Does the quality of institutions modify the economic growth-carbon dioxide emissions nexus? Evidence from a group of emerging and developing countries

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Does the quality of institutions modify the economic growth-carbon dioxide emissions nexus? Evidence from a group of emerging and developing countries

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ABSTRACT

The purpose of the study is to examine the impact of economic growth on carbon dioxide emissions dependent on the quality of institutions, for a sample of 93 emerging and developing countries over the period 1995–2014. We measured institutional quality using government effectiveness and control of corruption indicators. The GMM estimation results indicate that government effectiveness modifies the economic growth-emissions relationship. For low values of this institutional indicator, we found diminishing increments of CO_2 emissions as GDP grows. In the case of countries with high government effectiveness, we observed a statistically significant reduction in CO_2 emissions only in some specifications. We did not confirm the moderating role of the control of corruption in shaping the economic growth-carbon dioxide emissions nexus. These findings have important policy implications, suggesting that countries should direct efforts to improve the institutional background. Additionally, we provide empirical support for the presence of the inverted U-shaped relationship between economic growth and carbon dioxide emissions postulated by the environmental Kuznets curve (EKC).

1. Introduction

The constant deterioration of environmental quality is one of the most pressing problems facing the world and one of the most discussed issues in modern academic research. Excessive greenhouse gases (GHGs) emission is widely regarded as the predominant reason for the continued adverse climate change. This pressing issue has encouraged the governments of many countries to take political decisions in order to reduce emissions, yet most pollution still comes from developing economies, and consequently, the task of reducing emissions is virtually impossible.

One of the strands in the environmental and economic literature focuses on the relationship between economic growth and environmental quality. A sizeable amount of research on the environmental Kuznets curve (EKC), which has grown over recent decades, assigns great weight to the role of the country's level of economic development, measured by per capita income, in improvements in water and air quality. The EKC hypothesis propounds the existence of an inverted U-shaped relationship between per capita income and environmental quality. Initially, environmental quality worsens with per capita income, and then it improves as income rises after reaching a certain income threshold (Acaravci & Ozturk, 2010; Behera & Dash, 2017). This hypothesis was initially introduced and tested by Grossman and Krueger (1991).[1] Since then, numerous studies have examined it using various datasets and different econometric approaches; however, there is still no consensus in the literature regarding the potential reasons for such a relationship. Two possible explanations of the EKC shape point at factors related to structural change, going from agriculture through a heavy industry economy to information-intensive services and lighter manufacturing on the one hand, and growing environmental awareness among citizens of higher-income countries on the other (Dinda, 2004). Theoretically, along the economic development path, a clean environment becomes more appreciated, and the effectiveness of regulatory institutions improves (Dasgupta, Laplante, Wang, & Wheeler, 2002; Dinda, 2004; Kohler, 2013).

Despite decades of intensive research in this field of study, even the mere existence of the EKC is still questioned. The EKC hypothesis was supported by, among others, Apergis and Ozturk (2015), Apergis and Payne (2009), Apergis and Payne (2010), Aslan, Destek, and Okumus (2018), Atici (2009), Bilgili, Koçak, and Bulut (2016) (only for panel data), Farhani, Mrizak, Chaibi, and Rault (2014), Jalil and Mahmud (2009), Kasman and Duman (2015), Lau, Choong, and Eng (2014), Ozturk and Acaravci (2013), Öztürk and Öz (2016), Saboori, Sulaiman, and Mohd (2012a), Seker, Ertugrul, and Cetin (2015), Solarin, Al-Mulali, and Ozturk (2017), Tang and Tan (2015), Tiwari, Shahbaz, and Hye (2013), and Wawrzyniak (2018). On the other hand, the quadratic link was not confirmed by Abid (2016), Arminen and Menegaki (2019), Begum, Sohag, Abdullah, and Jaafar (2015), Chandran and Tang (2013), Mert and Bölük (2016), Ozturk and Al-Mulali (2015), Özokcu and Özdemir (2017), Pablo-Romero and De Jesús (2016), and Saboori, Sulaiman, and Mohd (2012b).[2]

Our study goes one step further in relation to the literature studying the economic growth-emissions nexus, as we revisit and reinterpret this relationship against the background of institutional quality. We argue and provide empirical evidence that it is not the increase in per capita income alone that contributes to the improvement of environmental quality, rather the institutional factors accompanying economic growth. In such a way we explore one of the potential explanations of the inverted U-shaped EKC, which emphasises the improvement of regulatory institutions resulting from the change of people's preferences regarding the protection of the natural environment as their income rises (Dinda, 2004). In our empirical procedure, we first verify the EKC hypothesis, as it serves as a starting point in our analysis. We then modify it, assuming the moderating role of institutional quality on the relationship between GDP and carbon dioxide (CO_2) emissions. In other words, this paper

examines the impact of per capita GDP on CO_2 emissions, conditional on the quality of institutions. As this research issue is somewhat underexplored, the main motivation of the article is to improve the understanding of the economic growth-emissions nexus and fill the research gap in the existing literature. Moreover, we test the impact of both renewable and fossil fuel energy consumption, while the majority of papers on CO_2 emissions investigate the effect of non-renewables or total energy consumption (Bilgili et al., 2016). We also contribute to the literature by analysing the impact of the inflow of foreign direct investment (FDI) and personal remittances on environmental degradation. A sample of 93 emerging and developing countries over the period 1995–2014 is utilised.

The paper is structured as follows. Section 2 reviews the literature. Section 3 introduces the econometric methods and describes the data used in our analysis, Section 4 reports and discusses empirical results, and finally, Section 5 concludes.

2. Literature review

To the best of our knowledge, only a limited number of studies have investigated the impact of institutional background on carbon dioxide emissions. In an analysis covering 14 Asian countries over the period 1990–2011, Apergis and Ozturk (2015) controlled for four institutional quality indicators, namely political stability and absence of violence, government effectiveness, quality of regulations and corruption control. The scholars found that all the analysed institutional quality indicators determined CO_2 emissions in a statistically significant manner. In another study, Ozturk and Al-Mulali (2015) concluded that incorporating variables which reflected control of corruption and government effectiveness did not lead to the confirmation of the inverted U-shaped relationship between CO_2 emissions and per capita income for Cambodia, though an improvement of institutional factors could reduce pollution. Abid (2016) investigated the impact of the institutional framework on CO_2 emissions using a sample of Sub-Saharan Africa countries between 1996 and 2010 and employed different institutional quality indices. He found that political stability, government effectiveness, democracy, and control of corruption contribute to a reduction in pollution, while an improvement of regulatory quality and rule of law lead to environmental degradation. This ambiguous result was interpreted using economic expansion as an intermediary variable between institutions and CO_2 emissions and scale effect experienced by the economies under study. Gani (2012) utilised the sample of 99 developing economies to test the impact of five institutional quality indicators, i.e. political stability, rule of law, control of corruption, government effectiveness, and regulatory quality. The scholar concluded that the first three measures are inversely and statistically significantly correlated with CO_2 emissions per capita while the effect of the last two was not confirmed. Gholipour and Farzanegan (2018), analysing Middle East and North Africa countries between 1996 and 2015, found that the effectiveness of government environmental protection spending facilitates a reduction in both PM10 and CO_2 emissions. Cole (2007) investigated the direct and indirect (by means of economic growth) effect of corruption on CO_2 emissions using a sample of 94 countries from 1987 to 2000. The researcher provided empirical evidence that corruption had a

positive direct and a negative indirect effect on per capita CO_2 emissions. As the direct effect was outweighed in absolute terms by the indirect effect, the total influence of corruption on emissions was found to be negative for most of the countries analysed. More recently, Zhang, Jin, Chevallier, and Shen (2016)[3] examined both of the abovementioned effects for Asia-Pacific Economic Cooperation countries over the period 1992–2012 and concluded that corruption may reduce environmental quality overall. Biswas, Farzanegan, and Thum (2012) analysed a panel of more than 100 countries between 1999 and 2005 and found the impact of the shadow economy on CO_2 emissions to be dependent on corruption level, as it was less destructive for lower levels of corruption. Goel, Herrala, and Mazhar (2013) also addressed the issue of corruption, the shadow economy and carbon dioxide emissions using data for more than 100 countries between 2004 and 2007; their study demonstrated that both higher corruption and a larger shadow economy resulted in lower recorded pollution levels. Arminen and Menegaki (2019), utilising a sample of high- and upper-middle-income countries from 1985 to 2011, did not find a statistically significant role of control of corruption in the energy-environment-growth nexus. Thus, they argued that control of corruption is of relatively little importance in mitigating CO_2 emissions. Wang, Danish, Zhang, and Wang (2018) investigated the moderating role of corruption on the economic growth-CO_2 emissions relationship using a sample of BRICS countries over the period 1996–2016 and found that corruption reduces the strength of the link between economic growth and CO_2 emissions. The scholars concluded that control of corruption results in a decline in air pollution. In a study by Kudłak (2019) for the European Union member states, Switzerland and Norway institutions were proxied with experts' survey assessments. According to the results of the research, national environmental regulations, environmental subsidies and corporate social responsibility reduce pollution. Farzanegan and Markwardt (2018) utilised a panel of 17 Middle Eastern and North African countries between 1980 and 2005. They confirmed the modifying role of the quality of democratic institutions in the case of SO_2 pollution, but it was not statistically significant for CO_2 emissions. The moderating impact of political and institutional factors on CO_2 emissions elasticity of GDP was also studied by Laegreid and Povitkina (2018) for 140 countries over the period 1972–2014. The results indicated a modifying role, albeit weak, of democratic institutions and lack of corruption, and the more profound impact of civil society participation. The pattern of moderation shows that in countries with a low level of per capita GDP, institutional factors contribute to higher CO_2 elasticity with respect to per capita GDP. This impact changes with rising per capita GDP, and CO_2 release is decoupled from economic growth in rich economies.

Our study differs from previous research in three main aspects. Firstly, it is one of the relatively few analyses taking into account the moderating role of institutional factors on the economic growth-CO_2 emissions relationship. Moreover, the estimation results are accompanied by a graphical presentation of the marginal effects of per capita GDP on CO_2 emissions as institutional quality changes. Incorporating figures makes it possible to interpret these effects through the entire range of institutional factors. Secondly, we incorporate into our models renewable energy consumption, while most studies related to EKC are based on either total or fossil fuel energy

consumption (Bilgili et al., 2016). Thirdly, we control for foreign direct investment inflows and personal remittances received, as these variables may be of particular importance due to their potential impact on both economic growth and environmental pollution, given the sample analysed.

3. Methodology and data

The economic growth-emissions relationship is commonly analysed within the EKC context. Most studies use the quadratic form of the relationship (see, inter alia, Ang, 2007; Apergis & Payne, 2010; Arouri, Youssef, M'henni, & Rault, 2012; Kasman & Duman, 2015):

$$\ln Poll_{it} = \alpha_0 + \alpha_1 Y_{it} + \alpha_2 Y_{it}^2 + \alpha_3 EC_{it} + \varepsilon_{it} \tag{1}$$

where *Poll*, *Y*, Y^2, and *EC* stand for the environmental pollution indicator, income, squared income and energy consumption, respectively.

The EKC hypothesis serves as a starting point in our empirical investigation, and thus we begin our analysis by examining whether the inverted U-shaped relationship between economic growth and CO_2 is supported for the analysed group of countries. We utilise CO_2 emissions as an environmental degradation indicator because this gas is considered to be a primary anthropogenic greenhouse gas, constituting ca. 73% of total greenhouse gases (Olivier & Peters, 2018).

Many studies that estimate the EKC use energy consumption as an explanatory variable, but the recent literature criticises such an approach. Statistics for CO_2 emissions are calculated using energy consumption data, which means that they are closely related (see, e.g. Arminen & Menegaki, 2019; Burnett, Bergstrom, & Wetzstein, 2013; Itkonen, 2012; Jaforullah & King, 2017), and thus using energy consumption may result in estimation bias. Taking this into consideration, we replace the energy consumption variable with two other regressors, namely renewable energy consumption and fossil fuel energy consumption. We follow Arminen and Menegaki (2019) and calculate fossil fuel energy consumption per capita (*FF)* as a product of energy use (in kg of oil equivalent per capita) and the share of fossil fuel energy consumption. In line with Bilgili et al. (2016) we compute renewable energy consumption per capita (*RNEW*) as the share of combustible renewables and waste in total energy multiplied by energy use (in kg of oil equivalent per capita). We also control for foreign direct investment inflows per capita and personal remittances received per capita as these variables may exert a substantial impact on both economic growth and CO_2 emissions, which can be even more pronounced in emerging and developing countries (cf. Pradhan, Arvin, Hall, & Nair, 2017).

Finally, we verify the EKC hypothesis employing the following equation:

$$\begin{aligned} CO2_{it} = {} & \alpha_0 + \alpha_1 Y_{it} + \alpha_2 Y_{it}^2 + \alpha_3 CO2_{it-1} + \alpha_4 FF_{it} + \alpha_5 RNEW_{it} + \alpha_6 REM_{it} \\ & + \alpha_7 FDI_{it} + \mu_t + \varepsilon_{it} \end{aligned} \tag{2}$$

where *CO2* is carbon dioxide emissions (measured in metric tons per capita), *Y* denotes the per capita GDP (in constant 2010 US\$), *RNEW* stands for renewable

energy consumption per capita, *FF* is fossil fuel energy consumption per capita, *REM* represents personal remittances received per capita (in constant 2010 US\$), and *FDI* denotes foreign direct investment inflows per capita (in constant 2010 US\$). All variables were transformed into two-year averages, to weaken measurement errors and cyclical fluctuations, and then log-transformed.[4] The base specification also includes time-fixed effects (μ_t). The subscripts *i* and *t* denote country and time period, respectively.

Under the EKC hypothesis, we expect the sign of α_1 to be positive, while for α_2 a negative sign. Following Bilgili et al. (2016), we anticipate that renewable energy consumption (as a clean source of energy power) will reduce CO_2 emissions. Consequently, we expect fossil fuel energy consumption to increase CO_2 emissions. We anticipate a positive relationship between CO_2 emissions and remittances as their inflow facilitates economic growth and thus contributes to environmental degradation (Ahmad et al., 2019). The sign on FDI might be either positive or negative (Rahman, Hongbo, & Ahmad, 2019). FDI inflow may reduce pollution levels if it brings advanced and clean technologies. However, in the case of the pollution-haven effect, the inflow of FDI increases pollution as countries with less stringent environmental regulations attract pollution-intensive technologies. We expect the latter effect to be stronger as we focus on emerging and developing countries, which attract dirty technologies from developed countries (Rahman, Chongbo, & Ahmad, 2019).

One of the possible explanations of the inverted U-shaped EKC is based on the quality of regulatory institutions, which improves with economic growth. This tendency reflects the fact that with rising income, people value the environment more (Dinda, 2004). We build upon this line of reasoning and develop a model in which the impact of per capita GDP is moderated by institutional quality. In other words, we claim that economic growth does not provide environmental protection itself; instead, it is the institutional factors accompanying the economic expansion that contribute to the improvement in environmental quality. Therefore, we investigate the impact of economic growth on air pollution, conditional on institutional quality.

To test the relationship between institutional quality and CO_2 emissions, we estimated the following equation:

$$CO2_{it} = \beta_0 + \beta_1 Y_{it} + \beta_2 QI_{it} + \beta_3 Y_{it}QI_{it} + \beta_4 FF_{it} + \beta_5 RNEW_{it} + \beta_6 CO2_{it-1} + \beta_7 REM_{it} + \beta_8 FDI_{it} + \mu_t + \varepsilon_{it} \tag{3}$$

where *QI* is the institutional quality indicator. Two measures of the quality of institutions were used on an alternative basis, namely government effectiveness (*GE*) and control of corruption (*CC*). These indicators were chosen due to their potential influence on CO_2 emissions. The indicators were standardised to have a mean of 0 and a standard deviation equal to 1. The base specification also includes time-fixed effects (μ_t). The subscripts *i* and *t* denote country and time period, respectively.

To estimate our models, we use a sample of 93 emerging and developing countries over the period 1995–2014. The data originate from the World Development Indicators (WDI) database of the World Bank. Our analysis ends in the year 2014 as this is the last year for which the CO_2 emissions data are available. The two institutional indicators were obtained from the World Governance Indicators (WGI)

Table 1. Summary statistics.

Variable	Mean	Std. Dev.	Min	Max
CO2	0.174	1.623	−4.108	4.183
Y	7.899	1.219	5.256	11.137
RNEW	4.108	1.890	−2.054	7.791
FF	6.268	1.518	1.607	10.004
REM	3.709	1.914	−4.816	7.348
FDI	4.208	1.992	−8.304	8.819
GE	0.000	1.000	−2.784	2.694
CC	0.000	1.000	−2.028	2.999

Source: own calculations.

database, which follows the methodology of Kaufmann, Kraay, and Mastruzzi (2010). As other data, the indicators were transformed into two-year averages. The descriptive statistics for all variables are given in Table 1.

We expect that the impact of economic development on CO_2 emissions will be dependent on the quality of institutions. We hypothesise that as per capita GDP rises, the better the quality of the institution, the greater the reduction in CO_2 emissions. It should be noted that following the suggestion of Brambor, Clark, and Golder (2006) we estimate the fully specified model, i.e. including all the constitutive terms (Y, QI) and the interaction term ($Y \times QI$).

Since the presented models (2) and (3) contain the lagged dependent variable, we employ the first-difference general methods of moments (GMM) estimator by Arellano and Bond (1991).[5] This estimation technique was developed to estimate dynamic panel data models, and it addresses both the simultaneity and adverse causality problems (Roodman, 2009b). The GMM difference estimator takes the first difference of the regression equation and eliminates bias related to time-invariant unobserved heterogeneity. It then utilises lagged values of the explanatory variables as instruments in the differenced equation. One of the benefits of applying such an estimator is that it uses internal instrumental variables, which partly solves the problem of finding good external instruments (Roodman, 2009a). Although this technique is appropriate in the cases of short and wide panels, it may lead to biased estimates due to instrument proliferation as the time dimension grows. We reduced the instrument count and included only a limited number of lags in our regression to keep the number of instruments below the number of countries. Specifically, when estimating Equations (2) and (3), we used lags 2–3 of the variables Y, FF, $RNEW$, $CO2_{t-1}$, REN and FDI in the full specification of the model and Y, FF, $RNEW$, and $CO2_{t-1}$ in the reduced form. We test the joint validity of instruments using Hansen's (1982) test of overidentifying restrictions, which in our case fails to reject the null hypothesis that the overidentifying restrictions are valid. We also report the Arellano–Bond test for first- and second-order autocorrelation, which suggests autocorrelation of order 1 and no autocorrelation of order 2 in our data. Consequently, the Arellano–Bond model assumptions are satisfied. The p-values of the Wald χ^2 statistics indicate the joint significance of the explanatory variables. We did not test the stationarity of data because of the relatively short time dimension, as in such a case, the tests are not reliable. According to Arminen and Menegaki (2019), it is probable that our data are I(1) and thus we estimate a long-run relationship between CO_2 emissions and its determinants, like Abid (2016).

4. Results and discussion

Table 2 shows the GMM estimation results of testing the EKC hypothesis. The coefficients on per capita GDP and its square term are statistically significant and have the expected signs for the reduced model (columns 3–4), thus confirming the presence of an inverted U-shaped relationship between CO_2 emissions and economic growth. However, the estimation results for the fully specified model (columns 1–2) are ambiguous, as the U-shaped relationship is evidenced only for the model without time-fixed effects (column 2). The impact of fossil fuel energy consumption is positive and significant, as anticipated, while the effect of renewable energy consumption is always insignificant. We found no impact of foreign direct investment inflows and personal remittances received on CO_2 emissions.

Tables 3 and 4 present the GMM estimates of Equation (3) using different proxies for institutional quality – the government effectiveness indicator and control of corruption, respectively. Columns 1 and 3 contain the results for models with time-invariant effects while columns 2 and 4 without. Here, we focus on interpreting the estimates obtained from the equations including time-fixed effects. This makes the assumption that there will be no correlation across individuals in the idiosyncratic disturbances is more likely to be met (Roodman, 2009b).

The coefficients on lagged CO_2 emissions and fossil fuel energy consumption are, as expected, positive and statistically significant across all models, which indicates the persistence in the CO_2 emissions and the increase of CO_2 emissions as fossil fuel use rises, respectively. Again, renewable energy consumption, foreign direct investment

Table 2. Estimations results of the EKC hypothesis.

Variables	(1)	(2)	(3)	(4)
Y	0.6020*	1.0337*	1.0378**	1.7095**
	(0.342)	(0.537)	(0.441)	(0.723)
Y^2	−0.0273	−0.0610**	−0.0587**	−0.1008**
	(0.019)	(0.029)	(0.029)	(0.042)
$CO2_{t-1}$	0.3937***	0.2419**	0.3935***	0.1647
	(0.077)	(0.121)	(0.085)	(0.135)
FF	0.6272***	0.6668***	0.6177***	0.6748***
	(0.067)	(0.095)	(0.098)	(0.132)
RNEW	−0.0062	0.0523	0.0247	0.0801
	(0.039)	(0.050)	(0.053)	(0.075)
REM	−0.0016	0.0019		
	(0.012)	(0.014)		
FDI	0.0032	0.0001		
	(0.011)	(0.011)		
Time dummies	Yes	No	Yes	No
N	640	640	728	728
Number of ids	91	91	93	93
AR(1) (*p*-value)	0.002	0.112	0.002	0.320
AR(2) (*p*-value)	0.767	0.814	0.535	0.813
Hansen's (*p*-value)	0.563	0.327	0.699	0.306
Number of instruments	96	88	66	58
Wald (χ^2)	1078.0	996.5	1027.0	658.3
Wald (χ^2) (*p*-value)	0.000	0.000	0.000	0.000

Notes: Heteroscedasticity and autocorrelation robust standard errors in parentheses.
Asterisks indicate significance at levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Instruments used: *Y, FF, RNEW, CO2_{t-1}, REM, FDI* - lags 2 to 3 (columns 1 and 2), *Y, FF, RNEW, CO2_{t-1}* - lags 2 to 3 (columns 3 and 4).
Source: own calculations.

Table 3. Estimation results of the interaction model with GE as a modifying variable.

Variables	(1)	(2)	(3)	(4)
Y	0.1289	0.0284	0.1093	0.0789
	(0.082)	(0.075)	(0.104)	(0.077)
GE	0.4830	0.8927**	0.8581*	1.2670**
	(0.333)	(0.367)	(0.441)	(0.561)
$Y \times GE$	−0.0661	−0.1160**	−0.1102*	−0.1641**
	(0.043)	(0.047)	(0.057)	(0.070)
FF	0.6139***	0.6413***	0.6662***	0.6809***
	(0.071)	(0.092)	(0.089)	(0.120)
RNEW	−0.0080	0.0161	−0.0128	−0.0235
	(0.040)	(0.046)	(0.056)	(0.068)
$CO2_{t-1}$	0.4308***	0.3726***	0.4390***	0.3343***
	(0.075)	(0.090)	(0.094)	(0.123)
REM	0.0012	0.0080		
	(0.011)	(0.013)		
FDI	0.0052	0.0009		
	(0.010)	(0.010)		
Time dummies	Yes	No	Yes	No
N	640	640	728	728
Number of ids	91	91	93	93
AR(1) (*p*-value)	0.001	0.009	0.004	0.029
AR(2) (*p*-value)	0.851	0.781	0.455	0.361
Hansen's (*p*-value)	0.540	0.442	0.681	0.515
Number of instruments	96	88	66	58
Wald (χ^2)	935.3	700.0	743.3	491.7
Wald (χ^2) (*p*-value)	0.000	0.000	0.000	0.000

Notes: Heteroscedasticity and autocorrelation robust standard errors in parentheses.
Asterisks indicate significance at levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Instruments used: Y, FF, RNEW, $CO2_{t-1}$, REM, FDI - lags 2 to 3 (columns 1 and 2), Y, FF, RNEW, $CO2_{t-1}$ - lags 2 to 3 (columns 3 and 4).
Source: own calculations.

Table 4. Estimation results of the interaction model with CC as a modifying variable.

Variables	(1)	(2)	(3)	(4)
Y	0.1151	−0.0345	0.0922	0.0426
	(0.085)	(0.073)	(0.127)	(0.082)
CC	0.5377	0.6544	0.8527	1.1037*
	(0.394)	(0.455)	(0.554)	(0.567)
$Y \times CC$	−0.0550	−0.0700	−0.0897	−0.1264*
	(0.048)	(0.055)	(0.068)	(0.072)
FF	0.6108***	0.6311***	0.6709***	0.7014***
	(0.077)	(0.095)	(0.098)	(0.118)
RNEW	0.0057	0.0387	0.0063	−0.0352
	(0.045)	(0.051)	(0.057)	(0.068)
$CO2_{t-1}$	0.4289***	0.3621***	0.4132***	0.2823**
	(0.071)	(0.086)	(0.091)	(0.113)
REM	0.0069	0.0187		
	(0.011)	(0.013)		
FDI	0.0045	0.0038		
	(0.011)	(0.010)		
Time dummies	Yes	No	Yes	No
N	640	640	728	728
Number of ids	91	91	93	93
AR(1) (*p*-value)	0.001	0.008	0.016	0.145
AR(2) (*p*-value)	0.686	0.569	0.431	0.233
Hansen's (*p*-value)	0.465	0.429	0.455	0.318
Number of instruments	96	88	66	58
Wald (χ^2)	863.8	686.5	598.7	473.4
Wald (χ^2) (*p*-value)	0.000	0.000	0.000	0.000

Notes: Heteroscedasticity and autocorrelation robust standard errors in parentheses.
Asterisks indicate significance at levels: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Instruments used: Y, FF, RNEW, $CO2_{t-1}$, REM, FDI - lags 2 to 3 (columns 1 and 2), Y, FF, RNEW, $CO2_{t-1}$ - lags 2 to 3 (columns 3 and 4).
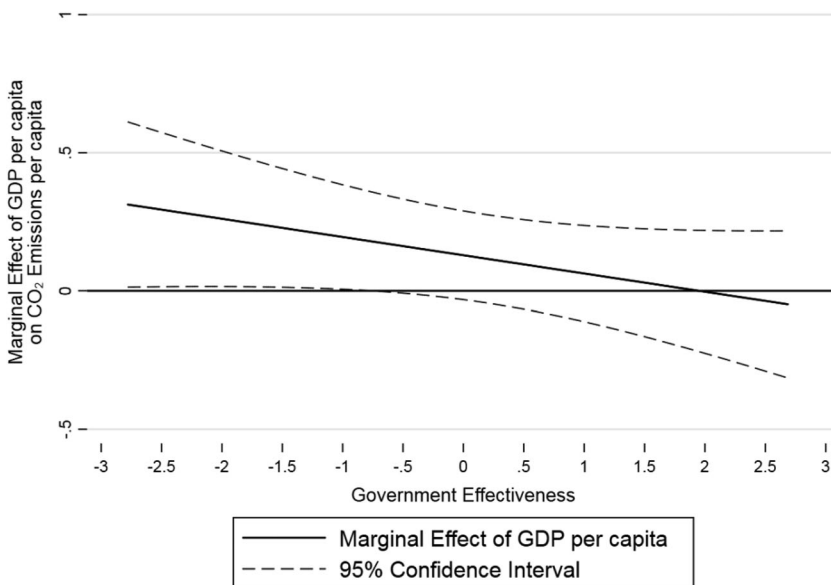*Source:* own calculations.

inflows, and personal remittances received do not affect CO_2 emissions in a statistically significant manner.

To investigate the conditional effect of institutions on environmental quality, we calculate the marginal effect of per capita GDP on CO_2 emissions as institutional quality changes. Mathematically, it is given by the expression:[6]

$$\partial CO2/\partial Y = \beta_1 + \beta_3 QI \qquad (4)$$

Using the GMM estimate results with time-fixed effects reported in column 1 of Table 3, we depict the conditional effect of economic growth on CO_2 emissions (vertical axis) at different levels of the governmental effectiveness index (horizontal axis) (cf. Figure 1). Figure 2 illustrates the analogous effect for the reduced form of the model, which corresponds to the results in column 3 of Table 3. Figures 3 and 4 depict the same effects for our second institutional quality proxy (control of corruption indicator). The graphical presentation of marginal effects calculated using models without time-fixed effects is presented within Appendix B (Figures B1–B4). The effects, indicated by the solid lines, are considered statistically significant only when the dashed lines representing the upper and lower bounds of the two-tailed 95% confidence interval are both above or below the horizontal axis.
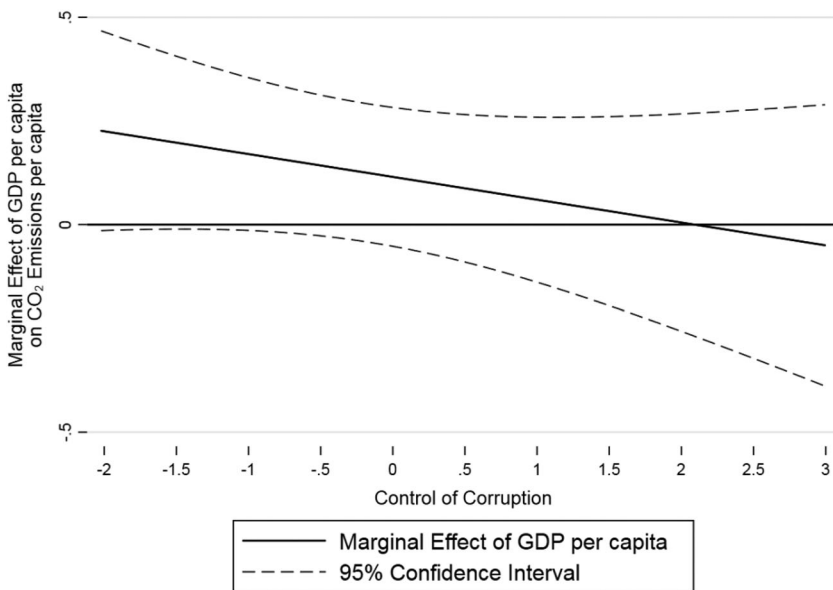
The marginal effect of per capita GDP on CO_2 emissions in Figures 1 and 2 is positive and statistically significant only in cases of lower than sample average levels of institutional quality measured by the governmental effectiveness index. As per capita GDP grows, its impact on CO_2 emissions declines and becomes statistically insignificant. The conditional effect of per capita GDP becomes negative for relatively high institutional quality values but is statistically insignificant (at the 0.05 level of significance). These results indicate that the impact of economic growth on CO_2

Figure 1. The marginal effect of per capita GDP on CO_2 emissions as government effectiveness changes based on estimation with time fixed effects (full specification). *Source:* own calculations.
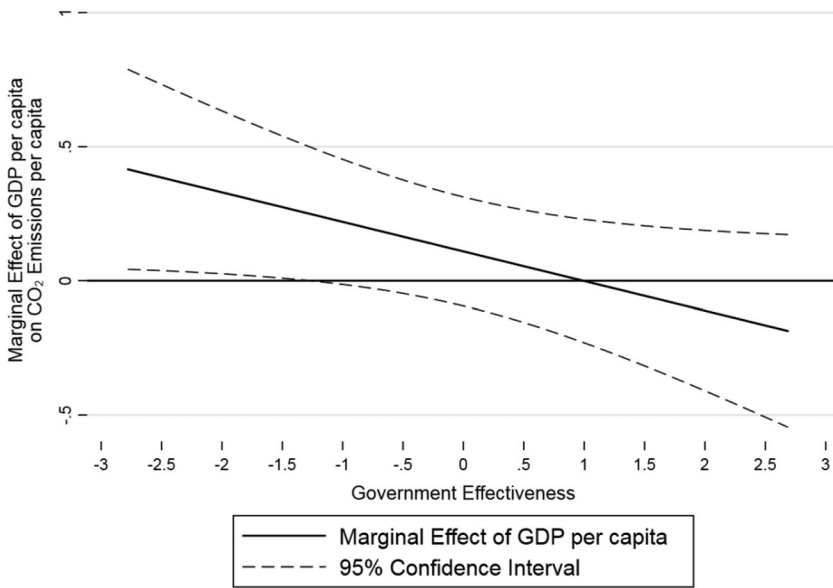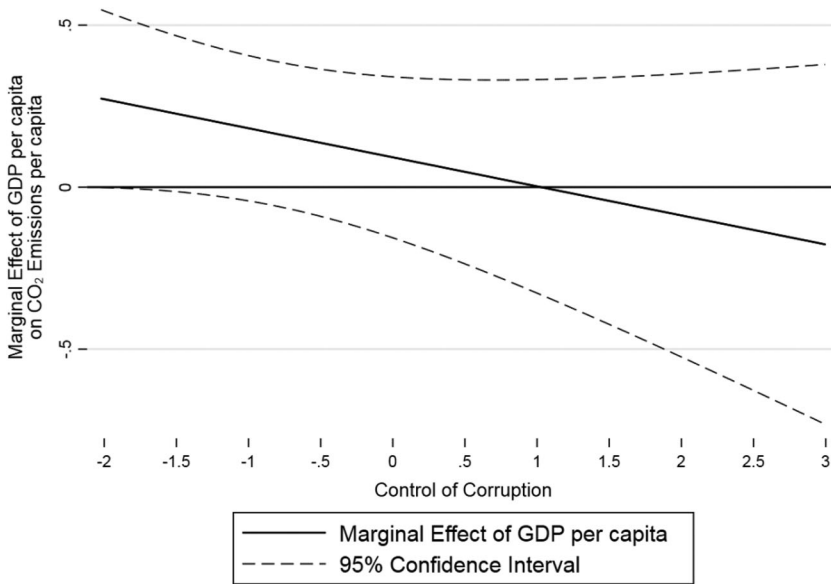
Figure 2. The marginal effect of per capita GDP on CO_2 emissions as government effectiveness changes based on estimation with time fixed effects (reduced specification). *Source:* own calculations.

Figure 3. The marginal effect of per capita GDP on CO_2 emissions as control of corruption changes based on estimation with time fixed effects (full specification). *Source:* own calculations.

emissions is related to the country's level of institutional quality measured by government effectiveness. In economies with relatively weak institutions, the rise of GDP contributes to an increase in CO_2 emissions, with constantly diminishing increments. Thus, the results do not confirm the expected negative impact of economic growth

Figure 4. The marginal effect of per capita GDP on CO_2 emissions as control of corruption changes based on estimation with time fixed effects (reduced specification). *Source:* own calculations.

on CO_2 emissions, conditional on government effectiveness. It should be noted, however, that we focus exclusively on emerging and developing counties, in which institutional quality remains relatively week. This may possibly explain the insignificant relationship for government effectiveness values higher than the sample average, as the values of the government effectiveness indicator remain relatively low in comparison with developed economies. The negative and statistically significant marginal effect of GDP on CO_2 emissions was observed when estimating model 3 without time dummies (cf. Figures B1 and B2 in Appendix B). This suggests that in economies with relatively strong institutional background, the rise of GDP may contribute to the reduction of environmental pollution. However, this finding should be treated with caution as the estimates of the model without time-fixed effect are less reliable.

Figures 3 and 4 depict the marginal effect of GDP on CO_2 emissions, conditional on the control of corruption. The effect of interest remains insignificant across all levels of the control of corruption indicator. Thus, we do not confirm the moderating role of *CC* in shaping the economic growth-carbon dioxide emissions nexus. This finding holds in the case of models without time dummies, as illustrated by Figures B3 and B4 in Appendix B.

As theorised by Dasgupta, Wheeler, Mody, and Roy (2001), and Dasgupta et al. (2002), environmental pollution may be related to the efficiency of legal and regulatory institutions, which is closely allied with legal tools for regulating, monitoring, and enforcing compliance with regulations. We assume that this effect is captured mainly by the government effectiveness indicator, which proxies, among others, the quality of policy formulation, its implementation, and the government's commitment to policies undertaken. The control of corruption indicator also reflects the same effect, to some degree, but given the estimation results we infer that the relationship

is less straightforward. Thus, we conclude that the actual impact of economic growth on CO_2 emissions, conditional on the level of institutional quality, depends on the institutional indicator used.

The impact of government effectiveness on CO_2 emissions was addressed in previous research by Abid (2016) and Ozturk and Al-Mulali (2015), who found a negative relationship between this indicator and emissions. Our results lend partial support to their findings, albeit our analysis differs as those scholars did not test the interaction effect. Apergis and Ozturk (2015) also explored the impact of the government effectiveness indicator on CO_2 emissions and confirmed its role in emissions reduction, but the interaction effect of government effectiveness and GDP was statistically insignificant. Our results for control of corruption are generally in line with the findings by Arminen and Menegaki (2019), as their study did not provide support for the impact of corruption. On the other hand, the moderating role of corruption on the economic growth-CO_2 emissions relationship was found by, e.g. Wang et al. (2018). These ambiguous results call for further empirical exploration of the relationship.

Recalling our hypothesis, economic growth does not solve the pollution problem itself, and thus environmental policy should not focus solely on growth but also take into consideration the institutional background underlying the pollution-economic growth nexus. Based on our findings, we argue that countries with weak institutions may not experience a decline in CO_2 emissions despite economic growth but improving institutional quality may result in diminishing increments of pollution growth as income rises. Therefore, our study suggests that actions aimed at improving institutional quality may also mitigate climate change.

5. Conclusions

This study presents a different perspective on the economic growth-emissions nexus, as it reinterprets this relationship through the lens of institutional quality. The main goal of this paper was to investigate the impact of per capita GDP on carbon dioxide emissions, conditional on the quality of institutions. Using annual data from 93 emerging and developing countries over the period 1995–2014, we found that an improvement in institutional quality may result in diminishing increments of CO_2 emissions growth as GDP increases. The evidence of a decline in CO_2 emissions with rising GDP, dependent on the quality of institutions, is less obvious, as the relationship was statistically significant only in some regressions. However, we argue that the results of our study do not indicate that countries with a strong institutional background will not experience a decline in CO_2 emissions with rising per capita GDP as our sample was comprised only of emerging and developing economies, in which institutional quality remains relatively week. Moreover, our study found that the moderating impact of institutional quality depends on the proxy used, as the effect was more pronounced for the government effectiveness indicator. In light of our results, this indicator proved to be of greater importance than the control of corruption. We also confirmed the presence of the environmental Kuznets curve for the country sample under analysis.

Future emissions reduction is the key challenge for today's policies regarding environmental protection and sustainable development, and therefore, it is one of the biggest issues facing the modern world. Our study has important policy implications, especially for countries with relatively weak institutional background. According to our findings, the abovementioned group of economies is more exposed to a deterioration of environmental quality as a result of economic expansion; consequently, one-dimensional actions aimed at mitigation emissions that focus solely on growth may not bring the expected outcomes in terms of reducing environmental pollution. Thus, we call for multidimensional actions in order to reduce carbon dioxide emissions, taking into consideration not only emissions limits or carbon taxation, but also actions aimed at facilitating the institutional development of emerging and developing economies. The results of our study show that improving institutional factors may contribute to the betterment of the environment, as with stronger institutions, GDP growth may lead to slower growth of CO_2 emissions. In our opinion, this finding is of crucial importance considering the fact that emerging and developing countries will be trying to grow faster to catch up with the developed economies, thus endangering what has already been achieved in terms of decarbonisation. In line with Abid (2016), our study suggests that economic growth may not be the only solution to address the deterioration of the environment. We anticipate that actions aimed at environmental protection will be more efficient if accompanied by institutional quality improvement. In light of our results, government effectiveness may help to mitigate emissions.

Since our study enables us to draw only some preliminary conclusions about the moderating role of quality of institutions in the economic growth-carbon dioxide emissions nexus, there are still some issues that require further investigation. Firstly, as new data become available, research should continue with the more recent data. Secondly, our study is limited to emerging and developing countries, and thus future research should be extended to advanced countries. Lastly, the panel data research should be accompanied by time-series estimations that focus on individual countries. This may give more insight into the idiosyncratic role of institutional quality improvement. We also call for the development of theoretical models that incorporate modifying variables that should be used to further explore the economic growth-pollution nexus.

Notes

1. For further details on the EKC hypothesis, see inter alia Coondoo and Dinda (2002), Dinda (2004), and Stern (2004).
2. For a survey of empirical studies, see also Al-Mulali, Solarin, and Ozturk (2016), Bilgili et al. (2016), Dogan and Seker (2016), Özokcu and Özdemir (2017), Ozturk and Al-Mulali (2015), Solarin et al. (2017), and Zoundi (2017).
3. See Zhang et al. (2016) for an excellent review of older studies on the corruption-pollution relationship.
4. The data definitions and sources are given in Table A1 (Appendix A).
5. Stata command xtabond2.
6. To improve clarity, we have omitted time and cross section subscripts.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix A. Data definitions and sources

**Table A1.** Data definitions and sources.

| Name	Definition	Source
CO_2 emissions	CO_2 emissions (in metric tons per capita)	World Development Indicators (WDI) database of the World Bank
Per capita GDP	GDP per capita expressed at market prices (constant 2010 US$)	World Development Indicators (WDI) database of the World Bank
Quality of institutions	Government effectiveness indicator/ Control of corruption indicator The missing data for 1997, 1999 and 2001 is calculated as means of adjacent years. The index is normalized to have a mean of 0 and a standard deviation equal to 1	World Governance Indicators (WGI) database, which follows the methodology of Kaufmann et al. (2010)
Fossil fuel energy consumption	Fossil fuel energy consumption per capita calculated as a product of energy use (in kg of oil equivalent per capita) and the share of fossil fuel energy consumption	World Development Indicators (WDI) database of the World Bank
Renewable energy consumption	Renewable energy consumption per capita calculated as a product of energy use (in kg of oil equivalent per capita) and the share of combustible renewables and waste in total energy	World Development Indicators (WDI) database of the World Bank
Remittances inflow	Personal remittances, received (in constant 2010 US$) calculated with GDP deflator	World Development Indicators (WDI) database of the World Bank
FDI inflow	Foreign direct investment, net inflows (in constant 2010 US$) calculated with GDP deflator	World Development Indicators (WDI) database of the World Bank

Source: own calculations.

List of Emerging & developing countries used in the study (classification according to the International Monetary Fund):

Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Cambodia, Cameroon, Chile, China, Colombia, the Democratic Republic of the Congo, the Republic of the Congo, Costa Rica, Croatia, Côte d'Ivoire, the Dominican Republic, Ecuador, Egypt, El Salvador, Eritrea, Ethiopia, Gabon, Georgia, Ghana, Guatemala, Haiti, Honduras, Hungary, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Lebanon, Libya, Malaysia, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, North Macedonia, Pakistan, Panama, Paraguay, Peru, the Philippines, Poland, Romania, the Russian Federation, Saudi Arabia, Senegal, Serbia, South Africa, Sri Lanka, Sudan, Suriname, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Ukraine, the United Arab Emirates, Uruguay, Uzbekistan, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe.
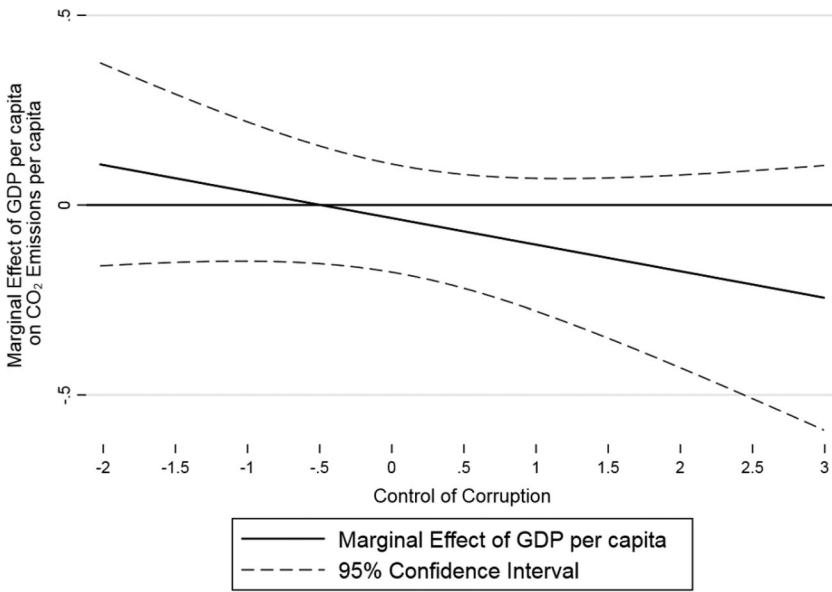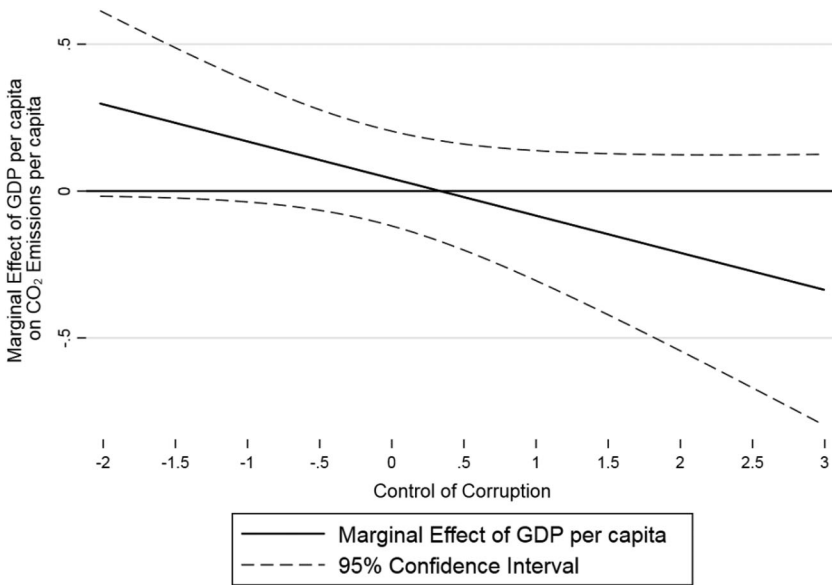
Appendix B. Marginal effects
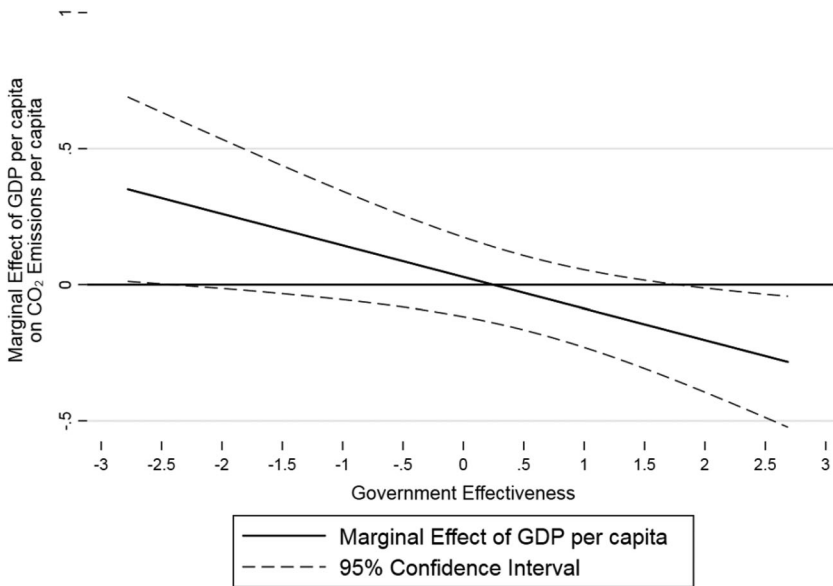
Figure B1. The marginal effect of per capita GDP on CO_2 emissions as government effectiveness changes based on estimation without time fixed effects (full specification). *Source:* own calculations.
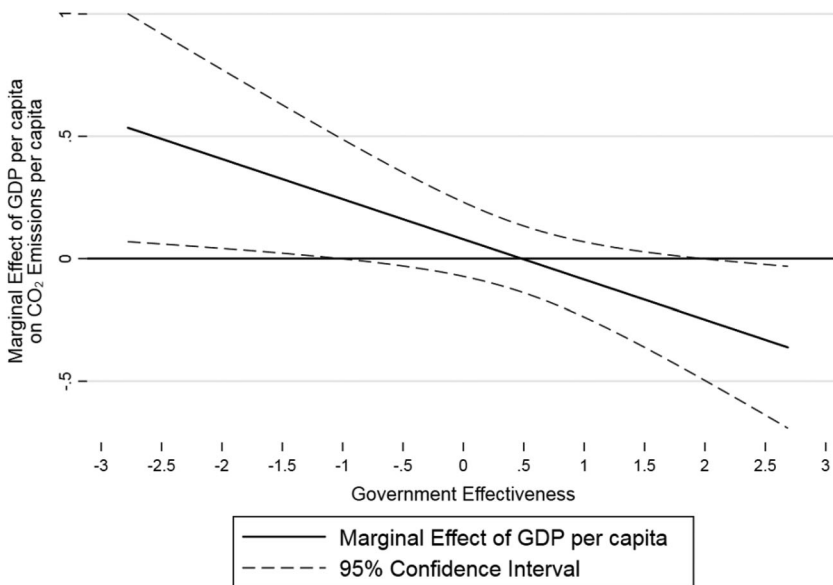
Figure B2. The marginal effect of per capita GDP on CO_2 emissions as government effectiveness changes based on estimation without time fixed effects (reduced specification). *Source:* own calculations.

Figure B3. The marginal effect of per capita GDP on CO_2 emissions as control of corruption changes based on estimation without time fixed effects (full specification). *Source:* own calculations.

Figure B4. The marginal effect of per capita GDP on CO_2 emissions as control of corruption changes based on estimation without time fixed effects (reduced specification). *Source:* own calculations.