300
	between		0.1810	-0.0042	0.4789	n = 500
	within		0.0448	0.0330	0.3546	T-bar = 8.6

Table 4.2: Summary Statistic for Dirty Industry

Variable		Mean	Std. Dev	Min	Max	Observations
lnexport	overall	17.3959	2.7481	4.6250	23.6754	N = 2868
	between		2.6780	9.0722	23.2577	n = 326
	within		0.7230	11.0919	23.5565	T-bar = 8.82462
lngdpc	overall	28.5901	1.4785	25.9887	30.4886	N = 2925
	between		1.1464	26.1885	30.3606	n = 325
	within		0.2185	27.8235	29.1567	T = 9
lngdpj	overall	26.4255	0.4998	25.5290	27.5453	N = 2925
	between		0.4228	26.0118	27.2055	n = 325
	within		0.2675	25.8420	26.7992	T = 9
lnpopc	overall	18.5424	1.7622	15.7408	21.0339	N = 2925
	between		1.7646	15.7673	21.0141	n = 325
	within		0.0150	18.5076	18.5740	T = 9
lnpopj	overall	17.6497	1.3080	15.2974	19.3546	N = 2925
	between		1.3090	15.4283	19.3028	n = 325
	within		0.0434	17.5189	17.7362	T = 9
lndistcj	overall	8.4166	0.7055	7.0175	9.6912	N = 2925
	between		0.7065	7.0175	9.6912	n = 325
	within		1.05E-15	8.4166	8.4166	T = 9
dcostcj	overall	0.3933	0.7539	0.0032	5.2159	N = 2925
	between		0.6766	0.0115	2.8408	n = 325
	within		0.3346	-1.1837	2.7683	T = 9
indcostcj	overall	2.9670	6.8993	0.2259	73.1240	N = 2925
	between		3.9204	0.3650	16.6754	n = 325
	within		5.6809	-10.6883	59.4157	T = 9
aggj	overall	0.2112	0.1884	-0.0960	0.5170	N = 2795
	between		0.1848	-0.0042	0.4789	n = 325
	within		0.0443	0.0140	0.3357	T-bar = 8.6

Table 4.3: Summary Statistic for Clean Industry

Variable		Mean	Std. Dev	Min	Max	Observations
	overall		2.5843	8.0285	24.0698	N = 1554
lnexport	between	18.6278	2.5219	12.5084	23.7504	n = 175
	within		0.5842	13.9585	24.1785	T-bar = 8.88
	overall		1.4787	25.9887	30.4886	N = 1575
lngdpc	between	28.5901	1.4662	26.1885	30.3606	n = 175
	within		0.2185	27.8235	29.1567	T = 9
	overall		0.4999	25.5290	27.5453	N = 1575
lngdpj	between	26.4255	0.4234	26.0118	27.2055	n = 175
	within		0.2676	25.8420	26.7992	T = 9
	overall		1.7625	15.7408	21.0339	N = 1575
lnpopc	between	18.5424	1.7669	15.7673	21.0141	n = 175
	within		0.0150	18.5076	18.5740	T = 9
	overall		1.3082	15.2974	19.3546	N = 1575
lnpopj	between	17.6497	1.3108	15.4283	19.3028	n = 175
	within		0.0434	17.5189	17.7362	T = 9
	overall		0.7056	7.0175	9.6912	N = 1575
lndistcj	between	8.4166	0.7074	7.0175	9.6912	n = 175
	within		1.05E-15	8.4166	8.4166	T = 9
	overall		0.7540	0.0032	5.2159	N = 1575
dcostcj	between	0.3933	0.6775	0.0115	2.8408	n = 175
	within		0.3346	-1.1837	2.7683	T = 9
	overall		6.9034	0.2259	73.1240	N = 1575
indcostcj	between	2.9577	3.9309	0.3650	16.6754	n = 175
	within		5.6818	-10.6976	59.4063	T = 9
	overall		0.1733	-0.0003	0.5170	N = 1505
aggj	between	0.2653	0.1680	0.0002	0.4789	n = 175
	within		0.0457	0.1608	0.3606	T-bar = 8.6

4.2 Empirical results

4.2.1 Results discussion

The main research methods of this study are Mixed-ML and Mixed REML which include both fixed and random effects and able to address hierarchical data clustering (Baltagi, 2013). Three series of testing were conducted separately based on the industry pollution intensity and the results were observed from four perspective. First, this study explored the explanatory power of gravity model on the exports of ASEAN-5 to ensure whether the overall equation is well established. The focus has then turned to direct environmental compliance cost and indirect compliance cost variable to find the evidence of pollution haven effect. Lastly, the results of agglomeration effect variable was observed to understand whether industry characteristic can affect exports flows in different industry groups.

I. The relationship between environmental compliance cost difference and trade flows of ASEAN-5.

Direct environmental compliance cost variable is positively correlated with the exports of all industry (as show in Table 4.4 and Table 4.5). The direct compliance cost is expected to negatively affect the exports in general, however, the sign is insignificant, implying there's no relationship between the two variables. It can be due to either the environmental costs were negligible to bring effect on exports (Copeland & Taylor, 2004; Ederington, Levinson, & Minier, 2003), or the environmental cost differences among ASEAN-5 countries and their trading partners have not changed substantially during the time period. It may also owing to the environmental awareness may not be high in most of the ASEAN-5 countries, therefore environmental cost which represented by ISO numbers may not significant for dirty industries[21].

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[21] The results must be accepted with care as obtaining ISO certification is not made mandatory by government and therefore contribute to insignificant results in ASEAN exports data sample.

It is worth to note that the coefficient of direct compliance costs are positively correlated with export in clean industry and significant. It is consistent with the hypothesis that the higher direct environmental compliance cost can promote clean industries' exports as industry which complying high standard of environment regulations may have better international reputation for their products.

Despite the coefficients of direct compliance are not significant in the specification of Mixed-ML and Mixed-REML, it but become significant when using FEM and REM model. This implies increase in direct compliance cost will discourage export in dirty industry. This is supporting the hypothesis of this study.

II. The indirect compliance cost and exports at industry with different level of pollution intensity.

Of special interest here is the coefficient on indirect compliance cost is negatively signed and significant with exports for aggregate, dirty, and clean industries in ASEAN-5 countries, indicating higher indirect cost can discourage export activities. This is consistent with the view of Anderson and Kagan (2000) in which a complex regulation system can cause compliance cost to be higher and negatively affect productivity, and thus export activities.

Achieving same sign for three group of samples also shows that the indirect compliance cost is common to industries with different level of pollution intensity while this study believes that dirty industries would be affected the most as the nature of their production may received greater attention from regulators, making the compliance cost tend to be higher. Compare to the industries that generating less pollution, the public, especially the environmental activism, has been watching close on highly polluting industries or companies, creating pressure to the regulators to be more stringent when governing these industries.

It is worth to note that the sizes of the coefficient support the hypothesis of this study (see Table 4.4 and 4.5) in which the coefficient of dirty industries is the largest (-0.0365) among three industry samples, this indicates every one point increase in indirect compliance cost will lead the export of dirty industries to decrease 0.0365. It is followed by all industry group (-0.0311) and the clean industries (-0.0202).

Comparing both the environmental variables in this research, indirect compliance cost appear to be a more critical factor in determining export flows in ASEAN-5 compared with direct environmental cost and implying its importance in assessing the real costs of complying environmental regulation.

III. The effect of industry characteristic and ASEAN-5 trade flows

Agglomeration effect variable and the exports in all and dirty industries have positive relationship. This results are in line with the view that if a country was agglomerating dirty industries, it will export more dirty goods. However, the signs are not statistical significant in Mixed-ML and Mixed-REML regression models and contrasted with the finding of Wagner and Timmins (2009) which pointed out the importance to control for stock externalities associated with FDI accumulation when examining the relationship between environmental cost and the exports trend.

Agglomeration which proxied by Stock of FDI, is not significant for all group of industries. On the other hand, agglomeration variables has a negative relationship and statistically significant with clean export which is not consistent with the hypothesis of this study.

There are two possible explanations: (1) The agglomerated clean industry FDI in ASEAN-5 could be a supporting industries for local production which are also targeting the local market but not for export. Hence, the increasing FDI resulted lesser export in related industry. (2) As the clean industry achieve higher agglomeration effect with more FDI, the business model of the industry has changed and export their production to the countries which are not included in the sample group of this study.

IV. Can gravity model explains the exports of ASEAN-5?

A summary of the results obtained following the estimation of gravity trade equation by using the Mixed-ML and Mixed REML regression method are presented in Table 4.4 and 4.5. In these two models, the random effect at sector level data have been nested into country groups. The variance-component estimates are now organized according to level. After adjusting for the nested-level error structure, this study finds that the coefficients of variables of basic gravity model include GDPs, population and distance are in line with the expected signs and statistically significant at all; dirty: and clean industry, excepts population of import countries.

The coefficient of GDP for both import and export countries (ASEAN-5) are positive, indicating the trading partners' economic production capacity increase the level of international trade. The scale are large at 0.9627 and 1.7920 respectively. This is consistent with the theory of gravity model that a country with a large economy has a greater ability to both import and export (Stay & Kulkarni, 2016).

The negative coefficients of the population variables support the explanation that a country with large population tend to have sufficient large market and therefore less motivated to engage in trade as compare to a country with small population (Bikker, 2010). It is interesting to note that the population variables are not significant to the dirty industry equation (see Table 4.4 column (2) and (5)).

Geographical attribute provides explanation for the results of population variables in which Southeast Asia is a region with relatively abundant of natural endowment but less populated, such as Philippines and Malaysia, therefore, these countries are likely to exports dirty commodities associated to natural resources, such as agriculture and forestry, logging, and mining, regardless the population size as comparative advantage at play.

For distance variables, the coefficient is negative and statistically significant, confirming the view that the trade between two countries will reduce when the geographical distance between them are increase due to higher trade costs (Bosker & Garrestsen, 2010; Azam, 2016).

Table 4.4: The Results of Mixed-ML Regression for All, Dirty and Clean Industry Groups

		Mixed-ML	
	(1)	(2)	(3)
Variables	All Industry	Dirty Industry	Clean Industry
lngdpc	0.9267***	0.7970***	1.1568***
	(0.1474)	(0.1492)	(0.2076)
lngdpj	1.7920***	2.1633***	1.0692***
	(0.3303)	(0.4171)	(0.4111)
lnpopc	-0.2187**	-0.1175	-0.4013**
	(0.0970)	(0.1180)	(0.1565)
lnpopj	-0.4362***	-0.2436	-0.7954***
	(0.1007)	(0.1536)	(0.1564)
lndistcj	-0.9518***	-1.0391***	-0.7762***
	(0.1634)	(0.2178)	(0.2424)
dcostcj	0.0988	-0.0084	0.2961**
	(0.1107)	(0.1304)	(0.1188)
indcostcj	-0.0311***	-0.0365***	-0.0202***
	(0.0046)	(0.0069)	(0.0038)
aggj	0.4407	1.0317	-0.4679
	(0.5895)	(0.9237)	(0.6427)
Constant	-35.6761***	-46.7072***	-14.1953
	(6.7713)	(7.2962)	(9.3364)
Observations	4,224	2,740	1,484
Number of groups	20	13	7

Note:

1) the abbreviation:

lngdpc	Gross Domestic Product of importing country c
lngdpj	Gross Domestic Product of exporting country j
lnpopc	Population of importing country c
lnpopj	Population of exporting country j
lndistcj	Distance between country c and j

dcostcj	Direct environmental cost differences between of importing country c and export country j
indcostcj	Indirect compliance cost differences between of importing country c and export country j
aggj	Agglomeration effect of industry i in exporting country j

2) The differences of the results of Mixed-ML (Table 4.4) and Mixed REML (Table 4.5) estimation are usually small and REML method will be the better model if significant difference are found. However, this study continue to use Mixed-ML estimation as this allows this study to compare the two models that differ in the fixed part in the regression coefficient using chi-square test based on likelihood function.

Table 4.5: The Results of Mixed-REML Regression for Pooled, Dirty and Clean Industry Groups

		Mixed-REML	
	(1)	(2)	(3)
Variables	All Industry	Dirty Industry	Clean Industry
lngdpc	0.9267***	0.7971***	1.1567***
	(0.1474)	(0.1492)	(0.2075)
lngdpj	1.7920***	2.1633***	1.0691***
	(0.3303)	(0.4171)	(0.4111)
lnpopc	-0.2187**	-0.1175	-0.4013**
	(0.0970)	(0.1180)	(0.1565)
lnpopj	-0.4362***	-0.2437	-0.7954***
	(0.1007)	(0.1536)	(0.1564)
lndistcj	-0.9518***	-1.0393***	-0.7762***
	(0.1634)	(0.2178)	(0.2423)
dcostcj	0.0988	-0.0084	0.2962**
	(0.1107)	(0.1304)	(0.1188)
indcostcj	-0.0311***	-0.0365***	-0.0202***
	(0.0046)	(0.0069)	(0.0038)
aggj	0.4413	1.0343	-0.4686
	(0.5895)	(0.9246)	(0.6426)
Constant	-35.6763***	-46.7067***	-14.1945
	(6.7714)	(7.2963)	(9.3354)
Observations	4,224	2,740	1,484
Number of groups	20	13	7

4.2.2 Sensitivity analysis

This subsection uses Static Linear Panel models including POLS, FEM and REM as a sensitivity analysis in contrast with the results of Multilevel Mixed-effects Linear Model. POLS models for regression at all, dirty and clean industry groups present largely similar results with the Mixed-ML and Mixed REML models (see Table 4.6) in which most of the variables obtain similar sign and significant. However, since the Modified Walt test in Table 4.9 shows there is heterogeneity in the regression, the state and region effects are not zero, and the corresponding standard errors and t-statistics are biased (Baltagi, Song, & Jung, 2001).

The POLS model is a standard error component model which assume there is homoskedasticity at the same variance across time and individual groups. The assumption could lead the regression coefficients to be consistent but not efficient as cross-sectional units may be varying in a panel data. In addition, robust standard errors are computed to correct for the possible presence of heteroskedasticity (Baltagi, 2013).

When this study further regresses the data sample and allows time and state specific effects through FEM and REM models, most of the variables turned out to be insignificant at the 5% level.

FEM is estimated by within effect estimation methods which individual effects is allowed to be correlated with other regressors as it is time invariant and being treated as a part of the intercept. Meanwhile, random effect model estimates by considering error term is an individual specific random heterogeneity in which the individual affects are assumed to be not correlated with any regressor.

The generally weaker results of FEM and REM models for three industry groups may due to these models do not work well because grouped data observations from the same country group are generally more similar as compare to other observations from different country groups, and therefore multilevel models are better estimator (Hox, 2010).

Table 4.6: The Results of Pooled OLS Regression for All, Dirty and Clean Industry Groups

Variables	(1) All Industry	(2) Dirty Industry	(3) Clean Industry
lngdp*c*	0.8084***	0.5658**	1.2835***
	(0.1951)	(0.2021)	(0.2918)
lngdpj	1.7421***	2.1368***	1.1642*
	(0.3172)	(0.3834)	(0.5431)
lnpopc	-0.1612	-0.0021	-0.4659*
	(0.1242)	(0.1303)	(0.2145)
lnpopj	-0.3103*	0.0221	-0.9082***
	(0.1588)	(0.1353)	(0.2130)
lndistcj	-0.7848***	-0.7134*	-0.9496**
	(0.2654)	(0.3433)	(0.3062)
dcostcj	0.1071	0.0151	0.2874*
	(0.1205)	(0.1694)	(0.1360)
indcost*cj*	-0.0296***	-0.0341***	-0.0227***
	(0.0044)	(0.0067)	(0.0049)
agg*j*	-1.7339	-3.9019*	1.2933
	(1.7646)	(2.0624)	(1.6485)
Constant	-35.1820***	-47.9260***	-16.1129
	(6.9573)	(7.1392)	(12.7938)
Observations	4,224	2,740	1,484
R-squared	0.0984	0.1812	0.1873
Number of groups			

Note:

lngdpc	Gross Domestic Product of importing country c
lngdpj	Gross Domestic Product of exporting country j
lnpopc	Population of importing country c
lnpopj	Population of exporting country j
lndistcj	Distance between country c and j
dcostcj	Direct environmental cost differences between of importing country c and export country j
indcostcj	Indirect compliance cost differences between of importing country c and export country j
aggj	Agglomeration effect of industry i in exporting country j

Table 4.7: The Results of FEM Regression for Pooled, Dirty and Clean Industry Groups

	(1)	(2)	(3)
Variables	All Industry	Dirty Industry	Clean Industry
lngdpc	0.5482***	0.5634***	0.5153***
	(0.1142)	(0.1660)	(0.1300)
lngdpj	-0.1561	-0.0953	-0.2627
	(0.3130)	(0.4448)	(0.3366)
lnpopc	-2.6262	-1.1023	-5.5379
	(2.9213)	(3.9835)	(4.0890)
lnpopj	-0.8908	-0.7698	-1.5987*
	(0.7987)	(1.2342)	(0.7160)
lndistcj			
dcostcj	-0.1319**	-0.1606**	-0.0702
	(0.0486)	(0.0659)	(0.0672)
indcostcj	-0.0073	-0.0066	-0.0059
	(0.0050)	(0.0066)	(0.0033)
aggj	0.3517	1.5774	-1.9906
	(0.8553)	(0.8979)	(1.3248)
Constant	70.4600	37.3443	142.1333
	(52.9380)	(65.8402)	(90.4498)
Observations	4,224	2,740	1,484
R-squared	0.1075	0.0763	0.2733
Number of idcode	500	325	175
Number of groups			

Table 4.8: The Results of REM Regression for Pooled, Dirty and Clean Industry Groups

Variables	(1) All Industry	(2) Dirty Industry	(3) Clean Industry
lngdpc	0.5055***	0.4988***	0.4857***
	(0.0983)	(0.1393)	(0.1104)
lngdpj	0.2883	0.6287**	-0.0951
	(0.2222)	(0.2832)	(0.2276)
lnpopc	-0.0819	-0.0213	-0.1716
	(0.1035)	(0.1308)	(0.1704)
lnpopj	-0.1528	0.0411	-0.5369***
	(0.1014)	(0.0968)	(0.1271)
lndistcj	-0.2865	-0.4650	0.0602
	(0.2071)	(0.2946)	(0.1428)
dcostcj	-0.1119***	-0.1214***	-0.0747
	(0.0346)	(0.0437)	(0.0571)
indcostcj	-0.0070	-0.0053	-0.0073*
	(0.0051)	(0.0069)	(0.0038)
aggj	0.1181	0.5447	-1.4326
	(0.8445)	(1.0059)	(1.1955)
Constant	2.3788	-9.8078	19.6444***
	(5.8398)	(6.9302)	(6.4832)
Observations	4,224	2,740	1,484
Number of groups			

Table 4.9: Autocorrelation and Heteroscedaticity Test

	Autocorrelation *Wooldrige test*	Heteroscedaticity *Modified Walt test*
All Industry	16.582***	870000***
Dirty Industry	8.435**	490000***
Clean Industry	27.212***	91228.91***

4.3 Major findings and conclusion

I. First research question: Is ASEAN-5 economies a pollution haven for their major trading partners?

The pollution haven effect refers to the phenomena of lower dirty goods exports (or higher clean goods imports) occurs when the environmental regulation has been tightened. Typically, a tightening of regulation will be manifested in the raises of production costs as the environmental control costs are added. The world's relative price structure will be changed when the production cost is higher and redefine the competitiveness of dirty industries, and thus the export flows (Taylor, 2004).

The central task of this study is to understanding whether ASEAN-5 economies have been a pollution haven for their major trading partners while they are increasingly open up their economy. Empirical evidence for a pollution haven effect can be in many sources, but often researchers test the pollution haven effect by focusing direct environmental control costs data. This study expects a relatively efficient or lax legal environment and administrative process (indirect compliance costs) for business can induce dirty exports as well.

To answer the first research question, both variables, direct and indirect compliance costs, would be observed when interpreting the results. The first major finding of this study is the pollution haven effect does not significant if only observing direct environmental cost, but it is found if indirect compliance cost is included in the model. The dirty industries in ASEAN-5 do not make production and exports decision based on direct environmental cost. However, they have gained cost advantages from low indirect compliance costs and therefore higher exports flows in dirty goods can be observed.

This can be ascribed to cost minimization process is not only determined by production costs, but also involves transaction costs which are the costs incurred from external environments to make the production happens. When the regulatory process costs or transaction costs with respect to environmental regulation are high, companies will face extra costs to increase their production as they have environmental regulation to comply or they have to negotiate with regulators for the increased production.

II. Second research question: How significant the indirect compliance costs as an environmental cost?

This empirical analysis controls the variables of basic gravity model and agglomeration effects to estimate the impact of direct environmental costs, indirect compliance costs toward the exports trend in ASEAN-5 countries and obtains statistically significant evidence with correct sign of indirect compliance costs for both the dirty and clean industry. This means that, at a higher degree of openness, the relative indirect compliance costs between ASEAN-5 countries with their trading partners can have its influence over export flows despite the size of the coefficients are relatively small.

The coefficient of indirect compliance cost variable is significant for three industry groups while direct compliance cost variable only significant for clean industry. This is supporting the view of this study that the indirect compliance cost plays a more important role in determining the type of exports and indicates the practicality to regard indirect compliance cost as part of the environmental compliance costs

This is due to regulatory process costs and legal environment consists of the larger part of the overall environmental compliance costs. This offers meaningful implication as governments of ASEAN-5 countries, for instance Malaysia and Singapore, are committed to improve competitiveness through minimizing the cost of doing business, and they have maintained high ranking in global competitive reports. Hence, it may be necessary to be aware of whether an excessive friendly environment toward businesses will have negative impact over environment, especially when environmental regulation is not fully enforced.

For instance, Both Malaysia and Singapore have high ranking in Global Competitive Index but the country with lower environmental standard which is Malaysia, will have more environmental issues or crisis, such as prolonged deforestation issue, Lynas issue 2012, Pahang bauxite mining issue 2016 and etc.

III. Third research question: Does environmental cost impacts differently on industries which have different industry characteristic?

This study envisages the dirty industries FDI agglomeration can lead the dirty goods exports in ASEAN-5 FDI to increase. However, the results show ASEAN-5's export flows are not influenced by the stock of FDI. The reason that can explain the results would be either the dirty industries in ASEAN-5 are largely made up of supporting industries for local production or the target market has changed after they achieve agglomeration effect. In short, agglomeration effect is not a key factor in determining ASEAN-5 export to China, Hong Kong, Korea, Japan and the US.

CHAPTER 5

CONCLUSION AND POLICY IMPLICATIONS

5.1 Summary and conclusion

While ASEAN-5 countries have seen decent economic growth over the last decades, it is however not without any downside in which this study concerning trade liberalization and the environment. This is because the source of growth of ASEAN-5 countries can be related to trade liberalization, and the environmental issues in the region are notable and need to be concerned.

Trade and environment is not a new research topic in which the economists and environmentalists have been constantly presenting their views, theories, and empirical findings with respect to the environmental consequences of liberalized trade for the last ten years. One of the important ideas that has been proposed is the pollution haven hypothesis. There has been much debate over pollution haven hypothesis, however, consensus among researchers are not reached yet.

While trade-induced scale effect will increase pollution level in a country is a straight forward tendency, environment implication of trade liberalization is also depend on composition effects which mainly determined by a country's comparative advantage. Environmental regulation differences (pollution haven hypothesis) and factor endowments (factor endowment hypothesis) are the two main sources of comparative advantage when examining trade and environment.

If low environmental standard or high environmental assimilative capacity has been a comparative advantage of a country, then it is likely to become pollution haven of the world economy. The environmental economists and researchers concerns about developing countries would potentially become pollution haven as they emphasize economic growth rather than environmental preservation.

In light of this, The central task of this study is to understanding whether ASEAN-5 economies have been a pollution haven for their major trading partners while they are increasingly open up their economy. In chapter 1, the background study indicates that ASEAN-5 countries probably the pollution haven as they are export-oriented and the trade composition are largely polluting industries while adopting lower than average environmental standards. This motivates this study to conduct further investigation in following chapters.

In Chapter 2, this study finds that the empirical evidence for pollution haven hypothesis are remain tenuous while vast amount of existing literature focus on studying the impact of environmental costs on trade pattern, this study expects a relatively efficient or lax legal environment and administrative process (indirect compliance costs) for businesses play important role in determining the export pattern, especially pollution intensive industries exports.

Gravity model of trade has been used as a basic framework of empirical study and panel data analysis, specifically the Mixed-ML and Mixed-REML methods, are conducted to test on the hypothesis of this study. As a result, this study finds the coefficient of indirect compliance cost variable is significant and has larger impact for dirty industry exports.

This means that if a country, to reduce the cost of doing business, intentionally brings down the legal process and transaction costs, it will lower the indirect compliance costs, and thus facilitates dirty industry's production and their exports. In addition, this research obtains positive relationship between environmental cost and clean industry export, implying higher environmental cost can be encouraged to promote clean industries in ASEAN-5 countries.

5.2 Policy Implications

Copeland and Taylor (2003) find consistent evidence pointing pollution haven effects are weaker in influencing trade flows compare to factor endowment differences, However, they also further explain that these evidence do not make pollution regulation differences irrelevant and a strong policy response can reverse the situation.

Policy makers whose are reluctant to implement stricter environmental policies may be decided based on a zero-sum game mentality over economic growth and environmental protection. However, there are two real examples could tell that such a view is not unquestionably true.

The first example is Singapore where the country achieved high income nation status and high trade activities without compromising its effort in environmental protection. It was done through shifting the composition effect towards clean industry.

If the comparative advantage of a country is naturally built upon polluting factor endowment, this study also expects the country still can achieve better environmental quality yet attaining economic development. Consider Australia as an example, the country relies heavily on resources-based industries which is highly polluting, however, it continues to deliver sustainable economic performance through implementing effective natural resources management policies (Kalirajan, Uz-Zaman, & Wijesekere, 2015).

In light of this, both the trade obligation and environmental protection should be incorporated in a coherent policy to balance the national interest between economic growth and environmental quality. Based on the finding in this study, several measurements are suggested to balance the economic development and environmental protection:

This study, in chapter 4, finds that the indirect compliance cost have negative influence over export flows and dirty industry is receiving the highest impact. This means increasing business competitiveness through lowering legal and adminstrative process costs can encourage pollution-intensive production more while other industries are benefited at the same time. For example the corporate law, which has usually been granted to firms at minimal requirements, especially when the governments adopt business friendly policies. The corporate law is environmental-neutral and not does not require corporates to comply with the laws of the state in order to maintain corporate status.

As such, the first policy implication can be suggested is a discriminative policy against clean and dirty industries for both local and foreign investors to increase indirect environmental compliance cost of pollution intensive industries but maintaining a generally low cost of doing business for other industries. Environmental regulators may require pollution intensive industries to submit specific documents regularly to report on their pollution emission level and the environmental controlling results.

The more important is the second policy implication. The policy makers would have to empower the local communities through making the information about environmental pollution available to the stakeholders and public as well as encouraging the participation of local communities in environmental impact assessment process and decision making, and making easy access to the legal system. Empowering local communities is an external force that can pressure firms to reconsider the cost of not complying environment regulations (when command-and-control approaches are not effective) or the cost of neglecting their harmful activities over environment. This type of cost is also refers to adversarial legalism which use sanction actions include legal penalties, adverse publicity, and reputational effects as a tool to influence firms to comply with environment regulations.

The third policy implication is strengthening the natural resource management (NRM). A low indirect compliance cost will increase export, which is supported by increase of local production. As trade affects environment through scale effect in which increases production for exports purpose, increase of production will not only generate more pollution as a by-products, it is also accelerating natural resources depletion if these productions are extensively relied on environmental input. Implementing a better natural resource management lead the real environmental costs to be internalized into the resources price by managing the supply. As a result, inefficiency of resources utilization or misallocation can be prevented and which in turn can alleviate the degradation of environmental quality.

The forth policy implication can be drawn from the finding that the direct environmental cost is positively correlated with clean industries export flow. Since introducing higher direct environmental costs can promote clean exports, ASEAN-5 policy makers should implement higher environmental standards to develop a new comparative advantage that specializing in clean industries. This means, with regard to this study, clean industries are encouraged to apply for ISO 14001 certification. By doing so, ASEAN-5 can improve environmental quality in a country while obtaining economic growth.

5.3 Limitation of the Study

A limitation of this study is related to the difficult in measuring environment stringency. Brunel and Levinson (2013) identified four fundamental conceptual obstacles to evaluating environmental regulations; that is multidimensionality, simultaneity, industrial composition, and capital vintage. Some of the problems pertaining to the data availability and flaws are as follows:

i. While ISO14001 data has the strength of comparable among sample countries, the data may not fully reflect the actual direct environmental costs in ASEAN-5. The more appropriate data would be compulsory environmental production and control cost data at industry level which may not be collected by authority of ASEAN-5 countries or the barrier to access these data is high.

ii. The data sample of 9 years (2006-2014) is relatively short to capture the change of export composition and industry development which may have longer time frame to change and take place at different time period in each ASEAN-5 countries.

iii. While Global Competitive Report has revealed explicitly its method of constructing the indexes, the usefulness of indirect compliance cost data in this study undeniably rely on the quality of measurement of the report.

iv. Although referring the pollution intensity indexes of different researchers that measure in different time period can ensure the reliability of the method to differentiate the industry sample into particular groups with different pollution level (dirty and clean industry), such a method is still not conducted based on one standardized measurement which could have certain level of deviation in different country and industry sample. However, constructing a measurement of pollution intensity might be a task importance enough to conduct separate study due to its technical complexity.

5.4 Recommendation for Future Studies

This study is expected to be repeatable in future research, hence it could also improved through considering other country samples such as China and European countries, industry characteristic variables such as fixed plant costs, and control variables include factor endowment which is standard comparative advantage that explain trade flows.

While this study is focusing on detecting pollution haven effect which is examining the link between variation in the cost of complying environmental regulations and the trade flows, Pollution haven hypothesis predicts that when trade barriers are reduced, pollution-intensive industries will concentrate in countries with lax environmental regulation. Despite the distinction between two concepts, pollution haven effect is an essential suggestive evidence for pollution haven hypothesis to hold. Therefore, given this study has obtained meaningful results of pollution haven effect, the study in future can extend this research to examine pollution haven hypothesis.

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APPENDIX

Appendix A.1: Mixed-effects ML Regression for All Industry Group

```
Bootstrap, reps(50) seed(10101) cluster(sector) nodots: xtmixed lnexport lngdpc
lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year || sector:
```

```
Mixed-effects ML regression                     Number of obs      =      4224
Group variable: sector                          Number of groups   =        20

                                                Obs per group: min =       202
                                                               avg =     211.2
                                                               max =       212


                                                Wald chi2(16)      =   2234.31
Log likelihood = -8355.2803                     Prob > chi2        =    0.0000

                                   (Replications based on 20 clusters in sector)
------------------------------------------------------------------------------
             |   Observed   Bootstrap                         Normal-based
    lnexport |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .9266773   .1473773     6.29   0.000     .6378231    1.215532
      lngdpj |   1.791961   .3303415     5.42   0.000     1.144504    2.439418
      lnpopc |  -.2187193   .0969724    -2.26   0.024    -.4087817   -.0286568
      lnpopj |  -.4361702   .1006621    -4.33   0.000    -.6334643   -.2388761
    lndistcj |    -.95179   .1634102    -5.82   0.000    -1.272068   -.6315119
     dcostcj |   .0987558    .110688     0.89   0.372    -.1181887    .3157003
   indcostcj |   -.031124     .00458    -6.80   0.000    -.0401007   -.0221474
        aggj |   .4407222   .5895185     0.75   0.455    -.7147128    1.596157
             |
        year |
       2007  |  -.2987808   .0635988    -4.70   0.000    -.4234322   -.1741294
       2008  |  -.4011032   .1123153    -3.57   0.000    -.6212372   -.1809692
       2009  |  -.3513181   .1078598    -3.26   0.001    -.5627195   -.1399168
       2010  |  -.6003489   .1363613    -4.40   0.000    -.8676121   -.3330856
       2011  |  -.8697282   .1773056    -4.91   0.000    -1.217241   -.5222156
       2012  |  -1.073516   .2213987    -4.85   0.000     -1.50745    -.639583
       2013  |   -1.16082    .229475    -5.06   0.000    -1.610583   -.7110572
       2014  |  -1.251181   .2514415    -4.98   0.000    -1.743997   -.7583644
             |
       _cons |  -35.67614   6.771325    -5.27   0.000    -48.94769   -22.40459
------------------------------------------------------------------------------

------------------------------------------------------------------------------
                             |   Observed   Bootstrap         Normal-based
  Random-effects Parameters  |   Estimate   Std. Err.     [95% Conf. Interval]
-----------------------------+------------------------------------------------
sector: Identity             |
                   sd(_cons) |   2.012314   .2059931      1.646498    2.459405
-----------------------------+------------------------------------------------
                sd(Residual) |   1.725821   .1153411      1.513937     1.96736
------------------------------------------------------------------------------
LR test vs. linear regression: chibar2(01) =  3425.86 Prob >= chibar2 = 0.0000
```

Appendix A.2: Mixed-effects REML Regression for All Industry Group

```
Bootstrap, reps(50) seed(10101) cluster(sector) nodots: xtmixed lnexport lngdpc
lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year || sector:,reml
```

```
Mixed-effects REML regression                   Number of obs      =      4224
Group variable: sector                          Number of groups   =        20

                                                Obs per group: min =       202
                                                               avg =     211.2
                                                               max =       212


                                                Wald chi2(16)      =   2234.36
Log restricted-likelihood = -8385.9386          Prob > chi2        =    0.0000

                                (Replications based on 20 clusters in sector)
------------------------------------------------------------------------------
             |   Observed   Bootstrap                         Normal-based
    lnexport |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .9267109    .147368     6.29   0.000      .637875    1.215547
      lngdpj |   1.791975   .3303441     5.42   0.000     1.144512    2.439437
      lnpopc |   -.218736   .0969702    -2.26   0.024     -.408794   -.0286779
      lnpopj |  -.4362052   .1006568    -4.33   0.000     -.633489   -.2389215
    lndistcj |  -.9518366   .1634034    -5.83   0.000    -1.272101   -.6315719
     dcostcj |   .0987531   .1106857     0.89   0.372    -.1181868    .3156931
   indcostcj |  -.0311245   .0045801    -6.80   0.000    -.0401014   -.0221476
        aggj |   .4413301   .5895451     0.75   0.454     -.714157    1.596817
             |
        year |
       2007  |  -.2987723   .0635986    -4.70   0.000    -.4234234   -.1741213
       2008  |  -.4011199   .1123199    -3.57   0.000    -.6212628   -.1809769
       2009  |  -.3513148   .1078624    -3.26   0.001    -.5627212   -.1399083
       2010  |  -.6003544   .1363669    -4.40   0.000    -.8676285   -.3330803
       2011  |  -.8697369   .1773127    -4.91   0.000    -1.217264   -.5222104
       2012  |  -1.073523   .2214068    -4.85   0.000    -1.507472   -.6395731
       2013  |  -1.160826   .2294833    -5.06   0.000    -1.610605   -.7110465
       2014  |  -1.251179   .2514482    -4.98   0.000    -1.744008   -.7583495
             |
       _cons |  -35.67628   6.771405    -5.27   0.000    -48.94799   -22.40457
------------------------------------------------------------------------------

------------------------------------------------------------------------------
                             |   Observed   Bootstrap         Normal-based
  Random-effects Parameters  |   Estimate   Std. Err.     [95% Conf. Interval]
-----------------------------+------------------------------------------------
sector: Identity             |
                   sd(_cons) |    2.06491   .2104788      1.690975    2.521536
-----------------------------+------------------------------------------------
                sd(Residual) |   1.729114   .1155665      1.516817    1.971126
------------------------------------------------------------------------------
LR test vs. linear regression: chibar2(01) =  3417.85 Prob >= chibar2 = 0.0000
```

Appendix A.3: Mixed-effects ML Regression for Dirty Industry Group

```
Bootstrap, reps(50) seed(10101) cluster(sector) nodots: xtmixed lnexport lngdpc
lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year || sector:
```

```
Mixed-effects ML regression                     Number of obs      =      2740
Group variable: sector                          Number of groups   =        13

                                                Obs per group: min =       202
                                                               avg =     210.8
                                                               max =       212


                                                Wald chi2(16)      =  20385.00
Log likelihood = -5413.5089                     Prob > chi2        =    0.0000

                                  (Replications based on 13 clusters in sector)

------------------------------------------------------------------------------
             |   Observed   Bootstrap                         Normal-based
    lnexport |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .7969761   .1492031     5.34   0.000     .5045433    1.089409
      lngdpj |   2.163326   .4170937     5.19   0.000     1.345837    2.980814
      lnpopc |  -.1174884   .1180342    -1.00   0.320    -.3488313    .1138544
      lnpopj |  -.2435804   .1535514    -1.59   0.113    -.5445356    .0573749
    lndistcj |  -1.039112   .2177819    -4.77   0.000    -1.465956   -.6122669
     dcostcj |  -.0084264   .1304247    -0.06   0.948    -.2640541    .2472012
   indcostcj |  -.0365358   .0068744    -5.31   0.000    -.0500093   -.0230622
        aggj |   1.031745   .9236885     1.12   0.264    -.7786516    2.842141
             |
        year |
       2007  |  -.3064946   .0924077    -3.32   0.001    -.4876103   -.1253788
       2008  |  -.4151245   .1431132    -2.90   0.004    -.6956212   -.1346278
       2009  |  -.3402345   .1442038    -2.36   0.018    -.6228688   -.0576002
       2010  |  -.7355979   .1940548    -3.79   0.000    -1.115938   -.3552575
       2011  |  -1.029675    .232057    -4.44   0.000    -1.484498   -.5748516
       2012  |   -1.32998   .2670235    -4.98   0.000    -1.853336   -.8066231
       2013  |   -1.38994   .2700789    -5.15   0.000    -1.919285   -.8605954
       2014  |  -1.518442    .295998    -5.13   0.000    -2.098588   -.9382969
             |
       _cons |  -46.70724   7.296215    -6.40   0.000    -61.00756   -32.40692
------------------------------------------------------------------------------

------------------------------------------------------------------------------
                             |   Observed   Bootstrap         Normal-based
  Random-effects Parameters  |   Estimate   Std. Err.     [95% Conf. Interval]
-----------------------------+------------------------------------------------
sector: Identity             |
                   sd(_cons) |   2.001276   .2637688      1.545676    2.591169
-----------------------------+------------------------------------------------
                sd(Residual) |   1.721816   .1584043      1.437731    2.062034
------------------------------------------------------------------------------
LR test vs. linear regression: chibar2(01) =  1962.43 Prob >= chibar2 = 0.0000
```

Appendix A.4: Mixed-effects REML Regression for Dirty Industry Group

```
Bootstrap, reps(50) seed(10101) cluster(sector) nodots: xtmixed lnexport lngdpc
lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year || sector:, reml
Mixed-effects REML regression                   Number of obs      =      2740
Group variable: sector                          Number of groups   =        13

                                                Obs per group: min =       202
                                                               avg =     210.8
                                                               max =       212


                                                Wald chi2(16)      =  20381.18
Log restricted-likelihood = -5440.4578          Prob > chi2        =    0.0000

                              (Replications based on 13 clusters in sector)
------------------------------------------------------------------------------
             |   Observed   Bootstrap                         Normal-based
    lnexport |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .7970973   .1491992     5.34   0.000     .5046723    1.089522
      lngdpj |    2.16334   .4170969     5.19   0.000     1.345846    2.980835
      lnpopc |  -.1175499   .1180339    -1.00   0.319     -.348892    .1137922
      lnpopj |  -.2437178   .1535549    -1.59   0.112      -.54468    .0572443
    lndistcj |  -1.039279   .2177827    -4.77   0.000    -1.466126   -.6124329
     dcostcj |  -.0084392   .1304259    -0.06   0.948    -.2640692    .2471908
   indcostcj |  -.0365371   .0068745    -5.31   0.000    -.0500109   -.0230633
        aggj |   1.034297   .9246064     1.12   0.263    -.7778978    2.846493
             |
        year |
       2007  |  -.3064593   .0924184    -3.32   0.001    -.4875961   -.1253225
       2008  |  -.4151682   .1431169    -2.90   0.004    -.6956723   -.1346642
       2009  |  -.3402124   .1442218    -2.36   0.018    -.6228819    -.057543
       2010  |  -.7355957   .1940731    -3.79   0.000    -1.115972   -.3552194
       2011  |  -1.029684   .2320706    -4.44   0.000    -1.484535   -.5748345
       2012  |   -1.32998   .2670472    -4.98   0.000    -1.853382   -.8065767
       2013  |  -1.389937   .2701095    -5.15   0.000    -1.919342   -.8605321
       2014  |  -1.518412   .2960369    -5.13   0.000    -2.098634   -.9381907
             |
       _cons |  -46.70666   7.296284    -6.40   0.000    -61.00711   -32.40621
------------------------------------------------------------------------------


------------------------------------------------------------------------------
                             |   Observed   Bootstrap         Normal-based
  Random-effects Parameters  |   Estimate   Std. Err.     [95% Conf. Interval]
-----------------------------+------------------------------------------------
sector: Identity             |
                   sd(_cons) |   2.083754   .2759679      1.607367     2.70133
-----------------------------+------------------------------------------------
                sd(Residual) |   1.726888   .1588878      1.441938    2.068148
------------------------------------------------------------------------------
LR test vs. linear regression: chibar2(01) =  1956.21 Prob >= chibar2 = 0.0000
```

Appendix A.5: Mixed-effects ML Regression for Clean Industry Group

```
Bootstrap, reps(50) seed(10101) cluster(sector) nodots: xtmixed lnexport lngdpc
lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year || sector:
```

```
Mixed-effects ML regression                     Number of obs      =      1484
Group variable: sector                          Number of groups   =         7

                                                Obs per group: min =       212
                                                               avg =     212.0
                                                               max =       212


                                                Wald chi2(14)      =         .
Log likelihood =  -2623.329                     Prob > chi2        =         .

                                   (Replications based on 7 clusters in sector)
------------------------------------------------------------------------------
             |   Observed   Bootstrap                         Normal-based
    lnexport |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   1.156785   .2075627     5.57   0.000     .7499696      1.5636
      lngdpj |   1.069168   .4111459     2.60   0.009     .2633373    1.874999
      lnpopc |   -.401325   .1565251    -2.56   0.010    -.7081085   -.0945415
      lnpopj |  -.7954002   .1564148    -5.09   0.000    -1.101968   -.4888329
    lndistcj |  -.7762498   .2423536    -3.20   0.001    -1.251254   -.3012455
     dcostcj |   .2961485   .1188187     2.49   0.013     .0632682    .5290288
   indcostcj |  -.0202485   .0037608    -5.38   0.000    -.0276195   -.0128774
        aggj |  -.4678774   .6426574    -0.73   0.467    -1.727463    .7917079
             |
        year |
       2007  |  -.2894942   .1006412    -2.88   0.004    -.4867472   -.0922411
       2008  |   -.365635   .1930234    -1.89   0.058    -.7439539    .0126838
       2009  |  -.3667668   .2052807    -1.79   0.074    -.7691096     .035576
       2010  |  -.3310705   .1591499    -2.08   0.038    -.6429986   -.0191424
       2011  |  -.5525636    .242704    -2.28   0.023    -1.028255   -.0768724
       2012  |  -.5820459   .2607627    -2.23   0.026    -1.093131   -.0709605
       2013  |  -.7158186   .2588049    -2.77   0.006    -1.223067   -.2085703
       2014  |  -.7412316   .2788357    -2.66   0.008     -1.28774   -.1947236
             |
       _cons |  -14.19531   9.336435    -1.52   0.128    -32.49439    4.103763
------------------------------------------------------------------------------


------------------------------------------------------------------------------
                             |   Observed   Bootstrap         Normal-based
  Random-effects Parameters  |   Estimate   Std. Err.     [95% Conf. Interval]
-----------------------------+------------------------------------------------
sector: Identity             |
                   sd(_cons) |    1.88661   .3938187      1.253138    2.840308
-----------------------------+------------------------------------------------
                sd(Residual) |   1.397589   .1449659      1.140481    1.712659
------------------------------------------------------------------------------
LR test vs. linear regression: chibar2(01) =  1478.11 Prob >= chibar2 = 0.0000
```

Appendix A.6: Mixed-effects REML Regression for Clean Industry Group

```
Bootstrap, reps(50) seed(10101) cluster(sector) nodots: xtmixed lnexport lngdpc
lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year || sector:
Mixed-effects REML regression                   Number of obs      =      1484
Group variable: sector                          Number of groups   =         7

                                                Obs per group: min =       212
                                                               avg =     212.0
                                                               max =       212


                                                Wald chi2(14)      =         .
Log restricted-likelihood = -2648.5684          Prob > chi2        =         .

                                    (Replications based on 7 clusters in sector)
------------------------------------------------------------------------------
             |   Observed   Bootstrap                         Normal-based
    lnexport |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   1.156732   .2075408     5.57   0.000     .7499594    1.563505
      lngdpj |   1.069129   .4111186     2.60   0.009     .2633509    1.874906
      lnpopc |  -.4012981   .1565243    -2.56   0.010    -.7080799   -.0945162
      lnpopj |  -.7953531   .1563977    -5.09   0.000    -1.101887   -.4888192
    lndistcj |  -.7761774   .2423184    -3.20   0.001    -1.251113    -.301242
     dcostcj |   .2961522   .1188217     2.49   0.013      .063266    .5290383
   indcostcj |  -.0202475   .0037605    -5.38   0.000    -.0276179    -.012877
        aggj |  -.4686131   .6426349    -0.73   0.466    -1.728154    .7909281
             |
        year |
       2007  |   -.289505   .1006373    -2.88   0.004    -.4867506   -.0922594
       2008  |  -.3656094   .1930047    -1.89   0.058    -.7438916    .0126728
       2009  |  -.3667674   .2052681    -1.79   0.074    -.7690855    .0355507
       2010  |  -.3310524   .1591171    -2.08   0.037    -.6429163   -.0191886
       2011  |   -.552537   .2426659    -2.28   0.023    -1.028153   -.0769205
       2012  |  -.5820261   .2607249    -2.23   0.026    -1.093038   -.0710147
       2013  |  -.7158019   .2587678    -2.77   0.006    -1.222977   -.2086263
       2014  |  -.7412279   .2788086    -2.66   0.008    -1.287683   -.1947731
             |
       _cons |  -14.19451   9.335421    -1.52   0.128     -32.4916    4.102577
------------------------------------------------------------------------------

------------------------------------------------------------------------------
                             |   Observed   Bootstrap         Normal-based
  Random-effects Parameters  |   Estimate   Std. Err.     [95% Conf. Interval]
-----------------------------+------------------------------------------------
sector: Identity             |
                   sd(_cons) |   2.038223   .4314486      1.346078    3.086263
-----------------------------+------------------------------------------------
                sd(Residual) |   1.405221   .1457572      1.146709    1.722011
------------------------------------------------------------------------------
LR test vs. linear regression: chibar2(01) =  1466.91 Prob >= chibar2 = 0.0000
```

Appendix B.1: Pooled OLS Regression for All Industry Group

```
. reg lnexport lngdpc lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year, robust cluster(sector)

Linear regression                                      Number of obs =    4224
                                                       F( 16,    19) =   99.78
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.0984
                                                       Root MSE      =  2.6291

                                 (Std. Err. adjusted for 20 clusters in sector)
------------------------------------------------------------------------------
             |               Robust
    lnexport |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .8083836   .1950619     4.14   0.001     .4001143    1.216653
      lngdpj |   1.742057   .3171621     5.49   0.000     1.078229    2.405885
      lnpopc |  -.1612236   .1242264    -1.30   0.210    -.4212324    .0987852
      lnpopj |   -.310322    .158808    -1.95   0.066    -.6427109    .0220669
    lndistcj |  -.7848278   .2653522    -2.96   0.008    -1.340216   -.2294393
     dcostcj |   .1071242   .1204798     0.89   0.385    -.1450429    .3592913
   indcostcj |  -.0295822   .0044317    -6.68   0.000    -.0388578   -.0203065
        aggj |  -1.733948   1.764588    -0.98   0.338    -5.427274    1.959377
             |
        year |
       2007  |  -.3277886   .0691345    -4.74   0.000    -.4724888   -.1830883
       2008  |  -.3313732   .1117598    -2.97   0.008    -.5652892   -.0974571
       2009  |  -.3628993    .104249    -3.48   0.003    -.5810951   -.1447036
       2010  |   -.577241   .1269051    -4.55   0.000    -.8428565   -.3116255
       2011  |  -.8402221   .1695767    -4.95   0.000     -1.19515    -.485294
       2012  |  -1.049784   .1978495    -5.31   0.000    -1.463888   -.6356801
       2013  |  -1.136279   .1983338    -5.73   0.000    -1.551396   -.7211617
       2014  |  -1.250635   .2168995    -5.77   0.000    -1.704611   -.7966594
             |
       _cons |  -35.18197   6.957319    -5.06   0.000     -49.7438   -20.62013
------------------------------------------------------------------------------
```

Appendix B.2: Pooled OLS Regression for Dirty Industry Group

```
. reg lnexport lngdpc lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year, robust cluster(sector)

Linear regression                                      Number of obs =    2740
                                                       F( 12,    12) =       .
                                                       Prob > F      =       .
                                                       R-squared     =  0.1812
                                                       Root MSE      =  2.5043

                                (Std. Err. adjusted for 13 clusters in sector)
------------------------------------------------------------------------------
             |               Robust
    lnexport |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .5657889   .2020557     2.80   0.016     .1255472     1.00603
      lngdpj |   2.136809   .3834284     5.57   0.000      1.30139    2.972227
      lnpopc |  -.0021294   .1303453    -0.02   0.987    -.2861275    .2818687
      lnpopj |   .0220968   .1352636     0.16   0.873    -.2726174    .3168109
    lndistcj |  -.7134057   .3433153    -2.08   0.060    -1.461425    .0346141
     dcostcj |   .0151374   .1694374     0.09   0.930     -.354035    .3843099
   indcostcj |  -.0341211   .0066788    -5.11   0.000    -.0486729   -.0195693
        aggj |  -3.901866   2.062375    -1.89   0.083    -8.395395    .5916618
             |
        year |
       2007  |  -.3726469   .0842124    -4.43   0.001    -.5561299   -.1891638
       2008  |  -.3142904    .138455    -2.27   0.042    -.6159578   -.0126229
       2009  |  -.3832215   .1068648    -3.59   0.004    -.6160598   -.1503832
       2010  |  -.7346502    .163689    -4.49   0.001    -1.091298   -.3780025
       2011  |  -1.015915   .2156396    -4.71   0.001    -1.485753   -.5460763
       2012  |  -1.327968   .2420594    -5.49   0.000     -1.85537   -.8005656
       2013  |  -1.391601    .256545    -5.42   0.000    -1.950565   -.8326374
       2014  |   -1.56698   .2696213    -5.81   0.000    -2.154434   -.9795257
             |
       _cons |  -47.92601   7.139187    -6.71   0.000    -63.48096   -32.37106
------------------------------------------------------------------------------
```

Appendix B.3: Pooled OLS Regression for Clean Industry Group

```
. reg lnexport lngdpc lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year, robust cluster(sector)

Linear regression                                      Number of obs =    1484
                                                       F(  5,     6) =       .
                                                       Prob > F      =       .
                                                       R-squared     =  0.1873
                                                       Root MSE      =  2.3457

                                 (Std. Err. adjusted for 7 clusters in sector)
------------------------------------------------------------------------------
             |               Robust
    lnexport |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   1.283462    .291752     4.40   0.005     .5695709    1.997354
      lngdpj |   1.164193   .5431116     2.14   0.076    -.1647534    2.493139
      lnpopc |  -.4658729   .2145191    -2.17   0.073    -.9907821    .0590363
      lnpopj |   -.908237   .2130226    -4.26   0.005    -1.429485   -.3869893
    lndistcj |  -.9495895   .3062329    -3.10   0.021    -1.698914   -.2002646
     dcostcj |   .2874478   .1359845     2.11   0.079    -.0452942    .6201898
   indcostcj |  -.0226683   .0048964    -4.63   0.004    -.0346492   -.0106873
        aggj |   1.293304   1.648469     0.78   0.463    -2.740356    5.326963
             |
        year |
       2007  |  -.2635438   .1197469    -2.20   0.070    -.5565539    .0294663
       2008  |   -.426934   .2578956    -1.66   0.149    -1.057982    .2041139
       2009  |   -.365184   .2538082    -1.44   0.200    -.9862303    .2558623
       2010  |  -.3743226   .2403772    -1.56   0.170    -.9625044    .2138592
       2011  |  -.6162958   .3543479    -1.74   0.133    -1.483354    .2507623
       2012  |  -.6293632   .3924335    -1.60   0.160    -1.589613    .3308869
       2013  |  -.7557875   .3885223    -1.95   0.100    -1.706467    .1948924
       2014  |  -.7501665   .3990282    -1.88   0.109    -1.726553    .2262204
             |
       _cons |  -16.11291   12.79381    -1.26   0.255    -47.41823    15.19241
------------------------------------------------------------------------------
```

Appendix C.1: Fixed-effect Regression for All Industry Group

```
xtreg lnexport lngdpc lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year,
fe robust cluster(sector)
```

```
Fixed-effects (within) regression               Number of obs      =      4224
Group variable: idcode                          Number of groups   =       500

R-sq:  within  = 0.1075                         Obs per group: min =         5
       between = 0.0257                                        avg =       8.4
       overall = 0.0236                                        max =         9

                                                F(15,19)           =     68.36
corr(u_i, Xb)  = -0.8594                        Prob > F           =    0.0000

                                 (Std. Err. adjusted for 20 clusters in sector)
------------------------------------------------------------------------------
             |               Robust
    lnexport |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .5481795   .1142389     4.80   0.000     .3090746    .7872843
      lngdpj |  -.1561284   .3130367    -0.50   0.624    -.8113218     .499065
      lnpopc |  -2.626185   2.921309    -0.90   0.380    -8.740555    3.488185
      lnpopj |  -.8907968   .7987047    -1.12   0.279    -2.562505    .7809114
    lndistcj |          0  (omitted)
     dcostcj |  -.1318801   .0486434    -2.71   0.014    -.2336919   -.0300682
   indcostcj |  -.0073238   .0049986    -1.47   0.159    -.0177859    .0031383
        aggj |   .3516588   .8552547     0.41   0.686     -1.43841    2.141728
             |
        year |
       2007  |    .088808   .0700451     1.27   0.220    -.0577981    .2354141
       2008  |   .1709317   .0932034     1.83   0.082    -.0241452    .3660086
       2009  |   .0712857   .0968603     0.74   0.471    -.1314452    .2740167
       2010  |   .4618477   .1913507     2.41   0.026      .061346    .8623493
       2011  |   .5312454   .2122342     2.50   0.022      .087034    .9754567
       2012  |   .5084255   .2380218     2.14   0.046     .0102401    1.006611
       2013  |   .5745337   .2315694     2.48   0.023     .0898535    1.059214
       2014  |   .5373083   .2625808     2.05   0.055    -.0122797    1.086896
             |
       _cons |   70.45996   52.93795     1.33   0.199    -40.34046    181.2604
-------------+----------------------------------------------------------------
     sigma_u |  5.2260326
     sigma_e |  .68496412
         rho |  .98311138   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix C.2: Fixed-effect Regression for Dirty Industry Group

```
xtreg lnexport lngdpc lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year,
fe robust cluster(sector)
note: lndistcj omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =      2740
Group variable: idcode                          Number of groups   =       325

R-sq:  within  = 0.0763                         Obs per group: min =         5
       between = 0.0632                                        avg =       8.4
       overall = 0.0567                                        max =         9

                                                F(12,12)           =         .
corr(u_i, Xb)  = -0.6545                        Prob > F           =         .

                               (Std. Err. adjusted for 13 clusters in sector)
------------------------------------------------------------------------------
             |               Robust
    lnexport |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .5633676   .1659942     3.39   0.005     .2016972    .9250379
      lngdpj |  -.0953019   .4448317    -0.21   0.834    -1.064507    .8739031
      lnpopc |   -1.10233   3.983477    -0.28   0.787     -9.78158     7.57692
      lnpopj |  -.7697644   1.234216    -0.62   0.545     -3.45889    1.919361
    lndistcj |          0  (omitted)
     dcostcj |  -.1606029   .0658717    -2.44   0.031     -.304125   -.0170807
   indcostcj |  -.0065593   .0065624    -1.00   0.337    -.0208575    .0077388
        aggj |   1.577387   .8979007     1.76   0.104    -.3789708    3.533744
             |
        year |
       2007  |   .1157426   .0896177     1.29   0.221    -.0795176    .3110027
       2008  |   .1710339   .1158424     1.48   0.166     -.081365    .4234328
       2009  |   .0754479   .1325243     0.57   0.580    -.2132978    .3641936
       2010  |   .3930722   .2393824     1.64   0.127    -.1284972    .9146416
       2011  |   .4699948   .2679814     1.75   0.105    -.1138865    1.053876
       2012  |   .3681658   .3034242     1.21   0.248    -.2929388     1.02927
       2013  |   .4414274   .2779113     1.59   0.138    -.1640892    1.046944
       2014  |   .3609466   .3347515     1.08   0.302    -.3684144    1.090307
             |
       _cons |    37.3443   65.84017     0.57   0.581    -106.1091    180.7977
-------------+----------------------------------------------------------------
     sigma_u |   3.432404
     sigma_e |  .74407876
         rho |  .95511545   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix C.3: Fixed-effect Regression for Clean Industry Group

```
xtreg lnexport lngdpc lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year,
fe robust cluster(sector)
note: lndistcj omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =      1484
Group variable: idcode                          Number of groups   =       175

R-sq:  within  = 0.2733                         Obs per group: min =         7
       between = 0.0059                                        avg =       8.5
       overall = 0.0054                                        max =         9

                                                F(6,6)             =         .
corr(u_i, Xb)  = -0.9660                        Prob > F           =         .

                                 (Std. Err. adjusted for 7 clusters in sector)
------------------------------------------------------------------------------
             |               Robust
    lnexport |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .5152916    .130039     3.96   0.007     .1970978    .8334855
      lngdpj |   -.262675   .3365858    -0.78   0.465    -1.086271    .5609206
      lnpopc |  -5.537886   4.088992    -1.35   0.224    -15.54329    4.467517
      lnpopj |  -1.598746   .7160204    -2.23   0.067    -3.350784    .1532933
    lndistcj |          0  (omitted)
     dcostcj |  -.0701689   .0671697    -1.04   0.336    -.2345272    .0941893
   indcostcj |  -.0058941   .0032534    -1.81   0.120     -.013855    .0020668
        aggj |  -1.990566   1.324806    -1.50   0.184     -5.23225    1.251117
             |
        year |
       2007  |   .0203508   .1297873     0.16   0.881    -.2972271    .3379288
       2008  |    .153204     .16712     0.92   0.395     -.255724     .562132
       2009  |   .0265676   .1484686     0.18   0.864     -.336722    .3898571
       2010  |    .570884   .3480553     1.64   0.152    -.2807768    1.422545
       2011  |   .6299041   .3717987     1.69   0.141    -.2798545    1.539663
       2012  |   .7409807   .4004988     1.85   0.114    -.2390045    1.720966
       2013  |   .7898606   .4346707     1.82   0.119    -.2737403    1.853462
       2014  |   .8187815    .438585     1.87   0.111    -.2543974     1.89196
             |
       _cons |   142.1333   90.44983     1.57   0.167    -79.18948     363.456
-------------+----------------------------------------------------------------
     sigma_u |  9.9084778
     sigma_e |  .53587995
         rho |  .99708356   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix D.1: Random-effect Regression for All Industry Group

```
xtreg lnexport lngdpc lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year,
re robust cluster(sector)
Random-effects GLS regression                   Number of obs      =      4224
Group variable: idcode                          Number of groups   =       500

R-sq:  within  = 0.1044                         Obs per group: min =         5
       between = 0.0447                                        avg =       8.4
       overall = 0.0512                                        max =         9

                                                Wald chi2(16)      =    873.53
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

                                 (Std. Err. adjusted for 20 clusters in sector)
------------------------------------------------------------------------------
             |               Robust
    lnexport |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .5055111   .0983058     5.14   0.000     .3128351     .698187
      lngdpj |   .2883148   .2221815     1.30   0.194    -.1471529    .7237825
      lnpopc |  -.0818989    .103483    -0.79   0.429    -.2847219     .120924
      lnpopj |  -.1527615   .1014449    -1.51   0.132    -.3515899    .0460668
    lndistcj |  -.2865188   .2070878    -1.38   0.166    -.6924034    .1193658
     dcostcj |  -.1119377   .0346031    -3.23   0.001    -.1797586   -.0441168
   indcostcj |  -.0070242   .0050577    -1.39   0.165     -.016937    .0028887
        aggj |   .1181008   .8444945     0.14   0.889    -1.537078     1.77328
             |
        year |
       2007  |  -.0252169   .0560671    -0.45   0.653    -.1351064    .0846726
       2008  |  -.0321981   .0756931    -0.43   0.671    -.1805537    .1161576
       2009  |  -.1478693   .0747831    -1.98   0.048    -.2944415    -.001297
       2010  |   .1254886   .1355061     0.93   0.354    -.1400986    .3910757
       2011  |   .1162871   .1483258     0.78   0.433    -.1744261    .4070003
       2012  |   .0413477   .1677014     0.25   0.805    -.2873411    .3700365
       2013  |    .065124   .1556014     0.42   0.676     -.239849    .3700971
       2014  |   .0003072   .1833427     0.00   0.999    -.3590379    .3596524
             |
       _cons |    2.37879   5.839793     0.41   0.684    -9.066995    13.82457
-------------+----------------------------------------------------------------
     sigma_u |  2.4416667
     sigma_e |  .68496412
         rho |  .92704365   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix D.2: Random-effect Regression for Dirty Industry Group

```
xtreg lnexport lngdpc lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year,
re robust cluster(sector)
Random-effects GLS regression                   Number of obs      =      2740
Group variable: idcode                          Number of groups   =       325

R-sq:  within  = 0.0688                         Obs per group: min =         5
       between = 0.0570                                        avg =       8.4
       overall = 0.0619                                        max =         9

                                                Wald chi2(12)      =         .
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =         .

                                 (Std. Err. adjusted for 13 clusters in sector)
------------------------------------------------------------------------------
             |               Robust
    lnexport |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .4988437   .1393118     3.58   0.000     .2257975    .7718898
      lngdpj |   .6287394   .2832385     2.22   0.026     .0736021    1.183877
      lnpopc |  -.0212868   .1307709    -0.16   0.871     -.277593    .2350194
      lnpopj |   .0410942   .0967735     0.42   0.671    -.1485783    .2307667
    lndistcj |  -.4650222    .294645    -1.58   0.115    -1.042516    .1124715
     dcostcj |    -.12135   .0437257    -2.78   0.006    -.2070508   -.0356493
   indcostcj |  -.0052755   .0069473    -0.76   0.448    -.0188919    .0083409
        aggj |   .5447415   1.005912     0.54   0.588     -1.42681    2.516293
             |
        year |
       2007  |  -.0545539   .0746597    -0.73   0.465    -.2008843    .0917765
       2008  |   -.126603    .104235    -1.21   0.225    -.3308998    .0776938
       2009  |  -.2446283   .1024312    -2.39   0.017    -.4453898   -.0438669
       2010  |  -.0944527   .1759006    -0.54   0.591    -.4392116    .2503062
       2011  |   -.123762   .2006586    -0.62   0.537    -.5170456    .2695215
       2012  |  -.2912535   .2214002    -1.32   0.188    -.7251899    .1426829
       2013  |  -.2722619   .2002512    -1.36   0.174     -.664747    .1202231
       2014  |  -.3864123   .2430352    -1.59   0.112    -.8627526     .089928
             |
       _cons |  -9.807786   6.930217    -1.42   0.157    -23.39076     3.77519
-------------+----------------------------------------------------------------
     sigma_u |  2.1863679
     sigma_e |  .74407876
         rho |  .89620023   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix D.3: Random-effect Regression for Clean Industry Group

```
xtreg lnexport lngdpc lngdpj lnpopc lnpopj lndistcj dcostcj indcostcj aggj i.year,
re robust cluster(sector)
Random-effects GLS regression                   Number of obs      =      1484
Group variable: idcode                          Number of groups   =       175

R-sq:  within  = 0.2660                         Obs per group: min =         7
       between = 0.1248                                        avg =       8.5
       overall = 0.1391                                        max =         9

                                                Wald chi2(6)       =         .
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =         .

                               (Std. Err. adjusted for 7 clusters in sector)
------------------------------------------------------------------------------
             |               Robust
    lnexport |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lngdpc |   .4856645   .1104189     4.40   0.000     .2692475    .7020815
      lngdpj |  -.0951378   .2275898    -0.42   0.676    -.5412056      .35093
      lnpopc |  -.1715987   .1704423    -1.01   0.314    -.5056596    .1624621
      lnpopj |  -.5368785   .1271216    -4.22   0.000    -.7860323   -.2877248
    lndistcj |   .0601661   .1428409     0.42   0.674     -.219797    .3401291
     dcostcj |  -.0746687   .0571077    -1.31   0.191    -.1865977    .0372604
   indcostcj |  -.0073423   .0037829    -1.94   0.052    -.0147567    .0000721
        aggj |  -1.432611   1.195485    -1.20   0.231    -3.775718    .9104966
             |
        year |
       2007  |  -.0444443   .0986907    -0.45   0.652    -.2378746     .148986
       2008  |    .025576   .1092779     0.23   0.815    -.1886047    .2397567
       2009  |   -.115741   .0900214    -1.29   0.199    -.2921797    .0606977
       2010  |   .3465222   .1926101     1.80   0.072    -.0309866    .7240311
       2011  |   .3442327   .1818428     1.89   0.058    -.0121726    .7006381
       2012  |   .4100332   .1819172     2.25   0.024     .0534821    .7665842
       2013  |   .4217817   .1914181     2.20   0.028     .0466091    .7969543
       2014  |   .4242052   .1983874     2.14   0.032     .0353731    .8130373
             |
       _cons |   19.64442   6.483243     3.03   0.002     6.937492    32.35134
-------------+----------------------------------------------------------------
     sigma_u |  2.3372489
     sigma_e |  .53587995
         rho |  .95005699   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```