Dirty Industry and Institutional Quality on Pollution: Evidence in Developing Countries

Ana Shohibul Manshur Al Ahmad
Economics Department Faculty of Economics & Business, Universitas Sebelas Maret, Indonesia
Tel. 62 81226007676 E-mail: shohibulana@staff.uns.ac.id

Agustinus Suryantoro
Economics Department Faculty of Economics & Business, Universitas Sebelas Maret, Indonesia
Tel. 62 85867812775 E-mail: agustinus_s59@staff.uns.ac.id

Sarjiyanto
Economics Department Faculty of Economics & Business, Universitas Sebelas Maret, Indonesia
Tel. 62 81393124000 E-mail: masyanto3105@gmail.com

Sarwoto
Management Department Faculty of Economics & Business, Universitas Sebelas Maret, Indonesia
Tel. 62 81329233581 E-mail: sarwoto220784@gmail.com

Abstract

Environmental standards and trade are double-edged knives and have mutually exclusive relationships. Economic openness and increased regulation of environmental awareness post-1960s created disputes and debates among stakeholders. The loose policy of dirty products in emerging countries brings a tendency to be a transitional place for developed countries. Therefore, environmental degradation is relatively preponderant in emerging countries. The purpose of this study is to analyze the patterns and effects of dirty and clean industry trade, institutional quality, and environmental policies on environmental pollution (pollution heaven) in developing countries. We use data sourced from the United Nations Commodity Trade Statistics Database (UN-COMTRADE), Wordbank, The United Nations Conference on Trade and Development (UNCTAD, and Global Carbon, in 2002-2018, namely Argentina, Armenia, Belarus, Bolivia, Brazil, Bulgaria, Cambodia, Chile, China, Colombia, Costa Rica, Ecuador, El Salvador, Ghana, Guatemala, India, Indonesia, Jordan, Kazakhstan, Korea, Lebanon, Malaysia, Mexico, Morocco, Pakistan, Paraguay, Peru, Philippines, Romania, Russian Federation, South Africa, Thailand, Tunisia, Turkey, Ukraine, and Vietnam. This study found different and partial evidence in the diversion of the pollution heaven, strong relationships in the wave of dirty product trade, and inconsistent and unequal comparative advantages in developing countries. Institution quality and environmental policy have a role in creating a clean environment. This study implies that strong environmental policies in developing countries, especially dirty industries, are needed.

Keywords: Dirty Product, Environmental Standards and Trade Pattern
JEL Classification: F13, F17, F18, F19, Q56

1. Introduction

International trades and environmental standard are double-edged knives in which one side is a mutually exclusive relationship and another side is a zero-one game or trade-off. Economic opened and the increase in the policies on environmental standard after the 1960s has created disputes and debates among policymakers and stakeholder, as well as creating heat instead of light. A relatively loose policy on environmental standard in developing countries tends to set the country into transit for the developed countries. Therefore, environmental degradation is relatively higher in developing countries, which makes these countries into a pollution haven. On the other hand, environmental policy affects the demand for factors of production, productions, and prices. A strict standard environmental regulation will not always reduce pollution substitute. On the contrary, pollution restriction will affect the output subsidy on the price of production factors/analogous effects in pollution restriction. Even though tightening regulation on environment/pollution in the developed countries has caused industries to leave these countries (industrial-flight).

A study on international trade and its environmental impact cause a discord. Developing countries with low income tend to be dirtier due to the international trades/pollution haven (Antweiler et al., 2001). The cascading pattern of trades between Japan, NIEs and ASEAN in which Japan exports for environmental factor services to NIEs and ASEAN has decreased significantly since the 1980s (Xu & Song, 2000); the increase in export increases the dirtiness of industries (Akbostancı et al., 2004); liberalization and increased international trade will damage the environment (Fujita et al., 1999) and (Rosenthal & Strange, 2001); the increase in production and international trade leads to the scaling up in pollution (Straumann, 2003); (Grether & Melo, 2002); (Copeland & Taylor, 2004) and (Sen, 2013). Inflow FDI to the developing countries has a positive contribution to the level of environmental pollution (Aliyu, 2005). However, developing countries need to attract FDI inflows because it has a positive effect on economic growth and environmental damage can be reduced through strong environmental policies and environmental tax. Trading agreement causes changes in the industrial structures and brings negative consequences on the environment, trades of dirty goods due to environmental regulation, capital abundance, the intensity of factors of production, the quality of governance, corruption and other determining factors (Taylor, 2005)

Several researchers argue that pollution haven in the developing countries will be self-limiting and heal on its own due to the balancing effect in the form of economic growth, improved regulation, technical expertise and investment in cleaner production sectors (Mani & Wheeler, 1997); the increase in international trades do not affect environmental pollution, environmental damage is caused by global pollution (Aktaş, 2015); environmental damage and pollution should be handled without using trade and globalization measures (Nordstrøm & Vaughan, 1999); economic development (trade) will lead to efficient use of resources and technology distribution (Tisdell, 2001), and other factors that can reduce the pressure/damage on the environment. Export does not have a negative correlation with the policy on environmental standards (Wilson et al., 2002). Pollution havens is a partial phenomenon with a limited number of cases, besides the trend of pollution havens is not significant (Indriya & Widodo, 2011). Environmental standard and export have a negative relationship and promote the improvement of environmental standard (Wilson et al., 2002).

Referring to the pollution haven hypothesis (PHH), the focus of this study is to examine and provide evidence on how international trades, both export and import, for dirty products, foreign direct investment (FDI), and the structure of institutional quality affect environmental pollution in the developing countries. Developing countries tend to become the pollution haven especially for dirty industries [(Cai et al., 2018); (Akbostanci et al.,, 2004); and (Speth, 1988)]. This is the result dirty industries relocation from the developed countries [(Dou & Han, 2019) and (Shen et al., 2019)] which usually have stronger policies/environmental standard compared to the developing countries [(Gill et al., 2018); (Solarin et al., 2017); (Zeng & Zhao, 2009); (Wilson, Otsuki, & Sewadeh, 2002); and (Neumayer, 2001)]. Besides that, intra-industry trade pattern among the developing countries have a potential of pollution transfer (PHH) through trades scheme, but this does not apply for developed countries [(Cai et al., 2018) and (Sen, 2013)].

Besides act as a driver of economic development, FDI in the developing countries also acts as the transmission of pollution/environmental pollution [(Hanif et al., 2019); (Sarkodie & Strezov, 2019); (Sapkota & Bastola, 2017), (Mutafoglu, 2014), and (Aliyu, 2005)], even though several studies refute this finding [(Fereidouni, 2013), (Shao, 2018), (Albulescu et al., 2019); and (Rafindadi et al., 2018)]. The decrease in the specialization of polluting products as the result of high costs of environmental control becomes a reason for the developing countries to loosen their environmental policies. This becomes a magnet for industrial countries (pollution industries) to invest their funds, both in term of FDI and relocation of industry to countries that have a negligent environmental policy (Chung, 2014) and (Dou & Han, 2019). While gross FDI has a very low contribution to the pollution in countries with strong environmental policies (Smarzynska & Wei, 2001).

Environmental policies depend on the quality of the institution/government as stakeholders. Institutional quality has a role in creating clean or dirty's FDI through a set of strong or weak environmental policies (Cole & Fredriksson, 2009) and (Dam & Scholtens, 2012). The low level of "aggregate honesty" in the parliament will stabilize the pollution haven as an institution because of FDI, thus, will result in loose environmental policies which contribute to environmental pollution (Cole et al., 2006). Corruption, as an indicator of low institutional quality, in the financial development contributes to the decline of environmental standard (Yahaya et al., 2020) and directly increase CO2 emission through the economic growth channel and opposite for an indirect effect (Sekrafi & Sghaier, 2018), the implementation of strict corruption control for resource allocation is needed to achieve a clean and healthy environment.

In this paper, Part 2 describes the research method that consists of framework, data and model analysis; Part 3 analyzes the findings and discussion. While Part 4 explains the summary, conclusions, implications, and limitations for future studies.

2. Research Method

2.1 Analytical framework

The framework of this study refers to Figure 1 on the pattern of relationship between CO2 emission and explanatory variables namely dirty product trade, foreign direct investment (FDI), and institutional quality according to the previous review. The model emphasizes the linkage between CO2 emission, export and import of dirty products, FDI, and good institutional quality as the explanatory variables or control variable. Institutional quality is a reflection from the quality of policies, so that institutional quality can have a direct and indirect effect or as control of other explanatory variables, export, import, and FDI. Export and import activities are highly determined by government policies, whether certain products are prohibited, controlled, restricted, and freely traded so that they will affect industry performance.

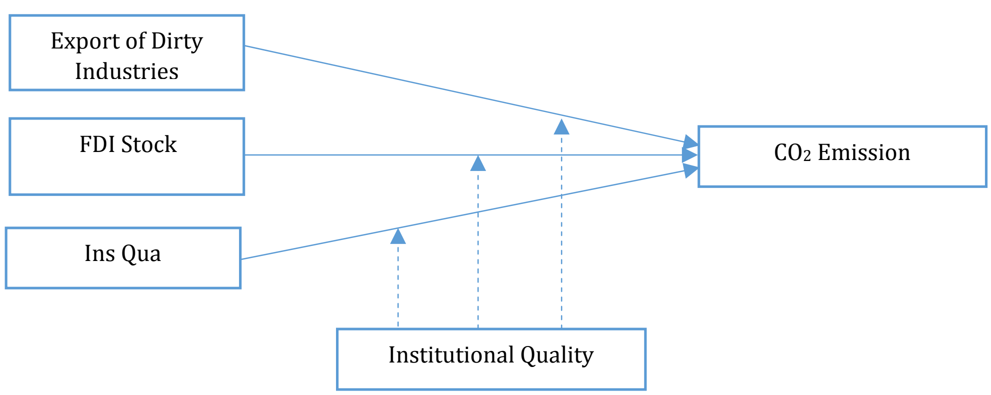

Figure 1 Framework for the Relationship between Dirty Industries, FDI and CO_2 Emission

The trade of dirty product, both export and import, is one of the causes of air pollution, the increase of CO2 emission, therefore, this is included as explanatory variables. In the production function, both primary and intermediate inputs are fulfilled from imports. Imports become one of the components that create air pollution. Figure 2 presents the use of various inputs in the production process (Hertel & Tsigas, 1997).

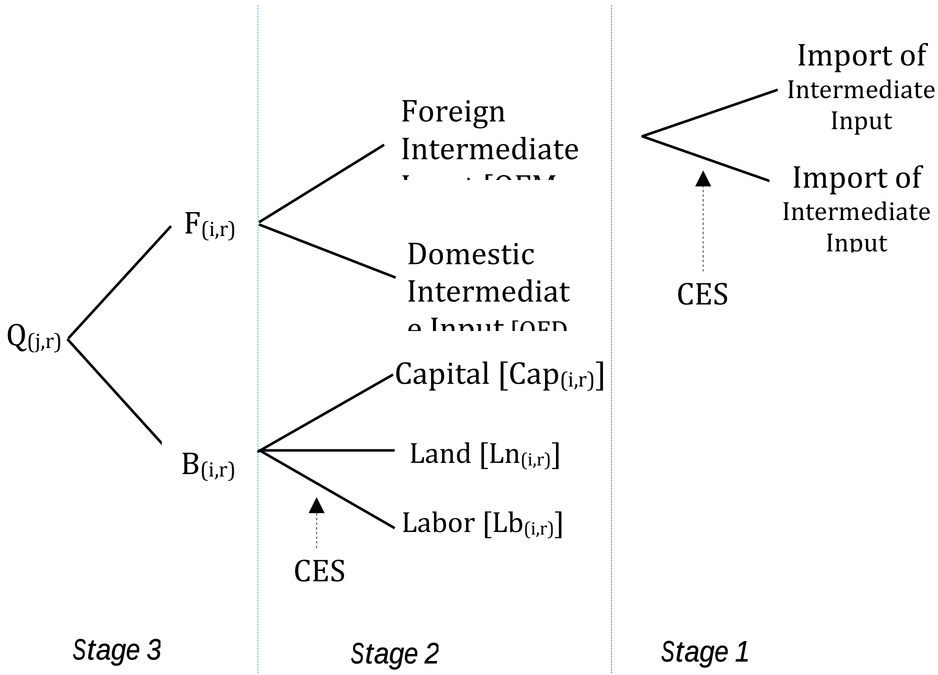

Figure 2 Industrial Behavior Diagram

The relationship between various inputs in producing top-level nest is determined by the added values of primary input [B(j,r)] and intermediary input [F(j,r)].

$$B_{ir} = f_{ir}(Lb_{ir}, Ln_{ir}, Cap_{ir};\ \vartheta_{ir}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$F_{ir} = g_{ir}(F^{f}_{1r}, F^{f}_{2r}, \ldots., F^{f}_{ir};\ \theta_{ir}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The level of demand for primary input from each sector,

$$Lb^{*}_{ir} = f^{-1}_{ir.Lb}\left({P^{Lb}_{ir}}/{P^{Ln}_{ir}}, {P^{Ln}_{ir}}/{P^{Cap}_{ir}}, {P^{Cap}_{ir}}/{P^{Lb}_{ir}}; \vartheta_{ir}, \bar{B}_{ir} \right) \ldots\ldots\ldots\ldots\ldots (3)$$

$$Ln^{*}_{ir} = f^{-1}_{ir.Ln}\left({P^{Lb}_{ir}}/{P^{Ln}_{ir}}, {P^{Ln}_{ir}}/{P^{Cap}_{ir}}, {P^{Cap}_{ir}}/{P^{Lb}_{ir}}; \vartheta_{ir}, \bar{B}_{ir} \right) \ldots\ldots\ldots\ldots\ldots (4)$$

$$Cap^{*}_{ir} = f^{-1}_{ir.Cap}\left({P^{Lb}_{ir}}/{P^{Ln}_{ir}}, {P^{Ln}_{ir}}/{P^{Cap}_{ir}}, {P^{Cap}_{ir}}/{P^{Lb}_{ir}}; \vartheta_{ir}, \bar{B}_{ir} \right) \ldots\ldots\ldots\ldots (5)$$

The function of demand for intermediary input from each sector,

$$F^{f*}_{1r} = g^{-1}_{ir.1}\left({P^{Ff}_{1r}}/{P^{Ff}_{2r}}, {P^{Ff}_{2r}}/{P^{Ff}_{3r}}, \ldots., {P^{Ff}_{is}}/{P^{Ff}_{i1}}; \theta_{ir}, \bar{F}_{ir} \right) \ldots\ldots\ldots\ldots\ldots (6)$$

$$F^{f*}_{2r} = g^{-1}_{ir.2}\left({P^{Ff}_{1r}}/{P^{Ff}_{2r}}, {P^{Ff}_{2r}}/{P^{Ff}_{3r}}, \ldots., {P^{Ff}_{is}}/{P^{Ff}_{i2}}; \theta_{ir}, \bar{F}_{ir} \right) \ldots\ldots\ldots\ldots\ldots (7)$$

$$F_{ir}^{f^*} = g_{ir.n}^{-1}\left(P_{1r}^{F^f} / P_{2r}^{F^f}, P_{2r}^{F^f} / P_{3r}^{F^f}, \dots, P_{is}^{F^f} / P_{is}^{F^f}; \theta_{ir}, \bar{F}_{ir} \right) \dots\dots\dots\dots\dots (8)$$

Therefore, the function of demand for each input is as follows:

$$B_{ir}^{*} = h_{ir}^{-1}\left(P_{ir}^{B} / P_{ir}^{F}, P_{ir}^{F} / P_{ir}^{B}; \alpha_{ir}, \bar{Q}_{ir} \right) \dots\dots\dots\dots\dots\dots\dots\dots\dots (9)$$

$$F_{ir}^{*} = h_{ir}^{-1}\left(P_{ir}^{F} / P_{ir}^{B}, P_{ir}^{B} / P_{ir}^{F}; \alpha_{ir}, \bar{Q}_{ir} \right) \dots\dots\dots\dots\dots\dots\dots\dots\dots (10)$$

To determine the added value from each sector on pollution, in this study the difference between export and import through the transmission of production output becomes a variable that determines CO2 emission. To avoid bias and double counting of the added value of production in each sector, net export is the most precise and valid variable in explaining the dependent variable, even though domestic consumption also contributes in CO_2 emission. This aims to reflect the real effect of each sector and trade pattern in the formation of CO_2 emission.

2.2 Empirical model

The specific empirical model in this study is as follows:

$$CO_2Emission_{it} = \alpha_{0i} + \alpha_1 FDI_{it} + \alpha_2 XMM_{it} + \alpha_3 XPNM_{it} + \alpha_4 XPP_{it} + \alpha_5 XPIS_{it} + \alpha_6 XCHM_{it} + \alpha_7 XCMT_{it} + \partial InsQu$$

In equation (11), CO_2 emission is the dependent variable measured based on location, 36 developing countries, namely Argentina, Armenia, Belarus, Bolivia, Brazil, Bulgaria, Cambodia, Chile, China, Colombia, Costa Rica, Ecuador, El Salvador, Ghana, Guatemala, India, Indonesia, Jordan, Kazakhstan, Korea, Lebanon, Malaysia, Mexico, Morocco, Pakistan, Paraguay, Peru, Philippines, Romania, Russian Federation, South Africa, Thailand, Tunisia, Turkey, Ukraine, and Vietnam. The explanatory variable, foreign direct investment (FDI) stock, export metal mining (XMM), primary non-ferrous metal (XPNM), pulp and paper (XPP), primary iron and steel (XPIS), chemical (XCHM), cement industry (XCMT), and institutional quality (InsQua). Institutional quality is proxied using 3 explanatory variables, or $InsQua = f(CC, RL, RQ)$. Based on the formula above, the specific model can be re-written as:

$$CO_2Emission_{it} = \alpha_{0i} + \alpha_1 FDI_{it} + \alpha_2 XMM_{it} + \alpha_3 XPNM_{it} + \alpha_4 XPP_{it} + \alpha_5 XPIS_{it} + \alpha_6 XCHM_{it} + \alpha_7 XCMT_{it} + \alpha_8 CC_{it} +$$

To measure the simultaneous effect of institutional quality on FDI and trades of dirty product, this study included institutional quality as a control variable for all explanatory variables, (CC, RL, and RQ) on FDI, and (CC, RL, and RQ) à all variables of dirty product export. The estimation of this formula is conducted on annual data from 36 developing countries from 2002-2018. Table 1 summarizes the summary statistic of data (mean, median, max, min, and standard deviation).

Table 1 Statistic Summary

	Unit	Mean	Median	Maximum	Minimum	Std. Dev.
CO2 Emission	Metric ton (MtCO2)	445.4628	77.4809	10064.69	2.2057	1362.63
FDI stock	US dollar at current prices (million)	102703.3	42996.43	1628261	684.466	174137
Chemical (XCHM)	US dollar at current prices	-1.74E+09	-6.12E+08	2.93E+10	-9.07E+10	9.23E+09
Cement industry (XCMT)	US dollar at current prices	2.08E+08	2434936	8.54E+09	-1.05E+09	9.42E+08
Metal mining (XMM)	US dollar at current prices	-1.68E+09	1064431	4.19E+10	-1.50E+11	1.31E+10
Primary iron and steel (XPIS)	US dollar at current prices	1.19E+09	-3.89E+08	7.01E+10	-1.72E+10	7.50E+09
Primary nonferous metal (XPNM)	US dollar at current prices	1.27E+08	-1.42E+08	2.32E+10	-3.34E+10	5.36E+09
Pulp and paper (XPP)	US dollar at current prices	-4.62E+08	-3.31E+08	1.03E+10	-2.09E+10	1.97E+09
Control corruption (CC)	Index (-2,5 - 2,5)	-0.360585	-0.399065	1.275488	-1.394238	0.506274
Rule of law (RL)	Index (-2,5 - 2,5)	-0.385947	-0.464982	1.23655	-1.335948	0.502056
Regulatory quality (RQ)	Index (-2,5 - 2,5)	-0.051661	-0.082615	1.43314	-1.622619	0.541984

2.3 Description of Variables

2.3.1 Pollution

CO_2 emission is a form of pollution emission used in this study, expressed in a metric ton ($MtCO_2$). The study on CO_2 emission as an indicator of pollution emission has been widely conducted (Speth, 1988); (Mani & Wheeler, 1997); (Wilson et al., 2002) and (Sarkodie & Strezov, 2019). Besides that, the measurement of pollution impact through CO_2 emission is more reliable than other emissions. CO_2 emission used in the study is the aggregate data from the developing countries obtained from (globalcarbonatlas, 2020); (Gilfillan et al., 2019); (UNFCCC, 2019); and (BP, 2019)

2.3.2 FDI

To explain the effect of FDI on the formation of CO_2 emission through industrial activities in the long-term, FDI stock is a more appropriate variable to be studied. In this study, FDI flow is transformed into FDI stock (Lan et al., 2012) and (Sapkota & Bastola, 2017):

$$\mathbf{FDI_{i,t+1} = (1-\vartheta)FDI_{it} + I^F_{i,t+1}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \mathbf{13}$$

FDI_i is FDI stock, ϑ is the average annual depreciation level, and I^F is FDI inflow in each country. The lag on FDI inflow of the current year (t) creates bias of FDI impact on the industry and CO_2 emission, thus I^F cannot reflect the real impact on emission formation.

PHH through FDI channel is quite possible to be implemented, both actively or reactively. The increase in FDI will bring a positive effect on the level of pollution, especially for pollution-dense industries. However, FDI flow also can reduce the level of pollution through the adoption of environmentally friendly technology, efficient energy consumption, and cleaner industry. The data was obtained from The United Nations Conference on Trade and Development (UNCTAD).

2.3.3 Trade of dirty industries

Dirty industries are pollution-dense industries that have the highest reduction cost that must be incurred for each unit of output (Tobey, 1990), (Mani M. , 1996), and (Mani & Wheeler, 1997). Based on these criteria, five groups of the industry as the leading dirty industry includes metal mining, primary non-ferrous metal, pulp and paper, primary iron and steel, and chemical. Besides these five pollutant-dense industries, this study added cement industry as one of the industries that have a significant effect on the formation of CO_2 emission (McKinsey&Company, 2009).

Referring to Kanemoto et al. (2012) and Kanemoto et al. (2014) to decompose production-based emissions into consumption-based emissions and the composition of emissions in export and import:

$$\mathbf{B^s_j \sum_r b^r_i \left\| \sum_{it} L^{rt}_{ij}\, y^{ts}_j - \sum_{it\neq s} L^{ts}_{ij} y^{ts}_j + \sum_{it\neq s} L^{rs}_{ij} y^{ts}_j \right\|} \dots\dots\dots\dots \mathbf{(14)}$$

Based on formula (14), the function of aggregate production is Qs = f(C-M+X), production is affected by the level of consumption, export, substracted by import. In which B is the emission in each country, b is emission

ISBN xxxx-xxxx

intensity, *r* is emission autarchy, *t* and *s* are the import supplier and destination, and reverse in exports, *y* is final demand, and *i* and *j* are industrial sectors.

The trade data used in this study are the net exports for dirty product category based on the Standard International Trade Classification (SITC Rev. 2) 3-digit published by the United Nation Comtrade (UN Comtrade) database in 2002-2018. Product composition for each category refers to the previous description (Tobey, 1990) and (Mani & Wheeler, 1997).

2.3.4 Institutional Quality

Institutional quality has an important role in producing environmental policies, both through FDI channel and export. The strength of environmental policies is affected by the rule of law, regulatory quality, government effectiveness and corruption (Sekrafi & Sghaier, 2018) and (Yahaya et al., 2020), in which the four predictor variables were extracted from World Bank. The rule of law (RL) reflects the quality of law enforcement for the perpetrator, regulatory quality (RQ) reflects government's ability in formulating and implementing regulation as well as encouraging the private sector, while corruption (CC) captures the perception on how the government/public officials use their position for personal gain and all other forms of corruption.

The institutional quality variable is the result of a World Bank survey in 2002-2018 provided in the form of an index. An institutional quality index (RL, RQ, and CC) are standardized and continuous quantitative measures, as a centralized and reduced variable (Sekrafi & Sghaier, 2018), which have a variation between –2.5 (as a form of government failure) and 2.5 (corruption level is very low, while rule of law, regulatory quality, and government effectiveness is very strong).

3. Result and Discussion

Table 2 summarizes the result of estimation for the three models on panel data using Least Squares Dummy Variable (LSDV) approach. The result of Hausman test between fixed-effect model versus random effect model shows that the p-value is lower than 0.05, thus, rejecting H_0, and suggesting that fixed effect model is more consistent and efficient compared to the random effect. Therefore, the model is selected as an appropriate estimator of the final model for further inferences.

The Adjusted R-squared for model 1, 2, and 3 are 0.98, 0.98, and 0.99 respectively, weighted and unweighted statistics. This indicates that almost all of the variance on CO_2 pollution level can be explained by the explanatory variables in the model. Besides, the control variable strengthens the overall model, which is reflected from the R-square (R^2) score in the third model compared to the other models. The F-statistic is < 0.05 (0.00) for all models (model 1, 2nd, and 3rd) and accepting "$H_{alternative}$" (H_1), thus, simultaneously the explanatory variables (FDI, the export of dirty goods, and institutional quality) have a significant effect in the formation of CO_2 emission.

FDI stock has a positive coefficient with t-test under 1 per cent, which means that FDI has a positive and significant effect on the increase of CO_2 pollution. This variable has a high consistency (= 0.00) for all models. This means FDI has a strong effect in the formation of CO_2 emission in all developing countries with and without the presence of institutional quality as explanatory and control variable. This finding contrasting the argument from Aliyu (2005), Shao (2018), and Rafindadi et al. (2018), but in line with Sarkodie & Strezov (2019) who state that FDI inflow increases CO_2 emission in the top five emitters of carbon through fuel burning in developing countries, and Sapkota & Bastola (2017) who find that for each one per cent increase of FDI will contribute to the 0.036 per cent increase of CO_2 pollution in Latin America. For each 1 million USD increase of FDI will result in 0.00036 metric ton ($MtCO_2$) of CO_2 pollution. The consistency and positive significant of FDI show that this finding supports the pollution haven hypothesis (PHH).

The trade of dirty industry (cement, primary iron and steel, and pulp and paper) has a positive and significant coefficient (= 0.00) on CO_2 pollution. Contrasting the finding from Tobey (1990), Lopez et al. (2018) and Shao (2018), this paper argues that the export of dirty product for the three industry categories become the cause of air pollution. Cement industry has the largest contribution on the formation of CO_2 emission compared to the other industries. This is in line with the report from McKinsey&Company (2009) that cement industry contributes up to 1.6 $GtCO_2$ (2005) and is estimated to reach 3.9 $GtCO_2$ in 2030 globally, while the primary iron and steel industries will grow faster and reach 4.7 $GtCO_2$ in the same year and baseline. The export of pulp and paper become one of contributors in CO_2 emission with 2.34 per cent and metal/steel pro-

Table 2 Fixed Effect Model in the Formation of CO_2 Emissions

	Model 1	Model 2	Model 3
FDI_S	0.000674 (19.594)***	0.000714 (19.571)***	0.000992 (16.715)***
XCHM	-4.66E-09 (-4.143)***	-4.72E-09 (-4.136)***	-5.65E-09 (-3.131)**
XCMT	1.18E-07 (9.518)***	1.36E-07 (9.808)***	1.42E-07 (6.274)***
XMM	-1.75E-08 (-14.984)***	-1.71E-08 (-14.814)***	-1.55E-08 (-9.694)***
XPIS	4.43E-09 (4.615)***	4.20E-09 (4.374)***	4.01E-09 (2.630)**
XPNM	-2.66E-09 (-1.716)*	-2.72E-09 (-1.759)*	-2.96E-09 (-1.373)
XPP	5.58E-09 (2.768)**	7.10E-09 (2.999)***	1.95E-08 (5.382)***
CC		9.876978 (2.169)**	6.909686 (2.029)**
RL		-22.4525 (-3.709)***	-32.2058 (-3.850)***
RQ		7.177255 (1.436)	13.35218 (1.856)*
(FDIxCC)			0.00024 (2.341)**
(FDIxRL)			-0.00085 (-7.772)***
(FDIxRQ)			0.000329 (3.334)***
(XCHMxCC)			-1.87E-08 (-4.014)***
(XCHMxRL)			1.20E-08 (2.554)**
(XCHMxRQ)			1.48E-08 (3.682)***
(XCMTxCC)			7.83E-08 (1.723)*
(XCMTxRL)			9.09E-08 (2.198)**
(XCMTxRQ)			-9.84E-08 (-2.386)**
(XMMxCC)			9.17E-09 (1.686)*
(XMMxRL)			1.21E-08 (1.956)*
(XMMxRQ)			6.10E-09 (1.038)
(XPISxCC)			-3.39E-09 (-1.515)
(XPISxRL)			-2.83E-09 (-1.545)
(XPISxRQ)			1.79E-10 (0.068)
(XPNMxCC)			-3.95E-09 (-1.165)
(XPNMxRL)			1.40E-09 (0.368)
(XPNMxRQ)			5.25E-09 (1.674)*
(XPPxCC)			4.43E-08 (3.631)***
(XPPxRL)			-6.81E-09 (-0.676)
(XPPxRQ)			-8.05E-08 (-6.503)***

Note: ***, **, and * indicate significance level below 1%, 5%, and 10% respectively.

duct with 2.06 per cent (Straumann, 2003). These industries (including cement) are industry-based abundance factor and primary industry in the developing countries so that the government tends to push the industry to maintain the specialization advantage and to support the economic growth. This condition brings a consequence of downplaying the input-output calculation in this industry so that the larger impact in the form of increased pollution and environmental damages tend to be ignored. Based on the perspective of the three industries, this result strongly supports the pollution haven hypothesis that the developing countries are the victims of the transfer of pollution-dense industries from the developed countries.

In contrast to the Straumann (2003), this study finds that metal mining and chemical industry can reduce CO_2 pollution. In average this product has negative coefficient/net importer, which shows that a greater production decomposition is allocated for consumption, therefore, the developing countries may have a higher consumption level than its production level. With the high standard for chemical in the developed countries and industrial shifting (flight industry) from the developed countries to the developing countries, it is estimated that the global production and consumption will reach 31 and 33 per cent in 2020. This requires developing countries to produce environmentally friendly and energy-saving high-tech products. The development of bulk organic chemical in the developing countries (> 60 per cent), the growth in the number of investors who are concerned to the environment & social governance (ESG), and the policy on sound chemical management (including active pharmaceutical ingredients/APIs) towards green economy becomes one of the backgrounds for this finding (UNEP, 2013).

Institutional quality especially corruption has a positive and significant coefficient at 95% confidence level, this shows that the perception of corruption in the developing countries contributes to the formation of CO_2 pollution (Yahaya et al., 2020). This indicates that developing countries with a higher level of corruption correlates with environmental damage, through financial development channel (state budget) and licensing and or other corruption elements. Corruption leads to inefficiency in the allocation of resources so that output and economic multiplier are not optimal (Bowles, 2000). In line with Welsch (2004) that corruption has a direct impact on pollution through income transmission. Public officials in the developing countries with relatively low income will try to increase their income through various means, through fraud, moral hazard, and corruption. High level of corruption leads to the creation of environmental policy that does not support a good environmental ecosystem (Pellegrini & Gerlagh, 2006). While the variable rule of law (RL) has a negative and significant effect (= 0.00) on the creation of pollution, both in model 1 and model 3. A series of policy and strong legal implementation in environmental problem will reduce industrial and investment impact on environmental damage. Enforcement on environment perpetrator will create a deterrent effect for the perpetrator, therefore environmental damage and pollution can be minimized. In the developing countries, enforcement to the industry that does not obey the policy of environmental standard will bring positive change on the business model that follows the environmental standard, however, this might also create new corruption during the process (Green, 1997).

This finding seems to support the hypothesis that countries with a loose environmental policy will attract pollution-dense industries from countries with strict environmental policy. Institution ability to produce, implement, and evaluate policies becomes the key factor in preventing pollution caused by industry and industry and FDI. Corruption and rule of law become evidence that strong policy will be able to control various factors that cause environmental damage and the increasing air pollution. Even though contrasting, both variables have the highest coefficient compared to the other variables. As the control variable for the FDI, cement, metal mining, and pulp and paper industries, corruption has a contribution to the formation of CO_2 emission in the developing countries. Corruption in FDI and the three industries shows unhealthy business practice that involves the stakeholders, including the policymakers. This will cause inefficiency in the allocation and utilization of resources (Bowles, 2000) thus, the output, both from industries and policies, become suboptimal and in turn leads to environmental damage and the increase in environmental pollution, especially CO_2 emission.

The power of environmental policy becomes the key factor in preventing environmental damage/the increase in CO_2 emission, especially in developing countries. This finding supports Chung (2014) who stated that weak regulation becomes the determining factor of pollution haven in the developing countries including international trade behavior. Dou & Han (2019) argue that high industrial mobility will lead more quickly to countries with laxer environmental policies and vice versa. Our finding concerning rule of law (RL) seems to contradict the pollution haven hypothesis. However, in connection to corruption, this finding will form a convergent and linear relationship on the impact of policy on the formation of CO_2 emission in the developing countries.

4. Conclusion

This paper provides a supplement and new insight into the pollution haven hypothesis by bringing up cross-regional evidence. Specifically, we examine the relationship between FDI stock, export dirty product, and institutional quality (corruption, rule of law, and regulatory quality) as explanatory and control variables and the formation of CO_2 emission in 36 low- and medium-income countries from 2002 to 2018. In general, this paper supports the pollution haven hypothesis in the developing countries, except for metal mining and primary iron and steel industry. This finding also provides evidence that (1) institutional quality, especially corruption, has a vital effect on the formation of CO_2 pollution, both as transmitter and directly. Corruption will lead to misallocation of resources and costs, both on FDI and export of dirty products so that environmental problem tends to be disregarded. (2) rule of law has a role in creating a clean environment, particularly in decreasing the CO_2 emission, but its relationship with sectoral export shows contradicting evidence. This shows that enforcement in dirty industry or those that break the environmental policies received less attention. The effective enforcement can be performed through channel FDI, in which the variable can change negative FDI effect into positive ones in reducing CO_2 pollution in the developing countries. Corruption control has a contradicting role on the formation of CO_2 emission, this means that strict action toward environmental offenders will loosen when it enters the verdict because of the higher level of corruption in that level. (3) the hypothesis which states that there is a transfer of dirty industry from countries with strong environmental policies to those with weak environmental policies is observed in this study. Place with dirty industries abundance tend to encourage FDI inflow more quickly to increase specialization advantage and economic growth than a clean environment. Strong policies on clean industry and the use of energy-friendly technology is a fixed price for developing countries to reduce their environmental pollution. The government must implement a higher tax for the dirty industry as a form of compensation for the pollution caused by the firm's production. The industry is also required to maintain environmental standard through various innovations on the process and technology that they use. Additionally, different tariff, particularly for import of dirty raw materials becomes one of the instruments to suppress the flight industry from the developed countries.

Further study on the pollution haven hypothesis in connection to FDI and the dirty industry is still needed. This study is aggregate and partially simultaneous and the sectoral impact is not well described. To examine the added value of FDI and dirty industry for each sector and its transmission on environmental pollution (CO_2) needs convergent and linear measurement model. This aims to assess the compensation that needs to be incurred by each sub-industry. Besides, the channel between institutional quality and the formation of CO_2 emission requires further identification. For example, strong environmental policy in a country with CO_2 pollution, it needs a transmission which is then differentiated and derived to measure its costs and impacts.

Bibliography

Akbostanci, E., Tunc, G. I., & Asik, S.-T. (2004). Pollution Haven Hypothesis and the Role of Dirty Industries inTurkeys Export. *ERC Working Paper in Economic 04/03*, 1-17.

Akbostancı, E., Tunç, G., & Türüt-Aşık, S. (2004). Pollution Haven Hypothesis and the Role of Dirty Industries in Turkey' Exports. *ERC Working Paper in Economic 04/03*, 1-14.

Aktaş, M. T. (2015). Did Globalization Promote Dirty Industries in Turkey? *International Journal of Business and Social Science*, *6*(5), 205-212.

Albulescu, C. T., Tiwari, A. K., Yoon, S.-M., & Kang, S. H. (2019). FDI, income, and environmental pollution in Latin America: Replication and extension using panel quantiles regression analysis. *Energy Economics*, 1-10.

Aliyu, M. A. (2005). Foreign Direct Investment and the Environment: Pollution HavenHypothesis Revisited. *Eight Annual Conference on Global Economic Analysis*, (pp. 1-35). Lübeck, Germany

Antweiler, W., Copeland, B. R., & Taylor, M. S. (2001). Werner Antweiler, Brian R. Copeland and M. Scott Taylor. *The American Economic Review*, *91*(4), 877-908.

Bowles, R. (2000). Corruption. In B. B. Geest, *Encyclopedia of Law and Economics* (Vol. 5, pp. 460-491). Cheltenham: Edward Elgar.

BP. (2019). *Statistical Review of World Energy*. Retrieved from "https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html" target="_blank">https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

Cai, X., Che, X., Zhu, B., Zhao, J., & Xie, R. (2018). Will developing countries become pollution havens for developed countries? An empirical investigation in the Belt and Road. *Journal of Cleaner Production*, *198*, 624-632.

Chung, S. (2014). Environmental regulation and foreign direct investment: Evidence from South Korea. *Journal of Development Economics*, *108*, 222-236.

Cole, M. A., & Fredriksson, P. G. (2009). Institutionalized pollution havens. *Ecological Economics*, *68*, 1239–1256.

Cole, M., Elliott, R., & Fredriksson, P. (2006). Endogenous pollution havens: does FDI influence environmental regulations. *Scandinavian Journal of Economics*, *108*(1), 157–178.

Copeland, B., & Taylor, M. (2004). Trade, Growth, and the Environment. *Journal of Economic Literature*, *42*(1), 7-73.

Dam, L., & Scholtens, B. (2012). The curse of the haven: The impact of multinational enterprise on environmental regulation. *Ecological Economics*, *78*, 148–156.

Dou, J., & Han, X. (2019). How does the industry mobility affect pollution industry transfer in China: Empirical test on Pollution Haven Hypothesis and Porter Hypothesis. *Journal of Cleaner Production*, *217*, 105-115.

Ekicia, Ş. Ö., Kabak, Ö., & Ülengin, F. (2019). Improving logistics performance by reforming the pillars of Glob Competitiveness Index. *Transport Policy*, *81*, 197-207.

Fereidouni, H. G. (2013). Foreign direct investments in real estate sector and CO2 emission Evidence from emerging economies. *Management of Environmental*, *24*(4), 463-476.

Fujita, M., Krugman, P., & Venables, A. (1999). *(1999)*, *The Spatial Economy: Cities*, *Re and International Trade*. Cambridge: MIT Press.

Gilfillan, D., Marland, G., Boden, T., & Andres, R. (2019). *Global*, *Regional*, *and National Fossil-Fuel CO2 Emissions*. Gilfillan, D., Marland, G., Boden, T., and RCarbon Dioxide Information Analysis Center at Appalachian State University.

Gill, F. L., Viswanathan, K. K., & Karim, M. Z. (2018). The Critical Review of the Pollution Haven Hypothesis. *International Journal of Energy Economics and Policy*, *8*(1), 167-174.

globalcarbonatlas. (2020, September 23). *http://www.globalcarbonatlas.org/en/content/welcome-carbon-atlas*. Retrieved from http://www.globalcarbonatlas.org: http://www.globalcarbonatlas.org/en/CO2-emissions

Green, R. (1997). Bureaucracy and Law and Order. In J. Faundez, *Good Government and Law: Legal and Institutional Reform in Developing Countries* (pp. 66-67). London : Macmillan.

Grether, J.-M., & Melo, J. d. (2002). Globalization and dirty industries: Do pollution havens matter? *CEPR/NBER/SNS International Seminar on International Trade "Challenges to Globalization"* (pp. 2-33). Stockholm: CEPR/NBER/SNS.

Hanif, I., Raza, S. M., Gago-de-Santos, P., & Abbas, Q. (2019). Fossil fuels, foreign direct investment, and economic growth have triggered CO2 emissions in emerging Asian economies: Some empirical evidence. *Energy*, *171*, 493-501.

Hertel, T. W., & Tsigas, M. E. (1997). Structure of GTAP. In T. W. Hertel, *Global Trade Analysis: Modeling and Applications*. Cambridge University Press.

Indriya, S., & Widodo, T. (2011). Do Pollution Havens Exist? Evidence from East Asia. *Munich Personal RePEc Archive MPRA Paper No. 79924*, 1-42.

Kanemoto, K., Lenzen, M., Peters, G., Moran, D., & Geschke, A. (2012). Frameworks for comparing emissions associated with production, consumption, and international trade. *Environment Sience & Technology*, *46*(1), 172-179.

Kanemoto, K., Moran, D., Lenzen, M., & Geschke, A. (2014). International trade undermines national emission reduction targets: New evidence from air pollution. *Global Environmental Change*, *24*, 52-59.

Lan, J., Kakinaka, M., & Huang, X. (2012). Foreign Direct Investment, Human Capital and Environmental Pollution in China. *Environmental & Resource Economics*, *51*(2).

Lopez, L. A., G. A., Kronenberg, T., & Rodrigues, J. F. (2018). Trade from resource-rich countries avoids the existence of a global pollution haven hypothesis. *Journal of Cleaner Production*, *175*, 599-611.

Mani, M. (1996). Environmental Tariffs on Polluting Imports: An Empirical Study. *Environmental and Resource Economics*, *7*, 391-411.

Mani, M., & Wheeler, D. (1997). In Search of Pollution Havens? Dirty Industry in the World Economy, 1960-1995. *OECD Conference on FDI and the Environment* (pp. 1-22). Hague: OECD.

McKinsey&Company. (2009). *Pathways to a Low Carbon Economy*. New York: McKinsey & Company.

Mutafoglu, T. H. (2014). Foreign Direct Investment, Pollution, and Economic Growth. *Journal of Developing Societies*, *28*(3), 281–297.

Neumayer, E. (2001). Pollution Havens: An Analysis of Policy Optionsfor Dealing With an Elusive Phenomenon. *Journal of Environment & Development*, *10*(2), 147-177.

Nordstrøm, H., & Vaughan, S. (1999). *Trade And Environment*. Special Studies 4: World Trade Organisation .

Pellegrini, L., & Gerlagh, R. (2006). Corruption, democracy, and environmental policy: An empirical contribution to the debate. *Journal of Environment and Development*, *15*(3), 332-354.

Rafindadi, A. A., Muye, I. M., & Kaita, R. A. (2018). The effects of FDI and energy consumption on environmental pollution in predominantly resource-based economies of the GCC. *Sustainable Energy Technologies and Assessments*, *25*, 126–137.

Rosenthal, S., & Strange, C. (2001). The Determinants of Agglomeration. *Journal of Urban Economics*, *50*, 191-229.

Sapkota, P., & Bastola, U. (2017). Foreign direct investment, income, and environmental pollution in developing countries: Panel data analysis of Latin America. *Energy Economics*, *64*, 206-212.

Sarkodie, S. A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science of the Total Environment*, *646*, 862–871.

Schwab, (. K. (2018). *The Global Competitiveness Report 2018*. World Economic.

Sekrafi, H., & Sghaier, A. (2018). The effect of corruption on carbon dioxide emissions and energy consumption in Tunisia. *PSU Research Review*, *2*(1), 81-95.

Sen, A. (2013). Intra-Industry Trade in Dirty Goods and Environmental Policies. *Munich Personal RePEc Archive MPRA No. 49167*.

Shao, Y. (2018). Does FDI affect carbon intensity? New evidence from dynamic panel analysis. *International Journal of ClimateChange Strategies and Management*, *10*(1), 27-42.

Smarzynska, B. K., & Wei, S.-J. (2001). Pollutan Haven and Foreign Direct Investment: Dirty secret or popular myth. *NBER Working Paper Series*, Working Paper 8465.

Speth, J. G. (1988). Environmental Pollution: A long-term perspective. *The Centennial Symposium* (pp. 262-282). Washington D. C.: EARTH '88: Changing Geographic.

Straumann, R. (2003). *Exporting Pollution? Calculating the embodied emissions in trade for Norway*. Oslo–Kongsvinger: Statistisk sentralbyrå - Statistics Norway

Taylor, M. S. (2005). Unbundling the Pollution Haven Hypothesis . *Discussion Paper 2005-15 University of Calgary* , 1-29.

Tisdell, C. (2001). Globalisation and Sustainability: Environmental Kuznets curve and the WTO. *Ecological Economics*, *39*, 185-196.

Tobey, J. (1990). The Effects of Domestic Environmental Policies on Patterns of World Trade: An Empirical Test. *Kyklos*, *43*(2), 191-209.

UNEP. (2013). *Global Chemicals Outlook - Towards Sound Management of Chemicals*. Nairobi: United Nations Environment Programme.

UNFCCC. (2019). *National Inventory Submissions 2019*. . United States: United Nations Framework Convention on Climate Change.

Welsch, H. (2004). Corruption, growth and the environment: A cross-country analysis. *Environment and Development Economics*, *9*(5), 663–693.

Wilson, J. S., Otsuki, T., & Sewadeh, M. (2002). Dirty Exports and Environmental Regulation: Do Standards Matter to Trade? *Policy Research Working Paper 2806* , 1-40.

Xu, X., & Song, L. (2000). Regional Cooperation and the Environment: Do "Dirty" Industries Migrate? *Weltwirtschaftliches Archiv*, *136*(1), 137-157.

Yahaya, N. S., Mohd-Jali, M. R., & Raji, J. O. (2020). The role of financial development and corruption in environmental degradation of Sub-Saharan African cuntries. *An International Journal*, *31*(4), 895-913.

Zeng, D.-Z., & Zhao, L. (2009). Pollution havens and industrial agglomeration. *Journal of Environmental Economics and Management* , *58*, 141-153.