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In between the superpowers: can American and Chinese FDI cause environmental degradation in developing countries?

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Abstract

Foreign Direct Investment (FDI) from the US and China, the two largest global superpowers, has consistently been on the rise in developing economies. In many countries, the rivalry between these giants has been even more intense in recent years. However, FDI comes with its lot of consequences, and many have warned against the possible environmental degradation it could cause. With the US and China being major global pollutants, the question then arises as to whether FDI from these countries can be detrimental to the environment in developing countries. Hence, this paper uses panel data from 77 countries from 2003 until 2019 to study and compare the effect of American and Chinese FDI on CO2 emissions in the developing world. The results indicate that FDI from the US decreases emissions in developing countries, while FDI from China has an inverted U-shaped effect on emissions. These results are highly significant and relatively robust to various sensitivity checks. Moreover, the results for the US support the Pollution Halo Hypothesis, while the results for China provide support for the Pollution Haven Hypothesis. The former predicts that FDI decreases emissions because it brings positive green technology spillovers, while the latter argues that FDI increases emissions because foreign firms seek pollution havens in developing countries. Hence, the results indicate significant heterogeneities in the impact of FDI on CO2, depending on the host region and home country considered.

Keywords: Foreign Direct Investment (FDI), Carbon Dioxide Emissions (CO2), Pollution Haven Hypothesis, Pollution Halo Hypothesis, United States, China, Developing Countries.

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1. Introduction

Foreign Direct Investment (FDI), defined as an investment by a foreign enterprise to acquire control or a lasting interest in an entity of the host economy (Moosa, 2002), is widely recognized as beneficial to the recipient economy. Among others, FDI is believed to facilitate technological progress of developing countries and boost economic growth (Borensztein et al., 1998). Moreover, it increases capital stocks and accelerates knowledge transfers between developed and developing economies (De Mello, 1997). Nevertheless, FDI is also associated with negative consequences, which are often disregarded. One of the most cited of these is the possibility of environmental degradation: it is often believed that FDI causes negative environmental externalities in developing countries (Zarsky, 1999). However, this is still subject to controversy and heavily debated in the literature: while some argue that polluting foreign firms are attracted to countries where environmental policy stringency is low, others claim that FDI propagates green technologies which help protect the environment (Zarsky, 1999).

While the impact of FDI on the environment is not clear, protecting the latter is more important than ever, and especially so in developing economies. Such economies are predicted to suffer the highest economic and human costs from global warming (Ravindranath and Sathaye, 2002). This is both because these countries are particularly geographically susceptible to the consequences of climate change, such as extreme weather events (e.g. cyclones, floods), and because they are economically and socially vulnerable to these changes (Mirza, 2003). Hence, they bear as much as 20 times the economic cost from climate change as developing countries do on a per capita GDP basis (Mirza, 2003). Moreover, in the last decade, greenhouse gas emissions from these countries have surpassed those of the developed world (Wei et al., 2016), which shows how crucial it is to limit emissions in emerging economies.

Moreover, in developing countries, the trade rivalry between the United States and China has been growing in the last few years (Kim, 2019). The strategic competition between the two largest superpowers is predicted to intensify over time as China's political and economic power keeps rising and the United States strives to remain the number one global force (Kim, 2019). Accordingly, the US and China are among the largest sources of FDI in developing countries (UNCTAD Stat, 2021). Adding on to this, the US and China being the world's two largest CO_2 emissions contributors (Lee et al., 2013), their concurrent influence in developing countries could have significant effects on their CO_2 emissions. Since it is crucial that actions are taken to limit emissions in developing countries (Lee et al., 2013), understanding how investment from the two economic giants influence local emissions is of growing societal and policy relevance. Moreover, to this date, no research has studied the impact of *bilateral* FDI from China and the US on CO2 emissions specifically, and instead the literature has generally focused on the effect of *total* FDI. Hence, in this paper, I attempt to answer the following research question: *What is the effect of FDI from the US and China on CO2 emissions in developing countries?*

To answer this question, I compile a panel dataset for 77 developing countries in South-East Asia, Africa, and Latin America from 2003 to 2019. Using fixed effects and controlling for possible confounding factors, I test the effect of American and Chinese FDI on CO2 emissions in developing economies. Moreover, I associate the hypotheses and the findings to the Pollution Haven and Halo Hypotheses, which make concurring predictions about the effect of FDI on emissions. The Pollution Haven Hypothesis is based on the theory of comparative advantages and predicts that FDI from countries where environmental policy stringency is high is more likely to stem from polluting industries, since firms are looking for pollution havens in countries where stringency is lower. Hence, according to the Pollution Haven Hypothesis, FDI into countries where stringency is low will increase their CO2 emissions. Conversely, the Pollution Halo Hypothesis postulates that FDI, especially when stemming from countries where environment-related technology development is high, creates green technology spillovers in the host country. These spillovers, in turn, reduce CO2 emissions. Hence, in addition to providing valuable insights on the possible reasons why FDI from the US and China increase or decrease such emissions, this research also allows for (in)validating these hypotheses.

The findings show that while FDI from the US significantly decreases emissions in developing countries, FDI from China has an inverted U-shaped effect. In other words, Chinese FDI is associated with an increase in developing countries' CO2 emissions up to a turning point, after which the effect turns negative. However, this threshold is located at a higher level of FDI than any of the sample countries currently receives. Therefore, in the present situation in developing countries, an increase in FDI from China is associated with increased carbon dioxide emissions. Moreover, the effect of FDI from China on emissions is significantly different from the effect of FDI from the US. These results are generally robust to various robustness checks, including using other measures for FDI and CO2 emissions and the inclusion of additional variables and lags.

Importantly, the results are partially consistent with both the Pollution Haven and the Pollution Halo Hypotheses. In fact, the results for China are consistent with the Haven Hypothesis, while those for the US are consistent with the predictions of the Halo Hypothesis. These findings indicate that the effect of FDI on CO2 is heterogenous depending on host and home country, and studies that consider the effect of FDI without taking this into account may be missing out on important heterogeneities. Most of the literature has studied the effect of *total* FDI on emissions; however, the results of this study show that focusing on *bilateral* FDI adds relevant insights and uncovers large regional differences. These heterogeneities, in turn, provide new insights on the validity of the Pollution Halo and Haven Hypotheses. Here, the results indicate that the Pollution Haven Hypothesis is valid when it comes to FDI from China, while the Pollution Halo Hypothesis is valid for the US. Therefore, looking at bilateral FDI also provides way for both Hypotheses to be valid simultaneously – they do not necessarily have to be contridactory, as it is more a question of which dominates the other.

Besides, the policy implications of the results are twofold. First, FDI from the US brings positive environmental externalities in developing countries, and this should at the very least be taken into account by policymakers when trying to reduce their emissions. Policies that encourage the diffusion of green technology from foreign to home firms could make this effect even stronger. Second, FDI from China creates negative environmental externalities, which indicates that the developing world should be wary when considering Chinese FDI. Policies that regulate the pollution intensity of incoming FDI could also help mitigating this and encourage cleaner FDI from abroad.

The remainder of this paper is organized as follows. In Section 2, I review the literature on FDI and environmental externalities. This literature can generally be related to the Pollution Haven and the Pollution Halo Hypotheses, which make contradicting predictions on the effect of trade and FDI on CO2 emissions. I describe each of these hypotheses, the related literature, and empirical evidence in turn. Using both theories, I propose three hypotheses for the effect of FDI from the US and China on CO2 emissions in developing countries. Section 3 then describes the data used and gives descriptive statistics. In Section 4, the methodology employed in this study is described. Section 5 presents the main results, and in Section 6, I conduct several robustness checks to test the sensitivity of the findings. Finally, Section 7 discusses the results and their policy implications, and Section 8 draws final conclusions.

2. Literature Review

As previously mentioned, the literature on FDI and environmental externalities has focused on the effect of total FDI on CO2 emissions rather than on bilateral FDI from individual countries. Since the 1990s, this topic has been at the center of a debate between the supporters of the Pollution Haven Hypothesis, who argue that FDI inflows into developing countries will lead to an increase in their CO2 emissions, and those of the Pollution Halo Hypothesis who argue that it will decrease emissions. As of today, even though these theories have been extensively reviewed and tested, the empirical literature is still inconclusive, and it is not clear whether either of these theories holds (Gill et al., 2018). In this section, I review both theories, their mechanisms, and their empirical evaluations. I also briefly review some of the literature on the effect of bilateral FDI from China and the US on other variables. I then propose hypotheses for the effect of FDI from the US and China on CO2 emissions in developing countries, which follow from the Pollution Haven and Halo Hypotheses.

2.1. Total FDI and CO2 emissions

2.1.1. The Pollution Haven Hypothesis

Although it was not named as such, the Pollution Haven Hypothesis was first suggested by Copeland and Taylor (1994). They propose a simple general equilibrium model with two countries – the North and the South – that differ in income and environmental stringency. Their study is the first to link trade, income, environmental regulations, and ensuing pollution. They find an equilibrium such that the North, which has a higher national income, chooses more stringent environmental regulations and specializes in less emission-intensive industries. In contrast, the South specializes in "dirty" sectors that are more emission-intensive and chooses laxer environmental regulations. Hence, the South acts as a "pollution haven" whereby, through international trade liberalization, it produces products in "dirty" industries for rich countries with stricter environmental policies.

As described by Eskeland and Harrison (2003), the theory of the Pollution Haven Hypothesis is based on the theory of comparative advantages. If a country has laxer environmental regulations (e.g., lower taxes on CO2 emissions), it will have a comparative advantage in producing emission-intensive products. Hence, polluting firms in countries with more stringent environmental regulations have an incentive to move to these "pollution havens" (Eskeland and Harrison, 2003). In other words, since complying with strict environmental regulations is costly for a profit-maximizing firm and especially for those in highly polluting industries, these firms have an incentive to move to countries with laxer regulations - assuming the costs of such relocation are low enough to make it cost-saving (Javorcik and Wei, 2003). This has important conclusions for treaties such as the Kyoto Protocol, which limit a country's territorial emissions of greenhouse gases for committing parties, but do not constrain the quantity of emissions they can "import" while trading internationally (European Commission, 2020). In this case, we are likely to see the displacement of "dirty" industries to countries that did not commit to the Protocol, a process also known as carbon leakage (Aichele and Felbermayr, 2015). This, in turn, increases emissions in these non-committing countries. Hence, the Pollution Haven Hypothesis postulates that FDI from richer, more environmentally stringent countries into developing countries with lax regulations increases CO_2 emissions in the latter.

However, critics of the Pollution Haven Hypothesis argue that it ignores important factors that determine the relocation of firms abroad. Gill et al. (2018) point out that firm relocation to a country with low environmental policy stringency can also cause a decrease in labor productivity and hence an increase in labor costs. Not to mention, there are also high sunk costs of shifting a firm abroad which may make relocation impossible. Moreover, they observe that countries with lax environmental regulations often have weak institutions and rule of law, which are likely to deter firms from relocating to these countries in the first place. Finally, firms may also be concerned with their corporate social responsibility and hence, may decide not to move to countries with lax environmental regulations even if that is cost-saving (Gill et al., 2018). Thus, there are multiple reasons why the Pollution Haven Hypothesis may not hold in practice when all relocation costs are taken into account.

Early evidence from Low and Yeats (1992) and Selden and Song (1994) suggests that developing countries do impose less stringent environmental regulations, which gives them a comparative advantage in the production of polluting goods. Nevertheless, the empirical evidence on the Pollution Haven Hypothesis is mixed. It postulates that countries with lax environmental regulations will attract more FDI from highly polluting industries and that this will lead to an increase in host country emissions. Hence, the hypothesis can generally be validated in two ways: one can (1) test if (highly-polluting) FDI is more likely in countries with lax environmental regulations, or (2) test if FDI in these countries leads to an increase in CO_2 emissions. The literature has addressed both questions extensively, and this paper focuses on the second.

Addressing the first question in an empirical evaluation of their model, Eskeland and Harrison (2003) examine the determinants of FDI in Mexico, Morocco, Côte d'Ivoire, and Venezuela using a fixed-effects specification and find that the evidence supporting the hypothesis is weak at best. FDI is not significantly related to local abatement costs (i.e., costs associated with polluting) in the receiving countries, and foreign firms actually pollute less than home firms. However, they find some evidence, albeit not robust, that foreign investment is concentrated in polluting industries. Levison and Taylor (2008) use a fixed-effects method to study the relationship between pollution abatement costs, which they use as proxy for the stringency of environmental regulations and traded products in the US, Canada, and Mexico. In contrast to Eskeland and Harrison (2003), they find that abatement costs are significantly positively related to net imports into the US. According to their estimates, a 1% increase in abatement costs for a given industry leads to a 0.2% and 0.4% increase in net imports from Mexico and Canada respectively, which is a sizeable effect.

In an early yet influential study, Grossman and Krueger (1991) examine the possible impact of the North-American Free Trade Agreement (NAFTA) on the environment. To do so, they study the relationship between abatement costs in the US, international trade with Mexico and investment in Mexico. They conclude that differences in pollution abatement costs across locations are too small compared to differences in production costs to significantly affect pollution through changes in investment and trade, which does not support the Pollution Haven Hypothesis.

Cole (2004) examines the relationship between air pollutants, dirty imports, and dirty exports. He finds that, in OECD countries, the quantity of the majority of territorial air pollutants is negatively associated with the country's share of dirty imports in total imports, providing support for the Haven Hypothesis. In other words, imports are on average more pollution-intensive in places where air pollution is lower. On the other hand, air pollutants are positively associated with the share of dirty exports. However, these effects are not found for all pollutants, and even when they are, their magnitude is small compared to other determinants of pollution such as national income.

Javorcik and Wei (2003) specifically test the Pollution Haven Hypothesis in Eastern Europe and the former Soviet Union by studying the association between FDI inflows and environmental regulations. The wide variation in environmental standards in these countries allows the authors to construct a robust identification strategy. They focus on the manufacturing sector, which is likely to be pollution-intensive, and hence where one would expect to observe pollution haven effects. Nevertheless, the authors do not find support for the Haven Hypothesis. On the contrary, they find that, if anything, FDI in the area is less likely to stem from pollution-intensive industries.

Honglei et al. (2011) focus on China and examine the relationship between FDI and environmental pollution at the regional level using a simultaneous equation model and find no such association. They argue that, instead of FDI inflows being attracted to the country by low environmental policy stringency, it is mainly drawn by China's cheap labor and large market. The latter finding is corroborated by Xiao (2016), who argues that FDI is not attracted to China because of its low environmental policy stringency, but rather by its infrastructure and technology, providing no support for the Haven Hypothesis. Confirming these findings for ASEAN and OECD countries, Rasit and Aralas (2017) find that even though environmental regulations are strongly correlated with trade, they are not significantly associated with FDI. This indicates that the Pollution Haven Hypothesis may or may not hold depending on whether one considers trade or FDI.

Addressing the second question on the effect of FDI on CO_2 emissions in a worldwide dynamic panel analysis of 188 countries, Shao (2018) finds evidence that FDI inflows have a significant detrimental impact on CO_2 emissions. The effect of FDI on CO_2 emissions is still positive when controlling for possible confounders such as urbanization, trade openness, or the share of fossil fuels. Likewise, Naz et al. (2019) study this relationship using panel data from Pakistan and a robust least square estimator while incorporating renewable energy consumption as a moderator. They find that FDI increases emissions, thereby validating the Pollution Haven Hypothesis.

Ren et al. (2014) use an input-output analysis using data from 18 Chinese industries to compute CO_2 emissions embodied in international trade and a General Method of Moments estimation to study the impact of FDI on emissions. They find that one of the main reasons for the dramatic increase in CO_2 emissions in China over time is its growing trade surplus. Moreover, FDI further increases carbon emissions, as predicted by the Pollution Haven Hypothesis. Consequently, they recommend that China promotes clean FDI to transition from being a pollution haven to a low-carbon economy. Similarly, He (2006) tests the effect of FDI in China at the provincial level and finds that it increases SO_2 emissions in the country.

Looking specifically at countries in East Asia, Ibrahim and Rizvi (2015) apply a panel co-integration analysis using a standard Environmental Kuznets Curve (EKC) non-linear setup. In addition, they include trade and energy in their model and find that trade has a detrimental effect on CO_2 emissions, especially in ASEAN countries. These results are confirmed by Behera and Dash (2017). The latter study the relationship between FDI, CO_2, urbanization and energy consumption using a Pedroni co-integration analysis and find that FDI significantly increases CO_2 emissions in South and South-East Asian countries. Moreover, Guzel and Okumus (2020) test the validity of the hypothesis in ASEAN-5 economies (Indonesia, Malaysia, Philippines, Singapore, and Thailand) using time-series data on FDI and CO_2 and also find that the Pollution Haven Hypothesis holds. According to their results, an increase in FDI is associated with an increase in emissions.

In contrast, Zhu et al. (2016) examine the impact of energy consumption, economic growth, and FDI on CO_2 emissions in the same countries using a panel quantile regression accounting for individual and distributional heterogeneity. They find that the effects of FDI are heterogenous: it has a negative impact on carbon emissions, except at the 5^{th} quantile, and this effect is significant only for the highest quantiles. Nevertheless, their results still indicate that overall, FDI reduces carbon emissions, which contradicts the Pollution Haven Hypothesis. However, as described in the next Section, their findings can be considered supportive of the Pollution Halo Hypothesis.

2.1.2. The Pollution Halo Hypothesis

In an attempt to disprove the Pollution Haven Hypothesis, Birdsall and Wheeler (1993) argue that trade liberalization and FDI inflows in Latin America did not lead to environmental degradation in the region. They present a qualitative case study of Chile where the evidence indicates a negative relationship between trade openness and pollution. Additionally, they make a cross-country comparison using panel data and find that the most open economies were the least pollution-intensive in Latin America for 1960-1988. However, they use a simple regression with no control variables and hence, they are likely missing out on the confounding effects of important omitted variables. Nevertheless, they argue that the Pollution Haven Hypothesis does not hold in this case because trade liberalization and foreign investment also eliminate barriers to importing foreign technologies, including green technologies that help reduce pollution. In other words, multinationals who invest in developing economies apply universal environmental standards and have access to cleaner technologies, which are then spread in the developing economy, spilling over to smaller local enterprises (Hoffman et al., 2005). This is the Pollution Halo Hypothesis: foreign enterprises produce a positive "halo" effect on local firms. According to the Halo Hypothesis, an increase in FDI will lead to a decrease in CO2 emissions in developing economies, contradicting the Pollution Haven Hypothesis.

Kim and Adilov (2012) point out that the Pollution Halo Hypothesis may hold because host countries impose stricter environmental stringency on foreign firms. Alternatively, foreign companies could be cautious with polluting the host country because they are uncertain about the environmental rules in place. It can also be that foreign investors want to please local governments or stakeholders in their home country. Finally and most importantly, foreign firms may have access to less-polluting production methods and technologies than local firms. These green technologies and processes then spill over to local firms, which in turn reduce their emissions. Taken together, these factors could indicate that FDI into developing economies leads to a reduction in local CO2 emissions.

Using firm-level data from Ghana, Cole et al. (2008) test if previous training of a firm's critical workers in a foreign-owned firm is associated with greener processes. In other words, they test if such workers can effectively transmit the knowledge of green technologies they gained in a foreign-owned firm to local firms. Such knowledge transfer would be an indication that the Pollution Halo Hypothesis holds. Their findings are as follows: even though foreign ownership itself does not decrease fuel energy use, experience at a foreign firm does, and more so in foreign-owned firms. This indicates that both the knowledge of cleaner technologies (i.e., having experience in a foreign-owned firm) and the ability to utilize that knowledge (e.g., working in a foreign-owned firm) matter for the channels of the Pollution Halo Hypothesis to work.

Asghari (2013) investigates whether the Pollution Haven or the Halo Hypothesis holds in the Middle-East and North Africa region and finds that his results support the latter. Atici (2012) studies the relationship between CO2 per capita, the ratio of (polluting) exports in total exports, and FDI inflows for the ASEAN countries. He uses panel data from 1970 to 2006 and a Hausman test to determine which of a fixed-effects or a random-effects method is most appropriate for his specification. His findings suggest that the share of "dirty" exports in total exports increases with emissions in the region, which does not support the Pollution Halo Hypothesis when it comes to trade - since one would expect emissions to decrease with the share of polluting exports. Instead, these results indicate that the Pollution Haven Hypothesis holds. Moreover, he observes that exports to China are associated with higher pollution levels, while exports to the US and Japan are not. However, FDI has a negative significant, although small, impact on carbon emissions, providing some support for the Pollution Halo Hypothesis.

Kim and Adilov (2012) test the validity of both the Pollution Haven Hypothesis and the Pollution Halo Hypothesis by regressing the growth of CO2 emissions on the net growth rate of productive FDI using a panel of 164 countries and 44 years. They control for country GDP, population growth, Kyoto Protocol ratification, and oil price growth, as these variables are likely correlated with both carbon emissions and FDI. Moreover, they include country-specific fixed effects to control for country-level differences in CO2 emissions. Using an Ordinary Least Squares (OLS) regression on the whole sample, they find that FDI has a significant negative impact on CO2 emissions. However, when they run their analysis separately for developed and developing countries, they find that FDI increases CO2 growth rates in the former and decreases them in the latter. This indicates that, while the Pollution Haven Hypothesis holds for developed countries, the Pollution Halo Hypothesis is relevant for the developing world. Their interpretation of these findings is that in developing countries, foreign firms are less polluting than local firms, and hence FDI spreads greener technologies. Conversely, in developed countries, foreign firms are more polluting than local firms, and thus foreign investment increases local emissions. Therefore, they interpret their findings as simultaneously supporting the Pollution Haven and the Pollution Halo Hypotheses, concluding that they are not necessarily contradictory. Since the former focuses on firms' decisions to locate to a country and the latter focuses on firms' behavior once settled in a country, it can be that a foreign firm relocates to a developing country in search of a pollution haven but still spreads greener technologies there. Hence, they argue that they can also simultaneously hold true.

Similarly, Huynh and Hoang (2018) find that the hypotheses are not necessarily conflicting. They use a panel dataset of 19 developing Asian countries to study the effect of FDI on pollution, with the inclusion of institutional quality as an interaction variable. They find that FDI is indeed detrimental to environmental quality when institutional quality is low, but that this effect turns positive once institutional quality is high enough. Hence, in that sense, both the Pollution Haven and Halo Hypotheses can hold simultaneously, and which one dominates depends on the country's level of institutional development.

Hoffman et al. (2005) use a panel dataset of 112 countries to conduct a Granger causality test of the relationship between FDI and CO2 emissions. Like Kim and Adilov (2012), they find that the results depend on the level of development of the host country. There is no causal relationship between CO2 and FDI for high-income countries, and thus neither the Pollution Haven Hypothesis nor the Pollution Halo Hypothesis holds. However, in contrast to the findings of Kim and Adilov (2012), for low-income countries there is such a causal relationship, which supports the Pollution Haven Hypothesis. They conclude that low-income countries can be seen as pollution havens while middle and high-income countries cannot.

Balsalobre-Lorente et al. (2019) connect the Pollution Halo Hypothesis to the concept of an Environmental Kuznets Curve (EKC). Supporters of the EKC envision the relationship between economic growth and environmental degradation as an inverted U-shaped curve (Lau et al., 2014). In other words, CO2 emissions increase with economic growth at low levels of economic development and decrease with growth once economic development has passed a turning point. Balsalobre-Lorente et al. (2019) confirm the existence of an EKC for MINT countries (Mexico, Indonesia, Nigeria, and Turkey). They find that an inverted U-shaped relationship also goes for FDI and CO2 emissions: the effects associated with the Haven Hypothesis hold before the turning point, and those of the Halo Hypothesis dominate thereafter. According to their results, all 4 MINT countries are situated after that turning point so that FDI decreases local CO2 emissions.

The literature on the effect of FDI on CO2 emissions is summarized in Table 1. In brief, the empirical evidence on the validity of the Pollution Haven Hypothesis and the Pollution Halo Hypothesis is inconclusive. Differences in findings can be attributed to differences in the choices of control variables and methods, such as the inclusion of urbanization and renewable energy (Balsalobre-Lorente et al., 2019). A strand of the literature, which considers mitigating factors such as institutional quality or non-linearities in the effect of FDI on CO2 emissions, suggests that both hypotheses may be valid simultaneously, and which one dominates depends on the specific setting. The empirical literature presented here is only a subset of the existing studies since the topic has been extensively reviewed and evaluated. Nevertheless, no conclusion on the general effect of FDI on CO2 emissions or the validity of the Pollution Haven or Halo Hypotheses can be drawn.

Table 1: Summary of literature on FDI and CO2 emissions

Authors	Journal	Region	Timeframe	Method	Findings
Shao (2018)	International Journal of Climate Change Strategies and Management	188 countries	1990-2013	System-generalized Method of Moments estimator	FDI↑ CO2↑
Naz et al. (2019)	Environmental Science and Pollution Research	Pakistan	1975-2016	Robust Least Square estimator	FDI↑ CO2↑
Ren et al. (2014)	China Economic Review	China	2001-2010	General Method of Moments	FDI↑ CO2↑
Behera and Dash (2017)	Renewable and Sustainable Energy Reviews	South and South-East Asia	1980-2012	Pedroni co-integration	FDI↑ CO2↑
Guzel and Okumus (2020)	Environmental Science and Pollution Research	ASEAN-5	1981-2014	Panel data techniques taking cross-sectional dependence and slope heterogeneity into account	FDI↑ CO2↑
Hoffman et al. (2005)	Journal of International Development	112 countries		Granger causality test	FDI↑ CO2↑*
Solarin et al. (2017)	Energy	Ghana	1980-2012	Autoregressive Distributed Lag Method	FDI↑ CO2↑
Cole et al. (2011)	Journal of Regional Science	China	2001-2004	Panel analysis with fixed effects	FDI↑ CO2↑
Zhu et al. (2016)	Economic Modelling	ASEAN-5 countries	1981–2011	Panel quantile regression	FDI↑ CO2↓**
Atici (2012)	Journal of the Japanese and International Economies	ASEAN countries	1970-2006	Panel analysis with fixed effects	FDI↑ CO2↓
Kim and Adilov (2012)	Applied Economics	164 countries	1961-2004	Panel analysis with fixed effects	FDI↑ CO2↓***
Sung et al. (2018)	Economic Systems	China	2002-2015	System Generalized Method of Moments	FDI↑ CO2↓
Pao and Tsai (2011)	Energy	BRIC countries	1992-2007	Multivariate Granger causality tests	FDI↑ CO2↓
Tang and Tan (2015)	Energy	Vietnam	1976-2009	Granger causality test and Johansen co-integration	FDI↑ CO2↓

Table 1, continued

Huyng and Hoang (2018)	Applied Economics Letters	19 developing Asian countries	2002-2015	Feasible Generalized Least Squares and Two-step Generalized Method of Moments	FDI↑ CO2↑ if INST is low, FDI↑ CO2↓ if INST is high
Balsalobre-Lorente et al. (2019)	Environmental Science and Pollution Research	Mexico, Indonesia, Nigeria, and Turkey	1990-2013	Modified Least Squares and Dynamic Ordinary Least Squares	FDI↑ CO2∩
Al-mulali and Tang (2013)	Energy Policy	Gulf Cooperation Council countries	1980-2009	Pedroni co-integration and Granger causality test	FDI↑ CO2✕
Chandran and Tang (2013)	Renewable and Sustainable Energy Reviews	ASEAN-5 countries	1971-2008	Granger causality test and Johansen co-integration	FDI↑ CO2✕

Note: FDI is Foreign Direct Investment, CO2 is CO2 emissions, and INST is institutional quality. ↑ signifies increases, ↓ signifies decreases and ∩ represents an inverted U-shaped relationship between FDI and CO2 (i.e., CO2 increases with FDI up to a turning point after which CO2 decreases with FDI). ✕ signifies that there is no relationship between FDI and CO2.
*FDI has a causal impact on CO2 in low-income countries, but there is no such causal relationship in high-income countries.
**FDI has a negative impact on carbon emissions, except at the 5th quantile, and this effect is significant only for the highest quantile.
***FDI has a significant and negative impact on CO2 emissions for the whole sample and developing countries, but this impact is negative for developed countries.

2.2. Bilateral FDI

The studies reviewed so far have focused on the effect of *total* FDI on host country CO2 emissions. However, a few authors have also researched the impact of *bilateral* FDI from a specific country on various outcomes, often economic growth. Unfortunately, to the best of my knowledge, none of these studies have looked at the effect of such bilateral FDI and CO2 emissions in particular. Nevertheless, some are worth mentioning and focus specifically on China or the US. For example, Busse et al. (2016) use a type of Solow growth model to study the impact of trade and FDI from China to Africa, and find that Chinese FDI does not significantly affect growth in the continent. In contrast, using a fixed-effects model, Doku et al. (2017) find that FDI from China does cause a significant increase in growth in Africa Moreover, they find that this causal relationship is unidirectional. Ngundu and Ngepah (2019) bring in an additional nuance to these findings by including institutional quality in their model: they find that FDI from China, Europe and the US has a positive impact on Africa's growth, but only once institutional quality has passed a certain threshold. They find that this threshold is lower when FDI originates from the US or Europe than when it comes from China. Moreover, the US and Europe mostly invest in countries with good governance, whereas China invests in countries with both good and bad institutional quality.

In a similar study, Tondl and Prüfer (2007) compare the effect of European and American FDI on economic development in Latin America. Just like Ngundu and Ngepah (2019), they find that the positive impact of FDI on growth is dependent on a high enough level of institutional quality. Moreover, their findings indicate that FDI from Europe is a strong, significant determinant of growth in the continent, but FDI from the US is not. Hence, their results suggest heterogeneity in the effect of FDI, which is similar to the findings of this study. Sung and Huk (2008) take a similar approach and compare the effect of FDI from Japan to that of the US in East Asia. They find that FDI from both countries increased economic growth in Honk Kong, Singapore, Taiwan and South Korea, but not in Malaysia, Indonesia and Thailand.

2.3. Contribution and hypotheses

As mentioned in the previous section, even though the effect of *total* FDI on host country CO2 has been extensively reviewed and discussed, very few studies have used data on *bilateral* FDI to test the validity of the Pollution Haven and Halo Hypotheses. Moreover, even though a strand of the literature has researched the effect of bilateral FDI from the US and/or China on growth, to the best of my knowledge, no study has tested their impact on carbon dioxide emissions specifically. The contribution of this study is to use data on bilateral FDI from the US and China into developing countries in relation to their territorial CO2 emissions.

The reasons to focus on developing countries, the US, and China are twofold. First, as shown by the increasing number of floods and cyclones that hit developing countries in the last decades, the developing world is highly vulnerable to climate change (Mirza, 2003). They are predicted to suffer the highest economic and human costs from global warming (Ravindranath and Sathaye, 2002). According to Mirza (2003), this is both because (1) they are geographically vulnerable to the consequences of global warming (e.g. higher sea levels), and (2) their population is highly economically and socially vulnerable to these consequences. Hence, in the 2000s in just a decade, they suffered over $35 billion costs per year because of natural disasters, which amounts to over 20 times the cost beared by developed countries on a per capita GDP basis (Mirza, 2003). Besides, although in the past the developed part of the world was the largest contributor to climate change, GHG emissions in emerging economies keep rising and the developing world has now overtaken developed economies as the largest contributor to global emissions (Wei et al., 2016). Hence, it is crucial to limit emissions in developing countries as well if climate change is to be containted.

Second, as it has everywhere else, the trade rivalry in developing countries between the US and China has been growing in the last few years (Kim 2019). The strategic competition between the two largest superpowers is also predicted to intensify over time, as China's political and economic power keeps rising and the United States strives to remain the number one global force (Kim, 2019). China's Belt and Road Initiative acts as reflection of this and goes hand in hand with the growth of the Chinese influence in developing countries, which the US is determined to counter (Kim, 2019). Accordingly, the US and China are among the largest sources of FDI in developing countries (UNCTAD Stat, 2021). This is of special relevance in this case, considering that the US and China are the world's two largest CO_2 emissions contributors (Lee et al., 2013). Hence, their concurrent influence in developing countries could have significant effects on their carbon emissions. Since it is crucial that actions are taken to limit emissions in these countries (Lee et al., 2013), understanding how trade and investment from the two economic giants affect local emissions is of growing societal and policy relevance.

In general, as reviewed in the previous section, the effect of overall FDI on CO_2 emissions has been well examined. Moreover, the effect of American and Chinese FDI on growth has been studied to a certain extent. However, to this date no research has compared the impact of FDI from the US and China on carbon emissions in developing countries. Hence, there is a gap in the literature that this study aims to fill. With the increasing competition between the two economic giants and the importance of controlling developing countries' carbon emissions, comprehending how FDI from the US and China affects CO_2 emissions in these economies is crucial to future climate planning policies and understanding the dynamics within these areas. Moreover, by analyzing the impact of American and Chinese FDI separately, new insights can be obtained on the validity of the Pollution Haven and Pollution Halo Hypotheses since the results can be associated with environmental regulation and green innovation levels in these countries.

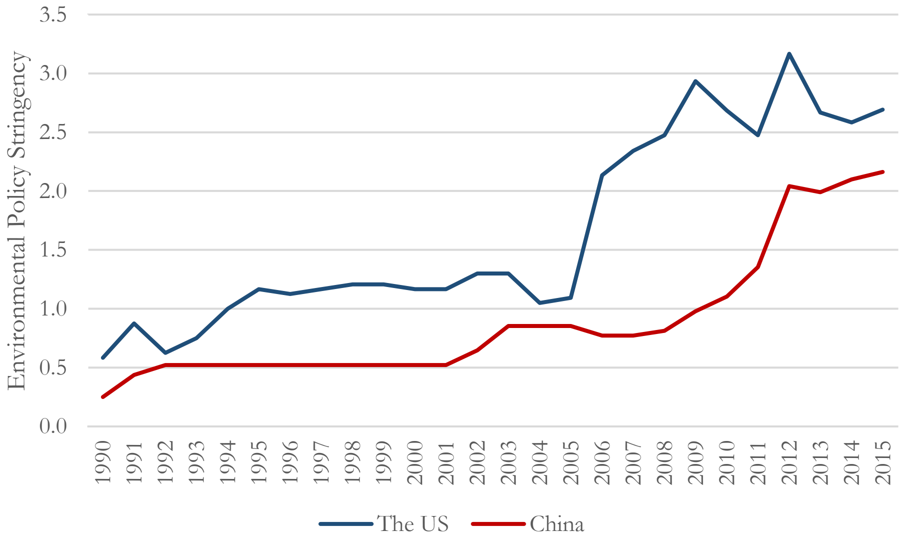
In order to propose hypotheses on the effect of FDI on CO_2 emissions from the US and China in developing countries, I use the Pollution Haven and Halo Hypotheses as a basis. Moreover, I use data on Environmental Policy Stringency (hereafter EPS) and Environment-Related Technology Development (ETD) for the countries under consideration. I consider each hypothesis in turn.

The theory of the Pollution Haven Hypothesis suggests that FDI from developed, environmentally stringent countries into environmentally-lax developing countries causes an increase in their CO_2 emissions. However, the theory goes further, as it postulates that firms in countries with strict environmental regulations are more likely to be looking for "pollution havens". Hence, FDI from such countries is more likely to increase CO_2 in developing countries. In other words, the hypothesis predicts that FDI from countries with higher EPS is more detrimental to the environment. Hence, by looking at EPS in the US and China compared to that in developing economies, one can infer for which of these two countries FDI is predicted to be more environmentally damaging by the theory.

Figure 1 depicts time-series data of EPS for the US and China, obtained from the OECD Environmental Policy Stringency Index. The index takes a minimum value of 0 (not stringent) and a maximum value of 6 (maximum stringency). The insights from Figure 1 are clear: EPS has been increasing over the last three decades for both the US and China, but it has been consistently higher in the US. EPS in China was stable at 0.5 until 2001, when it started increasing, corresponding to China's accession to the WTO. EPS in the US also significantly increased in the 2000s before stabilizing around 2.5. Thus, although there has been some catching up of China in the 2000s, EPS is still significantly higher in the US, just as it has been over the whole period under consideration. Hence, the Pollution Haven Hypothesis theory would predict that FDI from the US is more likely to increase CO2 in developing countries than FDI from China because firms in the US are more likely to be looking for "pollution havens" abroad.

Importantly, this is assuming that EPS is lower in the said developing countries than it is in the US. If this is not the case, there would be no incentive for American and Chinese firms to relocate to developing countries according to the Pollution Haven Hypothesis. Unfortunately, there is no time-series data on EPS available for most developing economies. Among the set of developing countries included in this study, it is only available in Indonesia, Brazil and South Africa. Data on

Figure 1. Environmental Policy Stringency in the US and China over time



Note: Environmental Policy Stringency takes a minimum value of 0 (not stringent) and a maximal value of 6 (maximum stringency). It is defined as "the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behavior" (OECD, 2021). It is calculated as a combination of 14 different policy instruments, mainly focusing on climate and air pollution. Source: OECD Environmental Policy Stringency Index, 2021.

these three countries from the OECD Environmental Policy Stringency Index indicates that their EPS has been consistently lower than in the US and generally lower than in China, as shown by Figure 4 in the Appendix. This will be taken as an indication that EPS is lower in developing countries than in the US and China. Moreover, cross-sectional data on EPS is available from the World Economic Forum Executive Opinion Survey of 2011-2012, which assesses EPS based on opinions from business leaders in over 140 countries (Schwab, 2012). Table 8 in the Appendix summarizes this data for China, the US, and countries in South-East Asia. For the sake of readability, however, not all 77 countries considered in this study are included in the table. Among developing countries included in the sample, EPS is only higher than in the US in Singapore. EPS in China is significantly lower and ranks at about the average EPS in South-East Asia. Hence, the data suggests a higher EPS in the US than in South-East Asia and China, which according to the Pollution Haven Hypothesis, is predicted to lead to American FDI being more detrimental to South-East Asian carbon emissions than FDI from China. The complete report from the Executive Opinion Survey shows that the same conclusions can be drawn for the set of 77 developing countries considered in this study.

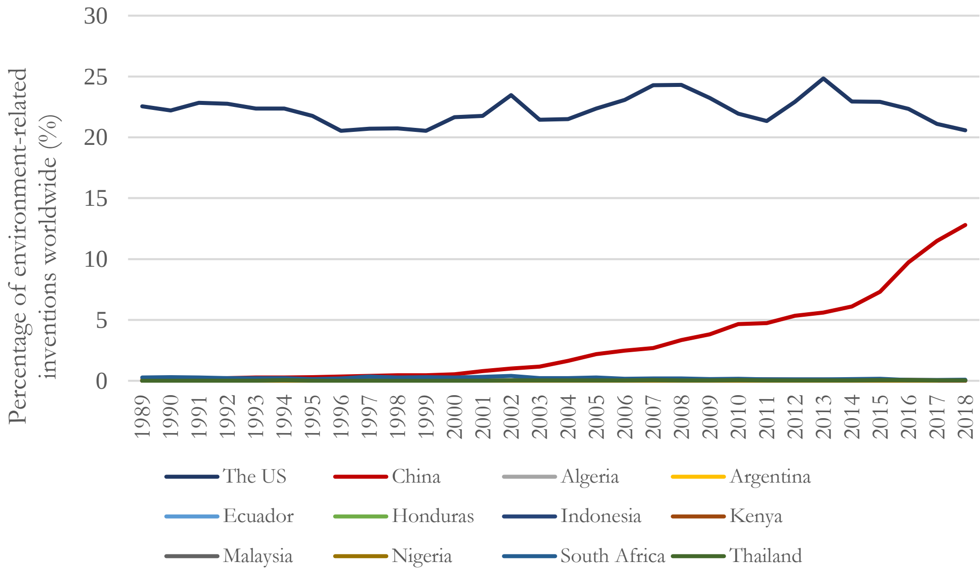
Hence, the theory of the Pollution Haven Hypothesis leads to two predictions: first, FDI from the US and China lead to an increase in developing countries' emissions. Second, highly polluting American firms have a stronger incentive to relocate to countries where environmental regulations are laxer to avoid the high costs of complying with the stringent American regulations. Therefore, I hypothesize:

> *Hypothesis 1 – the Pollution Haven Hypothesis is supported: An increase in FDI from the US or China increases CO2 emissions in developing countries, and more so when it originates from the US.*

I then turn to the Pollution Halo Hypothesis, which predicts that FDI can decrease the host country's CO2 emissions if it produces a "halo" effect by diffusing new environmental technologies and cleaner processes in the host country. Hence, the theory would predict that FDI into a country where Environment-related Technology Development (ETD) is low is more beneficial in the form of reduced CO2 emissions. In other words, we would expect FDI to be more beneficial when ETD in the receiving country is lagging behind: if the host country is not good at innovating in green technologies, FDI from other countries would cause more green spillovers. Nevertheless, that ETD be low in the receiving country is not necessarily a requirement for technology spillovers to take place. In fact, spillovers can take place even if ETD in the receiving country is high, as long as FDI is able to bring in new technologies. Hence, ETD in the home country also matters: the theory predicts for FDI to decrease CO2 by a larger extent if it originates from a country where ETD is high. All in all, according to the Pollution Halo Hypothesis, FDI should reduce CO2 by a large extent when ETD in the origin country is high, and ETD in the host country is low.

To see how this relates to the US, China, and developing countries, data on ETD is needed. The OECD provides different indicators of ETD for a number of countries, among which the country's share in ETD worldwide. This is displayed in Figure 2 below for the US, China, and selected developing countries for which ETD data is available. Figure 2 shows that the US has consistently provided over a fifth of environment-related patents worldwide, ranking as the most significant contributor. ETD in China has been increasing rapidly over the last three decades, although it is still smaller than in the US. Figure 5 in the Appendix displays Chinese and American ETD in absolute number of patents and confirms that ETD has been consistently higher in the US than in China over the years. In contrast, as shown in Figure 2, the contribution to ETD from developing countries remains small in comparison to that of the two superpowers.

Figure 2. Percentage of ETD worldwide, selected countries



Note: ETD is expressed as a percentage of total ETD worldwide, based on data on the number of environment-related technology patents issued by country. Source: OECD Patent Indicators, 2021.

Seeing as the data indicates that ETD is higher in the US than in China, while ETD in developing countries is much lower, the Pollution Halo Hypothesis makes two predictions. First, it suggests that FDI from the US and China cause a decrease in developing countries' emissions. Second, it predicts that FDI from the US leads to a more significant reduction in CO2 emissions than FDI from China. Indeed, if the US produces cleaner technologies, it is more likely to spread these when investing abroad and reduce local carbon emissions. Hence, this leads to the following hypothesis:

Hypothesis 2 – the Pollution Halo Hypothesis is supported: An increase in FDI from the US or China decreases CO2 emissions in developing countries, and more so when it originates from the US.

Hence, Hypothesis 1 and Hypothesis 2 point in opposite directions. Hypothesis 1, based on the Haven Hypothesis, predicts that FDI increases CO2, and more so when it originates from the US. Hypothesis 2, based on the Halo Hypothesis, postuates that FDI decreases emissions, and more so when it comes from the US. Nonetheless, it is also possible that the effect of FDI from the US is opposite to the effect of FDI from China – e.g. Chinese FDI could cause an increase in emissions while American FDI causes them to decrease. In this case, the results would simultaneously support the Haven and Halo Hypothesis: the Halo Hypothesis would be valid for China, while the Haven Hypothesis would be valid for the US. This leads to a third hypothesis:

Hypothesis 3 – both the Pollution Haven Hypotheis and the Pollution Halo Hypothesis are supported: The sign of the effect of FDI from the US on CO2 emissions in developing countries is different from the sign of the effect of FDI from China.

From the data and the theory, it is not possible to tell which of the three Hypotheses is valid at first glance. Hence, which of American or Chinese FDI is more detrimental/beneficial to environmental quality in developing countries, and which (if any) of these three hypotheses is valid is an empirical matter.

3. Data

In this section, I describe the data used to test the effect of FDI from the US and China on emissions in developing economies.

3.1. Bilateral FDI

Unfortunately, there is no single comprehensive data source on bilateral FDI flows/stocks for all pairs of countries and a sufficient number of years. Hence, data on bilateral FDI stocks and flows is obtained from various sources and assembled into one dataset. Data for bilateral FDI stocks from the US is obtained from the US Bureau of Economic Analysis, which covers direct investment position abroad of the US for all countries from 1982 to 2019, reported in millions of US dollars. Data on bilateral FDI stocks from China is obtained from the Ministry of Commerce of the People's Republic of China (MOFCOM). They report extensive statistics on outward FDI from China, in millions of US dollars, in yearly "Statistical Bulletin of China's Outward Foreign Investment". These bulletins are freely available on the website of the MOFCOM. Taken together, Chinese data on FDI stocks from these reports cover the years 2003-2019.

Data on bilateral FDI flows from the US and China is obtained from the United Nations Conference on Trade and Development (UNCTAD), which covers bilateral FDI flows and stocks for many countries from 2001 to 2012. Given that this source covers a shorter time range, data on FDI flows is used as a robustness check, and FDI stocks are used in the main specification. As shown in Section 6, the choice of the measure of FDI does not significantly alter the results.

3.2. CO2 emissions

Global emissions of greenhouse gases (GHGs) are recognized to be the main contributors to climate change (Letcher, 2019). Moreover, carbon dioxide is the most important of these GHGs in quantity and as a determinant of global warming (Letcher, 2019; Hoffman, 2005), and data on CO2 emissions is more easily available than that on other GHGs (Kim and Adilov, 2012; Hoffman, 2005). Hence, I use carbon dioxide emissions as the primary indicator of environmental externalities. In Section 6, I also test the robustness of the results by using a more general measure for GHGs emissions.

Data on CO2 emissions is obtained from the World Development Indicators (WDI), which provide extensive data on emissions for all countries starting in 1971. Moreover, their database includes different measures for carbon emissions, among which CO2 in kilotons, emissions per capita, emission intensity, emissions per sector, total GHG emissions, and many others. This allows me to conduct additional checks using alternative measures for CO2 emissions.

Albeit being complete, data on carbon emissions from the WDI only covers the years 1971-2016, which has the disadvantage of restricting the final sample to the years 2003-2016. Hence, I also use data from Our World in Data (OWID), which provides yearly statistics on CO2 emissions using a number of different measures up to and including 2019 for almost all countries in the sample. In Section 6, this data source is used to test the sensitivity of the findings to employing a different source for CO2 emissions.

3.3. Control variables

Given that the main specification includes country and year fixed effects, control variables that should be included are those that are likely correlated with both bilateral FDI stocks and CO2 emissions and vary over time and countries. An obvious choice for this is GDP, as it is widely recognized to be correlated with FDI (Basu et al., 2007; Hsiao and Hsiao, 2006) since one of the main determinants of FDI is the host country's market size (Rashid et al., 2016). GDP is also correlated with carbon emissions (Fan et al., 2006; de Souza Mendonça et al., 2020) as it reflects consumption and production in a country (Shafik, 1994). Hence, GDP is included as a control variable in the main specification. Population is included for analogous reasons: while a larger population is synonymous with a larger market, large markets attract more FDI (Rashid et al., 2016), and larger populations are associated with higher total CO2 emissions in a manner that is not necessarily proportional (Dietz and Rosa, 1997). Similarly, population density can be seen as a proxy variable for market size and land prices (Cole et al., 2008), which are likely correlated with FDI. Additionally, population density is likely associated with CO2 emissions, as found by Meng and Han (2018). Hence, population and population density are included as control variables.

Moreover, the Pollution Haven Hypothesis predicts a relationship between trade and CO2 emissions since it postulates that pollution havens are more likely to export CO2-intensive goods to countries with stringent environmental regulations (Eskeland and Harrison, 2003). This effect is, therefore, stronger when a given economy is more open to trade. Hence, openness to trade could be correlated with emissions, while it is also recognized to be correlated with GDP (Awokuse, 2011). Shen (2003) also finds that urbanization attracts more FDI since more developed cities often enjoy better infrastructure and connectivity. Meanwhile, urbanization is correlated with CO2: for example, Martinez-Zarzoso and Maruotti (2011) find that urbanization impacts CO2 emissions positively at low levels of urbanization and negatively afterward. Hence, it is important to control for trade openness and urbanization as well. Lastly, as shown by Omri and Hadj (2020), the host country's quality of regulations or governance is likely to affect both FDI and CO2 emissions in developing countries. Hence, this variable is also included in the main specification.

In summary, the final control variables included are GDP in current US dollars, total population, population density in number of people per square kilometer, trade as percentage of GDP, and urbanization measured by urban population as percentage of the total population. Data for all control variables is obtained from the WDI database, which reports statistics for all countries and all years in the sample. Moreover, to construct an indicator for quality of governance, I use the Worldwide Governance Indicators made available by the World Bank. They report data for six indicators of governance, namely: Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption (World Bank, 2021). For all six indicators, countries are given a score ranging from approximately -2.5 (poor governance) to 2.5 (good governance), with a mean of 0 and a standard deviation of 1 (World Bank, 2021). In order to construct one single indicator for quality of governance, I compute the average score for these six indicators for each country and year. However, in Section 6, I also test the findings' robustness to including all six indicators as control variables separately.

The relevant variables for the main specification, together with data sources and units of measurement, are summarized in Table 9 in the Appendix. The final sample includes yearly data for 77 developing countries in South-East Asia, Africa, and Latin America from 2003 until 2019. The final choice of countries included was determined by data availability, as complete statistics were not available for all developing countries in these regions. The final list of countries, listed by region, is reported in Table 7 in the Appendix.

Table 2 shows descriptive statistics for the included variables. The mean FDI stock from the US in the sample is 5445 million USD, while the mean FDI stock from China is 828 million. The minimum FDI stock from the US and China are -1344 and 0, respectively, with negative stocks possible if the loans from the affiliate in the host country to the parent firm are larger than those from the parent to the affiliate (OECD, 2020).

The correlation matrix for these variables is reported in Table 10 in the Appendix and indicates no particularly concerning high correlation. By definition, total FDI stock and FDI stock from the US are highly correlated, seeing as the US is the primary source of FDI for a large share of countries in the sample. As expected, FDI from China is also highly correlated with FDI from the US and total FDI. More problematic however, the correlation between FDI from the US and population density is high, and a Farrar-Glauber test (as proposed by Farrar & Gluber (1967)) confirms that there may be a multicollinearity issue for these two variables. Hence, as a robustness check, I also test the sensitivity of the findings to excluding population density from the list of control variables.

Additionally, Figure 3 illustrates FDI stocks from the US and China over time for selected countries, chosen to be representative of the sample in general. FDI stocks vary significantly in the sample and over time and are highest in Singapore for both the US and China (not displayed here). Overall, FDI stocks from the US have been somewhat constant over time, although there are significant variations. Conversely, FDI stocks from China were close to null in the early 2000s and have generally been increasing afterward for most countries in the sample.

4. Methodology

In this section, I describe the method used to test the effect of FDI from the US and China on CO2 emissions in developing countries.

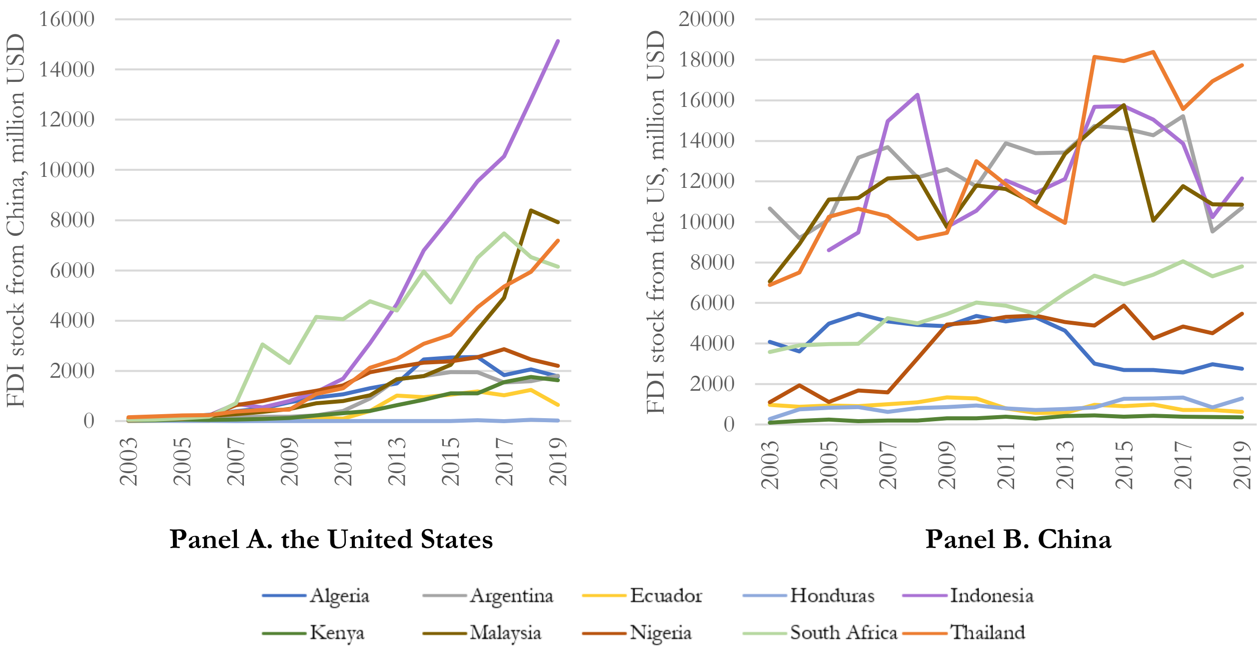
Since the dataset consists of panel data with a country-by-year dimension, a fixed-effects method or a random-effects method can be applied. Which of these methods is the most appropriate depends on the nature of the data. Importantly, when using random effects, one assumes that the unobserved effects and the explanatory variables are uncorrelated. In contrast, fixed effects methods are based on the assumption that they are indeed correlated (Wooldridge, 2012). As explained by Wooldridge (2012), fixed effects are often more appropriate when using time-varying

Table 2. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Dependent variable					
CO2 emissions (kilotons)	1231	43218.887	93867.29	102.676	563324.54
Independent variables					
FDI stock from the US (million current USD)	1189	5445.405	22385.844	-1344	293452
FDI stock from China (million current USD)	1289	827.83	3151.696	0	52636.56
Control variables					
Total FDI stock (million current USD)	1447	35127.475	115474.96	2.98	1697556.5
GDP (current USD)	1438	8.778e+10	2.320e+11	3.785e+08	2.616e+12
Trade (% of GDP)	1370	80.142	52.423	0.167	437.327
Population (total)	1455	26814377	42188069	255063	2.706e+08
Population density (population per square kilometer)	1376	174.174	801.552	2.215	7952.999
Urbanization (urban population as % of total population)	1455	48.729	21.441	8.461	100
Quality of Governance (Index)	1462	-0.521	0.669	-2.449	1.635

Note: for a complete description of the variables, see Table 9 in the Appendix.

Figure 3. FDI stock from the US and China by country over time



explanatory variables. This is because time-varying variables are often correlated with other unobserved variables, which can cause bias in the results if the latter cannot be controlled for by fixed effects. Since unobservable variables are likely to be correlated with FDI here, this would seem to be the case. For example, such an unobserved variable could be cultural ties between a developing country and the US or China, which could influence bilateral FDI as well as CO2 emissions. If one assumes that these cultural ties are time-invariant, they would be controlled for by the fixed effects, but could cause bias when random effects are used instead.

Nevertheless, a Hausman test can be applied to determine which of random effects or fixed effects are the most appropriate (Wooldridge, 2012). Therefore, I use a Hausman test to assess if a fixed-effects approach is indeed suitable. The results are clear cut: with a chi-square statistic of 44.416 and a p-value of 0.000, the Hausman test rejects the null hypothesis that random effects are more appropriate. Hence, I used fixed effects in my analysis, thereby controlling for unobserved (1) time-invariant but country-specific variables and (2) country-unspecific but time-variant variables. This implies the assumption that unobserved and uncontrolled for variables are either time-invariant or country-unspecific, so that they are accounted for by the fixed effects.

The regression equation is as follows:

$$CO2_{it} = \beta_0 + \beta_1 FDI\_US_{it} + \beta_2 FDI\_China_{it} + \beta_3 FDI\_stock_{it} + \beta X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Where i is country and t is year. *CO2* is carbon dioxide emissions in kilotons, and *FDI_US* and *FDI_China* are bilateral FDI stocks from the US and China, respectively, in millions of US dollars. *FDI_stock* corresponds to the total FDI stock in the host country. X is a vector of control variables containing GDP, Population, Population density, Trade, Urbanization, and Quality of Governance. μ_i and λ_t are country and year fixed effects, respectively, and ε_{it} is the error term. Since the data on FDI from the US and China contain many zeros, taking the natural logarithm of these variables would result in the loss of many valuable observations – hence, it is preferrable not to take the logarithm of FDI_US and FDI_China.

Hypotheses 1, 2 and 3 imply different expectations for the coefficients of interest, β_1 and β_2. First, Hypothesis 1 postulates that an increase in FDI causes an increase in CO2 emissions, and more so when it comes from the US. Hence, we have:

Hypothesis 1: β_1 and β_2 are positive, and $\beta_1 > \beta_2$.

Conversely, Hypothesis 2 postulates that an increase in FDI reduces CO2 emissions, and more so when it originates from the US. This gives:

Hypothesis 2: β_1 and β_2 are negative, and $\beta_1 < \beta_2$.

Hypothesis 3 considers the case in which the coefficients on American FDI and Chinese FDI take a different sign, providing partial support for both the Halo and Haven Hypotheses. This gives:

Hypothesis 3: β_1 is positive and β_2 is negative or β_1 is negative and β_2 is positive.

Moreover, theories such as that of the Environmental Kuznets Curves and the supporting literature indicate that the relationship between FDI and CO2 emissions may be nonlinear. Therefore, I also use the following regression equation:

$$CO2_{it} = \beta_0 + \beta_1 FDI\_US_{it} + \beta_2 FDI\_US^2_{it} + \beta_3 FDI\_China_{it} + \beta_4 FDI\_China^2_{it} + \beta_5 FDI\_stock_{it} + \beta X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

Where I include square terms for FDI from the US and China to test for non-linearities. In Section 6, I also test the sensitivity of the findings to varying the structure of equations (1) and (2) and the variables included.

5. Results

Table 3 below reports the results from estimating equation (1) and (2), first with simple OLS (Columns 1 and 2), then with fixed effects (Columns 3 and 4), and finally while taking non-linearities into account (Columns 5 and 6), with and without controls. A simple OLS regression of CO2 emissions on FDI from the US and China gives insignificant results for both countries. A t-test for the difference between β_1 and β_2 also does not reject the null hypothesis that the effect of FDI on CO2 emissions is the same for both countries. Hence, one would reject Hypotheses 1, 2 and 3 and conclude that FDI from the US and China do not significantly affect CO2 emissions. Results from a fixed-effects regression without any controls, as in Column 3, yield the same conclusions. However, Column 4, which does include control variables, shows that this is misguided. FDI from the US is significantly negatively associated with CO2 emissions, while the effect of Chinese FDI on emissions is significantly positive. More specifically, the results indicate that a one million USD increase in FDI from the US decreases CO2 emissions by 1.031 kilotons. Conversely, a one million USD increase in FDI from China increases CO2 emissions by 3.158 kilotons. In other words, an increase of one standard deviation in American FDI decreases emissions by 23,080 kilotons (24.6% of a standard deviation), and an increase of one standard deviation in Chinese FDI increases emissions by 9,953 kilotons (10.6% of a standard deviation) – a sizeable effect. Moreover, a t-test rejects the null hypothesis that β_1 and β_2 are equal, indicating that the effect of FDI from China is significantly different from the effect of American FDI on carbon emissions. Besides, the coefficient on total FDI stock is significantly positive, which indicates that FDI from countries other than China and the US, taken as a whole, increases carbon dioxide emissions. The results also show that a higher GDP is associated with higher emissions, while a higher population density is associated with lower emissions.

Table 3: Regression results, all countries

	(1) OLS, no controls	(2) OLS, with controls	(3) FEs, no controls	(4) FEs, with controls	(5) FEs, with non-linearities, no controls	(6) FEs, with non-linearities, with controls
FDI from the US	1.065	-3.379	-0.044	-1.031***	2.323*	-0.816*
	(2.015)	(2.807)	(0.628)	(0.262)	(1.264)	(0.475)
FDI from the US, squared					-9.71e-06**	3.91e-07
					(4.35e-06)	(1.46e-06)
FDI from China	4.419	11.295	2.062	3.158**	6.655***	5.226***
	(16.327)	(7.625)	(3.442)	(1.38)	(2.473)	(1.573)
FDI from China, squared					-0.0000423	-0.0000986***
					(0.0000441)	(0.0000351)
Total FDI stock		0.461		0.208***		0.186***
		(0.405)		(0.037)		(0.039)
GDP		1.19e-07*		5.22e-08***		5.08e-08***
		(6.28e-08)		(1.19e-08)		(1.3e-08)
Trade		203.918		5.082		-5.777
		(156.804)		(41.028)		(39.502)
Population		0.001***		0.001		0.001
		(0.0003)		(0.001)		(0.001)
Population density		-12.714		-43.842***		-53.714***
		(15.281)		(10.192)		(10.604)
Urbanization		800.901**		167.529		138.132
		(346.082)		(643.434)		(591.689)
Quality of Governance		15861.827		-3915.611		-4229.673
		(12738.412)		(4226.41)		(4124.122)
Constant	45798.15***	-44282.77**	43816.35***	23738.096	37729.801***	29775.234
	(10811.59)	(17472.132)	(3438.138)	(33309.964)	(4690.119)	(30432.159)
Observations	851	802	851	802	851	802
R-squared	0.078	0.721	0.204	0.61	0.386	0.618
Country fixed effects	NO	NO	YES	YES	YES	YES
Year fixed effects	NO	NO	YES	YES	YES	YES
P-value t-test $\beta_1 = \beta_2$	0.8512	0.1536	0.6016	0.0121	0.1178	0.0006

Note: In all columns, the dependent variable is CO_2 emissions in kilotons. Standard errors, clustered at the country level, are in parentheses. Columns (1) and (2) are simple OLS regressions, without and with controls. In Columns (3) and (4), country and year fixed effects are added. Columns (5) and (6) include squared terms for FDI from the US and China. In the last row, the p-value for a t-test of equality between β_1 and β_2 is displayed. *** is $p<0.01$, ** is $p<0.05$, * is $p<0.1$.

In Column 6, I test for non-linearities in the effect of FDI on CO2. The results show evidence that the impact of FDI from China is nonlinear while that of the US is not. Indeed, the coefficient on squared FDI from the US is positive but insignificant. In contrast, that of China is negative and highly significant. This indicates that FDI from China causes an increase in host country CO2 emissions up to a turning point, after which the effect of FDI becomes negative. However, according to the estimates of Column 6, this turning point is at 53,408 million USD, which is more FDI than any of the countries in the sample currently receives. Hence, for all the developing countries considered here, the results indicate that the effect of FDI from China is positive. Again, a t-test rejects the null hypothesis that β_1 and β_2 are equal in this case.

Overall, the results indicate that FDI from the US significantly decreases CO2 emissions while FDI from China significantly increases them. Therefore, the results do not provide unconditional support for either the Pollution Haven or the Pollution Haven Hypothesis, seeing as neither Hypothesis 1 nor Hypothesis 2 is validated. According to Hypothesis 1 (2), we would have expected both coefficients to be positive (negative). This is not the case; rather, the results corroborate Hypothesis 3 since the signs of the two coefficients of interest are different. This gives mixed results: while the Pollution Halo Hypothesis is valid for the US, the Pollution Haven Hypothesis is valid for China.

These results can also be decomposed by region: since the dataset contains information on countries in South-East Asia, Africa and Latin America, it is interesting to look at these regions separately to test if the findings apply to these differently. Ex ante, South-East Asia is a noteworthy case: home to the 4th largest market globally and with over 700 million inhabitants, South-East Asia is of increasing relevance both geopolitically and commercially for both the US and China (Green and Searight, 2020). The strategic competition between these two superpowers is now hinging on South-East Asia, and inhabitants of the region are increasingly concerned about its economic and geopolitical impact (Green and Searight, 2020). Meanwhile, as shown by the multiple cyclones and floods that stormed this region in recent years, it is highly vulnerable to climate change, and in the absence of important decarbonization policies, its CO2 emissions are predicted to continue increasing (Lee et al., 2013). Accordingly, climate change is viewed by inhabitants as the most severe threat to national security (Green and Searight, 2020). Thus, the impact of American and Chinese FDI is especially important for the region. Hence, I look specifically at South-East Asia to test if the results for the region differ from the results for all developing countries in the dataset. The sample includes 11 countries from South-East Asia. Unfortunately, due to missing values, the number of observations that can be used in the analysis is only 128, which increases standard errors and limits the extent to which significant results can be found. Hence, due to the limited number of observations included, these results are only interpreted as an indication. The findings of running equations (1) and (2) for the sample of South-East Asian countries only are reported in Table 4 below.

Table 4: Regression results, South-East Asia

	(1) OLS, no controls	(2) OLS, with controls	(3) FEs, no controls	(4) FEs, with controls	(5) FEs, with non-linearities, no controls	(6) FEs, with non-linearities, with controls
FDI from the US	-1.053	0.442	-0.396	0.386	-0.405	-0.996**
	(0.945)	(0.736)	(0.465)	(0.349)	(1.276)	(0.37)
FDI from the US, squared					2.94e-07 (4.46e-06)	4.60e-06*** (1.21e-06)
FDI from China	9.091	-5.056	1.843	-2.208	5.03	-2.187
	(8.453)	(4.695)	(3.205)	(1.4)	(4.283)	(1.983)
FDI from China, squared					-0.0001 (0.0001)	-0.00004 0.00003
Total FDI stock		0.274*		-0.043		-0.056
		(0.124)		(0.08)		(0.103)
GDP		3.21e-07**		9.35e-08		9.34e-08
		(1.09e-07)		(7.33e-08)		(7.13e-08)
Trade		899.227***		46.691		45.773
		(221.384)		(141.542)		(142.524)
Population		0.0009**		0.002*		0.002**
		(0.0003)		(0.001)		(0.001)
Population density		-68.403*** (12.17)		32.226* (15.332)		62.78** (20.958)
Urbanization		1575.183		7489.511***		8907.359***
		(1371.632)		(2038.92)		(2062.408)
Quality of Governance		-40195.19 (37702.48)		14300.62 (11711.84)		18195.96 (11582.21)
Constant	121958.4**	-166402.2	98526.72	-436420.8**	37729.8***	-521596.5***
	(43253.1)	(103303.9)	(9027.252)	(151616.1)	(4690.119)	(157072)
Observations	128	128	128	128	128	128
R-squared	0.0344	0.9392	0.0411	0.2473	0.0532	0.1524
Country fixed effects	NO	NO	YES	YES	YES	YES
Year fixed effects	NO	NO	YES	YES	YES	YES
P-value t-test $\beta_1 = \beta_2$	0.3024	0.33	0.5548	0.1591	0.3161	0.5522

Note: In all columns, the dependent variable is CO2 emissions in kilotons. The sample includes only South-East Asian countries, with a total of 10 countries included. Standard errors, clustered at the country level, are in parentheses. Columns (1) and (2) are simple OLS regressions, without and with controls. In Columns (3) and (4), country and year fixed effects are added. Columns (5) and (6) include squared terms for FDI from the US and China. In the last row, the p-value for a t-test of equality between β_1 and β_2 is displayed. *** is p<0.01, ** is p<0.05, * is p<0.1.

The results indicate that the effect of FDI from the US and China may be different in South-East Asia than it is in developing countries in general. Very few of the coefficients in Table 4 are significant, partially due to the low number of observations included. Nevertheless, when both fixed effects and controls are included in Column 4, the impact of FDI from the US on CO2 emissions is positive, while that of FDI from China is negative. This is the opposite of the pattern found to exist for the larger sample of developing countries. According to the results in Column 6, when non-linearities are taken into account, FDI from the US has a statistically significant U-shaped effect on CO2 emissions. Indeed, American FDI has a negative impact on emissions up to a turning point at 20,870 million USD in FDI, after which the effect of American FDI on emissions becomes positive. Since the average FDI stock from the US into South-East Asian countries is 20,503 million USD, about half of these countries stand after this turning point. According to the results in Column 6, the effect of Chinese FDI is beneficial at all levels of FDI stock – also when taking into account non-linearities - but insignificant. Moreover, a t-test does not reject the null hypothesis that β_1 and β_2 are equal, and hence, one cannot exclude the possibility that the effects of FDI from the US and from China are the same.

Results for Africa and Latin America are reported in Tables 11 and 12 in the Appendix. In a few words, FDI from the US has a U-shaped but weakly significant effect on African CO2 emissions, while FDI from China increases emissions but not significantly so. In Latin America, American FDI decreases emissions, although the effect is not statistically significant, and FDI from China is associated with an insignificant increase in CO2. Again, the weak significance of the results when looking at regions separately is partially due to the low amount of observations that can be included. Nevertheless, these findings indicate that there is significant heterogeneity in the effect of FDI on CO2 emissions, both depending on the origin and the host country.

6. Robustness checks and extensions

In this section, I conduct various robustness checks to test the sensitivity of the findings to alternative measures and specifications.

The CO2 emissions database from the World Development Indicators (WDI), as used in the main specification, only contains data until 2016, which restricts the sample size used to the years 2003-2016. Hence, I test the robustness of the findings by using a different source of data for CO2 emissions. Our World in Data (OWID) provides such data until 2019 using various indicators for carbon emissions and other GHGs. Unfortunately, not all countries considered in this analysis are present in this dataset. Nevertheless, by using this source, more data points and more years can be included. Hence, in Table 13 in the Appendix, I report the results obtained using data on CO2 emissions in kilotons from OWID. Results in Column 1 are for the linear specification with fixed effects, all counties and control variables included, and in Column 2, non-linearities are incorporated by adding squared terms for FDI from the US and China. In general, the results are robust to using a different data source for CO2 emissions. The coefficients on FDI from the US and China have the expected sign. However, significance in the linear specification is somewhat lower than in Table 3 since the coefficient on FDI from China is insignificant and the coefficient on FDI from the US is only significant at the 90% confidence level. Nevertheless, when using the nonlinear specification from equation (2), the results become more significant and similar in magnitude than those from the main specification in Table 3. I conclude that the results of the nonlinear specification are strongly robust to using a different source for carbon data. This indicates that the nonlinear specification is a more appropriate way to think about the relationship between FDI from the US and China and CO2 emissions.

This paper focuses on the effect of FDI on carbon emissions measured in absolute terms – in this case, in kilotons. Nevertheless, different ways to measure CO2 emissions exist, and it is interesting to test if the results also apply when using these as a dependent variable. Both the WDI and OWID report CO2 statistics in per capita terms, in relation to GDP, and decomposed in various indicators depending on the source of emissions. For example, in Table 13 Columns 3 and 4, I report the results when using carbon emissions per capita, obtained from OWID, as a dependent variable. In Column 3, when excluding the squared terms, the results are significant, and both the coefficients on FDI from the US and China are negative. This indicates that an increase in either FDI significantly decreases host country CO2 emissions per capita. This is consistent with the results from Kim and Adilov (2012), who find that per FDI per capita growth significantly decreases CO2 emissions growth per capita in developing countries. Nevertheless, this is a puzzling result, considering that the main specification in this paper controls for population and hence, one would have expected the coefficient on FDI from China to be positive, just as it is when using absolute CO2 emissions as dependent variable. This could be due to disparities in the way data on emissions is collected, since different data sources are used for CO2 emissions and CO2 emissions per capita. Alternatively, this could indicate that the positive effect of FDI from China on absolute CO2 emissions is driven by a few highly populated – and polluting – countries which receive a large amount of FDI from China. For such countries, total pollution is high while pollution per capita is low, which could drive such discreprancies in the results. However, when using a non-linear specification, the coefficients on FDI from the US are insignificant, and only the effect of squared FDI from China is significantly negative. Hence, from this I conclude that the finding that Chinese FDI increases emissions (and hence, the Haven Hypothesis) is less robust than is the finding that American FDI decreases emissions (the Halo Hypothesis).

Of course, CO2 is not the only GHG to cause environmental externalities. OWID also provides a general measure for GHG emissions, which I use to test the robustness of the findings. According to the theory, the results should also apply to other GHGs: the Pollution Haven

Hypothesis predicts that firms in countries with stringent environmental regulations will look for pollution havens where stringency is lower. Hence, this also applies to restrictions on GHG other than CO2, provided that environmental regulations also apply to these. Similarly, the Halo Hypothesis predicts that foreign investment from countries that innovate in green technologies will cause positive spillovers in the host country. Hence, if this green innovation also entails technology that helps reducing emissions of other GHGs, FDI can also help reduce emissions of these in host countries. Therefore, one should expect the results in Table 3 to apply to GHGs in general, especially given that CO2 is the most significant component of GHG emissions in magnitude. Results from using GHG emissions as a dependent variable are reported in Columns 5 and 6 of Table 13 in the Appendix. The findings are similar to when using CO2 emissions, although significance is somewhat lower. Again, the results indicate a significant nonlinear relationship between FDI from China and GHG emissions, whereas the relationship seems linear for American FDI. However, although the conclusions from using GHG emissions as a dependent variable are qualitatively similar to when using CO2, there are slight differences in the coefficients' magnitude. There can be multiple reasons for this, starting with the fact that the Pollution Haven and Halo Hypotheses may interplay differently when different GHGs are considered. For example, if ETD spillovers from the US are more likely to reduce CO2 emissions than other GHGs, the coefficient on FDI from the US would be more negative when using CO2 emissions as a dependent variable than when using GHG emissions. Nevertheless, we can still conclude that the general results apply to other GHGs, even though the magnitude of the effects may be different.

As an additional robustness check, I test the sensitivity of the findings to using flows instead of stocks as a measure of FDI. As mentioned in Section 3, data for bilateral FDI flows from the US and China into developing countries is only available for a limited amount of years. Therefore, fewer observations can be included, which is why flows are not the preferred specification. Nevertheless, if the results from Table 3 also hold when using FDI flows as independent variables, this would indicate that they are highly robust. These results are reported in Table 14 in the Appendix. Although the significance levels are somewhat lower, as can be expected from the lower number of years included, the results are very similar to when measuring FDI in stocks. The coefficients differ in magnitude, which was expected since the independent variables are measured differently. In the nonlinear specification, FDI flows from the US have a negative (but insignificant) effect on CO2, while FDI flows from China have a significant inverted U-shape effect. Hence, I conclude that the results are robust to using FDI flows instead of FDI stocks.

Still, one way to circumvent the lack of data for FDI flows may exist. By nature, FDI stocks and FDI flows are related: as explained by Wacker (2013), "FDI stocks are the (revalued) cumulation of past flows, while flows are the current transactions taking place in a certain period". This means that FDI stock in a given year is the sum of all past FDI flows. Hence, according to this reasoning, data on FDI flows could be obtained by simply taking the first difference in FDI stock. Doing so could provide data on FDI flows from 2004 to 2019, which would give the specification using FDI flows more statistical power. However, unfortunately things are not that simple. The problem arises as FDI stocks are reevaluated (e.g., because of depreciation or exchange rates): when such reevaluation occurs, it creates a discrepancy between flows and the first difference in stocks (Wacker, 2013). However, Wacker (2013) examines the data and finds that while the first difference in stocks is not a perfect measure of flows, it can be used as a reasonable approximation when data is missing. Hence, keeping in mind that manually computing FDI flows only gives a second-best measure, I conduct an additional analysis while using the first difference in FDI stock as a measure of FDI flows. The results from doing so are reported in Table 15 in the Appendix. In general, the resulting conclusions are similar from those obtained with FDI flow data from the UNCTAD (Table 14) since the coefficients have the expected sign, except all of them are insignificant. The magnitude of the coefficients is in the same range as those of Table 14, but there are still noticeable differences. These discreprancies indicate that using the first difference in FDI stock may indeed be a suboptimal measure for FDI flows, and these results are to be taken with a grind of salt.

As mentioned in Section 3, there are reasons to be concerned that population density may be correlated with the independent variables of interest. Hence, I test the robustness of the findings by excluding this variable from the specification. Moreover, trade is highly correlated with FDI, and one might worry that trade is a bad control for the latter. Indeed, bad controls can cause bias as they are themselves outcomes of the independent variables of interest (Angrist and Pischke, 2009), and this could be a problem if FDI causes trade to increase/decrease. Luckily, this problem should be minimal in this case as the trade variable considered here is trade *openness*, rather than trade in absolute value. Nevertheless, I also test the robustness of the findings to exluding trade from the list of control variables. Additionally, I test their sensitivity to including other control variables, including current exports and imports, GDP per capita, regulatory quality, government effectiveness, rule of law, voice and accountability, control of corruption, and political stability. The coefficients on FDI from the US and FDI from China are essentially unaffected when excluding population density or trade (see Table 16 in the Appendix), albeit somewhat less precise. The latter can be explained by the fact that population density and trade are important control variables that are significantly correlated with CO2 emissions, besides being associated with FDI. Therefore, excluding these variables increases the standard errors of the coefficients of interest. Nevertheless, since the coefficients remain remarkably similar with and without population density and trade included, I conclude that the results are robust to their exclusion. When incorporating additional controls, the results of the linear specification turn out to be highly robust: the coefficients on FDI from the US and FDI from China are both significant at the 99.9% confidence level and of similar magnitude than in Table 3. When including additional controls in the nonlinear specification, the coefficients of interest retain similar magnitude, but those on the squared terms lose in significance, indicating that the nonlinear specification may not be the most appropriate when additional variables are taken into account. Nevertheless, the general result that FDI from China is more detrimental to CO2 emissions than that of the US remains.

In addition, Singapore is an outlier in the data. The country receives more FDI from the US and China than others in the sample, and so over the whole period considered. In 2019, which is the last year included in this analysis, Singapore received over three times as much FDI from the US and 3.5 times as much FDI from China than any other country in the sample. Besides, Singapore is the only developing country considered here for which EPS is higher than it is in the US. GDP per capita is also much higher in Singapore than it is in the rest of the countries of the sample (The World Bank, 2021). Hence, there are reasons to be concerned that the results are driven by Singapore, as an outlier with a very different country profile. Thus, I test the robustness of the findings to excluding Singapore from the sample. The results of doing so are reported in Table 5, Column 1, and are unequivocal: the coefficients on FDI from the US and FDI from China remain highly significant and retain a magnitude of -1.015 and 4.931, respectively. Hence, if anything, the effects found are larger when Singapore is excluded, which indicates that the findings are not driven by this outlier. The exclusion of Brazil and Indonesia, respectively the second largest recipients of FDI from the US and China, also does not significantly alter the results.

When using FDI as the main independent variable, one issue to consider is that its effect on CO2 emissions may take time to materialize. For example, suppose we follow the reasoning of the Pollution Halo Hypothesis. In that case, green technology spillovers in the host country may take time to occur after the introduction of FDI – for instance, because a firm needs to first settle down before being able to propagate these technologies. For this reason, it is common in the literature to include lagged FDI as an independent variable. For example, Haug and Ucal (2019) study the impact of FDI on CO2 emissions in Turkey using a nonlinear autoregressive distributed lag (ARDL) model and find that effects of FDI on CO2 after one lag are significant, but long-run effects (i.e., longer lags) are insignificant. Similarly, Omri et al. (2014) find that a lag of one year significantly impacts current CO2 emissions. Hence, I include one lag for FDI from China, FDI from the US, and total FDI in the main model to test the sensitivity of the findings to doing so. The results are reported in Column 2 of Table 5. They are similar to those of the main specification:

current FDI from the US has a significant negative impact on CO2 emissions while that of China has a significant positive effect. However, contrary to what one might have expected, lagged FDI from China and the US are both insignificantly related to current CO2 emissions. Because lagged FDI stock is highly correlated with current FDI stock, the inclusion of the lagged variables also has the disadvantage of diminishing the general levels of significance in the model. Hence, I conclude that lagged variables do not add explanatory power to the model or relevant insights, and are not included in further specifications.

Thus far, the analysis has focused on the effect of FDI *levels* on carbon *levels*. However, it may also be that FDI *growth* affects CO2 emissions *growth*. To investigate whether this is the case, I test an alternative specification including growth instead of level variables:

$$CO2\_g_{it} = \beta_0 + \beta_1 FDI\_US\_g_{it} + \beta_2 FDI\_China\_g_{it} + \beta_3 FDI\_stock\_g_{it} + \beta X\_g_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Here, the affix *_g* indicates that the variable is a growth variable, measured as the percentage change from the previous to the current year. The results are reported in Column 3 of Table 5 and show that none of the coefficients of interest are significant, although they have the expected sign. Using a nonlinear model to test this relationship gives the same conclusions. Hence, growth in FDI from the US and China is not a good predictor for growth in CO2 emissions, although the signs of the results are still consistent with the *levels* specification. One possible reason for this is that using growth variables takes away some of the statistical power of the model. However, it is also consistent with the results from Hoffman et al. (2005), who find that the first difference in FDI does not Granger cause the first difference in CO2 emissions for developing countries. This is also consistent with Blanco et al. (2013), who do not find a robust causal relationship from FDI growth to CO2 growth, except in the "dirty" sector. However, the latter use a per capita measure for CO2 emissions growth instead of an absolute count.

Besides predicting that FDI increases host country CO2 emissions, the Pollution Haven Hypothesis also postulates that this mechanism is likely to be stronger under certain circumstances. It proposes that FDI into countries where EPS is low is more likely to be detrimental. This is because where policy stringency is lower, FDI from polluting industries is more likely as firms are looking for pollution havens, and hence it is more likely to cause an increase in CO2 emissions. Conversely, in countries where EPS is relatively high, FDI is unlikely to occur because firms search for pollution havens, and hence is unlikely to be pollution-intensive and cause an increase in emissions. The set-up of this study allows for testing whether this is true to gather additional insights on whether the Pollution Haven Hypothesis is valid in this case. To do so, I use cross-sectional data on EPS from the World Economic Forum Executive Opinion Survey of 2011-2012, which gives countries an EPS score (see Table 8 in the Appendix). I divide the sample of developing countries into countries with lower-than-average EPS and countries with higher-than-average EPS and test whether the effect of FDI from the US and China is different for these two groups. The results are reported in Column 4 of Table 5: the coefficients on FDI from the US and China remain significant and robust to this specification. Their interactions with "Low stringency" are positive as expected. However, the latter interactions are insignificant. In other words, the results indicate that FDI from the US and China cause a larger increase in CO2 emissions in countries where EPS is low, as predicted by the Pollution Haven Hypothesis, but not significantly so. Because of the lack of data for ETD in developing countries, I unfortunately cannot conduct a similar check for Pollution Halo Hypothesis: ideally, one would like to create an interaction variable between FDI from the US and China and ETD in the receiving country. This would allow for testing if FDI is more beneficial when ETD in the host country is lower, as predicted by the Halo Hypothesis, because larger green technology spillovers are likely in this case. However, doing so is not possible without robust data on green technology development in developing countries.

In their research, Huynh and Hoang (2018) find that institutional quality matters for the effect of FDI on CO2 emissions. Their findings indicate that FDI increases emissions until institutional quality is high enough; after this point, CO2 decreases when FDI increases. However, they use a total measure of FDI and do not differentiate by country of origin. Thus, I test whether the conclusions of their study also hold in this case and whether institutional quality influences the effect of FDI from the US and China on emissions. The measure for Quality of Governance used in this paper, which is a composite of five different governance measures and was included as a control variable in all specifications, happens to be identical to that used by Huynh and Hoang (2018). Therefore, I choose to use this measure for instituational quality, as it conveniently summarizes government effectiveness, voice and accountability, regulatory quality, rule of law, and control of corruption. In Column 5 of Table 5, I include an interaction variable between Quality of Governance and FDI from the US/China. The results show that the coefficients on both interaction variables are insignificant and negative. Besides, including these interactions also renders the coefficient on American FDI insignificant. Hence, the results do not provide evidence that instituational quality matters for the effect of FDI on CO2 emissions, and contradict the findings of Huynh and Hoang (2018). A reason for this contradiction could be the nature of their research, which focuses only on Asian countries, and on the effect of total rather than bilateral FDI. For instance, it could be that instituational quality matters for the effect of total FDI on emissions, but that it does not influence the effect of American or Chinese FDI specifically. This could be the case, for example, if instutional quality matters when FDI originates from other developing countries, but not when it does from the two superpowers.

Table 5: Regression results, sensitivity analyses

	(1) Excluding Singapore	(2) Including lagged FDI	(3) Growth specification	(4) Interaction with EPS level (binary)	(5) Interaction with Quality of Governance
FDI from the US	-1.015**	-0.842*	-0.00005	-1.172***	-0.274
	(0.508)	(0.505)	(0.0013)	(0.295)	(0.638)
FDI from China	4.931***	3.456**	0.00036	3.582**	3.869***
	(1.481)	(1.4)	(0.00088)	(1.646)	(1.384)
Total FDI stock	0.212***	0.055	-0.00306	0.238***	0.293***
	(0.0469)	(0.051)	(0.02159)	(0.047)	(0.045)
FDI from the US		-0.253			
(t-1)		(0.483)			
FDI from China		-1.477			
(t-1)		(1.51)			
Total FDI stock		0.213**			
(t-1)		(0.094)			
FDI from the US				1.445	
x Low stringency				(1.203)	
FDI from China				3.582	
x Low stringency				(4.433)	
FDI from the US					-0.507
x Quality of Governance					(0.452)
FDI from China					-0.232
x Quality of Governance					(1.673)
Observations	788	701	619	627	802
R-squared	0.679	0.3781	0.0308	0.3364	0.5096
Control variables	YES	YES	YES	YES	YES
Country fixed effects	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES
P-value t-test	0.0003	0.007	0.794	0.017	0.008
$\beta_1 = \beta_2$					

Note: In all Columns except Column 3, the dependent variable is CO2 emissions in kilotons. In Column 1, Singapore is excluded from the sample of countries. In Column 2, the independent variables include lagged (t-1) FDI from China and the US and lagged total FDI. In Column 3, the dependent variable is growth in CO2 emissions (in percent), and the independent variables are all measured as percent change since last year. In Column 4, an interaction variable between FDI from the US (China), as well as a binary variable for Low Stringency of environmental regulations (=1 if stringency is lower than average in the sample), are included. In Column 5, an interaction variable between FDI from the US (China) and Quality of Governance in the recipient country is included. In all columns, the following control variables are included: current GDP, trade, population, population density, urban population, and quality of governance. Standard errors, clustered at the country level, are in parentheses. In the last row, the p-value for a t-test of equality between β_1 and β_2 is displayed. *** is $p<0.01$, ** is $p<0.05$, * is $p<0.1$.

One possible concern with the specification in equations (1) and (2) is that to assume that the effect of FDI on CO2 emissions is causal, one must assume that there is no reverse causality from

CO2 to FDI. If, for some reason, the current level of CO2 in developing countries affects the current FDI stock in said country, the results could be biased. At first glance, there is no reason to expect CO2 emissions to impact incoming FDI from the US and China since the negative externalities (e.g., global warming) caused by CO2 emissions are not confined to the emitting country. Moreover, as explained by Herzer et al. (2008), the inclusion of lags can help to eliminate such endogeneity bias. As observed in Table 5, such lags do not affect the results, and the lagged variables are insignificant. Blanco et al. (2013) also test the causality patterns between FDI and CO2 emissions using a Granger causality test for Latin American countries and find unidirectional causality in "dirty" sectors running from FDI to CO2 emissions, with no evidence of reverse causality. However, also using a Granger causality test and focusing on BRIC countries, Pao and Tsai (2011) find bidirectional causality between FDI and emissions. Hoffman (2005) finds that these causal relationships depend on the level of development of the host country. Hence, to address these concerns, I test whether reverse causality is a concern in the sample used in this study. To do so, I conduct a Granger causality test. Granger causality tests are based on Vector Autoregressive (VAR) models and use lagged values of both independent and dependent variables to test whether one *Granger causes* the other (Wooldridge, 2012).

Using panel data and STATA, a Granger causality test can only be performed on stationary variables (i.e., without a unit root). As it turns out, when testing this condition, FDI stock from the US, FDI stock from China, and CO2 emissions are all non-stationary. Hence, I take the first difference of these variables, which allows me to create variables that are stationary. Moreover, a Granger causality test can only be performed on a balanced dataset. Hence, I clean the dataset by deleting observations that are out of range, missing, or associated with discontinuities, thereby obtaining a balanced dataset. This results in fewer observations being included. Since a minimum number of observations is needed for a Granger causality test to yield meaningful results, I choose to use OWID data on CO2 emissions instead of data from the WID to include a larger number of observations. As seen in Table 13, the use of OWID instead of WID data does not significantly alter the results. Hence, the results for a Granger causality test between the first difference in CO2 emissions, the first difference in FDI from the US, and the first difference in FDI from China are displayed in Table 6 below.

According to the results, CO2 emissions Granger cause neither FDI from the US nor FDI from China. Indeed, the p-value for the alternative hypothesis that emissions Granger cause FDI for at least one country are 0.1812 and 0.9633 for the US and China, respectively, which is far from significant. The test also cannot reject the null hypothesis that FDI from the US does not Granger cause CO2 emissions. However, the results show that FDI from China does have a causal effect on emissions, with a p-value of 0.0147, and this effect is positive. They also indicate bidirectional causality between FDI from China and FDI from the US. All in all, these results directly address reverse causality concerns and suggest that it should not be a problem in this case. Nevertheless, they have to be taken with caution since they concern the first differences in the variables instead of the variables themselves because of data limitations.

Table 6: Dumitrescu & Hurlin Granger non-causality test results

	(1) FDI from the US	(2) FDI from China	(3) CO2 emissions
FDI from the US		0.0577	0.8387
FDI from China	0.0958		0.0147
CO2 emissions	0.1812	0.9633	

Note: results displayed are for a Granger causality test with H0: The first difference in the Row variable does not Granger-cause the first difference in the Column variable, and H1: The first difference in the Row variable does Granger-cause the first difference in the Column variable for a least one country. The reported values are p-values associated with the z-bar statistic. The Granger causality test is conducted with lag order 1.

7. Discussion and policy implications

The above analyses yield some clear conclusions on the effect of FDI from the US and China on CO2 emissions in developing countries. As observed in Table 3, an increase in American FDI is associated with a significant decrease in CO2 emissions in these economies. Chinese FDI has a nonlinear effect on emissions since it causes them to increase until a turning point at 53,408 million USD, after which an increase in Chinese FDI causes a decrease in emissions. Importantly, this turning point happens to be at a higher level of FDI stock than any of the developing countries in the sample currently hosts – even for Singapore, an outlier in the sample, which receives significantly more FDI from China than other countries. Hence, in the current situation, the results indicate that an increase in FDI from China is associated with increased CO2 emissions. Moreover, the results also reject the null hypothesis that the effect of FDI from the US on emissions is the same as that of China. This is consistent with the findings of Asghari (2013), who finds that exports from ASEAN countries to China are associated with higher pollution levels, while exports to the US and Japan are not. Moreover, these results are relatively robust to different measures for CO2 and FDI and the inclusion of additional control variables or lags. In addition, a Granger causality test does not indicate that reverse causality should be a concern. This yields some important conclusions. First, Hypothesis 1 (*an increase in FDI from the US or China increases CO2 emissions in developing countries, and more so when it originates from the US)*, associated with the Pollution Haven Hypothesis, and Hypothesis 2 (*an increase in FDI from the US or China decreases CO2 emissions in developing countries, and more so when it originates from the US*), associated with the Pollution Halo

Hypothesis, are both rejected. For either the Pollution Haven or the Pollution Halo Hypothesis to be unconditionally supported, FDI from both the US and China should act in the same direction. Instead, we observe different signs on the coefficients for American and Chinese FDI: FDI from the US decreases emissions while FDI from China increases them. This supports Hypothesis 3 and gives mixed results: while the results for the US support the Pollution Halo Hypothesis, the results for China support the Pollution Haven Hypothesis. Hence, I find partial support for each of the Pollution Hypotheses, depending on which country is under consideration.

The fact that American FDI decreases CO2 emissions could be explained, according to the Halo Hypothesis, by the fact that ETD is high in the US while it is low in the developing world. Hence, its FDI causes green technology spillovers in developing countries. In contrast, the fact that Chinese FDI increases emissions could be because Chinese firms look for pollution havens in developing countries, thereby raising their emissions. Nevertheless, that the effect of FDI from the US is so different from the effect of FDI from China raises questions: why is one beneficial and the other harmful? Some answers may stem from the nature of FDI originiating from these countries: for one, their composition is different. Soumaré et al. (2016) compare Chinese FDI into Africa to that of other developed countries, and find that one of the main determinants of FDI from China is host country natural resources (e.g., coal and minerals, which are highly polluting). In contrast, FDI from OECD countries – among which the US – is determined by instutional and governance quality. This is corroborated by Kolstad and Wiig (2012), who find that Chinese FDI is mostly drawn to countries with poor institutions and large natural resources. Moreover, data from the International Trade Centre (2018) reveal that Chinese FDI is more concentrated than American FDI in the sectors "Agriculture, Forestry and Finishing", "Electricity, gas, and steam supply" and "Transportation". The later three sectors are amongst the largest contributors to GHG emissions according to United States Environmental Protection Agency (2021). Hence, the fact that FDI from China is more concentrated in polluting industries than FDI from the US could offer an explanation for the finding that the former is detrimental to the environment while the latter is not.

Besides, the nonlinear effect of FDI from China on emissions is in line with the predictions of the Environmental Kuznets Curves, which predict such an inverted U-shape relationship. This is also consistent with the findings of Balsalobre-Lorente et al. (2019), who find an inverted U-shaped relationship between FDI and ecological footprint for Mexico, Indonesia, Nigeria, and Turkey. However, in contrast to this study, they find that FDI into all four of these countries is higher than the turning point, after which FDI is associated with a decrease in emissions. Their findings are corroborated by Shahbaz et al. (2019), who find similar evidence for Middle East and North

African countries. However, in the context of this study, a nonlinear relationship does not seem to hold for American FDI, for which the effect is linear.

The policy implications of this are twofold: first, seeing as American FDI helps reduce CO_2 emissions in developing countries, it brings about positive externalities that are often not taken into account by policy-makers. Hence, these results provide additional motivation for developing countries to try to attract FDI from the US. If it is amongst a country's objectives to reduce its emissions, part of its strategy could be to attract such FDI to complement other policies. Following the reasoning of the Pollution Halo Hypothesis, if an increase in American FDI then causes spillovers in environment-related innovation, it will not only increase the host country's economic activity but also help the reduction of its emissions. Moreover, policies could make these technology spillovers more likely by facilitating the transfer of knowledge, innovation, and skills from foreign to home firms. How policies can do so is outside the scope of this study but presents a great opportunity for developing countries to build more sustainable economic growth.

On the other hand, the results show that FDI from China is detrimental to the environment in developing countries. Hence, they indicate that the developing world should be wary when considering FDI from China. The latter causes negative externalities, which should also be taken into account by policy-makers. Implementing additional regulations on incoming FDI from China, if possible, could help to make it more sustainable and reduce the negative externalities it is associated with. This could be achieved, for example, by regulating the pollution intensity of incoming FDI or encouraging green technology transfer from foreign Chinese firms to local firms.

It is evident that the environmental externalities described here are not the only consequences of incoming FDI from the two superpowers. There are undoubtedly other factors that are or should be considered when developing countries set up policies that relate to FDI. Some of these consequences are widely recognized as they present tangible benefits and costs (e.g., economic growth), while some others are difficult-to-measure externalities (e.g., human capital development) that require further study. The impact of FDI on such factors has been mainly studied from the perspective of *overall* FDI rather than FDI from individual countries. Hence, more research is needed on the impact of American and Chinese FDI on other variables, besides CO_2 emissions.

Unfortunately, the results when considering South-East Asia specifically are less clear-cut. Because the region comprises only 11 countries for which the data is not always complete, a low number of observations was included, resulting in low significance levels. Moreover, the results are different from that of the full sample of developing countries. In the linear specification, FDI from the US is associated with an insignificant increase in CO_2 emissions, while FDI from China is associated with an insignificant decrease. When non-linearities are taken into account, FDI from the US has a (weakly) statistically significant U-shape effect on emissions, with a turning point at 20,870 million USD, at about the average level of FDI in the South-East Asian sample. Conversely, FDI from China has a negative but insignificant effect on CO2 at all levels of FDI. Moreover, a t-test does not exclude the possibility that the effect of FDI from the US and from China on emissions are the same. What this means for Hypotheses 1, 2 and 3 in the region is not conclusive: since we cannot reject the null hypothesis that American and Chinese FDI have the same effect on emissions, none of the Hypotheses can be validated. Nevertheless, the results would support Hypothesis 3 if they were significant. However, the conclusions would be opposite to those found for the whole sample of developing countries, since the effect of Chinese FDI is now negative and that of American FDI is now positive.

There are multiple reasons why the findings may be different for South-East Asia than for the whole sample of developing countries. Regional differences are significant, and the increasing competition between the US and China for influence in the region could have a different impact than in areas where that competition is less influential. Results for African and Latin American countries also show that the findings are sensitive to which region is considered. Petri (2012) finds that intra-Asian FDI follows a different pattern than it does in other areas: while FDI is usually concentrated among high-technology countries, in Asia it instead runs from high-technology to medium-technology economies. The author also finds that intra-Asian FDI flows are especially conducive to technology transfers. He argues that in Asia, more than elsewhere, intra-region FDI causes important technology spillovers from fast-advancing countries to those where innovation is lagging. As an explanation for this, he writes: "because Asian resource endowments are similar, countries differ in development primarily due to technology. […] As a result, Asian FDI is more often driven by the conditions for technology transfer than by economies of scale or factor price differences, as is the case with Western flows" (Petri, 2012, p.203). Besides, he argues that intra-Asian FDI is more likely directed to countries with a low technology level *and* strong intellectual property right policies. Again, this creates the right conditions for FDI to be especially conductive to technology transfers to economies that are lagging behind technologically. Thus, these arguments could provide a direct explanation for the finding that FDI from China has a negative impact (although insignificant) on CO2 emissions in South-East Asia, while the effect is positive elsewhere: if intra-Asian FDI is more conducive to technological innovation, and since ETD in China has been increasing fast in the last decades, FDI from China could help reducing South-East Asian CO2 emissions by a larger extent than FDI from the US. The fact that FDI from the US is associated with an increase in regional emissions could mean that in this case, FDI is not conducive to significant ETD spillovers and/or that it is concentrated in polluting industries because firms are in search of pollution havens.

This study also consists of a new approach to the evaluation of the Pollution Haven and Halo Hypotheses. By looking at the effect of FDI from individual countries on CO2, in association with the different levels of EPS and ETD in said countries, new insights on the Hypotheses can be obtained. The general results for developing countries indicate that the Pollution Halo Hypothesis is valid for the US, while the Pollution Haven Hypothesis is valid for China. This suggests that FDI from the US is conductive to green technology development, which is an important conductor to reducing CO2 emissions. In contrast, FDI from China is conductive to highly polluting industries which cause negative environmental externalities. However, there are some important nuances to this point. First, although the general results are mixed and partially support both Hypotheses, the results from Table 5, when including an interaction variable between EPS and FDI, although insignificant, tend to support the Pollution Haven Hypothesis. Indeed, the findings indicate that for both the US and China, FDI increases emissions more for countries with lower-than-average EPS. However, this test is only an indication and must be considered cautiously. Second, and more importantly, the validation of one of these Hypotheses does not preclude the possibility that the other is valid too. This is consistent with the validation of Hypothesis 3 and the findings. In fact, the Pollution Hypotheses are not mutually exclusive: although their predictions point in opposite directions, they can both be at work at the same time and balance each other out. Indeed, the Pollution Haven Hypothesis makes predictions about why and which foreign firms decide to settle into a country, while the Pollution Halo Hypothesis is based on what happens when the foreign firm is already settled (Kim and Adilov, 2012). Hence, it can be that foreign firms' decision to settle in a developing country is based on their search for a pollution haven, but that they still spread green technologies when established (Kim and Adilov, 2012). This means that the negative environmental externalities associated with pollution haven effects can be outweighed by the positive externalities caused by technology spillovers. This is supported by the findings of Huynh and Hoang (2018) and Kim and Adilov (2012), and can also help explain the nonlinear relationship found between FDI from China and CO2 emissions: it is possible that up to the turning point, Chinese FDI is detrimental because Chinese firms are looking for pollution havens, but when FDI is large enough, the benefits from green technology spillovers become larger and outweigh the negative externalities. In that sense, the mechanisms of the Pollution Haven Hypothesis dominate at first, but those of the Pollution Halo Hypothesis dominate once FDI is large enough. Hence, an interpretation of the findings for the US could be that with American FDI, the mechanisms of the Pollution Halo Hypothesis (i.e., ETD spillovers) dominate that of the Pollution Haven Hypothesis (i.e., search of pollution havens). Unfortunately, in this study, I cannot decompose these two counteracting effects. Instead, I observe the overall impact of FDI on emissions, which is a composite of both Pollution Haven and Halo effects.

Lastly, these results have some methodological implications. Since they clearly show that the effect of FDI from the US is different from that from China, studying the impact of total FDI on CO2 emissions misses out on important heterogeneities. If FDI stock was taken as a total without differentiation by country, one would conclude that it has a significant inverted U-shaped effect on CO2 emissions. This would miss the fact that FDI from the US has a negative effect on emissions while FDI from China significantly increases them. So far, the literature has focused on the effects of total FDI. The recommendations from this study are to take origin country heterogeneities into account, as this would allow for a better understanding of the mechanisms and consequences of FDI. Understanding the per-country effects of FDI on CO2 could allow for FDI regulations to be set up on a per-country basis, which as the results show could be beneficial for the environment. Similarly, studies on the validity of the Pollution Haven and Halo Hypothesis have thus far mainly used total FDI or trade to test their hypotheses; the findings indicate that it might be more appropriate to take country heterogeneities into account, and doing so may even bring new insights on the validity of the hypotheses.

8. Conclusion

As an attempt to fill the gap in the literature, this paper has studied the effect of FDI from the US and China on CO2 emissions in developing countries. To do so, a panel dataset of 77 developing countries in South-East Asia, Africa, and Latin America from 2003 until 2019 was used together with a fixed-effects specification, while controlling for possible confounding factors. The findings show that FDI from the US is associated with a decrease in emissions, while FDI from China increases emissions up to a turning point. These results are significant and economically sizeable. Moreover, they are generally robust to a battery of robustness checks, including the inclusion of additional control variables and lags, different measures for CO2 and FDI, and a Granger causality test which excludes the possibility of reverse causality.

Given that American FDI increases CO2 emissions in developing countries, the findings for the US are consistent with the Pollution Halo Hypothesis. The latter predicts that FDI decreases emissions in host countries because it brings about positive green technology spillovers. Conversely, the Pollution Haven Hypothesis postulates that foreign firms look for pollution havens in places where environmental policy is lax, and hence FDI increases the host country's emissions. This is consistent with the findings for China: Chinese FDI significantly increases emissions, at least up to a turning point. After this turning point, the effect of Chinese FDI on emissions becomes negative, which suggests that the patterns of the Environmental Kuznets Curve hold for China, but not for the US. All in all, this shows that the effect of FDI on CO2 emissions differs by country, and studying the impact of total FDI without taking these heterogeneities into account, as is often done in the literature, may be misguided. The results also suggest that developing countries should be warier of FDI from China, which is more detrimental to the environment, than of FDI from the US, which causes positive environmental externalities. Given that climate change is an ever-important issue and especially so in developing countries, this is an important fact that should be taken into account by policymakers. Moreover, policies that encourage technology transfers from foreign to home firms can be beneficial to increase the positive spillovers associated with FDI. The results are also heterogeneous depending on which region is looked at: the impact of FDI on CO2 emissions is different in one continent versus another.

However, this study comports its limitations. First, the data when regions are taken separately is limited. This is both because considering regions individually reduces considerably the number of countries included and because of missing values in the data itself. Hence, future research should seek to obtain more complete data on these regions to evaluate the effects of incoming FDI. Since this study indicates that such effect may differ depending on which region, continent, or country one looks at, future research could also evaluate how FDI impacts CO2 emissions in other areas than those chosen here. Moreover, future research could also study the reasons for such regional heterogeneities. In addition, I chose here to focus on American and Chinese FDI, as these are major superpowers with very high levels of foreign investment, but one could also study the effects of FDI from other countries or regions. For example, it would be insightful to test how European FDI relates to emissions, which was not possible in this case because data on bilateral FDI from Europe was not available for a long enough timeframe.

Second, in this paper, I look at the effect of bilateral FDI as a total for all industries, and because of data limitations I cannot use sectoral information. It is possible that the impact of FDI on emissions is different depending on the sector in question (e.g., FDI in highly polluting industries could likely be more detrimental to CO2 emissions). Future research could seek to understand how the impact of FDI from the US and China on emissions differs per sector or industry.

Third, in this study, I cannot decompose the effect of positive externalities from green technology spillovers that result from FDI from the effect of negative externalities because foreign firms search for pollution havens. Instead, the effect that is observed is the total of these two counteracting forces, as well as possible other mechanisms, and conclusions can only be drawn about which of these dominates. Hence, although the mixed results indicate that both hypotheses may be simultaneously valid, nothing can be said about the size of the positive technology spillovers. Future research should seek to decompose these effects to gather more insights on the validity of both the Pollution Haven and Halo Hypotheses. Besides, in this paper, I attempt to gain insights into these hypotheses by including interaction variables with EPS. Still, these insights are limited because of the low availability of relevant data. No time-series data on EPS is currently available for the developing countries in the sample, and time-series data on ETD in China and the US is also suboptimal and does not allow me to conduct additional tests. Hence, future research could look at how ETD and EPS interact with the effect of FDI on CO2 emissions, which could provide more information on the validity of the Pollution Hypotheses.

The conclusions presented here also indicate further avenues for future research. The results suggest that both Hypotheses may be valid depending on which country is looked at. The case of the US support the Pollution Halo Hypothesis, which postulates that FDI decreases emissions because of green technology spillovers. Hence, it be would be interesting to study how the likelihood of such spillovers can be made higher. For example, one could look at which policies or factors facilitate the transfer of green technology from foreign to home firms. Conversely, the case of China supports the Haven Hypothesis, which argues that FDI is detrimental because more polluting firms are more likely to settle in a country in search for pollution havens. Hence, future research could look at possibilities for limiting this, for example by implementing regulation on the polluting behaivour of foreign firms, such as by using additional environmental taxes. If conclusive, results from such studies could provide readily available policies for developing countries to implement in order to reduce their emissions.

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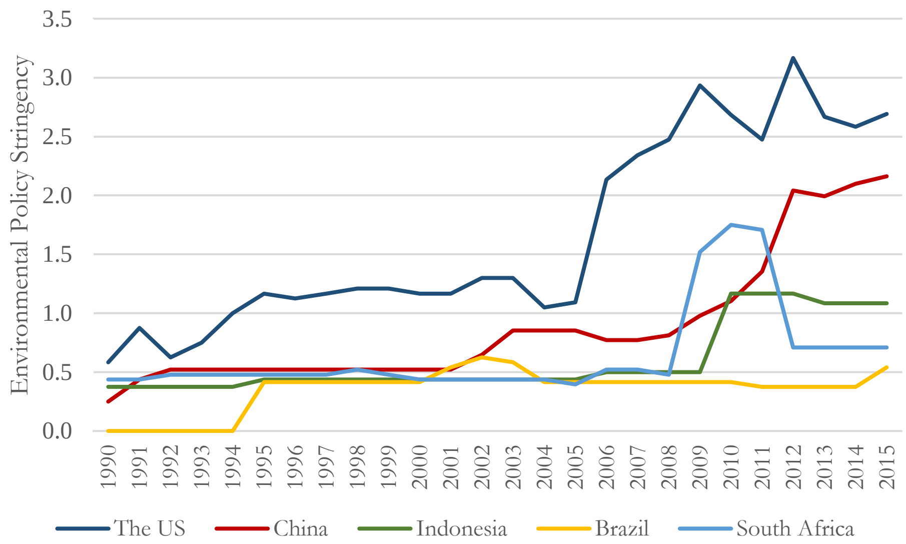
Appendix

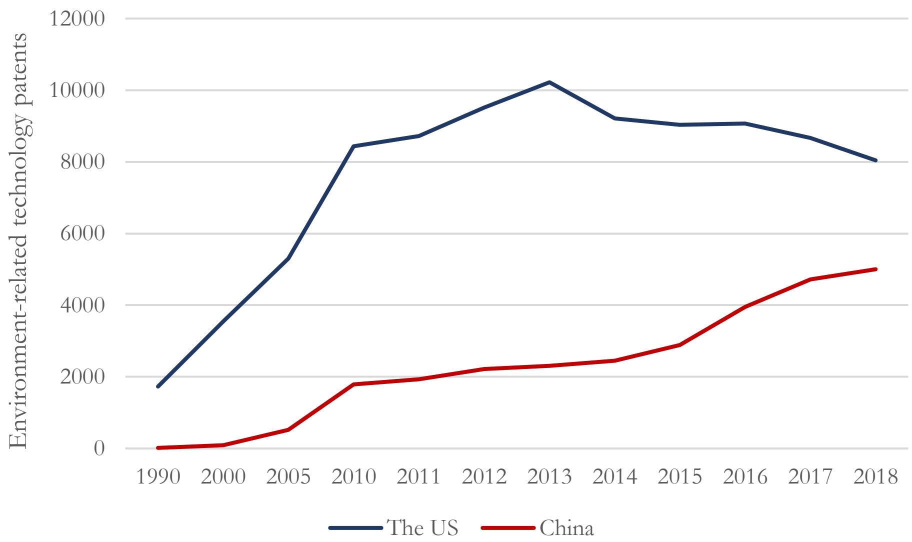
Appendix 1. Supplementary Figures

Figure 4. Environmental Policy Stringency in the US, China, Indonesia, Brazil and South Africa



Note: Environmental Policy Stringency takes a minimum value of 0 (not stringent) and a maximal value of 6 (maximum stringency). It is defined as "the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behavior" and is calculated as a combination of 14 different policy instruments, mainly focusing on climate and air pollution. Source: OECD Environmental Policy Stringency Index (2021).

Figure 5. Environment-related technology patents, China and the US



Note: Environment-related technology patents correspond to the environment-related inventions, in number of patents, developed by the country's inventors. Source: OECD Patent Indicators, 2020.

Appendix 2. Supplementary Tables

Table 7. List of countries in the sample

South-East Asia	Africa	Latin America
Brunei	Algeria	Argentinia
Cambodia	Angola	Belize
East-Timor	Benin	Bolivia
Indonesia	Botswana	Brazil
Laos	Burkina Faso	Chile
Malaysia	Burundi	Colombia
Myanmar	Cameroon	Ecuador
Phillippines	Cape Verde	El Salvador
Singapore	Central African Republic	Guatemala
Thailand	Chad	Guyana
Vietnam	Comoros	Honduras
	Congo	Nicaragua
	Congo	Panama
	Djibouti	Paraguay
	DR Congo	Peru
	Egypt	Suriname
	Equatorial Guinea	Uruguay
	Eritrea	Venezuela
	Ethiopia	
	Gabon	
	Gambia	
	Ghana	
	Guinea	
	Ivory Coast	
	Kenya	
	Lesotho	
	Liberia	
	Libya	
	Madagascar	
	Malawi	
	Mali	
	Mauritania	
	Mauritius	
	Morocco	
	Mozambique	
	Namibia	
	Niger	
	Nigeria	
	Rwanda	
	Senegal	
	Sierra Leone	
	Somalia	
	South Africa	
	Sudan	
	Tanzania	
	Togo	
	Tunisia	
	Uganda	
	Zambia	
	Zimbabwe	
Total = 11	Total = 49	Total = 17

Table 8. Stringency of Environmental Regulation, weighted average 2011-2012

Country	**Stringency of Environmental Regulation** Min = 1 (not stringent), Max = 7 (most stringent)	**Rank in the sample** (1 = most stringent, 140 = least stringent)
Singapore	5.6	18
United States	5.4	23
Malaysia	5.0	31
Brunei Darussalam	4.7	44
Philippines	4.0	66
China	4.0	67
Indonesia	3.8	76
Thailand	3.8	78
Cambodia	3.7	82
Vietnam	2.7	131
Sample mean	4.1	

Note: Column 2 displays country Stringency of Environmental Regulation scores obtained from answers to the World Economic Forum's Executive Opinion Survey 2011-2012 to the question "How would you assess the stringency of your country's environmental regulations?". A score of 1 corresponds to very lax environmental regulations, a score of 7 corresponds to the world's most stringent. Column 3 gives the Stringency of Environmental Regulation rank among 140 countries. Row 12 shows the mean Stringency of Environmental Regulation in 140 countries.

Table 9. Extensive variable descriptions and sources

Variable	**Definition** (all variables are measured on an annual country basis)	**Source**
CO2 emissions (CO2)	CO2 emissions in kilotons, including emissions stemming from the burning of fossil fuels and the manufacture of cement. This includes CO2 produced during consumption of solid, liquid, and gas fuels and gas flaring.	World Development Indicators (The World Bank)
CO2 emissions, alternative source (CO2)	CO2 emissions in kilotons attributed to the country in which they physically occur.	Our World in Data, sourced from the Global Carbon Project
FDI stock from the US (FDI_US)	US Direct Investment Position Abroad per country on a Historical-Cost Basis, in millions of US dollars.	US Bureau of Economic Analysis
FDI stock from China (FDI_China)	China's Outward FDI stock by country in millions of US dollars.	Ministry of Commerce of the People's Republic of China (MOFCOM), Statistical Bulletins of China's Outward Foreign Direct Investment in 2006, 2012 and 2019
FDI flows from the US (FDI_flows_US)	Outward Foreign Direct Investment from the US by country in millions of US dollars.	UNCTAD Stat
FDI flows from China (FDI_flows_China)	Outward Foreign Direct Investment flows from China by country in millions of US dollars.	UNCTAD Stat

Total FDI stock (FDI_stock)	Total Inward Foreign Direct Investment stock by country in millions of US dollars.	UNCTAD Stat
Total FDI flows (FDI_flows)	Total Inward Foreign Direct Investment flows by country in millions of US dollars.	UNCTAD Stat
GDP (GDP)	GDP in current US dollars.	World Development Indicators (The World Bank)
Trade (Trade)	Sum of exports and imports as a percentage of GDP.	World Development Indicators (The World Bank)
Population (Population)	Total population.	World Development Indicators (The World Bank)
Population density (Pop_density)	Population density measured by the average number of people living per square kilometer of land area.	World Development Indicators (The World Bank)
Urbanization (Urban)	Urban population as percent of total population, with urban population defined as population living in urban areas as defined by national statistical offices.	World Development Indicators (The World Bank)
Quality of Governance (Quality_gov)	Variable computed as the average Governance score based on six indicators: - Government effectiveness - Regulatory quality - Rule of Law - Voice and Accountability - Control of Corruption - Political Stability and Absence of Violence/Terrorism Where scores range from approximately -2.5 (poor governance) to 2.5 (good governance), with a standard deviation of 1 and mean 0.	World Governance Indicators (The World Bank)

Table 10: Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) FDI stock from the US	1.000								
(2) FDI stock from China	0.813	1.000							
(3) Total FDI stock	0.950	0.797	1.000						
(4) GDP	0.411	0.221	0.598	1.000					
(5) Trade	0.488	0.353	0.397	-0.120	1.000				
(6) Population	0.159	0.151	0.324	0.733	-0.245	1.000			
(7) Population density	0.835	0.646	0.723	0.058	0.681	-0.061	1.000		
(8) Urbanization	0.389	0.191	0.411	0.343	0.222	0.032	0.252	1.000	
(9) Quality of governance	0.412	0.249	0.408	0.150	0.365	-0.077	0.401	0.425	1.000

Note: Numbers in the table correspond to the correlation between the Row variables and corresponding Column variables.

Table 11: **Regression results, Africa**

	(1) OLS, no controls	(2) OLS, with controls	(3) FEs, no controls	(4) FEs, with controls	(5) FEs, with non-linearities, no controls	(6) FEs, with non-linearities, with controls
FDI from the US	16.1*** (4.495)	4.026 (2.65)	2.053 (1.418)	0.344 (0.795)	-0.398 (1.939)	-1.492 (1.132)
FDI from the US, squared					0.0002** (0.00007)	0.0001** (0.00005)
FDI from China	47.493*** (15.617)	-3.487 (6.971)	5.869*** (1.677)	2.282 (1.816)	11.376** (4.396)	5.48 (4.853)
FDI from China, squared					-0.001* (0.0006)	-0.0006 (0.0006)
Total FDI stock		2.455*** (0.68)		0.206 (0.168)		0.212 (0.166)
GDP		2.63e-07 2.63e-07		1.30e-07*** (4.12e-08)		1.15e-07*** (3.46e-08)
Trade		-180.007** (84.197)		6.501 (6.465)		13.769 (10.043)
Population		-0.0006* (0.0004)		-0.0005*** (0.0001)		-0.0004*** (0.0002)
Population density		-48.268** (21.776)		-42.827 (27.191)		-28.417 (26.043)
Urbanization		-223.267 (252.577)		-348.724 (306.627)		-313.946 (354.795)
Quality of Governance		8360.931 (6852.038)		-2242.56 (1631.25)		-1763.211 (1779.558)
Constant	-1576.878 (2841.954)	31175.66** 14929.48	22973.65*** (1931.815)	45954.19*** (14062.43)	23947.06*** (1862.584)	43548.16*** (15620.94)
Observations	535	497	535	497	535	497
R-squared	0.561	0.842	0.527	0.3748	0.3609	0.2928
Country fixed effects	NO	NO	YES	YES	YES	YES
Year fixed effects	NO	NO	YES	YES	YES	YES
P-value t-test $\beta_1 = \beta_2$	0.035	0.2247	0.1671	0.404	0.03	0.2

Note: In all columns, the dependent variable is CO_2 emissions in kilotons. The sample includes only countries from Africa, with a total of 49 countries. Standard errors, clustered at the country level, are in parentheses. Columns (1) and (2) are simple OLS regressions, without and with controls. In Columns (3) and (4), country and year fixed effects are added. Columns (5) and (6) include squared terms for FDI from the US and China. In the last row, the p-value for a t-test of equality between β_1 and β_2 is displayed. *** is $p<0.01$, ** is $p<0.05$, * is $p<0.1$.

Table 12: Regression results, Latin America

	(1) OLS, no controls	(2) OLS, with controls	(3) FEs, no controls	(4) FEs, with controls	(5) FEs, with non-linearities, no controls	(6) FEs, with non-linearities, with controls
FDI from the US	6.046***	3.93***	2.331***	-0.524	0.718	-0.335
	(0.75)	(0.681)	(0.444)	(0.579)	(1.108)	(0.656)
FDI from the US, squared					0.0002	-5.96e-06
					(0.00001)	(5.74e-06)
FDI from China	37.801**	14.215	14.998	4.512	14.958	-2.79
	(14.087)	(9.418)	(9.648)	(4.441)	(8.957)	(5.576)
FDI from China, squared					-0.00058	0.003
					(0.00635)	(0.003)
Total FDI stock		-0.235**		0.075***		0.097***
		(0.092)		(0.02)		(0.024)
GDP		4.24e-08		1.97e-08**		2.81e-08**
		(3.15e-08)		(8.34e-09)		(1.16e-08)
Trade		285.335		23.776		32.919
		(191.225)		(60.271)		(58.769)
Population		0.001***		0.006***		0.005***
		(0.0002)		(0.0007)		(0.0009)
Population density		-443.054		-1065.123*		-754.287
		(260.763)		(534.857)		(583.09)
Urbanization		1841.716***		1408.596		832.065
		(535.85)		(1835.776)		(1764.661)
Quality of Governance		-44517.64***		-5191.931		-1264.636
		(53147.13)		(9006.817)		(8069.536)
Constant	11726.81	-133063.9**	50163.66***	-166068.3	57333.08***	-127647.4
	(9171.968)	(53147.13)	(4759.089)	(104255.5)	(6815.168)	(101453)
Observations	188	177	188	177	188	177
R-squared	0.8317	0.9661	0.8300	0.8902	0.7615	0.8848
Country fixed effects	NO	NO	YES	YES	YES	YES
Year fixed effects	NO	NO	YES	YES	YES	YES
P-value t-test $\beta_1 = \beta_2$	0.05	0.307	0.219	0.299	0.161	0.657

Note: In all columns, the dependent variable is CO_2 emissions in kilotons. The sample includes only countries from Latin America, with a total of 17 countries. Standard errors, clustered at the country level, are in parentheses. Columns (1) and (2) are simple OLS regressions, without and with controls. In Columns (3) and (4), country and year fixed effects are added. Columns (5) and (6) include squared terms for FDI from the US and China. In the last row, the p-value for a t-test of equality between β_1 and β_2 is displayed. *** is p<0.01, ** is p<0.05, * is p<0.1.

Table 13: Regression results, alternative measures of CO2 emissions

	(1) Linear, OWID CO2 in kilotons	(2) Non-linear, OWID CO2 in kilotons	(3) Linear, OWID kilos of CO2 per capita	(4) Non-linear, OWID kilos of CO2 per capita	(5) Linear, OWID GHG emissions in megatons	(6) Non-linear, OWID GHG emissions in megatons
FDI from the US	-0.757*	-1.069**	-0.0133**	-0.039	-0.003*	-0.003
	(0.435)	(0.418)	(0.005)	(0.037)	(0.002)	(0.003)
FDI from the US, squared		1.23e-06		8.17e-08		3.95e-09
		(1.14e-06)		(1.00e-07)		(5.60e-09)
FDI from China	1.488	5.359***	-0.61***	-0.008	0.017**	0.024***
	(1.514)	(1.514)	(0.0219)	(0.045)	(0.007)	(0.008)
FDI from China, squared		-0.0001***		-2.26e-06***		-3.53e-07**
		(0.00002)		(5.3e-07)		(1.33e-07)
Total FDI stock	0.112	0.2***	0.001	0.003***	0.0002	0.0001
	(0.078)	(0.039)	(0.002)	(0.001)	(0.0003)	(0.0003)
GDP	7.62e-08***	5.08e-08**	3.54e-10	4.88e-11	-2.70e-10***	-2.7e-10***
	(2.83e-08)	(2.12e-08)	(5.93e-10)	(6.75e-10)	(9.75e-11)	(8.73e-11)
Trade	24.384	10.404	0.085	-0.022	0.157	0.125
	(55.607)	(45.472)	(1.866)	(1.666)	(0.164)	(0.163)
Population	0.0009	0.0007	-4.30e-06	-7.09e-06	3.90e-06***	3.63e-06***
	(0.0007)	(0.0005)	(0.00001)	(9.98e-06)	(1.42e-06)	(1.34e-06)
Population density	-23.23	-64.269***	0.14	-0.471	-0.015	-0.047
	(22.479)	(13.935)	(0.905)	(1.021)	(0.062)	(0.063)
Urbanization	459.434	36.531	-6.812	-16.798	-0.247	-0.481
	(762.569)	(633)	(41.144)	(40.905)	(2.209)	(2.145)
Quality of Governance	5.304	-1616.548	699.162*	656.103*	10.085	8.531
	(4554.59)	(4688.27)	(368.917)	(379.25)	(17.513)	(16.855)
Constant	-895.856	33325.67	2565.102	3266.595	89.839	116.522
	(41919.86)	(32055.74)	(1800.972)	(1808.147)	(95.611)	(90.447)
Observations	905	905	905	905	799	799
R-squared	0.6286	0.3280	0.0334	0.0602	0.4866	0.3889
Country fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
P-value t-test $\beta_1 = \beta_2$	0.247	0.0002	0.068	0.482	0.017	0.003

Note: Dependent variables differ by column and are displayed in the respective column header. In Columns (1) and (2), the dependent variable is CO2 emissions in kilotons obtained from OWID. In Columns (3) and (4), the dependent variable is CO2 emissions per capita, in kilos, obtained from OWID. In Columns (5) and (6), the dependent variable is total GHG emissions, in megatons, obtained from OWID. In all columns, country and year fixed effects are included. Columns (2), (4), and (6) additionally include squared terms for FDI from the US and China. Standard errors, clustered at the country level, are in parentheses. In the last row, the p-value for a t-test of equality between β_1 and β_2 is displayed. *** is p<0.01, ** is p<0.05, * is p<0.1.

Table 14: Regression results, FDI flows (UNCTAD)

	(1) OLS, no controls	(2) OLS, with controls	(3) FEs, no controls	(4) FEs, with controls	(5) FEs, with non-linearities, no controls	(6) FEs, with non-linearities, with controls
FDI from the US	20.334	10.132**	3.789	-1.443	5.389*	-0.373
	(14.41)	(4.464)	(2.499)	(1.253)	(2.718)	(1.704)
FDI from the US, squared					-0.0002	-0.0001
					(0.0002)	(0.0001)
FDI from China	-0.823	0.186	2.554	2.095	12.008*	9.583**
	(6.123)	(5.798)	(2.537)	(2.086)	(6.424)	(4.449)
FDI from China, squared					-0.001*	-0.0007**
					(0.0005)	(0.0004)
Total FDI flows		-5.273*		0.224		0.415*
		(2.674)		(0.22)		(0.227)
GDP		2.61e-07**		6.45e-08**		5.71e-08**
		(1.27e-07)		(2.51e-08)		(2.51e-08)
Trade		196.12		-8.43		-10.805
		(159.066)		(29.463)		(29.812)
Population		0.001***		0.001		0.001
		(0.0002)		(0.001)		(0.001)
Population density		-12.269		7.768		2.837
		(11.043)		(5.132)		(6.426)
Urbanization		577.259*		1332.154		1361.379
		(318.899)		(1108.334)		(1082.402)
Quality of Governance		27227.48		2987.058		2722.028
		(19160.58)		(7445.195)		(7287.895)
Constant	50619.5***	-21659.81	50661.16***	-59680.1	50277.42***	-58526.21
	(12508.53)	(29020.38)	(2665.833)	(78777.05)	(2651.01)	(76333.27)
Observations	500	469	500	469	500	469
R-squared	0.0967	0.6736	0.0698	0.6045	0.0902	0.6113
Country fixed effects	NO	NO	YES	YES	YES	YES
Year fixed effects	NO	NO	YES	YES	YES	YES
P-value t-test $\beta_1 = \beta_2$	0.174	0.164	0.728	0.168	0.364	0.07

Note: In all columns, the dependent variable is CO2 emissions in kilotons. FDI from the US and China and total FDI are measured as flows. Standard errors, clustered at the country level, are in parentheses. Columns (1) and (2) are simple OLS regressions, without and with controls. In Columns (3) and (4), country and year fixed effects are added. Columns (5) and (6) include squared terms for FDI from the US and China. In the last row, the p-value for a t-test of equality between β_1 and β_2 is displayed. *** is p<0.01, ** is p<0.05, * is p<0.1.

Table 15: Regression results, FDI flows (manual computation)

	(1) OLS, no controls	(2) OLS, with controls	(3) FEs, no controls	(4) FEs, with controls	(5) FEs, with non-linearities, no controls	(6) FEs, with non-linearities, with controls
FDI from the US	-1.834	-1.507	-0.884	-0.337	-1.525	-1.049
	(2.442)	(1.188)	(0.852)	(0.577)	(1.133)	(0.997)
FDI from the US, squared					0.00002	0.00003
					(0.00002)	(0.00002)
FDI from China	40.746	21.122	5.425*	2.575	7.865*	3.378
	(30.003)	(13.718)	(3.087)	(1.744)	(4.05)	(2.586)
FDI from China, squared					-0.0004	-0.00008
					(0.0003)	(0.0002)
Total FDI flows		-0.014		-0.108		-0.08
		(0.138)		(0.07)		(0.075)
GDP		1.38e-07**		8.69e-08***		8.62e-08***
		(6.36e-08)		(1.62e-08)		(1.60e-08)
Trade		233.661		18.621		15.085
		(155.937)		(47.771)		(46.709)
Population		0.001***		0.0009		0.0009
		(0.0002)		0.0007		(0.0007)
Population density		-24.225***		1.414		-8.457
		(9.016)		(4.601)		(8.535)
Urbanization		662.45**		638.731		647.706
		(313.98)		(785.213)		(769.603)
Quality of Governance		18306.91		-2092.359		-1744.505
		(16021.9)		(3809.436)		(3757.067)
Constant	53361.53***	-35797.17	48021.84	-14092.58	48151.41***	-11718.03
	(12528.89)	(23429.83)	(2214.566)	(44834.01)	(2181.939)	(44435.69)
Observations	739	701	739	701	739	701
R-squared	0.0414	0.6924	0.0156	0.6621	0.0212	0.6637
Country fixed effects	NO	NO	YES	YES	YES	YES
Year fixed effects	NO	NO	YES	YES	YES	YES
P-value t-test $\beta_1 = \beta_2$	0.1747	0.1310	0.1104	0.1868	0.048	0.1149

Note: In all columns, the dependent variable is CO2 emissions in kilotons. FDI from the US and China and total FDI are measured as flows, which are computed manually as the difference between FDI stock in year t and FDI stock in year t-1. Standard errors, clustered at the country level, are in parentheses. Columns (1) and (2) are simple OLS regressions, without and with controls. In Columns (3) and (4), country and year fixed effects are added. Columns (5) and (6) include squared terms for FDI from the US and China. In the last row, the p-value for a t-test of equality between β_1 and β_2 is displayed. *** is p<0.01, ** is p<0.05, * is p<0.1.

Table 16: Regression results, alternative combinations of control variables

	(1) Linear, without Population Density	(2) Non-linear, without Population Density	(3) Linear, without Trade	(4) Non-linear, without Trade	(5) Linear, additional controls	(6) Non-linear, additional controls
FDI from the US	-1.04***	-0.867*	-1.04***	-0.808*	-0.72***	-0.747
	(0.394)	(0.53)	(0.263)	(0.481)	(0.17)	(0.539)
FDI from the US, squared		1.65e-07		3.40e-07		1.94e-07
		(2.20e-06)		(1.49e-06)		(1.69e-06)
FDI from China	2.962**	4.358***	3.218**	5.302***	3.078***	3.264***
	(1.279)	(1.376)	(1.384)	(1.586)	(0.7)	(1.037)
FDI from China, squared		-0.00007*		-0.0001***		-0.00001
		(0.0004)		(0.00004)		(0.00004)
Total FDI stock	0.135***	0.108*	0.208***	0.185***	0.136***	0.137***
	(0.05)	(0.056)	(0.037)	(0.039)	(0.032)	(0.038)
GDP	7.37e-08***	7.59e-08***	5.34e-08***	5.19e-08***	1.66e-08	1.72e-08
	(1.53e-08)	(1.93e-08)	(1.19e-08)	(1.30e-08)	(2.65e-08)	(2.90e-08)
Trade	12.336	5.856			-37.814	-38.385
	(43.148)	(42.059)			(31.909)	(32.991)
Population	0.001	0.0005	0.0006	0.0005	0.0007	0.0007
	(0.001)	0.0006	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Population density			-43.691***	-53.406***	-82.212***	-82.553***
			(0.0005)	(10.649)	(18.941)	(17.97)
Urbanization	402.856	421.241	153.639	132.421	-298.992	-300.46
	(695.687)	(644.881)	(579.212)	(531.682)	(667.101)	(613.635)
Quality of Governance	-4122.56	-4360.447	-4075.784	-4303.576		
	(4280.691)	(4118.594)	(4114.288)	(4018.891)		
Exports					-7.52e-08	-7.48e-08
					(2.23e-07)	(2.29e-07)
Imports					4.08e-07	4.02e-07
					(3.17e-07)	(3.30e-07)
GDP per capita					-0.199	-0.201
					(0.399)	(0.401)
Regulatory quality					-2049.745	-2017
					(2638.399)	(2593.714)
Government effectiveness					2884.345	2919.791
					(3303.192)	(3356.972)
Rule of Law					-6647.993	-6738.474
					(5101.348)	(5193.367)
Voice and Accountability					1446.339	1412.857
					(2282.068)	(2214.175)
Control of corruption					-2157.829	-2127.473
					(4631.161)	(4679.727)
Political Stability					1494.317	1460.441
					(1263.482)	(1259.901)
Constant	5642.223	6858.485	25077.94	29661.9	54660.46	55151.97
	(35663.02)	(33011.23)	(29783.7)	(27385.84)	(4381.88)	(33340.21)
Observations	805	805	826	826	745	745
R-squared	0.689	0.69	0.408	0.34	0.2797	0.2651
Country fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES

P-value t-test $\beta_1 = \beta_2$	0.019	0.002	0.012	0.0006	0	0.002

Note: In all columns, the dependent variable is CO_2 emissions in kilotons. In all specifications, country and year fixed effects are included. Columns (1), (3) and (5) are linear regressions, and Columns (2), (4) and (6) include squared terms for FDI from the US and China. In Columns (1) and (2), Population Density is excluded from the list of controls, and in Columns (3) and (4) Trade is excluded. In Columns (5) and (6), the following control variables are added: current exports and imports, GDP per capita, regulatory quality, government effectiveness, rule of law, voice and accountability, control of corruption, and political stability. Standard errors, clustered at the country level, are in parentheses. In the last row, the p-value for a t-test of equality between β_1 and β_2 is displayed. *** is $p<0.01$, ** is $p<0.05$, * is $p<0.1$.