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FDI and CO_2 Emissions in the ASEAN-5 and India

by

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Abstract: With the tremendous increases in Foreign Direct Investment (FDI) in the last four decades arose the problem of a possible relationship between FDI and carbon dioxide (CO_2) emissions. Scholars have hypothesized that international companies invest in countries with lax environmental regulations to escape high production cost, we call this the *pollution haven hypothesis*. The ASEAN-5, i.e. Indonesia, Malaysia, the Philippines, Thailand, and Vietnam, as well as India are of particular interest as FDI is known for playing an important role in their economic development. However, a lack of studies using recent data in Southeast Asia became apparent. Hence, this study aimed at filling this gap. To achieve this goal, a structural break analysis and a Toda and Yamamoto causality test were conducted for the six countries. The findings were as follow: a relationship going from FDI to CO_2 emissions for India, the reverse for Vietnam and the Philippines, a bidirectional relationship for Thailand, and finally, no relationship for Indonesia and Malaysia. As the relationship is very country-specific, any policy regarding FDI must be implemented with care and special attention should be paid to the transfer of technology as it is key for a positive impact of FDI.

Keywords: FDI, CO_2 emissions, pollution haven hypothesis, Southeast Asia, Toda and Yamamoto causality, structural breaks

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List of Abbreviations

ADF	Augmented Dickey-Fuller test
AIC	Akaike Information Criterion
ASEAN-5	Association of Southeast Asian Nations (includes Indonesia, Malaysia, the Philippines, Thailand and Vietnam in this study)
BIC	Bayesian Information Criterion
BRIC	Brazil Russia India China
CO_2	Carbon dioxide
EDGAR	Emissions Database for Global Atmospheric Research
FDI	Foreign Direct Investment (inflows, except if stated otherwise)
GDP	Gross Domestic Product
ICT	Information Communication Technology
IEA	International Energy Agency
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
SO_2	Sulfur dioxide
UNCTAD	United Nations Conference on Trade and Development
VAR	Vector autoregression

1 Introduction

Foreign Direct Investment (FDI) flows have tremendously increased in the developing world over the last 50 years. FDI to emerging economies has risen from 28.4% in 1970 to 46.9% in 2017 as a share of world FDI (UNCTAD, 2019a). This phenomenon is especially striking in Southeast Asian countries where FDI is known to have been a major driver of economic growth (Anwar & Nguyen, 2011; Quazi, 2007; Quibria, 2002). However, concerns have been raised that FDI inflows might not only have positive effects. A potentially negative impact is air pollution and thus increasing human health risks. These concerns are not fully unfounded knowing that carbon dioxide (CO_2) emissions have been multiplied by a factor of approximately 7 between 1970 and 2014 in East Asia and Pacific (The World Bank, 2019a).

Accordingly, scholars have theorized that industrialized countries might outsource their heavy industries to emerging economies, where environmental regulations are more permissive (Copeland & Taylor, 1994). This phenomenon is called the *pollution haven hypothesis*. Many scholars have been trying to shed light on this hypothesis and mainly three different strategies have been implemented. The first type of research was to test whether environmental regulation stringency is a predictor of FDI flows (Cole & Elliott, 2005; Mani & Wheeler, 1998; Wagner & Timmins, 2009). However, other authors maintain that showing that lax environmental regulation attracts FDI does not directly relate to increased air pollution. As a result, the second set of research tested the relationship between FDI inflows and carbon dioxide emissions instead (Blanco, Gonzalez & Ruiz, 2013; Hoffmann et al., 2005; Zhang & Zhou, 2016). Finally, the third approach consisted of testing the CO_2-GDP-Energy Consumption-FDI nexus (Omri, Nguyen & Rault, 2014; Pao & Tsai, 2011; Zhu et al., 2016). The results of these have been inconclusive. Indeed, the evidence ranges from no relationship, a positive or negative relationship running from FDI to CO_2, a positive relationship running from CO_2 to FDI, to a bidirectional relationship.

Looking specifically at Southeast Asia, the conclusion is identical, the results of the multi-country and one-country analyses of the FDI-CO_2 relationship are pointing to all directions. However, to our knowledge, the data used in studies focusing on Southeast Asia dates back to 2011 at the latest. Therefore, this study aims at taking a fresh look at the FDI-CO_2 relationship in Southeast Asia using new data sets covering all years until 2016. This thesis will endeavor to answer the following research question: What causal relationship exists between FDI inflows and CO_2 emissions in the ASEAN-5 countries and India between 1970 and 2016? In order to answer this question, a structural break analysis and a Granger causality test using the Toda and Yamamoto (1995) procedure were conducted. The sample consisted of India, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam from 1970 to 2016. India was also included due to its similar level of development and its comparable relative share of FDI and CO_2

emissions in GDP to the ASEAN-5. These countries are interesting cases as FDI has been a major driver of economic growth in these countries. Moreover, due to their exceptional growth, the East Asian countries are a model for the developing world and this feature might get replicated in lower-developed countries. Hence, the sustainability of the model is of great interest as it could affect a large amount of countries and jeopardize climate change mitigation programs.

In section 2 of this thesis, a review of the related literature is presented. The following section includes a background of the countries under scrutiny as to their development of FDI and CO_2 emissions. Section 4 and 5 respectively include the description of the data and the method. Finally, the results are presented and discussed in chapter 6. The concluding remarks are presented in section 7.

2 Literature Review

In this section, we start by describing the pollution hypothesis and its counterpart, the pollution halo hypothesis. Previous research is then explored. As highlighted in the introduction, the literature is separated into three approaches. The first looks at the impact of environmental regulations on FDI. Part of this discourse is the relationship from CO2 to FDI. The second approach investigates the other side of the relationship, namely the influence of FDI on carbon dioxide emissions. Finally, the third approach investigates the causal relationship between the two variables within a broader context and includes GDP and energy consumption. The results of these studies are very diverse and reveal evidence for different signs and directions of the relationship (FDI to CO2, CO2 to FDI or bidirectional). Similar conclusions can be applied to studies focusing on the ASEAN-5 and India.

2.1 Pollution Haven Hypothesis

Before diving into the theory of the pollution haven hypothesis, it is important to define exactly what inward FDI entails. Based on the methodological note from the World Investment Report by the United Nations Conference on Trade and Development (UNCTAD) (2018) FDI includes investments made by foreign nationals that “involve a long-term relationship and reflect a lasting interest” (p.3). In other words, FDI signifies investments made by foreign investors that entail a degree of control over the management of the host company (UNCTAD, 2018).

The most prominent hypothesis that supports a relationship between FDI and pollution is called the *pollution haven hypothesis* (Copeland & Taylor, 1994). According to this hypothesis, international firms will relocate their “dirty” industries to countries with laxer environmental regulations to avoid high regulatory compliance costs in their country of origin (Zhang & Zhou, 2016). As a result of this, developing economies would become “pollution havens” and bear the cost of foreign pollution-intensive enterprises[1] (Zhang & Zhou, 2016). In addition, opponents to international trade postulate that one of the potential scenarios is that developing

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[1] A similar phenomenon was observed in Britain and Germany. As early industrializers, they bore the environmental burden, namely pollution and health issues, of producing the goods to satisfy the demand of the rest of Europe (Kander et al., 2017). It is often perceived that Asia is experiencing a similar situation and is often called “the workshop of the world” (Kander et al., 2017, p.33).

countries would try to undercut each other in terms of environmental regulation stringency to attract foreign capital (Copeland & Taylor, 1994).

Grossman and Krueger (1991) defined three channels through which FDI might impact on pollution: the scale effect, the composition effect and the technique effect. The scale effect refers to FDI being a potential engine of growth, and as a result, an increase in FDI inflows might result in increased economic activity (Grossman & Krueger, 1991). The scale effect has negative environmental impacts. The composition effect describes the phenomenon through which FDI influences the composition of industries and might either increase the polluting sectors or less-polluting ones. According to Grossman and Krueger (1991), this channel can have either positive or negative environmental impacts. Finally, the technique effect regards the technology improvements that can enhance energy efficiency and reduce emissions. Its environmental impact is positive (Grossman & Krueger, 1991). If the scale effect and the composition effect, when the shift is towards more polluting sectors, are stronger than the technique effect, we speak of a pollution haven effect.

However, in the reverse case where the technique effect and the composition effect (in case of a shift towards less polluting sectors) surpass the scale effect, we say that we have a *pollution halo* effect. The *pollution halo hypothesis* is the opposite of the pollution haven hypothesis. It predicts that FDI reduces pollution in the developing host country. This hypothesis proposes that multinational companies export their greener technologies to developing countries through FDI and will thus diffuse their more efficient technologies in the host country (Asghari, 2013; Eskeland & Harrison, 2003; Zhang & Zhou, 2016; Zhu et al., 2016). Dasgupta, Laplante and Mamingi (1997) explain that multinational enterprises decide to use their more expensive and greener technologies because highly emitting production might be an indicator of inefficient production techniques to investors, which would hurt their reputation and business in the long-run. Yet, the diffusion of technology is not the only channel through which FDI could reduce pollution. According to He (2006), FDI would also enhance competition in the developing host country, which would prompt local companies to invest in research and development and improve their production efficiency.

2.2 Previous Research

2.2.1 Environmental Regulation and FDI

Scholars have adopted three different methods to test the pollution haven hypothesis and define whether industrialized countries outsource their “dirty” industries to developing countries with laxer environmental regulations. The first approach tests this hypothesis by looking at whether environmental stringency is a predictor of FDI. Cole and Elliot (2005) investigated whether abatement cost in the USA led to outward FDI flows to Mexico and Brazil. The results of their research supported the hypothesis that high abatement costs in the country of origin push firms to outsource their dirty industries. However, their paper highlighted the importance of controlling for the capital endowment as pollution havens are formed in countries with a high capital endowment and lax environmental regulations according to their research. In response to this paper, Wagner and Timmins (2009) adopted an approach where environmental stringency was measured in the host country instead of the home country. They state that this is of high importance as FDI outflows might also be directed to countries with equally strict environmental regulations. In addition, Wagner and Timmins (2009) used the agglomeration of FDI as a control as they believe that capital tends to be concentrated in the same locations. Hence, Wagner and Timmins (2009) show that an agglomeration effect could be mistaken for a pollution haven effect. The authors found support for the pollution haven hypothesis, but only with reservations. Out of the six industries under scrutiny, only the chemical industry illustrated the features of a pollution haven, i.e. environmental stringency predicted the FDI inflows.

While these papers expressed general support to the theory that FDI flocks to emerging economies with lax environmental stringency, other scholars have found no correlation between the two variables. For example, Eskeland and Harrison (2003) state that their evidence of pollution havens is very weak. In a similar fashion to Cole and Elliot (2005), Eskeland and Harrison (2003) tested whether pollution abatement cost in the home country, the USA and France in their study, predicted foreign direct investment in Morocco, Côte d'Ivoire, Venezuela and Mexico. However, the results did not indicate a robust association between the two variables. Mani and Wheeler (1998) also belong to the scholars that believe the evidence in favor of the pollution haven hypothesis is weak. Through a cross-country comparison, they showed that the tendency towards the creation of such havens is limited by the pressures that economic growth brings to developing countries. Such developments include increasingly stringent regulations, higher professional expertise and cleaner production (Mani & Wheeler, 1998). In other words, Mani and Wheeler (1998) unveil that the pollution haven effects are only transient. Finally, Smarzynska and Wei (2003) reveal comparable results. Their study of investment decisions in 24 Eastern European countries revealed that FDI flows are not more likely to move to countries with lax environmental regulations (Smarzynska & Wei, 2003).

The authors cited above have taken multiple approaches to measure environmental regulation stringency. For example, Wagner and Timmins (2009) used data from a survey in which participants were asked to rate the environmental regulation stringency of the country. Smarzynska and Wei (2003) created their own index based on the number of environmental NGOs in the host country and the number of international treaties ratified. However, other scholars, such as MacDermott (2009) used carbon dioxide emissions as a proxy of environmental stringency. The assumption in this method is that raised CO_2 emissions are a consequence of lax environmental regulations (Gökmenoğlu & Taspinar, 2016; MacDermott, 2009; Pao & Tsai, 2011). Based on this reasoning, the pollution haven hypothesis would then predict that countries with high levels of carbon dioxide emissions would appeal to foreign investors. Confirming this hypothesis, MacDermott (2009) showed that firms invest in countries with high pollution emissions. Some scholars that investigate the CO_2-GDP-Energy Consumption-FDI nexus, which is further elaborated below, also found evidence of a relationship running from CO_2 to FDI. For example, Gökmenoğlu & Taspinar (2016), Pao and Tsai (2011) as well as Omri, Nguyen and Rault (2014) found a bidirectional relationship between FDI and CO_2 emissions. They explain the causality link going from CO_2 to FDI through the fact that foreign firms are attracted to the low environmental regulations that come with high emissions. This section explained one side of the relationship between CO_2 and FDI, the dynamics of the second direction are explained in the coming subchapter.

2.2.2 FDI and CO_2 Emissions

Authors from the first set of literature take for granted the link between FDI and CO2 emissions. In their interpretation, if the evidence shows that FDI flocks to countries with lax environmental regulations it must imply an increase in CO2 emissions in the host country. However, FDI enterprises might employ technologies that are more environmentally friendly than domestic firms and would eventually lead to a reduction in pollution as local firms learn and copy their foreign counterparts (Zarsky, 1999). This is the pollution halo effect. In addition, as Grossman and Krueger (1991) highlighted with the three possible channels through which FDI might impact CO_2 emissions, the link between the two variables is far from straight-forward. This highlights that the assumption that FDI leads to more pollution cannot be made. As stated by He (2006), even if the causality link between environmental regulations and FDI flows can be proven, it does not necessarily mean that emissions in the host country will increase as a result of FDI inflows. Therefore, the second set of literature investigated the pollution haven hypothesis by testing the relationship between pollution and FDI inflows. In this approach, the pollution haven hypothesis is accepted when an upsurge in FDI leads to a rise in pollution.

As in the research investigating the impact of environmental regulation stringency on FDI, the results of the studies regarding FDI and CO_2 are very contrasted. Some scholars came to the conclusion that FDI has a positive impact on pollution. For example, Blanco, Gonzalez, and Ruiz (2013) found that FDI inflows to dirty industries led to a rise in per capita CO_2 emissions based on a study in 18 Latin American countries. Their study supports the pollution haven hypothesis but with restrictions. Solely FDI in pollution-intensive sectors had a significant relationship with CO_2 emissions (Blanco, Gonzalez & Ruiz, 2013). Similarly, Hoffmann, Lee, Ramasamy, and Yeung's (2005) study validated the pollution haven hypothesis with limitations. Using panel date from 112 countries over 15-28 years, they concluded that a rise in FDI resulted in an upsurge of CO_2 emissions in low-income countries but not high-income countries (Hoffmann et al., 2005). In other words, the researcher observed that the causality relationship depended on the level of development of the countries. He's (2006) research of China's 29 provinces indicated a small positive impact of FDI on SO_2 emissions, another air pollutant. A 1% increase in FDI results in 0.098% increase in industrial SO_2 emissions based on their model. In addition, through a simultaneous model, He (2006) was also able to identify that the composition effect was an important driver of FDI increasing SO_2 emissions. In fact, the study showed that the pollution-intensive industries gained importance through FDI inflows. Another study that supports the pollution haven hypothesis came from Sapkota and Bastola (2017). Through an investigation of 14 Latin American countries, the authors showed that more FDI inflows led to a rise in CO_2 emissions. Interestingly, the results did not significantly vary across low-income and high-income countries.

Yet, Zhang and Zhou (2016) had contradictory results. Indeed, their research revealed that FDI inflows led to CO_2 reductions in China, supporting the fact that foreign firms bring with them their greener technologies. However, their study indicated that the region mattered as the effect was attenuated in the central and eastern regions. Finally, Asghari's (2013) research also indicated the presence of a pollution halo in six selected countries from the Middle East and North Africa, where increases in FDI led to a reduction in pollution.

Another set of literature that looked into the relationship between FDI and pollution are studies that investigated the CO_2-GDP-Energy Consumption-FDI nexus. Most of these studies aim at identifying the causality link between these variables. For example, Pao and Tsai (2011) who did a Granger causality test on the Brazil-Russia-India-China (BRIC) countries, state that the evidence indicated a bidirectional relationship between FDI and CO_2 emissions. Similarly, Omri, Nguyen, and Rault (2014) showed evidence through dynamic simultaneous panel data models of a bidirectional causality link between FDI and CO_2 emissions for all the panels observed except for the panel of Europe and North Asia. Gökmenoğlu & Taspinar (2016) undertook similar research for Turkey, albeit with a different design. The evidence suggested similar results to the research done by Pao and Tsai (2011) as well as Omri, Neguyen, and Rault (2014), i.e. a bidirectional relationship between pollution and FDI inflows. Lee (2013) narrowed down the nexus and focused specifically on the contribution of FDI to clean energy use, CO_2 emissions and GDP growth. Through panel cointegration tests, the author showed that no relationship could be found between FDI and CO_2 emissions. Moving on to Sarkodie and Strezov (2019), the authors made an interesting finding in their study of the five biggest carbon emitters of the developing world, i.e. China, India, Iran, Indonesia and South Africa. They found evidence of a pollution haven hypothesis for China, India, Iran and South Africa but only until a certain level of FDI. In fact, CO_2 emissions rise until a certain threshold of FDI and then start decreasing. As a result, this shows that there is room for improvement in terms of pollution once a sustained level of FDI is achieved (Sarkodie & Strezov, 2019). For Indonesia, the authors showed that the effect of FDI on CO_2 remains positive, i.e. an increase in FDI results in an upsurge of CO_2 for all levels of FDI.

2.2.3 Research on FDI-CO_2 in the ASEAN-5 and India

If we look at the research specific to the countries of interest, multi-countries and single-country analyses can be encountered. The multi-countries analyses that contain some of the countries under scrutiny are either of Asia as a whole or focused on the ASEAN countries. For example, Linh and Lin's (2015) study of the twelve most populous Asian countries, which included India and all ASEAN countries except Malaysia, indicated a long-run unidirectional relationship from CO_2 emissions to FDI. This is interesting as most of the studies tend to indicate a causality link running either from FDI to pollution or a bidirectional relationship. However, it must be said that another article by Linh and Lin (2014) that focused solely on Vietnam revealed similar results. The scholars used a cointegration and a Granger causality approach (Linh & Lin, 2014). It revealed that the causality link between the two variables was unidirectional from CO_2 emissions to FDI. Zhu, Duan, Guo & Yu (2016) investigated the CO_2-GDP-Energy Consumption-FDI nexus in the ASEAN-5 countries, which included Indonesia, Malaysia, the Philippines, Singapore and Thailand in their definition. They implemented a panel quantile regression model, which revealed that FDI had a negative impact on CO_2 emissions in high-emitting nations. Their article supported the pollution halo hypothesis. Yet, Baek (2016), who applied a pool mean estimator to the same panel of five countries, drew the inverse conclusion. Their study showed that FDI had a detrimental effect on the environment and supported the pollution haven hypothesis. Another attempt at studying the CO_2-GDP-Energy Consumption-FDI nexus in the ASEAN-5 countries was made by Chandran and Tang (2013). Using cointegration and Granger causality methods on each country, they determined that in Thailand and Malaysia FDI inflows Granger caused CO_2 emissions in the long run. By contrast, Indonesia had a bidirectional causality link between the two variables while Singapore and the Philippines only had a short-run relationship running from FDI to CO_2 emissions. Chandran and Tang's (2013) results for Malaysia were substantiated by Lau, Choong, and Eng's (2014) single country analysis. Indeed, their article also reveals a Granger causality link going from FDI to CO_2 emissions (Lau, Choong & Eng, 2014). Yet, an article written by Lee (2009) is partially contradicting these results. The scholar's study indicated only a short-run causal relationship from FDI to environmental degradation while the long-run relationship between the two variables does not appear to be significant. Looking at India specifically, a study done by Acharyya (2009) on the FDI, growth and environmental degradation nexus indicated a large long-run relationship between FDI flows and pollution. These results are to a large extent in line with Sarkodie and Strezov (2019) who highlighted that India showed evidence of a pollution haven, albeit, as mentioned above, their article stated that FDI had a positive impact on carbon emissions only until a threshold of FDI.

3 Background

The general background is provided, followed by a description of the development of FDI and CO2 emissions in the six countries of interest. It shows that the countries are similar in relative terms be it in development level, FDI inflows or CO_2 emissions. Moreover, the countries have comparable temporal dynamics in FDI, with the end of the 80s playing a central role.

3.1 General Context

The sample of countries presents similar levels of development. In fact, they currently all belong to middle-income countries based on the definition of the Organization for Economic Cooperation and Development (OECD) (2018). Malaysia and Thailand belong to the upper middle-income countries with a GDP per capita in 2017 of 11,528.34 2010 USD and 6126.24 2010 USD respectively. The rest of the nations, i.e. India, Indonesia, the Philippines and Vietnam, are part of the lower middle-income group (OECD, 2018). Figure 1 reveals that their GDP per capita in 2017 ranges from approximately 2,000 2010 USD in India and Vietnam to approximately 4,000 2010 USD in Indonesia. Comparing these countries internationally, India and Vietnam have similar development levels to Bolivia, Thailand to Peru and Malaysia to Argentina (UNCTAD, 2019b). The countries of interest are very well known for their incredible growth rates. According to Hanushek and Woessmann (2016), East Asia had an average growth rate of 4.5% between 1960 and 2016. East Asians are nine times better off as two generations ago while Latin Americans are only 2.5 times as prosperous (Hanushek & Woessmann, 2016).

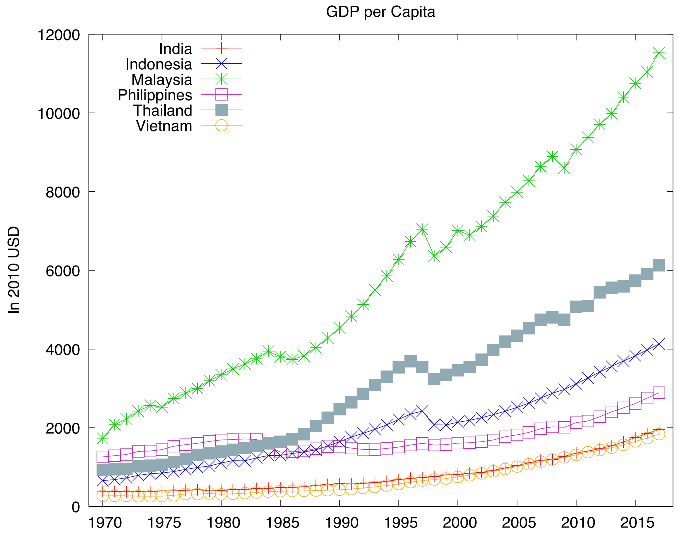

Figure 1: GDP per Capita (UNCTAD, 2019b)

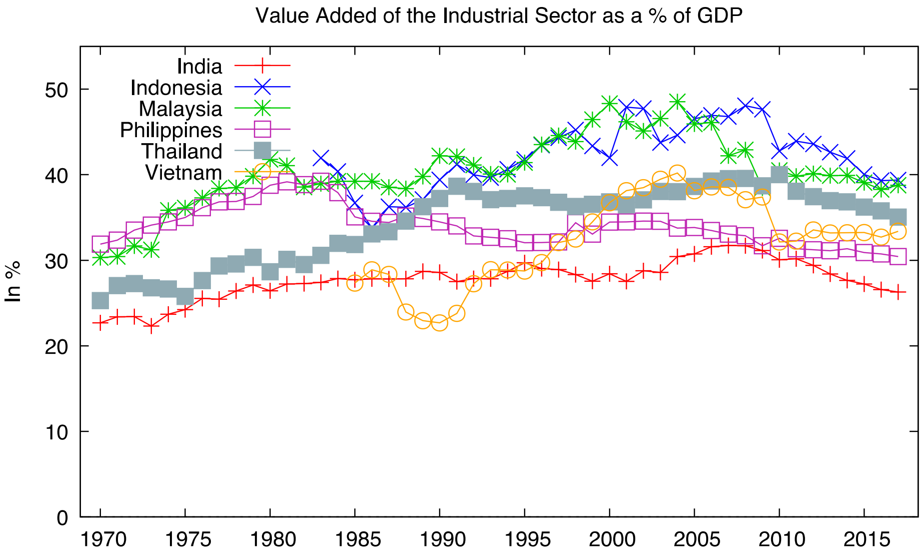

Figure 2: Value Added of the Industrial Sector as a percentage of GDP (The World Bank, 2019b)

In terms of the size of the industrial sector, the countries are on all shades of the spectrum. For example, Malaysia and Indonesia had a share almost reaching 50% of GDP at the beginning of the 2000s as reveals figure 2. By contrast, India has remained below 30% most of the last 50 years. The Philippines, Thailand and Vietnam remained in the middle of these two extremes. Overall, we can observe an upward trend in all of the countries, except the Philippines, until the beginning of the 2000s. This would indicate a structural transformation from an agrarian economy towards an industrial one. Since then the trend has been decreasing. This could be an early sign of a transition to a service economy.

3.2 Foreign Direct Investment

Foreign capital played an important role in this economic success. FDI was a key feature of the East Asian growth model but was particularly exploited by Southeast Asian economies (Quibria, 2002, pp.19–20). Indeed, Southeast Asian countries are known for their special open door policies with regards to foreign capital (Quazi, 2007). FDI inflows allowed the ASEAN countries to acquire mature foreign technologies, which ultimately fostered growth (Quibria, 2002, p.26; Weiss, 2005). This phenomenon started gaining momentum, especially in the late 80s, following the 1985 Plaza Accord (Quibria, 2002, pp.19–20). This agreement led to a broad currency revaluation in Asian countries, which resulted in new capital inflows in Southeast Asia coming from Japan, Taiwan and South Korea (Quibria, 2002, p.20). The graph below illustrates that FDI inflows in the ASEAN countries started taking off between 1985 and 1990, with Vietnam and Indonesia being the latecomers.

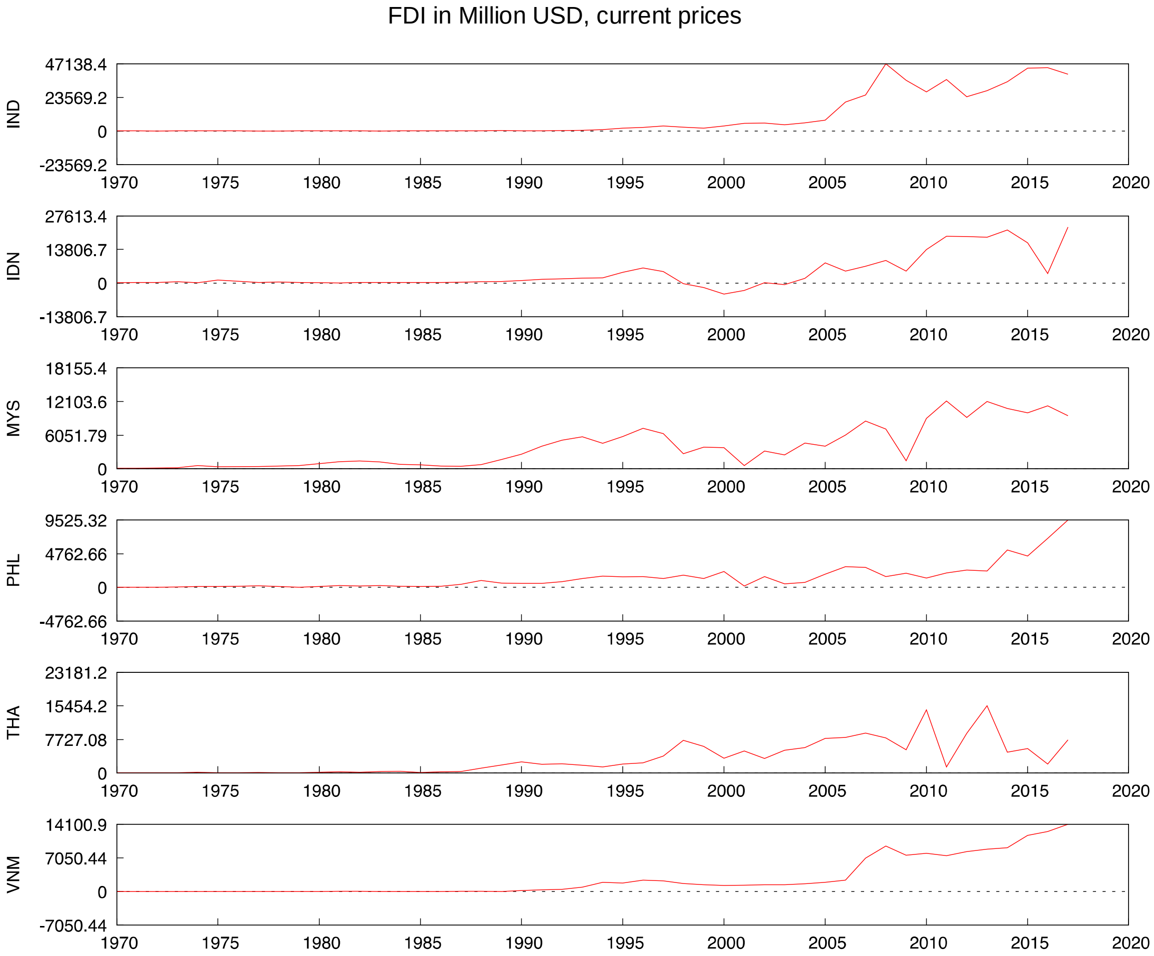

Figure 3: FDI in Million USD, Current Prices (UNCTAD, 2019a)

Focusing on Malaysia, the country stands out in the sense that it is the only one that benefitted from some FDI inflows already starting from the 70s. Like its peers, the Malaysian government used to implement an import substitution policy (Athukorala & Menon, 1996). However, a decisive shift away from a closed trade policy could be observed in the sixties. Already in 1968, the Malaysian government put incentives in place to attract FDI and eventually promote exports, a necessary action due to the internal market saturation for manufactured goods (Athukorala & Menon, 1996). In addition to the appealing incentives, the Malaysian stable macro environment and the industrial policies oriented towards the export of manufactured goods, especially electronics, were extremely appealing for foreign industrial firms (Athukorala & Menon, 1996). The result is that Malaysia is the second ASEAN country with the highest FDI stock per GDP ratio after Vietnam (UNCTAD, 2019a). However, in the last ten years, the ratio of FDI flow to GDP has been stabilizing around 2 and 3% except for a dip in 2009 as can be observed in figure 4. In addition, the industrial policy led to a concentration of FDI in the manufacturing sector (Choong & Lam, 2010).

On the other side of the spectrum lies Indonesia and the Philippines. Compared to Malaysia, Thailand and Vietnam, the Indonesian ratio of FDI to GDP remains comparatively small. This can be explained by the restrictive policies concerning foreign capital that were in place until the end of the 80s (Sjöholm, 2017). If we compare this to Malaysia who started openings its border to foreign capital in 1968, Indonesia is 20 years late on the agenda. Nonetheless, after the Plaza Accord, Indonesia started implementing industrial policies similar to Malaysia in order to attract FDI destined to boost exports of manufactured goods (Wie, 2005). Following the new industrial policy, Indonesia experienced an upsurge in FDI inflows at the beginning of the 90s. These flows were mainly coming from Northeast Asian states such as Taiwan and South Korea and were, as a rule, export-oriented (Wie, 2005). As for Malaysia, this resulted in the expansion of the export of manufactured products. Indonesia, however, was heavily impacted by the Asian financial crisis and the political turmoil that followed (Sjöholm, 2017). As a matter of fact, the country saw extremely large divestments by foreign firms between 1998 and 2003, with negative FDI inflows every year except for 2002 (figure 3). Nevertheless, the country recovered fairly quickly. By 2005 FDI surpassed the pre-crisis levels. Since then, the country saw dramatic growth in FDI, especially between 2009 and 2011 when the flows were multiplied by a factor of five. Sjöholm (2017) attributes this development to a form of catch-up from previously low flows due to restrictive policies and to a global increase of FDI flows.

The Philippines for its part also saw a slight rise at the end of the 80s. In 1980, the country attempted an economic liberalization and endeavored to adopt industrial policies meant to foster investments and exports, similar to the ones Indonesia and Malaysia put in place (Aldaba, 1994). However, the outcome was not as successful, mainly due to political and economic turmoil as stated by Aldaba (1994). Consequently, in contrast to other countries, the FDI flows

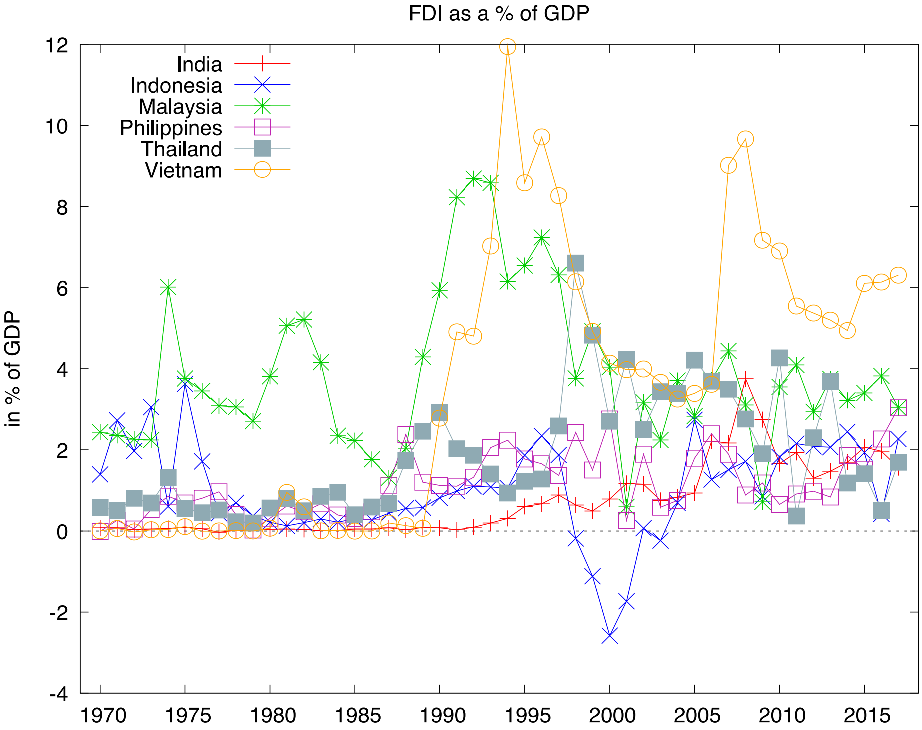

Figure 4: FDI as a Percentage of GDP (UNCTAD, 2019a)

fluctuated without following a precise pattern until 2013. However, between 2013 and 2017, the Philippines's FDI almost quadrupled. Overall, the Philippines have relatively low FDI inflows compared to its peers, especially Malaysia, Vietnam and Thailand (Aldaba, 1994). Looking at the destined sector of the flows, according to Aldaba (1994), 53% were directed to the manufacturing sector in 1993. Based on the preliminary values from the Philippine central bank for 2018, the share of FDI going to manufacturing was 47.72%. It is safe to say that the manufacturing sector played an important role in Philippine FDI.

Due to its conflictual history, Vietnam was naturally a latecomer like Indonesia. Vietnam only started opening its economy in 1986 with the reform policy called *Doi Moi* (Anwar & Nguyen, 2011). In 1987, the Vietnamese government implemented a new policy regarding foreign capital that was once again similar to Malaysia and Indonesia. It aimed not only at increasing the FDI inflows but also at acquiring foreign technology and promoting exports (Anwar & Nguyen, 2011). It resulted in the first surge in 1990, then the flows stabilized until 2006, suddenly almost tripled between 2006 and 2007, stabilized again for a few years to rise steadily again between 2015 and 2017. For the last ten years, Vietnam has been the biggest beneficiary of FDI in relative terms out of the five ASEAN countries. As a matter of fact, its ratio of FDI per GDP has remained between approximately 5 and 10% since 2007 while the other countries have had a ratio of 1 to 4% approximately as can be appreciated in figure 4. The main sector that benefitted from foreign investments was the industrial sector (Vu, Gangnes & Noy, 2008).

Moving on to Thailand, the Thai government started very early to promote FDI. Already in 1954, it implemented an Investment Promotion Act (Ngo, 1992). However, the act was hardly effective due to its complexity and lack of clarity (Ngo, 1992). Therefore, FDI was fairly modest until the mid-80s. Nonetheless, between modifications of the act and an evolving national plan that aimed at boosting FDI inflows destined to the export of manufactured products, the Thai government was able to attract very large flows from abroad (Ngo, 1992). Indeed, in the second half of the 80s Thailand started experiencing rapid FDI growth as can be seen in figure 3. The Plaza Agreement also played in their favor and brought funds from Korea, Taiwan, Singapore and Hong Kong (Jansen, 1995). Unfortunately, Thailand lost momentum with the Asian financial crisis. Yet, by 2005 the inflows of foreign capital were back to its pre-crisis levels. However, between 2005 and 2017, the inflows were extremely volatile with extreme plunges in 2012 and 2016 when flows decreased by a factor of 10 and 7 respectively compared to the previous year as can been observed in figure 3. In terms of relative numbers, Thailand has generally been in the upper part of the group together with Vietnam and Malaysia since the end of the 20th century. However, as mentioned the inflows have been very volatile in the last ten years, which was reflected in the relative numbers. Regarding the sectors of destination, until the end of the 70s, FDI went mostly to domains under import substitution industries, such as textiles and automobile (Kohpaiboon, 2003). In the 80s, there was a shift towards light manufacturing industries (Kohpaiboon, 2003). In 2017 and 2018, the biggest sector benefitting from FDI was still the industrial sector with 43% of the flows (Bank of Thailand, 2019). More specifically, within the industry, the automobile and the electronic manufacturers were the ones receiving most of the capital (Bank of Thailand, 2019).

India is a bit of a different story. Nevertheless, in terms of development, it is very close to the Philippines, the lowest ASEAN country of the cluster in GDP per capita as indicates figure 1. Compared to its Asian counterparts, India has been historically very closed off to foreign capital. It is only in 1991 that the Indian government started liberalizing trade and investment (Acharyya, 2009). From then on until 2005, India experienced moderate growth in its FDI flows, the annual amount slowly catching up to Vietnam, Malaysia and Thailand in absolute terms (figure 3). Yet, figure 2 shows that in between 2005 and 2008 FDI inflows exploded going from 7.6 billion USD to 47.1 billion USD. With this, India largely overtook the ASEAN countries in absolute values. Nevertheless, if we inspect the relative amounts in figure 4, its FDI per GDP ratio is similar to Indonesia and the Philippines. An important difference to ASEAN countries is the goal of opening up to FDI has not been centered on exports of manufactured products (Venkatesan, 2018). The objective has been more general, such as help farmers, create employment opportunities and reduce inflation (Venkatesan, 2018). In addition, the sector profiting the most from the capital flows was the service sector, with the IT companies playing an important role (Venkatesan, 2018).

In a nutshell, the countries have fairly similar temporal dynamics, with the end of the 80s being key in terms of liberalization of foreign capital. In terms of the magnitude, we have discrepancies among the countries under observation, with India being far above the five other countries in absolute terms, followed by Indonesia and Vietnam in 2017. Nonetheless, in relative terms, the countries have been fairly similar in the last 20 years, except for Vietnam which has an FDI inflow to GDP ratio more elevated. If we look at the per capita values, a similar conclusion can be drawn although FDI is relatively more intense in Malaysia. FDI was generally used for similar purposes: acquiring mature technologies and boost exports of manufactured goods except for India that had more general goals. Finally, the sector that received most of the flows was the industrial sector in all ASEAN countries, excluding India where the service sector has been the biggest beneficiary of foreign capital.

3.3 CO_2 Emissions

Carbon dioxide (CO_2) is one of the most relevant forms of greenhouse gases. Carbon dioxide creates a layer in the atmosphere which traps heat and ultimately leads to global warming and climate change (Rockström et al., 2009). CO_2 emissions are commonly used to define goals in international agreements, for example in the Paris Agreement in which most countries set themselves objectives in terms of CO_2 emissions (United Nations, 2016). Furthermore, other greenhouse gases, such as ozone, methane, and nitrous oxide, are commonly converted to carbon dioxide equivalents (CO_2e or CO_2-eq) according to their relative global warming impact. This illustrates how widespread the concept of carbon dioxide emissions has become.

Looking at the absolute carbon emissions in the ASEAN countries and India in figure 5, India is the biggest emitter due to its much larger population and industry. As a matter of fact, India

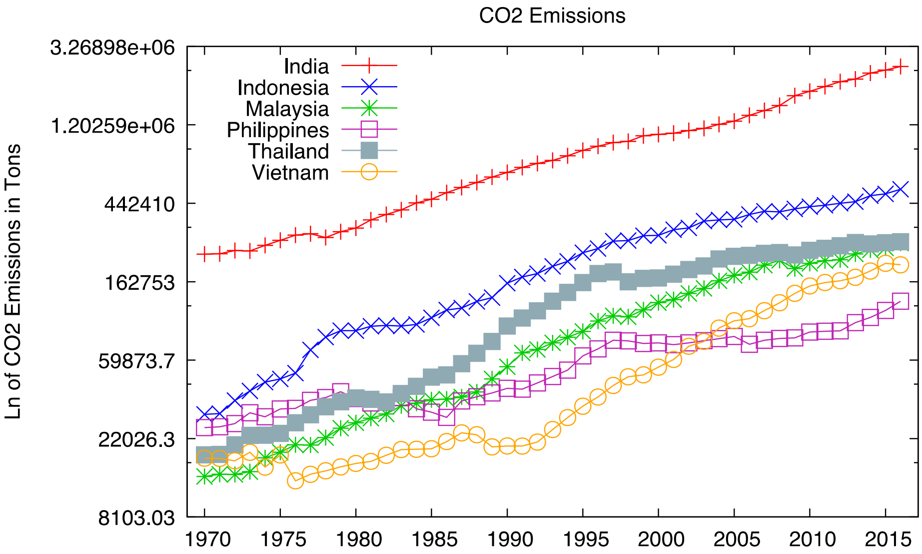

Figure 5: Natural Logarithm of Carbon Dioxide Emissions in Tons 1970-2016 (Muntean et al., 2018)

is the fourth largest emitter in the world (Muntean et al., 2018). If the values are taken in per capita terms the picture is much different as illustrates figure 6. In fact, India has then similar levels of CO_2 emissions to Indonesia and Vietnam. By contrast, Malaysia has much higher per capita CO_2 emissions, effectively around four times the amount of its peers as highlights figure 6. Internationally, Malaysia has similar levels of carbon dioxide emissions to the average of EU-28 and China (Muntean et al., 2018). This shows that the sample of countries is composed of relatively low emitters except for Malaysia.

However, the fact that the sample of countries consists of relatively low emitters must not be taken lightly. Figure 5 reveals that the emissions have been constantly rising in the last four decades. The most important sources of CO_2 emissions in Southeast Asia has been electricity and heat production as well as transportation (Lee et al., 2013). These three elements heavily rely on coal production, natural gas and oil powered systems (Kumar, 2016). Electricity and heat production, as well as transportation, are the domains that have seen the most significant growth across all countries including India (Muntean et al., 2018, pp.117, 118, 143, 173, 212, 231). The sharp growth in these domains can be explained by four major phenomena: economic growth, industrialization, population growth and the Information Communication Technology (ICT) revolution (Lee & Brahmasrene, 2014; Lee et al., 2013). In India, primary energy supply is the major contributor to the growing CO_2 emissions, out of which the coal consumption was the most important driver (Muntean et al., 2018, p.11). Oil consumption also played an important role, however, its contribution was not as extensive as its share of the total primary supply is 24.3% compared to a 42.6% for coal (Muntean et al., 2018, p.11).

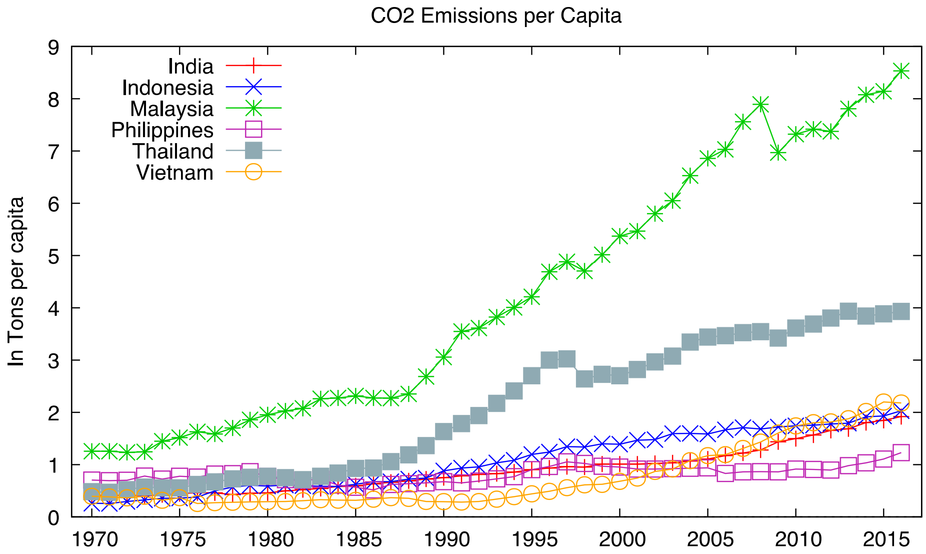

Figure 6: Carbon Dioxide Emissions per Capita, 1970-2016 (Muntean et al., 2018)

4 Data

This section defends the choice of variables and data sources. In addition, the summary statistics for the two variables of interest are provided for each country.

4.1 Source Material

The data employed in this study are time series starting in 1970 and ending in 2016 for India, Indonesia, Malaysia, the Philippines, Thailand and Vietnam. The two variables of interest are inward FDI per capita and CO_2 emissions per capita. Inflows of FDI per capita were taken from UNCTADstat (UNCTAD, 2019a), a database developed by the United Nations Conference on Trade and Development (UNCTAD). This department of the United Nations collects the data mostly from the national banks of the countries and the IMF. In most countries, data is unavailable before the 90s. As a result, UNCTAD makes its own predictions by accumulating flows since 1970. However, it was defined as the best source in terms of quality, completeness and comparability. Another possible source would have been the World Development Indicators by the World Bank (2019c). However, the data is partly taken from UNCTADstat itself. The data represents the net inflows of foreign direct investments that can occur in three forms: 1) equity capital, 2) reinvested earnings or 3) intercompany loans (UNCTAD, 2018).

CO_2 emissions were chosen as a proxy for pollution. While there are multiple other air pollutants such as SO_2 and NO_x, CO_2 is commonly used in the literature due to its role in global warming and its use as target in international agreements (Acharyya, 2009; Blanco, Gonzalez & Ruiz, 2013; Chandran & Tang, 2013; Hoffmann et al., 2005; Zhang & Zhou, 2016). Moreover, Hoffmann et al. (2005) state that CO_2 has a correlation coefficient above 0.95 with both SO_2 and NO_x, which confirms that taking CO_2 as a proxy for pollution is valid. Finally, the data for CO_2 emissions is readily available and of reliable quality (Hoffmann et al., 2005).

This study used time series of CO_2 emissions from the Emissions Database for Global Atmospheric Research (EDGAR), a joint research center under the directorate of the European Commission. The chosen dataset was called EDGARv4.3.2_FT2016, which was published by Muntean et al. (2018). Regarding the measurement of CO_2 emissions, EDGAR computes CO_2 emissions based on fossil fuel combustion of coal, oil and gas coming from fossil fuel use, industrial processes or product use (Muntean et al., 2018). For this, it uses mainly energy balance statistics supplied by the International Energy Agency (IEA). The OECD also provides statistics regarding carbon dioxide emissions. However, the time span offered only went as early as 1990. In addition, it did not contain the countries that are under scrutiny in this study.

By contrast, the Carbon Dioxide Information Analysis Center contained all nations necessary. However, as the organization ceased its activity in September 2017, the data only goes until 2014, while EDGAR offered data until 2016. As offering a fresh eye on the topic in Southeast Asia was a central part of the motivation of this study, the data gathered by EDGAR seemed more legitimate.

4.2 Descriptive Statistics

In this study, both linear and logged values were used. The linear variables, i.e. FDIperCapita and EmisperCapita, were used only in the first part of the analysis, while the logged values were present in both parts. The variables were logged because the models used assume normality of the residuals and logging values are known to help with this potential issue. However, the FDI series of India, Indonesia, the Philippines, and Vietnam contained negative values in their linear form. Hence, before the variables were transformed into logarithms, a constant was added (0.1 for India, the Philippines and Vietnam, 22 for Indonesia). This was considered as a valid procedure as the method used in the subsequent part of the study is based on trends and does not require the interpretation of coefficients. Therefore, the addition of a constant should not impact the results negatively.

Table 1: Descriptive Statistics

Country	Variable	Nbr of observation	Mean	Median	Minimum	Maximum	Standard deviation	5% percentile	95% percentile
India	FDIperCapita	46	7.2521	0.57572	-0.055436	39.346	11.478	0.0146	33.633
	l_FDIperCapita	46	0.25793	-0.39197	-3.1108	3.6749	2.0983	-2.1691	3.5185
	EmisperCapita	46	0.90266	0.82752	0.40591	1.9194	0.4364	0.41314	1.8301
	l_EmisperCapita	46	-0.55256	-0.92904	-1.355	0.78811	0.7161	-1.2841	0.7476
Indonesia	FDIperCapita	46	15.652	4.6518	-21.422	85.487	25.172	-11.803	77.744
	l_FDIperCapita	46	3.4042	3.2829	-0.54883	4.6774	0.79999	2.2937	4.6026
	EmisperCapita	46	1.0765	1.0366	0.25678	2.0308	0.55437	0.27451	1.9245
	l_EmisperCapita	46	-0.089155	0.03596	-1.3595	0.70842	0.61577	-1.2947	0.65468
Malaysia	FDIperCapita	46	157.97	122.73	8.7005	425.97	128.55	9.4506	390.09
	l_FDIperCapita	46	4.5847	4.81	2.1634	6.0544	1.1232	2.2447	5.9648
	EmisperCapita	46	4.2335	3.8232	1.2325	8.5337	2.4302	1.2505	8.1148
	l_EmisperCapita	46	1.2567	1.3411	0.20903	2.144	0.64139	0.22353	2.0937
Philippines	FDIperCapita	46	14.53	9.4052	-0.029046	66.929	14.344	0.12558	49.163
	l_FDIperCapita	46	2.0188	2.2518	-2.6457	4.2051	1.4626	-1.4935	3.893
	EmisperCapita	46	0.8233	0.82895	0.51733	1.2323	0.15113	0.58453	1.0864
	l_EmisperCapita	46	-0.21109	-0.1876	-0.65908	0.20885	0.18551	-0.53753	0.082619
Thailand	FDIperCapita	46	50.431	32.924	1.0237	227.36	56.485	1.1722	185.5
	l_FDIperCapita	46	2.9619	3.4942	0.023441	5.4265	1.677	0.15877	5.2002
	EmisperCapita	46	2.0921	2.1724	0.4732	3.9366	1.2707	0.49949	3.9143
	l_EmisperCapita	46	0.49765	0.77583	-0.74824	1.3703	0.7514	-0.69476	1.3646
Vietnam	FDIperCapita	46	28.012	12.766	-0.019539	133.24	39.879	-0.0046199	119.85
	l_FDIperCapita	46	1.1367	2.5546	-2.52	4.8929	2.8378	-2.3503	4.785
	EmisperCapita	46	0.75623	0.39493	0.25796	2.1992	0.60876	0.27691	2.1134
	l_EmisperCapita	46	-0.55256	-0.92904	-1.355	0.78811	0.7161	-1.2841	0.7476

5 Methods

In this chapter, the methodology employed is described. Two analyses are utilized. The first is a structural break analysis, which is a primary exploration of the direction and sign of the relationship between FDI and CO_2 emissions. The second analysis is done through the Toda and Yamamoto (1995) procedure for Granger causality.

5.1 Structural Break Analysis

This study contains two stages. In the first stage, an analysis of the structural breaks of the time series of FDI per capita and CO_2 emissions per capita was done for each country. This analysis was inspired by Ben-David and Papell (2000), which aimed at analyzing common periods of slowdowns or growth among the G7 countries. In their paper, Ben-David and Papell (2000) determined structural breaks in the time series of per capita real GDP, and subsequently, computed the trends between each of the breaks. This dissertation implemented the same method but with a different goal. This approach was used to determine whether a change in the trend of one of the variables was consistently followed by a change in the trend of the other variable. Indeed, if the breaks in FDI precedes the breaks in CO_2 emissions, it would support the hypothesis that FDI is a predictor of CO_2 emissions. Overall, the structural analysis would give valuable information regarding the direction and the sign of the relationship.

To determine the structural breaks in each series, the Kapetanios (2005) test was implemented. Kapetanios (2005) established a test of the null hypothesis that a series contains a unit root against the alternative hypothesis that the series contains an undetermined number of breaks. According to Kapetanios (2005), this test is more computationally efficient than other tests accounting for structural breaks such as Lumsdaine and Papell (1997). Although this test is generally used as a stationarity test, it also returns the number of structural breaks within the series and provides the year of the breaks. A major advantage of this test is that only the maximum number of breaks must be specified, in contrast to other tests where the exact number of breaks must be stated such as the Zivot and Andrews (2002) test (Kapetanios, 2005).

The trends between each break were calculated by a simple ordinary least squares (OLS) regression based on the following model:

$$\log y_t = \mu_0 + \alpha_1 t + \varepsilon_t \tag{1}$$

μ_0 is a constant and ε_t is the error term. Finally, α_1 represents the trend. Due to the log-lin transformation a coefficient of α_1 will represent a yearly growth rate of $e^{\alpha_1} - 1$. Establishing the growth rates enabled the author to determine whether the break led to a higher or lower growth rate in the first variable and whether it resulted in a lower or higher growth rate in the other variable. In other words, it gave an indication of the sign (positive or negative) of the relationship.

5.2 Toda and Yamamoto Causality Test

In a subsequent step, a Granger (1969) causality test was conducted. Granger causality is based on the concept that cause cannot come after the outcome. We say that X Granger causes Y if Y can be explained better when X is taken into account than when X is disregarded. This method was picked for two reasons. Firstly, it is a proven and widely recognized way to test causality (Alimi & Ofonyelu, 2013). In addition, it was chosen due to its prevalence among previous studies researching the pollution haven hypothesis, including in most recent research (Blanco, Gonzalez & Ruiz, 2013; Hoffmann et al., 2005; Linh & Lin, 2015; Pao & Tsai, 2011).

It was decided to apply the Toda and Yamamoto procedure (1995) to test for Granger causality. The advantage of the Toda and Yamamoto test is that it can be applied on the levels regardless of the order of integration of the series (Toda & Yamamoto, 1995). Therefore, it enables statisticians to run causality tests even in the case where the series are integrated of different orders, which standard Granger causality tests would not permit (Wolde-Rufael, 2005). In addition, this feature minimizes issues related to the wrong identification of the order of integration through the unit root tests (Amiri & Ventelou, 2012). Finally, it eliminates the need for cointegration tests as the Toda and Yamamoto test can be applied irrespective of cointegration (Guru-Gharana, 2012).

The Toda and Yamamoto test (1995) is based on the estimation of an artificially augmented vector autoregression (VAR) model. It supplements the optimal order of the VAR, *k*, by the maximum order of integration, d_{max}, which guarantees that the test statistics have the correct asymptotic distribution (Wolde-Rufael, 2005). The Toda and Yamamoto VAR model is defined as follows:

$$y_t = \mu_0 + \left(\sum_{i=1}^{k} \alpha_{1t}\, y_{t-i} + \sum_{i=k+1}^{d_{max}} \alpha_{2t}\, y_{t-i} \right) + \left(\sum_{i=1}^{k} \beta_{1t}\, x_{t-i} + \sum_{i=k+1}^{d_{max}} \beta_{2t}\, x_{t-i} \right) + \varepsilon_{1t} \tag{2}$$

$$x_t = \phi_0 + \left(\sum_{i=1}^{k} \gamma_{1t}\, x_{t-i} + \sum_{i=k+1}^{d_{max}} \gamma_{2t}\, x_{t-i} \right) + \left(\sum_{i=1}^{k} \delta_{1t}\, y_{t-i} + \sum_{i=k+1}^{d_{max}} \delta_{2t}\, y_{t-i} \right) + \varepsilon_{2t} \tag{3}$$

Where y_t is logged CO_2 emissions per capita and x_t is logged FDI per capita. μ_0 and ϕ_0 are constants while ε_1 and ε_2 are error terms. The test is conducted as follows. The first step is to define the order of integration of each series, and thereby, determine the maximal order of integration denoted by d_{max}. In this study, the order of integration was primarily defined using the Kapetanios unit root test due to its higher robustness to structural breaks. An Augmented Dickey-Fuller (ADF) test was also conducted as a robustness check. The second step of the Toda and Yamamoto test consists of determining the true lag length of the system *k*. The primary criterion for the lag selection was the Akaike Information Criterion (AIC). According to Liew (2004), the AIC is best suited for small samples bellow 60 observations, which corresponds to this study as each series includes 47 observations. Subsequently, the unrestricted model as described in equation (1) and (2) is estimated. The last stage is to test the Granger causality by running the standard Wald tests. However, the Wald tests are only applied on the k coefficients matrix, the last d_{max} lags being disregarded for this step as these are only in the model to assure the asymptotic chi-square distribution (Guru-Gharana, 2012). The Wald tests will verify the following two sets of hypotheses:

FDI→CO_2: H_0: FDI per capita does not Granger cause CO_2 per capita
H_a: FDI per capita Granger causes CO_2 per capita

CO_2→FDI: H_0: CO_2 per capita does not Granger cause FDI per capita inflows
H_a: CO_2 per capita Granger causes FDI per capita inflows

To conclude this section, as the Granger causality does not allow to determine whether the relationship is positive or negative, the structural break analysis is what provided insights into the sign of the relationship.

6 Empirical Analysis

The empirical analysis contains first of all the results of the structural break analysis and the Toda and Yamamoto causality test. The robustness of the results is then discussed in a sensitivity analysis. This is followed by a discussion and analysis of the results obtained. Finally, the limitations of this study are examined.

6.1 Results

6.1.1 Structural Break Analysis

For the Kapetanios test, a maximum of three breaks was selected, together with a maximum number of lags of four and a trimming factor of 25%. A maximum of three breaks was decided based on the sample size and graphical evidence. More than one break every 15 years was assumed to be unlikely when screening the data. This was confirmed by the subsequent tests as all countries have less than 3 breaks for both variables. The maximum number of lags was decided based on the cubic root criterion which states that a good approximation of the appropriate maximum number of lags is the cubic root of the number of observations. The trimming factor was decided following Bai and Perron’s (2006, p.226) findings that small trimming factor such as 5% leads to substantial size distortion, which disappears when the trimming parameter reaches beyond 15%. Therefore, a larger trimming factor is more recommendable. Finally, only structural breaks in trends were taken into account. The results of the structural break analysis indicate that as a rule structural breaks in CO_2 emissions took place before or at the same time as the FDI breaks.

India

Looking at India, the structural break occurred first in CO_2 emissions with an increase in the growth rate in 1982 as indicates figure 9. It was followed seven years later by FDI, which also experienced an upsurge in its growth rate, albeit a much more important one than for CO_2 emissions. However, the second break in 2002 was simultaneous and the effects were contradictory to the first break, while the CO_2 emissions growth rate went up, the FDI growth rate declined. This evidence would not support a relationship between the two variables as the first breaks imply a positive relationship while the second one a negative one.

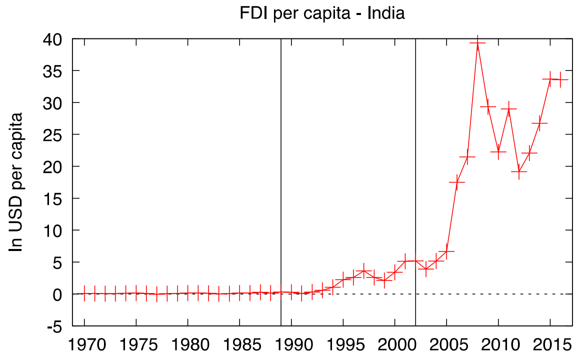

Figure 7: Indian FDI per capita with structural breaks (UNCTAD, 2019a)

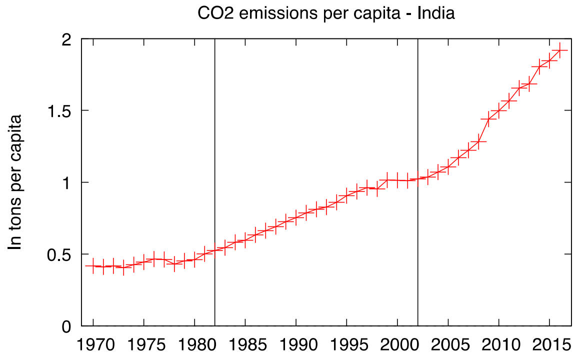

Figure 8: Indian CO$_2$ Emissions per Capita with structural breaks (Muntean et al., 2018)

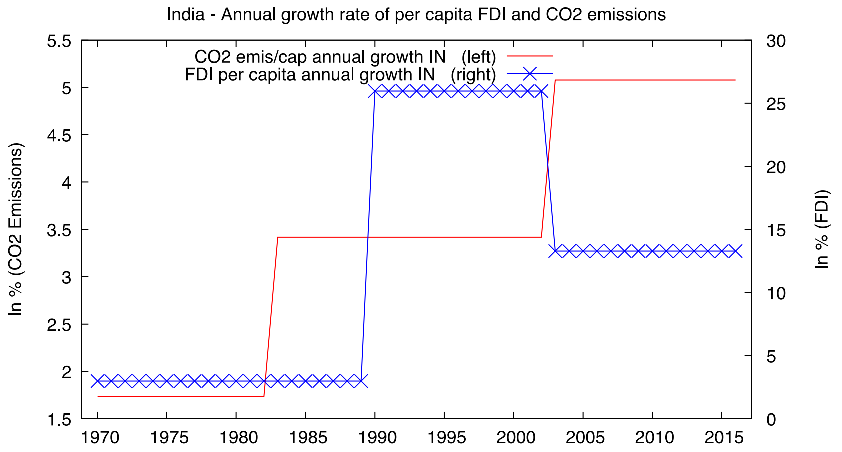

Figure 9: Annual Growth Rate of per Capita FDI and CO$_2$ Emissions (Own Calculations)

Indonesia

Like India, Indonesia's break in CO$_2$ emissions precedes the first structural break of the FDI data. While the growth rate of CO$_2$ emissions declined substantially in 1982, the FDI growth rate nose-dived to a highly negative rate a few years later in 1990 (figure 12). In 2002, Indonesia saw another break in its carbon dioxide trend and its growth once again declined considerably, although this time it was followed by a major jump in the FDI growth rate a year later. As in the Indian case, these contradictory reactions of FDI to CO$_2$ emissions do not support the existence of a causal relationship between the two.

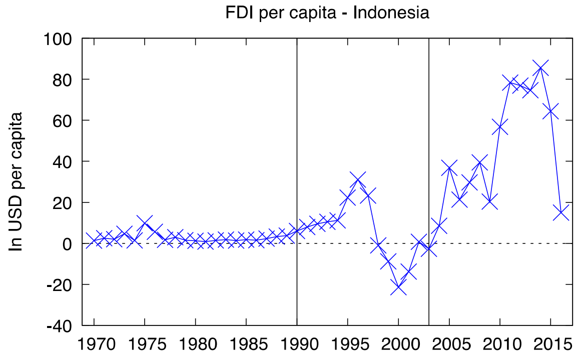

Figure 11: Indonesian FDI per capita with structural breaks (UNCTAD, 2019a)

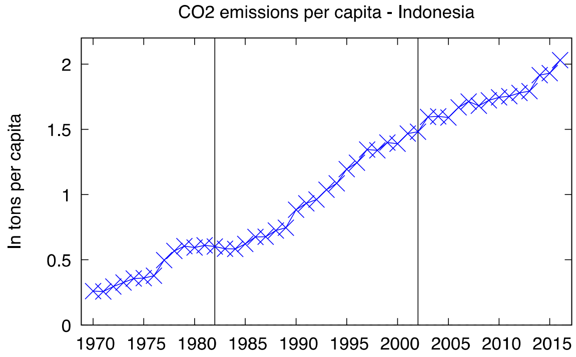

Figure 10: Indonesian CO$_2$ Emissions per Capita with structural breaks (Muntean et al., 2018)

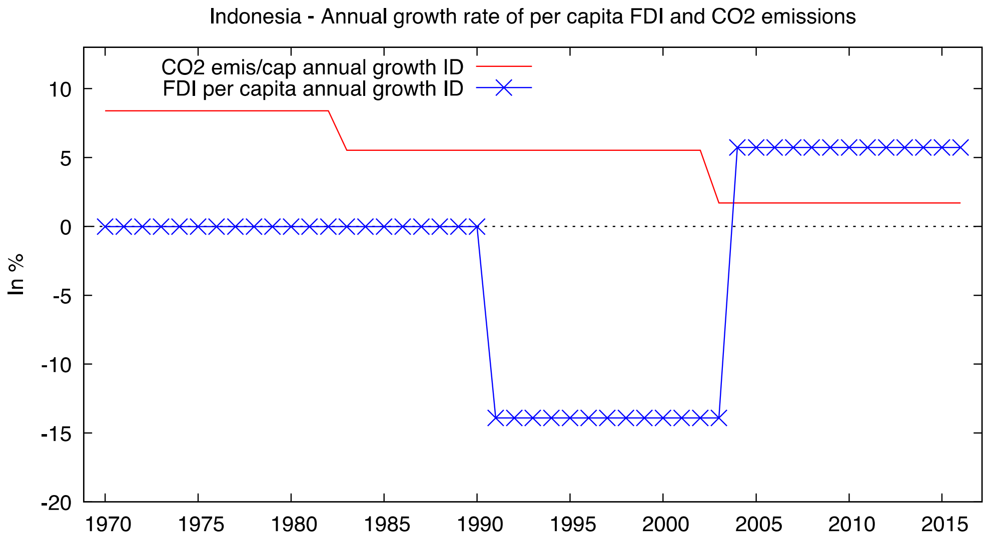

Figure 12: Indonesian Annual Growth Rate of per Capita FDI and CO₂ Emissions (Own Calculations)

Malaysia

For Malaysia, the first structural break in CO_2 emissions took place in 1986 and preceded the first break of the FDI series. As reveals figure 15, the break consisted of a rise in the growth rate of carbon dioxide emissions. The trend in FDI broke in 1990, but in contrast to the CO_2 emissions growth rate that surged, the FDI growth rate vastly declined. In fact, FDI experienced a negative growth rate after the first structural break. As in the Indian case, the second break happened in the same year for both variables. FDI growth increased significantly and CO_2 emissions growth shrank by two thirds.

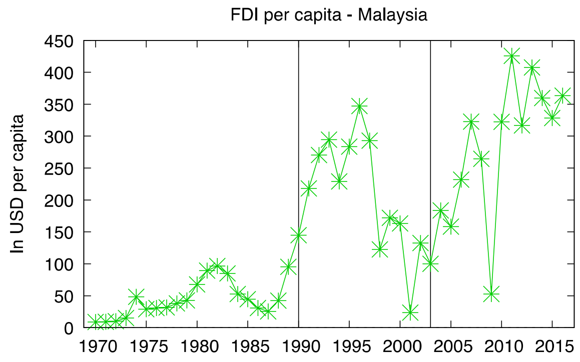

Figure 13: Malaysian FDI per capita with structural breaks (UNCTAD, 2019a)

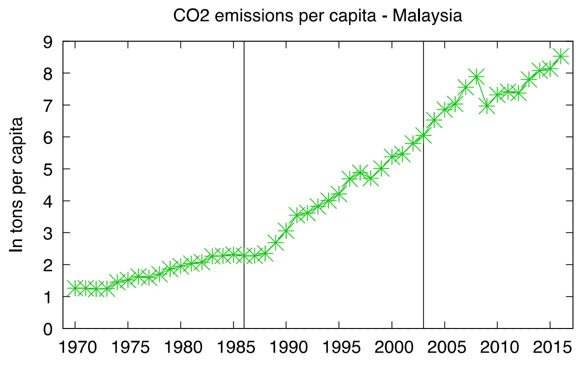

Figure 14: Malaysian CO₂ Emissions per Capita with structural breaks (Muntean et al., 2018)

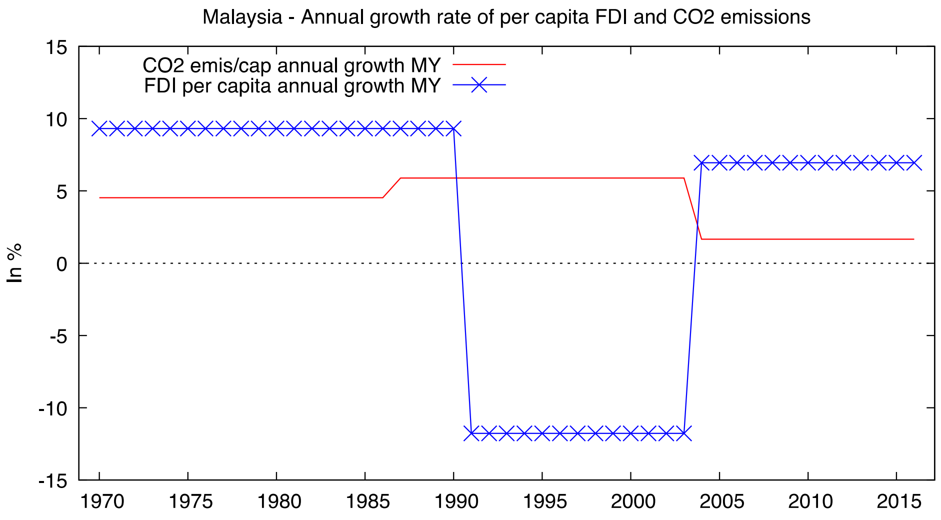

Figure 15: Malaysian Annual Growth Rate of per Capita FDI and CO_2 Emissions (Own Calculations)

Philippines

The Philippines first experienced a break in its CO_2 emissions trend in 1984. It entailed a significant rise in the annual growth rate to 5% as can be observed in figure 18. With a delay of six years, FDI saw its growth decline largely. In 1997 the CO_2 emissions had a second structural break where the growth rate declined to approximately 0.6%. FDI answered once again six years later, this time with an increase in its annual growth rate. The data of the Philippines would support a negative relationship running from CO_2 to FDI.

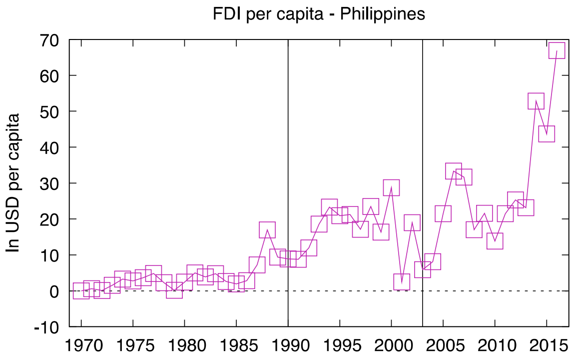

Figure 16: Philippine FDI per capita with structural breaks (UNCTAD, 2019a)

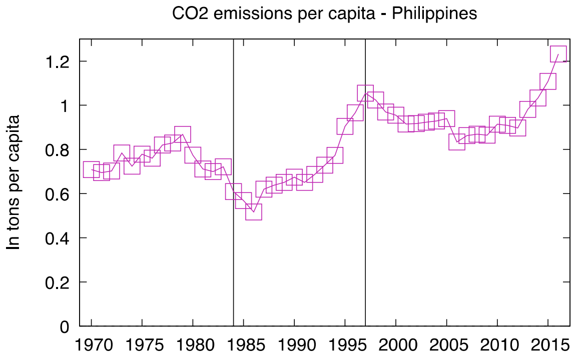

Figure 17:Philippine CO_2 Emissions per Capita with structural breaks (Muntean et al., 2018)

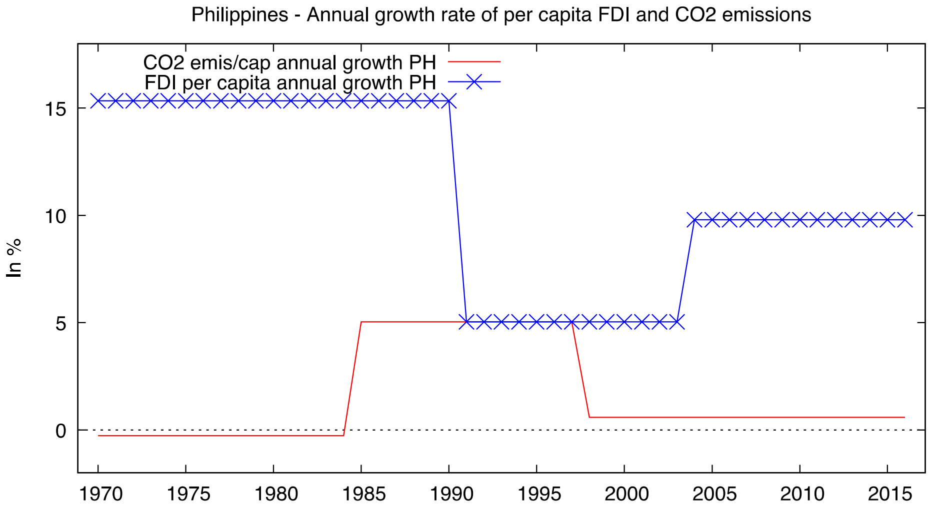

Figure 18: Philippine Annual Growth Rate of per Capita FDI and CO_2 Emissions (Own Calculations)

Thailand

The CO_2 emissions growth rate is once again the series with the earliest break. Comparing the growth rate pre and post 1982, it has more than doubled (figure 21). The structural break in FDI followed in 1985 with a rise in the growth rate of approximately three points. The second break in CO_2 emissions happened in 1995 with a very large drop in the CO_2 emissions growth rate. It was followed by a massive second structural break in the FDI yearly growth rate. The second FDI structural break was delayed by eight years compared to only a three years lag in the first. Looking at the sign and direction of the relationship, the Thai data would indicate a relationship running from CO_2 and FDI, with a positive sign.

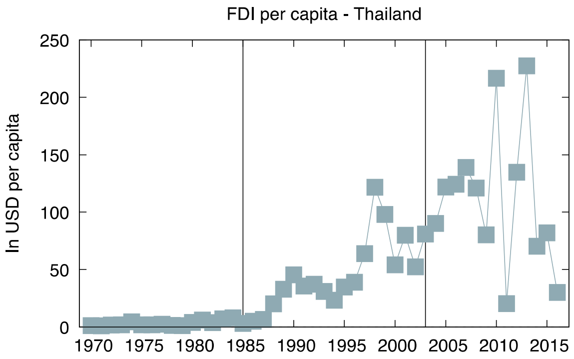

Figure 19: Thai FDI per capita with structural breaks (UNCTAD, 2019a)

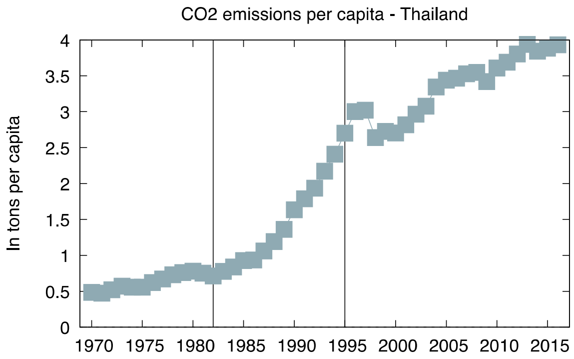

Figure 20: Thai CO_2 Emissions per Capita with structural breaks (Muntean et al., 2018)

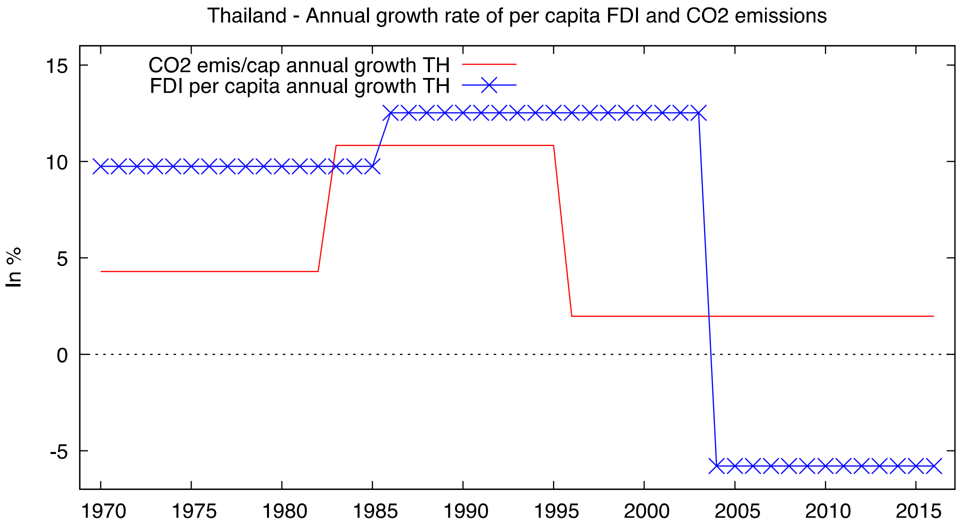

Figure 21: Thai Annual Growth Rate of per Capita FDI and CO_2 Emissions (Own Calculations)

Vietnam

A special feature of Vietnam, as figures 22 and 23 highlight, is that the series of CO_2 emissions only has one structural break according to the Kapetanios test while the FDI series has two. This would potentially indicate that the two variables do not have a relationship. Indeed, while the first break in FDI is followed 8 years later by CO_2 emissions, the second quite important break in the FDI trend does not have a corresponding reaction in CO_2 emissions. An important factor to note is that Vietnam is the only country where the first series to break was FDI.

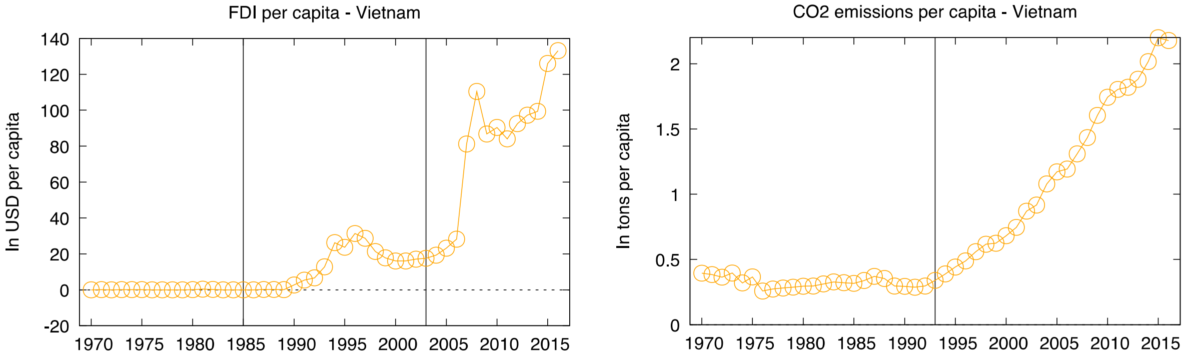

Figure 22: Vietnamese FDI per capita with structural breaks (UNCTAD, 2019a)

Figure 23: Vietnamese CO_2 Emissions per Capita with structural breaks (Muntean et al., 2018)

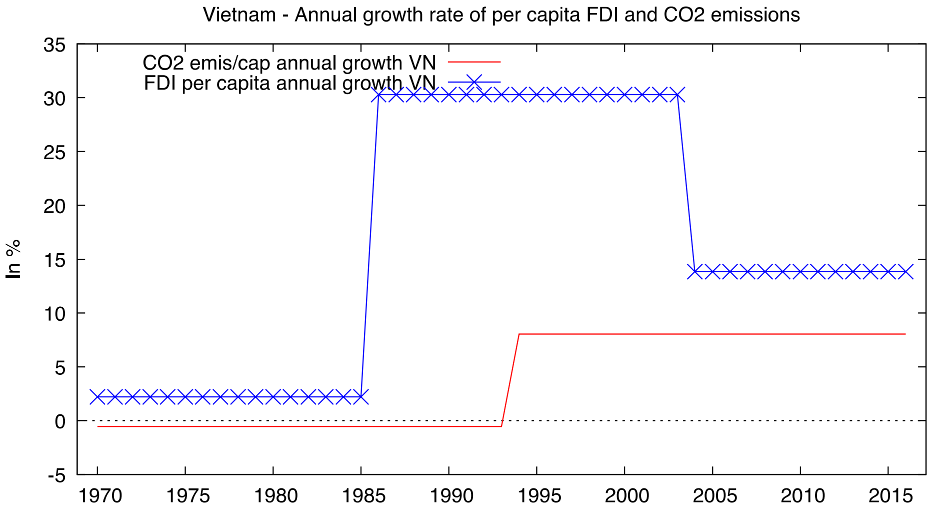

Figure 24: Vietnamese Annual Growth Rate of per Capita FDI and CO_2 Emissions (Own Calculations)

6.1.2 Toda and Yamamoto Causality Test

As mentioned in the methodology, the first step taken in this part of the study was to verify the maximum order of integration for the pair of FDI and CO_2 emissions for each country. The outcome of the tests can be found in Appendix A. The test was run including a constant and a trend. The Kapetanios test revealed that all CO_2 emissions series had unit roots in the levels, which the ADF test confirmed, using both BIC or AIC as a criterion for the lag length. The same could not be said for the levels of the logged FDI per capita series. The Vietnamese *l_FDIperCapita* variable was stationary at a 1% significance level according to the Kapetanios test. The Philippines has a similar situation, however, with a 5% significance level. In these two cases, the maximum order of integration d_{max} depended on the integration level of the per capita CO_2 emissions series. D_{max} for Vietnam and Philippines turned out to be 1 as the first difference of the carbon dioxide series were stationary at a 1% significance level. In the case of Malaysia, both FDI and CO_2 emissions per capita were of integration order one as the hypothesis of a unit root in the differenced series was rejected at the 1% significance level. Therefore, d_{max} was equal to 1 for Malaysia. While CO_2 emissions in Thailand was also of integration order one, the Thai series of FDI per capita was revealed to be non-stationary also in its first difference based on the Kapetanios test. Indeed, the null hypothesis of a unit root could not be rejected even with a 10% significance level. However, when the data was differentiated once again, the tests were passed with a 1% significance level. These results implied that d_{max} for Thailand was equal to two. The Indian case was a bit less straight forward in terms of FDI per capita. Indeed, while CO_2 emissions were $I(1)$ like in the other countries, some judgment had to be exercised regarding the order of integration of FDI per capita. The levels were clearly not stationary with the t-statistics well above the critical values but the Kapetanios test of the differentiated values had a p-value between the 5% and 10% significance levels. In order to make a decision, the results of the ADF test were taken into account. Both the results based on the AIC or the

Bayesian Information Criterion (BIC) indicated stationarity of the differentiated FDI per capita series. As a result, it was considered that FDI per capita was integrated of order one and therefore, d_{max} was defined as one.

Once d_{max} was defined, the lag length k had to be determined for all VAR models. Using a maximum of four lags, the optimal lag length was tested down and selected based on AIC. The tests were conducted with a constant as well as with a constant and a trend. The lag length selection tests can be found in Appendix B. The results of the lag selection are summarized in table 2 together with d_{max}.

We proceeded with the estimation of all the VAR models, which each contained ($k+d_{max}$) lags. To make sure that the software did not take the last d_{max}-th lags in the Granger causality tests into account, these last d_{max}-th lags were entered as exogenous in the model. The results of the Granger causality tests can be found in Table 3.

Based on the Wald tests for India, it appears that per capita FDI and CO_2 emissions have a unidirectional relationship running from FDI to CO_2 emissions. In fact, the p-value regarding the hypothesis that *l_FDIperCapita* does not Granger causes *l_EmisperCapita* is rejected at the 1% significance level. The reverse hypothesis cannot be rejected as the p-value is insignificant at approximately 0.55. Overall, we can say that FDI per capita Granger causes CO_2 emissions but the reverse cannot be stated.

In Malaysia, both hypotheses that FDI does not Granger cause CO_2 emissions and CO_2 emissions do not Granger cause FDI are rejected. Accordingly, both p-values are highly insignificant at respectively 0.82 and 0.70 and the null hypotheses cannot be rejected. Based on these results, FDI does not affect CO_2 and CO_2 does not affect FDI, the relationship is non-directional.

The evidence of the Philippines shows similar results. The hypothesis that FDI does not Granger cause CO_2 emissions had a p-value of 0.49 which does not allow us to reject the null hypothesis. Similarly, the reverse hypothesis faced a 0.33 p-value, which led to similar conclusions. The relationship is thus non-directional in the Philippines.

In Thailand, we cannot reject the null hypothesis that CO_2 emissions do not Granger cause FDI as the p-value is highly insignificant at 0.51. However, the contrary hypothesis passes the 1%

Table 2: Summary of results from lag length selection and unit root tests for the maximal order of integration

Summary	Lag Length k	d_{max}
India	1	1
Indonesia	1	1
Malaysia	1	1
Philippines	1	1
Thailand	4	2
Vietnam	2	1

Table 3: Toda and Yamamoto Procedure for Granger Causality Test

Toda-Yamamoto Granger causality test	Nbr of lags k	P-value	Decision	Granger causality
India				
H0: FDI does not Granger cause CO2	1	[0.0058]	Reject	FDI --> CO2
H0: CO2 does not Granger cause FDI	1	[0.5516]	Do not reject	
Indonesia				
H0: FDI does not Granger cause CO2	1	[0.8211]	Do not reject	0
H0: CO2 does not Granger cause FDI	1	[0.9841]	Do not reject	
Malaysia				
H0: FDI does not Granger cause CO2	1	[0.8187]	Do not reject	0
H0: CO2 does not Granger cause FDI	1	[0.7043]	Do not reject	
Philippines				
H0: FDI does not Granger cause CO2	1	[0.3272]	Do not reject	0
H0: CO2 does not Granger cause FDI	1	[0.4906]	Do not reject	
Thailand				
H0: FDI does not Granger cause CO2	4	[0.0033]	Reject	FDI --> CO2
H0: CO2 does not Granger cause FDI	4	[0.5113]	Do not reject	
Vietnam				
H0: FDI does not Granger cause CO2	2	[0.6075]	Do not reject	CO2 --> FDI
H0: CO2 does not Granger cause FDI	2	[0.0388]	Reject	

significance level. As a result, it can be said that Thailand has a unidirectional relationship between the two variables, indeed, FDI Granger causes CO_2 emissions in Thailand

Finally, Vietnam has an insignificant p-value (0.60) and we, therefore, cannot reject the null hypothesis about FDI not Granger causing CO_2 emissions. However, the other sense of the relationship shows a significant p-value inferior to 1%. Consequently, we reject the null hypothesis and can state that the two variables have a unidirectional relationship and CO_2 emissions Granger cause FDI in Vietnam.

6.2 Sensitivity Analysis

6.2.1 Structural Break Analysis

In order to test the robustness of the structural break analysis, the Kapetanios was conducted by changing the lag lengths. These were implemented by deducting one lag, as well as adding one and two lags. The aim was to analyze whether the years of the structural break varied significantly if the lag parameter was modified. The outcome of the tests can be found in Appendix C.

The structural breaks defined for India by the Kapetanios test were not found to be very robust. On the contrary, by adding lags we find a relationship going from FDI to CO2 emissions, while the initial test indicated no relationship. In addition, by removing one lag, we found support for the direction FDI-CO2 in the first break while for the second break the evidence reveals a CO2-FDI relationship.

In the Malaysian case, especially the CO2 emissions series is volatile. Indeed, when a lag is added or removed a break disappears. This indicates that the results are sensitive and not very robust. Hence, the evidence of the structural break analysis for Malaysia must be considered with care.

Vietnam faces the opposite situation. When adding lags to the Kapetanios test, a second structural break, which had not been present with four lags, appears in the CO2 emissions per capita series. Thus, the results from the Vietnamese structural break analysis must be treated with caution.

However, for Indonesia, the Philippines and Thailand, the years of structural breaks remain fairly stable. By removing or adding lags the break years either remain the same or only increase by a year, which does not impact the order of the breaks. Therefore, the results of the structural break analysis can be considered as robust for these three countries.

6.2.2 Toda and Yamamoto Causality Test

According to Kónya (2006), the definition of the lag length is crucial to the Granger causality. Both underfitting and overfitting may create problems. For example, including too many lags usually increases the standard errors of the coefficients (Kónya, 2006). On the other hand, underfitting would mean the omission of variables, which would lead to bias in the coefficients and therefore, it would lead to incorrect conclusions (Kónya, 2006). Thus, the sensitivity analysis for the Granger causality was undertaken through a modification of the lags. For countries that had a selected lag length k equal to one, one, two and three lags were added for the sensitivity analysis. For Vietnam, which had a lag length of two, the effect of removing a lag and adding one or two lags was tested. For Thailand, one and two lags were added and removed as it had a selected lag length $k = 4$.

The analysis reveals that the results are quite robust for India, Indonesia, Malaysia, Thailand, and Vietnam. For India, by adding lags the p-value gradually augmented. Nevertheless, with three lags added ($k = 4$) the p-value regarding whether FDI does not Granger cause CO_2 emissions was still equal to 0.06, easily passing the 10% significance level. As a result, we could conclude that the Indian Granger causality results were quite robust.

The Malaysian and Indonesian Toda and Yamamoto test remained insignificant for both direction of the causality link, be it supplemented with one, two or three lags. The p-values remained far from any possibilities of rejecting the null hypotheses. Consequently, we were quite confident in our finding that CO_2 and FDI do not have a Granger causality link.

By adding lags to the Thai model, it becomes apparent that the model is not very sensitive to the number of lags. As a matter of fact, the causality link running from FDI to CO_2 emissions remain significant at 1% level for $k = 5$ and at the 5% level for $k = 6$. While it is true that removing a lag raises the p-value to 0.102, the p-value almost reaches the 10% significance level. The other side of the relationship was insignificant with any number of lags, except for $k = 2$, i.e. when two lags are deducted from the model. Therefore, it appears that the Toda and Yamamoto test for Thailand is not very sensitive to the lag selection.

Vietnam for its part, showed a fairly steady behavior when adding or suppressing a lag. When a lag was removed, the results showed once again that CO_2 emissions Granger caused FDI, passing the 5% significance level. When a lag was added, the same could be said but based on a 10% significance level. The p-value of the FDI-CO_2 relationship remained consistently insignificant along the different tests. As a result, we can conclude that the results are robust.

In contrast, the Philippines had more volatile results. When adding a lag, the Granger causality link running from FDI to CO_2 emissions suddenly became significant at a 5% significance level and at 10% significance when adding two lags. As a consequence, the findings of the Toda and Yamamoto test were not considered very robust for the Philippines.

6.3 Discussion

At first sight, the results from the two analyses are not compatible for some of the countries as can be observed in table 4. For example, the structural break analysis supports a unidirectional relationship running from CO_2 to FDI for Thailand. These results support the pollution haven hypothesis in the sense that it indicates that FDI funds go to countries that have lax environmental regulations. Nevertheless, the Granger causality test done on the Thai series points towards a relationship running in the opposite direction, i.e. from FDI to CO_2 emissions, findings that are corroborated by Chandran and Tang (2013). The Granger causality test would support that FDI impacts on carbon dioxide emissions. However, the Thai results could also be an indicator of a feedback mechanism and a vicious cycle. Namely high per capita carbon dioxide emissions are an indicator of lax environmental regulations and of a higher level of development which would attract FDI inflows. FDI inflows would then enhance CO_2 emissions through the scale effect and/or through an intensification of the industrial sector. The implications of this are not favorable for the development of Thailand as it has been a key tool in their recent growth spells as discussed in the background section. This implies that their current development model is unstainable and even self-reinforcing.

Table 4: Summary of Structural Break Analysis and the Granger Causality Test

Country	Granger causality	Structural break analysis	
India	FDI --> CO_2	1st Break 2nd Break	CO_2 --> FDI + Simultaneous
Indonesia	0	1st Break 2nd Break	CO_2 --> FDI + CO_2 --> FDI -
Malaysia	0	1st Break 2nd Break	CO_2 --> FDI - Simultaneous
Philippines	0	1st Break 2nd Break	CO_2 --> FDI - CO_2 --> FDI -
Thailand	FDI --> CO_2	1st Break 2nd Break	CO_2 --> FDI + CO_2 --> FDI +
Vietnam	CO_2 --> FDI	1st Break 2nd Break	FDI --> CO_2 + 0

Looking at the Philippines, the two analyses support different directions of the relationship. The structural break analysis consistently and robustly supported the existence of a relationship running from CO_2 to FDI. Yet, the Toda and Yamamoto analysis revealed no relationship between the variables but with results that were not robust. Accordingly, we can say that the results coming from the structural break analysis might be more reliable. As mentioned in the description of the results, the structural break analysis shows an unconventional relationship where a rise in CO_2 emissions has a deterrent effect on FDI. This would entail a strong rejection of the pollution haven hypothesis. These findings would sustain to some extent the paper by Dasgupta, Laplante, and Mamingi (1997) who state that the environmental impact of a firm matters to investors. Although they use this argument to explain why foreign investors decide to use cleaner technologies than required in the host country, it might also explain why some countries decide not to invest at all in such countries. Indeed, they might not want to be associated with non-environmentally friendly countries, which might hurt their image.

The Vietnamese results from the structural break were not conclusive with a first break supporting a relationship from FDI to CO_2 emissions and a second break in FDI that was not followed by a trend break in carbon dioxide emissions. Moreover, the results were not robust and very sensitive to the lag selection. However, the findings from the Granger causality indicated a relationship in the reverse direction and they proved to be insensitive to lag selection. In addition, the relationship finds support in the literature. As a matter of fact, Linh and Lin (2014) provided evidence of the same direction in the relationship and confirmed that foreign capital is attracted to laxer environmental regulations. Their study also confirmed that the reverse relationship does not hold (Linh & Lin, 2014). Tang and Tan (2015) for their part also found the causality link from CO_2 to FDI to be significant. As the structural break analysis does not provide a definite sign of the relationship, we cannot say whether this finding reveals a pollution haven effect. Investor's approach to climate change and clean investment will be decisive in the sign of the relationship. Indeed, the host country has little control over the outcome. Interestingly, augmentations in FDI does not appear to be linked to increases in CO_2 emissions. This means that Vietnam can enjoy the benefits of FDI in terms of technology and know-how without facing negative environmental consequences. A hypothesis for this is that the new technology brought by foreign investors compensate for the scale effect of the added economic activity.

India has a similar situation to Vietnam, with a structural break analysis having results that were very sensitive to lag selection in the Kapetanios test and a Granger causality test that was robust. Indeed, out of all the countries, India is the only country with a significant relationship where the results remained the same through all the robustness checks of the Granger causality. In addition, two studies done by Acharyya (2009) and Sarkodie and Strezov (2019) reveal the same findings. Consequently, confidence is high in the evidence that FDI Granger causes CO_2 emissions. These findings can have positive or negative implications. On the one hand, if the relationship is negative, FDI is an opportunity to reduce CO_2 emissions through technology transfers. This would bring hope regarding the sustainable development of India. Especially considering the size of the country and how the emissions have been rising, the positive environmental impact could be extensive. However, if the relationship is positive the implications could be unfavorable to the current growth model. In this case, the impact could be disastrous, due to the size of the country even small increases in per capita carbon dioxide emissions would translate in very large absolute amounts. Acharyya's (2009) as well as Sarkodie and Strezov's (2019) findings would support the second scenario with a positive relationship, unfortunately.

For Malaysia and Indonesia, the results of no relationship from the Granger causality test are consistent with the structural break analysis. Indeed, the second structural break happened simultaneously in both variables for Malaysia, which would imply no relationship. The same conclusion can be drawn for Indonesia where the second break has a different sign of the relationship than the first break. The evidence for both countries seems also robust considering that the outcome of the Toda and Yamamoto was not sensitive to the addition of one, two, or three lags. Same conclusions were drawn from the sensitivity analysis conducted for the structural breaks. Looking at studies on Malaysia, it is apparent that the evidence is very diverse. The present study finds support in Lee's (2009) paper which maintains that the two have no long-run relationship. As in the Vietnamese case, the implications for Malaysia are quite encouraging in the sense that FDI can be exploited as a tool for sustainable development without the fear of negative environmental consequences.

6.4 Limitations

An important limitation of this study is that another variable could be driving the relationship, namely GDP per capita. In other words, this study might suffer from omitted variable bias. However, the two variables seem to have their own patterns as indicated the structural break analysis. As a result, the possible omitted variable should not impact too negatively this study.

In addition, the effect of FDI might have changed over time, for example, the technology transfer could have been weak in the past due to different policies by the host country or the foreign investors did not utilize their higher technologies as a result of the general disregard for environmental impact. Conversely, nowadays governments might have realized the importance of technology transfer, both in terms of development and environment, and implemented policies accordingly. This could disturb the results. In the structural break analysis, a changing relationship would have been interpreted as no relationship. In addition, it weakens the predictable power of the Granger causality test.

Finally, it was decided to use CO_2 emissions as an estimator of pollution in this study. However, there are other pollutants such as methane and nitrous oxide that play also an important role (1990). As these are not air pollutants, they might not be correlated to CO_2 emissions. As a consequence, the empirical results might be very different if a different greenhouse gas was used. However, it remains that CO_2 emissions are the largest contributor to greenhouse gas emissions at 77% in 2005 (Herzog, 2009).

7 Conclusion

7.1 Research Aims

Due to the large increases in FDI flows particularly to East Asia and its role in their development, the potential consequences of foreign flows have become of great importance. The relation between CO2 emissions and FDI is one of the main problems arisen. The topic has been thoroughly investigated by scholars in the last 30 years, however, the lack of fresh evidence on the topic in Southeast Asia and India became soon evident. Accordingly, this dissertation aimed at filling this gap by investigating the FDI-CO_2 emissions causal relationship in the ASEAN-5 and India for the period of 1970 to 2016. To achieve this goal, a structural break analysis and a Toda and Yamamoto procedure for Granger causality test were conducted. The empirical results indicated that the causal relationship varied very much from one country to the next. No causal relationship was found in Indonesia and Malaysia, a relationship running from carbon dioxide to FDI was observed in the Philippines and Vietnam while the reverse was found for India, and finally, Thailand showed a possible bi-directional relationship. Regarding the pollution haven hypothesis, only Thailand seemed to indicate such an effect. Vietnam could possibly also have a similar phenomenon. However, as the structural break analysis was inconclusive, the sign of the relationship could not be determined. This means that CO_2 emissions could have either a positive or negative effect on foreign capital inflows. Indeed, the Philippines confirmed the existence of the negative relationship where CO_2 emissions repel FDI inflows. India, a country in which FDI Granger causes CO_2 emissions, could also have a pollution haven in the sense that FDI could increase air pollution either through an intensification of the dirty sector or the scale effect. However, it is also possible that they have a pollution halo as the sign of the relationship was not defined due to the lack of indication from the structural break analysis.

7.2 Practical Implications

The practical implications for India are that FDI can have adverse effects on air pollution due to the causal link going from FDI to CO_2 emissions. However, this relationship also means that FDI can be a tool for the opposite as the pollution halo predicts. Indeed, foreign capital can be a way of boosting technology advancements in the host country through competition and technology transfers. Therefore, this gives the opportunity to policymakers to make advancements on their climate change mitigation plans. This shows that the policy on technology transfers plays a central role. China might provide a very good example in this regard. The Chinese government implemented tough restrictions on foreign investors, e.g. companies could have only a maximum of 50% of foreign ownership, which allowed them to acquire the more evolved foreign technologies (Rodrik, 2006).

The implications of the potential vicious cycle in Thailand are negative for the environment. Indeed, it predicts a perpetual worsening of air pollution. They would need to break this cycle, and similarly to India, technology transfer plays a key role. Comparable recommendations to India can be made. Another important point for Thailand comes from the positive CO_2-FDI relationship which implies that low environmental regulations attract foreign investors. This signifies that a tightening of international agreements on air pollution, such as the Paris Agreement, represent a threat to the inflows of FDI and indirectly to the development of the country. There are little possibilities for the host country to counteract this adverse effect. Instead, it calls for a change in paradigm in investors' strategies towards more environmental engagement.

The Philippines face the contrary situation where CO_2 emissions displace FDI to other countries. This might imply that a change of approach to investment might have already taken place. Contrary to Thailand, these results mean that international environmental agreements would have a positive impact on foreign capital inflows in the Philippines. The implications would be very promising for the development of the country. Moreover, as the reverse relationship is not significant, it shows that they do not need to fear harmful repercussions from the additional flows.

Vietnam also shows a CO_2-FDI causal relationship as Thailand and the Philippines. However, the sign of the relationship was not determined as the structural break analysis was not conclusive. Therefore, the same implications as described both for Thailand and the Philippines on the CO_2-FDI relationship are applicable. A tightening of environmental regulations could have both a negative or a positive influence. In addition, it implies that FDI can be used without a negative environmental impact.

Malaysia and Indonesia have no relationship between FDI and air pollution based on the two analyses. Similar to the Philippines and Vietnam, this signifies that they enjoy from the lack of negative consequences of FDI. However, it also means that they do not benefit from the possibility of using FDI to reduce carbon dioxide emissions.

Overall, this shows that the technology transfer is key. Special attention should be paid to it by policymakers as its outcome could never be detrimental. In addition, while the nefarious effects of environmental regulations on FDI have been widely documented, it is interesting to note that it can also be positive as the evidence from the Philippines indicates. This shows the importance of changing the mindset of investors and sensitizing economic actors to climate change.

7.3 Future Research

An important domain that would necessitate further research is the type of FDI. In fact, it would be worth investigating whether FDI inflows to agriculture, industries or services have different impacts on pollution. Blanco et al. (2013) have done such a study but focused on Latin America, a similar study applied to Southeast Asia would be valuable. It would give these countries an indication of where to focus its resources in mitigating potential nefarious effects. Another question with important practical implications is why high environmental stringency repels FDI in some countries while it attracts FDI in others and how we can spread this phenomenon across the world. Indeed, if a competition to high environmental stringency could be implemented the world would only benefit from it.

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Appendix A

Unit root tests to define d_{max} for the Toda and Yamamoto procedure

	Kapetanios		ADF						
			AIC			BIC			
India	Test Statistic	P-Value	Test Statistic	P-Value	Lag Length	Test Statistic	P-Value	Lag Length	
l_FDIperCapita	-4.20532	>10%	-2.8375 🔴	0.192	0	-2.8375 🔴	0.192	0	with a trend and a constant
	1 break		-0.194542 🔴	0.932	0	-0.194542 🔴	0.932	0	with a constant
l_EmisPerCapita	-3.9399	>10%	-2.37466 🔴	0.387	0	-2.37466 🔴	0.387	0	with a trend and a constant
	2 breaks		1.50397 🔴	0.999	0	1.50397 🔴	0.999	0	with a constant
d_l_FDIperCapita	-5.67483	5%-10%	-7.06875 🟢	0.000	0	-7.06875 🟢	0.000	0	with a trend and a constant
	1 break		-7.06459 🟢	0.000	0	-7.06459 🟢	0.000	0	with a constant
d_l_EmisPerCapita	-9.59976	<1%	-6.23868 🟢	0.000	0	-6.23868 🟢	0.000	0	with a trend and a constant
	2 breaks		-1.89791 🔴	0.334	4	-6.0756 🟢	0.000	0	with a constant
Dmax		1	1			1			
Indonesia	Test Statistic	P-Value	Test Statistic	P-Value	Lag Length	Test Statistic	P-Value	Lag Length	
l_FDIperCapita	-7.48919	<1%	-3.34613 🔴	0.072	0	-3.34613 🔴	0.072	0	with a trend and a constant
	2 breaks		-3.11331 🔴	0.032	0	-3.11331 🔴	0.032	0	with a constant
l_EmisPerCapita	-3.94031	>10%	-1.51909 🔴	0.809	0	-1.51909 🔴	0.809	0	with a trend and a constant
	1 break		-2.52376 🔴	0.117	0	-2.52376 🔴	0.117	0	with a constant
d_l_FDIperCapita	-10.3511	<1%	-7.70171 🟢	0.000	0	-7.70171 🟢	0.000	0	with a trend and a constant
	2 breaks		-7.79864 🟢	0.000	0	-7.79864 🟢	0.000	0	with a constant
d_l_EmisPerCapita	-7.10714	<1%	-6.08479 🟢	0.000	0	-6.08479 🟢	0.000	0	with a trend and a constant
	2 breaks		-5.40688 🟢	0.000	0	-5.40688 🟢	0.000	0	with a constant
Dmax		1	1			1			
Malaysia	Test Statistic	P-Value	Test Statistic	P-Value	Lag Length	Test Statistic	P-Value	Lag Length	
l_FDIperCapita	-5.30973	>10%	-3.69168 🟢	0.033	0	-3.69168 🟢	0.033	0	with a trend and a constant
	2 breaks		-2.25763 🔴	0.186	1	-2.4905 🔴	0.124	0	with a constant
l_EmisPerCapita	-3.88009	>10%	-1.27561 🔴	0.882	0	-1.27561 🔴	0.882	0	with a trend and a constant
	2 breaks		-0.908311 🔴	0.777	0	-0.908311 🔴	0.777	0	with a constant
d_l_FDIperCapita	-9.99082	<1%	-8.90638 🟢	0.000	0	-8.90638 🟢	0.000	0	with a trend and a constant
	2 breaks		-8.94432 🟢	0.000	0	-8.94432 🟢	0.000	0	with a constant
d_l_EmisPerCapita	-6.86193	<1%	-5.9366 🟢	0.000	0	-5.9366 🟢	0.000	0	with a trend and a constant
	2 breaks		-5.88713 🟢	0.000	0	-5.88713 🟢	0.000	0	with a constant
Dmax		1	1			1			
Philippines	Test Statistic	P-Value	Test Statistic	P-Value	Lag Length	Test Statistic	P-Value	Lag Length	
l_FDIperCapita	-6.65329	<1%	-5.53857 🟢	0.000	0	-5.53857 🟢	0.000	0	with a trend and a constant
	2 breaks		-2.19995 🔴	0.206	1	-3.51054 🟢	0.012	0	with a constant
l_EmisPerCapita	-3.61695	>10%	-2.07584 🔴	0.559	2	-1.37039 🔴	0.857	0	with a trend and a constant
	1 break		-1.0413 🔴	0.741	2	-0.374445 🔴	0.905	0	with a constant
	-10.4273	<1%	-10.4571 🟢	0.000	0	-10.4571 🟢	0.000	0	with a trend and a constant
	2 breaks		-10.5692 🟢	0.000	0	-10.5692 🟢	0.000	0	with a constant
d_l_EmisPerCapita	-8.52518	<1%	-5.79649 🟢	0.000	0	-5.79649 🟢	0.000	0	with a trend and a constant
	2 breaks		-5.74904 🟢	0.000	0	-5.74904 🟢	0.000	0	with a constant
Dmax		1	1			1			
Thailand	Test Statistic	P-Value	Test Statistic	P-Value	Lag Length	Test Statistic	P-Value	Lag Length	
l_FDIperCapita	-5.36095	>10%	-2.91526 🔴	0.167	0	-2.91526 🔴	0.167	0	with a trend and a constant
	2 breaks		-1.80178 🔴	0.380	1	-1.80178 🔴	0.380	1	with a constant
l_EmisPerCapita	-3.50147	>10%	-0.938883 🔴	0.950	1	-0.938883 🔴	0.950	1	with a trend and a constant
	2 breaks		-1.6638 🔴	0.450	1	-1.6638 🔴	0.450	1	with a constant
d_l_FDIperCapita	-5.67632	>10%	-4.50044 🟢	0.001	4	-9.52188 🟢	0.000	0	with a trend and a constant
	2 breaks		-9.39415 🟢	0.000	0	-9.39415 🟢	0.000	0	with a constant
d_l_EmisPerCapita	-6.57459	5%-1%	-4.59596 🟢	0.003	0	-4.59596 🟢	0.003	0	with a trend and a constant
	2 breaks		-4.32683 🟢	0.001	0	-4.32683 🟢	0.001	0	with a constant
d_d_l_FDIperCapita	-10.2958	<1%	-10.3613 🟢	0.000	1	-10.3613 🟢	0.000	1	with a trend and a constant
	2 breaks		-10.4538 🟢	0.000	1	-10.4538 🟢	0.000	1	with a constant
Dmax		2	1			1			

Vietnam	Test Statistic	P-Value	Test Statistic		P-Value	Lag Length	Test Statistic		P-Value	Lag Length	
l_FDIperCapita	-6.86948	<1%	-2.6749	🔴	0.247	3	-2.05077	🔴	0.559	0	with a trend and a constant
	2 breaks		-0.577249	🔴	0.866	0	-0.577249	🔴	0.866	0	with a constant
l_EmisPerCapita	-4.76111	>10%	-2.2156	🔴	0.480	2	-2.15872	🔴	0.500	0	with a trend and a constant
	2 breaks		0.395124	🔴	0.983	2	1.41693	🔴	0.999	0	with a constant
	-6.78925	<1%	-2.92812	🔴	0.153	2	-6.22342	🟢	0.000	0	with a trend and a constant
	1 break		-2.96824	🟢	0.038	2	-6.28981	🟢	0.000	0	with a constant
d_l_EmisPerCapita	-9.59976	<1%	-3.44387	🟢	0.046	1	-3.44387	🟢	0.046	1	with a trend and a constant
	1 break		-3.01497	🟢	0.034	1	-3.01497	🟢	0.034	1	with a constant
Dmax		**1**	**1**				**1**				

Note on Kapetanios:
For two breaks
Significance level: 10% 5% 1%
Critical values: -5.847 -6.113 -6.587
For one break:
Significance level: 10% 5% 1%
Critical values: -4.820 -5.081 -5.704

Appendix B

Selection of lag length *k* of VAR models for the Toda and Yamamoto procedure

With a trend				**Without a trend**				**Selected Lag Length k**
India								
lags	AIC	BIC	HQC	lags	AIC	BIC	HQC	**1**
1	-3.008152*	-2.680487*	-2.887319*	1	-2.944366*	-2.698617*	-2.853741*	
2	-2.958349	-2.466851	-2.7771	2	-2.906011	-2.496429	-2.75497	
3	-2.897618	-2.242288	-2.655953	3	-2.847157	-2.273743	-2.6357	
4	-2.770013	-1.95085	-2.467931	4	-2.724528	-1.987281	-2.452654	
Indonesia								
lags	AIC	BIC	HQC	lags	AIC	BIC	HQC	**1**
1	-0.933769*	-0.606104*	-0.812936*	1	-0.923361*	-0.677612*	-0.832736*	
2	-0.805457	-0.313959	-0.624208	2	-0.768024	-0.358442	-0.616983	
3	-0.688139	-0.032808	-0.446473	3	-0.613915	-0.040501	-0.402458	
4	-0.591913	0.22725	-0.289831	4	-0.565186	0.17206	-0.293312	
Malaysia								
lags	AIC	BIC	HQC	lags	AIC	BIC	HQC	**1**
1	-1.778243*	-1.450577*	-1.657410*	1	-1.827119*	-1.581370*	-1.736495*	
2	-1.688865	-1.197367	-1.507616	2	-1.744485	-1.334904	-1.593444	
3	-1.536823	-0.881493	-1.295158	3	-1.599694	-1.02628	-1.388236	
4	-1.547148	-0.727985	-1.245066	4	-1.559139	-0.821893	-1.287265	
Philippines								
lags	AIC	BIC	HQC	lags	AIC	BIC	HQC	**1**
1	-0.315079*	0.012586*	-0.194246*	1	-0.122546*	0.123202*	-0.031922*	
2	-0.25985	0.231647	-0.078601	2	-0.035597	0.373984	0.115444	
3	-0.194054	0.461276	0.047611	3	0.049823	0.623237	0.261281	
4	-0.072639	0.746524	0.229443	4	0.205555	0.942802	0.477429	
Thailand								
lags	AIC	BIC	HQC	lags	AIC	BIC	HQC	**4**
1	-0.769895	-0.442230*	-0.649063	1	-0.837953	-0.592204*	-0.747328*	
2	-0.836393	-0.344896	-0.655144*	2	-0.887095	-0.477514	-0.736054	
3	-0.817228	-0.161897	-0.575562	3	-0.886292	-0.312879	-0.674835	
4	-0.846495*	-0.027332	-0.544413	4	-0.892728*	-0.155482	-0.620854	
Vietnam								
lags	AIC	BIC	HQC	lags	AIC	BIC	HQC	**2**
1	-0.354525	-0.026859*	-0.233692*	1	-0.188538	0.057211*	-0.097913*	
2	-0.395655*	0.095843	-0.214406	2	-0.244201*	0.165381	-0.09316	
3	-0.370736	0.284595	-0.12907	3	-0.206056	0.367358	0.005402	
4	-0.361444	0.457719	-0.059362	4	-0.189606	0.547641	0.082268	

Appendix C

Sensitivity Analysis for the Kapetanios test used to define the year of structural breaks.

India	# of lags			Structural Break 1		Structural Break 2		
CO2 emis./cap.	4	1970	-	1982	-	2002	-	2016
	3	1970		1982		2002		2016
	5	1970		1990		2003		2016
	6	1970		1990		2003		2016
FDI per capita	4	1970	-	1989	-	2002	-	2016
	3	1970		1986		1999		2016
	5	1970		1986		1999		2016
	6	1970		1986		1999		2016
Indonesia	# of lags			Structural Break 1		Structural Break 2		
CO2 emis./cap.	4	1970	-	1982	-	2002	-	2016
	3	1970		1983		2001		2016
	5	1970		1982		2002		2016
	6	1970		1982		2002		2016
FDI per capita	4	1970	-	1990	-	2003	-	2016
	3	1970		1991		2004		2016
	5	1970		1991		2004		2016
	6	1970		1991		2004		2016
Malaysia	# of lags			Structural Break 1		Structural Break 2		
CO2 emis./cap.	4	1970	-	1986	-	2003	-	2016
	3	1970		1992		2016		
	5	1970		1992		2016		
	6	1970		1992		2016		
FDI per capita	4	1970	-	1989	-	2003	-	2016
	3	1970		1989		2003		2016
	5	1970		1989		2003		2016
	6	1970		1989		2003		2016
Philippines	# of lags			Structural Break 1		Structural Break 2		
CO2 emis./cap.	4	1970	-	1984	-	1997	-	2016
	3	1970		1984		1997		2016
	5	1970		1984		1997		2016
	6	1970		1984		1998		2016
FDI per capita	4	1970	-	1990	-	2003	-	2016
	3	1970		1991		2004		2016
	5	1970		1991		2004		2016
	6	1970		1991		2004		2016
Thailand	# of lags			Structural Break 1		Structural Break 2		
CO2 emis./cap.	4	1970	-	1982	-	1995	-	2016
	3	1970		1982		1995		2016
	5	1970		1982		1995		2016
	6	1970		1982		1995		2016
FDI per capita	4	1970	-	1985	-	2003	-	2016
	3	1970		1985		2004		2016
	5	1970		1985		2004		2016
	6	1970		1990		2004		2016
Vietnam	# of lags			Structural Break 1		Structural Break 2		
CO2 emis./cap.	4	1970	-	1993	-	2016		
	3	1970		1993		2016		
	5	1970		1985		1998		2016
	6	1970		1985		1998		2016
FDI per capita	4	1970	-	1985	-	2003	-	2016
	3	1970		1985		2003		2016
	5	1970		1986		2004		2016
	6	1970		1986		2004		2016