South East European Journal of Economics and Business
Volume 17 (2) 2022, 125-141
DOI: 10.2478/jeb-2022-0019

THE IMPACT OF INSTITUTIONS ON ECONOMIC AND ENVIRONMENTAL PERFORMANCE: EVIDENCE FROM EUROPE

Maria Panteli, Sofia Delipalla

Abstract

Within the Environmental Kuznets Curve framework, we investigate whether the effect of institutions on environmental quality differs among the Western Balkans, the other European post-socialist states, and Western Europe. We estimate both direct and indirect effects of institutions on air pollution for each respective sub-sample and for the whole European region (45 countries during 1996-2014). The negative direct effect is greater for non-post-socialist states, compared to post-socialist ones. Regarding the indirect effect, improving the quality of economic institutions induces an increase in the scale of economic activity, leading to an increase in CO_2 emissions per capita. Estimated elasticities of CO_2 emissions with respect to institutions, for all sub-groups, uncover a total positive effect, which is larger for Central-eastern and South-eastern European states. Improving the quality of institutions should go hand in hand with stricter formation and implementation of policies designed to decouple economic growth from CO_2 emissions.

Keywords: *Environmental quality, carbon dioxide (CO2) emissions, institutional quality, corruption, economic performance, Europe.*

JEL classification: *D02, Q01, Q53*

1. Introduction

Climate change manifestations range from shifting weather patterns to rising sea levels, highly increasing the risk of catastrophic events and affecting economies and societies around the globe in an unparalleled scale (United Nations (UN) n.d.). In our focus area, the European region, the pressure exerted on the environment is linked to adverse environmental, social, and economic sustainability effects. There exist, however, wide disparities in emissions trends between European Union (EU) member countries and post-socialist states in Central-eastern and South-eastern Europe and, especially, the countries in the Western Balkans region.

The hypothesized non-linear relationship between income and environmental quality, as

Maria Panteli, PhD (corresponding author)
Post-doctoral Researcher in Economics
Department of Balkan, Slavic and Oriental Studies
School of Economics and Regional Studies,
University of Macedonia
156 Egnatia Street, GR-546 36, Thessaloniki, Greece
E-mail: panteli@uom.edu.gr
ORCID: 0000-0003-4929-8891

Sofia Delipalla, PhD
Professor of Economics
Department of Balkan, Slavic and Oriental Studies
School of Economics and Regional Studies,
University of Macedonia
Thessaloniki, Greece
E-mail: sd@uom.edu.gr
ORCID: 0000-0002-8711-6705

depicted by the Environmental Kuznets Curve (EKC), has received considerable attention in the literature. Under the EKC hypothesis, economic growth and environmental protection may not necessarily be mutually exclusive, as the deterioration of environmental quality following an increase in the magnitude of economic activity (scale effect) may prevail only at the outset of economic development. In later stages, alterations in the economy structure (i.e., a move from the primary and secondary sector to the service sector) and technological improvements in production methods may lead to reductions in pollution levels at higher incomes (Grossman and Krueger 1991, 1995). Results examining the potentially inverted U-shape pattern in the relationship between income and environmental degradation have been at best mixed, as various pollution indicators, time frames, samples of countries and estimation methods have been used in the empirical studies; see, for example, Stern (2004), for an early study, and Shahbaz and Sinha (2019).

The EKC framework, apart from its importance in studying economic growth sustainability, has offered a basis for examining the potential relationship between institutional quality and environmental performance. Rising income levels, along with other factors such as environmental awareness and education, can lead to a point where demand for better environmental quality induces improvements in environmental performance (Panayotou 1993). In the absence of institutional quality and in the presence of corruption, however, government rent-seeking behavior may undermine society's preferences for pro-environmental policies and stricter environmental regulation. Actual pollution levels can depart significantly from the optimal ones and the EKC pattern may occur at significantly higher income per capita levels or may not materialize at all (López and Mitra 2000).

We investigate the impact of institutional quality and corruption control on CO_2 per capita emissions in a panel of 45 European countries during 1996-2014. We place emphasis on Central-eastern and South-eastern Europe by investigating the possibility of a differential impact of institutions/corruption control on CO_2 emissions compared to other non-post-socialist European states. The hypothesis of the existence of a differential effect of institutions on the environment among the countries in the Western Balkans, European post-socialist states – Western Balkans excluded, and Western Europe is also tested.

Central-eastern and South-eastern European states have been undergoing a process of post-socialist transformation. Institutional structures have fundamentally changed and market economies have been established. Environmental quality has been influenced by past legacies, including the pre-transition economic structures, population's environmental behavior and attitude, and in some cases by armed conflict (UNDP 2009; EEA 2010). While institutional inefficiency and corruption prevalence has been pinpointed as a significant obstacle to environmental protection and effective implementation of environmental policies in Central-eastern and South-eastern Europe, and especially in the Western Balkans (Börzel and Fagan 2015), statistical analysis investigating the exact impact of institutions/corruption control on air pollution has been limited. To the best of our knowledge, no empirical analysis focuses on differences in the effect of institutions on air pollution among post-socialist states in Central-eastern and South-eastern Europe, the Western Balkans, and Western Europe. This paper seeks to fill this gap. Moreover, to the best of our knowledge, this is the first study to estimate both the direct and indirect effects of overall institutions (not just corruption) on environmental pollution.

The reminder of the paper is organized as follows. In section 2, we briefly review the literature. In section 3, we describe the methodology and data sources. In section 4, specification issues and estimation methods are discussed. Results are presented in section 5, followed by a discussion in section 6. Finally, section 7 concludes.

2. Literature review

Among governance dimensions, corruption has been studied more extensively. Theoretical analysis demonstrates that rent-seeking and corrupt transactions, involving bribery of government officials and policy makers, can impact negatively on environmental policy stringency (e.g., Fredriksson and Svensson 2003; Damania *et al*. 2003; Wilson and Damania 2005). Corruption in bureaucratic administration can reduce environmental regulation's effectiveness, decreasing compliance (e.g., Damania 2002; Wilson and Damania 2005).

Cross-country empirical studies have shown that the stringency of environmental policy and actual pollution levels can be significantly affected by the presence of corruption (e.g., Pellegrini and Gerlagh 2006b; Fredriksson and Vollebergh 2009; Welsch 2004). Corruption has been found to have either a positive (e.g., Welsch 2004; Biswas *et al*. 2012; Zhang *et al*. 2016) or negative (Cole 2007; Goel *et al*. 2013) relationship with pollution, with both direct and indirect effects been identified. Pollution increases at given income levels due to the "direct" impact of corruption. The "indirect" effect arises from the negative relationship between corruption and economic growth and a subsequent impact on environmental quality through income (Welsch 2004; Cole 2007). The net impact depends crucially on the sign and relative magnitude of the estimated effects. There are also studies which do not confirm the existence of a statistically significant relationship between corruption and environmental degradation (e.g., Bernauer and Koubi 2013).

In general, quality of institutional setups can be a significant determinant of environmental performance (e.g., Panayotou 1997; Esty and Porter 2005; Gani 2012; Ali *et al*. 2019). A large part of the literature has focused on developed (e.g., Fredriksson and Vollebergh 2009) and developing countries (e.g., Gani 2012; Ali *et al*. 2019) or world samples (e.g., Cole 2007; Leitão 2010; Biswas *et al*. 2012; Goel *et al*. 2013; Akhbari and Nejati 2019). From a regional policy-making perspective, however, estimates of the effect of institutions and corruption control on air pollution are very important.

With respect to Central-eastern and South-eastern European countries, limited research has investigated the effect of institutions on the environment. Solakoglu (2007) finds preliminary evidence of a positive effect of property rights on environmental quality, comparing transition countries which became EU member states in 2004 and the rest of transition economies. Tamazian and Rao (2010), in a sample of 24 transition economies during 1993-2004, find institutional quality to be a significant determinant of environmental performance. Both studies focus exclusively on countries in transition and neither takes into account direct and indirect effects of institutions on environmental quality.

In sum, empirical findings are not uniform. Direct and indirect effects of corruption on environmental performance have been found either to reinforce or contradict each other. Results regarding the sign of the total effect are still inconclusive, while statistical significance of the relationship has also been contested. Furthermore, it is not only the presence of corruption that can induce indirect effects. Economic institutions, broadly defined, can have a statistically significant impact on economic performance (Knack and Keefer 1995; Hall and Jones 1999; Acemoglu *et al*. 2001; Hall and Ahmad 2014), hence affecting the environment indirectly through income. To the best of our knowledge, there is no empirical study estimating direct and indirect effects of institutions on the environment in the European sub-regions and in the whole continent, an issue that we investigate extensively below.

3. Methodology and data

We follow the methodology proposed by Welsch (2004) and Cole (2007) and formulate two equations to be estimated simultaneously. An important contribution within this framework is that we take into account overall institutional quality (and not just the effect of corruption) on environmental performance. Our environmental indicator is carbon dioxide (CO_2) emissions per capita (C), expected to be a direct function of institutions ($Inst$), income (GDP) per capita, and a vector of factors (Z) commonly examined in the EKC literature. Hence,

$$C = f(Inst, GDP, Z) \tag{1}$$

The explanatory variables in Z include the share of industry in GDP, energy efficiency, energy production structure, openness to international trade, and population characteristics such as population density, population growth, and degree of urbanization.

The indirect effect of institutional quality on environmental performance arises from the positive effect of economic institutions on economic performance. Thus, institutions can influence per capita CO_2 emissions indirectly through their effect on income, a significant determinant of environmental quality. Under the neoclassical framework, income per capita is modeled as a function of economic institutions and factors common in neoclassical growth literature. Hence,

$$GDP = g(Inst, H) \tag{2}$$

where H includes a proxy of physical capital, a measure of human capital, the rate of population growth, and openness to trade.

The total effect of institutions on CO_2 per capita emissions is estimated as

$$\frac{dC}{dInst} = \frac{\partial C}{\partial Inst} + \frac{\partial C}{\partial GDP} * \frac{\partial GDP}{\partial Inst} \tag{3}$$

where C is again CO_2 emissions per capita, GDP is income per capita and $Inst$ denotes the quality of economic institutions. The first term on the right-hand side of equation (3) captures institutions' direct effect. This direct effect is expected to be negative, i.e., an improvement in institutional quality is expected, ceteris paribus, to lead to a reduction in CO_2 emissions. The indirect effect, the change in pollution caused by the change in income due to changes in institutional quality, is captured by the second term. It should be noted that the sign and magnitude of the indirect effect are crucial in determining the overall impact of economic institutions on air quality. If an inverted U-shape pattern in the relationship between income and CO_2 emissions is not confirmed, then an increased scale of economic activity (due to improved institutional structures) may lead to a positive indirect impact of institutions on CO_2 emissions. The total effect will then be determined by the relative magnitude of the direct and indirect effect.

Before proceeding to model specification and estimation method, we discuss further the choice of institutional quality measure and control variables used in the analysis. Our indicator of institutional quality is measured as a simple average of four dimensions of governance pertaining to government effectiveness, rule of law, regulatory quality and corruption control, following the categorization developed in the Worldwide Governance Indicators (WGI) project by Daniel Kaufmann and Aart Kraay (n.d.). Since governance dimensions, as constructed in the WGI project, are not suitable for time series and panel data analysis (Arndt and Oman 2006), we use data from the "IHS Markit World Economic Service", obtained through the WGI website. Our variable captures cross-country and over-time variation in economic institutions, with its values laying between zero (lower quality) and one (higher quality).

The use of a single measure indicating institutional quality is deemed more appropriate. The inclusion of four variables proxying different governance dimensions into one regression could have raised serious concerns of bias in the estimates, due to multicollinearity among the independent variables. On the other hand, the examination of the effect of each institutional dimension in a separate regression could possibly suffer from omitted variables bias.

Perceptions-based data are only imperfect proxies for measuring institutional quality (e.g., Gleaser *et al.* 2004; Kurtz and Schrank 2007). Nevertheless, their use is prevalent in empirical research since in most cases they can overcome the bias caused by the use of objective measures (Lambsdorff 2006). The choice of the specific data source ensures wide European country coverage, limiting issues of sample selection bias.

When it comes to the control variables in equation (1), the structure of the economy can play a significant role in the deterioration of environmental quality, a relationship described by Grossman and Krueger (1991, 1995) as the composition effect. For this reason, the share of industry in GDP is included in the analysis and is expected to have a positive relationship with CO_2 emissions. Energy efficiency is expected to have a negative sign. A higher share of coal as a primary source in electricity generation is expected to have a positive sign.

The relationship between openness to international trade and air pollution is theoretically ambiguous. Trade openness can have a negative impact on air quality through a scale effect (Grossman and Krueger 1991). The composition effect is also relevant, through the possible specialization of countries with more lax environmental regulations in the production of pollution intensive goods; this is the Pollution Haven Hypothesis (PHH) (see Gill *et al.* (2018) for a review). If the PHH holds, increased international trade and trade liberalization can reinforce this pattern, increasing emissions for certain countries while reducing them for others. Openness to trade can also have a positive effect on air quality. First, through its effect on economic growth, income and subsequently demand for environmental protection (Grossman and Krueger 1991) and, second, through the adoption of cleaner technologies by local economies (OECD n.d.).

Population growth is expected to have a positive impact on CO_2 emissions (e.g., Liddle 2013; Weber and Sciubba 2019), as is the degree of urbanization (e.g., Al-Mulali *et al.* 2015). Population density has been previously found to have either a positive (e.g., Marshall *et al.* 2005) or negative (e.g., Glaeser and Khan 2010) relationship with pollution levels. In areas/countries with low population density, the impact of commuting on the environment can be higher (Muñiz and Galindo 2005), as is the case with household fuel consumption (Brownstone and Golob 2009). On the other hand, an increase in density of (especially) urban population can lead to increased demand for transportation (Frank and Engelke 2005) and an exacerbation of traffic problems (Marshall *et al.* 2005).

GDP per capita and data on all variables are obtained by the World Bank's WDI. Variables' notation and definition are presented in Table A1 in the Appendix.

4. Model specification and estimation

To find the total effect of institutional quality on air pollution, we estimate first the relationship between institutions and income per capita. Hence,

$$lnGDPpc_{it} = \beta_0 + \beta_1 lnInst_{it}$$
$$+\beta_3 H_{it} + \zeta_i + \delta_t + v_{it} \tag{4}$$

where, subscripts i and t denote country and year respectively, ζ_i are country specific effects, δ_t are year specific effects and v_{it} is the error term. Income per capita ($GDPpc$) and economic institutions ($Inst$) are expressed in natural logarithms, as is gross capital formation included in H. Enrollment rates to secondary education, the share of exports and imports of goods and services in GDP and the variable capturing population growth are included as further controls in H.

An important issue which may cause bias in the estimates is the problem of endogeneity between income and institutions. To address this, two-stage least squares (2SLS) is frequently used, provided that suitable instrumental variables are available; the most common instruments include ethnolinguistic fragmentation (Mauro 1995), distance from the equator, the extent to which the primary Western European languages are currently spoken as first languages outside Europe (Hall and Jones 1999), and settler mortality rates (Acemoglu *et al*. 2001). The validity of all instruments has been contested (e.g., Easterly and Levine 1997; Diamond 1997; Sachs 2001; Gleaser *et al*. 2004; McCord and Sachs 2013). Moreover, the theoretical argument for the use of these instruments pertains to other contexts.

Given our specific sample of countries and in the absence of valid instruments, we follow an alternative approach common in recent empirical research (e.g., Biswas *et al*. 2012). We use the second and up to four lags of institutional quality as instruments for current institutions. According to Reed (2015), this is an effective strategy provided two conditions are met: the lags do not belong in the model and are adequately correlated with the endogenous variable. Although the conditions are strong, we assume that, when we estimate the contemporaneous relationship between income and institutions, past institutional quality effects on GDP per capita entirely pass through current institutions. Regarding the second condition, the correlation coefficient between economic institutions and its second and third lags are 0.979 and 0.972, respectively. The correlation coefficient with the fourth lag is 0.968.

Two-stage least squares estimation is performed with fixed effects. We opt for this method, since it is most unlikely that all the time invariant factors affecting income per capita which are omitted from our model are uncorrelated with the independent variables used in our analysis. Summary statistics, reporting, among others, overall, between and within variation in our data used in estimating equation (4), are reported in Table A2 in the Appendix.

Results (fitted values) from estimated equation (4) are used to estimate the direct effect of institutions on per capita CO_2 emissions. Our chosen specification is

$$lnC_{it} = \alpha_0 + \alpha_1 lnInst_{it} + \alpha_2 lnGDPpc_{it} + \alpha_3 (lnGDPpc_{it})^2 + \alpha_4 Z_{it} + \gamma_i + \eta_t + u_{it} \tag{5}$$

where CO_2 emissions per capita (C), institutional quality ($Inst$), income per capita (predicted values from equation (4)) and energy efficiency included in (Z) are expressed in natural logarithms. Further controls in the (Z) matrix (already outlined above) enter the model into their original forms. Country and year specific effects are also included in the model. The error term is represented by u_{it}.

5. Results

5.1. Impact of Institutional Quality on Income

The estimated impact of institutions on income per capita is presented in Table 1. The coefficient of the quality of economic institutions is highly statistically significant across all specifications. The elasticity of income with respect to institutional quality in the bivariate regression (model GDP-1) is estimated to be 1.1, i.e., a one percent increase in mean institutional quality is expected to increase mean income per capita by 1.1 percent. The inclusion of further controls leads to a decrease in this elasticity, which in our full specification is equal to 0.77 (model GDP-3). Due to missing data in school enrolment rates, in model GDP-3, the number of countries drops to 43. To compare results with and without the inclusion of human capital, we re-estimate the model (GDP-6) excluding school enrollment rates, but with the same sample of countries as in model GDP-3. Estimates are almost identical. Thus, the omission of human capital does not cause significant bias in the estimates, and we prefer the results from model GDP-2.

With respect to the internal instruments, in columns 1-3, 6 and 7, the second lag of institutional quality is employed. The use of a single instrument for the endogenous variable does not allow to test for exclusion restrictions, since this is only possible when there are more instrumental variables than endogenous variables, i.e., when the model is over-identified.

In models GDP-4 and GDP-5, the instruments used are the second and third lags of institutions, and the second and up to the fourth lag of institutions, respectively. In these models, the Sargan statistic does not reject the null hypothesis of joint validity of the instruments, and the models pass the weak identification and under-identification tests.

Note that the higher the value of the weak identification test, compared to the Stock-Yogo (2005) critical

Table 1. Effect of institutional quality on income per capita

lnGDPpc	GDP-1	GDP-2	GDP-3	GDP-4	GDP-5	GDP-6	GDP-7
lnInst	1.1*** (0.09)	0.89*** (0.13)	0.77*** (0.09)	0.8*** (0.11)	0.83*** (0.15)	0.77*** (0.09)	0.89*** (0.32)
lninvest		0.21*** (0.03)	0.24*** (0.02)	0.14*** (0.02)	0.14*** (0.02)	0.24*** (0.02)	0.21*** (0.06)
popgrowth		0.015 (0.01)	0.004 (0.009)	0.023** (0.009)	0.024** (0.01)	0.004 (0.008)	0.015 (0.02)
trade		-0.0014*** (0.0003)	0.00006 (0.0003)	0.0004 (0.0004)	0.0006* (0.0004)	0.00006 (0.0003)	-0.0014 (0.001)
school			0.0003 (0.0006)	-0.0005 (0.0007)	-0.0005 (0.0007)		
No. of countr.	45	45	43	43	43	43	45
No of obs.	621	605	545	396	356	545	605
Sargan	-	-	-	0.908	0.144	-	-
Weak Identification Cragg-Donald Wald F statistic	766.9	303.1	221.9	41.89	17.1	227.1	303.1
Under Identification Chi-sq(1) P-val	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007

*Notes: Standard errors in parentheses. ***, ** and * indicate significance at the 99%, 95% and 90% levels, respectively. 2SLS with fixed effects is used in all specifications. In models GDP-1 through GDP-3, GDP-6 and GDP-7, the second lag of institutional quality is used as an instrument. In model GDP-4, the second and third lags of institutions are used as instruments. In model GDP-5, the second and up to the fourth lags are employed. Goodness-of-fit measures are unclear with fixed effects estimation, thus R^2 is not reported. Unreported year specific effects are included in all models.*
For models GDP-1 to GDP-3, GDP-6 and GDP-7 the Stock-Yogo (2005) weak identification test critical value for 10% maximal IV relative bias is 16.38. For model GDP-4 the critical value for 10% maximal IV relative bias is 19.93, while for model GDP-5 the critical values for 5% and 10% maximal IV relative bias are 13.91 and 9.08, respectively.

values for maximal IV relative bias given in Table 1, the more confidence we have that the instruments used in the analysis are not weak. With respect to the under-identification test, the p-value obtained throughout Table 1 leads to a rejection of the null hypothesis, which states that the equation is under-identified.

The use of a higher number of internal instruments in models GDP-4 and GDP-5 reduces the number of observations employed in estimation. The value of the weak identification test is significantly lower than the one reported in previous models. Thus, we conclude that our best estimate of the impact of institutions on income per capita is obtained from model GDP-2 and, in what follows, we make use of these results. Finally, to address the potential issue of serial correlation, we conduct the Wooldridge (2002) test for autocorrelation in panel data obtaining a test statistic of 0.389. Thus, we fail to reject the null hypothesis of no first-order autocorrelation. Nevertheless, in model GDP-7 we re-estimate model GDP-2 correcting for within-panel serial correlation and cross-sectional heteroskedasticity.

5.2. Impact of Institutional Quality on Environment

Results of the direct effect of institutional quality on CO_2 emissions are presented in Table 2. In models CO-1 and CO-2, a fixed effects estimation method is used. The result of the Hausman test in model CO-1 provides evidence in favour of random effects estimation, since we fail to reject the null hypothesis that the difference in coefficients between fixed and random effects is not systematic. Including further controls in model CO-2, however, makes the p-value highly statistically significant, indicating that fixed effects should be used.

The issue of serial correlation is also relevant in the case of estimating the direct effect of institutions on CO_2 per capita emissions. For this reason, we apply the Wooldridge (2002) test for first-order serial correlation in the set of variables used in estimating equation (5), obtaining a test statistic equal to 0.0000. Under this result, we reject the null hypothesis of no first-order serial correlation and procced our estimation in models CO-3 to CO-7 employing a GLS random-effects estimator with an AR(1) disturbance. The Hausman test, in models CO-3 to CO-5, validates the choice of using

Table 2. Effect of institutional quality on CO_2 emissions per capita

lnCO_2 per capita	CO-1	CO-2	CO-3	CO-4	CO-5	CO-6	CO-7	CO-8
lncInst	-0.31*** (0.116)	-0.22** (0.11)	-0.41*** (0.08)	-0.38*** (0.08)	-0.41*** (0.08)	-0.44*** (0.11)	-0.42*** (0.11)	-0.51*** (0.16)
(lncInst)^2								-0.3 (0.25)
(lncInst)^3								-0.18 (0.13)
lnGDPpc	0.68 (0.48)	1.25*** (0.45)	0.21 (0.47)	0.33 (0.47)	0.25 (0.47)	0.47 (0.48)	0.56 (0.49)	0.38 (0.49)
(lnGDPpc)^2	-5.99e-06 (0.027)	-0.034 (0.026)	0.021 (0.026)	0.014 (0.026)	0.02 (0.03)	0.002 (0.027)	-0.003 (0.03)	0.01 (0.03)
lnenergeff		-0.39*** (0.04)	-0.61*** (0.04)	-0.61*** (0.04)	-0.62*** (0.04)	-0.65*** (0.04)	-0.65*** (0.04)	-0.62*** (0.04)
indshare		0.007*** (0.002)	0.007*** (0.002)	0.007*** (0.002)	0.008*** (0.002)	0.009*** (0.002)	0.009*** (0.002)	0.008*** (0.002)
coalelectr		0.005*** (0.0009)	0.004*** (0.0006)	0.005*** (0.0006)	0.004*** (0.0006)	0.004*** (0.0006)	0.004*** (0.0006)	0.004*** (0.0006)
trade		0.0008** (0.0004)	0.0015*** (0.0003)	0.0013*** (0.0003)	0.0013*** (0.0003)	0.0012*** (0.0003)	0.0012*** (0.0003)	0.0014*** (0.0003)
popgrowth		0.04*** (0.011)		0.012 (0.009)				
populdens		-0.001 (0.0006)		0.0005** (0.0003)	0.0006** (0.0003)	0.0002 (0.0003)	0.0002 (0.0003)	0.0006*** (0.0003)
populurban		0.005*** (0.0015)		0.0009 (0.0008)				
dPS						-0.51*** (0.12)		
dPS2							-0.51*** (0.13)	
dWB							-0.59*** (0.19)	
*dPS*lnInst*						0.12 (0.1)		
*dPS2*lnInst*							0.13 (0.1)	
*dWB*lnInst*							-0.007 (0.15)	
Hausman Prob>chi2	0.0597	0.0001	0.7758	0.7163	0.9995	-	-	0.9883
No of obs.	683	682	682	682	682	682	682	682
No of countr.	45	45	45	45	45	45	45	45

*Notes: Standard errors in parenthesis. ***, ** and * denote significance at the 99%, 95% and 90% levels, respectively. Estimation is performed using results from model GDP-2 (Table 1). Fixed effects estimation is used in models CO-1 and CO-2. GLS random effects estimation with an AR(1) disturbance is used in models CO-3 to CO-7. Unreported year specific effects are included in all models.*

random effects estimation. Note that, in models CO-6 and CO-7, we report no values for the Hausman test since the inclusion of dummy variables that are constant over time does not permit to test if the difference in coefficients between fixed and random effects is not systematic.

Institutional quality is found to be a negative and highly statistically significant determinant of CO_2 emissions across all specifications. In model CO-1, where only institutional quality and GDP per capita are included in the regression, a one percent increase in mean institutional quality is expected to decrease mean CO_2 emissions per capita by 0.31 percent. In model CO-2, the inclusion of further controls slightly influences the significance of the coefficient of institutions, while its magnitude decreases. In subsequent models, in which a random effects estimator with an AR(1) disturbance is employed, the coefficient of institutional quality is statistically significant at the one percent level, while its magnitude increases compared to fixed effects estimation results.

Energy efficiency decreases (as expected) mean CO_2 emissions per capita, while its coefficient is considerable in magnitude and highly statistically significant. A larger mean share of coal-based electricity production leads to an increase in mean CO_2 emissions per capita, a relationship which is again highly statistically significant and holds across all specifications. Openness to trade, on the other hand, is found to have a statistically significant relationship with mean CO_2 emissions at the five percent level, when fixed effects estimation is used. When the issue of serial correlation is dealt with in models CO-3 to CO-7, trade openness is found to be a positive and highly statistically significant determinant of CO_2 per capita emissions in Europe, although the magnitude of its effect is smaller compared to other factors, such as institutional quality and energy efficiency.

As expected, population growth and urbanization have a positive relationship with CO_2 emissions per capita. While in model CO-2 a highly significant effect of these variables is estimated, in model CO-4 their coefficients lose their statistical significance. Hence, they are dropped from subsequent models. The coefficient of population density has a negative sign with fixed effects estimation, indicating that, on average, more densely populated countries have lower mean CO_2 emissions per capita. However, the sign of the relationship changes once a random effects estimator with an AR(1) disturbance is used.

It is worth noting that we find no evidence for the existence of an EKC pattern in the relationship between income and CO_2 emissions. In most specifications, the linear and the squared income terms have a positive sign, indicating that air pollution emissions increase as income level rises. Moreover, in the cases where a negative sign of the squared income term is obtained, its magnitude is so small compared to the linear term, leading to a hypothetical EKC with a turning point at an implausible income per capita level.

In models CO-6 and CO-7, we test if there is a statistically significant different effect of institutional quality on CO_2 emissions per capita between countries with a socialist history in Central-eastern and South-eastern Europe and countries that did not have centrally planned economies in past decades. Emphasis is placed on possible differences between the countries in the Western Balkans and the other sub-groups defined throughout the analysis so far. In model CO-6, an interaction term between institutional quality and the dummy variable indicating European post-socialist states is included. In model CO-7, we distinguish between countries in the Western Balkans and the rest of post-socialist states by including in our regression separate interaction terms between the dummy variables indicating these groups and institutions. The estimated average marginal effects of institutions on CO_2 emissions per capita for each group of countries, as well as the differences in the estimated coefficients of institutions across the geopolitical European sub-regions, are presented in Table 3.

Estimates in Tables 2 and 3 indicate that, in Western European countries, an improvement in the mean quality of economic institutions by one percent leads to a reduction in mean CO_2 emissions per capita by 0.44 percent. In post-socialist states, this mean reduction is equal to 0.32 percent. However, while the average marginal effects of institutions on CO_2 emissions are individually significantly different from zero, there is no evidence that the estimated difference between subgroups is also statistically significant.

Likewise, the average marginal effect of institutions on CO_2 per capita emissions for the countries in the Western Balkans is estimated at 0.427, i.e., a one percent increase in mean institutional quality is associated with a decrease in mean CO_2 emissions by 0.427 percent. For Western European countries, this mean reduction is estimated at 0.42 percent, while for post-socialist states – Western Balkans excluded, it is estimated at 0.29 percent. Again, despite the fact that the simple slopes of institutions are found to be statistically significant for each respective European sub-region, the difference in the effect of institutional quality on CO_2 emissions among Western European countries, post-socialist states – Western Balkans excluded, and the countries in the Western Balkans region is not found to be significantly different from zero.

Table 3. Average marginal effects of institutions on CO_2 emissions by sub-region

lnCO_2 per capita	Average marginal effects Model CO-6	Average marginal effects Model CO-7
lncInst		
Western Europe	-0.44*** (0.11)	
dPS	-0.32*** (0.08)	
Western Europe vs dPS	0.12 (0.1)	
Western Europe		-0.42*** (0.11)
dPS2		-0.29*** (0.09)
dWB		-0.427*** (0.12)
Western Europe vs dPS2		0.13 (0.1)
Western Europe vs dWB		-0.01 (0.15)

Findings in model CO-7 are surprising, in the sense that, in our sample, non-post-socialist European states and the countries in the Western Balkans region are the subgroups with the highest and the lowest mean performance, respectively, with respect to institutional quality. At the same time, estimates indicate that these two geopolitical regions have, on average, the greatest direct improvement in environmental quality, resulting from improved institutional structures. Since this result cannot be attributed to their differences with respect to past economic and political organization, we have to consider the possibility of the existence of a nonlinear relationship between the quality of economic institutions and environmental degradation.

In model CO-8, we include a quadratic and a cubic term of institutional quality in our specification. Testing for joint significance of the coefficients of economic institutions, we obtain a p-value equal to 0.000. Our results indicate that the direct effect of an improvement in mean institutional quality on mean CO_2 emissions is negative throughout the sample's institutional quality range. That is, improved institutional structures lead to reduced emission levels. This effect (which is non-linear in nature), however, is higher towards the upper and the lower ends of the institutional quality range in our sample (see, Table A3 and Figure A1 in the Appendix).

5.3. Total Impact of Institutional Quality on Emissions

We now turn to calculating the total effect of institutions on CO_2 per capita emissions. For this, we need to estimate the indirect effect. Indirect and total effects are calculated for our sample as a whole. Given the nonlinear nature in the relationship between institutions and CO_2 per capita emissions, we also calculate indirect and total effects at the mean institutional quality level of post-socialist versus non-post-socialist European states, and the Western Balkans versus the other subgroups separately.

For estimating total effects, the coefficients of interest from Tables 1, 2 and Table A3 (in the Appendix) are plugged into equation (3). As discussed already in the Methodology and Data section, the direct effect is captured by the first term of the right-hand side of equation (3). It is the average marginal effect of institutions at the mean institutional quality level (of the sample, and of each respective subsample) estimated using results from model CO-8 in Table 2 (see, Table A3, in the Appendix). The indirect effect of institutional quality on CO_2 emissions per capita is the product of the change of emissions caused by income and the change of income caused by institutions. The change of emissions caused by income is obtained from the coefficients of the linear and the squared income per capita terms (model CO-8) in Table 2. To calculate the slope of the relationship between income and CO_2 per capita emissions, which is non-constant and depends on the given income level, we use

$$\%\Delta co2pc \approx [\alpha_2 + 2\alpha_3 lnGDPpc]\%\Delta GDPpc \quad (6)$$

where $\%\Delta co2pc$ stands for the percentage change is CO_2 emissions per capita, $\%\Delta GDPpc$ stands for the percentage change in income per capita, α_2 and α_3 are the estimated coefficients of the linear and the squared income terms, respectively (Table 2), and $lnGDPpc$ is the natural logarithm of GDP per capita at which we choose to estimate our elasticity (Wooldridge 2012, p.198). We calculate the indirect (and total) effect of institutions on air pollution at the median income level.

For the whole sample of the 45 European countries, the direct effect of a one percent increase in mean institutional quality on mean CO_2 emissions per capita is -0.36 percent (Table A3, Appendix). Using formula (6), at the median income level (US$ 15,064.5), the change of CO_2 per capita emissions caused by income is 0.61. The total effect of institutional quality on CO_2 emissions per capita is then

$$\frac{dC}{dInst} = (-0.36) + [(0.61) * (0.89)] = 0.18$$

That is, in Europe, one percent increase in mean institutional quality is expected to increase mean CO_2 per capita emissions by 0.18 percent.

The indirect and total effects are calculated in the same manner for European post-socialist states versus Western European countries, using estimated average marginal effects from Table A3 (Appendix), coefficients from models GDP-2 and CO-8, and the corresponding values of the median income per capita levels in each subgroup. They are also estimated separately for the Western Balkans region. Findings are presented in Table 4.

To sum up results displayed in Table 4, the direct impact of institutional quality on CO_2 emissions per capita is always negative, as expected. A higher mean quality of economic institutions results in a lower mean level of per capita air pollution emissions. The direct effect of one percent increase in mean institutional quality in the European region is estimated to be -0.36 percent while, when we examine the effect separately for European post-socialist states and Western Europe, it is larger for the latter group (|0.34| compared to |0.44|).

The direct negative effect of institutional quality on air pollution is found to be close in magnitude between the countries in the Western Balkans region and post-socialist states – Western Balkans excluded, with the former, however, being slightly more pronounced. At the same time, Western European states enjoy the highest mean decrease in CO_2 per capita emissions resulting from improved institutional structures (Table 4). Therefore, these results indicate that improvements in the underlying dimensions of governance and in the overall quality of economic institutions have a more pronounced direct impact on environmental performance in the upper and lower ends of the institutional quality range of our sample.

Improvements in the quality of economic institutions, however, are not necessarily associated with an overall improvement in air quality since, apart from the direct effect, economic institutions positively affect the level of economic development. Thus,

Table 4. Total impact of institutions on per capita CO2 emissions

	Direct	Indirect	Total
Europe (45 countries)	-0.36	0.54	0.18
Central-eastern & South-eastern Europe, Western Balkans included	-0.34	0.53	0.19
Western Europe	-0.44	0.55	0.11
Central-eastern & South-eastern Europe, Western Balkans excluded	-0.34	0.54	0.2
Western Balkans region	-0.36	0.53	0.17
Western Europe	-0.44	0.55	0.11

institutional quality can impact emissions indirectly (scale effect), especially if an EKC pattern in the relationship between income and air pollution does not materialize. If the indirect impact is positive, the net result crucially depends on the magnitude of the opposite effects.

The indirect impact of improvements in economic institutions and control of corruption on CO_2 emissions is indeed positive, i.e., increased income per capita resulting from better institutions leads to higher mean CO_2 emissions per capita (Table 4). This indirect impact is found to be positive for the whole sample (with an elasticity of 0.54) and for each respective subsample examined. This was anticipated, given that the existence of an EKC pattern between income and air pollution is not confirmed (Table 2).

Total effect is always positive, since the indirect effect outweighs the direct one. The calculation of different elasticities of CO_2 emissions, with respect to institutions for Central-eastern and South-eastern European states and Western Europe, reveals that the total negative effect of institutions on air quality is larger in magnitude for European former socialist countries. In Central-eastern and South-eastern Europe, an improvement in the mean quality of economic institutions by one percent is expected to lead to an increase in mean CO_2 emissions per capita by almost 0.19 percent (Table 4). In the rest of Europe, this mean increase is lower in magnitude and estimated to be 0.11 percent.

Finally, when we examine the total effect of institutions on air pollution for the countries in the Western Balkans, post-socialist states – Western Balkans excluded, and Western European states separately, we see that it is mainly influenced by, and closely follows, the pattern of the direct effect. Hence, the total positive effect of improved institutional structures on air pollution emissions is found to be the largest for Central-eastern and South-eastern European states – Western Balkans excluded.

6. Discussion

Our findings indicate that an improvement in the quality of economic institutions and higher corruption control can lead to significant benefits, both in terms of increased income per capita and in terms of reduced CO_2 emissions per capita through the direct channel. This conclusion applies to the sample as a whole but also to subsamples of countries which have (in some cases markedly) different mean levels of institutional quality.

The analysis also reveals that an increase in mean income per capita resulting from improved institutional structures is most likely to increase mean emissions, an effect which outweighs improvements in air quality achieved through the direct channel. Under these findings, the goal of improving the quality of governance structures throughout Europe should go hand in hand with stricter formation and implementation of policies designed to decouple economic growth from CO_2 emissions.

Regarding research limitations, employing a single measure of institutional quality makes it impossible to estimate the magnitude and significance of each governance dimension and the presence of corruption on environmental performance separately. However, the current limitations in measuring economic institutions, the possibility that individual measures broadly capture the same thing (Langbein and Knack 2010), and the fact that the underlying components of the quality of governance most probably simultaneously determine the overall quality of an economy's institutional structure, lead us to believe that the selected measure is better suited for analyzing the link between institutions and environmental quality, overcoming serious estimation challenges.

7. Conclusion

Our results identify a statistically significant effect of institutional quality on CO_2 emissions per capita in the European region. The estimated elasticities of CO_2 emissions with respect to institutions, for all sub-groups in Europe, uncover a total positive effect, which is larger in magnitude for Central-eastern and South-eastern European countries – Western Balkans excluded. This result, which is mainly influenced by the pattern and relative magnitude of the direct effect, cannot be attributed to differences in past economic and political organization, but to the non-linear nature of the relationship between economic institutions and air pollution.

Although previous studies examining the effect of (just) corruption on pollution have estimated both direct and indirect effects (e.g., Welsch 2004; Cole 2007), no study, to the best of our knowledge, examining the effect of overall institutions (not just corruption) on pollution has estimated the indirect effect. Regarding the direct effect, our results are in accordance with previous estimates, identifying a statistically significant (negative) direct effect of institutions on air pollution (e.g., Panayotou 1997; Esty and Porter 2005; Gani 2012; Ali *et al*. 2019 and Salakoglu 2007; Tamazian and Rao 2010 for transition economies). Our study, to the best of our knowledge, is the first to estimate both the direct and indirect effects, finding that the overall impact of institutions on environmental pollution is positive.

In the whole European region, the magnitude of the indirect positive effect of institutional quality always outweighs the direct negative one, resulting in a net positive impact of institutional quality on environmental degradation. This finding is very important from a policy-making perspective, since the goals of accelerating economic performance, improving standards of living (through improvements in institutional quality), and mitigating the effects of climate change through reductions in air pollution emissions, are not expected to be simultaneously met without further effort.

Our results indicate that a simple formula, which boils down to improving institutions, advancing economies and then improving environmental quality (achieved both through improved governance structures and higher environmental protection at higher income levels), is not expected to work without further action in terms of decoupling economic activity from air pollution emissions. Since we found no evidence for the existence of an EKC pattern in the relationship between CO_2 emissions and income per capita, an increase in the level of economic development resulting from improved governance structures is expected to induce further environmental problems.

This does not mean that efforts directed towards improving economic institutions are fruitless. Institutional quality is an important determinant of economic performance and therefore its enhancement can be a significant step in achieving higher living standards and convergence among European sub-regions. Moreover, improvements in institutional quality are expected to have a direct negative effect on environmental degradation in the European region. Given, however, that in all subsamples the net effect is estimated to be positive, greater attention should be paid to making economic growth environmentally sustainable.

Finally, although per capita CO_2 emissions are generally considered a good indicator of overall environmental performance, results obtained from analyzing different types of air pollutants and other forms of environmental degradation may be very different from the ones presented here. Future research could concentrate on examining the direct and indirect effect of overall institutional structures on other pollution sources.

References

Acemoglu, D., Johnson, S., Robinson, A. J. 2001. The Colonial Origins of Comparative Development: An Empirical Investigation. American Economic Review 91 (5): 1369-1401.

Akhbari, R., Nejati, M. 2019. The effect of corruption on carbon emissions in developed and developing countries: empirical investigation of a claim. Heliyon 5 (9): 1-9.

Al-Mulali, U., Ozturk, I., Lean, H. H. 2015. The influence of economic growth, urbanization, trade openness, financial development, and renewable energy on pollution in Europe. Natural Hazards 79 (1): 621-644.

Ali, H. S., Zeqiraj, V., Lin, W. L., Law, H. S., Yusop, Z., Bare, U., Chin, L. 2019. Does quality institutions promote environmental quality? Environmental Science and Pollution Research 26 (11): 10446-10456.

Arndt, C., Oman, C. 2006. Uses and Abuses of Governance Indicators. Development Center Studies, Paris: OECD Publishing https://doi.org/10.1787/9789264026865-en

Bernauer, T., Koubi, V. 2013. Are bigger governments better providers of public goods? Evidence from air pollution. Public Choice 156 (3): 593-609.

Biswas, K. A., Farzanegan, M. R., Thum, M. 2012. Pollution, shadow economy and corruption: Theory and evidence. Ecological Economics 75: 114-125.

Börzel, T. A., Fagan, A. 2015. Environmental governance in South East Europe/ Western Balkans: Reassessing the transformative power of Europe. Environment and Planning C: Government and Policy 33 (5): 885-900.

Brownstone, D., Golob, F. T. 2009. The impact of residential density on vehicle usage and energy consumption. Journal of Urban Economics 65 (1): 91-98.

Cole, M. A. 2007. Corruption, income and the environment: An empirical analysis. Ecological Economics 62 (3-4): 637-647.

Damania, R. 2002. Environmental controls with corrupt bureaucrats. Environment and Development Economics 7 (2): 407-427.

Damania, R., Fredriksson, P. G., List, J. A. 2003. Trade liberalization, corruption, and environmental policy formation: Theory and evidence. Journal of Environmental Economics and Management 46 (3): 490-512.

Diamond, J. 1997. Guns, Germs, and Steel: The Facts of Human Societies. New York: W.W. Norton.

Easterly, W., Levine, R. 1997. Africa's Growth Tragedy: Policies and Ethnic Divisions. Quarterly Journal of Economics 112 (4): 1203-1250.

Esty, D. C., Porter, M. E. 2005. National environmental performance: an empirical analysis of policy results and determinants. Environmental and Development Economics 10 (4): 391-434.

European Environmental Agency (EEA) 2010. Environmental trends and perspectives in the Western Balkans: future production and consumption patterns. EEA Report No. 1/2010, Luxembourg: Office for Official Publications of the European Union.

Frank, D. L., Engelke, P. 2005. Multiple Impacts of the Built Environment on Public Health: Walkable Places and the Exposure to Air Pollution. International Regional Science Review 28 (2): 193-216.

Fredriksson, P. G., Svensson, J. 2003. Political instability, corruption and policy formation: The case of environmental policy. Journal of Public Economics 87 (7/8): 1383-1405.

Fredriksson, P. G., Vollebergh, H. 2009. Corruption, federalism, and policy formation in the OECD: the case of energy policy. Public Choice 140 (1/2): 205-221.

Gani, A. 2012. The relationship between god governance and carbon dioxide emissions: evidence from developing countries. Journal of Economic Development 37 (1): 77-93.

Gill, F. L., Viswanathan, K. K., Karim, M. 2018. The Critical Review of the Pollution Haven Hypothesis. International Journal of Energy Economics and Policy 8 (1): 167-174.

Glaeser, E. L., La Porta, R., Lopez-de-Silanes, F., Shleifer, A. 2004. Do institutions cause growth? Journal of Economic Growth 9 (3): 271-303.

Glaeser, E. L., Khan, M. E. 2010. The greenness of cities: Carbon dioxide emissions and urban development. Journal of Urban Economics 63 (3): 404-418.

Goel, R. K., Herrala, R., Mazhar, U. 2013. Institutional quality and environmental pollution: MENA countries versus the rest of the world. Economic Systems 37 (4): 508-521.

Grossman, M. G., Krueger, B. A. 1991. Environmental Impacts of a North American Free Trade Agreement, NBER Working Paper Series, Working Paper No. 3914. DOI: 10.3386/w3914.

Grossman, M. G., Krueger, B. A. 1995. Economic growth and the Environment. The Quarterly Journal of Economics 110 (2): 353-377.

Hall, R. E., Jones, C. I. 1999. Why Do Some Countries Produce So Much More Output per Worker than Others? The Quarterly Journal of Economics 114 (1): 83-116.

Kaufmann, D. Kraay, A. n.d. Worldwide Governance Indicators. Available at https://info.worldbank.org/governance/wgi/

Knack, S., Keefer, P. 1995. Institutions and economic performance: Cross-country tests using alternative institutional measures. Economics and Politics 7 (3): 207-227.

Kurtz, M., Shrank, A. 2007. Growth and Governance: Models, Measures and Mechanism. The Journal of Politics 69 (2): 538-554.

Lambsdorff, G. J. 2006. Causes and consequences of corruption: What do we know from a cross-section of countries? In International Handbook on the Economics of Corruption, edited by S. Rose-Ackerman, 3-51. Cheltenham UK: Edward Elgar.

Langbein, L., Knack, S. 2010. The Worldwide Governance Indicators: Six, One, or None? Journal of Development Studies 46 (2): 350-370.

Leitão, A. 2010. Corruption and the environmental Kuznets Curve: Empirical evidence from sulfur. Ecological Economics 69 (11): 2191-2201.

Liddle, B. 2013. Population, affluence, and environmental impact across development: evidence from panel cointegration modeling. Environmental Modeling and Software 40: 255-266.

López, R., Mitra, S. 2000. Corruption, Pollution, and the Kuznets Environment Curve. Journal of Environmental Economics and Management 40 (2): 137-150.

Marshall, D., McKone, T. E., Deakin, E., Nazaroff, W. W. 2005. Inhalation of motor vehicle emissions: effects of urban population and land area. Atmospheric Environment 39 (2): 283-295.

Mauro, P. 1995. Corruption and Growth. The Quarterly Journal of Economics 110 (3): 681-712.

McCord, C. G., Sachs, J. D. 2013. Development, Structure, and Transformation: Some Evidence on Comparative Economic Growth. NBER Working Paper No. 19512.

Muñiz, I., Galindo, A. 2005. Urban form and the ecological footprint of commuting. The case of Barcelona. Ecological Economics 55 (4): 499-514.

OECD n.d. Trade and the environment: How are trade and environmental sustainability compatible? Available at https://www.oecd.org/trade/topics/trade-and-the-environment/

Panayotou, T. 1993. Empirical tests and policy analysis of environmental degradation at different stages of economic development. Working paper WP238. Geneva: International Labor Office.

Panayotou, T. 1997. Demystifying the environmental Kuznets curve: turning a black box into a policy tool. Environment and Development Economics 2 (4): 465-484.

Pellegrini, L., Gerlagh, R. 2006b. Corruption, Democracy, and Environmental Policy: An Empirical Contribution to the Debate. The Journal of Environment and Development 15 (3): 332-354.

Reed, R. W. 2015. On the Practice of Lagging Variables to Avoid Simultaneity. Oxford Bulletin of Economics and Statistics 77 (6): 897-905.

Sachs, J. D. 2001. Tropical Underdevelopment. NBER Working Paper No. 8119.

Shahbaz, M., Sinha, A. 2019. Environmental Kuznets Curve for CO2 emissions: a literature survey. Journal of Economic Studies 46 (1): 106-168.

Solakoglu, E. G., 2007. The Effect of Property Rights on the Relationship between Economic Growth and Pollution for Transition Economies. Eastern European Economics 45 (1): 77-94.

Stern, D. 2004. The rise and fall of the environmental Kuznets curve. World Development 32 (8): 1419-1439.

Stock, J. H., Yogo, M. 2005. Testing for weak instruments in linear IV regression. *In* Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg, edited by D.W.K. Andrews and J.H. Stock, 80-108. Cambridge: Cambridge University Press.

Tamazian, A., Bhaskara, R. 2010. Do economic, financial and institutional developments matter for environmental degradation? Evidence from transition economies. Energy Economics 32 (1): 137-145.

UNDP 2009. The Western Balkans Environmental Programme: Review of Policy Integration and Capacity Development Need Assessment Studies. UNDP Montenegro. Available at http://www.un.org.me/Library/Environment-and-Green-Economy/8%20Review%20of%20Policy%20Integration%20and%20Capacity%20Development%20Need%20Assessment%20Studies%202009.pdf

UNEP/UNECE 2016. *GEO-6* Assessment for the pan-European region (rev. I). Nairobi, Kenya: United Nations Environment Programme.

United Nations n.d. Sustainable Development Goals – Climate action. Available at https://www.un.org/sustainabledevelopment/climate-action/

Weber, H., Sciubba, J. D. 2019. The Effect of Population Growth on the Environment: Evidence from European Regions. European Journal of Population 35: 379-402.

Welsch, H. 2004. Corruption, growth, and the environment: A cross-country analysis. Environment and Development Economics 9 (5): 663-693.

Wilson, J. K., Damania, R. 2005. Corruption, political competition and environmental policy. Journal of Environmental Economics and Management 49 (3): 516-535.

Wooldridge, J. M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.

Wooldridge, J. M. 2012. *Introductory Econometrics: A Modern Approach*. 5th ed., Mason, Ohio: South-Western, Cengage Learning.

World Bank 2021. World Development Indicators. Available at https://databank.worldbank.org/source/world-development-indicators

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

Appendix

List of countries included in the sample:

Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia & Herzegovina, Cyprus, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Latvia, Lithuania, Luxembourg, Moldova, Montenegro, Netherlands, North Macedonia, Norway, Poland, Romania, Russian Federation, Portugal, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, The Republic of Malta, Turkey, Ukraine, United Kingdom

Table A1. Definition of variables and data sources

Variable	Definition	Source
co2pc	Carbon dioxide emissions, metric tons per capita	World Bank – World Development Indicators (WDI)
GDPpc	GDP per capita in constant 2010 US$	World Bank – WDI
GE	Government effectiveness. Scale 0-1 (higher values indicate higher effectiveness). IHS Markit World Economic Service	Accessed through the Worldwide Governance Indicators (WGI)) website
RQ	Regulatory quality. Scale 0-1 (higher values indicate better quality). IHS Markit World Economic Service	Accessed through the WGI website
RL	Rule of law. Scale 0-1 (higher values indicate better quality). IHS Markit World Economic Service	Accessed through the WGI website
CC	Control of corruption. Scale 0-1 (higher values indicate less corruption). IHS Markit World Economic Service	Accessed through the WGI website
Inst	Institutional quality measured as a simple average of government effectiveness, regulatory quality, rule of law, control of corruption. Scale 0-1 (higher values indicate better institutional quality)	Own calculation
indshare	Industry (including construction), value added (% of GDP)	World Bank – WDI
coalelectr	Electricity production from coal sources (% of total)	World Bank – WDI
energeff	Energy efficiency: GDP per unit of energy use	World Bank – WDI
popgrowth	Population growth (annual %)	World Bank – WDI
populdens	Population density: people per square kilometer of land area	World Bank – WDI
populurban	Urban population (% of total)	World Bank – WDI
invest	Gross capital formation in constant 2010 US$	World Bank – WDI
trade	Sum of imports and exports of goods and services (% of GDP)	World Bank – WDI
dPS	Dummy variable indicating post-socialist states (1 if post-socialist, 0 otherwise)	
dWB	Dummy variable indicating the six countries in the Western Balkans (1 for Western Balkans countries, 0 otherwise)	
dPS2	Dummy variable indicating post-socialist countries, Western Balkans excluded	

Table A2. Summary statistics

Variable		Mean	Median	Std. dev.	Min	Max	Obs.	No. of countries	Units
GDPpc	overall	24,346.6	15.064,5	23,083.8	946.4	111,968.4			
	between			23,102.6	1,369.9	97,756.6	854	45	2010 US$
	within			3,188.1	1,380.1	38,558.4			
Inst	overall	0.72	0.76	0.21	0.24	1			
	between			0.206	0.36	0.98	711	45	Index
	within			0.05	0.54	0.96			
invest	overall	9.67e+10	3.12e+10	1.57e+11	8.40e+07	7.33e+11			
	between			1.54e+11	9.89e+08	6.68e+11	817	45	2010 US$
	within			2.77e+10	-8.84e+10	2.64e+11			
popgrowth	overall	0.17	0.17	0.83	-3.8	2.9			
	between			0.71	-1.26	1.62	854	45	% (annual)
	within			0.43	-3.3	2.33			
trade	overall	99.8	87.1	50.57	24.17	382.3			
	between			48.1	47.6	290.2	851	45	% (of GDP)
	within			16.8	0.05	191.9			
school	overall	100.7	98.3	15.4	61.96	162.3			
	between			14.4	74.67	155.6	755	44	% (of gross)
	within			6.56	74.75	134.3			

Table A3. Average marginal effects of institutions on CO_2 emissions at different institutional quality levels

$lnCO_2$ per capita		Model CO-8
Institutional quality at sample	*min*	-0.78*** (0.26)
	25th percentile	-0.34*** (0.089)
	mean	-0.36*** (0.09)
	median	-0.39*** (0.09)
	75th percentile	-0.45*** (0.13)
	max	-0.51*** (0.16)
at Western Europe	*mean*	-0.44*** (0.12)
at Post-socialist states	*mean*	-0.34*** (0.09)
at Post-socialist states,Western Balkans excluded	*mean*	-0.34*** (0.09)
at Western Balkans	*mean*	-0.36*** (0.09)

Figure A1. Average marginal effects of institutions on CO_2 emissions