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Master Thesis [Strategy Economics]

The Environmental Footprint of the Belt and Road Initiative: Effects of Chinese Investments on Host Country Pollution

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Abstract

The rise of China’s presence on the world stage has not gone unnoticed. The recently implemented Belt & Road Initiative (BRI) has created a substantial rise of Chinese investments abroad. Using a robust panel Instrumental Variable (IV) regression for 202 countries for the period from 2008 up and until 2016, this thesis investigates the impact of Chinese investments under the BRI on environmental pollution. Results show Chinese investments in Belt & Road (B&R) countries are relatively more polluting as compared to those in non-B&R countries. A possible explanation is that a majority of investments is in infrastructure projects. However, upon closer examination, by adding a dummy for infrastructure projects, and the resulting triple interaction, a surprising outcome if found. Infrastructure projects under the BRI show to be less polluting as compared to those in non-B&R countries. Underlying literature in environmental economics argues theorises the existence of the Environmental Kuznets Curve (EKC). This thesis finds proof supporting the EKC in all models. Lastly, a system Generalised Methods of Moments (GMM) model is introduced to kickstart future research in the isolation of Foreign Direct investments (FDI) inflows.

Keywords: Foreign Direct Investment, Environmental Kuznets Curve, Pollution Haven Hypothesis, Chinese Outward Direct Investment, Belt and Road Initiative

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Table of Contents

1. Introduction

Trade liberalisation has been an important topic in research. Questions concerning the optimal strategy for countries to pursue high growth rates and rapid economic expansion have received much attention. Especially to developing countries, an outer-oriented strategy can bring an initial period of high economic growth (Krueger, 1998). Economies that wish to experience a temporary surge in growth may consider loosening up restrictions to trade, however, it does not provide a guarantee to long-term economic expansion. Literature finds openness and income growth, a proxy for economic development, are positively related (Baldwin & Winters, 2004; Jones, 1999; Winters, 2004). For countries that find themselves in early stages of development, the weight of this potential early 'economic boost' may be even larger. The terms trade liberalisation and Foreign Direct Investments (FDI) are often used interchangeably. The more open economic policy in a country is, the higher its inflows and outflows of FDI are. Keeping in mind the benefits trade openness may bring, the following section will focus on the advantages of engaging in FDI and its determinants.

1.1 Foreign Direct Investment and Chinese Outward Direct Investments

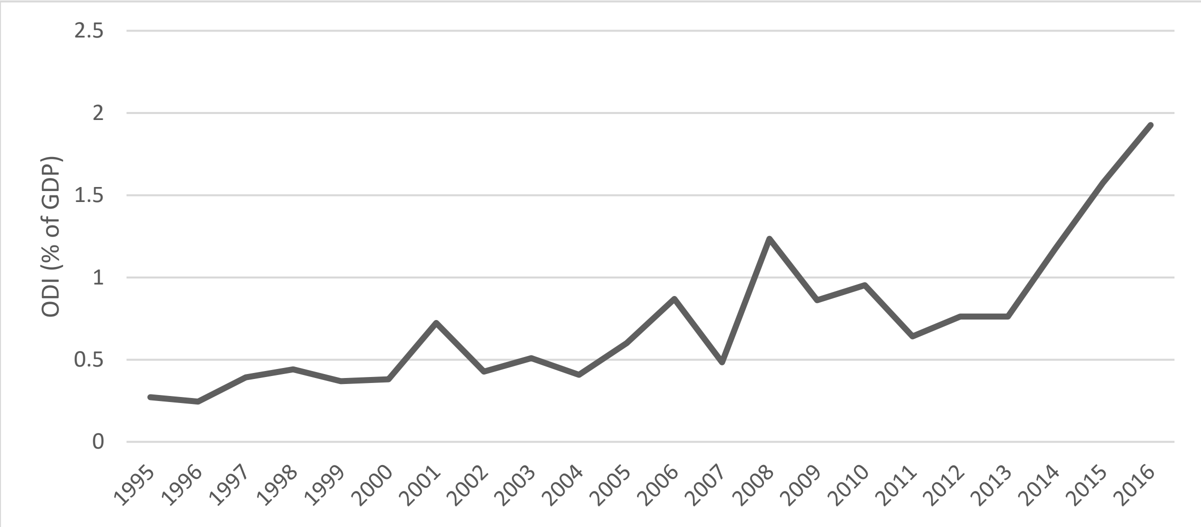
Effects of FDI have been widely researched in academia. Building on the advantages of trade openness, FDI can stimulate innovation spillovers, increase economic development, and promote economic growth in developing countries (Adams, 2009; Cheung & Lin, 2004; Levine, 2005). The eagerness of these countries to engage in FDI is huge, potentially leapfrogging technological capabilities and creating a more sustainable situation both politically and economically.

More recently, the focus within FDI research has shifted to location-oriented aspects. Specifically, the determinants of location specific FDI have received more attention. One of the new entrants to the world stage of major FDI exporters is China, for which FDI from Chinese origin is referred to as Chinese outward direct investment (ODI). The rapid and vast global expansion of the Asian country has gained ground under the newly implemented Belt and Road Initiative (BRI). The main goals of this policy are described as "… to set up development-oriented financial institutions, accelerate the construction of infrastructure connecting China with neighbouring countries and regions, and work hard to build a Silk Road Economic Belt and a Maritime Silk Road, so as to form a new pattern of all-round opening" (Central Committee, 2013: p. 7). Academic interest has been sparked and both determinants and effects of Chinese ODI have undergone intense study in recent years. Considering the importance of FDI for the host country, it is valuable to expound upon the determinants and effects of Chinese ODI.

China's path to internationalisation began under Deng Xiaoping. Ever since the opening of China to the world in the 1980s, the country maintained control over its evolutionary path to internationalisation. In 2000, the government officially launched the “Going Abroad” policy, providing support to those firms that wished to expand beyond China’s borders, thereby significantly increasing ODI, as can be seen in Figure 1 (Buckley et al., 2007; Luo et al., 2010; World Bank, n.d.).

Figure 1

Chinese FDI outflows (% of GDP) from 1995-2016



Note. Retrieved from World Bank database.

Subsequently, a wide body of literature has studied the determinants of Chinese ODI because underlying characteristics may differ from conventional ODI. There are several reasons for this, firstly, a majority of Chinese firms investing abroad are state-owned enterprises (SOEs). These firms may have different objectives compared to private firms as not only profit maximisation is at play. In fact, besides the goal of profit maximisation, investments of SOEs may reflect political goals (Amighini et al., 2013; Kolstad & Wiig, 2012). To some extent, these secondary objectives may even trickle down to private Chinese firms (Cheng & Ma, 2010). Second, the institutional environment in China differs greatly from other industrialised economies as, for example, corruption levels are higher. Reflecting a background of lower quality institutions causes Chinese firms to have a competitive advantage in dealing with such environments abroad, facing a lower ‘liability of foreignness’, thus preferring relatively riskier countries to invest in (Buckley et al., 2007). Consequently, besides having additional goals, Chinese ODI may identify other opportunities as compared to traditional FDI investments (Kolstad & Wiig, 2012). Lastly, to maintain high growth rates, China needs secure access to energy resources. Several studies show the relative preference of Chinese investments for resource rich countries (Amighini et al., 2013; Cheng & Ma, 2010; Kolstad & Wiig, 2012). All in all, ODI originating from China prefer to pursue both profits as well as political goals in institutionally weak countries with high resource availability.

1.2 Environmental impact of Chinese ODI

Whereas previous literature has mostly aimed to discover how determinants of Chinese ODI differ compared to those of traditional investing countries, more recently, focus has shifted towards the impact of FDI. The academic literature sees a shift from general effects of FDI incurred by trade liberalisation to determinants of FDI, and later to the impact of location specific FDI, taking into account the environmental impact as well. Table 1 presents a brief overview of the most important changes in research focus within the context of this thesis.

Table 1

Literature overview

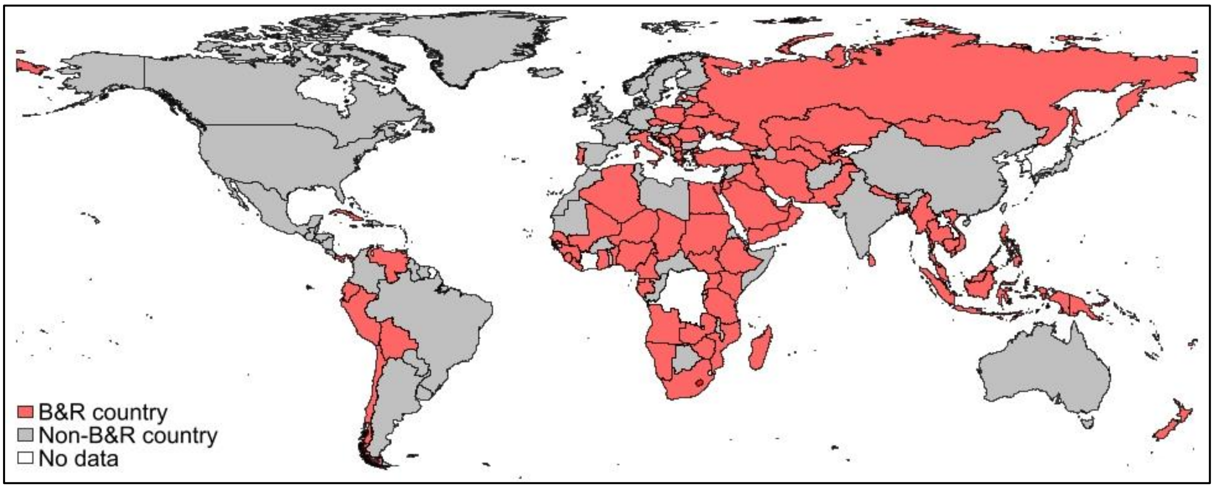
Author	Focus	Findings
Effects of trade liberalisation		
Jones (1999)	Economic growth model.	Trade important factor in broader study of growth.
Baldwin & Winters (2004)	Empirical effects of trade liberalisation.	Openness contributes to economic growth.
Winters (2004)	Literature overview on trade and economic growth relation.	Liberalisation contributes to economic growth on the short run, the long term less certain.
Taylor (2004)	Literature overview on trade and environmental pollution.	Support for PHH is weak although theorisation is strong.
Dinda (2004)	Literature overview on inverted u-shape relation between trade and environmental pollution.	Evidence in favour of EKC depends on the category of dependent variable chosen, in which air quality indicators show most favourable results.
Determinants of location-oriented FDI		
Buckley et al. (2007)	Test general theory of multinational firm on Chinese ODI.	Association with high levels of political risk, cultural proximity, market size, and geographic proximity.
Kolstad & Wiig (2012)	Empirical analysis of host-country determinants of Chinese ODI.	Attracted to large markets and countries that have both large natural resource stock and poor institutions.
Amighini et al. (2013)	Empirical analysis of host-country determinants of Chinese ODI.	Determinants of SOEs: strategic needs of home country and natural resources Determinants of private firms: large markets and strategic assets.
Impact of location-specific FDI		
Du & Zhang (2018)	Changes in Chinese ODI following announcement of BRI.	Post-announcement overseas trade increased and SOEs expanded in infrastructure sector.
Saud et al. (2019)	Empirical analysis of growth and FDI on environmental quality in BRI countries.	No support for PHH is found, yet partial evidence in favour of EKC is found.
Wu et al. (2020)	Empirical analysis of Chinese ODI and Green Total Factor Productivity (GTFP) in BRI countries.	Chinese ODI improves GTFP contradicting PHH, excluding Middle East and North Africa.
Muhammad & Long (2021)	Empirical analysis of institutional quality and environmental pollution.	Political stability, corruption control and rule of law negatively impact environmental pollution.

Note. Abbreviations are written out in full in Appendix A and in text.

As stated previously, an increasing body of literature has centred on the environmental aspect of the Chinese ODI. Stimulated by an awakening interest of scientists, combatting climate change has become a more prevalent topic in recent times. Global frameworks such as the 2015 Paris Climate Agreement and its predecessor, the 1997 Kyoto Protocols, amplify this importance by advocating both the public and private sector to act. The potential impact of increased investments shows a clear relevance for research. To visualise the rise under the BRI, the following map depicts the countries participating in the investment initiative.

Figure 2

Countries participating in the BRI in 2016



Note. Adapted from Chinese Global Investment Tracker database.

Given the topic of Chinese ODI and environmental pollution has received little attention in the existing literature embodies the main relevance of the subject. Due to the attractiveness of FDI and the advantages it brings, learning about the impact beyond solely economic benefits is vital to anticipate on the future. The combination of divergent determinants for Chinese ODI as well as the momentary increased investments abroad make the topic especially relevant now. Additionally, most studies focus on aggregate effects of FDI instead of single-origin impact. Knowing more about FDI originating from 1 country is valuable, especially when its target countries are the focus of a long-term investment programme such as the BRI. Therefore, the main research question is:

What is the impact of the investments under the Belt and Road Initiative on the environmental pollution of its host countries compared to non-B&R countries?

This research provides novelty to the academic literature by investigating the inverted U-shaped relation with single-origin FDI as an explanatory variable, as later explained in more detail. The single-origin FDI has not been used in previous literature as a result of which the novel methodology brings different insights. The results of this thesis may reiterate the importance of incorporating environmental impact into decision making of policy makers to optimise trade relations. The remainder of this thesis includes a literature review in chapter 2, data and methodology in chapter 3, results in chapter 4, and finally, a conclusion with discussion of limitations in chapter 5.

2. Literature Review and Hypotheses Development

Taking the perspective of environmental economics, Chinese ODI literature revolves around two main schools of thought. On the one hand, the Pollution Haven Hypothesis (PHH), which builds on the effect of escaping home country environmental regulations and moving polluting industries to host countries through FDI, resulting in negative environmental effects for the receiving country. On the other hand, a positive impact of FDI on the host country may occur due to a net positive effect, also known as the Environmental Kuznets Curve (EKC). This section will further elaborate on each of both theories as well as placing them in the context of Chinese investments and the research done within this area.

2.1 Pollution Haven Hypothesis

Ever since trade liberalisation has gained ground following globalisation, the effects of free trade have received increasing attention. More possibilities for mobility and flexibility have given firms an advantage to optimise location strategy. Part of the trade-off firms face is the regulations that need to be dealt with in the country in which they are located. As a result of changing rules and regulations firms may decide to move activities such as production elsewhere (Cole, 2004). For example, more stringent rules may induce higher compliance costs. A rise in cost may be one of many reasons for firms to move production abroad. Attractive alternatives include those locations where less strict rules apply, so as to avoid these compliance costs. When focused on the realm of environmental regulations, this mechanism is referred to as the Pollution Haven Hypothesis (PHH). It predicts firms to move to countries with less stringent environmental rules. More specifically, the PHH argues that due to the increased welfare of developed countries, higher environmental quality standards have been put in place due to which multinational corporations (MNCs) will move polluting activities to less developed countries in the form of FDI (Cole, 2004).

The theory on FDI distinguishes two important mechanisms. Firstly, the *pollution haven effect* (PHE) shows how changes in regulation result in deterrence of exports of polluting industries (Taylor, 2004). Whereas this mechanism focuses on the consequences of newly imposed environmental regulations, the *pollution haven hypothesis* (PHH) aims at predicting the change in trade patterns after new legislation. The former is predominantly studied in the literature due to its relative simplicity compared to testing the PHH. Additionally, the importance of the PHE is underpinned in its contribution to finding evidence for the PHH. When no PHE are found, the PHH may be rejected. Moreover, finding relatively small effects may lead to evidence contradicting the PHH. In other words, the prediction in changing patterns of trade can only be confirmed when significant effects are in place for the PHE (Taylor, 2004). Therefore, although the two mechanisms differ, the PHE is pivotal in providing evidence supporting or contradicting the PHH.

As previously touched upon, academic literature surrounding the trade effects of environmental regulation mainly focus on the PHE, simply because of the relative ease of methodology in comparison to the PHH (Taylor, 2004). Although the theory has been widely studied, results are mixed. Cole (2004) finds some evidence of pollution haven effects, but only in certain sub-samples as well as effects of relatively minor impact. Eskeland & Harrison (2003) only find minor effects in industries with high levels of air pollution, with a sample focusing solely on US outbound investments. On the other hand, some literature has not found evidence for the presence of PHE despite clear and sound theory (Chichilnisky, 1994; Copeland & Taylor, 1994). Part of the reason as to why evidence may be difficult to find lies in the factors determining location choices for firms. For example, Tobey (1990) finds the aforementioned compliance costs to environmental regulation only constitute 2% of the total firm costs and are therefore relatively minor. As a result, the weight of these costs may not influence the location choice to the extent of an expensive undertaking such as moving abroad. Moreover, countries characterised by lenient regulation may be less attractive for firms due to corruption and poor infrastructure (Cole, 2004). Another factor influencing attractiveness of the host country is the firm reputation which might be affected when firms decide to move. Moving to a country with lenient regulation may damage the reputation as it can be perceived as taking advantage of these poor conditions (Cole, 2004). Especially in today's society where corporate social responsibility has taken a more prominent role for firm image. Another important aspect of the PHH is that reverse causality might be at play, which should be taken into account in the model. In other words, instead of FDI positively affecting pollution, high levels of pollution attract FDI due to seemingly fewer environmental regulations (Chandran & Tang, 2013; Wagner & Timmins, 2009). The discrepancy in theorisation and empirical findings for the PHE suggests an ambiguous relation between FDI and environmental pollution. The aim of this paper is to shed further light on this relationship in a relevant context by specifying the effect to single-origin FDI.

Shifting focus to the environmental impact of the BRI within the context of the PHH, literature provides mixed results. Firstly, evidence for the PHH is dependent on the stage of economic development of the host country (Muhammad & Long, 2021). Using an IV-GMM model observing differences for country income groups, the authors find support for the PHH in lower-, lower-middle, and upper-middle-income countries. However, higher-income countries experience reduced levels of pollution of carbon emissions as FDI inflows increase. This indicates higher-income countries to be in a further stage of development and thus the only group of countries to experience environmental benefits from FDI by having transitioned to a green economy (Dinda, 2004). The technological effects, benefits brought through new technologies, thus exceed the PHE and a net positive effect of FDI is the result for these developed economies. The validity of the PHH only holds for those countries in early stages of development. Contradicting these results, Saud et al., (2019) find no support for the PHH in a sample of 58 BRI countries, in fact presenting evidence that increased levels of FDI and energy consumption improve environmental quality. This might be explained by the fact that the authors do find presence of the EKC, therefore, FDI and environmental quality are positively related on average. Some of the evidence found intuitively implies existence of the EKC as well as the PHH, as will be explained in the next section.

Although empirical results are uncertain, based on the theoretical arguments presented above, a positive relation between the variables is expected, however, a priori, it is uncertain what the causal relation is. As a result, the first hypothesis is formulated:

H1 FDI and environmental pollution are positively related.

2.2 Environmental Kuznets Curve

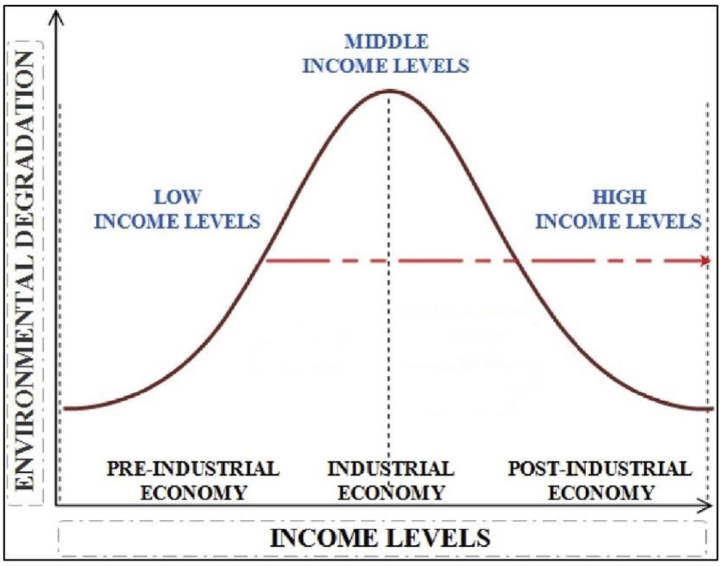
Whereas the PHH builds upon the negative effects of globalisation and of trade, the EKC takes a more positive approach, considering the positive externalities of FDI. Taking the PHH as a foundation, this theory encompasses the element of time-variant effects of trade. In other words, FDI initially leads to environmental degradation. However, over the course of time, the host country will experience positive effects of FDI contributing to economic development to then improve environmental quality. As a result, the EKC theorises economic development and environmental quality to be related in an inverted U-relationship (Grossman & Krueger, 1991). There are several factors behind this mechanism. Three of the most prevalent ones will be discussed after a brief introduction of the theory. Lastly, empirical evidence brought forth by the literature is discussed.

The name of the EKC refers to the Kuznets Curve, depicting an inverted-U shape between income inequality and economic development. As the first to make the generalisation, Simon Kuznets observed the rise in income quality before World War I and after World War II, which led him to further study this relation and earn the Nobel Prize for his work in 1971 (Abramovitz, 1986; Kuznets, 1953). The new theorisation sparked debate and still inspires researchers today to discover more about the role of income inequality. In essence, the Kuznets curve describes countries in early stages of development will experience increasing income inequality. As they develop further, income inequality will then decrease. Putting this relation in an environmental context, the EKC was coined by Panayotou (1994), building on previous work by Grossman & Krueger (1991) who were the first to empirically study the theory and point out the inverted-U relationship between emissions and income per capita.

The relation hypothesises that economies follow an evolutionary path, going through different stages of development over time. At first, environmental degradation increases with growing income levels because of low environmental awareness and lack of proper technology and resource allocation to combat the consequent problems. This stage is characterised by resource depletion and an increase in production of waste and its toxicity (Dinda, 2004). It is often described as the initial phase of economic development, the transition from an agrarian economy to a polluting industrial one (Arrow et al., 1995). As the economy further develops, income per capita grows and willingness to pay for higher quality goods increases as environmental awareness is raised. Simultaneously, the economy transitions towards a knowledge- or information-intensive industry. Other characteristics at this stage include advanced technology and enforced environmental regulations, allowing for improvement of environmental quality. Past this turning point the country has shifted into a clean service economy (Arrow et al., 1995). In essence, the EKC summarises a process of a transitioning economy as depicted in Figure 3 below.

Figure 3

Graphical depiction of Environmental Kuznets Curve



Note. Adapted from "Empirical study of the Environmental Kuznets Curve and environmental sustainability curve hypothesis for Australia, China, Ghana, and USA." by Sarkodie & Strezov (2018), *Journal of Cleaner Production* 201: 98-110.

The three main factors that drive this mechanism are income elasticity of environmental quality demand, scale, technological and composition effects, and the pollution haven hypothesis (Dinda, 2004). Firstly, income elasticity, one of the basic propositions of microeconomics revolving around utility of a good. With a rise in income, demand of certain goods rises. This term also explains demand of environmental quality, being one of the most important factors in shaping the EKC (Bo, 2011; Dinda, 2004; McConnell, 1997). Higher income gives rise to higher standards of living and increased returns of utility from a better environment. The willingness to pay for obtaining this higher utility increases as more value is attached to environment amenities, in microeconomic terms, environmental quality proves to be a 'luxury good' (Dinda, 2004). In other words, low-income individuals have little demand for a clean-living environment. As their income increases however, low environmental pollution is valued higher and demand for environmental quality increases. This mechanism stimulates a reduction in pollution because of increased income levels. Secondly, scale, technological and composition effects serve as a mediating mechanism between economic growth and environmental quality. In their paper, Grossman & Krueger (1991) point to these three factors as crucial to the inverted U-shape of the EKC. The scale effect portrays the intuition of increased international trade leading to increased production and pollution, assuming composition of the country's industry does not change. The technological effect states the method of production may change when trade liberalisation is introduced. Economies may learn from the newly engaged bilateral trade relations, with firm technological advancement as a consequence. Especially for less developed countries this is an important notion, as it allows them to leapfrog technologies obtained from developed countries (Mielnik & Goldemberg, 2002). Additionally, trade liberalisation increases income levels which may result in higher demand for cleaner production methods as an expression of increased wealth, as portrayed in the previous argument. The composition effect focuses on specialisation of countries to pursue a competitive advantage when exposed to trade liberalisation. When differences in environmental regulations are the basis of competitive advantage, economic liberalisation will be harmful for the environment as countries further specialise in these pollution-intensive industries. The net composition effect on pollution thus depends on which industries expand as a result from trade liberalisation. The EKC tends to argue that at initial stages of development, the scale effect has the upper hand, whereas at later stages positive impact on environmental quality will prevail and lower the emission levels (Vukina et al., 1999). Thirdly, as explained in previous arguments, international trade influences the EKC as well. Two main effects form the basis of the mixed influence of international trade on environmental quality. The PHH, as discussed, shows the relocation of pollution-intensive industries to less developed countries. This results in a negative effect of trade on environmental effects. At the same time, FDI brings learning effects for these less developed countries through which they may benefit from liberalisation. Consequently, the net effect trade liberalisation has on environmental quality is uncertain.

Similar to the PHH, theorisation of the EKC is straight forward, however, the empirical evidence provided for this theory is not as clear cut. Most studies find common ground in their methodology to empirically test for the EKC by use of the following simplified model:

$$y_{it} = \alpha_i + \beta_1 x_{it} + \beta_2 x_{it}^2 + \beta_3 z_{it} + \varepsilon_{it} \quad (0)$$

Where *y* denotes environmental quality measures, *x* denotes income per capita as a proxy for economic development, and *z* captures control variables influencing the dependent variable. Moreover, *i* denotes the country and *t* denotes time, and, lastly, α is the constant. Evidence for the EKC's inverted U-shape is found when β_1 is positive and significant and β_2 is negative and significant (Dinda, 2004; Haans et al., 2016). The exact proceedings are further explained in the methodology section. For now, the results found in previous literature are the main point of interest. In the literature overview presented by Dinda (2004), evidence for the EKC seems to depend on the category of environmental quality measure used. Several categories are seen in the general body of literature, air quality indicators, water quality indicators, and other environmental indicators. Air quality indicators, such as carbon dioxide and sulphur dioxide, have found the most convincing evidence of the EKC (Grossman & Krueger, 1995; Roca, 2003; Stern & Common, 2001). A distinction is observed between local and global pollutants, in which the latter depicts higher frequency of conflicting results. Local air pollutants thus portray the most convincing evidence for the inverted U-shape between environmental quality and income. The next category, water quality indicators, provides a less clear-cut picture of the EKC. Both conflicting results as well as a different curve shape is found for measures such as concentration of pathogens in the water and amount of toxic chemicals and heavy metals in the water (Hettige et al., 2000; Shafik, 1994). Lastly, for other environmental indicators, such as energy use and access to safe drinking water, little evidence in favour of the EKC is found (Bulte & Van Soest, 2001). As income rises these indicators show a similar steady rise and do not fall, thus only partially explaining the EKC. The literature discussed forms the fundament of future research concerning the EKC, which over time has shifted towards the location-specific dimension.

Within the context of Chinese ODI and the BRI, similarly contradicting results are found when studying the EKC as with the PHH. Muhammad & Long (2021) find the EKC only holds for those countries who have not fallen victim to the PHH, being the higher-income countries, of which economies are in a further stage of development. Likewise, Saud et al. (2019) show that the EKC is validated for only 23 BRI countries in their sample. The authors do not categorise these countries in any way, as a result of which it is uncertain whether the remaining countries have yet to reach the turning point of their economic development. In other words, the contradicting and weak support for the EKC can be explained due to the time lag involved to reach the turning point, therefore they are not visible in the evidence. Other studies consider different dependent variables, making the connection to the PHH and the EKC more difficult. For example, Sarkodie & Strezov (2019) study the effects of FDI on the Green Total Factor Productivity (GTFP) in a variety of BRI countries. Evidence suggests the PHH to hold on the aggregate level whilst at the same time finding support for the EKC in a small sample of countries. Using the same independent variable of GTFP, Wu et al. (2020) show that Chinese ODI in specific helps fostering environmental quality in BRI countries. The system GMM model confirms the importance of institutional quality as a mediator, as the positive effect on GTFP is bigger for those countries with better institutions. The effect found does depend on region, as the Middle East and Northern Africa do not enjoy the advantages of Chinese ODI. As stated earlier, the results for the EKC are contingent on the dependent variable used, as shown in the brief overview of the literature presented here.

The presence of the EKC seems to depend mostly on the choice of measurement for environmental degradation. Evidence of the EKC is found but it is not unilateral. On the contrary though, theorisation is clear-cut and is used as the fundament for the second hypothesis:

H2 Economic development and environmental pollution are related in an inverted U-shape.

2.3 Chinese ODI

The previous sections have discussed the impact of FDI and economic development on the environment, building on literature that has laid the groundwork for much of the theory today. This section shifts focus toward issues addressed in more recent literature, to be more specific, the role of Chinese ODI and its impact. Transitioning to impacts of trade on the environment in the context of the BRI requires expounding on recent developments of Chinese ODI on a global scale. First, a brief shift in Chinese ODI behaviour is addressed after which the BRI investments are linked to the theoretical framework of this paper; the PHH and the EKC. Lastly, ensuing from the context, Chinese ODI specific hypotheses are developed.

To briefly recapitulate from the introduction, Chinese ODI is characterised by different determinants as compared to traditional international trade models. Due to the role of SOEs, a duality of objectives is pursued in both profit maximisation as well as political aims. Moreover, as a result of low home-country institutional quality, Chinese firms feel more at ease in internationalising in similar environments, portraying a relative preference for riskier countries with low institutional quality. Lastly, securing energy resources is important to maintain high growth rates in the future. Consequently, Chinese ODI prefers to invest in countries with high availability of resources. Recently, the impact of these investments has received increased attention. More specifically, the consequences of engaging in trade with China under the BRI has been studied.

In terms of general effects, little research has been done to study the benefits Chinese ODI in specific. Isolating the effect of Chinese ODI from aggregate FDI inflows adds complexity to the models used and may therefore be a less popular method of choice. Nonetheless, the introduction of the BRI has caused for a change in preferences of Chinese ODI pre- and post-announcement. Du & Zhang (2018) find the initiative has promoted overseas investments. Additionally, a large part of these investments is observed flow to infrastructure sectors which increases number of investments significantly. This finding is reaffirmed by Huang, et al. (2018), who find a positive relation between Chinese ODI and investments in infrastructure in countries along the BRI. These developments show preferences and impact of Chinese ODI have changed succeeding the introduction of the BRI.

As discussed in section 2.1 and 2.2, research on the PHH and the EKC covers a wide array of topics and perspectives. Nonetheless, some issues are left open for discussion, most prevalently, there seems to be a discrepancy in the level of detail concerning Chinese investments. Several studies take a multi-country approach and study aggregate FDI levels thereby neglecting specific effects and environmental impact of Chinese ODI (e.g. Muhammad & Long, 2021; Sarkodie & Strezov, 2019; Saud et al., 2019). Other studies, however, focus on a specific host country and the particular relationship found (e.g. Zhou et al., 2018, zooming in on Chinese urban data). This thesis expands the existing body of literature by studying the effects of single-origin FDI, more specifically Chinese ODI and its environmental impact. Increased Chinese investments, a majority of which has been directed at particularly polluting sectors such as infrastructure, are likely to show a more clear-cut effect than the aggregate FDI data previously studied. The launch of the BRI has created urgency and relevance for going beyond the economic fortune investments may bring and to learn about the footprint they leave behind. The preference of the investments in contaminating industries makes the appropriation of the PHH more likely for Chinese ODI in specific. In other words, due to the negative impact of these industries on the environment, Chinese investments under the BRI are likely to contribute to environmental pollution. This leads to the following hypothesis for this thesis:

H3 The positive relation between Chinese investments under the BRI and environmental pollution is larger in B&R countries compared to non-B&R countries.

As stated in the introduction, the BRI focuses on connecting countries through establishing a New Silk Road. To do so, one of the main targets is enhancing local infrastructure (Central Committee, 2013; Du & Zhang, 2018). Several studies have shown the positive impact of Chinese investments on infrastructure in the host country, albeit sometimes, at higher costs and unfair prices (Huang et al., 2018; Klaver & Trebilcock, 2011). Nonetheless, the relative importance of infrastructure, and its polluting characteristic as a sector, invokes an interesting sub-analysis on the sector level. With infrastructure investments being one of the main points of focus within the BRI, the extra attention is likely to positively influence the attractiveness of, and preference for, relatively polluting sectors of Chinese ODI in comparison to countries not partaking in such a long-term investment programme. In essence, Chinese investments may therefore prefer these sectors, increasing the pollution in target countries relatively more. I refer to this to as the *polluting preference*. In contrast, China has recently announced devotion to renewable energy resources and decreasing emissions, a sector analysis expands knowledge on how this message is implemented abroad (Central Committee, 2016). One might expect the influence of SOEs to embrace this strategy outside the country's borders by promoting green methods of production, I refer to this as the *renewable advocates* effect. Advocating green investments abroad would indicate a decrease of emissions for polluting sectors compared to other countries. As a result, an opposing effect is expected as compared to the relative preference for polluting sectors. The opposing nature of both these effects requires further research to shed light on this ambiguity. Although, a priori, the direction of this possible relation is uncertain, the *polluting preference* effect is expected to outweigh the *renewable advocates* effect. The former has been in place for a substantial period of time whereas the latter has only been a more recent development. As a result, considering the time span of the data at hand, the *polluting preference* is expected to be prevalent. In other words, it is expected that Chinese infrastructure investments under the BRI will be more polluting than non-infrastructure projects. Consequently, a sector-level analysis will be introduced leading to the following hypothesis:

H4 The impact of Chinese ODI in the infrastructure sector on environmental pollution is larger compared to other sectors in B&R countries relative to non-B&R countries.

The goal of this thesis is to expand the body of knowledge on the environmental footprint of Chinese ODI and the impact of implementing a large-scale investment project like the BRI. The hypotheses will contribute to answering the main research question of this research. The next section expounds upon the data and methodology used to answer the research question at hand.

3. Data, methodology, and variable description

A variety of the variables and data used are based on previous literature on the EKC and the PHH, a part of which has been introduced in the previous chapter. Due to the novel approach in isolating the effect of Chinese ODI, some adaptations are made to the existing methodology. To accomplish this isolation and the potential endogeneity, the gravity model is used as a basis for an instrumental variable approach. Four models are tested for this research, each of which is discussed in more detail below, followed by the conceptual model and an overview of the variables used (see table 2), concluding with a discussion of summary statistics.

3.1 Data Collection

This thesis aims to study the effect of Chinese ODI on environmental quality in the B&R countries compared to non-B&R countries. The Chinese investment data shows 107 countries have received a B&R investment out of the 210 countries in the complete dataset (see Appendix A for a complete list of included B&R countries). The balanced panel dataset spans from 2008 to 2016 and most data is retrieved from the World Development Indicators and the China Global Investment Tracker. The timeline was chosen to analyse effects of the BRI by considering the most recent data available as well as studying the period leading up to the BRI. Taking a recent set of data allows for specific policy recommendations to incorporate the environmental impact in trade between China and the B&R host country. An overview of all variables, their operationalisation and source are given in table 2 following the next sub-section.

3.2 Methodology

This section introduces the three different models tested, each building up in specificity following the hypotheses. The model to test hypothesis 1 and 2 builds on methodology in line with Cole (2004), Sarkodie & Strezov (2019), and Saud et al. (2019), through which the following variable selection is made. As a dependent variable, the annual CO_2 emissions in kiloton (*CO2kt*) are retrieved from the World Bank Development Indicators. Although often subject to limited data availability, other variables to measure environmental pollution are available and are discussed in the results section. The explanatory variables used are GDP per capita (*GDPpc*) as a proxy for economic development (Cole, 2004), the quadratic term of GDP per capita to investigate the inverted U-shape, and FDI inflows (*FDIgpd*) measured as the net FDI inflows as a percentage of GDP (Saud et al., 2019). Optimisation of the models, such as accounting for size variables and introducing logarithms, is addressed in section 3.4. This leads to the following estimation to test the general model for hypothesis 1 and 2:

$$CO2kt_{it} = \beta_0 + \beta_1 GDPpc_{it} + \beta_2 GDPpc_{it}^2 + \beta_3 FDIgdp_{it} + \gamma_1 cntrl_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (1)$$

In the equation, i denotes continent and t time in years. The model includes continent-fixed effects (μ_i) and time-fixed effects (ν_t) to control for specific continent- and time-characteristics that may change, such as technological progress. This model tests hypothesis 1 and 2, consequently, the coefficients of interest are β_1, β_2, and β_3. In line with hypothesis 1, testing the presence of the PHH, a positive coefficient is expected for β_3, however, this is not a causal relationship due to reverse causality, and therefore, endogeneity concerns. The methodology for testing an inverted U-shape will be explained in more detail in section 3.2.1. In line with H2, a positive coefficient is expected for β_1, and a negative coefficient for β_2, together presenting an inverted U-shape. The control variables included in this model are trade openness, population size, institutional quality, captured in *cntrl*. Trade openness (*open*) may have either a positive or a negative effect on environmental pollution as discussed in detail by Cole (2004) and Saud et al. (2019). A large part of emissions is determined by the size of a country, more specifically, by the size of its population (Dietz & Rosa, 1997). To control for this, population size (*population*) is added to the model. Additionally, due to the influence on absorptive capacity for technology, institutional quality (*wgi*) is added as a control following Wu et al. (2020). The introduction of new technology depends on existing rules and regulations, characterised by the institutional environment. Consequently, for the effectiveness of FDI in the host country, institutional quality is expected to play a significant role. To remain within the scope of this thesis, institutional quality will be added as a control instead of being studied in further detail. The controls as mentioned are implemented in the remaining models as well.

The second model introduces specificity in the form of Chinese ODI. By first examining the effect of aggregate FDI inflows and a subsequent division of Chinese ODI and FDI of 'the remainder', the difference in magnitude of coefficients is comparable. The endogenous nature of the explanatory variable requires an instrumental variable approach. These concerns originate from the fact that the direction of causality a priori is unclear. Reverse causality could therefore be at play and the explanatory variable needs to be treated as endogenous. Consequently, the instrument is selected by drawing upon previous literature following the Gravity model (Anderson, 2011). This model uses physical distance to explain the location choice of investments. Buckley et al. (2007) confirm the negative relation between physical distance to China and FDI inflows. Following a manually computed 2-step-least-squares (2-SLS) approach, the first step determines the strength of the instrument, physical distance to China (*dist*), followed by the second step to estimate the coefficients of the desired model with the remaining variance (Wooldrige, 2002). Variables influencing the dependent variable, CO2 emissions (*CO2kt*), are included in both equations. Chinese Direct Investment Intensity (*CDII*), is measured as the Chinese direct investment as a percentage of total GDP (Pan et al., 2020). The following equations add *CDII* and show the two-stage regression:

$$\widehat{CDII}_{it} = \beta_0 + \beta_1 GDPpc_{it} + \beta_2 GDPpc_{it}^2 + \beta_3 BRI_{it} + \beta_4 dist_{it} + \gamma_1 cntrl_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (2a)$$

$$CO2kt_{it} = \beta_0 + \beta_1 GDPpc_{it} + \beta_2 GDPpc_{it}^2 + \beta_3 \widehat{CDII}_{it} + \beta_4 BRI_{it} + \delta_1 BRI_{it} * \widehat{CDII}_{it} + \gamma_1 cntrl_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (2b)$$

These models apply the same control variables as Model 1, as well as including both continent- and time-fixed effects. With the same dependent variable but an added explanatory variable, the controls remain relevant in this model as well. The coefficient δ_1 in Model 3 is the main variable of interest as it explains the effect of Chinese investments on emission levels in B&R countries compared to other countries. Additionally, since an IV approach is used, the coefficient of β_4 in Model 2 is of importance as it illustrates the strength of the instrument. For the instrument to be relevant, the covariance between the endogenous X variable, *CDII*, and the instrument, *dist*, should be different from 0. In other words, the first stage coefficient of β_4 should be negative and significant. The validity assumption cannot be fully tested but relies on previous literature indicating the validity of the Gravity model as previously explained. Moreover, since the fitted values of *CDII* are also to be used in the interaction term with BRI, the first stage only estimates the fitted values for *CDII* after which the interaction is included in the second stage to ensure this term uses the endogenous values of *CDII* as well.

The last model includes the sector analysis, by introducing a dummy variable for investments in the infrastructure sector (*infra*). It aims to test hypothesis 4, thereby determining the effect of infrastructure investments under the BRI on environmental pollution. In other words, a triple interaction term is used to study this effect. This leads to the following equations for the 2-SLS IV regression:

$$\widehat{CDII}_{it} = \beta_0 + \beta_1 GDPpc_{it} + \beta_2 GDPpc_{it}^2 + \beta_3 BRI_{it} + \beta_4 dist_{it} + \beta_5 infra_{it} + \delta_2 infra_{it} * BRI_{it} + \gamma_1 cntrl_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (3a)$$

$$CO2kt_{it} = \beta_0 + \beta_1 GDPpc_{it} + \beta_2 GDPpc_{it}^2 + \beta_3 \widehat{CDII}_{it} + \beta_4 BRI_{it} + \beta_5 infra_{it} + \delta_1 BRI_{it} * \widehat{CDII}_{it} + \delta_2 infra_{it} * BRI_{it} + \delta_3 infra_{it} * \widehat{CDII}_{it} + \delta_4 infra_{it} * BRI_{it} * \widehat{CDII}_{it} + \gamma_1 cntrl_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (3b)$$

Model 4 employs the same methodology as the other models by including both continent- and time-fixed effects. The variable of interest in this model is the triple interaction term with coefficient δ_4. A positive coefficient is expected as investments in infrastructure in a B&R country are likely to increase the pollution more as compared to projects that fall outside of this category. For an investment to be classified as infrastructure it must fall in one of the following sectors: energy, logistics, real estate, transport, or technology. Computation results in a dummy variable of whether or not a country has received infrastructure investments in a given year. Only sector-specific investment data is available for Chinese ODI, consequently, the interaction term focuses on the Chinese infrastructure investments only and effect on the aggregate FDI inflows cannot be observed. However, the difference between whether the target country is a B&R country is observed.

3.2.1 Testing the Inverted U-Shape

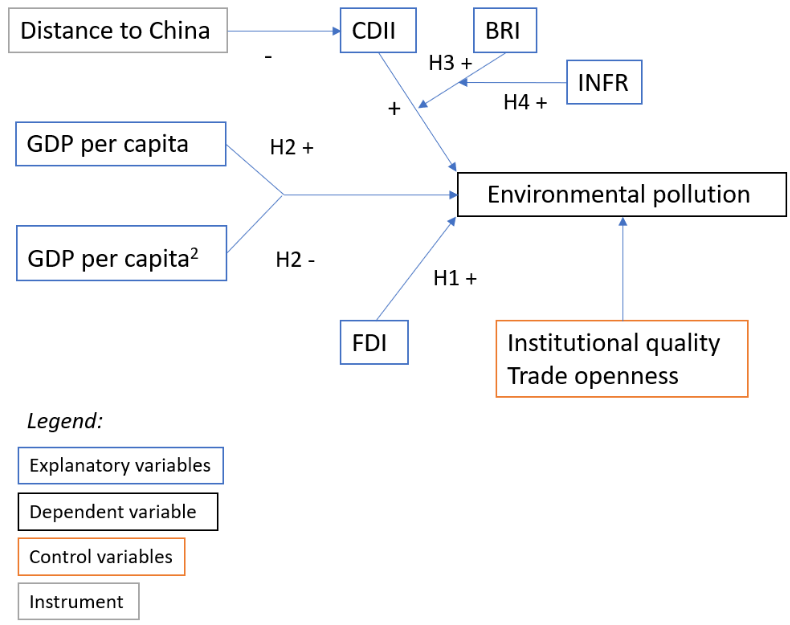
This thesis studies the effect of Chinese ODI on environmental pollution. Panel regression analysis is used to test for the expected inverted U-shape relationship (Haans et al., 2016; Lind & Mehlum, 2010). Based on these papers, a three-step model is followed to ensure the most appropriate method of analysis. Firstly, the quadratic term for GDP per capita must be negative and significant, illustrating the presence of an inverted U-shape. Thereafter, the gradient of the curve must be sufficiently steep at both ends of the data. If only one of the slopes tests positive a half-inverted U-shape may be present, therefore more closely resembling a logarithmic or exponential relation. Lastly, as clearly illustrated by Lind & Mehlum (2010), the turning point of the inverted U-curve, its maximum, must be located within the data range. This is computed by differencing the equation at hand and setting it to zero, depending on the model at hand. These three steps serve as a solid foundation for testing an inverted U-shape, as the EKC is theorised to be. To aid interpretation and clarity of results, the results are visualised in a graph for the main model using FDI aggregates.

Moreover, it is important to address the problems of reverse causality and unobserved heterogeneity to ensure a causal relation is found (Haans et al., 2016; Lind & Mehlum, 2010). As previously explained, an IV approach is used to deal with endogeneity of the main explanatory variable. A Hausman test reveals the more efficient model is a random effects model. Moreover, country clustered standard errors are used to account for serial correlation (Wooldrige, 2002). Heteroskedasticity may influence the standard errors of the model and will thus be considered even though the relatively large number of observations and an acceptable number of waves. In summary, a random effects IV panel regression with clustered standard errors is the method of choice. Moreover, to ensure robustness of the theorised inverted U-shape to be found, a variety of robustness tests are included. The majority of these test a variety of different dependent and independent variables to verify the results found in the main model. The outcome of these robustness tests is shown and discussed in the results section.

3.3 Conceptual Model

Figure 4

Conceptual model



The model tested in this thesis is as follows. It includes all relationships to be studied summarised in one model; therefore, it is important to note that not all these relations will be tested simultaneously. The different models as presented in section 3.2 serve as the structure for the methodology.

3.4 Variable Description and Summary Statistics

The following table shows the variables used in the main models as previously presented, including variable names, operationalisation, source, and the location from which the data was retrieved.

Table 2

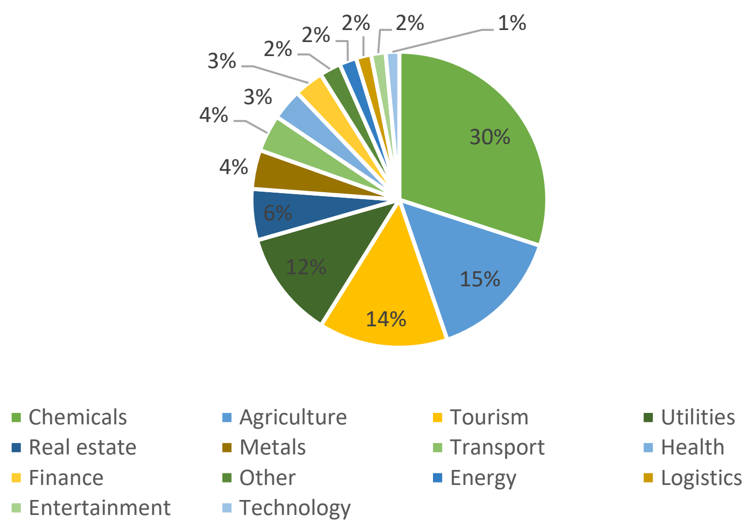
Variable overview

	Variable name	Description	Operationalisation	Source	Retrieved from
Dependent variable	*CO2kt*	Pollution	Annual CO2 emissions measured in kiloton	Cole (2004), Sarkodie & Strevoz (2019), Saud, et al. (2019)	https://data.worldbank.org/
Independent variables	*GDPpc*	Economic development	GDP per capita	Cole (2004), Sarkodie & Strevoz (2019), Saud, et al. (2019)	https://data.worldbank.org/
	FDIgdp	FDI inflows	Net FDI inflows as a share of GDP	Saud, et al. (2019)	https://data.worldbank.org/
	CDII	Chinese direct investment intensity	Chinese direct investment as a share of GDP in constant 2010 prices	Pan, et al. (2020)	https://www.aei.org/china-global-investment-tracker/
	BRI	Dummy if country is a B&R country	Turns 1 from year country receives first BRI investment		https://www.aei.org/china-global-investment-tracker/
	infra	Dummy if investment industry is infrastructure	1 if subsector is: autos, aviation, coal, construction, gas, hydro, oil, rail, or shipping		https://www.aei.org/china-global-investment-tracker/
	dist	Distance to China	Distance taken from centroid to centroid	Buckley, et al. (2007)	http://worldmap.harvard.edu/data/geonode:country_centroids_az8
Control variables	*open*	Trade openness	Sum of exports and imports as a share of GDP	Cole (2004) & Saud, et al. (2019)	https://data.worldbank.org/
	wgi	Institutional quality	Mean score of 6 indicators compiled to overall institutional quality	Wu, et al. (2020)	https://databank.worldbank.org/source/worldwide-governance-indicators

On an aggregate level, before analyses are done, the Chinese investment data offers some interesting insights. The total amount of Chinese investments from 2008-2016 accumulates to $ 1,2 trillion USD (constant 2010). Additionally, splitting these investments in different sectors reveals the preferred area of investing. Figure 5 shows the main sectors of interest are chemicals, agriculture, tourism, utilities, and real estate. Together, these account for 76% percent of total investments. Some of the sector names require further explanation. For example, the sector ‘utilities’ consists of investments mainly done by Chinese telecommunications or constructions companies. Moreover, the vast majority of investments in the ‘real estate’ sector focus on construction projects. It is uncertain as to what ‘tourism’ exactly pertains, this sector has no sub-sectors and is therefore difficult to further explain. Lastly, the chemicals sector contains a high volume of project related to projects in natural resources, for example, constructing refineries and infrastructure for mining. Although the aggregate sector names suggest otherwise, many of the investments focus on infrastructural projects. These aggregate level data give a clearer picture of the preferences of Chinese investments abroad.

Figure 5

Chinese ODI on sector level



Note. The ‘infrastructure’ sector as worked with in this thesis is comprised of a selection of the sub-sectors. This chart depicts the sector-level division because of which infrastructure is not one of the sectors. Adapted from Chinese Global Investment Tracker database.

Continuing, the summary statistics, see table 3 below, take the longitudinal component of the data into account and show several notable findings. By use of scatterplots, minima, and maxima, skewness as well as several outliers have been detected and dealt with. First considering skewness, several variables in the analysis are size variables, taking the logarithm of these is a logical choice to enhance comparability. Scatter plots confirm the suspected skewness in the data for nearly all variables at hand, including the size variables. As a result, logarithms have been taken of the affected variables, with normally distributed data as well as comparability as a result. This alteration applies to the following variables: *CO2kt*, *GDPpc*, *CDII*, and *dist*. The *CDII* variable is a special case for which many observations are zero and therefore $\log(1 + CDII)$ is taken to prevent missing observations. Not only does this ensure normally distributed data without losing observations, but another advantage is also improved simplicity for interpretation of the variables at hand.

Furthermore, scatterplots reveal *FDIgdp*, *open* and *CDII* show several extreme values. For example, values exceeding 400 for *FDIgdp*, intuitively this would mean their FDI inflows are 4 times bigger compared to their GDP. The countries that stand out are the Cayman Islands, the Virgin Islands, Liechtenstein, Malta, Cyprus, Sao Tome and Principe, and Monaco. The extreme values found for these observations are not realistic as nearly all the countries in question are either tax havens or micro-states. Winsorisation, minimising the influence of outliers, is therefore seen as a valid solution to prevent data disturbance. Lastly, China is disregarded from the dataset as well, as analysing within country investments would interfere with results. Consequently, the new dataset has a total of 202 countries, of which 104 are B&R countries.

Moreover, the variable with the fewest number of observations by some distance is *infra*, with 684 observations. The dummy variable provides further specification of Chinese investments, showing 1 for 589 observations which fall in the infrastructure sector. In other words, 86 percent of Chinese investments target the infrastructure sector. Attrition, data disturbance because of loss of study units from the sample, is not a concern in this dataset as all units are present in all waves.

Table 3

Summary statistics

	Mean	Std. Dev.	Min	Max	Observations
CO2kt	118380.5	439129.5	40.337	5614111	N = 1746
FDIgdp	5.136742	8.353768	-37.15476	103.3374	N = 1655
GDPpc	14575.92	19946.94	219.9615	110467.7	N = 1722
CDII	1.24374	5.396964	0	83.25596	N = 1818
BRI	0.1644664	0.3708003	0	1	N = 1818
dist	8581.993	4023.761	1141.882	19577.78	N = 1818
infra	0.3239824	.4681221	0	1	N = 1818
population	2.83E+07	9.71E+07	9880	1.32E+09	N = 1818
open	92.65455	54.341	0.1674176	442.62	N = 1638
wgi	48.52384	26.57331	0	98.79171	N = 1771

The correlation table (Appendix C) shows no particular problems in the dataset at hand. The most extreme cases of correlation are between *open* and *FDIgdp* at 0.4568. However, openness gives an indication about how much FDI a country receives, i.e., how open to trade it is. The same goes for the correlation between *open* and *GDPpc*, which, at 0.3195, is relatively high but easily explainable. A high correlation between these variables is therefore not surprising. Another notable medium correlation value is between the *population* and *CO2kt* at 0.5202, suggesting 52 percent of variance between this variable is explained by the other. However, this correlation is in line with expectation and therefore not a cause for concern. The other variables portray relatively small correlations of below 0.30. Moving on, the results of these models will be discussed in the next section.

4. Results

The results section builds on the methodology as described. A brief reiteration of the previous section is given after which the base models and their robustness checks are discussed at length. Each model adheres to a specific type of complexity based on the equations as introduced in section 3.2. The result sections therefore begin with explaining where the model originates from, and which tests are run to ensure model fit. Afterwards, the regression output of the model in question is discussed in detail.

4.1 Base Model 1

From the methodology section, an initial Ordinary Least Squares (OLS) regression model without robust and clustered standard errors is run. Continuing, the OLS is transformed into a pooled OLS regression to account for the longitudinal component in the data. Further specification is introduced by running a pooled OLS regressions with robust country-clustered standard errors to consider heteroskedasticity in standard errors and within the different countries. This leads to Model 1, which tests hypothesis 1 and 2. The initial model will be discussed first as it serves as a steppingstone from which the other models are further specified, the Gravity model and instrumental variable approach are thus not yet used in Model 1.

4.1.1 Regression Output

Model 1 gives an overall indication of the presence of the PHH and the EKC (see table 4). *FDIgdp* shows the expected positive sign, but this relation is not significant at the 10 percent level. Hypothesis 1 is rejected because there is no evidence that FDI increases emittance of CO_2, the PHH does not seem to hold. In line with expectations, the coefficient of *log of GDPpc* is positive and highly significant at the 1 percent level, its squared term is negative and highly significant at the 1 percent level. In other words, evidence is found supporting the EKC and thus hypothesis 2. Further focusing on the EKC, the validation of the expected inverted U-shape is reaffirmed by plotting the fitted values of the estimated model. The

Table 4

Regression output base model 1

log of CO2 in kt	Model 1
log of GDPpc	4.038^{***} (0.815)
log of GDPpc squared	-0.199^{***} (0.0436)
FDI (% of GDP)	0.000334 (0.000608)
Population	3.95e-09 (2.46e-09)
Trade (% of GDP)	-0.00110^{*} (0.000618)
Institutional quality	0.000119 (0.00252)
East Asia & Pacific	-1.579^{***} (0.613)
Latin America & Caribbean	-1.566^{***} (0.438)
Middle East & North Africa	0.703^{**} (0.319)
North America	0.343 (2.042)
South Asia	-0.378 (1.066)
Sub-Saharan Africa	-1.051^{**} (0.415)
Constant	-10.97^{***} (3.715)
Within R-squared	0.354
Between R-squared	0.399
Overall R-squared	0.415
Number of groups	175
Observations	1498

Note. Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

graph shows a clear presence of the inverted U-shape (see Appendix D). As explained in the methodology, for an inverted U-shape to be present, the turning point must fall within the data range. Using the appropriate U-test introduced by Lind & Mehlum (2010), two further conclusions can be drawn regarding the EKC (see Appendix E). First, the slope is sufficiently steep at both ends of the curve. Second, and more importantly, the turning point of the curve falls within the range of data where GDP per capita equals US$ 24,270.67 (or *log of GDPpc* is 10.097). In other words, ceteris paribus, after reaching this point of economic development countries will transition into a cleaner, more sustainably oriented economy and environmental pollution will decrease. Furthermore, the overall test for presence of a U-shape is significant at the 1 percent level, with a p-value of 0.002.

All in all, evidence is found supporting hypothesis 2, economic development and environmental pollution are related in an inverted U-shape. It must be stated this model serves as one of the preparatory models, therefore no magnitude of coefficients is discussed.

4.2 Base Models 2 & 3

4.2.1 Pre-analysis optimisation

Moving on, Model 1 is further specified by introducing log of Chinese investments (*log of CDII*) as well as the IV approach based on the Gravity model. After introducing *log of CDII*, the model is tested for misspecification by means of a Ramsey RESET test to check the model fit. The RESET test checks for omitted variables, which, when present, may lead to inflated errors and biased coefficients. The significant test outcome indicates model misspecification because of which an instrumental variable might pose an appropriate solution.

Furthermore, after inclusion of the instrument *log of dist*, the influence of heteroskedasticity should be considered. The Brausch-Pagan test helps determine whether systematic change of residuals measured is present or not. For this model, the test outcome's p-value is significant at the 1% level, revealing heteroskedasticity is present thus there is need for robust standard errors, as done in Model 1.

Continuing, the use of an IV approach requires the instrument to be relevant and endogenous. The first stage output of the 2-SLS approach gives an initial indication for these conditions. The output of this stage shows the instrument is significant at the 1 percent level and thus relevant for Model 2 (see Appendix F). Besides the significance of the instrument, the negative coefficient confirms the expected relation; FDI inflows decrease as countries are further away from China, in line with the theory of the Gravity model. For Model 3, this does not seem to be the case, the consequences of which will be addressed at a later stage. Another test for endogeneity of the instrument is Woolridge's

(1995) score. Given the significant p-value of the test outcome, it reaffirms endogeneity of the independent variable and thus, the appropriate use of the IV approach.

To further optimise the base models testing hypotheses 3 and hypothesis 4, a Hausman test is computed to decide whether fixed or random effects leads to the most efficient and consistent model. The test checks the influence of time invariant characteristics on the model. The insignificant p-value of the test indicates this is not the case, as a result, running a random effects model seizes the most consistent outcomes and is the appropriate method of choice. Random effects is thus the efficient model.

Finally, using random effects leaves the opportunity to investigate the model fit when using correlated random effects (CRE). Allowing for some correlation between the unobserved heterogeneity and the independent variable, this model has more lenient assumptions as compared to random effects and is therefore more realistic. From the CRE results however, the model shows highly insignificant and unexpected signs of coefficients, signalling an inefficient and biased model.

The optimisation of this model is the basis for Model 2. However, as the next model, Model 3, only adds one complexity to the equation, this basis is used for Model 3 as well. Summarising, Models 2 and 3 use a 2-SLS random effects panel IV estimation with robust country-clustered standard errors. The following section discuss the results of the second stage output, first stage output can be found in Appendix F.

4.2.2 Regression Output Model 2

This section discusses the regression output of Model 2. First, the output of the first stage needs to be addressed briefly, in which the fitted values of the explanatory variable *CDII* are estimated (see Appendix F). The variable *log of dist* shows to be significant at the 5 percent level and depicts a negative sign. In other words, ceteris paribus, the larger the distance between country j and China, the lower the Chinese investments that country receives will be. This is in line with expectations and the instrument is thus deemed valid to use for Model 2.

Moving on, the second stage result of Model 2 will now be discussed (see table 5). The EKC established in Model 1 is reaffirmed in Model 2, where *log of GDPpc* shows a positive and significant coefficient at the 1 percent level. The squared term shows a negative and significant coefficient at the 1 percent level as well. The results from Model 1 thus seem to be robust when including Chinese investments into the equation. Besides, the model shows Chinese investments and environmental pollution are positively related, this relation is significant at the 1 percent level. In other words, ceteris paribus, a 1 percent increase of the Chinese investments relative to GDP will increase the CO2 emissions 9.478 percent. The impact of Chinese investments on environmental pollution thus seems quite substantial. Moreover, compared to non-B&R countries, countries that fall under the BRI have lower CO2 emissions, significant at the 1 percent level. A possible explanation for the relatively low emissions could be countries in need of infrastructure and economic boosts are more interested in an investment project like the BRI, as they are less developed and thus have lower emissions. The variable of interest, the interaction term of *BRI* and *log of CDII*, is positive and significant at the 1 percent level. Compared to non-B&R country, ceteris paribus, B&R countries receiving 1 percent additional Chinese investments relative to GDP increases the CO2 emissions 0.38 percent relatively. Support in favour of hypothesis 3 is found; Chinese FDI have a positive relation with environmental pollution in BRI countries.

Table 5

Regression output base model 2

log of CO2 in kt	Model 2 (second stage)
log of GDPpc	6.920***
	(1.141)
log of GDPpc squared	-0.325***
	(0.0568)
Log of CDIIhat	9.478***
	(2.176)
BRI	-5.863***
	(1.286)
BRI # lCDIIhat	0.383***
	(0.0912)
Population	7.17e-09***
	(2.23e-09)
Trade (% of GDP)	-0.00302***
	(0.000749)
Institutional quality	0.00683**
	(0.00270)
East Asia & Pacific	-2.390***
	(0.584)
Latin America & Caribbean	-1.050**
	(0.457)
Middle East & North Africa	0.465
	(0.350)
North America	-0.723
	(1.968)
South Asia	-2.719**
	(1.086)
Sub-Saharan Africa	-3.325***
	(0.641)
Constant	-27.52***
	(5.838)
Within R-squared	0.375
Between R-squared	0.457
Overall R-squared	0.477
Number of groups	178
Observations	1522

Note. Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Concerning the control variables, two of three controls are statistically significant at the 1 percent level. One surprising finding concerns the control for *open*, for which the negative coefficient indicates more trade leads to lower environmental pollution. One explanation could be the learning effect induced by more international interaction. The second control variable, *wgi*, has a positive effect on CO2 emissions. The third control, *population*, is positively related to environmental pollution, the relation is significant at the 5 percent level. More generally, the explanatory power of the model seems stable, especially considering it is panel data, at an overall R-squared is 47.7 percent. Compared to the full dataset, there are missing observations as the model has 178 groups, which may be explained by missing values for *log of CO2kt*. Furthermore, the continent fixed effects also show an interesting result. Not all continents show a significant outcome, suggesting results apply to a selection of regions.

Compared to the base level, which is Europe & Central Asia, continents that show significant results at the 1 percent level are East Asia & Pacific and Sub-Saharan Africa. Moreover, Latin America & Caribbean and South Asia show statistically significant results at the 5 percent level. For the Middle East & North Africa and North America, no significant relationships are found which could originate from fewer observations. As an additional check to verify the results as described, a Kernel Density Estimation is run to check the normal distribution of the residuals of the error term. As shown in Appendix G, the distribution of residuals approaches a normal distribution slightly skewed to the right. The positive outcome leads to conclude that results are verified.

Table 6

Regression output base model 3

log of CO2 in kt	Model 3 (second stage)
log of GDPpc	10.30***
	(1.788)
log of GDPpc squared	-0.401***
	(0.0694)
Log of CDIlhat	24.91***
	(5.707)
BRI	-4.985***
	(1.125)
BRI # lCDIlhat	0.522***
	(0.134)
infra	-22.44***
	(5.123)
BRI # infra	-1.283***
	(0.248)
infra # lCDIlhat	0.0753*
	(0.0425)
BRI # infra # lCDIlhat	-0.177*
	(0.107)
Population	3.50e-08***
	(7.06e-09)
Trade (% of GDP)	-0.0261***
	(0.00575)
Institutional quality	0.0118***
	(0.00337)
East Asia & Pacific	-3.071***
	(0.662)
Latin America & Caribbean	-3.059***
	(0.583)
Middle East & North Africa	3.239***
	(0.646)
North America	0.687
	(1.893)
South Asia	-2.840***
	(1.019)
Sub-Saharan Africa	-5.237***
	(1.003)
Constant	0
	(.)
Within R-squared	0.377
Between R-squared	0.474
Overall R-squared	0.493
Number of groups	178
Observations	1522

Note. Standard errors in parentheses:
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2.3 *Regression Output Model 3*

Model 3 adds another level of complexity by introducing the infrastructure dummy (*infra*) to observe differences between Chinese infrastructure investments in B&R countries to those in non-B&R countries. Model 3 builds on the previous model and, as with that model, the first stage regression needs to be studied before addressing the output itself (see Appendix F). In contrast to the Model 2, the instrument for Model 3 is not significant after adding *infra*. Although the depicted sign is negative and thus in line with expectations, the instrument is not significant at the 10 percent level. The theoretical foundation for the instrument remains unchanged compared to the previous model, consequently, the validity of the instrument is assumed to have remained unchanged. However, the insignificance in the first stage may signal a weaker instrument in the new context, therefore results need to be interpreted with additional caution.

Turning to the regression outcome of the second stage, evidence is found again in favour of the inverted U-shape, reaffirming the findings in Model 1, albeit with more caution. The *log of GDPpc* as well as its squared term show coefficients in line with expectations, a positive and negative coefficient respectively and both are significant at the 1 percent level. In line with Model 2, the signs and significance of the other variables of interest are unchanged, apart from some changes in magnitude of coefficients. More specifically, a positive relation between Chinese investments and environmental pollution is found, significant at the 1 percent level. Besides, the dummy for B&R countries is negative and significant at the 1 percent level, similar to the results as presented in Model 2. The interaction term for B&R countries and Chinese investments also depicts comparable results, showing a positive coefficient at the 1 percent level. As interpretation for this model should be more cautious, further explanation on magnitude of variables is arduous. The focus now shifts to the variables of interest for Model 3, the introduction of *infra*. First, the dummy shows, ceteris paribus, Chinese infrastructure projects and environmental pollution are negatively related compared to non-infrastructure projects, this relationship is significant at the 1 percent level. Infrastructure projects are mostly environmentally degrading, therefore, this result contrasts expectations. These results suggest Chinese infrastructure projects allow for an improvement of environmental quality. Given a majority is invested in infrastructure, the skewed distribution may cause biased estimates. Moreover, when the few remaining investments fall in more energy-intensive sectors, infrastructure may look relatively environment-friendly. This seems not to be a stand-alone effect, when looking at the variable of interest, the interaction between B&R countries, infrastructure projects and Chinese investments, the unexpected results are reiterated. The triple interaction term shows, compared to non-B&R countries and non-infrastructure projects, Chinese infrastructure investments in countries falling under the BRI are relatively less harmful to the environment. The negative coefficient of the interaction term is significant at the 10 percent level. The explanation for this result is addressed in the discussion. The null hypothesis cannot be rejected, the impact of Chinese ODI in the infrastructure sector on environmental pollution in B&R-countries is not larger compared to other sectors. In other words, even considering the weaker statistical significance, no support is found for hypothesis 4.

The control variables remain unchanged as compared to Model 2. On a more general level, Model 3 shows similar characteristics to that of the previous model, 49.3 percent of the overall variance is explained by the model. Interestingly, the continent dummy is significant for all continents at hand except for North America, in which it differs substantially from Model 2. North America only has 19 observations for infrastructure projects, a logical explanation for the insignificant outcome. Given the previously addressed necessary caution with Model 3, this could be one of the consequences of the insignificant, and thus weak, instrument.

An important note to make for all these models concerns the intuitive validity of the results at hand. Although the models have been found to be valid and efficient, the intuitive interpretation of the results may not be in line with the purely statistical interpretation. For example, the dependent variable *log of CO2kt* is not country-bound. In other words, pollution in country X may simply move to country Y due to which the true pollution in country X is measured in country Y. There may be many factors to influence pollution, for which Chinese investments is just one of them. Consequently, it is strongly recommended to interpret these results with caution and place them into the context.

4.3 Robustness checks

To further verify the results several robustness checks have been performed. As addressed in the literature review, one would ideally use several alternatives for both the dependent and independent variables at hand. However, due to data limitations the best viable alternative for the dependent variable is deemed invalid for use. The variable best alternative variable, Total Greenhouse Gas Emissions, has no observations from 2015 onwards, leaving it impossible to test the hypotheses in the context of the BRI this thesis studies. The reason for this lack of data might be due to a discrepancy in the time interval the surveys obtaining the data occur at. A variety of datasets and sources has been studied but as observations differed from the main database the credibility of these alternatives is doubtful. Consequently, no viable alternative for the dependent variable has been tested. Nonetheless, results will be subject to robustness by using different independent variables. As most important outcomes are portrayed in Model 2, this model will be the main point of focus for robustness checks (for regression output see Appendix H). Lastly, an alternative model is introduced to kickstart future research.

4.3.1 Robust Model 4 using Chinese ODI

The first robustness model, Model 4, introduces the alternative log of Chinese ODI (*log of CODI*) as an independent variable. In contrast to Model 2, the Chinese ODI in this model is not relative to the GDP of the country, the model does still control for market size by the control variable *population*. The first stage shows the instrument to be valid, similar to Model 2. Moreover, Model 4 shows similar results to that of the initial model, because of which the majority of findings can be reaffirmed. The only major difference, however, concerns the interaction term between *BRI* and *log of CODI*, which has turned insignificant after replacing the independent variable. Without directly controlling for market size in the explanatory variable, as done in Model 2, this factor may influence in the relationship between the interaction and environmental pollution. Its omittance may cause the significance of the relationship to disappear.

4.3.2 Robust Model 5 using count of Chinese investments

The second robustness model, Model 5, uses another alternative independent variable in the form of a count variable of the number of Chinese investments in the country. As with the previous robustness test, the majority of findings is confirmed; the instrument is negative and significant and most of the variables show similar signs as well as significance levels. Similar to the last model, Model 5 does not control for country size in the form of GDP, which is deemed the most likely cause for the interaction not to be significant in this model either. The count variable has been transformed to control for economic size of the country. Even though the interaction in the second stage now did turn significant and positive, the instrument was left statistically insignificant as a result. Consequently, the results seem to depend on the economic size of a country, omitting this controlling factor turns the interaction insignificant. Models 4 and 5 indicate robust results at the general level. As for the interaction term, the dependence on GDP leads to hypothesis 3 being conditionally accepted.

4.3.3 Robust Model 6 using count of infrastructure projects

The third robustness check, Model 6, verifies the results for Model 3. An alternative measure for the infrastructure dummy, *count infra*, is introduced in this robustness test. Instead of looking at whether an investment has been done in infrastructure, the new variable accumulates the number of infrastructure projects per country per year. Whether an investment is done in a country depends on the size of the country. Larger countries attract more infrastructure projects as they have more land for these projects to be initiated on. Consequently, to control for size the count of infrastructure projects has been divided by GDP. Running the robust first stage model shows the instrument is negative and significant at the 5 percent level, thus valid for further use. Proceeding to the second stage of the robust model, the model looks quite similar to Model 3, the major difference occurs for the interaction terms in which both the fitted values of log of *CDII* and the robust infrastructure variable are included. The coefficients are statistically significant at the 1 percent level, therefore already showing a contrasting result compared with Model 3, however, the coefficients are very high in magnitude. This does not seem to be a reliable result; therefore, this model is merely introduced as suggestion for future research but should not be seen as a valid robustness test.

4.3.4 Robust Model 7 & 8 using system GMM estimation

The final robustness test done concerns a different optimisation of Model 2. Instrument validity is always an econometric concern as it is impossible to check both assumptions adhering to it. Moreover, the instrument used in the IV approach is time-invariant. Consequently, the fixed effects that remain in the error term may still be correlated with individual panels. Introducing a dynamic model which takes the dimension of time into account is one way to overcome this issue. Put in the context of this thesis, the chance of persistency of the dependent variable is high, assuming that past pollution determines future pollution. To control for this endogeneity, as well as the reverse causality of *log of CDII*, the lagged values of the dependent and independent variables are added. The application of such a model is known as generalised methods of moments (GMM). The robustness check applied in this paper concerns a one-step system IV-GMM, similar to Muhammad & Long (2021) and Wu et al. (2020). The coefficients of difference GMM may be downward biased as they are below those of the fixed effects estimate and thus show weak instrumentation, consequently, system GMM is preferred over difference GMM (Bond & Hoeffler, 2001). IV-GMM provides consistent and reliable estimates in the unknown presence of heteroskedasticity as well as being robust to auto-correlation (Roodman, 2009).

Several factors are important to ensure validity of IV-GMM models (see table 7 on the next page for the regression outcome of Model 7). The Hansen statistic reports on overidentification of instruments, for the model to not be overidentified, an insignificant p-value slightly higher than 0.10 is desirable. Model 7 shows an insignificant p-value of 0.130 indicates instruments are not over-identified. Additionally, in line with expectations, the Arellano-Bond test for first and second order autocorrelation ensure absence of autocorrelation influencing model estimates. For this to be the case, the first test outcome has to be significant whereas the second order autocorrelation test should be insignificant. The results of these tests in Model 7 are in line with these expectations, the Arellano-Bond test for first order autocorrelation is significant and the second order test is insignificant, at p-values of 0.000 and 0.438 respectively. Autocorrelation is thus not an issue in Model 7. Thereby, GMM requires the number of instruments to be smaller than the number of groups. The Hansen statistic gives a first indication of instrument validity, which is reaffirmed by the ratio of instruments over groups. Lastly, the lagged value of the dependent variable, *log of CO2kt (t-1)* has to be stationary. In other words, for extreme values not to influence the regressors and cause explosive growth, its coefficients must be below 1.0. As the coefficient is 0.995, this is indeed the case.

Turning to the regression results, previous pollution levels indeed affect future pollution levels on the short term, as indicated by the positive and significant coefficient of *log of CO2kt (t-1)*. In other words, ceteris paribus, a 1 percent increase of pollution last year leads to a 0.995 percent increase of pollution on the short term, significant at the 1 percent level. Similar to Model 2 and other robustness checks, the inverted U-shape on the short term seems to hold in a dynamic GMM setting. The coefficient of *log of GDPpc* is positive and significant at the 10 percent level and its squared term is negative and significant at the 10 percent level. Contrary to previous findings, the variable of interest, *log of CDII*, is not significantly related to the *log of CO2kt*. The GMM model does therefore not provide robust results to the main models of the normal panel IV regression. In contrast to a normal panel IV regression, GMM takes fewer assumptions in turn giving a more realistic model. Therefore, a possible explanation for this finding might lie in the nature of assumptions of the IV regression which might be more favourable to the earlier results. A less restrictive model may indeed give a more realistic depiction of the true relation, however, since this model is purely an added robustness test and not one of the main models of this thesis, this discussion is left to future research. Lastly, the long run estimates of the significant variables were computed but did not yield significant results, indicating the results found for Model 7 are only to be interpreted for the short term.

The same computation has also been done for Model 3, which introduces one-step system GMM model including the infrastructure dummy. GMM Model 8, which is the result from this robustness test, did not seize adequate results as it the significant p-value of the Hansen statistic indicated the model is overidentified. The model has been reported in Appendix G but should merely be seen as an indication for future research to focus upon. Due to the overidentification, the coefficients and their significance should be interpreted only with great caution.

Table 7

GMM model regression output

log of CO2kt	Model 7 One-step System IV-GMM
log of CO2kt (t-1)	0.995***
	(0.00934)
log of GDPpc	0.238*
	(0.139)
log of GDPpc squared	-0.0143*
	(0.00777)
log of CDII	-0.0233
	(0.0185)
log of CDII (t-1)	0.0132*
	(0.00737)
BRI	-0.00393
	(0.0296)
BRI # lCDII	0.0152
	(0.0341)
Population	9.83e-12
	(9.05e-11)
Trade (% of GDP)	-0.0000417
	(0.000123)
Institutional quality	0.0000265
	(0.000153)
Europe & Central Asia	-0.0198
	(0.0171)
Latin America & Caribbean	-0.0331*
	(0.0171)
Middle East & North Africa	0.0150
	(0.0231)
North America	0.0485
	(0.0319)
South Asia	0.0474**
	(0.0234)
Sub-Saharan Africa	0.0210
	(0.0187)
Constant	-0.878
	(0.574)
Year dummies	Yes
Observations	1511
Groups/instruments	178/142
AR (2)	0.438
Hansen statistic	0.130

Note. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; p-values reported for AR (2) and Hansen statistic.

5. Conclusion

It is clear the rise of China and their novel foreign policy has had a significant global impact. This thesis has aimed to shed light on the question: *What is the effect of Chinese investments on environmental pollution under the Belt and Road Initiative (BRI)?*

Studying a time frame from 2008 up and until 2016, Chinese investments are found to contribute to environmental pollution. Other interesting results have been found as well. First, Chinese infrastructure projects under the BRI seem to positively effect to environmental quality. Moreover, evidence supporting the Environmental Kuznets Curve (EKC) was found in all models. No support is found for the Pollution Haven Hypothesis (PHH). The research conducted may have several limitations revolving around composition of the dataset, data availability and methodological choices. It is important to address these points of improvement for future researchers to learn from and be aware of. After these econometric limitations have been addressed, a more general reflection is given.

5.1 Limitations

Firstly, the construction of the infrastructure variable used in model 3 requires additional explanation. The dataset came with a sector division for investments; however, subsectors were unclear because of which the composition of sectors to be infrastructure was done manually. Though this manual construction is deemed intuitively correct, different perspectives may lead to other compositions of this variable and thus the results. A clear overview on the subsectors included has been given in section 3.4. Secondly, the limited availability of data caused the timeline of the research stretch no further than 2016. As the dependent variable, environmental pollution, has no observations past this point, the analysis was not able to delve into more recent developments. As the effects of a long-term projects such as the BRI may develop over time, this is pivotal to understanding the impact of these investments. The insignificant long-term coefficients of the GMM model hint at this inability as well. As addressed previously, this is one of the main recommendations for future research to ensure up-to-date knowledge on the topic at hand. Furthermore, the observations on Chinese investments are at risk of being incomplete. As stated by Mr Scissors, the data "represents nearly all Chinese investments of $95 million or more" (personal communication, June 6, 2021), thus excluding those below this value as well as reneging the completeness of investments above this threshold. Consequently, the missing observations have been characterised as the country receiving zero investments from Chinese origin. Even though the Chinese Global Investment Tracker is deemed a credible source for data on Chinese investments, the risk of missing observations is an issue that may impact the results found. It is therefore recommended researchers use a variety of data sources to verify the investments. Thirdly, a few methodological choices also need to be addressed. For the instrument, distance from one country centroid to another was used. However, this may not reflect the perceived distance from country to country. For example, the centre of China is far land-inward, whereas most trading hotspots are located close to the sea. Intuitively, countries may be more interested in the 'economic centroid' of a country as compared to its geographical centre. As a result, the instrument may not represent the most relevant point in the country to measure distance from even though it is in line with the essence of the Gravity model. It is advised to explore different aspects of the Gravity model, such as cultural proximity, to study differences in results. Furthermore, as explained in the beginning of section 3, outliers have been detected in the data. Winsorising these outliers creates a normally distributed dataset which is preferred for running efficient models. On the other hand, deleting observations should always be done with great care and even though reasons for doing so were evident and clear, it does change the outcome. Future research should carefully consider the countries that have been excluded from this analysis and explore opportunities to include them. This will increase generalisability of the results, bringing more economic relevance and policy recommendations in return.

More generally, it is important to reflect on the model in general terms as well. The results presented in this paper satisfy the initial inquiry and research goal of clarifying the environmental impact of Chinese investments under the BRI. Nonetheless, the data limitations bring more ambiguity to the robustness of results than ideally preferred. Thereby, aggregating results means disregarding regional variance. Although controlled for by means of the continent dummy, the contextual aspect of research should always be considered. Lastly, a wider variety of robustness tests may be done in the future to ensure validity of results, for example, by using different infrastructure measures or other sources of data as argued in the second limitation. Although the current set of robustness checks is deemed valid, scientists should always strive for improved validity of results.

5.2 Discussion

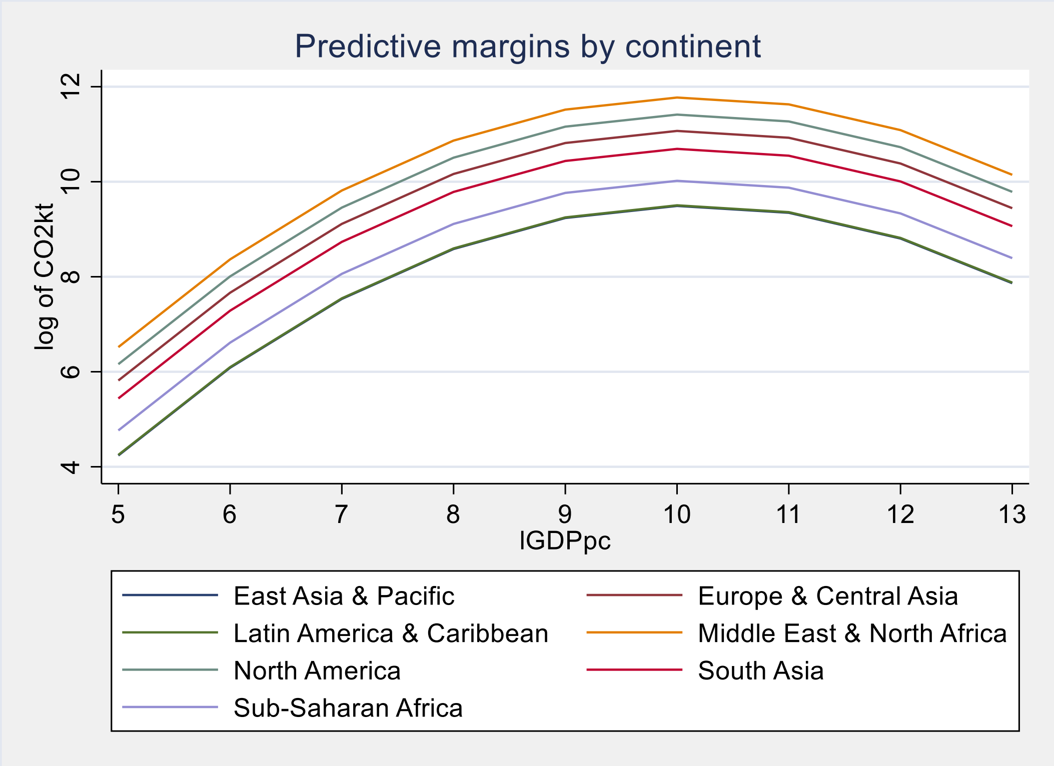
Turning to the discussion of results found in this paper. As briefly summarised above, Chinese investments under the BRI differ significantly from those which do not fall under this policy, the former having found to be relatively more polluting. Other notable findings of this thesis include the presence of the EKC, for which evidence was found in all models, including the robustness checks. Perhaps the most surprising result concerns the effect of infrastructure projects under the BRI. This thesis finds Chinese infrastructure projects pollute comparatively less when evoked under the BRI. The explanation for this might lie in the relative importance given to BRI countries as compared to those which are not participating in the programme. Newer and more advanced technology might be prioritised for those projects falling under the BRI. It therefore seems Chinese international investment policy embraces the *renewable advocates* position, as discussed in section 2.3. In other words, Chinese investments abroad promote the country's green methods of production. Infrastructure is one of the main pillars of the BRI, consequently the choice to focus on more sustainable production methods for these investments could be a strategic choice. However, this surprising finding may be the result of a statistical error as the instrument in stage 1 of Model 3 is insignificant at the 10 percent level. An interesting area of future research is the clarification of this finding as no other literature has been able to do so thus far. Lastly, the robustness checks confirm a majority of the findings, under the condition of controlling for GDP directly in the explanatory variable.

The analysis done brings novelty by isolating location oriented FDI from aggregate levels. By analysing individual home-country effects, specific consequences of policies can be studied, such as the BRI. For future investments projects such as the European Green Deal this opens up a new area of future research. Additionally, by adding the triple interaction term, this thesis has taken a triple difference approach to study this policy effect, which, to the author's knowledge, has not been done in previous literature within this context. Lastly, the introduction of the one-stage system GMM model as a robustness check adds dynamic effects to the model. Combining this with the home-country FDI isolation serves as a good foundation to kickstart future research. The results of this model stress the need of more research to fully understand the relation between environmental pollution and Chinese investments. Econometric tools such as the ones this thesis implements, may help future researchers to take a variety of perspectives in analysing new policy introductions.

The findings of this thesis may help policy makers to streamline their trade strategy with China. The established EKC creates a tangible goal for countries to strive for in realising a turnaround in both economic development as well as environmental degradation. As shown in Figure 6 below, this goal differs per region, highlighting the importance of contextuality. Therefore, for policy to be effective, it is important that future research focuses on studying country- or continent-specific regressions to add regional specificity. Moreover, the positive relation between Chinese investments and CO_2 emissions should be considered in the trade optimisation process. Given these investments are relatively more polluting in B&R countries, stresses the importance of careful analysis of the trade-off for policy makers. Often, infrastructure is a more polluting sector to invest in, however, this thesis has shown infrastructure to be less polluting when originating from China. This might be a determining factor for countries in considering new infrastructure projects in the future to boost their economy. Concluding, this thesis helps to inform countries on their investment decisions, especially those wishing to reach past the turning point of the EKC, with a novel perspective of the consequences of investments made under the BRI.

Figure 6

Predictive margins of the EKC by continent



6. References

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Appendix A

Table of Abbreviations

2

2-SLS - 2-stage-least-squares

B

BRI - Belt and Road Initiative
B&R - Belt & Road

C

CDII - Chinese Direct Investment Intensity
CODI - Chinese Outward Direct Investment
CO2kt - Carbon Dioxide in kiloton
CRE - Correlated Random Effects

D

Dist - Distance to China

E

EKC Curve - Environmental Kuznets

F

FDI - Foreign Direct Investments
FDIgdp - Foreign Direct Investments inflows as a share of GDP

G

GMM - Generalised Methods of Moments
GTFP - Green Total Factor Productivity
GDPpc - Gross Domestic Product per Capita

I

IV - Instrumental Variable
Infra - Infrastructure dummy

M

MNC - Multinational Corporation

O

ODI - Outward Direct Investments
OLS - Ordinary Least Squares
Open - Trade openness

P

PHH - Pollution Haven Hypothesis
PHE - Pollution Haven Effects

S

SOE - State-owned Enterprise

W

Wgi Indicators - World Governance

Appendix B

B&R countries in sample

Afghanistan, Algeria, Angola, Antigua and Barbuda, Austria, Azerbaijan, Bangladesh, Barbados, Belarus, Benin, Bolivia, Bosnia and Herzegovina, Brunei Darussalam, Cabo Verde, Cambodia, Cameroon, Chad, Chile, Congo, Rep., Costa Rica, Cote d'Ivoire, Croatia, Cuba, Czech Republic, Ecuador, Egypt, Arab Rep., Equatorial Guinea, Ethiopia, Fiji, Gabon, Georgia, Ghana, Greece, Guinea, Guyana, Hungary, Indonesia, Iran, Islamic Rep., Iraq, Israel, Italy, Jamaica, Jordan, Kazakhstan, Kenya, Korea, Rep., Kuwait, Kyrgyz Republic, Lao PDR, Latvia, Lesotho, Liberia, Luxembourg, Madagascar, Malaysia, Maldives, Mali, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nepal, New Zealand, Niger, Nigeria, North Macedonia, Oman, Pakistan, Panama, Papua new Guinea, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Rwanda, Samoa, Saudi Arabia, Senegal, Serbia, Sierra Leone, Singapore, Slovenia, South Africa, South Sudan, Sri Lanka, Sudan, Tajikistan, Tanzania, Thailand, Timor-Leste, Trinidad and Tobago, Turkmenistan, Uganda, Ukraine, United Arab Emirates, Uzbekistan, Vietnam, Yemen, Rep., Zambia, Zimbabwe.

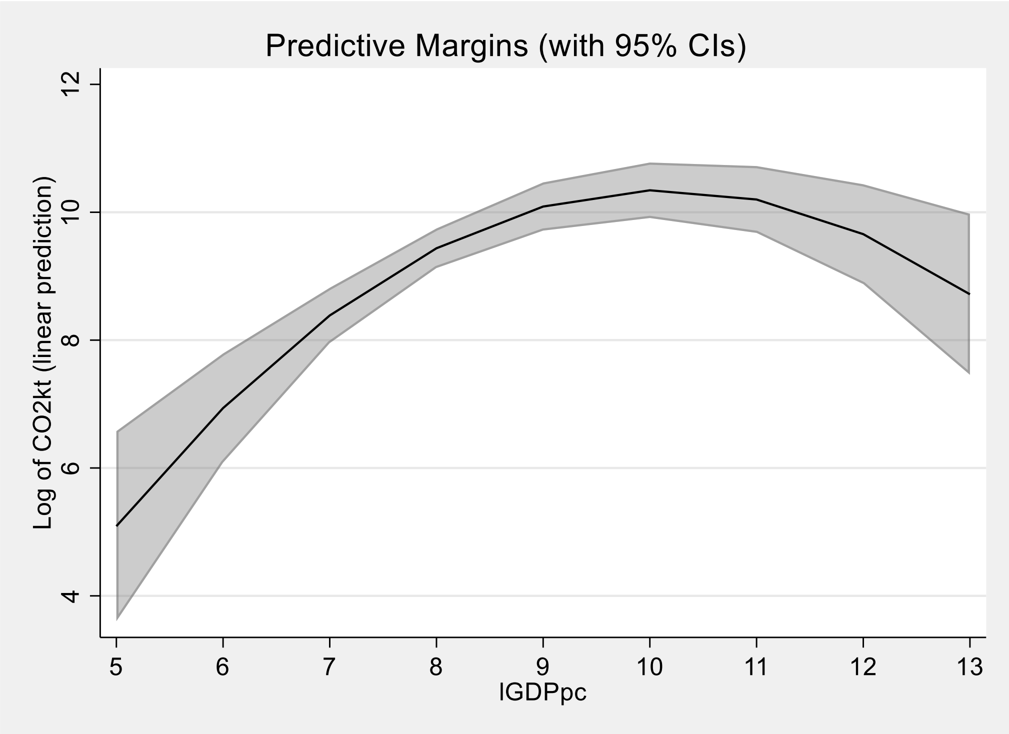
Appendix C

Correlation table

	CO2kt	*FDIgdp*	*GDPpc*	*CDII*	*BRI*	*dist*	*infra*	*population*	*open*	*wgi*
CO2kt	1									
FDIgdp	-0.1096	1								
GDPpc	0.2265	0.155	1							
CDII	-0.1393	0.1522	-0.217	1						
BRI	-0.1339	-0.0424	-0.1649	0.0957	1					
dist	-0.0430	0.0250	-0.0419	0.0078	-0.0554	1				
infra	0.0430	0.0354	-0.0330	0.0569	0.0569	-0.1129	1			
population	**0.5202**	-0.1086	-0.0848	-0.1141	-0.1074	-0.1604	0.0863	1		
open	-0.1932	**0.4568**	**0.3195**	0.0268	0.0591	-0.2008	0.0031	-0.2056	1	
wgi	0.2987	-0.019	0.1915	-0.0818	-0.1314	-0.0677	0.0168	0.2562	-0.1367	1

Appendix D

Predictive margins of base model 1



Appendix E

Estimates of the EKC

Dependent variable: lCO2kt		
log GDP per capita (x)	$\widehat{\beta_1} =$	4.26***
log GDP per capita squared (x^2)	$\widehat{\beta_2} =$	-0.21***
Slope at x_l	$\widehat{\beta_1} + 2\widehat{\beta_2}x_l =$	1.9825
Slope at x_h	$\widehat{\beta_1} + 2\widehat{\beta_2}x_h =$	-0.6492
Appropriate U-test		2.86***
Extreme point	$-\widehat{\beta_1}/(2\widehat{\beta_2}) =$	10.09703
95% confidence interval, Fieller method		[9.628, 10.8838]

Appendix F

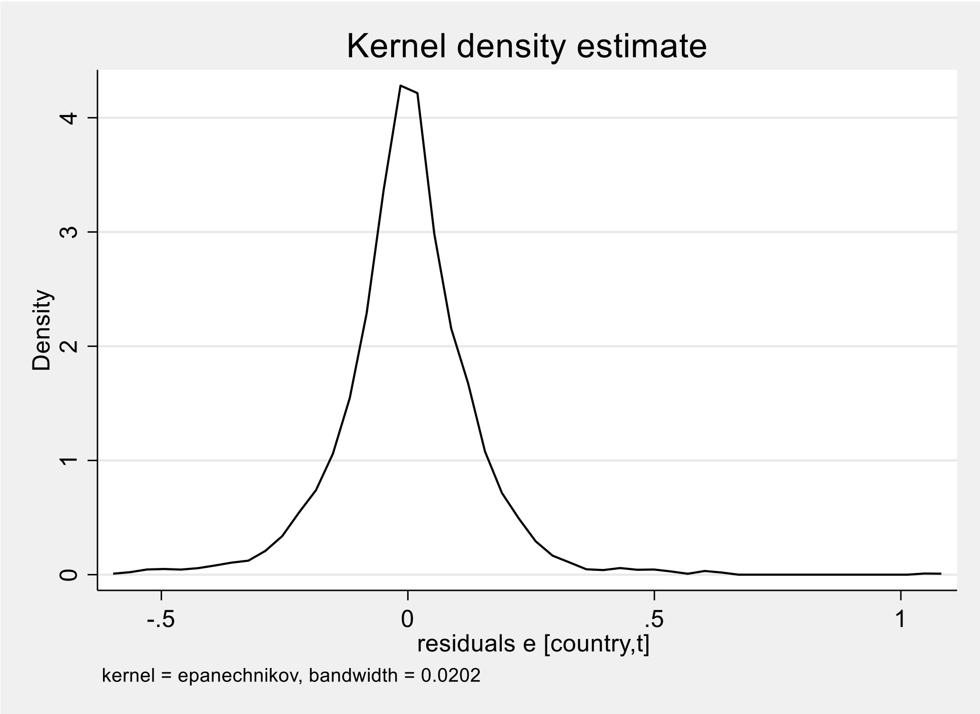
Regression output base model first stages

	Model 2 (first stage)	Model 3 (first stage)
log of distance to China	-0.200**	-0.0753
	(0.0916)	(0.0757)
log of GDPpc	-0.389	-0.289
	(0.300)	(0.231)
log of GDPpc squared	0.0179	0.0102
	(0.0164)	(0.0127)
BRI	0.590***	0.197***
	(0.0685)	(0.0719)
Infra		0.897***
		(0.0692)
BRI # infra		0.0406
		(0.104)
Trade (% of GDP)	0.000296	0.00125**
	(0.000473)	(0.000504)
Institutional quality	-0.000818	-0.00123
	(0.000946)	(0.000861)
Population	-3.14e-10	-1.18e-09***
	(2.09e-10)	(4.13e-10)
East Asia & Pacific	0.0276	0.0378
	(0.0653)	(0.0557)
Latin America & Caribbean	0.149*	0.137*
	(0.0834)	(0.0733)
Middle East & North Africa	0.0473	-0.0926
	(0.0441)	(0.0652)
North America	0.222**	0.0214
	(0.0970)	(0.151)
South Asia	0.0819	0.0257
	(0.256)	(0.201)
Sub-Saharan Africa	0.324***	0.199***
	(0.0907)	(0.0666)
Constant		2.223*
		(1.172)
Within R-squared	0.0638	0.387
Between R-squared	0.491	0.625
Overall R-squared	0.231	0.478
Number of groups	183	183
Observations	1565	1565

Note. Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix G

Kernel density estimates for base model 2



Appendix H

Regression output robustness checks

log of CO2 in kt	Model 4 using lCODI (based on Model 2)	Model 5 using count lCODI (based on Model 2)	Model 6 using count infra (based on Model 3)
log of GDPpc	6.577***	7.279***	3.299***
	(1.005)	(1.110)	(0.744)
log of GDPpc squared	-0.385***	-0.431***	-0.161***
	(0.0613)	(0.0694)	(0.0402)
Linear prediction	0.773***	9.276***	-0.0710***
	(0.174)	(2.093)	(0.0234)
BRI	-4.672***	-3.821***	-0.112**
	(1.077)	(0.877)	(0.0436)
BRI # lCODIhat	-0.00366		
	(0.00932)		
BRI # count lCODIhat		0.00164	
		(0.108)	
BRI # lCDIIhat			-0.0710***
			(0.0234)
count infra			0
			(.)
BRI # count infra			0
			(.)
count infra # lCDIIhat			76958677.0***
			(22878754.3)
BRI # lCDIIhat			0.266***
			(0.0512)
BRI # count infra # lCDIIhat			-203025297.9***
			(51073008.6)
Trade (% of GDP)	0.0144***	0.0158***	-0.000759
	(0.00352)	(0.00383)	(0.000590)
Institutional quality	0.00759***	0.00653**	0.00104
	(0.00292)	(0.00278)	(0.00238)
Population	-8.70e-09**	-1.32e-08***	4.69e-09*
	(3.96e-09)	(4.78e-09)	(2.52e-09)
East Asia & Pacific	-2.243***	-3.679***	-1.476**
	(0.571)	(0.765)	(0.620)
Latin America & Caribbean	-0.144	-0.769	-1.337***
	(0.535)	(0.473)	(0.438)
Middle East & North Africa	-1.502**	-1.636**	0.892***
	(0.617)	(0.642)	(0.331)
North America	-1.278	-6.914***	0.400
	(1.952)	(2.569)	(2.035)
South Asia	-1.932*	-2.390**	-0.521
	(1.043)	(1.073)	(0.999)
Sub-Saharan Africa	-2.103***	-2.431***	-1.080***
	(0.479)	(0.518)	(0.407)
Constant	-23.29***	0	-7.307**
	(4.890)	(.)	(3.537)
Within R-squared	0.359	0.360	0.389
Between R-squared	0.354	0.354	0.278

Overall R-squared	0.375	0.376	0.307
Number of groups	178	178	178
Observations	1522	1522	1522

Note. Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix G

GMM robustness output model 3

log of CO2kt	Model 8 One-step System IV-GMM
log of CO2kt (t-1)	0.997***
	(0.00905)
log of GDPpc	0.247*
	(0.143)
log of GDPpc squared	-0.0152*
	(0.00797)
log of CDII	0.00721
	(0.0356)
log of CDII (t-1)	0.0128
	(0.00831)
BRI	0.00493
	(0.0547)
Infra	0.0771**
	(0.0371)
BRI # log of CDII	-0.0919*
	(0.0518)
Infra # log of CDII	-0.0685*
	(0.0357)
Infra # BRI	-0.0752
	(0.0827)
BRI # infra # log of CDII	0.149**
	(0.0646)
Population	-8.59e-11
	(8.35e-11)
Trade (% of GDP)	0.0000994
	(0.000115)
Institutional quality	0.0000448
	(0.000154)
Europe & Central Asia	-0.0233
	(0.0168)
Latin America & Caribbean	-0.0276*
	(0.0167)
Middle East & North Africa	0.00438
	(0.0224)
North America	0.0337
	(0.0405)
South Asia	0.0434*
	(0.0250)
Sub-Saharan Africa	0.0230
	(0.0183)
Constant	-0.940
	(0.593)
Year dummies	Yes
Observations	1512
Groups/instruments	178/143
AR (2)	0.457
Hansen statistic	0.069*

Note. Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. P-values reported for AR (2) and Hansen statistic