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Institutional determinants of environmental performance

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ABSTRACT

This note examines the impact of three institutional factors on environmental performance and carbon intensity of gross domestic product (GDP) for a cross-section sample of 154 countries. The institutional factors are democratization, market orientation of the economy, and prevalence of corruption. Per capita income is generally used as a control variable. As the distribution of some of the variables is highly skewed, we apply several robust regression methods, in comparison to ordinary least squares (OLS). Results differ depending on the estimation method, but generally per capita income is negatively related to carbon intensity but positively correlated with environmental performance. The higher the degree of democratization, the better the state of the environment and the lower the carbon intensity. Market orientation of the economy is ambiguous at first sight, but if an interaction variable with the democracy index is applied, the effect is quite large and highly significant. In this case, the impact of the corruption variable fades. Sensitivity analyses reveal, that introducing a democratic market economy is the most promising strategy to promote environmental performance as well as to cut the carbon emission intensity.

Contribution/ Originality: This paper is the first that tests the impact of three institutional variables on two environmental output variables using robust regression methods. In addition, the paper is the first that addresses interaction effects.

1. INTRODUCTION

Capitalist market economies frequently have a bad reputation regarding environmental protection. They are blamed for environmental degradation, resource depletion and climate change. Accordingly, the idea that there can be something like sustainable, green growth is rejected (Hickel & Kallis, 2020; Mikkelson, 2013). What is striking about these contributions is the mostly verbal and descriptive approach; there are hardly any mathematical models in the tradition of neoclassical growth models (Smulders, Toman, & Withagen, 2014) or statistical hypothesis tests. In this article, the discussion about green growth in general will not be summarized. Rather, we shall concentrate on a somewhat narrower question that deals with a sub-area of green growth. It is about the institutional determinants of the state of the environment, which are to be examined at country level. Institutional determinants are in particular the economic system, the political system, the existence of a constitutional state and the prevalence of corruption.

These determinants will be examined empirically with regard to their effects on the general state of the environment in a certain country and the emission of carbon dioxide that is "needed" for the manufacture of one dollar of gross domestic product.

2. MEASURING THE STATE OF THE ENVIRONMENT

The environmental status of a country is a complex variable that can be measured on the one hand by the pollution of soil, water, and air with pollutants, i.e. immissions. On the other hand, the consumption of resources (soil, renewable resources, exhaustible resources) can be taken into account. The more sustainable the consumption of resources, the better the environmental status must be attested. In this article, Yale University's Environmental Performance Index (EPI) (Wolf, Emerson, Esty, De Sherbinin, & Wendling, 2022) is used, which is recognized and widely used in the literature as a comprehensive indicator of the state of the environment in a country. It is available for a large number of countries and is updated annually. It is a combined indicator that includes both "load variables" and "consumption variables" and contains 40 individual indicators that are grouped into 11 sub-categories and 3 main categories ("Climate Change", "Ecosystem Vitality", "Environmental Health"). The main category "Climate Change" accounts for 39 percent of the overall weighting.

Due to the eminent importance for the earth's climate, another load indicator will be used. It is the emission of carbon dioxide that has to be accepted for one dollar of gross domestic product. The lower the value, the better the global environmental status, because CO2 emissions represent global negative externalities. This variable also is available for many countries.

3. INSTITUTIONAL FACTORS

In this paper, three institutional factors shall be examined with regard to their impact on environmental quality. The first factor is a country's degree of democratization. The "Index of Democracy" provided by the magazine "The Economist", which was compiled for a large number of countries, is widely used. The index comprises five sub-areas (electoral process, civil liberties, functioning of the government, political participation, political culture) and aggregates them into an overall index (DEM). This ranges from 0 (perfectly authoritarian regime) to 10 (perfect democracy). Most western countries are within a range from 8 to 10. The second factor describes a country's economic order using the Fraser Institute's "Economic Freedom Index" (EFI). As with the "Index of Democracy", it can take values between 0 and 10. The reference model here is a typical free market economy in the "laissez faire" style of the 19th century, which is assigned an index value of 10. An index value of 0 is assigned to centrally planned economies or extremely interventionist systems. The EFI contains five components (state influence, legal system and property rights, stable money, international freedom of trade, regulation). The third institutional factor is the level of corruption in a country. This article uses Transparency International's "Corruption Perception" Index. The CORR index ranges from 0 (extremely corrupt) to 100 (almost no corruption). It is based on the assessment of the country-specific corruption situation by experts and businesspeople and includes 10 aspects of corruption. All three indices are ordinally scaled but are consistently interpreted as metric variables in the literature, likely because of their fine gradation.

4. HYPOTHESES AND LITERATURE FINDINGS

Based on the existing literature, hypotheses about the effects of the independent institutional variables on the two dependent environmental variables can be formulated as follows:

H1: There is a positive relationship between the degree of democratization and the state of the environment. More democracy leads to better environmental performance. Compared to a dictatorship, political opinions can be formed and expressed freely, including questions of environmental policy. On the other hand, a government in a democratic state has the mandate and likely an interest in limiting or preventing negative externalities in order to promote the common weal.

H2: The relationship between economic freedom and the quality of the environment is ambivalent. On the one hand, a completely unregulated market economy will cause negative externalities that are not mitigated via Coase agreements. The uncontrolled emission of carbon dioxide is an example. On the other hand, the efficiency of market forces can be used to limit or eliminate environmental damage. Appropriate regulation is at the responsibility of the government (regulatory policy).

H3: Rampant corruption is more likely to ensure that politicians do not concern themselves with providing public goods or avoiding negative external effects, but primarily focus on their own well-being. Even formally existing environmental policy rules are easily undermined by corruption. Consequently, freedom from corruption, and environmental quality should be positively correlated.

There already are a number of articles on the hypotheses that have been put forward, the results of which will be briefly presented below. Regarding the H1 hypothesis, there are some findings that confirm the positive association between environmental quality and democratic forms of government. This applies in particular when appropriate regulations combined with legal certainty are in place (Esty & Porter, 2005). These results are confirmed by Zhao and Madni (2021) using panel regression. The results of Joshi and Beck (2018) who examine whether there is a connection with political (and economic) freedom, are unclear. Even a negative impact is found by De Soysa (2022). Here, however, "democracy" in general is not the independent variable, but an "egalitarian democracy" with strong redistribution mechanisms. This determinant is represented by a single dummy variable (yes/no), a simplification given the availability of high-resolution indices. The influence on the dependent variable "atmospheric pollution" is surprisingly positive. More redistribution is associated with higher environmental pollution. However, the author does not provide an explanation. Overall, the findings in the literature are not as clear as expected.

The relationship between economic freedom and environmental quality is theoretically ambivalent (H2). This is also reflected in the literature. Most papers find a positive relationship. For example, Ali, Audi, and Hamadeh (2022) find that greater entrepreneurial freedom leads to less environmental pollution. However, this study lacks per capita income as a control variable. Bjørnskov (2020) comes to a similar conclusion, but here the EFI indicator is the only institutional determinant. Sart, Bayar, Danilina, and Sezgin (2022) and Setyadharma, Nikensari, Oktavilia, and Wahyuningrum (2021) confirm these findings, but their analysis is restricted to EU (European Union) members and ASEAN (Association of Southeast Asian Nations) member states, respectively. De Soysa (2022) finds, that more economic freedom leads to lower emissions intensity, measured in terms of carbon dioxide emissions per dollar of gross domestic product produced. Per capita income as a control variable is included here. Adesina and Muteba Mwamba (2019) restrict their analysis to African countries and carbon dioxide emissions. They note that higher EFI values generally reduce emissions, but that there are differences between country groups. In addition, the individual EFI components show different effects. Country group effects are also revealed by Rapsikevicius, Bruneckiene, Lukauskas, and Mikalonis (2021). The authors show that more economic freedom is beneficial for environmental performance, except in a group of mostly small high-income countries. Contradictory results are presented by Sofrankova, Kiselakova, and Onuferova (2021) who find that economic freedom does not promote sustainable economic development as defined by the Boston Consulting Group. Herzog and Wood (2014) show that more economic freedom reduces particulate matter, but not carbon emissions.

Loris and Nichols (2021) on the other hand, find a generally positive effect of economic freedom on the Environmental Performance Index, but present only a simple correlation, and control variables are missing. In addition, the suspicion of outliers arises during the visual inspection of a scatterplot given. This point has received remarkably little attention in the empirical literature.

The role of corruption has also been examined in the empirical literature. The results mostly show the expected correlation; more corruption results in less environmental quality. Corresponding results are found by Gallego-Álvarez, Vicente-Galindo, Galindo-Villardón, and Rodríguez-Rosa (2014); Ganda (2020); Rohov, Prykhodko, Kolodiziew, Sybirtsev, and Krupka (2021) and Sofrankova et al. (2021). However, Morse (2006) points out that the influence of corruption becomes weaker when per capita income is included as a control variable.

The article presented here represents an attempt to close the existing gaps in empirical research.

This will be done.

a) By simultaneously including all three institutional determinants as well as per capita income.

b) By the study of interactions between variables.

c) Through the additional estimation with a robust regression method in order to be able to better tackle outliers and to ensure more reliable estimates of the quantitative effects.

5. DATA AND ECONOMETRIC ESTIMATION

A few panel studies have been carried out in the literature (e. g. (De Soysa, 2022; Zhao & Madni, 2021)) which are able to use the information contained in the data simultaneously at the time series and cross-sectional level, but they can only be used without restrictions if the measurement of the variables included remains constant over time. This is not the case for some of the variables used here. For example, both the EPI and the EFI have changed in their composition and survey accuracy. For this reason, a simple cross-sectional estimate is carried out here with the latest variants of the respective variables. Dependent variables are the 2022 Environmental Performance Index and the 2021 carbon emissions per dollar of gross domestic product. Independent variables are the 2021 US$ per capita income, the 2021 Democracy Index, the 2021 Corruption Index and the 2020 Economic Freedom Index. The sample, all variables considered, includes 154 countries when the dependent variable is the EPI and 145 countries when this is the carbon dioxide intensity. In order to assess the effect of possible outliers, a LAD (least absolute deviations) estimate is also carried out in addition to the simple OLS estimate. This is more robust to outliers than OLS, since it does not minimize the residual sum squared, but the sum of the absolute deviations. As a result, the influence of extreme values is lower, since in OLS the outliers are included in the minimization calculation with their squared weight (Foss, Myrtveit, & Stensrud, 2001).

Other robust estimation techniques are the M-regression, S-regression, and MM (modified maximum likelihood)-regression. Monte Carlo and empirical comparisons show that S-estimation (Singgih & Fauzan, 2022; Susanti, Pratiwi, Sulistijowati, & Liana, 2014) and the MM-method (Almetwally & Almongy, 2018) proved superior. We therefore estimate all regression models with OLS, OLS with standard errors corrected for heteroskedasticity, LAD, and S- and MM-regressions.

5.1. Determinants of Environmental Performance

Table 1 presents the estimation results for the EPI as dependent variable.

Table 1. Dépendent variable: EPI.

Variable	OLS	OLS Huber-white	LAD	S-estimation	MM-estimation
PCI	0.000 (3.963)***	0.000 (3.144)***	0.000 (3.065)***	0.000 (5.453)***	0.000 (4.542)***
DEM	1.569 (3.160)***	1.569 (2.999)***	1.494 (2.439)**	1.900 (3.252)***	1.402 (2.771)***
CORR	0.165 (2.035)**	0.165 (2.078)**	0.098 (1.056)	0.001 (0.008)	0.141 (1.707)*
EFI	0.111 (0.096)	0.111 (0.095)	1.656 (1.284)	2.131 (1.565)	0.460 (0.389)
Constant	21.719 (3.403)***	21.719 (3.143)***	14.016 (1.852)*	10.825 (1.444)	20.618 (3.169)***
R-squared	0.589	0.589	0.385	0.404	0.494
Adj. R-squared	0.577	0.577	0.368	0.388	0.480

Note: T-statistics are given below the coefficients; *, **, *** denote statistical significance at the 10%, 5%, and 1% level.

Only the variables PCI (Per Capita Income) and DEM are significant at the 99% level and CORR at the 95% level. Economic freedom has no significant impact. The robust regression methods reveal different results. On the one hand, the goodness of fit is lower, which has to be the case, because OLS, by definition, provides the best goodness of fit, measured by the coefficient of determination. However, the clear drop in the coefficient of

determination also indicates that outliers play a role. The significance of PCI and DEM is not affected, but the corruption index variable loses most of its significance. Regarding economic freedom, statistical significance is generally missing though the robust methods drastically change the coefficients of EFI. The results of the EFI index indicate in particular that the environmentally harmful and environmentally beneficial effects of economic freedom may cancel each other out. The next step is to check whether interactions play a role. Two interaction variables were tested, DEM*EFI and DEM*CORR. However, the last interaction variable introduces a high degree of multicollinearity, since DEM and CORR already correlate with r = 0.75. For this reason, the variable EPI is estimated depending on the per capita income and the interaction DEM*EFI. Table 2 reports the estimation results:

Table 2. Dependent variable: EPI.

Variable	OLS	OLS Huber-white	LAD	S-estimation	MM-estimation
PCI	0.000 (3.907)***	0.000 (3.107)***	0.000 (2.958)***	0.000 (5.688)***	0.000 (4.442)***
DEM*EFI	0.239 (3.878)***	0.239 (3.599)***	0.285 (3.803)***	0.310 (4.259)***	0.226 (3.598)***
CORR	0.122 (1.544)	0.124 (1.585)	0.093 (0.978)	-0.011 (0.120)	0.109 (1.324)
Constant	23.853 (11.614)***	23.853 (10.792)***	23.255 (8.640)***	24.179 (9.959)	24.380 (11.645)***
R-squared	0.598	0.598	0.391	0.407	0.501
Adj. R-squared	0.590	0.590	0.378	0.395	0.491

Note: T-statistics are given below the coefficients; *, *** denote statistical significance at the 10%, and 1% level.

OLS as well as robust methods show that per capita income and the interaction variable are significant at the 99% level. The corruption variable is not significant. The higher the per capita income, the better the state of the environment. However, this should not be due to carbon dioxide emissions, as these increase with rising incomes. Rather, the results suggest that the other components of the EPI (Environmental Performance Index) cause the improvement as income increases. The importance of the interaction variable is remarkable. Apparently, it is the combination of democratic governance and a market economy that is making the environment healthier (the effect is more pronounced for the LAD and the S-estimate). Since the variable EFI alone is not significant, this indicates that a legal framework with prioritized environmental protection provided by a democratic government is likely to unleash te efficiencies of a market economy to improve the environment and limit external effects. The role of corruption, however, seems to be very limited at best.

5.2. Determinants of Carbon Intensity

We shall now examine the relationship between carbon dioxide emissions per dollar of gross domestic product and the institutional variables. The dependent variable shows a positively skewed distribution and a large range. The smallest value is 0.02 kg/$, the largest 1.16 kg/$, a ratio of 1:58. The initial hypothesis assumes a positive relationship between per capita income and pollutant emissions, since the industrialized nations are among the largest emitters. Regarding the institutional variables an inverse connection with the democracy index and the corruption index and an ambivalent connection with the index of economic freedom is to be expected. The nexus between income and the emission variable is best represented functionally by an inverse relationship. A regression on the independent variables income, democracy, corruption, and economic freedom provides only insignificant estimation results for the institutional determinants with both OLS and robust methods, while the coefficient of the inverted per capita income is negative, at high significance levels. Again, a model specification with the interaction variable DEM*EFI shows the best results. The corruption index is insignificant for all model specifications and estimation methods. In Table 3, the results from OLS and robust estimation methods are presented.

Table 3. Dependent variable: Carbon intensity.

Variable	OLS	OLS Huber-White	LAD	S-estimation	MM-estimation
1/PCI	-293.501 (3.990)***	-293.501 (5.155)***	-306.635 (4.261)***	-294.215 (5.107)***	-241.661 (5.132)***
DEM*EFI	-0.002 (2.515)**	-0.002 (3.057)***	-0.002 (3.288)***	-0.002 (3.487)***	-0.002 (3.454)***
Constant	0.363 (8.806)***	0.363 (10.291)***	0.343 (8.459)***	0.314 (9.737)***	0.312 (11.824)***
R-squared	0.103	0.103	0.092	0.124	0.106
Adj. R-squared	0.090	0.090	0.079	0.111	0.094

Note: T-statistics are given below the coefficients; *, **, *** denote statistical significance at the 10%, 5%, and 1% level.

The interaction variable again is highly significant and shows that the freer and more democratic a country is, the smaller the emission volume that has to be accepted to generate one dollar of gross domestic product. However, the goodness of fit of the model is relatively poor. This can be explained by a large number of country-specific variables that were not taken into account in our model. Important determinants are, for example, traffic density, energy intensity (Chen & Mkumbo, 2020; Xiaoyang, Kanaado, & Epadile, 2022) industry in proportion to GDP (Neenu & Nishad, 2021) transaction costs (Salim, Xavera, Ricado, Paul, & Christian, 2023) and the type of power generation. Even within the group of industrialized countries, it is obvious that there are notable differences, though income, the degree of democracy, and economic freedom are comparable. The countries with very low emissions (Switzerland with 0.07 kg/$, Norway with 0.1kg/$) use renewable energies intensively, especially hydropower. France and Sweden, which show very low figures at 0.12 kg/$ and 0.10 kg/$ respectively, owe these values to the intensive use of nuclear energy, while Germany does significantly worse at 0.19 kg/$. However, the USA and Australia emit much higher amounts of carbon at 0.30 kg/$ and 0.34 kg/$ respectively.

Based on the LAD estimates, some example calculations will now be presented that show the response of the carbon dioxide intensity of gross domestic product with respect to income and interaction variable changes.

a) We first set the mean value of the interaction variable DEM*EFI of 38.4485 as a reference value which is kept constant as income varies. A per capita income of US$ 2,000 is assumed to be low and US$ 100,000 to be high. (The minimum value is US$ 793, the maximum value is US$ 134,754.) Low income results in emissions of 0.094 kg/$ and high income in 0.244 kg/$. High income therefore is associated with about 2.6 times higher carbon dioxide intensity.

b) As an alternative, we keep the mean income, which is US$ 23,503.6, constant and compare it to a high interaction term of 70 (maximum value = 77.49) and a low interaction term of 10 (minimum value = 6.05). This results in an emission of 0.188 kg/$ with little economic freedom and an authoritarian regime and 0.038 kg/$ with high economic freedom and full democracy. This is a difference of 4.95:1.

c) If the income is reduced to the minimum value of US$ 793, a hypothetical emission value results which is even negative, which can be explained with the model specification with the reciprocal of income as the dependent variable. In reality, this means that theoretically the carbon emissions per dollar of gross domestic product drop to zero if an absolutely, bitterly poor subsistence economy is assumed. In the "reference" country Burundi, 65% of the population live in extreme poverty, i.e. less than US$ 2.15 per head per day (Worldbank, 2023).

d) However, in realistic ranges carbon emissions per dollar of gross domestic product produced are far more sensitive to the interacting institutional variables of democracy and market economy than to per capita income. This implies, that policies should be more directed to introducing a democratic and economically free system, but not to promote poverty through shrinking of the economy. This result confirms the findings and recommendations of Salim et al. (2023).

6. CONCLUSION

Regression results for the environmental performance index as well as for the carbon intensity consistently show a strong impact of the combined democracy and economic freedom interaction index. Freer and more democratic countries have better environmental performance as well as lower carbon intensities. Contrary to some literature findings, corruption does not seem to play a major role for both dependent variables. Application of robust regression methods indicates that outliers may play a role, but OLS and robust methods results do not show large deviations. However, the impact of the institutional interaction variable seems to be underestimated by OLS due to the presence of outliers. We therefore generally recommend application of robust regression methods.

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APPENDIX

Data Sources

Environmental Performance Index: https://epi.yale.edu/

Carbon Dioxide Emissions per Dollar of Gross Domestic Product: https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

Per Capita Income: https://data.worldbank.org/

Economic Freedom Index: https://www.fraserinstitute.org/studies/economic-freedom-of-the-world-2022-annual-report

Index of Democracy: https://www.eiu.com/n/campaigns/democracy-index-2021/?utm_source=economist&utm_medium=daily_chart&utm_campaign=democracy-index-2021

Corruption Perception Index: https://www.transparency.org/en/cpi/2021?gclid=EAIaIQobChMIurCHrZe__AIVmuhRCh387QLcEAAYASAAEgJMV_D_BwE