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THE DIFFERENCE IN THE FDI - CO_2 EMISSIONS RELATIONSHIP BETWEEN DEVELOPED AND DEVELOPING COUNTRIES: EMPIRICAL EVIDENCE BASED ON INSTITUTIONAL PERSPECTIVE

Van Bon Nguyen*

Faculty of Finance-Banking, University of Finance Marketing (UFM), Ho Chi Minh, Vietnam.
nv.bon@ufm.edu.vn; boninguyen@gmail.com

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Abstract

The role of FDI relating to the problems of environmental pollution in host countries has been recognized by related literature. Some papers posit the pollution haven hypothesis while others advocate the pollution halo hypothesis. The paper provides empirical evidence to demonstrate that the relationship between FDI and environment quality varies based on the governance environment of host countries. The findings support the pollution halo hypothesis in 31 developed countries with a good governance environment and the pollution haven hypothesis in 55 developing countries with a bad one using the two-step system GMM estimator from 2005 to 2018. Besides, the results indicate that the difference in the impact of economic growth on environmental quality between developed and developing countries approves the hypothesis of the environmental Kuznets curve. The robustness of these estimates is checked by the PMG estimator. These findings suggest some policy implications for developing countries in improving environmental quality.

Keywords: FDI, environmental pollution, developed countries, developing countries, environmental Kuznets curve, GMM estimator, PMG estimator
JEL Classification Codes: C23, F21, F64, Q56, Q58

I. *Introduction*

The role of the institutional environment in dealing with the problems of environmental pollution and global warming stemming partly from FDI inflows is a hotly debated topic of interest among economists and policy-makers. Starting from the seminal works by Copeland & Taylor (1994) and Grossman & Krueger (1995), a large strand of related literature has examined the relationship between FDI and environmental quality, attempting to test the

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negative/positive contribution of FDI inflows to environmental quality. Meanwhile, FDI inflow is a crucial capital source to promote economic growth and development in both developed and developing countries. The great contribution of FDI inflows in host countries is innovative capacity, capital accumulation, know-how acquisition, and technology transfer (Agosin & Machado, 2005). Thus, the majority of countries always try to adjust and improve regulations and policies to attract more FDI inflows. However, so far no existing studies provide empirical evidence to show that the FDI – environmental pollution relationship will vary based on the institutional environment.

Given the relevance of this topic, the pollution haven hypothesis by Copeland & Taylor (1994) and the pollution halo hypothesis by Grossman & Krueger (1995) are two main theories to explain the negative/positive impact of FDI inflows on environmental quality in host countries. The pollution haven hypothesis notes that foreign enterprises will look for the cheapest costs relating to natural resources, labor, land, and raw material access when they seek to set up offices or factories overseas. Hence, foreign investors that choose to physically invest abroad tend to locate the countries with cheap natural resources, labor, land, and the lowest environmental standards or weakest enforcement, and so the environmental quality in host countries is degraded (Copeland & Taylor, 1994). In contrast, the pollution halo hypothesis posits that foreign enterprises transfer their greener technology to the host country via FDI inflows. Green technologies include renewable energy-using technologies, pollution abatement technologies, and advanced energy-efficient technologies, and so the environmental quality in host countries is improved (Grossman & Krueger, 1995). If so, some factors can be the causes to lead to the different effects of FDI inflows on environmental quality. We rely on the institutional perspective to explain these effects. In this study, it should be the governance environment in host countries. Li & Filer (2007) argue that the influence of the governance environment on investment behavior is established on the institutional approach to economic activities. Social institutions hinder or enhance economic activities by increasing or decreasing transaction costs. Li et al. (2004) support that there is a clear difference between relation-based governance (poor institutional environment) and rule-based governance (good institutional environment). The advanced and developed countries with good governance environments (rule-based governance) are likely to have similar institutional environments, including a transparent legal system with rules of conduct made through a representative democracy, which is universally put into practice and interpreted by an independent judicial system, and the state can impartially and efficiently enforce the public laws and rules, on which people predominantly rely to protect their social and economic exchange. Under these governance environments, policies and regulations are designed, formulated, and implemented in a manner that selectively receives FDI inflows to eliminate adverse impacts on economic development (i.e. environmental pollution). Only high-quality FDI inflows are allowed to enter these countries, and as a result, environmental quality in these host countries is better enhanced. In contrast, the developing countries with poor governance environments (relation-based governance) are likely to have a non-transparent legal system in which the judicial system is not independent of political influence; laws and rules are arbitrarily interpreted, and the state cannot impartially and efficiently enforce the public laws. Under these governance environments, policies and regulations are designed, formulated, and implemented in a manner that mostly receives all FDI inflows to deal with the shortage of domestic investment capital and high unemployment. More low-quality FDI inflows are allowed to enter these countries, and as a result, environmental quality in these host countries is getting worse.

Motivated by the fact that the governance environment greatly contributes to the relationship between FDI and environmental quality, we empirically examine the difference in the FDI – environmental pollution relationship between developed countries and developing countries. Using governance indicators, FDI, and CO_2 emissions data from 31 developed countries with a good governance environment and 55 developing countries with a poor governance environment between 2005 and 2018, we discover that FDI increases CO_2 emissions in developing countries, supporting the pollution haven hypothesis, but decreases CO_2 emissions in developed countries, validating the pollution halo hypothesis via the two-step system GMM Arellano-Bond estimator (S-GMM). In particular, the robustness of these estimates is checked by the PMG estimator.

The paper is constructed in the following way. Section 2 is a literature review that focuses on the relationship between FDI and environmental quality. The model specification and research data are presented in Section 3 that especially emphasizes the characteristics and appropriateness of S-GMM and PMG. Section 4 shows the empirical results consisting of estimates and a robustness check. The final section concludes and suggests some important policy implications from the findings in Section 4.

II. *Literature review*

Given the relevance of the topic, the majority of studies support either the pollution haven hypothesis or the pollution halo hypothesis. Furthermore, some studies report a mixed result, nonlinearity, or no impact on the relationship between FDI inflows and environment quality.

Regarding supporting the evidence of pollution haven hypothesis, most of the studies use the estimators of fixed effects, random effects, and OLS for estimates (Jiang, 2015; Frutos-Bencze et al., 2017; Zhu et al., 2017; Pazienza, 2019; Sarkodie & Strezov, 2019; Wang et al., 2019). Pazienza (2019) finds the positive impact of FDI on CO_2 emissions in 30 OECD countries over the period of 1989-2016 with the estimators of OLS, fixed effects, and random effects while Sarkodie & Strezov (2019) provide the evidence on pollution haven hypothesis in top five emitters of greenhouse gas emissions from fuel combustion in the developing countries (China, India, Iran, Indonesia, and South Africa) during the period from 1982 to 2016 using the panel data regression with Driscoll-Kraay standard errors and the panel quantile regression with non-additive fixed-effects; and Wang et al. (2019) indicate a valid pollution haven hypothesis for a unique dataset of 157 county-level administrative units in Beijing -Tianjin- Hebei in China from 2014 to 2016 via a fixed effects regression model. Meanwhile, a few studies apply the Error Correction Model (Baek, 2016; Zhang & Zhang, 2018) or Autoregressive Distributive Lag model (Solarin et al., 2017; Hanif et al., 2019). Baek (2016) shows that FDI inflows stimulate CO_2 emissions in five ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, Thailand) over 1981-2010 and Zhang & Zhang (2018) report it in China from 1982 to 2016. Solarin et al. (2017) have the same results in Ghana for the period of 1980-2012 while Hanif et al. (2019) emphasize that FDI is a source of environmental degradation that increases CO_2 emissions in fifteen developing Asian countries for the period from 1990 to 2013. Some remaining studies note the adverse influence of FDI inflows on environment quality via GMM Arellano-Bond estimators (Ren et al., 2014; Abdouli & Hammami, 2017; Shahbaz et al., 2019).

Abdouli & Hammami (2017) and Shahbaz et al. (2019) both provide empirical evidence on the bad role of FDI inflows in the environmental pollution in 17 Middle East and North African countries (MENA) over the period 1990-2012/2015.

Concerning advocating the pollution halo hypothesis, some investigations use estimators of fixed effects, random effects, and OLS (Kirkulak et al., 2011; Al-Mulali & Tang, 2013; Zhu et al., 2016; Jiang et al., 2018). Zhu et al. (2016) show the negative impact of FDI inflows on environmental quality in ASEAN-5 (Indonesia, Malaysia, the Philippines, Singapore, and Thailand) over the period 1981-2011 while Jiang et al. (2018) indicate it for a city-level dataset of 150 Chinese cities in 2014. Meanwhile, a few investigations apply the Error Correction Model (Rafindadi et al., 2018; Yang & Wei, 2019). Rafindadi et al. (2018) find the adverse influence of FDI inflows on environmental quality in the 6 countries of GCC (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates) from 1990 to 2014 using PMG estimator and Yang & Wei (2019) indicate it in 30 provinces in China from 2000 to 2017 via the Panel-Corrected Standard Error model (PCSE). In particular, most of the investigations provide empirical evidence on the pollution halo hypothesis via one-step difference and system GMM Arellano-Bond estimators (Hao & Liu, 2015; Liu et al., 2017; Shao, 2018; Sung et al., 2018). Shao (2018) reports a negative impact of FDI inflows on environment quality using the panel data of 188 countries during 1990-2013 while Sung et al. (2018) note it for a panel data of 28 subsectors of the Chinese manufacturing sector over the period 2002-2015. Furthermore, a few investigations use some different estimators (Zhang & Zhou, 2016; Hille et al., 2019). Zhang & Zhou (2016) use Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model for 29 Chinese provinces from 1995 to 2010 and Hille et al. (2019) apply simultaneous equations model for 16 Korean provinces and self-governing cities during the period from 2000 to 2011.

Unlike the above-mentioned investigations, Kim & Adilov (2012), Liu et al. (2018), and Ansari et al. (2019) are studies to show a mixed result for FDI – environment quality relationship. Kim & Adilov (2012) find it in 164 countries from 1961 to 2004 via estimators of OLS, fixed effects, and random effects. Similarly, Liu et al. (2018) confirm that FDI inflows have distinct effects on different environmental pollutants in 285 Chinese cities during the period 2003-2014 using a spatial lag model (SLM) and a spatial error model (SEM). More recently, Ansari et al. (2019) show the pollution haven hypothesis only in East Asian countries and the pollution halo hypothesis in the Southeast Asian countries over the period 1994-2014 with fully modified ordinary least squares (FMOLS). Similarly, Abdouli et al. (2018), Balsalobre-Lorente et al. (2019), Junxian et al. (2019), Xie & Sun (2020) are studies to report a nonlinear relationship between FDI inflows and environmental pollution. Abdouli et al. (2018) show it for BRICTS countries (Brazil, the Russian Federation, India, China, Turkey, and South Africa) from 1990 to 2014 using applying both static (OLS, fixed effects, and random effects) and dynamic (system GMM) panel data approach. In the same vein, Balsalobre-Lorente et al. (2019) indicate it in MINT countries (Mexico, Indonesia, Nigeria, and Turkey) in the period 1990-2013 with estimators of FMOLS and DOLS while Junxian et al. (2019) note it in 29 provinces in China from 1996 to 2015 with estimators of fixed effects and random effects. Lately, Xie & Sun (2020) present it in 11 selected emerging countries (China, India, Brazil, Russia, Indonesia, South Korea, Mexico, Argentina, Saudi Arabia, Turkey, and South Africa) spanning the period 2010-2016 via a generalized panel smooth transition regression (GPSTR). Notably, Albulescu et al. (2019) and Liobikienė & Butkus (2019) affirm that FDI inflows have no impact on environmental pollution. Albulescu et al. (2019) indicate it in 14 Latin American countries over the period 1980 to 2010 using estimators of fixed effects and random effects while Liobikienė & Butkus (2019) report it in 147 countries between 1990 and 2012 with the one-step system GMM estimator.

From the literature perspective, in summary, this paper provides three highlight aspects. First, the study empirically demonstrates that the FDI – environmental quality relationship completely varies based on the quality of the governance environment. Second, the study finds out that the environmental Kuznets curve is validated when the income per capita shifts from low and middle in developing countries to high in developed countries. Third, the study uses the two-step system GMM Arellano-Bond estimator for estimation and the PGM estimator for robustness check.

III. *Methodology and research data*

1. Methodology

Based on the work developed by Albulescu et al. (2019), the empirical equation is extended as follows:

$$CO2_{it}=\beta_0+\beta_1 CO2_{it-1}+\beta_2 FDI_{it}+\beta_3 GOV_{it}+X_{it}\beta'+\eta_i+\xi_{it} \quad (1)$$

where subscript i and t are the country and time index, respectively. $CO2_{it}$ is carbon dioxide emissions (metric tons per capita) which is proxy for environmental pollution; $CO2_{it-1}$ is the initial level of carbon dioxide, FDI_{it} is net FDI inflows, and GOV_{it} is governance environment (six dimensions of governance, including control of corruption, government effectiveness, political stability and absence of violence, regulatory quality, rule of law, voice and accountability). X_{it} is a set of control variables such as economic growth, private investment, trade openness, and infrastructure; η_i is an unobserved time-invariant, country-specific effect and ζ_{it} is an observation-specific error term; β_0, β_1, β_2, β_3 and β' are estimated coefficients.

We apply Equation (1) to examine the FDI – environmental pollution for the group of 32 developed countries with a good governance environment and the group of 55 developing countries with a bad one. To measure the governance environment, we use six dimensions of governance from the World Bank in which each dimension receives the value from -2.5 to 2.5 (Kaufmann et al., 2011). World Bank (2017) shows that governance is considered a process through which non-state and state actors interact to design, formulate, and implement policies and regulations within a certain set of informal and formal rules that establish and are established by power. Meanwhile, the lack of a good governance environment in most developing countries results in adverse impacts on the economic outcomes in the future; hence, reforming the governance environment importantly contributes to the development process in these countries. More importantly, a good governance environment will set up constructive governments with the ability to design, formulate, and implement development policies (Hope Sr, 2009).

We apply the GMM (general method of moments) by Arellano and Bond (1991) first proposed by Holtz-Eakin et al.for estimation. First, we take first difference in regressors to remove the country-fixed effects. Next, we use the regressors in first difference as instrumented by their lags with the assumption that time-varying white noises in the original models are not serially correlated (Judson & Owen, 1999). It is called the difference GMM estimator (D-GMM) that can handle the simultaneity biases in regressions.

Equation (1) can be transformed into an equation in first difference as follows:

$$CO2_{it}-CO2_{it-1}=\beta_1(CO2_{it-1}-CO2_{it-2})+\beta_2(FDI_{it}-FDI_{it-1})+\beta_3(GOV_{it}-GOV_{it-1}) \\ +(X_{it}-X_{it-1})\beta'+(\xi_{it}-\xi_{it-1}) \quad (2)$$

In case variables are persistent, their past values show little information about their future changes, making their lags become weak instruments for their differenced series. Thus, Arellano & Bover (1995) suggests a combination of Equation (1) and Equation (2) to form a system of two equations, an equation in difference series instrumented by lagged levels, and an equation in levels instrumented by lagged differences to which GMM is applied. It is known as the system GMM estimator, a strategy that can enhance efficiency via its reduction in biases and solving the problem of the weak instrument in the difference GMM estimator. The consistency of the system GMM estimator is based on the assumption that the error terms are uncorrelated, the instruments are valid, and the changes in additional instruments are not correlated with province-fixed effects.

The two-step GMM is more asymptotically efficient than the one-step GMM. However, Using two-step GMM in small samples, as in this study, has some problems (Roodman, 2006). These problems are established by the proliferation of instruments, which quadratically increase as the time dimension increases. It can cause the number of instruments to be very large relative to the number of provinces. To avoid it, the rule of thumb should be applied to maintain the number of instruments less than or equal to the number of panel units (Roodman, 2006).

In the estimation process, the Sargan statistic, Hansen statistic, and Arellano-Bond statistic will be used to examine the validity of instruments in S-GMM. The Sargan and Hansen tests with null hypothesis H0: the instrument is strictly exogenous, which means that it does not correlate with errors. The Arellano-Bond test is used to detect the autocorrelation of errors in first difference. Thus, the test result of first autocorrelation of errors, AR(1) is ignored while the second autocorrelation of errors, AR(2), is tested on the first difference series of errors to detect the phenomenon of first autocorrelation of errors, AR(1).

To check the robustness of S-GMM estimates, we use the PMG estimator developed by Pesaran et al. (1999). The PMG estimator allows the short-term parameters to be heterogeneous between groups while imposing homogeneity of the long-term coefficients between countries. It is one advantage of the PMG estimator. Furthermore, the PMG estimator highlights the adjustment dynamic between the short-run and the long-run. The heterogeneity of short-run slope coefficients allows the dynamic specification to differ across countries. However, the drawback of the PMG estimator is that it cannot deal with the endogeneity of variables in the model.

The PMG estimator - based error correction model as follows:

$$\Delta Y_{it}=\varnothing S_{it-1}+\sum_{j=1}^{p}\delta_{ij}\Delta X_{it-j}+\eta_{it}+\xi_{it} \text{ where } S_{it-1}=Y_{it-1}-\theta X_{it-1} \quad (3)$$

where Y is CO_2 emissions; S_{it-1} is the deviation from long-run equilibrium at any period for group i, and φ is the error-correction coefficient (speed of adjustment). The vector θ captures the long-run coefficients which do not vary across groups; these coefficients represent the long-run elasticity of carbon dioxide emissions with respect to each variable in X_{it-1}. The short-run responses of the X variables are captured by the vector δ. η_i is an unobserved time-invariant, country-specific effect and ζ_{it} is an observation-specific error term. The validity of the PMG estimates is based on the level and significance of the error-correction coefficient φ (negative, smaller than 1).

2. Research data

The variables are carbon dioxide emissions per capita, FDI, six dimensions of governance, real GDP per capita, private investment, trade openness, and infrastructure. Data are taken from the World Bank World Development Indicators (WDI) and Worldwide Governance Indicators (WGI) database. The research sample contains 31 developed countries[1] and 55 developing countries[2] from 2005 to 2018.

Table 1A, Table 2A, and Table 3A in the Appendix present the definition and descriptive statistics of the dataset. In comparison with that in the group of 34 developed countries, the governance environment in the group of 93 developing countries is relatively low. Accordingly, developed countries have a good governance environment but most developing countries have a poor one. Notably, the approach in Li (2003) and Li and Filer (2007) also indicates that most developing countries are those with a poor governance environment (relation-based governance) while most developed countries are those with a good one (rule-based governance). In particular, Li (2003) argues that in catching-up countries (developing economies), in general, there is no rule-based governance; so the only suitable system to enforce agreements is relation-based governance. Therefore, investing in relations is a rational solution to get benefits, especially in developing economies.

IV. *Results and discussion*

1. S-GMM estimates

S-GMM estimates are shown in Table 1 and Table 2. Each column in each table is the model in correspondence with each dimension of governance. In all estimation procedures, we detect that governance is endogenous, thus we use governance as instrumented in the GMM-

[1] Australia, Austria, Belgium, Canada, Czech, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Korea, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Singapore, Slovak, Spain, Sweden, Switzerland, United Kingdom, and the United States.

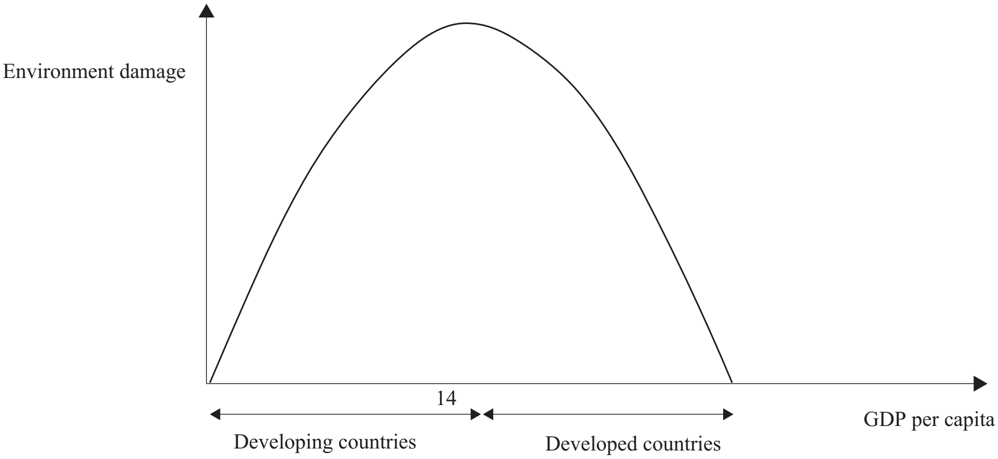
[2] Albania, Angola, Argentina, Armenia, Bahamas, Bangladesh, Barbados, Belize, Bhutan, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Cambodia, Chile, China, Colombia, Congo Republic, Costa Rica, Cote d'Ivoire, Croatia, Dominican Republic, Egypt, El Salvador, Georgia, Ghana, Guatemala, Honduras, India, Indonesia, Jordan, Kuwait, Lebanon, Madagascar, Malaysia, Mauritius, Moldova, Mongolia, Morocco, Namibia, Paraguay, Peru, Philippines, Poland, Romania, Russian Federation, South Africa, Sri Lanka, Thailand, Togo, Tunisia, Ukraine, Uruguay, and Vietnam.

style and the remaining variables (CO_2 emissions, FDI, economic growth, private investment, trade openness, and infrastructure) as instruments in the IV-style.

The results across all models for the group of 31 developed countries are reported in Table 1 while those for the group of 55 developing countries are presented in Table 2. In the group of 55 countries, FDI stimulates CO_2 emissions, supporting the pollution haven hypothesis. In sharp contrast, FDI reduces CO_2 emissions in the group of 31 countries, validating the pollution halo hypothesis. All these results are highly consistent for all six dimensions of governance. From an institutional perspective, these results imply that the effect of FDI inflows on CO_2 emissions can be strongly conditioned to the governance environment. FDI increases CO_2 emissions under a poor governance environment (developing countries) but decreases under a good one (developed countries). Indeed, there may be some factors that affect the FDI – CO_2 emissions relationship which leads to the difference in the FDI – CO_2 emissions relationship between developed countries and developing. However, in this study, we rely on the institutional perspective to explain. The difference in the FDI – CO_2 emissions relationship between developed countries and developing countries can mainly stem from the difference in governance environment. Under a poor governance environment (relation-based governance) foreign investors seek to establish relations and cooperate with domestic enterprises to control and protect their investments. Linking and engaging with rent-seeking public officials in host countries is one of the appropriate solutions to get the introduction of cooperation with domestic enterprises. In some cases, these domestic enterprises can also be the backyard businesses of these officials. This is also considered a common loophole in developing countries with a weak institutional environment, enabling public officials and interest groups to seek rent. Due to the rent-seeking of public officials and interest groups, the design, formulation, and implementation of rules and policies relating to environmental standards in these countries have loopholes, facilitating conditions for environmental-unfriendly FDI inflows to these countries. As a result, environmental-unfriendly FDI inflows into developing countries with weak governance settings make the environment more polluted. In contrast, under a good governance environment (rule-based governance) the design, formulation, and implementation of rules and policies relating to environmental standards are strictly and transparently monitored and supervised to eliminate loopholes. FDI inflows will be publicly assessed for their compliance with environmental criteria to meet the high standards of developed countries. In particular, the rent-seeking of public officials and interest groups is excluded due to the supervision of the people. Therefore, environmental-friendly FDI inflows into these countries will make the environment in these countries greener and cleaner.

In both groups, governance environment and private investment promote CO_2 emissions. The majority of countries worldwide focus on promoting economic growth and development, creating more jobs through stimulating consumption and production. The process of design, formulation, and implementation of policies is aimed at economic growth and development, especially creating more jobs to ensure social security. Therefore, the governance environment in most countries now makes the environment quality worse. Meanwhile, private investment leads to more increases in production and consumption which more produces CO_2 emissions. This finding can be found in some studies such as Ren et al. (2014), Jiang (2015), Liu et al. (2017), Sung et al. (2018), Albulescu et al. (2019), Huynh & Hoang (2019), and Pazienza (2019). Furthermore, trade openness and infrastructure in developed countries foster CO_2 emissions. The openness of trade results in more activities of investment and consumption,

FIGURE 1. THE ENVIRONMENTAL KUZNETS CURVE



which greatly contributes to producing more CO_2 emissions. The positive impact of trade openness is shown in Abdouli & Hammami (2017), Frutos-Bencze et al. (2017), Solarin et al. (2017), Huynh & Hoang (2019), Pazienza (2019), and Wang et al. (2019). Infrastructure development promotes economic activities of the private sector and product consumption. Hence, infrastructure, directly and indirectly, creates CO_2 emissions, thus reducing the environmental quality.

Notably, the economic growth increases CO_2 emissions in developing countries but decreases in developed countries, which supports the environmental Kuznets curve as shown in Figure 1. It implies that people in developing countries with low levels of income tend to use environmentally unfriendly products and services, contributing to increased CO_2 emissions. In contrast, people in developed countries with high levels of income seem to use eco-friendly products and services, contributing to decreased CO_2 emissions. Therefore, the finding in the paper indicates that the hypothesis of the environmental Kuznets curve is completely validated when considering the shift of per capita income from low (developing countries) to high (developed countries). Ren et al. (2014), Jiang (2015), Abdouli & Hammami (2017), Hao & Liu (2015), Shao (2018), Zhang & Zhang (2018), Albulescu et al. (2019), Junxian et al. (2019), and Shahbaz et al. (2019) also show this finding in their studies.

2. Robustness check

To check the robustness of estimates, we re-estimate Equation (1) using the PMG estimator. In this estimation, we use only the control variables such as governance, economic growth, and private investment. The PMG estimator-based error correction model requires the existence of co-integration between the dependent variable and explanatory variables. So, the paper first tests the co-integration developed by Westerlund (2007). The Westerlund panel co-integration tests in Table 3 and Table 4 indicate that all four tests reject the null of no co-integration, a covariate is considered co-integrated with the dependent variable. So, the variables FDI, governance, economic growth, and private investment are co-integrated with

TABLE1. FDI AND ENVIRONMENTAL POLLUTION: S-GMM ESTIMATES, 2005-2018 (31 DEVELOPED COUNTRIES)

Dependent variable: CO_2 emissions

Variables	GOV1	GOV2	GOV3	GOV4	GOV5	GOV6
CO_2 (-1)	0.948***	0.951***	0.952***	0.954***	0.955***	0.951***
	(0.004)	(0.004)	(0.002)	(0.004)	(0.004)	(0.003)
FDI	-0.020***	-0.017***	-0.013***	-0.021***	-0.014***	-0.013***
	(0.002)	(0.001)	(0.001)	(0.004)	(0.003)	(0.000)
Governance	1.416**	1.252***	1.429***	1.479***	0.893**	1.630***
	(0.197)	(0.316)	(0.315)	(0.426)	(0.333)	(0.324)
Economic growth	-0.004**	-0.005**	-0.005***	-0.007***	-0.006**	-0.008***
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
Private investment	0.326***	0.328***	0.206***	0.209***	0.206***	0.247***
	(0.022)	(0.023)	(0.026)	(0.027)	(0.026)	(0.025)
Trade openness	0.002***	0.001**	0.003***	0.002***	0.003***	0.009***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Infrastructure	0.022***	0.020***	0.024***	0.026***	0.026***	0.027***
	(0.004)	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)
Instrument	31	30	31	30	30	31
Country/Observation	31/403	31/403	31/403	31/403	31/403	31/403
AR(2) test	0.171	0.171	0.170	0.170	0.169	0.165
Sargan test	0.442	0.415	0.619	0.462	0.443	0.602
Hansen test	0.362	0.421	0.434	0.408	0.405	0.410

*Note: ***, ** and *denote significance at 1 percent, 5 percent and 10 percent respectively*

TABLE2. FDI AND ENVIRONMENTAL POLLUTION: S-GMM ESTIMATES, 2005-2018 (55 DEVELOPING COUNTRIES)

Dependent variable: CO_2 emissions

Variables	GOV1	GOV2	GOV3	GOV4	GOV5	GOV6
CO_2 (-1)	0.976***	0.958***	0.978***	0.973***	0.974***	0.976***
	(0.005)	(0.007)	(0.004)	(0.004)	(0.005)	(0.00)
FDI	0.403***	0.340***	0.215**	0.221**	0.271*	0.435***
	(0.086)	(0.114)	(0.100)	(0.096)	(0.152)	(0.103)
Governance	3.548***	7.968***	1.291***	7.277***	1.577*	4.310**
	(0.969)	(2.534)	(0.459)	(1.362)	(0.874)	(1.682)
Economic growth	0.004*	0.010**	0.006**	0.010***	0.005*	0.005**
	(0.002)	(0.004)	(0.002)	(0.003)	(0.002)	(0.001)
Private investment	0.112**	-0.078	0.080**	-0.006	0.093**	0.111***
	(0.049)	(0.069)	(0.039)	(0.049)	(0.041)	(0.037)
Trade openness	0.002***	-0.008	-0.018	-0.007	-0.019	0.007
	(0.013)	(0.011)	(0.014)	(0.012)	(0.015)	(0.016)
Infrastructure	-0.014***	-0.011	-0.007	-0.002	-0.004	-0.020**
	(0.005)	(0.011)	(0.005)	(0.008)	(0.005)	(0.008)
Instrument	32	32	34	33	32	31
Country/Observation	55/660	55/715	55/715	55/715	55/660	55/660
AR(2) test	0.662	0.557	0.535	0.547	0.622	0.650
Sargan test	0.584	0.474	0.127	0.076	0.421	0.811
Hansen test	0.253	0.512	0.368	0.161	0.251	0.231

*Note: ***, ** and *denote significance at 1 percent, 5 percent and 10 percent respectively*

TABLE3. WESTERLUND PANEL CO-INTEGRATION TESTS: 2005-2018 (31 DEVELOPED COUNTRIES)

Normalized variable: : CO_2 emissions

Covariates	G_t	G_α	P_t	P_α
FDI	-4.871***	-20.544***	-26.504***	-17.349***
Governance 1	-4.194***	-17.268***	-21.648***	-13.547***
Governance 2	-4.254***	-15.501***	-19.658***	-12.481***
Governance 3	-4.954***	-16.111***	-19.800***	-12.760***
Governance 4	-4.849***	-14.778***	-15.918***	-14.433***
Governance 5	-4.815***	-17.959***	-24.951***	-13.316***
Governance 6	-4.062***	-15.604***	-21.636***	-12.844***
Economic growth	-3.677***	-16.481***	-19.012***	-13.734***
Private investment	-4.270***	-18.832***	-22.455***	-15.477***

Note: ***, ** *and* **denote significance at 1 percent, 5 percent and 10 percent respectively*

TABLE4. WESTERLUND PANEL CO-INTEGRATION TESTS: 2005-2018 (55 DEVELOPING COUNTRIES)

Normalized variable: : CO_2 emissions

Covariates	Gt	Gα	Pt	Pα
FDI	-4.496***	-18.956***	-28.628***	-22.648***
Governance 1	-4.657***	-16.596***	-21.969***	-13.893***
Governance 2	-4.189***	-17.264***	-31.612***	-16.786***
Governance 3	-4.967***	-14.815***	-22.78***	-13.080***
Governance 4	-4.017***	-18.237***	-21.579***	-13.576***
Governance 5	-4.460***	-18.009***	-22.421***	-16.456***
Governance 6	-4.569***	-19.391***	-20.802***	-11.622***
Economic growth	-4.262***	-7.809***	-19.833***	-8.389***
Private investment	-4.483***	-15.859***	-20.927***	-15.195***

Note: ***, ** *and* **denote significance at 1 percent, 5 percent and 10 percent respectively*

CO_2 emissions.

The corresponding results across all models are reported in Table 5 and Table 6. In line with S-GMM, we find that FDI reduces CO_2 emissions for the group of 31 developed countries with a good governance environment (Table 5), but stimulates for the group of 55 developing countries with a poor one (Table 6). Governance environment and private investment foster CO_2 emissions in both groups. Furthermore, economic growth increases CO_2 emissions in developing countries and decreases in developed countries, which validating the environmental Kuznets curve. In particular, the level and significance of the error-correction coefficients shown at the bottom of the tables suggest that PMG estimates are highly reliable.

Table5. FDI and Environmental Pollution: PMG Estimates, 2005-2018 (31 Developed Countries)

Long run co-integrating vectors
Dependent variable: CO_2 emissions

Variables	GOV1	GOV2	GOV3	GOV4	GOV5	GOV6
FDI	-1.695***	-0.283***	-0.087***	-0.037***	-0.000	0.435***
	(0.227)	(0.040)	(0.010)	(0.009)	(0.029)	(0.103)
Governance	2.295	13.024***	14.684***	37.617***	27.246***	4.310**
	(4.362)	(0.913)	(1.302)	(0.747)	(1.660)	(1.682)
Economic growth	-0.526***	-1.222***	-0.302***	-0.141***	-0.750***	0.005**
	(0.084)	(0.046)	(0.047)	(0.006)	(0.100)	(0.001)
Private investment	2.701***	3.372***	3.884***	0.260***	3.193***	0.111***
	(0.297)	(0.035)	(0.124)	(0.094)	(0.069)	(0.037)
Error correction	-0.246***	-0.272***	-0.158***	-0.203***	-0.303***	-0.746***
Observation	403	403	403	403	403	403
Log likelihood	-1017.54	-879.83	-1028.48	-1007.87	-1009.71	-1661.30

*Note: ***, ** and *denote significance at 1 percent, 5 percent and 10 percent respectively*

Table6. FDI and Environmental Pollution: PMG Estimates, 2005-2018 (55 Developing Countries)

Long run co-integrating vectors
Dependent variable: CO_2 emissions

Variables	GOV1	GOV2	GOV3	GOV4	GOV5	GOV6
FDI	0.640***	0.182	0.890***	0.988***	0.749***	0.643***
	(0.152)	(0.151)	(0.126)	(0.086)	(0.148)	(0.148)
Governance	15.355***	11.474***	13.369***	21.274***	13.905***	6.491**
	(2.732)	(2.680)	(1.057)	(2.860)	(4.198)	(3.253)
Economic growth	1.086***	0.889***	0.811***	1.356***	1.515***	1.471***
	(0.140)	(0.138)	(0.096)	(0.132)	(0.169)	(0.153)
Private investment	0.046	0.835***	0.068	-0.289	-0.223	-0.024
	(0.140)	(0.219)	(0.110)	(0.239)	(0.188)	(0.147)
Error correction	-0.532***	-0.536***	-0.560***	-0.553***	-0.490***	-0.507***
Observation	715	715	715	715	715	715
Log likelihood	-1937.99	-2061.15	-1942.14	-1931.81	-2016	-1955.76

*Note: ***, ** and *denote significance at 1 percent, 5 percent and 10 percent respectively*

V. *Conclusion and policy implications*

Driven by the fact that the governance environment plays a crucial role in the FDI – environmental quality relationship, the paper empirically investigates the difference in the FDI – environmental pollution relationship between developed countries and developing ones. By using S-GMM for the panel data of 31 developed countries with good governance environment and 55 developing countries with poor governance environment over the period of 2005-2018, we find that FDI stimulates CO_2 emissions in developing countries, supporting the pollution haven hypothesis, but reduces CO_2 emissions in developed countries, validating the pollution halo hypothesis. The robustness of these estimates is checked by the PMG estimator. The estimated results also show that economic growth increases CO_2 emissions in developing countries, but decreases in developed countries, which supports the environmental Kuznets curve. Besides, the governance environment and private investment are determinants of CO_2 emissions in both developed and developing countries.

The findings in this paper suggest some crucial implications in the design, formulation, and implementation of policies relating to the relationship between FDI and environmental quality. The implication is that the governance environment strongly decides the FDI – environmental quality relationship, and the good one not only improves environmental quality but sets up a helpful mechanism for this dynamic relationship as well. Therefore, governments should strongly implement institutional reforms to provide a conducive environment for the FDI – environmental quality relationship. We believe that reforming the governance environment in developing countries someday will create conditions to attract more FDI inflows and, in particular, these capital inflows will enhance environmental quality. Over time, the process of improving the governance environment will lead to high economic growth, more jobs, high income, and high living standards for people from increasing FDI. More importantly, developing countries need to find solutions to eliminate loopholes that enable officials and interest groups to seek rent.

By the way, we note that in this study, we rely on the institutional perspective to explain the difference in the FDI – environmental quality relationship between developed and developing countries. It is also the limitation of the study. Therefore, future research should focus on the relationship between FDI and environmental quality by sector/industry under different governance environments and other factors.

Appendix

Table 1A. Data Description

Variable	Definition	Type	Source
CO2 emissons	CO_2 emissions (metric tons per capita)	log	World Bank
FDI	Foreign direct investment, net inflows (% of GDP)	%	World Bank
Economic growth	GDP per capita (constant 2010 US$)	log	World Bank
Private investment	Domestic private sector's investment (% of GDP)	%	IMF
Trade openness	Trade is the sum of exports and imports of goods and services (% of GDP)	%	World Bank
Infrastructure	Fixed telephone subscriptions (per 100 people)	log	World Bank
Regulatory Quality Rule of Law Voice and Accountability Control of Corruption Government Effectiveness Political Stability	Dimensions of governance	level	World Bank

Table 2A. Descriptive Statistics for 31 Developed Countries

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2 emissons per capita	434	9.415	4.108	3.754	24.824
FDI	434	6.861	12.098	-58.322	86.610
GDP per capita	434	42212.8	19943.7	8014.6	111968
Private investment	434	17.456	4.229	7.875	36.544
Trade openness	434	113.247	90.361	20.685	442.62
Fixed telephone subscribers	434	45.932	12.466	9.800	74.616
Regulatory quality	434	1.487	0.707	-0.189	2.469
Rule of Law	434	1.502	0.476	0.197	2.436
Voice and Accountability	434	.840	0.562	-1.626	1.755
Control of Corruption	434	1.424	0.361	0.329	2.260
Government Effectiveness	434	1.455	0.467	0.267	2.100
Political Stability	434	1.200	0.390	-0.387	1.800

Table 3A. Descriptive Statistics for 55 Developing Countries

Variable	Obs	Mean	Std. Dev.	Min	Max
CO_2 emissons per capita	770	3.401	4.437	0.073	31.515
FDI	770	4.563	4.649	-5.208	50.018
GDP per capita	770	5998.5	7028.92	374.489	49576.7
Private investment	770	14.549	6.466	1.736	41.211
Trade openness	770	83.627	32.459	22.105	210.373
Fixed telephone subscribers	770	14.578	11.549	0.190	52.407
Regulatory quality	770	-0.232	0.694	-1.496	1.724
Rule of Law	770	-0.131	0.621	-1.553	1.572
Voice and Accountability	770	-0.212	0.775	-2.374	1.283
Control of Corruption	770	-0.053	0.566	-1.463	1.538
Government Effectiveness	770	-0.223	0.638	-1.617	1.555
Political Stability	770	-0.101	0.704	-1.748	1.292

ORCID
Van Bon Nguyen http://orcid.org/0000-0002-6281-9893

References

Abdouli, M. and S. Hammami (2017), "Economic growth, FDI inflows and their impact on the environment: an empirical study for the MENA countries", *Quality & Quantity*, *51*(1), pp.121-146.

Abdouli, M., O. Kamoun and B. Hamdi (2018), "The impact of economic growth, population density, and FDI inflows on CO_2 emissions in BRICTS countries: Does the Kuznets curve exist?", *Empirical Economics*, *54*(4), pp.1717-1742.

Agosin, M.R. and R. Machado (2005), "Foreign investment in developing countries: does it crowd in domestic investment?", *Oxford Development Studies*, *33*(2), pp.149-162.

Albulescu, C.T., A.K. Tiwari, S.M. Yoon and S.H. Kang (2019), "FDI, income, and environmental pollution in Latin America: Replication and extension using panel quantiles regression analysis", *Energy Economics*, 104504.

Al-Mulali, U. and C.F. Tang (2013), “Investigating the validity of pollution haven hypothesis in the gulf cooperation council (GCC) countries”, *Energy Policy*, *60*, pp.813-819.

Ansari, M.A., N.A. Khan and A.A. Ganaie (2019), “Does foreign direct investment impede environmental quality in Asian countries? A panel data analysis”, *OPEC Energy Review*, pp.1-27.

Arellano, M. and S. Bond (1991), “Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations”, *The Review of Economic Studies*, *58*(2), pp.277-297.

Arellano, M. and O. Bover (1995), “Another look at the instrumental variable estimation of error-components models”, *Journal of Econometrics*, *68*(1), pp.29-51.

Baek, J. (2016), “A new look at the FDI-income-energy-environment nexus: dynamic panel data analysis of ASEAN”, *Energy Policy*, *91*, pp.22-27.

Balsalobre-Lorente, D., K.K. Gokmenoglu, N. Taspinar and J.M. Cantos-Cantos (2019), “An approach to the pollution haven and pollution halo hypotheses in MINT countries”, *Environmental Science and Pollution Research*, pp.1-17.

Copeland, B.R. and M.S. Taylor (1994), “North-South trade and the environment”, *The Quarterly Journal of Economics*, *109*(3), pp.755-787.

Frutos-Bencze, D., K. Bukkavesa and N. Kulvanich (2017), “Impact of FDI and trade on environmental quality in the CAFTA-DR region”, *Applied Economics Letters*, *24* (19), pp.1393-1398.

Grossman, G.M. and A.B. Krueger (1995), “Economic growth and the environment”, *The Quarterly Journal of Economics*, *110*(2), pp.353-377.

Hanif, I., S.M.F. Raza, P. Gago-de-Santos and Q. Abbas (2019), “Fossil fuels, foreign direct investment, and economic growth have triggered CO_2 emissions in emerging Asian economies: some empirical evidence”, *Energy*, *171*, pp.493-501.

Hao, Y. and Y.M. Liu (2015), “Has the development of FDI and foreign trade contributed to China’s CO_2 emissions? An empirical study with provincial panel data”, *Natural Hazards*, *76*(2), pp.1079-1091.

Hille, E., M. Shahbaz and I. Moosa (2019), “The impact of FDI on regional air pollution in the Republic of Korea: A way ahead to achieve the green growth strategy?”, *Energy Economics*, *81*, pp.308-326.

Holtz-Eakin, D., W. Newey and H.S. Rosen (1988), “Estimating vector autoregressions with panel data”, *Econometrica: Journal of the Econometric Society*, pp.1371-1395.

Hope Sr, K.R. (2009), “Capacity development for good governance in developing countries: some lessons from the field. *Intertional Journal of Public Administration*, *32*(8), pp.728-740.

Jiang, L., Zhou, H.F., Bai, L. and Zhou, P. (2018), “Does foreign direct investment drive environmental degradation in China? An empirical study based on air quality index from a spatial perspective. *Journal of Cleaner Production*, *176*, 864-872.

Jiang, Y. (2015), “Foreign direct investment, pollution, and the environmental quality: A model with empirical evidence from the Chinese regions”, *The International Trade Journal*, *29* (3), pp.212-227.

Junxian, L., Q. Jingya and Z. Kai (2019), “Is China’s Development Conforms to the Environmental Kuznets Curve Hypothesis and the Pollution Haven Hypothesis?”, *Journal of Cleaner Production*, 234, pp.787-796.

Judson, R.A. and A.L. Owen (1999), "Estimating dynamic panel data models: a guide for macroeconomists", *Economics Letters*, *65*(1), pp.9-15.

Kim, M.H. and N. Adilov (2012), "The lesser of two evils: an empirical investigation of foreign direct investment-pollution tradeoff", *Applied Economics*, *44*(20), pp.2597-2606.

Kirkulak, B., B. Qiu and W. Yin (2011), "The impact of FDI on air quality: evidence from China", *Journal of Chinese Economic and Foreign Trade Studies*, *4*(2), pp.81-98.

Kaufmann, D., A. Kraay and M. Mastruzzi (2011), "The worldwide governance indicators: methodology and analytical issues", *Hague Journal on the Rule of Law*, *3*(2), pp.220-246.

Li, J.S. (2003), "Relation-based versus rule-based governance: An explanation of the East Asian miracle and Asian crisis", *Review of International Economics*, *11*(4), pp.651-673.

Li, S. and L. Filer (2007), "The effects of the governance environment on the choice of investment mode and the strategic implications", *Journal of World Business*, *42* (1), pp.80-98.

Liobikienė, G. and M. Butkus (2019), "Scale, composition, and technique effects through which the economic growth, foreign direct investment, urbanization, and trade affect greenhouse gas emissions", *Renewable energy*, *132*, pp.1310-1322.

Liu, Q., S. Wang, W. Zhang, D. Zhan and J. Li (2018), "Does foreign direct investment affect environmental pollution in China's cities? A spatial econometric perspective", *Science of the Total Environment*, *613*, pp.521-529.

Liu, Y., Y. Hao and Y. Gao (2017), "The environmental consequences of domestic and foreign investment: evidence from China", *Energy Policy*, *108*, pp.271-280.

Maddala, G.S. and S. Wu (1999), "A comparative study of unit root tests with panel data and a new simple test", *Oxford Bulletin of Economics and Statistics*, *61*(S1), pp.631-652.

Pazienza, P. (2019), "The impact of FDI in the OECD manufacturing sector on CO_2 emission: Evidence and policy issues", *Environmental Impact Assessment Review*, *77*, pp.60-68.

Pesaran, M.H., Y. Shin and R.P. Smith (1999), "Pooled mean group estimation of dynamic heterogeneous panels", *Journal of the American Statistical Association*, *94*(446), pp.621-634.

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

Ren, S., B. Yuan, X. Ma and X. Chen (2014), "International trade, FDI (foreign direct investment) and embodied CO_2 emissions: A case study of Chinas industrial sectors", *China Economic Review*, *28*, pp.123-134.

Roodman, D. (2009), "How to do xtabond2: An introduction to difference and system GMM in Stata", *The Stata Journal*, *9*(1), pp.86-136.

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

Shahbaz, M., D. Balsalobre-Lorente and A. Sinha (2019), "Foreign direct Investment-CO_2 emissions nexus in Middle East and North African countries: Importance of biomass energy consumption", *Journal of Cleaner Production*, *217*, pp.603-614.

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

Solarin, S.A., U. Al-Mulali, I. Musah and I. Ozturk (2017), "Investigating the pollution haven hypothesis in Ghana: an empirical investigation. *Energy*, *124*, pp.706-719.

Sung, B., W.Y. Song and S.D. Park (2018), "How foreign direct investment affects CO_2 emission levels in the Chinese manufacturing industry: Evidence from panel data", *Economic Systems*, *42*(2), pp.320-331.

Wang, H., C. Dong and Y. Liu (2019), "Beijing direct investment to its neighbors: A pollution haven or pollution halo effect?", *Journal of Cleaner Production*, *239*, pp.118062.

World Bank (2017), *World Development Report 2017: Governance and the Law*, Washington, DC: World Bank. doi: 10.1596/978-1-4648-0950-7. License: Creative Commons Attribution CC BY 3.0 IGO. Accessed online 20 February 2018.

Xie, Q. and Q. Sun (2020), "Assessing the impact of FDI on PM2.5 concentrations: A nonlinear panel data analysis for emerging economies", *Environmental Impact Assessment Review*, *80*, pp.106314.

Yu, Y. and W. Xu (2019), "Impact of FDI and R&D on China's industrial CO_2 emissions reduction and trend prediction", *Atmospheric Pollution Research*, *10*(5), pp.1627-1635.

Zhang, C. and X. Zhou (2016), "Does foreign direct investment lead to lower CO_2 emissions? Evidence from a regional analysis in China", *Renewable and Sustainable Energy Reviews*, *58*, pp.943-951.

Zhang, Y. and S. Zhang (2018), "The impacts of GDP, trade structure, exchange rate and FDI inflows on China's carbon emissions", *Energy Policy*, *120*, pp.347-353.

Zhu, H., L. Duan, Y. Guo and K. Yu (2016), "The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: evidence from panel quantile regression", *Economic Modelling*, *58*, pp.237-248.

Zhu, L., Q. Gan, Y. Liu and Z. Yan (2017), "The impact of foreign direct investment on SO_2 emissions in the Beijing-Tianjin-Hebei region: A spatial econometric analysis", *Journal of Cleaner Production*, *166*, pp.189-196.