Ibero-Amerika Institut für Wirtschaftsforschung
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Georg-August-Universität Göttingen
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Diskussionsbeiträge · Documentos de Trabajo · Discussion Papers

Nr. 212

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September 2011

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How well did the Kyoto Protocol work? A dynamic-GMM approach with external instruments

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[*] Financial support from the Spanish Ministry of Science and Innovation (ECO 2010-15863) is gratefully acknowledged. The authors would like to thank the participants at the CESifo Venice Summer Institute 2009 for their helpful and constructive comments. Corresponding author: ngrunew@uni-goettingen.de

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Abstract

This paper assesses the impact of the Kyoto Protocol on CO_2 emissions. With this aim a dynamic panel data model is estimated for a cross-section of 213 countries over the period 1960 to 2009. The model, based on a STIRPAT approach, also integrates the EKC approach and specifically considers the endogeneity of the policy variable. To sort out causality the number of financed CDM projects is used as an external instrument. The main results indicate that obligations from the Kyoto Protocol have a measurable reducing effect on CO_2 emissions and indicate that a treaty often seen as "failed" in fact may be producing some non-trivial effects.

Keywords: Environmental Kuznets Curve, Kyoto Protocol, panel data, Clean Development Mechanism

JEL Classification: Q54 Q56

1 Introduction

Among the six dominant greenhouse gases mentioned by the UNFCCC, carbon dioxide emissions (CO_2) are considered to have the strongest impact on climate change. In 2009, total global CO_2 emissions amounted to 31.3 billion tonnes, an increase of almost 40% since 1990, the base year of the Kyoto Protocol. The very large regional variation in emission trends in 2009 resulted in a 53% share of developing countries versus 44% for industrialised countries with mitigation targets for total greenhouse gas emissions under the Kyoto protocol. The

Annex B countries are due to cut emissions to an average of at least 5.2 percent below 1990 levels (22.5 billion tonnes) by 2008-2012.[1] Although those countries reduced CO_2 emissions by about 7% in 2009, a large part of the decrease was due to a drop in economic activity in response to the crisis. Indeed, emissions could increase toward pre-recession levels as developed countries recover their normal economic activity levels.

Given the current policy debate and the importance of evaluating the effectiveness in terms of emission reductions of the already established climate agreements, the main aim of this paper is to analyze to what extent emission reduction obligations from the Kyoto Protocol have an effect on CO_2 emissions. In other words, how much more CO_2 would the countries have emitted in the absence of their Kyoto Protocol ratification. This question is important to evaluate present international climate negotiations and to encourage future climate negotiations which could introduce binding emission reduction obligations to all countries without jeopardizing the growth of developing countries.

From a theoretical point of view, we base our analysis on the so-called Environmental Kuznets Curve (EKC) and on the STIRPAT model: a more elaborated version of the simple IPAT formulation proposed by Dietz and Rosa (1997). The EKC theory hypothesizes an inverse U-shaped relationship between per capita income and environmental degradation. With increasing income per capita environmental degradation first rises and after having reached a maximum level of degradation (the turning point) it starts to decline. Grossman and Krueger (1991, 1995), Holtz-Eakin and Selden (1995) as well as Selden and Song (1994) were some of the first to find this relationship, which is derived from the work of Kuznets (1955) on economic growth and income inequality. As recently pointed out by Carson (2011),

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[1] The Annex B countries are industrialized countries which signed the Kyoto Protocol. Their emission reduction goals are mentioned in the Annex B of the treaty. For a list of all Annex B countries refer to Appendix 1.

the early EKC literature contributed to a shift of the IPAT view, which is shared by policy makers and environmentalists, away from that growth is associated with environmental degradation, towards the belief that economic growth can be good for the environment. After almost twenty years of EKC investigations,[2] the inverse U-shaped income-emissions relationship is far from being an empirical fact and the recent literature recognizes that income affects enissions through other factors (Carson, 2011). In this sense, it is worth to investigate the underlying mechanisms through which, in some cases, the EKC prevails.

Among the studies that analyze the relationship between income growth and CO_2 emissions, to our knowledge only two of them have specifically considered the Kyoto Protocol as one of the underlying mechanisms that could be behind the EKC. In the first study, Mazzanti and Musolesi (2009) evaluate the impact of time related factors, including policy events, on carbon emissions and find that the income-emissions relationship is affected by policy events such as the UNFCCC in 1992 and the Kyoto Protocol in 1997. A second investigation by Aichele and Felbermayr (2010) analyzes whether ratifying the Kyoto Protocol has an effect on the carbon content of bilateral trade and conclude that it can indeed lead to carbon leakage. However, none of them focus explicitly on the effectiveness of the Kyoto Protocol and the country coverage of both studies is limited. The first paper focuses only on EU countries and the second on 38 countries (27 facing binding emissions). This investigation attempts to fill these gaps.

The major contribution of the paper is to assess the impacts of the Kyoto protocol by considering a broad sample of countries (213) and by evaluating the role played by the Protocol in reducing CO_2 emissions in Annex B countries. With this aim, a dynamic panel-data model is estimated that specifically considers the endogeneity of the policy variable. We

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[2] For a summary of earlier investigations see Appendix 2.

employ panel data methods to control for unobserved heterogeneity and use as external instrument for the Kyoto variable the number of financed CDM projects. The CDM as one of the flexible mechanisms from Kyoto Protocol is correlated with the emission reduction obligations of the investing country but not with its current CO_2 emissions. In this way we are able to interpret our estimates as causal effects. It is also worth noting that the fact that we use the STIRPAT approach and integrate it with the EKC approach helps bridge the gap between the literature in economics (where STIRPAT sees some use) and the larger environmental science and social science literature, where STIRPAT is very common.

The paper is structured as follows. International climate policy is briefly described in Section 2. Section 3 discuses the measurement and sources of the data used and presents the empirical analysis and main findings. Finally, some concluding remarks are outlined in Section 4.

2 Literature Review

2.1 Kyoto Protocol

The Kyoto Protocol was prepared by the annual meetings of the UNFCCC and adopted for use at the 1997 meeting in Kyoto. The protocol divides the member countries into different groups: Annex-B with GHG emissions reduction obligations and the Non-Annex-B without emission reduction obligations. It covers the main GHGs such as CO_2, which represents the biggest share, and five other GHGs. The goal of the protocol is a reduction of GHGs by 5.3% by 2012, compared to the countries’ emission levels in 1990. It finally entered into force in 2005 after Russia’s ratification. It was then that the established prerequisite of at least 55 countries emitting at least 55% of the global GHG emissions had ratified the treaty was fulfilled.

The reason for the long delay between the adoption and the entering into force of the protocol was related to the question of which countries should have binding emission reduction obligations and what are the estimated costs from these obligations.[3] There was also the question of how to incorporate and support developing countries, which in 1997 did not account for a big share in emissions but now do. China for example saw strong increases in its emissions during recent years. To overcome the difficulty of how to integrate developing countries the Kyoto Protocol tries to enhance sustainable development among developing countries via the Clean Development Mechanism (CDM).

The CDM opens the possibility to fulfill a country's GHG emission reduction obligations with Certified Emission Reduction Units (CERs) from any developing country which is a member of the UNFCCC. Hence, it works like a back door for the developed countries to get CERs to fulfill their obligations at low cost. The CDM aims at achieving four goals. First, it shall integrate developing countries in the international framework on environmental regulations without putting any costly obligations on those countries. Second, the mechanism opens new markets to those countries, or integrates those countries into a new market such as the international carbon market, which trades the CERs obtained from CDM projects. Third, the CDM could be a tool to achieve sustainable development among poorer countries. Finally, and probably most criticized but also most reasonable goal, emissions are reduced at the lowest cost possible. The technology applied in developed countries might be at a higher level of energy efficiency than the technology applied in developing countries (e. g. it could be possible to reduce five times more GHG emissions in China than in Germany with the same amount of money invested).

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[3] For a list of the countries with emission commitments refer to appendix 3.

Swinton and Sarkar (2007) analyze costs and benefits for developing countries from the Kyoto Protocol and draw an optimistic perspective. Developing countries are integrated into international markets and can exhibit comparative advantages since they reduce GHG emissions at a lower unit cost. They can also attract foreign capital which creates positive side effects and can lead to a cleaner growth path. The integration in international environmental law may also lead to an improvement in the developing countries institutions. Rose and Spiegel (2008) find engagement in non-economic agreements to be growth enhancing and that joint environmental interests do foster economic ties. They provide evidence that non-participation may lead to costs in terms of lower economic exchange in international trade and foreign direct investment. Aichele and Felbermayr (2010) analyze if the emission reduction obligations from Kyoto Protocol have an effect on the carbon content of bilateral trade. They find that ratifying the Protocol leads to an increase in the carbon content of imports, in other words, it leads to carbon leakage.

2.2 The Environmental Kuznets Curve Hypothesis

Since the first EKC studies, Grossman and Krueger (1991) and Roberts and Grimes (1997), much work relating pollution and emissions to income has been conducted - an excellent survey of early studies can be found in Stern (1998) - but the findings do not seem to support the EKC hypothesis in a general way. In particular, the results are strongly dependent on the pollutant indicators chosen as well as on the functional form estimated and the explanatory variables included in the regression. Most criticisms are related to the econometric techniques and the presence of omitted-variables bias (Perman and Stern, 2003). Borghesi and Vercelli (2003) state that the studies based on local emissions present acceptable results, whereas those concerning global emissions do not offer the expected outcomes. Therefore the EKC hypothesis cannot be generally accepted. Overviews of the most recent literature, covering different sources for the EKC hypothesis can be found in Stern (2004), Galeotti (2007) and

Carson (2011). These authors conclude that the model is misspecified, the underlying mechanisms are missing and the data used are of poor-quality and not always comparable.

Concerning the studies that focus on CO_2 per capita as dependent variable (listed in Appendix 2), the results are also mixed. Most recent studies indicate that the EKC hypothesis is valid only for a subset of developed countries. Some studies which support this results are Panayotu et al. (2000), Bengochea et al. (2001), Dijkgraaf and Vollenbergh (2001), Mazzanti and Musolesi (2009) and Lamla (2009). Mazzanti and Musolesi (2009) find that policy events such as the UNFCCC in 1992 and the Kyoto Protocol in 1997 may be part of the drivers of the robust EKC shapes they find for EU north countries, although the oil price shock in the 1980's and the following restructuring of the energy-economy may also play a role. Lamla (2009) also confirms an EKC for CO_2 for a small sample of countries and points to the importance to control for variables like population and technological change when analyzing the pollution-income relationship.

In many other studies the EKC hypothesis is rejected. In some cases because the turning point is out of sample (Shafik and Bandyopadhyay, 1992; Shi, 2003; York et al., 2003), in others because the relationship is N-shaped (Moomaw and Unruh, 1997; Martínez-Zarzoso and Bengochea-Morancho, 2004) or because the squared income term is not statistically significant (Agras and Chapman, 1999; Roca et al., 2001; Baiocchi and di Falco, 2001; Martínez-Zarzoso, 2009). Agras and Chapman (1999) control for past years emissions by applying a dynamic approach and find no EKC for CO_2. York et al. (2003) extend the IPAT model with squared income per capita and find rising emissions with rising GDP but at a declining pace. Martínez-Zarzoso (2009) also does not find evidence for an EKC for CO_2 when controlling for population and technological change.

As stated by Barbier (1997) there is widespread interest on the part of academics in this analysis and on the part of policymakers in the resulting implications for environment and development. The analysis of the shape of the pollution-income relationship could be important for establishing public policies that target emissions reduction. But even more important is to recognize that if we cannot accept the EKC hypothesis in a general way, we could deduce that environmental intervention is needed because economic growth will not be the solution for all environmental problems. We would therefore like to know whether the actions taken, in form of international agreements or regulations, have positive implications for the environment.

3 Empirical Analysis

In this section we present the empirical model and the estimation results to evaluate the EKC hypothesis for CO_2 and to test whether the Kyoto Protocol has an impact on CO_2 emissions. We estimate an EKC version of the stochastic impact from population affluence and technology model (STIRPAT) as used by York et al. (2003) and Martínez-Zarzoso (2009). We will start the analysis with the traditional static regression model and then compare those results to a dynamic model. Given the revealed persistence of CO_2 emissions a dynamic specification allows to account for the path-dependent nature of the distributional pattern (Agras and Chapman, 1999; Martínez-Zarzoso and Maurotti, 2011) and to distinguish between short and long term effects.

3.1 Model and Hypotheses

Recent macroeconomic pollution-income regressions are more general than those in the EKC literature, not only because they include a variety of demographic and institutional variables but also because the population elasticity is allowed to differ from unity. Following York et al (2003), Shi (2003) and Cole and Neumayer (2004) amongst others, we specify a model in which emissions are explained with income, population, industrialization and our policy variable. This framework is related to the STIRPAT model which has its origin in the IPAT formulation.

Dietz and Rosa (1997) consider the rise in CO_2 emissions to be mainly caused by human activities and apply an environmental impact model (IPAT) according to which all impacts of human activities (I) can be divided into four anthropogenic forces. These are considered to be the main driving forces behind the rise in CO_2 emissions. The first one is population (P). The second is economic activity, which is referred to as affluence (A) in the model and which is measured in GDP per capita. The third is technology (T) which describes the technical standard of production and is measured in energy efficiency or industrial activity. Further determinants of CO_2 are political and economic institutions as well as attitudes and beliefs.

The STIRPAT model, as initially proposed by Dietz and Rosa (1997), is given by,

$$I_i = \alpha P_i^{\beta} A_i^{\gamma} T_i^{\delta} \varepsilon_i \tag{1}$$

where P, A and T denote respectively population, affluence and technology and α, β, γ and δ are parameters to be estimated. The error term, which captures all the unexplained variance of the model, is denoted by ε. Finally, i stands for countries and indicates that the quantities of A, P, T and ε vary across countries.

Dietz and Rosa (1997) include T in the error term and do not separately estimate the influence of technology on emissions, whereas York et al. (2003) extend the model and introduce T as another explanatory variable. By adding the time dimension and taking natural logarithms (*ln*) on both sides of equation 1, we obtain

$$\ln I_{it} = \alpha_0 + \beta \ln P_{it} + \gamma \ln A_{it} + \delta \ln T_{it} + \mu_{it} \tag{2}$$

where α_0=lnα and $\mu_{it} = \ln \varepsilon_{it}$.

York et al. (2003) also investigate the introduction of further variables such as variables for institutions and squared variables to measure nonlinearities in the model. They lay the foundation for the model specification which we apply

$$\ln CO_{2it} = \alpha_i + \lambda_t + \beta_1 \ln P_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln GDP_{it}^2 + \beta_4 \ln IA_{it} + \beta_5 KyotoOb + \nu_{it} \qquad (3)$$

where the dependent variable in (3) is CO_2 emissions measured in metric tons. α_i and λ_t are country and year specific effects that control for unobservable country-heterogeneity and common time-varying effects that could affect emissions. Population is measured in number of inhabitants. Cramer (1998) and Cramer and Cheney (2000) are among the first to test whether the elasticity of emissions with respect to population is unity.[4]

The variables GDP per capita and GDP per capita squared are a proxy for affluence and represent the corner stone of the analysis for the EKC.[5] The squared term accounts for non-linearities of the pollution-income relationship. Grossman and Krueger (1995) as well as Harbaugh et al. (2002) find an N-shaped EKC for local pollutants.[6] As a proxy for technological change we use industrial activity *(IA)* calculated by the share of the manufacturing industry in total GDP.[7] We would assume that countries which are specialized on agricultural production facilities will show a low share and those who are in the stage of

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[4] In the EKC approach it is assumed to be unity by using the logarithm of the pollutant in per capita terms.

[5] We followed the approach of Harbaugh et al. (2002) trying to identify the right empirical specification for the EKC. Nevertheless the selected quadratic specification did yield more robust results than the cubic specification of GDP per capita which was also estimated (the results are available upon request).

[6] They further introduce three-year averaged lagged values of GDP to account for possible dynamics. We obtained non-significant results on those coefficients but we will account for possible effects from past GDP on present emissions by applying a dynamic panel data model.

[7] We also estimated different specifications using additional variables, namely energy efficiency (oil input per output in terms of GDP) and the number registered patents as a proxy technological change. The results were neither convincing nor did they fit into the scheme of the IPAT model in the case of the second variable.

industrialization will show a high share of manufactured goods in GDP. Developed countries might show already a low share if they specialized in service industries.

In order to measure the impact of the Kyoto Protocol on CO_2 emissions we create the variable *KyotoOb* (Kyoto obligations) that takes the value one if a country has ratified the Kyoto Protocol and faces emission commitments from the treaty, otherwise it takes the value zero. This dummy variable takes the value one from the year in which the country has ratified the Kyoto Protocol onwards. Most of the countries with emission commitments ratified the protocol in 2002. It is worth to notice that a number of high income countries, namely the US, Israel, South Korea and Singapore did not ratify the Protocol and therefore the *KyotoOb* dummy is not highly correlated with the level of per capita income, making possibly the identification of separated effects.

It could also be argued that since the Protocol did not come into force until 2005 when sufficient countries ratified it, it would make more sense to switch the dummy variable on in 2005 for all countries. However, there are several reasons to support the argument that the dummy should be constructed using the ratification date and not the entry into force. First, the entry into force does not have immediate consequences and second, politics, the media and the voters are actors involved in the ratification process and it is after the ratification of the Protocol when the relevant domestic policy settings are fixed.

The main hypotheses are:

1. The variable KyotoOb has a negative effect on CO_2 *emissions and therefore policy measures can have an influence on emissions.*

2. The EKC hypothesis is not generally valid for CO_2 *emissions.*

In order to allow comparison, we first estimate Equation (3) by ordinary least squares (OLS) assuming that there is no unobserved heterogeneity across countries ($\alpha_{i=}\alpha$) and assuming also common slope coefficients β for all countries.[8] Due to the existence of unobserved heterogeneity the estimated OLS coefficients are biased. Therefore, country specific effects (α_i) are used to model the unobserved heterogeneity between the observed countries. We take account for those effects by estimating a random effects (RE) regression and testing with the Lagrange Multiplier test for the significance of country specific effects. The outcome of the test[9] indicates that there are country specific effects to be taken into account.

The RE error component model assumes that the country specific effects α_i are not correlated with the independent variables x_{it}, in other words $E(x_{it}\ \alpha_i)=0$. If this assumption is not fulfilled, the RE coefficients are inconsistent and the unobserved heterogeneity should be modeled using the fixed effects (FE) estimator. The Hausman test[10] suggests that the RE estimator is inconsistent and, consequently, we will continue with the FE estimator, which uses only the variation within countries over time, being less efficient than the RE but consistent.

There are two further issues concerning the consistency of our model in Equation (3). One is heteroscedasticity in the error term, which could lead to consistent but inefficient estimates of the FE estimator. The second one refers to serial correlation in the error term. The error term of the current period v_{it} could be correlated with the error term of the previous period v_{it-1}. We test for heteroscedasticity by applying the White test for heteroscedasticity and find the error term to be heteroscedastic.[11] We further apply the Wooldridge test for autocorrelation of first

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[8] The results of the OLS regression are reported in Appendix 6 column (1).

[9] (chi2(1) = 22536.79 and Prob > chi2 = 0.00).

[10] (chi2(25) = 102.52 and Prob>chi2 = 0.00).

[11] The test is applied by a regression using as dependent variable the squared error term and as independent variables all the variables in the model plus the prediction from the FE model squared and in higher exponential

order which suggests that autocorrelation of order one is present in the error term.[12] To deal with both problems simultaneously, heteroscedasticity and autocorrelation, a within FE estimator with Driscoll-Kraay standard errors is applied.[13] This approach allows us to adjust the model to an autocorrelation structure of order 1 (AR1) with heteroscedastic-robust standard errors (Driscoll and Kraay, 1998).

Next, to test for endogeneity of right-hand-side variables we apply the Durbin Wu Hausman test and find our *KyotoOb* variable to be endogenous.[14] Indeed, a country with emission reduction obligations from the Kyoto Protocol will tend to emit lower amounts of CO_2 emissions, but at the same time the ratification of the Kyoto protocol could also depend on the country's CO_2 emissions level. To overcome this endogeneity problem we instrument the variable *KyotoOb* with the number of CDM projects financed by the investing country. The CDM as one of the flexible mechanisms from Kyoto Protocol is correlated with the emission reduction obligations of the investing country but not with its current CO_2 emissions. Industrialized countries with high emission reduction obligations, such as the Netherlands, which at the same time face high emission reduction costs have an incentive to reduce emissions abroad via the CDM. The first and second stages of the IV approach are

$$\ln KyotoOb_{it} = \alpha_i + \lambda_t + \beta_1 \ln P_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln GDP_{it}^2 + \beta_4 \ln IA_{it} + \beta_5 CDM_{it} + v_{it} \qquad (4)$$

$$\ln CO_{2it} = \alpha_i + \lambda_t + \beta_1 \ln P_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln GDP_{it}^2 + \beta_4 \ln IA_{it} + \beta_5 KyotoOb + v_{it} \qquad (5)$$

The instrumental variable approach given by equations (4) and (5) accounts for the endogeneity of the variable *KyotoOb* but it cannot account for heteroscedasticity or

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orders. Since the estimated coefficients for the added variables are significant, they explain some of the variance in the error term and we have to consider that the error terms is heteroscedastic.

[12] (F(1,161) = 55.829 and Prob > F = 0.00).

[13] The results are presented in Appendix 6, column (3).

[14] The endogeneity test result for *KyotoOb* gives: ($chi^2(31) = 425.11$ and $Prob>chi^2 = 0.00$).

autocorrelation in the error term and it is therefore though consistent, inefficient (Baum et al. 2003). Accounting for endogeneity, the estimated coefficient of the variable KyotoOb is also negatively signed but higher in magnitude (0.30 versus 0.20) as shown in Appendix 6, columns 3 and 4. It is worth noting that the effect is under-estimated when endogeneity is not modeled.

Next, we specify a dynamic approach that assumes that today's CO_2 emissions are driven by past emissions. To measure this impact we introduce last year's CO_2 emissions $\ln CO2_{it-1}$ as additional explanatory variables in the model:

$$\ln KyotoOb_{it} = \alpha + \lambda_t + \beta_1 \ln CO_{2it-1} + \beta_2 \ln P_{it} + \beta_3 \ln GDP_{it} + \beta_4 \ln GDP_{it}^2 + \beta_5 \ln IA_{it} + \beta_6 CDM_{it} + v_{it} \quad (6)$$

$$\ln CO_{2it} = \alpha + \lambda_t + \beta_1 \ln CO_{2it-1} + \beta_2 \ln P_{it} + \beta_3 \ln GDP_{it} + \beta_4 \ln GDP_{it}^2 + \beta_5 \ln IA_{it} + \beta_6 KyotoOb + v_{it} \quad (7)$$

Equations (6) and (7) are estimated using the difference- and system-GMM estimators proposed by Arellano and Bond (1991) and Blundell and Bond(1998) that allow for an efficient estimation in the presence of heteroscedasticity of unknown form (Baum et al., 2003). Fixed-effect dynamic models suffer from an endogeneity bias of the lagged dependent variable. Since $\ln CO_{2it}$ is a function of v_{it}, then $\ln CO_{2it-1}$ will be a function of v_{it} as well and is therefore endogenous. The instruments Z should be exogenous $E(Z_i \; u_i)=0$. The instruments yield a set of L moment conditions, $g_i(\hat{\beta}) = Z_i' \hat{u}_i = Z_i' \left(y_i - X_i \hat{\beta} \right)$ where g_i is L x 1. The intuition of the GMM is to find the estimator which solves $\bar{g}(\hat{\beta}) = 0$. The instruments have to fulfill two conditions. They have to be correlated with the instrumented variables and they should not be correlated with the error terms. The system-GMM estimator proposed by Blundell and Bond (1998) uses the lagged differences of the variables as instruments for the variables in levels and the lagged levels of the variables as instruments for the variable in first differences, and is therefore considered more efficient than the IV-GMM by Baum et al. (2003), based on Arellano and Bond (1991).[15]

3.2 *Data*

The data comes from the World Development Indicators (WDI) 2010 and covers a panel of 213 countries from 1960 until 2009. For the data on CO_2 emissions we referred to the Carbon Dioxide Information Analysis Center CDIAC.[16] The panel is not balanced since the data on CO_2 emissions for economies in transition is only available from 1992 onwards. The data on the Kyoto Protocol ratification and the CO_2 emission reduction obligations is from the UNFCCC (2010) and data on the number of financed CDM projects by country comes from the UNEP Risoe Centre (2010).[17] Emissions of CO_2 are steadily increasing over time for the whole period and set of countries. The high and upper-middle income countries emit a much higher amount of CO_2 and show a stronger volatility. The low income countries emitted in 2004 about one fifth of the amount of CO_2 in kilo tons compared to the high income countries. Summary statistics for the variables used in the analysis are presented in Appendix 5.

3.3 *Main Results*

We selected the dynamic model as more appropriate than the static one given the statistically significance of the lagged dependent variable in all specifications. The system-GMM

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[15] We also apply panel unit-root tests for the variables in levels and in first differences. We are able to reject the presence of a unit root for the dependent variable; meanwhile we find mixed results for the independent variables in levels. By first-differencing the series, the tests indicate that all the variables are stationary. Results are available upon request.

[16] The CO_2 emission data includes emissions from solid, liquid as well as gas fuel consumption and emissions from cement production as well as gas flaring.

[17] To analyze differences between high, middle and low income countries we grouped countries according to their GNI (results available upon request). Economies are divided according to 2009 GNI per capita, calculated using the World Bank Atlas method. The groups are: low income, $995 or less; lower middle income, $996 - $3,945; upper middle income, $3,946 - $12,195; and high income, $12,196 or more. The results are available upon request.

estimator is the preferred estimator since it is more efficient than the difference GMM estimator. The short and long run elasticities of the model are reported in column (2) of Table 1.[18]

Table 1 Main Results of the Dynamic Model

The long run coefficient of population is about unity and the coefficients of GDP per capita show evidence of an environmental Kuznets Curve. Our variable of interest *KyotoOb* has a long run coefficient of -0.28 that is significant at a 10% level for a one sided test.[19] A country that ratified the Kyoto Protocol will emit on average 24.5% less CO_2 in the long term, ceteris paribus (than the same country without emission reductions obligations).[20] As a robustness check in column (3) we let our dummy for Kyoto obligations turn one if a country did ratify the protocol and faces emission reduction obligations compared to their GHG levels in 1990.[21] The new *KyotoOb* variable shows a higher coefficient that is now statistically significant at the five percent level. The sign and significance of the other estimated coefficients remain almost unchanged. Therefore as regards our *first hypothesis,* we obtain that the variable *KyotoOb* has a negative and significant effect on emissions. Hence, a country with emission reduction obligations emits on average around 3 percent less CO_2 in the short run and around 50 percent less CO_2 in the long run than a country without obligations.[22] Figure 1 displays graphically how emissions developed for high income countries with and without emission reduction obligations from the Kyoto Protocol and shows that they diverge

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[18] The long-run elasticities are calculated as $\beta x_{it}/(1-\beta CO_{2it-1})$.

[19] Since we assume a negative coefficient we can apply a one sided test.

[20] We estimate a semilogarithmic model with a dummy variable. The marginal effect of the *KyotoOb* variable is calculated as (exp(-0.28)-1)*100=-24.5%.

[21] Some countries like New Zealand, Russian Federation, Ukraine, Norway, Australia, Iceland, Finland, France, Sweden, Ireland, Spain, Greece, Portugal are allowed to keep their emissions levels or expand them compared to 1990.

[22] Since most of the countries with emission reduction obligations ratified the Kyoto Protocol in 2002, we introduce interaction terms for the variable *KyotoOb* and the years 2001 to 2007, to see if there are year specific effects (see Appendix 6, column (1) and (2)). Those interaction terms turned out to be not significant in the preferred specification and therefore are not reported.

from 1992 onward. Mazzanti and Musolesi (2009) find as well an effect of the Kyoto Protocol on CO_2 emissions for the northern EU country group. In fact, they state that the inverted U-shape relationship between emissions and GDP is, according to their results, driven by policy events such as the UNFCCC, the Kyoto Protocol and price shocks such as the oil price shock in the1980's.

Figure 1 CO_2 Emissions in Countries with and without Emission Commitments

With respect to our *second hypothesis (EKC)* the GDP variables indicate that emissions first increase with rising GDP and after some turning point they decline with rising GDP. We find an inverted U-shape as in Mazzanti and Musolesi (2009); however, the turning point at an annual average GDP per capita of $209,452 is out of sample. Most of the countries studied face rising emissions with rising income, since the maximum GDP per capita of the sample is $95,434 (PPP adjusted). Figure 2 displays the pollution-income relationship for four countries.

Figure 2 Scatter Plot CO_2 and Income

While the Netherlands face rising emissions with rising income but at a slower path, Brazil, China and India face rising steeply emissions with rising income. The graphs explain the position of the individual countries on the inverted U-curve. Mazzanti and Musolesi (2009) also find a quadratic relationship between CO_2 emissions and income. Similar to our study they obtain insignificant income variables when applying a cubic specification. They find an inverted U-curve for the group of northern European countries with turning points around $13000[23]. The different in results might be due to the grouping of countries done by Mazzanti

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[23] In 1995 constant USD.

and Musolesi (2009) and their smaller sample. Compared to our sample they analyze mostly high income countries divided into three groups.[24]

Our results are in line with the literature which states that there is an EKC for some countries (mainly high income countries which took early actions in environmental policies). Mazzanti and Musolesi (2009) do mostly consider countries with emission reduction obligations from Kyoto Protocol. We apply a potentially more comprehensive model specification of the EKC on a larger panel of countries and contribute to the literature by controlling for the endogeneity of the Kyoto variable.

4 Conclusion

In this paper we analyzed and tested two relevant hypotheses. First, we tested for an effect of the Kyoto Protocol on CO_2 emissions. Our long run elasticity estimates indicate that countries with emission commitments from the Kyoto Protocol emit on average 24.5 percent less CO_2 than similar countries that did not ratify the Protocol. We conclude that there is a potential effect from the Kyoto policy on emissions in those countries. Since the number of countries which ratified the protocol and face emission commitments is rather small compared to the number of countries which did not ratify the protocol and those which do not face any emission commitments under the Kyoto Protocol, a matter of concern is whether we can indeed attribute the whole estimated effect to the Kyoto Protocol. It could be argued that the Annex I countries would have been doing the most to tackle their CO_2 emissions, even in the absence of the protocol. Indeed it is often claimed that regulatory stringency is a positive function of per capita income and in the last decade many developed countries have been

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[24] In an earlier version of the paper we also divide the sample into four sub-samples by income group. We come to the conclusion that analyzing the full sample and controlling for country fixed effects provides more robust results.

taking action to reduce emissions, irrespective of the modest commitments required by the protocol. In this line, we leave for further research the inclusion in the model of better proxies for regulatory stringency that will help to support our findings. We argue in our favour that per capita GDP was used as a proxy for regulatory stringency and that the estimated effect (24.5%) is a long-run elasticity, whereas the short-run effect is much smaller (around 2 %) Assuming that our identification strategy of the causal effect, using external instruments, is valid, we should obtain an accurate estimation of the Kyoto effect.

Second, we examined the EKC hypothesis for a cross-section of 163 countries over a period of 28 years. Our findings indicate that an inverted-U relationship exists among some high-income countries such as Germany or Belgium, whereas for middle- and low-income countries there is no evidence for future declining emissions with rising income. The transfer of end-of-pipe technology could contribute to make growth in those countries greener and avoid high emission levels, which may cause irreversible damage.

To stabilize global warming at a 2 degrees Celsius much stronger measures will have to be taken. Although emissions from the developed countries with reduction obligations have declined and some countries like France, the UK and Germany have been successful in meeting their targets, the decline in emissions is unlikely to be enough to stabilize levels of GHG in the atmosphere. Emissions from emerging countries, namely China and India, are expected to increase substantially in the near future. Even if the involved developed countries achieve the Kyoto target in 2012, this can only be considered a partially successful agreement that is not going to be sufficient to solve the global warming problem. Possible solutions could be to integrate more countries in the treaty, including developing countries, or to establish an international carbon tax on GHG emissions. Since the first commitment round of the Kyoto Protocol will close in 2012 and we observe large emission reductions which are due to the Protocol, it would be desirable to establish as soon as possible effective measures and mechanisms for the next phase, which will cover the period after 2012.

Finally, we would like to close the discussion by pointing out that according to our findings even a treaty often seen as "failed" may in fact be producing some non-trivial effects.

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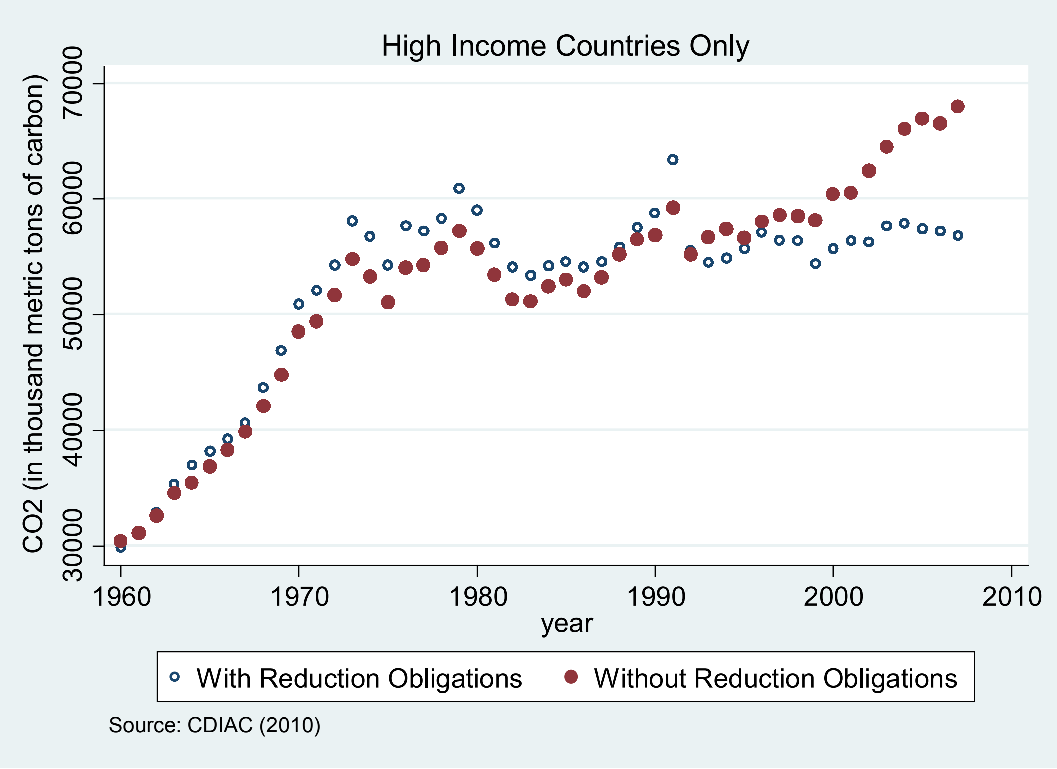
Table 1 Results Dynamic Model

	(1)		**(2)**		**(3)**	
	IV-GMM		**System GMM**		**System GMM**	
VARIABLES	**lnCO$_2$**		**lnCO$_2$**		**lnCO$_2$**	
	short run	**long run**	**short run**	**long run**	**short run**	**long run**
lnPop	0.1300**	0.4962	0.0713***	1.0186	0.0708***	1.0261
	(0.0570)		(0.0239)		(0.0256)	
lnGDP	0.3200**	1.2214	0.2560***	3.6571	0.2500**	3.6232
	(0.1290)		(0.0927)		(0.0967)	
lnGDP^2	-0.0063	-0.0242	-0.0104**	-0.1486	-0.0101**	-0.1464
	(0.0074)		(0.0044)		(0.0045)	
lnIA	0.0721***	0.27512	0.0111	0.1586	0.0085	0.1232
	(0.0170)		(0.0095)		(0.0092)	
KyotoOb	-0.1080***	-0.4122	-0.0197	-0.2814	-0.0324**	-0.4696
	(0.0211)		(0.0139)		(0.0158)	
lnCO$_{2t-1}$	0.7380***		0.9300***		0.9310***	
	(0.0438)		(0.0229)		(0.0243)	
Constant			-1.9600***		-1.9250***	
			(0.6580)		(0.7040)	
Time Dum.	yes		yes		yes	
Endogenity Test	5.106					
	0.024					
Hansen Test	0		74.940		74.370	
	0		(0.144)		(0.086)	
Sargan Test			182.010		182.520	
			(0.000)		(0.000)	
ABond AR(1)			-4.970		-5.000	
			(0.000)		(0.000)	
ABond AR(2)			-1.370		-1.360	
			(0.172)		(0.174)	
No. Instruments	33		97		97	
No. Observations	3,520		3,521		3,521	
No. Countries	162		163		163	

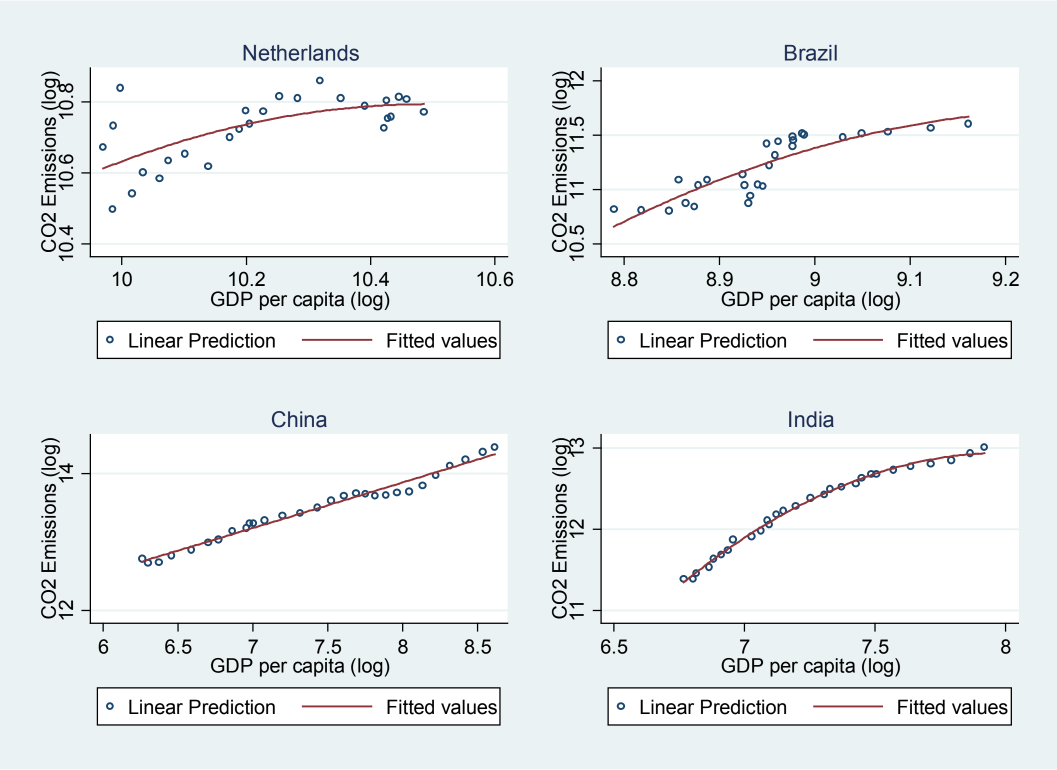
*Note: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Hansen, Sargan and, Endogeneity and A-Bond test for autocorrelation report p-values in parenthesis.*

Figure 1 **CO$_2$ Emissions in Countries with and without Reduction Obligations**



Source: CDIAC (2010)

Figure 2 Scatter Plot CO_2 and Income



Source: WDI, and CDIAC (2010).

Appendix

Appendix 1 List of Annex B Countries from the Kyoto Protocol

Annex B	**Annex B**
Australia	Latvia
Austria	Lithuania
Belgium	Luxembourg
Bulgaria	Netherlands
Canada	New Zealand
Croatia	Norway
Czech Republic	Poland
Denmark	Portugal
Estonia	Romania
Finland	Russian Federation
France (including Monaco)	Slovakia
Germany	Slovenia
Greece	Spain
Hungary	Sweden
Iceland	Switzerland (including Liechtenstein)
Ireland	Ukraine
Italy (including San Marino)	United Kingdom
Japan	United States of America

Source: UNFCCC (1997), 20.

Appendix 2 Literature on the Relationship between CO_2 and Income

Authors	Turning Points	EKC	Countries
Shafik and Bandyopadhyay (1992)	$7 Million	No	118-153
Holtz-Eakin and Selden (1995)	$35428 (level) - $8 Million $35000	Yes	108
Tucker (1995)	Decreasing over Time	In 11 Years	137
Sengupta (1996)	$8740	Yes	16 Developed and Developing
Cole, Rayner and Bates (1997)	$25100 (levels) - $62700 (logs)	Yes	7 World Regions
Dietz and Rosa (1997)	$10000	Yes (for 25%)	111
Moomaw and Unruh (1997)	$12813	N-Shaped	16 Developed
Roberts and Grimes (1997)	$8000 - $10000	Yes, after the 70s	Developed and Developing
Schmalensee, Stoker and Judson (1998)	Within sample	Yes	141
Agras and Chapman (1999)	$13630	No	34
Galeotti and Lanza (1999)	$15073- $21757	Yes	110
Panayotou, Peterson and Sachs (2000)	$29732 -$40906 (1950-1990)	Yes for Developed	17 Developed
Heerink et al. (2001)	$68871	Yes	118-153
Roca et al. (2001)	GDP non significant	No	Spain
Baiocchi and di Falco (2001)	GDP non significant	No	160
Bengochea et al. (2001)	$24427 - $73170	For some Countries	UE
Dijkgraaf and Vollebergh (2001)	$20647	Yes 5 Rich Countries	24 OECD
Shi (2003)	Out of sample	Yes	93
York et al. (2003)	$61000 (out of sample)	No	146
Martínez-Zarzoso and Bengochea-Morancho (2004)	$4914 - $18364	N-Shaped	22 OECD
Lamla (2009)	$80000	Yes	47 Countries
Martínez-Zarzoso (2009)	GDP2 non significant	No	121
Mazzanti and Musolesi (2009)	$12000 - $236000	Yes for EU North	21

Source: Authors and Martínez-Zarzoso et al. (2007), p.508, f.

Appendix 3 List of countries which had ratified Kyoto Protocol by 22.08.2011

Country	Ratification Date	GHG Obligation in % Compared to 1990
ALBANIA	4/1/2005	
ALGERIA	2/16/2005	
ANGOLA	5/8/2007	
ANTIGUA AND BARBUDA	11/3/1998	
ARGENTINA	9/28/2001	
ARMENIA	4/25/2003	
AUSTRALIA*	12/12/2007	8.00
AUSTRIA *	5/31/2002	-13.00
AZERBAIJAN	9/28/2000	
BAHAMAS	4/9/1999	
BAHRAIN	1/31/2006	
BANGLADESH	10/22/2001	
BARBADOS	8/7/2000	
BELARUS*	8/26/2005	
BELGIUM*	5/31/2002	-7.50
BELIZE	9/26/2003	
BENIN	2/25/2002	
BHUTAN	8/26/2002	
BOLIVIA	11/30/1999	
BOSNIA AND HERZEGOVINA	4/16/2007	
BOTSWANA	8/8/2003	
BRAZIL	8/23/2002	
BRUNEI DARUSSALAM	8/20/2009	
BULGARIA*	8/15/2002	-8.00
BURKINA FASO	3/31/2005	
BURUNDI	10/18/2001	
CAMBODIA	8/22/2002	
CAMEROON	8/28/2002	
CANADA*	12/17/2002	-6.00
CAPE VERDE	2/10/2006	
CENTRAL AFRICAN REPUBLIC	3/18/2008	
CHAD	8/18/2009	
CHILE	8/26/2002	
CHINA	8/30/2002	
COLOMBIA	11/30/2001	
COMOROS	4/10/2008	
CONGO	2/12/2007	
COOK ISLANDS	8/27/2001	
COSTA RICA	8/9/2002	
COTE D'IVOIRE	4/23/2007	
CROATIA*	5/30/2007	-5.00
CUBA	4/30/2002	
CYPRUS	7/16/1999	
CZECH REPUBLIC*	11/15/2001	-8.00
DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA	4/27/2005	
DEMOCRATIC REPUBLIC OF CONGO	3/23/2005	
DENMARK*	5/31/2002	-21.00
DJIBOUTI	3/12/2002	
DOMINICA	1/25/2005	
DOMINICAN REPUBLIC	2/12/2002	
ECUADOR	1/13/2000	
EGYPT	1/12/2005	
EL SALVADOR	11/30/1998	
EQUATORIAL GUINEA	8/16/2000	
ERITREA	7/28/2005	
ESTONIA*	10/14/2002	-8.00
ETHIOPIA	4/14/2005	
EUROPEAN UNION	5/31/2002	
FIJI	9/17/1998	

FINLAND*	5/31/2002	0.00
FRANCE*	5/31/2002	0.00
GABON	12/12/2006	
GAMBIA	6/1/2001	
GEORGIA	6/16/1999	
GERMANY*	5/31/2002	-21.00
GHANA	5/30/2003	
GREECE*	5/31/2002	25.00
GRENADA	8/6/2002	
GUATEMALA	10/5/1999	
GUINEA	9/7/2000	
GUINEA-BISSAU	11/18/2005	
GUYANA	8/5/2003	
HAITI	7/6/2005	
HONDURAS	7/19/2000	
HUNGARY*	8/21/2002	-6.00
ICELAND *	5/23/2002	10.00
INDIA	8/26/2002	
INDONESIA	12/3/2004	
IRAN (ISLAMIC REPUBLIC OF)	8/22/2005	
IRAQ	7/28/2009	
IRELAND*	5/31/2002	13.00
ISRAEL	3/15/2004	
ITALY *	5/31/2002	-6.50
JAMAICA	6/28/1999	
JAPAN *	6/4/2002	-6.00
JORDAN	1/17/2003	
KAZAKHSTAN	6/19/2009	
KENYA	2/25/2005	
KIRIBATI	9/7/2000	
KUWAIT	3/11/2005	
KYRGYZSTAN	5/13/2003	
LAO PEOPLE'S DEMOCRATIC REPUBLIC	2/6/2003	
LATVIA*	7/5/2002	-8.00
LEBANON	11/13/2006	
LESOTHO	9/6/2000	
LIBERIA	11/5/2002	
LIBYAN ARAB JAMAHIRIYA	8/24/2006	
LIECHTENSTEIN *	12/3/2004	-8.00
LITHUANIA *	1/3/2003	-8.00
LUXEMBOURG *	5/31/2002	-28.00
MADAGASCAR	9/24/2003	
MALAWI	10/26/2001	
MALAYSIA	9/4/2002	
MALDIVES	12/30/1998	
MALI	3/28/2002	
MALTA	11/11/2001	
MARSHALL ISLANDS	8/11/2003	
MAURITANIA	7/22/2005	
MAURITIUS	5/9/2001	
MEXICO	9/7/2000	
MICRONESIA (FEDERATED STATES OF)	6/21/1999	
MONACO	2/27/2006	
MONGOLIA	12/15/1999	
MONTENEGRO	6/4/2007	
MOROCCO	1/25/2002	
MOZAMBIQUE	1/18/2005	
MYANMAR	8/13/2003	
NAMIBIA	9/4/2003	
NAURU	8/16/2001	
NEPAL	9/16/2005	
NETHERLANDS *	5/31/2002	-6.00
NEW ZEALAND	12/19/2002	

NICARAGUA	11/18/1999	
NIGER	9/30/2004	
NIGERIA	12/10/2004	
NIUE	5/6/1999	
NORWAY *	5/30/2002	1.00
OMAN	1/19/2005	
PAKISTAN	1/11/2005	
PALAU	12/10/1999	
PANAMA	3/5/1999	
PAPUA NEW GUINEA	3/28/2002	
PARAGUAY	8/27/1999	
PERU	9/12/2002	
PHILIPPINES	11/20/2003	
POLAND *	12/13/2002	-6.00
PORTUGAL *	5/31/2002	27.00
QATAR	1/11/2005	
REPUBLIC OF KOREA	11/8/2002	
REPUBLIC OF MOLDOVA	4/22/2003	
ROMANIA *	3/19/2001	-8.00
RUSSIAN FEDERATION *	11/18/2004	0.00
RWANDA	7/22/2004	
SAINT KITTS AND NEVIS	4/8/2008	
SAINT LUCIA	8/20/2003	
SAINT VINCENT AND THE GRENADINES	12/31/2004	
SAMOA	11/27/2000	
SAN MARINO	4/28/2010	
SAO TOME AND PRINCIPE	4/25/2008	
SAUDI ARABIA	1/31/2005	
SENEGAL	7/20/2001	
SERBIA	10/19/2007	
SEYCHELLES	7/22/2002	
SIERRA LEONE	11/10/2006	
SINGAPORE	4/12/2006	
SLOVAKIA *	5/31/2002	-8.00
SLOVENIA *	8/2/2002	
SOLOMON ISLANDS	3/13/2003	
SOMALIA	7/26/2010	
SOUTH AFRICA	7/31/2002	
SPAIN *	5/31/2002	15.00
SRI LANKA	9/3/2002	
SUDAN	11/2/2004	
SURINAME	9/25/2006	
SWAZILAND	1/13/2006	
SWEDEN *	5/31/2002	4.00
SWITZERLAND *	7/9/2003	-8.00
SYRIAN ARAB REPUBLIC	1/27/2006	
TAJIKISTAN	12/29/2008	
THAILAND	8/28/2002	
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA	11/18/2004	
TIMOR-LESTE	10/14/2008	
TOGO	7/2/2004	
TONGA	1/14/2008	
TRINIDAD AND TOBAGO	1/28/1999	
TUNISIA	1/22/2003	
TURKEY *	5/28/2009	
TURKMENISTAN	1/11/1999	
TUVALU	11/16/1998	
UGANDA	3/25/2002	
UKRAINE *	4/12/2004	0.00
UNITED ARAB EMIRATES	1/26/2005	
UK AND NORTHERN IRELAND *	5/31/2002	-12.50
UNITED REPUBLIC OF TANZANIA	8/26/2002	
UNITED STATES OF AMERICA *		-7.00

URUGUAY	2/5/2001
UZBEKISTAN	10/12/1999
VANUATU	7/17/2001
VENEZUELA	2/18/2005
VIET NAM	9/25/2002
YEMEN	9/15/2004
ZAMBIA	7/7/2006
ZIMBABWE	6/30/2009

Note: * Indicates countries which are part of the Annex I to the UNFCCC.

Source: WDI (2010).

Appendix 4 Cross Correlations of the Variables

	lnCO$_2$	**lnPop**	**lnGDP**	**lnAI**	**KyotoOb**	**CDM**	**High Inc.**	**Up.-Mid. Inc.**	**Low.-Mid. Inc.**	**Low. Inc.**
lnCO$_2$	1									
lnPop	0.7665	1								
lnGDP	0.5004	-0.1009	1							
lnIA	0.5642	0.4368	0.2821	1						
KyotoOb	0.1998	0.0639	0.2809	0.1234	1					
CDM	0.0873	0.0512	0.1031	0.0214	0.2833	1				
High Inc.	0.3898	-0.02	0.7223	0.1333	0.2757	0.1185	1			
Up.-Mid. Inc.	0.0429	-0.1368	0.259	0.1414	-0.0111	-0.0345	-0.2959	1		
Low.-Mid. Inc.	-0.0457	0.0369	-0.2212	-0.0099	-0.1237	-0.0403	-0.3378	-0.3689	1	
Low. Inc.	-0.3649	0.1163	-0.7105	-0.2572	-0.1199	-0.0355	-0.2975	-0.325	-0.3709	1

Source: WDI, CDIAC and UNEP (2010).

Appendix 5 Summary Statistics

Variable		**Mean**	**Std. Dev.**	**Min**	**Max**	**Observations**
CO$_2$	overall	29239.21	127923.6	1	1783028	N = 8383
	between		120725.4	6.638298	1276868	n = 198
	within		41424.33	-450861.1	1220606	T = 42.3384
Pop	overall	3.10E+07	1.41E+08	12116	1.93E+09	N = 9803
	between		1.34E+08	16655.32	1.44E+09	n = 210
	within		3.21E+07	-5.09E+08	5.21E+08	T-bar = 46.681
GDP	overall	9390.418	11282.54	150.807	95434.18	N = 4741
	between		11232.45	411.0772	62585.48	n = 178
	within		3153.71	-11633.27	51962.45	T-bar = 26.6348
IA	overall	14.70933	8.279062	0.1	46.24833	N = 5117
	between		7.655	0.3968254	37.1295	n = 179
	within		3.692319	-5.448036	37.25037	T-bar = 28.5866
KyotoOb	overall	0.0225549	0.1484868	0	1	N = 10419
	between		0.0514561	0	0.1632653	n = 213
	within		0.1393166	-0.1407104	0.9613305	T-bar = 48.9155
CDM	overall	0.2767539	6.872481	0	455	N = 10092
	between		1.85398	0	22.64583	n = 213
	within		6.615572	-22.36908	432.6309	T = 47.3803

Source: WDI, CDIAC and UNEP (2010)

Appendix 6 Results Static Model

VARIABLES	(1) OLS $lnCO_2$	(2) Within $lnCO_2$	(3) Within ar het $lnCO_2$	(4) IV Within $lnCO_2$
lnPop	1.053***	0.828***	1.197***	0.799***
	(0.00613)	(0.198)	(0.0446)	(0.0962)
lnGDP	2.512***	1.287**	1.028***	1.250***
	(0.238)	(0.530)	(0.243)	(0.186)
$lnGDP^2$	-0.0878***	-0.0274	-0.00676	-0.0251**
	(0.0134)	(0.0326)	(0.0136)	(0.0116)
lnIA	0.175***	0.246***	0.220***	0.246***
	(0.0227)	(0.0445)	(0.0268)	(0.0204)
KyotoOb	0.118	-0.0852***	-0.207***	-0.306**
	(0.164)	(0.0257)	(0.0578)	(0.131)
Up.-mid. Inc.	-0.385***			
	(0.0468)			
Low.-mid. Inc.	-0.349***			
	(0.0681)			
Low Income	-0.748***			
	(0.109)			
KyotoOb 2001	0.158			
	(0.177)			
KyotoOb 2002	-0.395**	-0.0987***		
	(0.189)	(0.0283)		
KyotoOb 2003	-0.361*	-0.117***		
	(0.189)	(0.0295)		
KyotoOb 2004	-0.276	-0.140***		
	(0.194)	(0.0344)		
KyotoOb 2005	-0.282	-0.171***		
	(0.194)	(0.0387)		
KyotoOb 2006	-0.209	-0.191***		
	(0.198)	(0.0446)		
KyotoOb 2007		-0.273***		
		(0.0488)		
Constant	-23.64***	-14.62***	-19.69***	-14.01***
	(1.072)	(3.305)	(0.997)	(1.847)
Time Dum.	yes	yes	no	yes
Observations	3,537	3,537	3,537	3,537
R-squared	0.933	0.584		
Countries		163	163	163

Note: Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$.