FDI and negative environmental externalities in Asia

Master Thesis

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Summary

This study researches the relationship between FDI and negative environmental externalities in 13 Asian countries in the period 2003 to 2012. The pollution haven hypothesis, the pollution halo hypothesis, and the EKC hypothesis are addressed. The analyses are performed using the random effects model and the pooled OLS model as robustness check. The main analyses are performed using Total FDI as main explanatory variable and CO_2 emissions and N_2O emissions as dependent variables. Additional analyses are performed using sectoral FDI – i.e. construction FDI, manufacturing FDI, resource FDI, and service FDI – as main explanatory variables. The results provide no base for a clear conclusion regarding the existence of the pollution haven hypothesis or the pollution halo hypothesis. Though, the results indicate that the relationship between FDI and negative environmental externalities is an inverted U-shaped curve. Therefore, support for the EKC hypothesis is found in this study.

1. Introduction

Foreign direct investment (FDI) is the investment of a multinational enterprise (MNE) in another country, also referred to as host country, e.g. by the opening of new plants or subsidiaries (Lee, 2013). Traditionally, FDI is linked with the transfer of knowledge, technology, and management practices from the MNE to the host country (Doytch & Narayan, 2016). FDI has been positively associated with economic growth through several channels, such as technology transfer, productivity gains, spill-over effects, and the introduction of new processes and managerial skills. Additionally, FDI can provide direct capital financing and lead to positive externalities (Lee, 2013).

Though, FDI is also regarded as one of the major factors leading to environmental degradation (Omri, Nguyen, & Rault, 2014). FDI serves an important function in economic development in many developing countries, which at the same time raises two concerns. First, faster rates of economic development that are driven by FDI may result in a greater burden on the natural resources and environment of the host country. Additionally, by attracting FDI, developing countries might also attract pollution, as environmental standards are usually weaker in these countries compared to the environmental standards in developed countries (Kim & Adilov, 2012).

In the past years, the relationship between FDI and environmental effects has been studied frequently. These studies can be divided into three main categories: (1) the pollution haven hypothesis, (2) the pollution halo hypothesis, and (3) the Environmental Kuznets Curve (EKC). The pollution haven hypothesis and the pollution halo hypothesis are related to the environmental effects of FDI, whereas the EKC focuses on the functional form of the relationship between economic development or FDI and the environment.

The pollution haven hypothesis expects FDI to be positively associated with negative environmental externalities, as this hypothesis states that MNEs tend to locate their activities in countries with relaxed or weak environmental standards (Kim & Adilov, 2012). These countries are attractive for FDI when pollution abatement costs in the home country are high. Though, studies on the pollution haven hypothesis are inconclusive: some studies find support for the hypothesis, such as Kim and Adilov (2012) and Di (2007), while other studies find evidence to reject this hypothesis, such as Eskeland and Harrison (2003).

The pollution halo hypothesis expects FDI to be negatively associated with negative environmental externalities. According to the pollution halo hypothesis, MNEs use greener or cleaner technologies for their production processes in host countries (Zhu, Duan, Guo, & Yu, 2016). Because of these greener or cleaner technologies, MNEs will not lead to an additional burden to the environment in the host country. Additionally, local firms or existing firms in the host country might adopt these greener or cleaner technologies in their own production processes. Several empirical studies provide support for the pollution halo hypothesis, such as Eskeland and Harrison (2003), Atici (2012), and Abdouli and Hammami (2017). A more specific relation within the pollution halo hypothesis is the relationship between FDI and energy consumption. This relationship has been studied repeatedly as well, though, the findings are mixed (Doytch & Narayan, 2016).

The EKC is the curve that shows the relationship between economic development and environment. As FDI is an important factor for economic development, this curve is also relevant for the relationship between FDI and environment. The EKC is shaped as an inverted U, indicating that the environmental degradation is limited to a certain level (Abdouli & Hammami, 2017). The empirical studies on the EKC are inconclusive. Some studies indeed find an inverted U-shaped curve, such as Fodha and Zaghdoud (2010) and Orubu and Omotor (2011), while others find a N-shaped curve, such as Friedl and Getzner (2003). Wang, Zhou, Zhou, and Wang (2011) find an U-shaped curve between economic growth and negative environmental externalities.

As shown in the previous paragraphs, empirical studies on the negative environmental effects of FDI provide mixed results. A possible explanation for these inconclusive findings is the use of different approaches. E.g., the studies use different measures for environmental degradation, FDI, and the stringency of (environmental) regulations. Additionally, the datasets used in the empirical analyses cover different periods and different countries or regions (Kim & Adilov, 2012; Amri, 2016; Doytch & Narayan, 2016). Additionally, endogeneity problems could have played a role.

Endogeneity problems could be a result of omitted variable bias. For example, endogeneity problems could occur when unobserved firm or industry heterogeneities, which are not included in the model, i.e. omitted variable bias, are correlated with the stringency of environmental regulations, which would be one of the explanatory variables (Di, 2007).

The main objective of this study is to examine the relationship between FDI and negative environmental externalities in Asia. Existing studies focus on either one Asian country or use a collection of many regions, including Asia. However, studies on Asian countries alone are limited (Kim & Adilov, 2012; Zhu, Duan, Guo, & Yu, 2016). The environmental effects of FDI in Asia might differ from those in other regions, e.g. due to the rapid economic growth in Asia in the past decades. There might even be different results between the Asian countries, as their national growth rates might differ significantly between those countries. As negative environmental externalities have become a greater problem in Asia in the past decade, a study on the relationship between FDI and these negative environmental externalities could give some insights for policy makers in Asia (Wang, Zhou, Zhou, & Wang, 2011; Begum, Sohag, Abdullah, & Jaafar, 2015; Zhu, Duan, Guo, & Yu, 2016). Therefore, the research question of this study is the following:

"To what extent is an increase in FDI associated with an increase in negative environmental externalities in Asia?"

As FDI is important to developing countries, it is necessary to understand the interactions between environmental pollution, economic growth, and FDI inflows. This understanding should be used as a foundation for the development of sound economic policies (Omri, Nguyen, & Rault, 2014). This study aims to provide insight in the relationship between FDI and negative environmental externalities, and whether other factors also have an influence on these negative environmental externalities. Policy makers could use this insight while making decisions on attracting FDI as well as in their environmental policy.

The data in this study is mainly obtained from fDi Markets and the World Development Indicators (WDI) database developed by the World Bank Group. The dataset covers 13 Asian countries in the period 2003 to 2012. Longitudinal as well as cross-sectional estimation techniques are used to perform the analyses.

This study is structured as follows. Section 2 contains the theoretical framework and the hypotheses derived from this framework. In section 3 the data and methodology are described. Section 4 provides an overview of the results, and section 5 discusses and concludes this study.

2. Theoretical Framework

As mentioned in the introduction, the relationship between FDI and negative environmental externalities has been studied by testing the pollution haven hypothesis and the pollution halo hypothesis. The first hypothesis expects FDI to lead to more negative environmental externalities, whereas the latter expects the opposite. Additionally, the EKC has been studied in order to establish the curve representing the relationship between economic growth, or FDI, and negative environmental externalities. In this section these studies are elaborated on. First, the pollution haven hypothesis and pollution halo hypothesis are discussed, after which the EKC is examined. This section concludes with the hypotheses for this study.

2.1. The pollution haven hypothesis

According to the pollution haven hypothesis, MNEs tend to locate their production facilities in countries with relaxed or weak environmental standards (Kim & Adilov, 2012). This is especially the case for firms that are engaged in pollution-intensive activities, such as petrochemicals, paper, and steel. After all, if conforming to more stringent environmental requirements increases the costs for a firm, a firm would want to relocate to a country with less stringent environmental requirements, assuming this firm aims to maximize its profits and relocating costs less than conforming to the requirements in the home country (Javorcik & Wei, 2004).

Developing countries tend to overlook environmental concerns by relaxing their regulations in order to attract FDI (Zhu, Duan, Guo, & Yu, 2016). Therefore, compared to developed countries, developing countries usually have weaker environmental standards and by attracting FDI, these countries might also be attracting pollution (Kim & Adilov, 2012). In theory, it is plausible that countries with weak environmental standards attract FDI, though empirical studies have shown conflicting results regarding the pollution haven hypothesis (Javorcik & Wei, 2004).

There are three dimensions of importance in the pollution haven hypothesis. First, as previously mentioned, the relocation of pollution-intensive activities from countries with stringent environmental regulations to countries with relaxed environmental regulations. This relocation is also encouraged by global free trade (Aliyu, 2005). Secondly, the dumping of hazardous waste in developing countries that is generated from developed countries, such as industrial and nuclear energy production. The third dimension is the unrestricted extraction of non-renewable natural resources in developing countries. These resources are used by MNEs in their production processes for the production of petroleum and petroleum products. These dimensions are important for policy makers when making decisions on environmental policy (Aliyu, 2005).

Kim and Adilov (2012) empirically test the validity of the pollution haven hypothesis as well as the pollution halo hypothesis by examining the effects of FDI on carbon dioxide (CO_2) emission levels. The authors obtained the data on CO_2 emissions from the World Development Indicators (WDI) database, which is developed by the World Bank Group. The results on the pollution halo hypotheses are elaborated on in the next paragraph. Their dataset includes 164 countries over a period of 44 years. In order to take into the environmental regulations into account, the authors use the *"Kyoto"* dummy, which takes the value of one when the country has ratified the Kyoto Protocol (Kim & Adilov, 2012).

The authors divide their sample into developed in developing countries, as earlier studies have indicated that the environmental impacts of FDI could be different in high-income and low-income countries. The results show that GDP is positively associated with CO_2 emissions growth rates in developing and developed countries. However, FDI is positively associated with CO_2 emissions growth rates in developed countries and negatively associated with CO_2 emissions growth rates in developing countries. They conclude that in developing countries foreign companies are less polluting compared to local firms, indicating that FDI brings cleaner technologies in developing countries. This is consistent with the pollution halo hypothesis (Kim & Adilov, 2012).

Though, FDI increases CO_2 emissions growth rates in developed countries. One of the intuitive explanations for this finding provided by the authors is that foreign companies that are relocating from one developed country to another developed country might prefer those countries with less strict environmental standards (Kim & Adilov, 2012). FDI inflow in developed countries increases pollution growth rates, while FDI outflows reduce pollution growth rates. The authors conclude that a positive coefficient for the variable *"FDI"* in developed countries is consistent with the pollution haven hypothesis. The findings simultaneously support the pollution halo hypothesis and the pollution haven hypothesis; therefore the authors conclude that the two hypotheses are not contradictory (Kim & Adilov, 2012).

Tobey (1990) uses Heckscher-Ohlin-Vanek (HOV) equations to test the pollution haven hypothesis using data on 23 countries. The author measures the degree of environmental stringency on a scale ranging from one (tolerant) to seven (strict). The average degree for developed countries is 6.1 and for developing countries 3.1. The results indicate that the world distribution of pollution-intensive industries is not influenced by differences in the degrees of environmental stringency. The author provides several possible explanations for this result, of which the following the most reasonable is according to the author: the magnitude of environmental expenditures in countries with a high degree of environmental stringency is not large enough to lead to a noticeable effect (Tobey, 1990).

This is corroborated by a study by Grossman and Krueger (1993) that examines the environmental impacts of the North American Free Trade Agreement (NAFTA). The authors study the impact of pollution abatement costs of American industries on the trade pattern and investment pattern between the United States and Mexico in the period 1977 to 1988. The effects of cross-industry differences in pollution abatement costs on imports from Mexico to the United States are statistically insignificant. The authors conclude that the differences in the abatement costs are small and do not play a significant role compared to more substantial production costs (Grossman & Krueger, 1993).

A study by Eskeland and Harrison (2003) find no evidence of pollution havens. The authors use data on four developing countries to test the pollution haven hypothesis: Mexico, Venezuela, Morocco, and Cote d'Ivoire. The data covers different periods for the four countries, however, the periods are relatively comparable (they are all between 1977 and 1990). The authors focus on the impact of pollution abatement costs on the composition of FDI and on the role of FDI in improving the environment by using more energy-efficient technologies and cleaner energy sources (Eskeland & Harrison, 2003).

Environmental regulations are included in the models by using a parameter that represents the pollution abatement costs. Additionally, in one model the pollution abatement costs are replaced by three measures of emission intensities: air pollution, water pollution, and toxicity. They also include regulatory barriers against FDI, which were obtained from policy reports and various publications for potential investors. The results do not show that foreign investors are concentrated in pollution-intensive activities. Moreover, the authors find no significant correlation between environmental standards in industrialized countries and FDI in developing countries. Their empirical tests show no evidence of pollution havens (Eskeland & Harrison, 2003).

Javorcik and Wei (2004) test the pollution haven hypothesis by using data on FDI flows from multiple source countries to 25 host countries in Eastern Europe and the former Soviet Union. The authors explicitly take into account the effect of host country corruption, as the prevalence of corruption in a host country might discourage FDI while at the same time the corruption might be correlated with the weak environmental regulations. The focus of the study is on manufacturing FDI, as this sector is expected to have more environmental impact compared to for example service FDI. In order to measure the pollution intensity of industries, the authors follow Eskeland and Harrison (2003) by measuring pollution emissions and abatement costs. The strength of environmental standards is measured by both participation in international treaties and the quality of air and water ambient and emission standards (Javorcik & Wei, 2004).

Additionally, the authors take into account both the pollution intensity of the MNE looking for an investment location as well as the environmental stringency of a potential host country. This allows them to examine whether FDI is more likely to be located in countries with relaxed environmental standards and whether pollution-intensive industries are more likely to engage in FDI, as previous studies have only examined one of the two relationships. By taking into account both aspects, the authors can test whether dirty industries are relatively more likely to locate in countries with weak environmental regulations (Javorcik & Wei, 2004).

The data indicate that environmental standards of the host country have little impact on FDI inflows in terms of volume as well as in terms of composition (i.e., whether more polluting industries are more affected by stricter environmental standards). The empirical analyses do not show support for the pollution haven hypothesis, as the authors do not find robust evidence of FDI in pollution-intensive industries relocating to countries with relaxed environmental regulations. In fact, the authors find that firms engaged in less polluting activities are more likely to locate in countries with relaxed environmental standards (Javorcik & Wei, 2004).

Cole (2004) examines to which extent trade – through pollution haven effects and structural change – contributes to the EKC. The author uses four developed-developing trade pairs in the period 1975 to 2000: USA-Asia, USA-Latin America, UK-Asia, and Japan-Asia. By calculating the net exports as a proportion of consumption for the four trade pairs, the author measures whether the developed country reduces its specialization in the industry relative to its consumption. The net exports as a proportion of consumption should fall over time according the pollution haven hypothesis, as a decrease indicates that the demand is being met by the developing country (Cole, 2004).

The results show that for certain sectors in certain trade pairs, the course of the net exports as a proportion of consumption is in line with the pollution haven hypothesis. Though, sectors with low pollution intensities have also experienced a decline in the net exports as a proportion of consumption, which would mean that factors other than differences in environmental regulations play a role. The author concludes that if pollution havens have been formed, they have only been temporary and limited to certain sectors and regions. However, that does not exclude the possibility that the formation of pollution havens have influenced pollution emissions (Cole, 2004).

Hoffmann et al. (2005) use data on 112 countries for the period 1971 to 1999 to test for Granger causality between FDI and pollution (proxied by CO_2 emissions from industrial processes). The authors find support for the pollution haven hypothesis with respect to low-income countries. They provide two interpretations for this finding: (1) when a low-income country has no factors that could attract FDI, such as infrastructure and skilled labour, this country might use relaxed environmental regulations to attract FDI, and (2) low-income countries might not be able to afford to implement and monitor environmental regulations, leading to the existence of "innocent" pollution havens (Hoffmann, Lee, Ramasamy, & Yeung, 2005).

Di (2007) studies location choices of FDI in Chinese provinces and tests the pollution haven hypothesis. The author uses only data on new manufacturing FDI firms that were established during the period 1992 – 1995. In China a nationwide pollution levy system is applied with fixed levy rates, and pollution levies are per-unit charges for pollution that exceeds the standard pollution level. Therefore, the author uses *"effective levy rates"* – more specifically, *"effective water levy"* and *"effective air pollution levy"* – of each Chinese province to take into account the provincial environmental regulatory stringency (Di, 2007).

The results show that firms with pollution-intensive activities are more likely to locate in provinces with more possibilities to benefit from costs savings related to environmental regulations. Additionally, there is a tendency to locate in provinces that are less developed or provinces with fewer similar polluting industries by firms that are engaged in relatively pollution-intensive activities. Compared to firms in non-polluting industries, firms in polluting industries are more sensitive to regulation and development status. Moreover, firms choose to locate in provinces where they have more bargaining power with local governments. These results indicate that there are domestic pollution havens in China (Di, 2007).

Kheder and Zugravu (2012) test the pollution haven hypothesis by using data on 1,374 French investments in 74 countries in the period 1996 to 2002. The authors analyse the impact of environmental regulations on the location choice of French manufacturing firms. In order to measure environmental stringency, the authors compute for each country in the sample a global Environmental Regulation (ER) index. This index integrates three variables: (1) multilateral environmental agreements (MEAs) ratified, which distinguishes the countries that ratified several MEAs, (2) International non-governmental organisations (NGO), which represents the international NGOs' members per million of population, and (3) energy efficiency, measured as GDP per unit of energy used. The results show that the estimated coefficient of the ER index is significant at the 1% significance level and negative. This means that the existence of a more stringent environmental regulation in a country discourages French manufacturing FDI. The authors conclude that in the presence of heterogeneous countries, French MNEs are more likely to invest in countries with more relaxed environmental regulations, given that the regulations are not more relaxed than an accepted level ensuring wealthy business environment (Kheder & Zugravu, 2012).

In order to test the pollution haven hypothesis in Asia, the relationship between FDI and CO_2 emissions and the relationship between FDI and nitrous oxide (N_2O) emissions are examined in this study.

2.2. The pollution halo hypothesis

The pollution halo hypothesis states that an increase in FDI is not necessarily associated with an increase in pollution, as MNEs can also conduct business in an environmentally friendly manner by using greener or cleaner technologies or applying a more environmentally friendly way of conducting business (Kim & Adilov, 2012). This could also increase environmental awareness in the host countries (Zhu, Duan, Guo, & Yu, 2016).

Kim and Adilov (2012) provide several reasons as to why the pollution halo hypothesis is plausible. First, host countries could have set the environmental standards higher for foreign companies compared to the environmental standards for local firms. Moreover, foreign companies might be more cautious as they might be uncertain about the local regulations, and in order to avoid violation of local environmental regulations, they produce less pollution compared to local firms. A possible explanation for the pollution halo hypothesis could also be that MNEs might have access to less polluting production methods compared to local firms. Additionally, MNEs might feel more pressured to use greener technologies in host countries in order to prevent repercussions in their home countries (Kim & Adilov, 2012).

Though the pollution halo hypothesis seems to be stating the opposite of what the pollution haven hypothesis is stating, Kim and Adilov (2012) find support for both hypotheses and conclude that the two hypotheses do not have to be contradictory. This could be plausible, as the pollution halo hypothesis focuses on how a firm performs once it is located in a country, and not why this firm locates in a specific country. The pollution haven hypothesis focuses on the latter (Zarsky, 1999).

Other studies find support for the pollution halo hypothesis as well. Eskeland and Harrison (2003) find that MNEs are less polluting than comparable local firms in developing countries. By using a proxy for pollution intensity – the use of energy and dirty fuels – they find that foreign firms are significantly more efficient in their energy consumption and that these firms use cleaner types of energy. Though, the authors conclude that this finding does not rule out that a pollution haven could exist (Eskeland & Harrison, 2003).

Atici (2012) studies the relationship between trade and the environment – measured as carbon emissions – in Association of Southeast Asian Nations (ASEAN) countries. The results show that FDI – measured as the ratio of net FDI inflow to current GDP - does not tend to increase pollution levels in the ASEAN countries. The author also finds that higher tariff levels are associated with higher emission levels. This indicates that countries with higher protection levels (measured as tariff levels) are not able to use their resources efficiently, or that those countries use inefficient technologies, which lead to higher emission levels (Atici, 2012).

The findings of Atici (2012) are supported by the results of Zhu, Duan, Guo, and Yu (2016). They study the impact of FDI, economic growth, and energy consumption on carbon emissions in five ASEAN countries (ASEAN-5). Their findings provide support for the pollution halo hypothesis conform Atici (2012). They find no evidence that FDI has a deteriorating impact on environmental quality (Zhu, Duan, Guo, & Yu, 2016).

Abdouli and Hammami (2017) examine the causality between environmental quality, FDI, and economic growth by using data on 17 Middle East and North African (MENA) countries over the period 1990 to 2012. The results show that FDI stocks – lagged by two periods (years) – lead to a decrease of the environmental degradation, which is measured as CO_2 emissions per capita, due to the pollution halo effect (Abdouli & Hammami, 2017).

As mentioned before, MNEs can conduct a more environmental friendly way of business by using greener or cleaner technologies. An important aspect is the energy consumption. The relationship between FDI and energy consumption has been a popular strand of research in the past years, though the results are inconclusive (Amri, 2016). Energy is essential in the production processes of goods and services. The consumption of goods and services – such as automobiles and houses – and the production of those goods and services – such as the construction of new plants and factories – increase the demand for energy. Energy-related greenhouse gases, such as CO_2 and N_2O, make up the majority of greenhouse gas emissions (Sadorsky, 2010).

FDI in developing countries could result in an increase in the use of green energy and a decrease in the use of traditional energy sources – such as gas, oil, and coal – through competition or direct knowledge transfer. When firms are exposed to foreign competition, this raises the bar for those firms to become more efficient. Foreign companies can therefore act as a catalyst that makes domestic firms more energy efficient. Domestic firms could also replicate the energy-saving practices that foreign firms transfer from their home countries. These practices might be beneficial for domestic firms as energy savings could decrease production costs. Existing empirical literature on the relationship between FDI and energy consumption is scarce and provide mixed findings (Doytch & Narayan, 2016).

Amri (2016) uses data on 75 countries in the period 1990 to 2010 to study this relationship. The author makes a distinction between renewable energy consumption and non-renewable energy consumption. The results show a positive association between FDI and renewable energy consumption as well as between FDI and non-renewable energy consumption. Compared to developing countries, the contribution of FDI to energy consumption is more important in developed countries (Amri, 2016).

The results of a study by Mielnik and Goldemberg (2002) indicate the opposite: the energy intensity decreases as FDI increases. The authors include 20 developing countries in their study in the period 1971 to 1999. They provide an explanation for their finding: FDI in those countries resulted in the use of modern technologies. Advanced management combined with the use of modern technologies is likely to increase the efficiency of FDI (Mielnik & Goldemberg, 2002).

Doytch and Narayan (2016) show similar findings. They make a distinction between renewable and non-renewable industrial energy consumption and they use a sectoral distribution of FDI. They also perform sub-sample analyses and find that manufacturing FDI reduces the consumption of renewable energy in high-income countries, whereas financial service FDI significantly decreases the use of non-renewable energy and increases the consumption of renewable energy. In the low-income countries, mining FDI encourages the transfer of energy-saving practices and reduces the non-renewable energy consumption. Overall, the findings indicate that FDI contributes to the reduction of non-renewable energy consumption and the increase of renewable energy consumption, though the effects differ in magnitude and significance by sectoral FDI. The authors also find that economic growth increases both renewable and non-renewable energy consumption (Doytch & Narayan, 2016).

By examining the relationship between FDI and CO_2 emissions and the relationship between FDI and N_2O emissions in Asia in this study, the pollution halo hypothesis is tested.

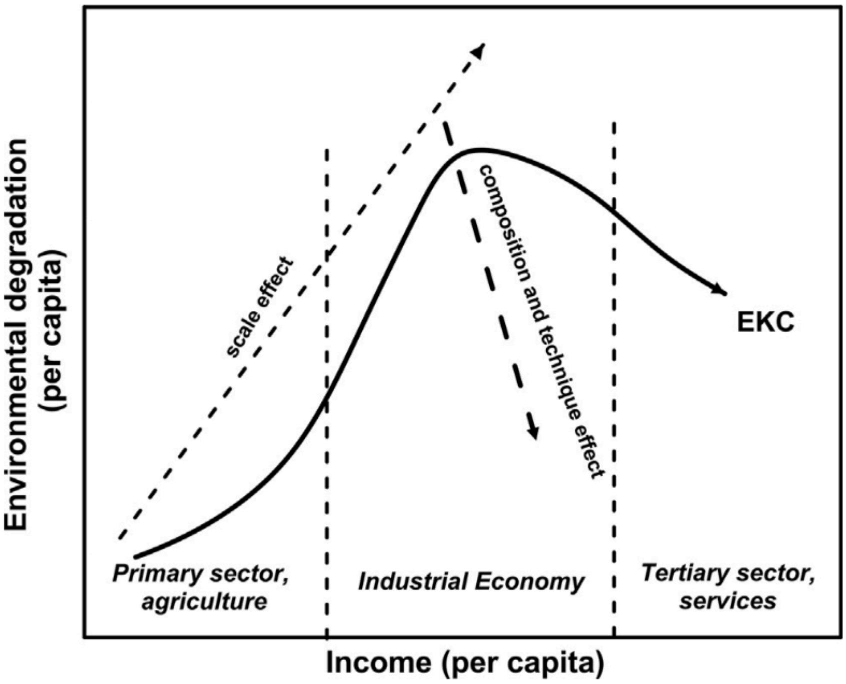
2.3. Environmental Kuznets Curve (EKC)

The EKC represents the relationship between economic development and environment (Abdouli & Hammami, 2017). As FDI is positively associated with economic growth (Lee, 2013), the relationship between economic development and environment could be affected by FDI. For example, in Malaysia, patterns of environmental destruction – such as greenhouse gas emissions, deforestation and loss of biodiversity – have been stimulated by an increase in economic activities in the past decade. FDI has become an increasingly significant contributor to these patterns (Hitam & Borhan, 2012).

According to the EKC hypothesis, this relationship is shaped like an inverted U-shaped curve. In other words, the economic development of a country increases the level of environmental degradation of this country, though, the level of environmental degradation decreases after a certain level of income is reached (Abdouli & Hammami, 2017). According to his hypothesis, no policy intervention is needed regarding environmental issues, as economic growth could solve these issues (Fodha & Zaghdoud, 2010). Cole (2004) examines to what extent the EKC can be explained by the pollution haven hypothesis, as the pollution haven hypothesis expects the relocation of MNEs to countries with less stringent environmental regulations, which would lead to more pollution in those host countries (Cole, 2004). However, according to the pollution halo hypothesis, FDI decreases negative environmental externalities, which could be the downward slope after the turning point of the EKC. The pollution haven hypothesis and the pollution halo hypothesis could therefore be related to the EKC.

Theoretically, the inverted U-shaped curve can be explained using three aspects: (1) scale effects, (2) composition effects, and (3) technology effects (Grossman & Krueger, 1993). The scale effect consists of two types of environmental pressure: increased inputs and increases associated waste. Materials and natural resources (inputs) are necessary to produce output, which will lead to economic development. Increased uses of resources have a depletion effect. Simultaneously, more output is associated with more waste and emissions, which increase environmental degradation in the form of a pollution effect (Orubu & Omotor, 2011). This is shown in the figure below.

Figure 1: The three aspects of the EKC. Source: (Kaika & Zervas, 2013)



The composition effect refers to the composition of production activities of a country's output. The common phases an economy goes through during economic development are from subsistence agriculture – which is less polluting – to more energy-intensive methods of agricultural production to light manufacturing, which are more polluting activities. As an economy moves into the phase of heavy industry, its pollution intensity will be highest and this will decline as the economy shifts towards high technology and knowledge- and service-based industries. Thus, in the earlier phases of economic development, the composition effect is likely to strengthen environmental pressures, whereas it counteracts in later phases of economic development (Orubu & Omotor, 2011). The earlier phases of economic development could be related to the pollution haven hypothesis, whereas the later phases could be related to the pollution halo hypothesis.

Technological effects occur as an economy's state of technology improves. Technology improvements, e.g. improvements in production processes, usually lead to less pollution, e.g. by reducing the use of material inputs. The technological effects are therefore related to the inputs needed for production output and the residuals intensity of production (Orubu & Omotor, 2011). These technological effects could be related to the pollution halo hypothesis. The EKC hypothesis has been examined in several studies (Cole, 2004).

Shafik (1994) studies the relationship between per capita income and environmental quality. The author uses data on 149 countries in the period 1960 to 1990. The following indicators are used to measure environmental quality: (1) the lack of clean water, (2) the lack of urban sanitation, (3) ambient levels of suspended particulate matter (SPM), (4) ambient sulfur oxides (SO_2), (5) change in forest area between 1961 and 1986, (6) the annual rate of deforestation between 1962 and 1986, (7) dissolved oxygen in rivers, (8) fecal coliforms in rivers, (9) municipal waste per capita, and (10) carbon emissions per capita (Shafik, 1994).

The author finds different functional forms for the indicators of environmental quality. E.g., the lack of clean water and sanitation decreases as income per capita increases. The relationship between per capita income and SPM and SO_2 show an inverted U-shaped curve, conform the EKC hypothesis. Some indicators worsen steadily with rising incomes, such as dissolved oxygen in rivers, municipal waste per capita, and carbon emissions per capita. Moreover, the turning points at which the relationship with income per capita changes, vary significantly across the indicators (Shafik, 1994).

The author finds that the functional forms of the relationship between environmental quality and per capita income are a reflection of the relative costs and benefits attached to addressing environmental problems at different stages of economic development. E.g., clean water and sanitation are among the earliest environmental problems that are addressed by countries and these have relatively low costs and high benefits. Some environmental problems are more likely to be addressed when a country reaches a middle-income level, as middle-income economies are usually energy-intensive and industrialized and these environmental problems become more severe in this stage of economic development. Moreover, the benefits of addressing these problems are greater and it is more affordable to address these problems at this stage. When environmental issues can be externalized, it is less likely that there is an incentive to pay for the substantial abatement costs associated with reduced emissions and wastes (Shafik, 1994).

As mentioned before, the technology aspect is important in the EKC hypothesis. Shafik (1994) finds that technology is critical when the costs of environmental degradation are local and trigger demand for improvements. When the costs of environmental degradation are dispersed or there is a lack of knowledge about the negative external effects, there will be little or no demand for technological improvements that aim to reduce environmental degradation. Additionally, the author finds that it is possible for countries to 'grow out of' certain environmental problems, though, this is not something that happens automatically. Usually, policy interventions and investments are necessary to reduce environmental degradation (Shafik, 1994).

Fodha and Zaghdoud (2010) examine the EKC hypothesis for Tunisia during the period 1961 to 2004. The authors use per capita CO_2 emissions and per capita SO_2 emissions as indicators for the level of environmental degradation. The results show an increasing linear relationship between per capita CO_2 emissions and per capita GDP, the economic indicator. The relationship between SO_2 emissions and per capita GDP, on the other hand, follows an inverted-U curve, and supports the EKC hypothesis. One of the reasons provided by the authors why an inverted U-shaped curve is found between SO_2 emissions and economic development is that SO_2 emissions mainly affect the local or regional population, whereas CO_2 emissions mainly affect the global population (Fodha & Zaghdoud, 2010). Orubu and Omotor (2011) also use two different measures for environmental degradation and find for one of the measures, namely suspended particulate matter, support for the EKC hypothesis (Orubu & Omotor, 2011).

Though, Wang, Zhou, Zhou, and Wang (2011) find an U-shaped curve between economic growth and CO_2 emissions in China during the period 1995 to 2007, which is contradictory to what the EKC hypothesis states. As the turning point of 3287 Chinese Yuan has been attained, the CO_2 emission per capita in China will continue to increase as the economic development is increasing (Wang, Zhou, Zhou, & Wang, 2011). Begum, Sohag, Abdullah, and Jaafar (2015) examine the relationship between CO_2 emissions and GDP growth, energy consumption, and population growth in Malaysia during the period of 1970 to 1980. The authors also find a U-shaped curve and conclude that the EKC curve is not valid (Begum, Sohag, Abdullah, & Jaafar, 2015).

Friedl and Getzner (2003) test the EKC hypothesis using data on Austria during the period 1960 to 1999, and find a clear rejection of the EKC hypothesis as the coefficient for the quadratic term is insignificant. The authors test a number of functional forms and find that the cubic relation between CO_2 and GDP is the most appropriate form. This indicates that a N-shaped relationship exists between emissions and economic growth, meaning that initially CO_2 emissions increase as economic development increases, and after a period of stabilization or reduction of CO_2 emissions, the emissions increase again (Friedl & Getzner, 2003).

Orubu and Omotor (2011) also find a N-shaped relationship for one of their measures for environmental degradation. The authors examine the relationship between per capita income and environmental degradation in Africa. They use two measures for environmental degradation: suspended particulate matter and organic water pollutants. For the latter, they find relatively stronger evidence in favour of the N-shaped relationship (Orubu & Omotor, 2011).

The EKC hypothesis is tested in this study by taking into account the functional form of the relationship between FDI and CO_2 and N_2O emissions.

2.4. Hypotheses

In the previous sections, three theories regarding the relationship between FDI and pollution have been examined. The pollution haven hypothesis basically states the opposite of what the pollution halo hypothesis states, so by testing the pollution haven hypothesis (i.e. a positive relationship between FDI and negative environmental externalities), the pollution halo hypothesis is tested as well (i.e. a negative relationship between FDI and negative environmental externalities). Though, a small differentiation can be made, as the pollution haven hypothesis mainly focuses on the location choice among MNEs, whereas the pollution halo hypothesis focuses on the effects of FDI.

The EKC hypothesis states that the functional form of the relationship between economic development and environment is an inverted U-shaped curve. As FDI forms an essential part of economic development, this hypothesis can be applied to the relationship between FDI and environmental externalities as well. In this study, these three hypotheses are tested.

In this study, there are two main hypotheses, and each hypothesis is divided into two sub hypotheses.

Hypothesis 1: An increase in FDI increases negative environmental externalities in the host country.

Hypothesis 1 tests the pollution haven hypothesis, i.e., a positive relationship between FDI and negative environmental externalities is expected. As mentioned before, by testing the pollution haven hypothesis, the pollution haven hypothesis is tested as well. As there are two measures for negative environmental externalities in the dataset – CO_2 emissions and N_2O emissions – hypothesis 1 is divided into the following sub hypotheses:

Hypothesis 1a: An increase in FDI increases CO_2 emissions.

Hypothesis 1b: An increase in FDI increases N_2O emissions.

Hypothesis 2: The relationship between FDI and negative environmental externalities is an inverted U-shaped curve.

Hypothesis 2 tests the EKC hypothesis. Where hypothesis 1 tests whether the relationship between FDI and negative environmental externalities is positive, hypothesis 2 tests the functional form of this relationship. Similar to hypothesis 1, hypothesis 2 is divided into two sub hypotheses, as there are two measures for negative environmental externalities:

Hypothesis 2a: The relationship between FDI and CO_2 emissions is an inverted U-shaped curve.

Hypothesis 2b: The relationship between FDI and N_2O emissions is an inverted U-shaped curve.

3. Data and Methodology

In this section the data used in this study is described, followed by a description of the dependent and explanatory variables as well as the control variables. This section concludes with an explanation of the methodology used.

3.1. Data

In this study data is obtained from several sources. The data on FDI is obtained from fDi Markets, which is a service from the Financial Times. It is a very comprehensive online database containing data on all cross border Greenfield investments in all countries and sectors worldwide (fDi Markets, 2017). The data on economic indicators is obtained from the World Development Indicators (WDI) database developed by the World Bank Group. This database collects data on development indicators from officially recognized international sources and it includes national, regional, and global estimates (The World Bank, 2017).

An overview of the sources per variable is shown in Table A1 of the Appendix. Table A2 of the Appendix shows the countries that are included in the study and their average Total FDI, GDP per capita, and population growth. The dataset covers the period 2003 to 2012.

3.2. Dependent variables and explanatory variables

Studies on pollution have used different measures for negative environmental externalities, such as CO_2 emission, SO_2 emission, suspended particulate matter, and organic water pollutants (Kim & Adilov, 2012; Fodha & Zaghdoud, 2010; Orubu & Omotor, 2011). In this study, CO_2 emissions are used as one of the measures for negative environmental externalities. CO_2 is a well-known contributor to global warming and data on CO_2 emissions are more readily available than data on other pollutants (Kim & Adilov, 2012).

Additionally, N_2O emissions are used as a measure for negative environmental externalities. N_2O emissions are one of the most important emissions that lead to ozone depletion. Moreover, it is expected to continue as the largest emission throughout the 21st century (Ravishankara, Daniel, & Portmann, 2009). For both dependent variables, the natural logarithm *(ln)* is taken, as CO_2 and N_2O do not appear to follow the normal probability function. By taking the natural logarithm, normality can be achieved and the range of the emissions values is narrowed (Wooldridge, 2012).

Total FDI, measured in million US dollars, is used as explanatory variable. Since Total FDI contains many zeros, which correspond to the cases where investments are not made, this variable should be transformed in order to reduce the influence of extreme observations. Taking the natural logarithm of Total FDI as a transformation of this variable is not desirable as Total FDI often has the value of zero, and taking the natural logarithm results in many missing values. Therefore, the inverse hyperbolic sine transformation (IHS) of total FDI is used. The IHS transformation will behave like a log transformation if the values are large enough (Burbidge, Magee, & Robb, 1988).

Total FDI is the sum of all investments made in the four sectors of FDI. As not all sectors of total FDI have a similar effect on the environment, and in order to analyse the effects of sectoral FDI, analyses are also performed for sectoral FDI. The dataset consists of data on the following sectors of FDI: (1) construction FDI, (2) manufacturing FDI, (3) (natural) resource FDI, and (4) service FDI. Resource FDI is the sum of investments in agriculture, metals and other minerals, gold and silver, and oil and gas. The variables for sectoral FDI are also used in the IHS transformation. The squared term of the IHS transformation of total FDI is also included in the models in order to obtain insight in the functional form of the relationship between FDI and emission levels, i.e. to test the EKC hypothesis (Shafik, 1994). As an increase in (sectoral) FDI does not necessarily have to influence the environmental degradation in the same year, the analyses are also performed using the lags of (sectoral) FDI (Abdouli & Hammami, 2017).

Table 1 contains descriptive statistics of the dependent and explanatory variables of the sample. Table 2 contains descriptive statistics of the explanatory variables of the sample that are used in the additional analyses.

Table 1: Descriptive statistics of the dependent and explanatory variables of the sample (standard deviation between brackets)

	Variable	Mean	Minimum	Maximum
Dependent	CO_2 emissions *(ln)*	0.332 (1.044)	-1.687	2.454
Dependent	N_2O emissions *(ln)*	9.924 (1.672)	7.083	13.283
Explanatory	Total FDI *(IHS)*	6.121 (2.913)	0	10.557

Table 2 Descriptive statistics of the explanatory variables of the sample used in the additional analyses (standard deviation between brackets)

Variable	Mean	Minimum	Maximum
Construction FDI *(IHS)*	0.566 (1.479)	0	7.953
Manufacturing FDI *(IHS)*	3.686 (3.210)	0	9.628
Resource FDI *(IHS)*	3.287 (3.038)	0	9.857
Service FDI *(IHS)*	4.967 (3.452)	0	10.401

3.3. Control variables

Table 3 shows the control variables that are included in the analyses, as they are expected to have an influence on the dependent variables (CO_2 emissions, N_2O and emissions) and the explanatory variables (Total FDI, construction FDI, manufacturing FDI, resource FDI, and service FDI). The natural logarithms are taken of GDP per capita, as this variable does not appear to follow the normal probability function. By taking the natural logarithm, normality can be achieved, as a lognormal distribution appears to fit GDP per capita well. The natural logarithm of this variable is also used, as a nonlinear relationship between this variable and the dependent variables (CO_2 and N_2O) is expected (Wooldridge, 2012).

Table 3: Descriptive statistics of the control variables of the sample (standard deviation between brackets)

Variable	Mean	Minimum	Maximum
GDP per capita *(ln)*	7.314 (0.793)	5.887	9.253
Population growth	1.395 (0.551)	0.464	2.500
Quality of Governance Index	-0.483 (0.374)	-1.177	0.490
Kyoto Protocol entry into force	0.800 (0.402)	0	1
Exports (trade openness)	47.618 (26.580)	12.848	115.373

GDP per capita is a measure for economic growth. Economic growth is expected to be associated with FDI (Lee, 2013). GDP per capita is also regarded as one of the determinants of environmental degradation, as it reflects the structure of production, urbanization, and consumption patterns of private goods (Shafik, 1994). This is also related to population growth: an increase in population growth could be associated with an increase in the consumption of private goods and services.

Several studies have shown the importance of governmental control. E.g., Javorcik and Wei (2004) find that the coefficient of environmental standards is only statistically significant in their study when this variable is accompanied by a proxy for corruption. They conclude that including a variable for corruption is important (Javorcik & Wei, 2004). The Quality of Governance Index by Kaufmann consists of six dimensions of governance: (1) Voice and Accountability, (2) Political Stability and Absence of Violence, (3) Government Effectiveness, (4) Regulatory Quality, (5) Rule of Law, and (6) Control of Corruption (The World Bank Group, 2017). The variable Quality of Governance Index is created by taking the average of the six previously mentioned dimensions of governance.

The Kyoto Protocol is a proxy to measure environmental regulations as well. This Protocol was adopted in Kyoto on 11 December 1997 and commits its parties by setting internationally binding targets for the reduction of emissions (United Nations Framework Convention on Climate Change, 2017). Kim and Adilov (2012) use the ratification of the Kyoto Protocol as a measure, i.e., whether countries have ratified this Protocol. Though, in this study, the entry into force of the Kyoto Protocol is used as a measure for environmental regulations, which was on 16 February 2005 for most countries. The Protocol could only enter into force when at least 55 Parties to the United Nations Framework Convention on Climate Change (UNFCCC) had deposited their instruments of ratification, acceptance, approval or accession of the Protocol (United Nations Framework Convention on Climate Change, 2017). By using the entry into force, the Protocol is expected to have more impact on environmental policies of the Parties than when the ratification of this Protocol is used.

Exports, as a measure for trade openness, is included as trade openness can have an influence on CO_2 emissions. Abdouli and Hammami (2017) find that trade openness has a positive and significant impact on CO_2 emissions in Oman, but their results show that an increase in trade openness in Qatar decreases the CO_2 emissions per capita in that country. They compare their results with other studies and conclude that both results – i.e. a positive impact and a negative impact – are found by several other studies (Abdouli & Hammami, 2017).

The correlation matrix is shown in Table A3 of the Appendix. In general, the correlation coefficients are low, though, some correlation coefficients are relatively high and significant at the 1% significance level. E.g., this is the case for the correlation coefficient between Total FDI and manufacturing FDI (absolute value: 0.799) and between Total FDI and service FDI (absolute value: 0.877). These relatively high coefficients are expected, as manufacturing FDI and service FDI are a form of FDI. If manufacturing FDI or service FDI increases, Total FDI increases as well. Though, Total FDI and manufucaturing FDI and service FDI are not used in the same regression models, therefore, no multicollinearity issues are expected. The correlation coefficient between CO_2 and GDP per capita is relatively high as well (absolute value: 0.797), and these variables are used in the same regression models.

If there is a relatively high correlation between two variables, and both variables are used in the same regression model, this could result in multicollinearity problems. In order to assess whether there are multicollinearity issues in the random effects models, separate regressions are performed with and without the variables that are highly correlated to assess whether the coefficient of the main explanatory variables (FDI, manufacturing FDI, and resource FDI) changes with the inclusion or exclusion of the variables.

In order to test whether multicollinearity issues arise in the pooled Ordinary Least Squares (OLS) regression models, the Variance Inflation Factor (VIF) is used. The VIF measures the extent to which the variance of an estimated regression coefficient is increased due to collinearity (O'Brien, 2007). A mean VIF of 5 and an individual VIF of 10 is considered to be acceptable (O'Brien, 2007). The correlation between the IHS of Total FDI and the IHS of Total FDI squared is very high (almost 1, but not shown in the correlation matrix), which is to be expected, as the variable Total FDI *(IHS)* is used to create the variable Total FDI squared *(IHS)*. As these variables are used in the same regression models, this would increase the mean VIF significantly. Therefore, the mean VIF with FDI squared as well as the mean VIF without FDI squared are shown in the result tables.

3.4. Methodology

In order to specify the models, a 'general-to-specific' specification search is applied. This method allows avoiding the risk of deleting an important variable – along a single search path – that should not be deleted in the final model specification. Additionally, this method minimizes the risk of retaining too many variables that are included in the model as proxies for the missing variables. Including too many variables could result in an over-parameterized final model (Kim & Adilov, 2012).

As the dataset contains panel data, a longitudinal estimation technique is applied. Additionally, pooled Ordinary Least Squares (OLS) models with clustered standard errors are used for comparison purposes. Clustered standard errors are used in order to avoid possible heteroscedasticity problems. In case of heteresocedasticity, the estimated coefficients are not efficient – though they are still unbiased – and the standard errors are biased and inconsistent. In that case, the inferences are no longer valid (Wooldridge, 2012). Moreover, when a pooled OLS model is performed while ignoring the panel nature of the data, the model assumes there is no correlation between errors that belong to the same country. E.g., if CO_2 emissions are higher than average in a certain year for a certain country, given the GDP per capita of this country, it is likely that the CO_2 emissions will be higher than average in other years as well. Using clustered standard errors takes this into account (Hill, Griffiths, & Lim, 2012).

When a longitudinal estimation technique – the random effects model or the fixed effects model – is applied, it can be useful to estimate the pooled OLS estimates for comparison purposes. The results of the random effects model, the fixed effects model and the pooled OLS model can be compared in order to determine the nature of the biases caused by the unobserved effect α_i. In the pooled OLS model the unobserved effect is left entirely in the error term, whereas in the random effects model this effect is left partially in the error term. If the unobserved effect is correlated with one or more explanatory variables in the model, the pooled OLS estimates are biased and inconsistent. Though, even if the unobserved effect is uncorrelated with all explanatory variables in all time periods, the standard errors and tests statistics of the pooled OLS model are generally invalid as they ignore the serial correlation in the composite errors v_{it}, which is often substantial (Wooldridge, 2012).

When choosing between the random effects model and the fixed effects model as longitudinal estimation techniques, the Hausman test can be applied. This test tests for statistically significant differences in the coefficients on the time-varying explanatory variables. The null hypothesis states that the difference in the coefficients is not systematic. In case the null hypothesis is rejected, the random effects model is not consistent, thus the fixed effects model is preferred (Wooldridge, 2012).

Though, conceptually the random effects model is a better fit. The fixed effects model exploits the within dimension of the data, which means that the estimation of the coefficient only depends on the variation of the dependent variable and explanatory variables within a country (Hill, Griffiths, & Lim, 2012). The interest of this study lies in the variation between countries, and not solely in the variation within a country. The random effects model exploits the correlation between the error terms and combines the within and between dimensions efficiently (Wooldridge, 2012). Therefore, the random effects model is used in this study.

The pooled OLS regression models are based on equation (1) for CO_2 emissions and equation (2) for N_2O emissions:

$$CO_2\ emissions\ (ln)_{it} = \beta_0 + \beta_1 * \ FDI\ (IHS)_{1it} + \cdots + \beta_n * x_{nit} + e_{it} \quad (1)$$

$$N_2O\ emissions\ (ln)_{it} = \beta_0 + \beta_1 * FDI\ (IHS)_{1it} + \cdots + \beta_n * x_{nit} + e_{it} \quad (2)$$

where i denotes the country, t the time period, x_n the control variables, and e_{it} the error term for country i at time period t.

The random effects models are based on equation (3) for CO_2 emissions and equation (4) for N_2O emissions:

$$CO_2\ emissions\ (ln)_{it} = \beta_0 + \beta_1 * FDI\ (IHS)_{1it} + \cdots + \beta_n * x_{nit} + v_{it} \quad (3)$$

$$N_2O\ emissions\ (ln)_{it} = \beta_0 + \beta_1 * FDI\ (IHS)_{1it} + \cdots + \beta_n * x_{nit} + v_{it} \quad (4)$$

where i denotes the country, t the time period, x_n the control variables, and v_{it} the composite error term that consists of the error term that captures all unobserved, time-constant factors that affect the dependent variable (α_i) and the idiosyncratic error or time-varying error (u_{it}). The latter represents the factors that change over time and affect the dependent variable. In the random effects model, it is assumed that α_i is uncorrelated with each explanatory variable in all time periods (Wooldridge, 2012).

Additional analyses are performed using the lags of Total FDI and the four variables of sectoral FDI as explanatory variables in the regressions models. The lag of Total FDI shows the amount of Total FDI at T – 1. These lags are included in the additional analyses as an increase in (sectoral) FDI does not necessarily have to influence the environmental degradation in the same year, but the influence could occur in the following year (Abdouli & Hammami, 2017).

In order to test the EKC hypotheses, the squared term of Total FDI is included in the models. Additionally, Total FDI and Total FDI squared are tested for joint significance.

4. Results

In this section the results are discussed. As many analyses are performed, the results of these analyses are discussed in several sections. First, the pooled OLS estimation results and random effects estimation results for hypotheses 1a and 1b are discussed. This is followed by a discussion of the results for hypothesis 1. Afterwards, the pooled OLS estimation results and random effects estimation results for hypotheses 2a and 2b are analysed, followed by an analysis of the results for hypothesis 2.

The additional analyses, i.e. the analyses on sectoral FDI and the lags of Total FDI and sectoral FDI, are discussed in the last section. The tables showing these results can be found in Tables A4 to A7 of the Appendix.

4.1. Results for hypothesis 1a

Table 4 shows the results for hypothesis 1a. The results indicate there is no significant relationship between Total FDI and CO_2 at the 10% significance level (Table 4, Column I and II), so hypothesis 1a is rejected.

GDP per capita is significant at the 1% significance level in both the pooled OLS model and the random effects model, though the coefficient in the latter is smaller. Based on the pooled OLS model, a 1% increase in GDP per capita increases CO_2 emissions by 0.740% (Table 4, Column I), ceteris paribus. In the random effects model, a 1% increase in GDP per capita increases CO_2 emissions by 0.512% (Table 4, Column II), ceteris paribus. This positive association between GDP per capita and CO_2 emissions is in line with the findings of Shafik (1994).

In the random effects model, the dummy variable Kyoto Protocol entry into force is significant at the 1% level, whereas in the pooled OLS model this variable is significant at the 10% significance level. Based on the random effects model, when the Kyoto Protocol has entered into force, CO_2 emissions decrease by 6.3% (Table 4, Column II), ceteris paribus. Trade openness is also significant in the random effects model: a 1 percentage point increase in exports increases CO_2 emissions by 0.6% (Table 4, Column II), ceteris paribus.

Table 4: Pooled OLS (POLS) estimation results and random effects (RE) estimation results for CO_2 emissions, main explanatory variables: Total FDI

Dependent variable: CO_2 emissions (ln)	*POLS: Total FDI (I)*	*RE: Total FDI (II)*
Intercept	-4.784*** (1.490)	-4.001*** (0.523)
Total FDI *(IHS)*	0.053 (0.067)	0.007 (0.006)
GDP per capita *(ln)*	0.740*** (0.184)	0.512*** (0.053)
Population growth	-0.142 (0.238)	0.285 (0.202)
Quality of Governance Index	0.675 (0.607)	0.199 (0.146)
Kyoto Protocol entry into force	-0.268* (0.141)	-0.063*** (0.023)
Exports (trade openness)	0.003 (0.007)	0.006** (0.003)
Adjusted R^2	0.707	
Mean VIF	1.91	
Number of observations	117	117

*** Denotes significance at 1%; ** at 5%; * at 10%
(Clustered standard errors are between brackets)

4.2. Results for hypothesis 1b

Table 5 shows the results for hypothesis 1b. The results of the pooled OLS model indicate there is a significant relationship between Total FDI and CO_2 at the 1% significance level (Table 5, Column I), so the null hypothesis of hypothesis 1b is rejected in the pooled OLS model. A 1% increase in Total FDI increases CO_2 emissions by 0.397% (Table 5, Column I), ceteris paribus. In the random effects model, hypothesis 1b is rejected, as there is no significant relationship between Total FDI and N_2O emissions (Table 5, Column II). This difference in results would indicate that the unobserved effect α_i is relatively important (Wooldridge, 2012).

Unlike the results in Table 4, GDP per capita is not significant at the 1% significance level in the estimated models, though population growth is significant at the 5% significance level in the random effects model. A 1 percentage point increase in population growth decreases N_2O emissions by 34.0% (Table 5, Column II), ceteris paribus. This is not what was previously expected, as a positive relationship between population growth and emissions level was expected.

Table 5: Pooled OLS (POLS) estimation results and random effects (RE) estimation results for N_2O emissions, main explanatory variables: Total FDI

Dependent variable: N_2O emissions (ln)	*POLS: Total FDI (I)*	*RE: Total FDI (II)*
Intercept	10.487***	9.175***
	(2.967)	(0.986)
Total FDI *(IHS)*	0.397***	0.007
	(0.114)	(0.007)
GDP per capita *(ln)*	-0.231	0.130
	(0.445)	(0.114)
Population growth	-0.748	-0.340**
	(0.490)	(0.149)
Quality of Governance Index	-0.388	-0.246
	(0.987)	(0.181)
Kyoto Protocol entry into force	-0.150	0.004
	(0.315)	(0.075)
Exports (trade openness)	-0.008	0.002
	(0.014)	(0.002)
Adjusted R^2	0.560	
Mean VIF	1.91	
Number of observations	117	117

*** Denotes significance at 1%; ** at 5%; * at 10%
(Clustered standard errors are between brackets)

4.3. Results for hypothesis 1

Hypothesis 1 states that an increase in FDI increases negative environmental externalities in the host country. Table 4 and 5 show that an increase in FDI only significantly increases N_2O emissions in the pooled OLS model. There is weak support for hypothesis 1. Hypothesis 1a is rejected and based on the random effects model hypothesis 1b is rejected as well. The null hypothesis of 1b is only rejected in the pooled OLS model. The differences in the results are discussed in section 5.1.

4.4. Results for hypothesis 2a

Table 6 shows the results for hypothesis 2a. The results of the pooled OLS model show there is no significant relationship between FDI and CO_2 emissions at the 10% significance level (Table 6, Column I).

The results of the random effects model show a positive relationship between FDI and CO_2 emissions and this is significant at the 5% significance level (Table 6, Column II). Moreover, the squared term of FDI is significant at the 5% significance level and FDI and the squared term of FDI are jointly significant at the 5% significance level *(p=0.036)*. A 1% increase in FDI increases CO_2 emissions by 0.041%, ceteris paribus. This effect diminishes as FDI increases until the turning point (Total FDI *(IHS)* =5.125[1]) (Table 6, Column II). The results indicate that the relationship between FDI and CO_2 emissions is inverted U-shaped. This is in line with the EKC hypothesis. Based on the random effects model, hypothesis 2a is accepted.

Similar to the results of hypothesis 1a, GDP per capita is significant at the 1% significance level in both the pooled OLS model and the random effects model, though the coefficient in the latter is smaller. Moreover, the dummy variable Kyoto Protocol entry into force and trade openness are significant as well in the random effects model, similar to the results of hypothesis 1a (Table 6, Column II).

[1] This is calculated as follows: |FDI/(2*FDI squared)|=5.125.

Table 6: Pooled OLS (POLS) estimation results and random effects (RE) estimation results for CO_2 emissions, main explanatory variables: Total FDI

Dependent variable: CO_2 emissions (ln)	*POLS: Total FDI (I)*	*RE: Total FDI (II)*
Intercept	-4.482** (1.473)	-4.081*** (0.554)
Total FDI *(IHS)*	-0.081 (0.096)	0.041** (0.016)
Total FDI squared *(IHS)*	0.013 (0.012)	-0.004** (0.002)
GDP per capita *(ln)*	0.719*** (0.186)	0.528*** (0.061)
Population growth	-0.130 (0.217)	0.244 (0.182)
Quality of Governance Index	0.625 (0.631)	0.232 (0.160)
Kyoto Protocol entry into force	-0.293* (0.148)	-0.059** (0.027)
Exports (trade openness)	0.004 (0.008)	0.006** (0.003)
Adjusted R^2	0.717	
Mean VIF (including Total FDI squared)	5.33	
Mean VIF (without Total FDI squared)	1.91	
Number of observations	117	117

*** Denotes significance at 1%; ** at 5%; * at 10%
(Clustered standard errors are between brackets)

4.5. Results for hypothesis 2b

Table 7 shows the results for hypothesis 2b. The results of the pooled OLS model show a significant negative relationship between Total FDI and N_2O emissions (Table 7, Column I). The squared term of Total FDI is significant at the 1% significance level and Total FDI and the squared term of Total FDI are jointly significant at the 1% significance level as well *(p=0.000)*. A 1% increase in Total FDI decreases N_2O emission levels by 0.301% (Table 7, Column I), ceteris paribus. This effect increases as Total FDI increases until the turning point (Total FDI *(IHS)* = 2.181). These results indicate that the relationship between Total FDI and N_2O emissions is U-shaped, unlike the relationship between Total FDI and CO_2 emissions. This is not in line with the EKC hypothesis, but supports the findings by Wang, Zhou, Zhou, and Wang (2011).

Based on the random effects model, the relationship between Total FDI and N_2O emissions is positive (Table 7, Column II), unlike the results of the pooled OLS model. Though, this effect is only significant at the 10% significance level. The squared term of Total FDI is not significant in this model, though Total FDI and the squared term of Total FDI are jointly significant at the 5% significance level *(p=0.040)*. Similar to the results of hypothesis 2a, this would indicate that the relationship between Total FDI and N_2O emissions is inverted U-shaped.

The results of Table 7 indicate that the unobserved effect, which is entirely captured in the error term of the pooled OLS model and only partially in the error term of the random effects model, is relatively important. The estimates of the pooled OLS model might not be valid. Based on the random effects model hypothesis 2b is accepted.

Table 7: Pooled OLS (POLS) estimation results and random effects (RE) estimation results for N_2O emissions, main explanatory variables: Total FDI

Dependent variable: N_2O emissions (ln)	*POLS: Total FDI (I)*	*RE: Total FDI (II)*
Intercept	12.050*** (2.048)	9.257*** (1.031)
Total FDI *(IHS)*	-0.301** (0.126)	0.047* (0.027)
Total FDI squared *(IHS)*	0.069*** (0.018)	-0.004 (0.003)
GDP per capita *(ln)*	-0.344 (0.292)	0.137 (0.114)
Population growth	-0.682 (0.400)	-0.431** (0.208)
Quality of Governance Index	-0.651 (0.696)	-0.223 (0.197)
Kyoto Protocol entry into force	-0.280 (0.201)	0.005 (0.080)
Exports (trade openness)	-0.002 (0.011)	0.001 (0.003)
Adjusted R^2	0.685	
Mean VIF (including Total FDI squared)	5.33	
Mean VIF (without Total FDI squared)	1.91	
Number of observations	117	117

*** Denotes significance at 1%; ** at 5%; * at 10%
(Clustered standard errors are between brackets)

4.6. Results for hypothesis 2

Hypothesis 2 states the following: The relationship between FDI and negative environmental externalities is an inverted U-shaped curve. Table 6 and 7 show the results for hypothesis 2.

Table 6 shows there is no significant relationship between Total FDI and CO_2 emissions in the pooled OLS model, though the results of the random effects model provide support for the EKC hypothesis. The results of the pooled OLS model in Table 7 indicate that the relationship between Total FDI and N_2O emissions is U-shaped, though the results of the random effects model in Table 7 suggest that this relationship is inverted U-shaped. Hence, based on the random effects models hypothesis 2 is accepted. The difference between the pooled OLS estimates and the random effects estimates might be caused by the unobserved effect, which is discussed in section 5.1.

4.7. Results of additional analyses: sectoral FDI and lags of FDI

As mentioned before, not all sectors of FDI have a similar effect on environmental degradation and the effect of FDI on the environment does not necessarily occur in the same year. Therefore, additional analyses are performed using sectoral FDI and the lags of Total FDI and sectoral FDI, i.e., the value of FDI in the previous year (T-1). These results are shown in Tables A4 to A7 of the Appendix.

The results of hypothesis 1a show that Total FDI does not significantly increase CO_2 emission levels. Table A4 shows the results of the pooled OLS model and random effects model with CO_2 emissions as dependent variable and the sectors of FDI as explanatory variables. The results indicate that none of the four sectors of FDI significantly increases CO_2 emission levels. Table A5 shows the results of the regression models with the lag of FDI and of sectoral FDI as explanatory variables. The results suggest that the lag of FDI and the lag of sectoral FDI do not significantly increase CO_2 emission levels either.

The results of hypothesis 1b show that Total FDI only significantly increases N_2O emissions in the pooled OLS model. The results of the pooled OLS model in

Table A6 show that each sector of FDI increases N_2O emissions significantly and that the effects of construction FDI and manufacturing FDI are largest. The pooled OLS model results in Table A7 show that the lag of Total FDI significantly increases N_2O emissions. This is also the case for the sectors of FDI except for the lag of resource FDI. Though, the results of the random effects model show no significant results for the relationship between sectoral FDI and N_2O emissions (Table A6), only for the relationship between the lag of service FDI and N_2O emissions (Table A7, Column X).

5. Conclusion and Discussion

In this section the main findings are discussed. This is followed by an explanation of the academic contribution and the policy implications of this study. Finally, the limitations of this study and recommendations for future research are explained.

5.1. Main findings

This study analyses two aspects of the relationship between FDI and negative environmental externalities: (1) the pollution haven hypothesis, i.e., whether the aforementioned relationship is positive, and (2) the EKC hypothesis, i.e., whether this relationship is inverted U-shaped. Two measures for negative environmental externalities are used in order to perform the analyses: CO_2 emissions and N_2O emissions. FDI is measured as Total FDI and additional analyses use the lags of Total FDI and sectoral FDI: construction FDI, manufacturing FDI, resource FDI, and service FDI.

The results regarding the first aspect indicate that the relationship between Total FDI and the dependent variables is not significant at the 10% significance level. The results of the additional analyses do not show that a significant relationship between sectoral FDI and CO_2 emissions or N_2O emissions exists. Therefore, no clear conclusion can be made regarding the pollution haven hypothesis or the pollution halo hypothesis. The results for the second hypothesis, i.e., the EKC hypothesis, indicate that an inverted U-shaped relationship between Total FDI and negative environmental externalities exists.

Several control variables are included in the regression models, though there is no clear result for the control variables in all models. Though, it is clear that GDP per capita significantly increases CO_2 emissions. This variable is significant at the 1% significance level in all models, though has no significant effect on N_2O emissions.

In several tables, the results of the pooled OLS model differ from the results of the random effects model. The difference between the results of the two models could be due to the difference in the structure of the models. The pooled OLS model is a cross-sectional analysis with observations on different individuals, or in this case different countries, at different points in time. It does not take into account that the same individuals (or in this case: countries) are observed at different points in time, which implicates that the unobserved effect is not captured. The unobserved effect, or unobserved heterogeneity, is a time-constant factor that affects the dependent variable. In this study, this unobserved heterogeneity could also be regarded as country heterogeneity, i.e. the unobserved characteristics of the countries in the sample. The unobserved effect is in the composite error in each time period, and the pooled OLS model ignores this serial correlation (Wooldridge, 2012).

The random effects model does take into account that the same individuals (or in this case: countries) are observed over time and efficiently combines the within and between dimensions between the countries. Moreover, the random effects model takes the unobserved effect into account. The random effects model allows explanatory variables that are constant over time, as this model assumes that the unobserved effect is uncorrelated with all explanatory variables in the model, whether these explanatory variables are time-constant or not (Wooldridge, 2012).

The discrepancy in the results of the random effects model and of the pooled OLS model could indicate that the unobserved effect α_i is relatively important and correlated with the explanatory variables. The results of the pooled OLS model might be biased and invalid, as this model ignores the serial correlation in the error term. Therefore the random effects model is the preferred model in this study and the pooled OLS model serves as robustness check.

5.2. Academic contribution and policy implications

In the past years, the relationship between FDI and environmental effects has been studied frequently. These studies can be divided into three main categories: (1) the pollution haven hypothesis, (2) the pollution halo hypothesis, and (3) the Environmental Kuznets Curve (EKC). Though, empirical studies on the negative environmental effects of FDI provide mixed results (Eskeland & Harrison, 2003) (Kim & Adilov, 2012).

This study aims to examine the relationship between FDI and negative environmental externalities in Asia, as negative environmental externalities have become a greater problem in Asia in the past decade and FDI is regarded as one of the main factors causing environmental degradation (Wang, Zhou, Zhou, & Wang, 2011; Omri, Nguyen, & Rault, 2014; Begum, Sohag, Abdullah, & Jaafar, 2015; Zhu, Duan, Guo, & Yu, 2016).

This study can be used as a foundation for future research, as not many studies on the relationship between FDI and the environment focus solely on the Asian region, even though Asian countries are important host countries for FDI. Future research could extend the dataset by adding more countries and more years of observations.

The results of this study do not provide clear insight in whether the relationship between FDI and negative environmental externalities is positive or negative, therefore it cannot provide direct suggestions for policy makers in their policies regarding attracting FDI. Though, it might be interesting for policy makers to take into account that the effects on emission levels might be different for different sectors of FDI. Additionally, the effect of certain control variables, e.g. GDP per capita differs for different measures of negative environmental externalities. In case of CO_2 emissions, the coefficient of GDP per capita is positive and significant at the 1% significance level, whereas in the models with N_2O emissions as dependent variables, the coefficient of GDP per capita is negative, though not significant at the 10% significance level.

5.3. Limitations and recommendations for future research

This study has several limitations, which could be taken into account and be improved upon in future research. First of all, this study has some limitations regarding the dataset. Even though the dataset was quite extensive, some important information was missing. For example, there was no information on Singapore and Japan, which could be important for the analyses on sectoral FDI, as these countries might be important host countries for service FDI.

Additionally, there was no appropriate measure or proxy for the state of technology, which could have influenced the results, as it is important for the pollution halo hypothesis. The state of technology in a country could be important for the amount of FDI in that country, e.g., a low state of technology might not attract much service FDI. The state of technology could also be important for the emission levels, as it could play a role in the capabilities of firms to use greener technologies. The state of technology is linked with the availability of greener or cleaner technologies. If these technologies do not exist in (some of) the countries in the dataset, it makes more sense that no support was found for the pollution halo hypothesis. This could have been an unobserved effect and might have been captured in the error terms of the pooled OLS model (completely) and the random effects model (partially).

Future research could use a data on a longer period of time. The dataset used in this study only covers ten years. Extending the dataset with more years of observation could provide more insight in the development of FDI and negative environmental externalities. Since the effects of negative environmental externalities are not immediately visible, it might be useful to study the effects over a longer period of time. This would also increase the number of observations, which would allow for more control variables to be included. Moreover, it could make the fixed effects model more appropriate, as the within variation might increase with a dataset that covers a longer period of time. Though, in case of a fixed effects model, time-invariant (control) variables cannot be included. When both the fixed effects model and the random effects model are used, the results of those models can be compared.

Furthermore, the countries in this dataset are quite diverse regarding several aspects, such as size, amount of FDI and GDP per capita. E.g., the effect of FDI on the environment in China and India might differ significantly from the effect in Papua New Guinea. This was partially controlled for by including control variables such as GDP per capita and population growth, though using a fixed effects model might be more suitable as this model assesses the within variation. In future research, and in a more extensive research, the effect of FDI in each country could be examined separately.

6. References

- Abdouli, M., & Hammami, S. (2017). Investigating the Causality Links Between Environmental Quality, Foreign Direct Investment and Economic Growth in MENA Countries. *International Business Review, 26* (2), 264-278.
- Aliyu, M. A. (2005). Foreign Direct Investment and the Environment: Pollution Haven Hypothesis Revisited. *Eight Annual Conference on Global Economic Analysis*, (pp. 9-11). Lübeck, Germany.
- Amri, F. (2016). The Relationship Amongst Energy Consumption, Foreign Direct Investment and Output in Developed and Developing Countries. *Renewable and Sustainable Energy Reviews, 64* (1), 694-702.
- Atici, C. (2012). Carbon Emissions, Trade Liberalization, and the Japan–ASEAN Interaction: A Group-Wise Examination. *Journal of the Japanese and International Economies, 26* (1), 167-178.
- Begum, R. A., Sohag, K., Abdullah, S. M., & Jaafar, M. (2015). CO2 Emissions, Energy Consumption, Economic and Population Growth in Malaysia. *Renewable and Sustainable Energy Reviews, 41* (1), 594-601.
- Burbidge, J. B., Magee, L., & Robb, A. L. (1988). Alternative Transformations to Handle Extreme Values of the Dependent Variable. *Journal of the American Statistical Association, 83* (401), 123-127.
- Cole, M. A. (2004). Trade, the Pollution Haven Hypothesis and the Environmental Kuznets curve: Examining the Linkages. *Ecological Economics, 48* (1), 71-81.
- Di, W. (2007). Pollution Abatement Cost Savings and FDI Inflows to Polluting Sectors in China. *Environment and Development Economics, 12* (6), 775-798.
- Doytch, N., & Narayan, S. (2016). Does FDI Influence Renewable Energy Consumption? An Analysis of Sectoral FDI Impact on Renewable and Non-Renewable Industrial Energy Consumption. *Energy Economics, 54* (1), 291-301.

- Eskeland, G. S., & Harrison, A. E. (2003). Moving to Greener Pastures? Multinationals and the Pollution Haven Hypothesis. *Journal of Development Economics, 70* (1), 1-23.
- fDi Markets. (2017). *fDi Markets.com*. Opgeroepen op 10 10, 2017, van fDi Markets.com: https://www.fdimarkets.com
- Fodha, M., & Zaghdoud, O. (2010). Economic Growth and Pollutant Emissions in Tunisia: An Empirical Analysis of the Environmental Kuznets Curve. *Energy Policy, 38* (2), 1150-1156.
- Friedl, B., & Getzner, M. (2003). Determinants of CO2 Cmissions in a Small Open Economy . *Ecological Economics, 45* (1), 133-148.
- Grossman, G., & Krueger, A. (1993). Environmental Impacts of a North-American Free Trade Agreement. In P. Garber, *The U.S.-Mexico Free Trade Agreement* (pp. 13-56). Cambridge: MIT Press.
- Hill, R., Griffiths, W., & Lim, G. (2012). *Principles of Econometrics. Fourth Edition. International Student Version.* New Jersey: John Wiley & Sons, Inc.
- Hitam, M. B., & Borhan, H. B. (2012). FDI, Growth and the Environment: Impact on Quality of Life in Malaysia. *Social and Behavioral Sciences, 50* (1), 333-342.
- Hoffmann, R., Lee, C.-G., Ramasamy, B., & Yeung, M. (2005). FDI and Pollution: A Granger Causality Test Using Panel Data. *Journal of International Development, 17* (3), 311-317.
- Javorcik, B., & Wei, S.-J. (2004). Pollution Havens and Foreign Direct Investment: Dirty Secret or Popular Myth? *Contributions to Economic Analysis & Policy, 3* (2), 1-32.
- Kaika, D., & Zervas, E. (2013). The Environmental Kuznets Curve (EKC) Theory—Part A: Concept, Causes and the CO2 Emissions Case. *Energy Policy, 62* (1), 1392-1402.
- Kheder, S. B., & Zugravu, N. (2012). Environmental Regulation and French Firms Location Abroad: An Economic Geography Model in an International Comparative Study. *Ecological Economics, 77* (1), 48-61.

- Kim, M. H., & Adilov, N. (2012). The Lesser of Two Evils: An Empirical Investigation of Foreign Direct Investment-Pollution Tradeoff. *Applied Economics, 44* (20), 2597-2606.
- Lee, J. W. (2013). The Contribution of Foreign Direct Investment to Clean Energy Use, Carbon Emissions and Economic Growth. *Energy Policy, 55* (1), 483-489.
- Mielnik, O., & Goldemberg, J. (2002). Foreign Direct Investment and Decoupling Between Energy and Gross Domestic Product in Developing Countries. *Energy Policy, 30* (2), 87-89.
- O'Brien, R. (2007). A Caution Regarding Rules of Thumb for Variance Inflation Factors. *Quality & Quantity, 41* (5), 673-690.
- Omri, A., Nguyen, D. K., & Rault, C. (2014). Causal Interactions Between CO2 Emissions, FDI, and Economic Growth: Evidence from Dynamic Simultaneous-Equation Models. *Economic Modelling, 42* (1), 382-389.
- Orubu, C. O., & Omotor, D. G. (2011). Environmental Quality and Economic Growth: Searching for Environmental Kuznets Curves for Air and Water Pollutants in Africa. *Energy Policy, 39* (7), 4178-4188.
- Ravishankara, A., Daniel, J. S., & Portmann, R. W. (2009). Nitrous Oxide (N2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century. *Science, 326* (5949), 123-125.
- Sadorsky, P. (2010). The Impact of Financial Development on Energy Consumption in Emerging Economies. *Energy Policy, 38* (5), 2528-2535.
- Shafik, N. (1994). Economic Development and Environmental Quality: An Econometric Analysis. *Oxford Economic Papers, 46* (1), 757-773.
- The World Bank Group. (2017). *Worldwide Governance Indicators*. Accessed on 11/11/2017, from Worldwide Governance Indicators: http://info.worldbank.org/governance/wgi/#home
- The World Bank. (2017). *World Development Indicators*. Accessed on 10/10/ 2017, from The World Bank: https://data.worldbank.org/data-catalog/world-development-indicators
- Tobey, J. A. (1990). The Effects of Domestic Environmental Policies on Patterns of World Trade: An Empirical Test. *Kyklos, 43* (2), 191-209.

- United Nations Framework Convention on Climate Change. (2017). *Kyoto Protocol*. Accessed on 10/10/2017, from Kyoto Protocol: http://unfccc.int/kyoto_protocol/items/2830.php
- Wang, S., Zhou, D., Zhou, P., & Wang, Q. (2011). CO2 Emissions, Energy Consumption and Economic Growth in China: A Panel Data Analysis. *Energy Policy, 39* (9), 4870-4875.
- Wooldridge, J. M. (2012). *Introductory Econometrics. A Modern Approach.* Ohio: South-Western.
- Zarsky, L. (1999). Havens, Halos and Spaghetti: Untangling the Evidence about Foreign Direct Investment and the Environment. *Foreign Direct Investment and the Environment, 13* (8), 47-74.
- Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The Effects of FDI, Economic Growth and Energy Consumption on Carbon Emissions in ASEAN-5: Evidence from Panel Quantile Regression. *Economic Modelling, 58* (1), 237-248.

7. Appendix

Table A1: Overview of variables

Variable	Description	Source
CO_2 emissions	CO_2 emissions (metric tons per capita) *CO_2 emissions are emissions from the burning of fossil fuels and the manufacture of cement, including CO_2 produced during the consumption of solid, liquid, and gas fuels and gas flaring.*	World Development Indicators (WDI) database
N_2O emissions	Nitrous oxide emissions (thousand metric tons of CO_2 equivalent) *N_2O emissions are emissions from agricultural biomass burning, industrial activities, and livestock management.*	World Development Indicators (WDI) database
Total FDI	Amount of FDI invested in a country in a year in million US dollars.	fDi Markets *(A service from the Financial Times Ltd.)*
Construction FDI	Amount of construction FDI invested in a country in a year in million US dollars.	fDi Markets *(A service from the Financial Times Ltd.)*
Manufacturing FDI	Amount of manufacturing FDI invested in a country in a year in million US dollars.	fDi Markets *(A service from the Financial Times Ltd.)*
Resource FDI	Amount of resource FDI invested in a country in a year in million US dollars. Resource FDI consists of investments in: agriculture, metals and other minerals, gold and silver, and oil and gas.	fDi Markets *(A service from the Financial Times Ltd.)*
Service FDI	Amount of service FDI invested in a country in a year in million US dollars.	fDi Markets *(A service from the Financial Times Ltd.)*
GDP per capita	GDP per capita in current US dollars. *GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.*	World Development Indicators (WDI) database
Population growth	Annual population growth rate for year t, measured as the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage. *Population includes all residents regardless of legal status or citizenship.*	World Development Indicators (WDI) database
Quality of Governance Index	An index, created by taking the average of the following six dimensions: (1) Voice and Accountability, (2) Political Stability and Absence of Violence, (3) Government Effectiveness, (4) Regulatory Quality, (5) Rule of Law, and (6) Control of Corruption. Higher values correspond to better governance.	Worldwide Governance Indicators (WGI); fDi Markets

Kyoto Protocol entry into force	Dummy variable, indicating whether the Kyoto Protocol entry has been enforced. (1) Yes (0) No	United Nations Framework Convention on Climate Change
Exports (% of GDP) (trade openness)	Exports as a percentage of total GDP in a country. *Exports of goods and services represent the value of all goods and other market services provided to the rest of the world, including the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services.*	World Development Indicators (WDI) database

Table A2: Overview of countries

	Country	Mean Total FDI *(N=10)*	Mean GDP per capita *(N=10)*	Mean population growth *(N=12)*
1	Bangladesh	4.896	537.247	1.404
2	Cambodia	2.218	648.574	1.630
3	China	9.764	3,235.033	0.562
4	India	9.301	1,050.299	1.516
5	Indonesia	8.607	2,140.78	1.355
6	Malaysia	7.935	7,328.009	1.914
7	Mongolia	3.107	1,839.969	1.336
8	Pakistan	5.513	915.5635	2.085
9	Papua New Guinea	3.617	1,169.613	2.399
10	Philippines	7.048	1,721.433	1.806
11	Sri Lanka	4.379	1,855.851	0.755
12	Thailand	7.509	3,783.345	0.623
13	Vietnam	5.686	1,058.188	1.121

**Initially, the dataset contained more Asian/Pacific countries, though countries with less than five observations for Total FDI were removed from the dataset.*
The removed countries are: Fiji, Lao PDR, Maldives, Marshall Islands, Myanmar, Nepal, Samoa, Solomon Island, and Vanuatu.

Table A3: Pearson Correlation Matrix

	CO_2 (ln) (1)	N_2O (ln) (2)	Total FDI (IHS) (3)	Construction FDI (IHS) (4)	Manufac-turing FDI (IHS) (5)	Resource FDI (IHS) (6)	Service FDI (IHS) (7)	GDP per capita (ln) (8)	Population growth (9)	Quality of Governance (10)	Kyoto (11)	Exports (12)
1	1.000											
2	0.282**	1.000										
3	0.443***	0.650***	1.000									
4	0.247***	0.459***	0.409***	1.000								
5	0.543***	0.659***	0.799***	0.484***	1.000							
6	0.273***	0.471***	0.648***	0.345***	0.479***	1.000						
7	0.412***	0.710***	0.877***	0.404***	0.747***	0.423***	1.000					
8	0.797**	0.114	0.430***	0.194**	0.535***	0.231***	0.443***	1.000				
9	-0.268**	-0.369**	-0.240***	-0.135	-0.288***	-0.022	0.352***	-0.247***	1.000			
10	0.704**	-0.047	0.257***	0.189**	0.383***	0.081	0.273***	0.679***	-0.183**	1.000		
11	0.088	0.033	0.098	0.089	0.163*	0.047	0.126	0.326***	-0.080	-0.029	1.000	
12	0.417**	-0.349**	-0.144	-0.073	0.023	-0.177*	-0.126	0.434***	0.119	0.566***	-0.005	1.000

* denotes $p<0.10$
** denotes $p<0.05$
*** denotes $p<0.01$

Table A4: Pooled OLS (POLS) estimation results and random effects (RE) estimation results for CO_2 emissions, main explanatory variables: Construction FDI, Manufacturing FDI, Resource FDI, and Service FDI

Dependent variable: CO_2 emissions (ln)	*POLS: Construction FDI (I)*	*POLS: Manufacturing FDI (II)*	*POLS: Resource FDI (III)*	*POLS: Service FDI (IV)*	*RE: Construction FDI (V)*	*RE: Manufacturing FDI (VI)*	*RE: Resource FDI (VII)*	*RE: Service FDI (VIII)*
Intercept	-5.198** (1.799)	-4.679*** (1.418)	-4.809** (1.712)	-4.975*** (1.372)	-4.014*** (0.531)	-3.959*** (0.488)	-4.068*** (0.531)	-4.037*** (0.525)
Construction FDI *(IHS)*	0.050 (0.067)				0.003 (0.006)			
Manufacturing FDI *(IHS)*		0.051 (0.063)				0.008 (0.006)		
Resource FDI *(IHS)*			0.049 (0.039)				-0.002 (0.004)	
Service FDI *(IHS)*				0.023 (0.067)				0.001 (0.004)
GDP per capita *(ln)*	0.851*** (0.225)	0.746*** (0.180)	0.779*** (0.225)	0.803*** (0.190)	0.516*** (0.056)	0.507*** (0.046)	0.524*** (0.056)	0.518*** (0.053)
Population growth	-0.145 (0.250)	-0.122 (0.231)	-0.185 (0.248)	-0.125 (0.263)	0.302 (0.209)	0.302 (0.210)	0.298 (0.199)	0.301 (0.207)
Quality of Governance Index	0.624 (0.630)	0.630 (0.656)	0.692 (0.559)	0.676 (0.607)	0.197 (0.146)	0.199 (0.160)	0.194 (0.148)	0.192 (0.148)
Kyoto Protocol entry into force	-0.311* (0.165)	-0.293* (0.160)	-0.266 (0.154)	-0.288* (0.148)	-0.059*** (0.020)	-0.062*** (0.023)	-0.063*** (0.020)	-0.061*** (0.021)
Exports (trade openness)	0.001 (0.007)	0.002 (0.007)	0.002 (0.006)	0.001 (0.008)	0.006** (0.003)	0.006** (0.003)	0.006** (0.003)	0.006** (0.003)
Adjusted R^2	0.697	0.709	0.710	0.695				
Mean VIF	1.75	1.88	1.79	1.91				
Number of observations	117	117	117	117	117	117	117	117

*** Denotes significance at 1%; ** at 5%; * at 10%
(Clustered standard errors are between brackets)

Table A5: Pooled OLS (POLS) estimation results and random effects (RE) estimation results for CO_2 emissions, main explanatory variables: lag of Total FDI, lag of Construction FDI, lag of Manufacturing FDI, lag of Resource FDI, and lag of Service FDI

Dependent variable: CO_2 emissions (ln)	*POLS: Total FDI (I)*	*POLS: Construction FDI (II)*	*POLS: Manufac-turing FDI (III)*	*POLS: Resource FDI (IV)*	*POLS: Service FDI (V)*	*RE: Total FDI (VI)*	*RE: Construction FDI (VII)*	*RE: Manufac-turing FDI (VIII)*	*RE: Resource FDI (IX)*	*RE: Service FDI (X)*
Intercept	-4.910*** (1.489)	-5.291** (1.825)	-4.780*** (1.339)	-4.974** (1.735)	-5.037*** (1.422)	-4.189*** (0.582)	-4.237*** (0.621)	-4.173*** (0.618)	-4.226*** (0.624)	-4.258*** (0.622)
Lag of Total FDI *(IHS)*	0.045 (0.073)					0.007 (0.005)				
Lag of Construction FDI *(IHS)*		0.058 (0.075)					0.003 (0.007)			
Lag of Manufacturing FDI *(IHS)*			0.041 (0.068)					0.004 (0.006)		
Lag of Resource FDI *(IHS)*				0.043 (0.042)					0.002 (0.005)	
Lag of Service FDI *(IHS)*					0.026 (0.070)					0.005 (0.003)
GDP per capita *(ln)*	0.762*** (0.187)	0.860*** (0.225)	0.763*** (0.186)	0.798*** (0.223)	0.804*** (0.186)	0.519*** (0.055)	0.529*** (0.058)	0.519*** (0.060)	0.528*** (0.060)	0.528*** (0.057)
Population growth	-0.129 (0.247)	-0.133 (0.254)	-0.122 (0.242)	-0.158 (0.259)	-0.106 (0.268)	0.426* (0.229)	0.433* (0.232)	0.431* (0.231)	0.425* (0.228)	0.447* (0.236)
Quality of Governance Index	0.672 (0.621)	0.605 (0.658)	0.632 (0.670)	0.693 (0.574)	0.663 (0.645)	0.245 (0.175)	0.249 (0.178)	0.246 (0.184)	0.249 (0.173)	0.244 (0.177)
Kyoto Protocol entry into force	-0.265* (0.130)	-0.321* (0.165)	-0.276** (0.126)	-0.245 (0.138)	-0.301 (0.172)	-0.054** (0.022)	-0.055*** (0.021)	-0.052** (0.020)	-0.053*** (0.019)	-0.060*** (0.021)
Exports (trade openness)	0.003 (0.007)	0.001 (0.006)	0.002 (0.007)	0.002 (0.006)	0.002 (0.008)	0.005* (0.003)	0.006* (0.003)	0.005* (0.003)	0.006* (0.003)	0.005* (0.003)
Adjusted R^2	0.699	0.693	0.698	0.702	0.693					
Mean VIF	1.86	1.71	1.87	1.73	1.85					
Number of observations	104	104	104	104	104	104	104	104	104	104

*** Denotes significance at 1%; ** at 5%; * at 10% | (Clustered standard errors are between brackets)

Table A6: Pooled OLS (POLS) estimation results and random effects (RE) estimation results for N_2O emissions, main explanatory variables: Construction FDI, Manufacturing FDI, Resource FDI, and Service FDI

Dependent variable: N_2O emissions (ln)	*POLS: Construction FDI (I)*	*POLS: Manufacturing FDI (II)*	*POLS: Resource FDI (III)*	*POLS: Service FDI (IV)*	*RE: Construction FDI (V)*	*RE: Manufacturing FDI (VI)*	*RE: Resource FDI (VII)*	*RE: Service FDI (VIII)*
Intercept	7.383 (4.223)	11.380*** (2.040)	9.153* (4.648)	10.843*** (2.715)	9.042*** (1.024)	9.265*** (1.024)	8.934*** (0.965)	9.157*** (0.988)
Construction FDI *(IHS)*	0.443** (0.156)				-0.002 (0.011)			
Manufacturing FDI *(IHS)*		0.394*** (0.088)				0.010 (0.007)		
Resource FDI *(IHS)*			0.220* (0.110)				-0.001 (0.007)	
Service FDI *(IHS)*				0.363*** (0.090)				0.008 (0.007)
GDP per capita *(ln)*	0.578 (0.452)	-0.213 (0.308)	0.304 (0.555)	-0.242 (0.422)	0.143 (0.127)	0.119 (0.119)	0.146 (0.121)	0.131 (0.114)
Population growth	-0.764 (0.615)	-0.593 (0.442)	-0.940 (0.620)	-0.461 (0.484)	-0.308** (0.123)	-0.327** (0.147)	-0.270*** (0.090)	-0.322** (0.140)
Quality of Governance Index	-0.855 (1.479)	-0.740 (0.733)	-0.284 (1.570)	-0.446 (0.858)	-0.246 (0.173)	-0.247 (0.193)	-0.232 (0.181)	-0.252 (0.179)
Kyoto Protocol entry into force	-0.495 (0.324)	-0.339 (0.242)	-0.228 (0.445)	-0.227 (0.259)	0.006 (0.074)	0.004 (0.070)	0.009 (0.069)	0.002 (0.076)
Exports (trade openness)	-0.019 (0.016)	-0.013 (0.011)	-0.017 (0.018)	-0.008 (0.012)	0.003 (0.002)	0.002 (0.003)	0.004** (0.002)	0.002 (0.002)
Adjusted R^2	0.385	0.632	0.374	0.609				
Mean VIF	1.75	1.88	1.79	1.91				
Number of observations	117	117	117	117	117	117	117	117

*** Denotes significance at 1%; ** at 5%; * at 10%
(Clustered standard errors are between brackets)

Table A7: Pooled OLS (POLS) estimation results and random effects (RE) estimation results for N_2O emissions, main explanatory variables: lag of Total FDI, lag of Construction FDI, lag of Manufacturing FDI, lag of Resource FDI, and lag of Service FDI

Dependent variable: N_2O emissions (ln)	*POLS: Total FDI (I)*	*POLS: Construction FDI (II)*	*POLS: Manufac-turing FDI (III)*	*POLS: Resource FDI (IV)*	*POLS: Service FDI (V)*	*RE: Total FDI (VI)*	*RE: Construction FDI (VII)*	*RE: Manufac-turing FDI (VIII)*	*RE: Resource FDI (IX)*	*RE: Service FDI (X)*
Intercept	11.255*** (3.377)	7.962 (4.547)	12.912*** (2.294)	9.772* (4.950)	11.201*** (3.035)	9.301*** (1.027)	9.262*** (1.029)	9.457*** (1.212)	9.017*** (0.995)	9.215*** (1.010)
Lag of Total FDI *(IHS)*	0.392*** (0.118)					0.016 (0.011)				
Lag of Construction FDI *(IHS)*		0.508** (0.185)					0.031 (0.023)			
Lag of Manufacturing FDI *(IHS)*			0.401*** (0.100)					0.013 (0.014)		
Lag of Resource FDI *(IHS)*				0.210 (0.118)					-0.001 (0.006)	
Lag of Service FDI *(IHS)*					0.371*** (0.091)					0.022* (0.013)
GDP per capita *(ln)*	-0.305 (0.458)	0.541 (0.472)	-0.416 (0.355)	0.237 (0.555)	-0.258 (0.426)	0.101 (0.121)	0.111 (0.121)	0.088 (0.149)	0.133 (0.122)	0.113 (0.115)
Population growth	-0.792 (0.542)	-0.832 (0.617)	-0.726 (0.477)	-0.943 (0.665)	-0.457 (0.497)	-0.359** (0.141)	-0.312** (0.134)	-0.364** (0.157)	-0.299*** (0.088)	-0.316* (0.162)
Quality of Governance Index	-0.200 (1.106)	-0.787 (1.560)	-0.614 (0.833)	-0.047 (1.670)	-0.413 (0.950)	-0.423 (0.287)	-0.375 (0.256)	-0.419 (0.296)	-0.429 (0.300)	-0.420 (0.286)
Kyoto Protocol entry into force	-0.141 (0.398)	-0.628** (0.283)	-0.220 (0.266)	-0.127 (0.414)	-0.530 (0.334)	-0.008 (0.065)	-0.014 (0.060)	-0.004 (0.067)	-0.004 (0.063)	-0.041 (0.064)
Exports (trade openness)	-0.008 (0.014)	-0.020 (0.016)	-0.010 (0.013)	-0.017 (0.018)	-0.007 (0.012)	0.002 (0.003)	0.002 (0.002)	0.002 (0.003)	0.003 (0.002)	0.001 (0.003)
Adjusted R^2	0.532	0.371	0.595	0.340	0.607					
Mean VIF	1.86	1.71	1.87	1.73	1.85					
Number of observations	104	104	104	104	104	104	104	104	104	104

*** Denotes significance at 1%; ** at 5%; * at 10% | (Clustered standard errors are between brackets)