Legal Families and Environmental Protection: Is there a Causal Relationship?

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Summary

In this paper we build up the analysis of La Porta et al. (1998), to investigate the importance of legal families in explaining the variations in pollution emissions in different countries. The main intuition behind our analysis is that the nations in which the rights of shareholders are more protected, promote real and financial investment; this increases the speed at which the per-capita income corresponding to the declining branch of the Environmental Kutznets Curve (EKC) is achieved. In econometrics different regression analyses were performed using as dependent variables three different kinds of pollutants (CO_2, fine suspended particulates and waste), including as an explanation some financial variables never before considered in this kind of study.

Keywords: Dummy Variables, Environmental Kutznets Curve, Legal Families, Panel Data, Pollution Emissions

JEL Classification: K4, Q0

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1. Introduction. Since the seminal paper of La Porta *et al*. (1998), increasing attention has been paid to the differences in the economic performance of countries as a result of their legal systems (i.e. *civil-law* or *common-law*) (Glaeser *et al*., 2002, 2004, Djankov *et al*., 2003). In particular, it has been shown that common-law countries offer greater protection to shareholders and creditors (Djankov *et al.*, 2007, La Porta *et al*. 1998, Roe, 2006), thus promoting investment in the capital market, reducing both interest and discount rates. Despite the growing interest in this topic, nobody has so far investigated the effects of the differences in legal families with regard to the levels of environmental protection and pollution. This may be due to the fact that the income-pollution relationship has usually been explained by factors more closely related to technological choices or other institutional factors (see Dinda, 2004, for a detailed survey).

Recently a few scholars (Chavas, 2004, Di Vita, 2007a, 2007b) have emphasized the differences among countries in capital cost and rate of intertemporal preferences, as a device to shed light on the relationship between per capita income and pollution emissions (the so-called Environmental Kuznets Curve, EKC for short). In particular, theoretical analyses have shown that there is a negative relationship in developing countries between the interest rate and pollution, while this relationship is reversed in wealthy nations.

The main contribution of this paper is to develop both streams of the economic literature previously mentioned and thence to account for the effects of differences in legal families and financial market development on pollution emissions, thus contributing to a better understanding of the EKC dynamics. In other words the addend value of this paper is to put emphasis on variables like interest rate, market capitalization level and legal system never accounted before in previous analyses on income pollution relationship.

This study is based on the intuition that a more effective protection of investors and creditors may reduce the time taken in developing countries to achieve the per capita income level at which the pollution level starts to decline with growth in income, through the channels of both interest and discount rates, as a result of well-developed financial markets. In wealthy nations, the availability of capital reduces the cost of implementation of more environmental-friendly technologies. In other words the question that we want to address in this paper is: do the differences in legal families, among groups of countries, have any effect on the environment? If the answer is yes, the other question is: through which channel?

Ex ante we expect capital markets to be more developed in countries where shareholders' rights are better protected. Thus we may predict that the interest rate will be lower, and capital accumulation higher, in these cases than in countries where investors are not so well protected (as in nations that fall within the legal family of civil law) (La Porta *et al.*, 1997, 2000).

Beck *et al.* (2000) and La Porta *et al.* (2000) affirm that there are three channels by means of which financial development may promote economic growth: a) savings accrual; b) capital accumulation; c) allocation of financial resources to more productive uses.

The emphasis in this analysis is placed equally on the importance of differences between legal families, on the financial market capitalization level and on the protection of creditors, to explain the differences in pollution levels.

In the empirical analysis we use data covering the period from 1995 to 2002, for forty-eight countries, the same used by La Porta *et al.* (1998), with the exception of Taiwan, because its figures are not available in the World Development Indicator data-set (World Bank, 2006), from which are drawn all the data used in this paper. We account data for eight years because the statistics for the three indicators of pollution are not available for all the countries accounted for a longer period of time (see Panayotou, 1997 and Selden and Song, 1995 for applied analysis on EKC of similar temporal length).

Eighteen nations belong to the common law system, equally divided within the sample between industrialized and developing countries. In this paper we ignore the division, within the *civil law* countries, into French, German and Scandinavian, because we want to focus on the differences between the two legal families in general. Twenty-five countries are classified as developed, while the rest are considered developing, following a criteria supplied by Esty (2001), that assumes the turning point of the EKC for a per capita income greater than eight thousand dollars, thus we assume the per capita income to be higher than this in industrialized nations. In this manner we expect there to be a direct relationship between per capita income and emissions pollution in less developed countries, while the relationship is reversed in industrialized nations.

In the econometric analysis three kinds of pollutants were used as dependent variables (CO2, fine particulates of air pollutants, and waste), and some explanatory financial variables, not usually included in empirical analysis on the EKC, were also used. Two dummy variables were included among the regressors to account for the relevance of legal families in explaining the differences in the pollution levels observed.

The rest of the paper is organized as follows. After this introduction, section two is devoted to giving a theoretical overview of the choice of variables considered. Section three is dedicated to data overview; section four describes the econometric analysis. Final remarks conclude the paper.

2. Theoretical background and choice of variables. Following the recent studies that show how the interest and discount rates may be useful to better understand the income-pollution pattern (Chavas, 2004, Di Vita, 2007a, 2007b), we expect that in countries where the rights of both creditors and investors are more protected, like in economy belonging in the area of common law, the pollution level will be lower for developed economies and higher for poor countries. In fact high availability of capital renders easier the adoption of more environmental friendly measures.

Not many words are necessary to explain the issue of the relevance of legal families on the performance of economies. This topic has been extensively explored in previous literature (see Siems, 2006, for an overview). Here the difference between countries of common law and civil law is tackled by means of two dummy variables. For the first dummy, the value of one is assumed for common law countries and of zero for the others, while for the second dummy variable, the value of one is assumed for civil law countries and of zero for nations with a legal system of English origin.

Three different kinds of pollutants were used. The first, carbon dioxide emissions (CO2), is a type of pollutant that affects future generations more than the current one (Binder and Neumayer, 2005, Dinda 2004, Panayotou, 2000). The other two, particles suspended in air (PM10) and waste, are more offensive to the current generations. The choice of these three kinds of pollutant was constrained by the availability of the data we draw from World Development Indicators supplied by World Bank (World Bank, 2006), for the countries accounted in La Porta *et al.* (1998).

Thus we expect the threshold of per capita income at which pollution starts to decline (Binder and Neumayer, 2005, 530) to be higher for the first pollutant (CO2) than for the other two (Dinda 2004, Panayotou, 2000).

We are thus aware that the first pollutant (CO2) may have a higher threshold level than the other pollutants, of per capita income at which pollution begins to fall with income growth,. In particular, we report the results of previous empirical analyses on the EKC, to affirm that CO2 usually shows an inversed-U shaped curve, and that its turning point is included within a range of per capita income values from 10.000$ to 35.400$ (Cole *et al.*, 1997, Galeotti and Lanza, 1999, Holtz-Eakin and Selden, 1995, Roberts and Grimes, 1997, Schmalensee *et al.*, 1998, Unruh and Moomaw, 1998). With regard to air particles emissions a variety of dynamics were found (quadratic, linear downward and U-inverted quadratic), with a peak around a per capita income between 7.300$ and 9.800$ (Carson *et al.*, 1997, Cole *et al.*, 1997, Islam *et al.,* 1999, Panayotou, 1993, Selden and Song, 1994, Shafik and Bandyopadhyay, 1997, Schmalensee *et al.,* 1998). Finally, waste still offers a mixed behaviour over time and with income growth (inverse-U shaped, linear increasing, quadratic), and it was not possible to determine the per capita income level at which the maximum of the EKC curve occurred (Cole *et al.*, 1997, Shafik and Bandyopadhyay, 1997, Shafik, 1994).

It is a little more complicated to clarify, from a theoretical point of view, how and why we choose the explanatory variables employed in our empirical analysis.

In the introduction we referred to a recent branch of economic literature that placed emphasis on interest and discount rates in order to explain the relationships between per capita income and pollution emissions (Chavas, 2004, Di Vita 2007a, 2007b). Our theoretical benchmark is that the decision to implement more environmental friendly devices is driven by the discount rate, which in cost-benefit analysis on expenses is the key factor to ameliorate and preserve the environment . Countries with a low per capita income show high levels of both intertemporal preferences and rates of interest. On one hand, impatience about the future implies that developing nations have to postpone the moment in time when more ecological technologies are implemented, because they have first to satisfy their present needs. On the other hand, scarcity of capital and high rates of interest are both an obstacle to growth for less wealthy nations, rendering more difficult the achievement of a per capita income level at which the EKC may show a declining behaviour. Shareholder protection and financial market development may also be useful in promoting savings accumulation and investments (domestic and foreign), thus boosting growth in developing countries and reducing the time necessary before it is possible to implement more clean technologies, creating an inverse relationship between per capita income and pollution.

A more effective protection of creditors in common law countries (La Porta *et. al.*, 1998, Djankov, *et al.* 2007) may also stimulate foreign direct investment (FDI) and savings accrual, promoting growth in developing countries and the achievement of a per capita income level compatible with a decline in emissions.

The data of exports and imports was also included among the explanatory variables for two reasons: a) international trade has a strong effect on emissions levels (Antweiler *et al.*, 2001); b) different degrees of protection of creditors may drive exports and imports in such a way as to justify the non-homogenous performances in foreign exchange, between countries with unlike legal systems. In common law countries we expect a higher level of financial market capitalization and a lower real rate of interest, as a result of greater protection accorded to shareholders in the countries that belong to this kind of legal family.

Although the per capita income is implicitly taken into consideration in the data, as a result of the division of the countries into developing or industrialized, according to their per capita income level, we follow the empirical literature on the EKC that usually includes it among the explanatory variables (Panayotou, 2000). Finally, the growth rate of the Gross Domestic Product (GDP) is also accounted for, because it was considered as one of the independent variables in some econometric analyses on the income-pollution pattern (Panayotou, 1997).

3. Data overview. To render the reader's task easier we have listed all the countries accounted for in the paper in Table 1, divided by their per capita income levels.

TABLE 1

COUNTRY CLASSIFICATION

(a)	(b)
AUSTRALIA$^{\theta}$	ARGENTINA
AUSTRIA	BRAZIL
BELGIUM	CHILE
CANADA$^{\theta}$	COLOMBIA
DENMARK	ECUADOR
FINLAND	EGYPT
FRANCE	INDIA$^{\theta}$
GERMANY	INDONESIA
GREECE	JORDAN
HONG KONG$^{\theta}$	KENIA$^{\theta}$
IRELAND$^{\theta}$	MALAYSIA$^{\theta}$
ISRAEL$^{\theta}$	MESSICO
ITALY	NIGERIA$^{\theta}$
JAPAN	PAKISTAN$^{\theta}$
NETHERLANDS	PERU
NEW ZEALAND$^{\theta}$	PHILIPPINES
NORWAY	SOUTH AFRICA$^{\theta}$
PORTUGAL	SRI LANKA$^{\theta}$
SINGAPORE$^{\theta}$	TRINIDAD$^{\theta}$
SPAIN	TURKEY
SWEDEN	URUGUAY
SWITZERLAND	VENEZUELA
UNITED KINGDOM$^{\theta}$	ZIMBABWE$^{\theta}$
UNITED STATES$^{\theta}$	
SOUTH COREA	

θ denotes the countries with a *common law* system, following the criteria of La Porta *et al.* (1998). Column (a) lists the twenty-five developed countries with a per capita income greater than 8.000 US $, while column (b) lists the twenty-three developing countries with a lower per capita income level.[1] We think that the criteria used in order to split the countries into two subsets, according to their per capita income level, is right because all the developing nations included in the sample showed external debt, while none of the wealthy nations proved to be borrowers from abroad in the period under study.

Before performing the econometric analysis, it is worth having a look at the data reported in the following Table 2.

TABLE 2

DATA OVERVIEW (1995-2002)

	CIVIL LAW COUNTRIES			COMMON LAW COUNTRIES		
	All the sample	Rich	Developing	All the sample	Rich	Developing
CO2♥	5.584	6.798	2.752	8.314	12.359	4.269
PM10♦	4.560	3.120	6.251	5.408	3.006	7.810
Waste♠	9.279	5.976	13.053	21.594	2.762	40.426
Exports	30.696	34.744	25.781	43.728	48.722	39.288
FDI	3.1323	3.3053	2.6896	4.4380	6.2525	2.6243
GDS	21.9315	24.6754	18.7957	23.7530	25.4424	22.0636
Imports	31.5862	34.5898	28.1225	41.7124	46.0655	37.8971
Market capitalization	33.8523	101.0399	31.2580	93.2567	117.9137	68.5998
Real Interest rate	10.8173	5. 0797	18.0176	6.6958	5.9083	7.4610
Per capita income♣	15.467	23.751	5.995	14.181	24.304	4.149
GDP growth	2.6721	2.8073	2.5175	3.8380	4.2713	3.4846

Note: The data report the average of the variables accounted for during the period under study. All the variables with their implications and their sources are fully explained in the Appendix. ♥ Carbon dioxide emissions (CO2) are expressed in metric tons per capita. ♦ Particle matter concentrations (PM10), refer to the fine suspended particles of less than 10 microns of diameter (at a national level, measured in micrograms per cubic meter). ♠ Combustible renewables and waste comprise solid biomass, liquid biomass, biogas, industrial waste, and municipal waste, measured as a percentage of total energy use. ♣ per capita income is based on purchasing power parity (PPP). Real interest rates are expressed in ratios. Finally, the other variables, without prime are measured as a percentage of the GDP.

From the figures reported above, it is possible to affirm that, in general, all three indicators of the pollution level (CO2, PM10 and waste), are higher in common law countries than in the others. Looking more closely at the single pollutants, we may observe that in developed countries, with a legal system of English origin, only the CO2 emissions are greater than in civil law nations, while the average levels for other pollutants are lower. This difference in values for carbon dioxide may be due to the fact that it is more harmful to future generations than the current one, so that an increase in the per capita income does not necessarily imply investment in devices to abate CO2

[1] This system of classification of the countries examined follows from the finding of Esty (2001), that estimates the

emission . Moreover, we may note that this kind of pollutant shows a peak level at a per capita income level higher than the other two.

It is true, for all the pollutants examined, that the emissions are higher in developing countries belonging to the legal family of common law than in nations with a civil law legal system. This may be due both to the higher GDP rate of growth and to the lower per capita income levels in less wealthy nations of common law.

This first empirical evidence is useful to affirm that an effective protection of creditors and investors in developing countries of common law boosts growth and also increases pollution, while the opposite is true for wealthy nations, with the exception of CO2.

Exports, imports, foreign direct investment (FDI), gross domestic savings (GDS), GDP growth rate (GDPgr) and market capitalization (MC) are greater in countries with a common law system, without any distinction between industrialized and developing ones. As we had supposed, the real interest rate (RIR) is always lower in nations with a legal system of English origin. Finally, the per capita income (PCI) for all the countries included in the sample is greater in civil law countries, but it is higher in wealthy nations with a common law legal system.

It is worth noting that in countries with a legal system of English origin the market capitalization level is in general almost three times as high as in civil law nations.

4. Econometric analysis. The differences that were noticed in the data reported in Table 2, offer the information that, among the countries considered, and in the period under study, the performances of the economy varies according to which legal family the country belongs to, but this does not mean that these relationships also explain the

per capita income level at which the EKC starts to decline at about 8.000 US $.

differences in pollution levels or that they are statistically significant. This is why it is necessary to perform the econometric analysis to make these latter points clear.

Based on the previous economic analysis, we expect *ex ante* the dummies introduced among the independent variables in order to detect any systematic differences in pollution levels attributable to legal families, to be statistically significant and at the same time to possess a positive algebraic sign. We also assume that the market capitalization level may be useful in explaining the differences in pollution levels, with asymmetric effects between industrialized and developing countries. In the first case (industrialized countries) it is assumed to be positively correlated with emissions, while in the second (kind of countries) it is negatively related to pollution, through the channel of the capital cost.

The real rate of interest is another crucial variable to explain the income-pollution relationship: low rates, due to the abundance of capital, render easier the implementation of environmental friendly devices. Thus in general we expect there to be an inverse correlation between the pollution level and this variable, at the first stage of the development process, until the per capita income level is reached at which the pollution level starts to decline as the GDP grows. In wealthy nations the readier availability of capital simplifies the adoption of more clean technologies and therefore the preservation of the rights of future generations. This implies a direct relationship between emissions and the real rate of interest in developed countries (Di Vita, 2007b).

We expect gross domestic savings and foreign direct investments to have effects similar to the financial market capitalization level, because the accrual of savings and the stream of foreign capital reduce the real interest rate within the nation considered.

For obvious reasons of connection, the international trade components have to be taken into account together, despite the fact that exports increase income, and therefore we assume that they must reduce the pollution level in wealthy nations and increase emissions in developing countries, while imports reduce income inside the country considered and thus their effects should be the opposite to that of exports. Finally, the per capita income and the growth rate of the economy in general raise the pollution level, but even in this hypothesis we foresee that there will be different effects for the two groups of countries considered, with regard to income, with a positive correlation in less wealthy nations and a negative relationship in industrialized countries.

4.1 Variables. In the econometric analysis the three pollutant indicators explained in detail above were used as dependent variables, and three different sets of regressions were performed separately for each environment indicator. For each dependent variable (pollutant) a regression was made for all the countries in the sample, and, to make clear the asymmetric effects of the explanatory variables, econometric analyses were also performed on the two subsets of data, considering the industrialized and developing countries separately and using as a classification system the per capita income, as shown before in Table 1. The explanatory variables used were the same as in Table 2, for the period from 1995 to 2002. The entire panel data set of observations was employed in the empirical analysis.

Two dummy variables were considered in the analysis in order to determine the effects of differences in pollution indicators depending on the legal family belonged to by each country. The first dummy (dum1) was given the value of one for countries of English origin, and zero otherwise. The second dummy (dum 2) assumed the value of one for nations belonging to the civil law system, and zero for those belonging to the common law system. To make the statistical analysis more reliable regressions were also made considering only dummy two, that in this case measured the differences in dependent variables (pollutant indicators), according to the different legal system

(Baltagi, 2002, Johnston, 1981). In the latter case a constant was also taken into account among the independent variables.

The econometric analysis was performed using the OLS technique,[2] by means of microfit software.

4.2 The regression model. To perform the econometric analysis the following very simple model was used:

[1] Pollutant indicator = α_1Exports + α_2FDI + α_3GDS + α_4Imports + α_5MC + α_6RIR + α_7PCI + α_8GDPgr + α_9Dum1 + α_{10}Dum2 + u_t.

Where:

u_t = is a stochastic term, which satisfies the standard assumptions;

α_i = are coefficient regressors, with i = 1, 2, … , 10.

Before performing the econometric analysis, it was necessary to verify the relevance of the dummies. To this aim we followed Brown (1975) who emphasizes that to avoid misinterpreting or overestimating the role of dummies it is useful to make regression without these explanatory variables, to see if the differences in coefficient of determination are quantitatively relevant. To measure the lack of information in R^2 by performing regressions without dummy variables, we report the differences in the coefficient of determination in Table 3.

[2] Following La Porta *et al.* (2006) we assume that the use of legal origins is a remedy to the problem of endogenity.

TABLE 3

DIFFERENCES IN R^2 WITH AND WITHOUT DUMMY VARIABLES

Dependent variables	All	Rich	Developing
CO2	-8.511	-23.343	-5.986
PM10	-30.274	-21.213	-9.312
Waste	-36.488	-14.910	-57.522

Note: The differences reported above are obtained by performing regressions with the same explanatory variables and econometric model described in (1).

As we can see, the differences in the coefficient of determination obtained in the regressions, with and without the dummy variables and with no intercept terms, are large enough to justify the use of the dummies variables in our regressions.

The make the econometric analysis more reliable a regression was also performed for each explanatory variable using the following specification

[2] Pollution indicator = α_1Const + α_2Exports + α_3FDI + α_4GDS + α_5Imports + α_6MC + α_7RIR + α_8PCI + α_9GDPgr + α_{10}Dum2 + u_t.

where Const = is the intercept term. In this case we enclosed an intercept term, and excluded the first dummy (dum1).

4.3 Regressions results. The outcomes of empirical analysis are fully reported in Tables A1, A2, A3, in the Appendix, but their synthesis is fully described in the following Table 4.

TABLE 4

SYNTHESIS OF RESULTS OF REGRESSIONS

		DEPENDENT VARIABLES		
		CO2	PM10	waste
EXPLANATORY VARIABLES				
Constant term		+ / <1%	+ / <1%	+ / <1%
Dummy 1	(1)	+ / < 1%	+ / < 1%	+ / < 1%
	(2)	+ / < 1%	+ / < 1%	+ / No
	(3)	- / No	+ / < 1%	+ / < 1%
Dummy 2	(1)	- / < 5%	+ / < 1%	+ / < 1%
	(2)	+ / No	+ / < 1%	+ / < 10%
	(3)	- / < 1%	+ / < 1%	+ / < 1%
Market capitalization	(1)	- / No	- / < 1%	- / < 1%
	(2)	- / < 1%	+ / No	+ / < 1%
	(3)	- / < 15%	- / < 5%	- / No
Real interest rate	(1)	- / No	+ / < 5%	- / No
	(2)	+ / < 1%	+ / No	- / No
	(3)	- / < 15%	+ / < 10%	+ / < 15%
Gross domestic savings	(1)	+ / < 1%	- / No	- / < 15%
	(2)	+ / < 5%	+ / < 5%	+ / < 1%
	(3)	- / No	- / No	- / < 15%
Foreign direct investment	(1)	+ / No	- / No	+ / No
	(2)	+ / No	- / No	+ / No
	(3)	+ / < 1%	- / < 1%	- / No
Exports of goods and services	(1)	- / < 1%	+ / No	+ / < 10%
	(2)	- / < 1%	- / < 5%	- / No
	(3)	+ / No	- / No	+ / No
Imports of goods and services	(1)	+ / No	- / No	-/ < 5%
	(2)	- / < 1%	+ / < 1%	- / No
	(3)	- / No	+ / No	-/ < 5%
Per capita income PPP	(1)	+ / < 1%	- / No	- / < 1%
	(2)	+ / < 1%	- / < 1%	- / No
	(3)	+ / No	- / No	+ / < 1%
GDP growth	(1)	+ / < 10%	- / No	- / No
	(2)	+ / < 5%	+ / No	- / No
	(3)	+ / < 15%	+ / No	- / No
R^2	(1)	.60433	.30566	.44253
	(2)	.58642	.24030	.18631
	(3)	.54064	.17426	.62869

The numbers in brackets report, respectively, the results of regressions for: (1) All the countries in the sample; (2) High per capita income countries; (3) Low per capita income countries; Constant terms apply exclusively to the regressions regarding all the countries in the sample, with only the second dummy variable. For each column we report first the algebraic sign of the regressor (+/-) and then its level of statistical significance. ***No*** means that the regressor is not statistically significant.

First of all we have to comment on the results of the regressions regarding dummy variables, which are always statistically significant. In particular, looking at the first row of Table 4, and column (4) in Tables A1-A3, it is possible to see that the second dummy variable, that in this case measures the differences in the pollution levels between civil law and common law nations, is always negative and statistically significant at the 1% level. This is consistent with our preliminary data analysis, reported in Table 2, and confirms that the pollution of all the countries considered is greater in those within the common law system and may be explained by the legal family belonged to.

As the theory suggests, a well-developed financial market may be helpful in reducing the level of pollution. For all three pollutant indicators, in fact, this explanatory variable proved to have a negative sign for the sample as a whole, and in general it was statistically significant. Moreover, with the exception of regressions results in the case of CO2, the asymmetric effects of the market capitalization level on pollution also proved to be negative in developing countries and positive in wealthy ones.

With regard to the real rate of interest, we may affirm that it possesses the expected negative algebraic sign in cases of CO2 and waste, while it is always positive for PM10. In general this explanatory variable is of weak statistical significance. The results of the regressions for CO2 and waste fully confirmed that there is an asymmetric effect of the real interest rate between wealthy and developing economies. A negative relationship was found to exist in the first , while the opposite was obtained for the less wealthy nations. Finally, with regard to PM10, it is worth noting that, despite the fact that the coefficient of this regressor is always positive, its magnitude is greater in the case of developing countries and is also statistically significant.

In general the gross domestic savings possessed the predicted algebraic sign; a negative relationship proved to exist between savings accumulation and the pollution indicator, with the exception of the case of carbon dioxide. The statistical significance is weak but it is confirmed, as with the market capitalization level, that there are asymmetric effects in developed countries where a positive relationship was found between the pollution indicator and this variable, while the opposite was seen to exist in developing nations.

Foreign direct investment increases the emissions level in general, and is not very statistically significant for any of the countries in the sample, including the rich ones. Despite this weak empirical evidence it is highly relevant for developing nations, especially to explain the behaviour of CO_2 and PM_{10}. Even in this case we observe that for air particulates and waste its algebraic sign is negative, while for CO_2 it is positive. In other words, in less wealthy countries the FDI is useful to reduce the environmental impact of economic growth, in the same way as the financial market capitalization level.

For their undeniable connection we must comment on the result for exports and imports together. Although the two components of international trade have different effects on the emissions and income of the economy considered, it is possible to affirm that both are weakly statistically significant; exports however, for the sample as a whole, have a negative effect on the pollution level, with asymmetric effects between industrialized and developing countries, and with some differences regarding the kind of pollutant considered. Imports in general reduce pollution in developing countries and increase emissions in wealthy nations, with the exception of CO_2, where the regressor is statistically significant only for less industrialized countries. The pollution level increases with per capita income rises, but with mixed evidence when the countries are differentiated with regard to income. Similar results are obtained for the growth rate of the economy, that is statistically significant only to explain carbon dioxide pollution and always possesses a positive algebraic sign. For other kinds of pollutant this regressor is not statistically significant, but shows a different relationship within the two groups of countries. Finally, all the values of R-squared are quite high for panel data regressions.

5. Conclusions. As in La Porta *et al.* (1997, 2000) we find that countries that are more protective to shareholders and creditors show more developed financial markets and higher levels of exports, imports, foreign domestic investment, gross domestic savings and gross domestic growth. In economies with a legal system of English origin, the real interest rates are lower as a result of the readier availability of capital.

Econometric analysis confirms that the dummies included among the regressors, in order to account for the differences in pollution levels among economies with dissimilar legal systems, are always statistically significant. This supports our initial hypothesis that legal families are relevant, among other factors, in explaining the dissimilarity in emissions rates among the nations observed. Countries with a legal system of English origin, that ensure high level of protection for shareholders and creditors, show lower level of pollution for industrialized countries than the nations of civil law legal system, while the reverse happens for developing countries.

The level of financial market capitalization of the economy is always statistically significant and possesses the correct algebraic sign, with asymmetric effects within industrialized and developing countries.

On the basis of the outcomes of empirical analysis, it is possible to affirm that less wealthy economies show weak direct relationships between the per capita income and pollution emission, with the exception of CO2. This may be explained by the fact that this kind of pollutant follows different dynamics from the others, because the harm it causes is not of immediate evidence for the current generation (Panayotou, 2000), while for the other two pollutants it was verified that when income is low, emission and per capita income grow together, while when countries become wealthy they move in opposite directions.

There is weak statistical evidence that exports increase emissions in developing economies, while the opposite is true for wealthy nations.

In the interpretation of the econometric results we have to consider that the three kinds of pollutants considered in this paper possess different dynamics and show dissimilar per capita income levels at which the peak of the EKC occurs.

Our analysis has some implications to economic policy. Ensure high level of protection to investors and creditors boost the growth and allows to developing countries to achieve the per capita income level at which the pollution emission show a declining behavior. While in wealthy nations financial market development ensure low discount and interest rates, which render easier the implementation of more environmental friendly measures.

Deeper analyses will probably be necessary in future to confirm our results, for example taking into consideration some other pollutants or lengthening the period of time considered. We find that this could be a good topic for future research.

APPENDIX

Variables Notation

Let us adopt the following description of the variables considered in the econometric analysis:

CO2 emissions - Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during the consumption of solid, liquid, and gas fuels and gas flaring. Source: Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, U.S. state of Tennessee.

Combustible renewables and waste (% of total energy) - Combustible renewables and waste comprise solid biomass, liquid biomass, biogas, industrial waste, and municipal waste, measured as a percentage of total energy use. Source: International Energy Agency

Exports of goods and services (% of GDP) - Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, information, as well as financial, business, personal, and government services. They exclude labor and property income (formerly called factor services) as well as transfer payments. Source: World Bank national accounts data, and OECD National Accounts data files.

Foreign Direct investments, net inflows (% of GDP) - Foreign direct investments are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in a business operating in an economy different from that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows in the reporting economy and is divided by GDP. Source: International Monetary Fund, International Financial Statistics and Balance of Payments databases, World Bank, Global Development Finance, and World Bank and OECD GDP estimates.

Gross domestic savings (% of GDP) - Gross domestic savings are calculated as GDP less final consumption expenditure (total consumption). Source: World Bank national accounts data, and OECD National Accounts data files.

GDP Growth (annual %) - Annual percentage growth rate of the GDP at market prices based on constant local currency. Aggregates are based on constant 2000 U.S. dollars. The GDP is the sum of gross value added by all resident producers in the economy, plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources. Source: World Bank national accounts data, and OECD National Accounts data files.

Imports of goods and services (% of GDP) - Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, information, as well as financial, business, personal, and government services. They exclude labor and property income (formerly called factor services) as well as transfer payments. Source: World Bank national accounts data, and OECD National Accounts data files

Market capitalization of listed companies (% of GDP) - Market capitalization (also known as market value) is the share price times the number of shares outstanding. Listed domestic companies are the domestically incorporated companies listed on the country's stock exchange at the end of the year. Listed companies do not include investment companies, mutual funds, or other collective investment vehicles. Source: Standard & Poor's, Emerging Stock Markets Factbook and supplemental S&P data, and World Bank and OECD GDP estimates.

PM10, country level (micrograms per cubic meter) - Particle matter concentrations refer to the fine suspended particles of less than 10 microns in diameter that are capable of penetrating deep into the respiratory tract and causing significant health damage. The state of the country's technology and pollution controls is an important determinant of particle matter concentrations. Source: Kiren Dev Pandey, David Wheeler, Bart Ostro, Uwe Deichmann, Kirk Hamilton, and Katherine Bolt. "Ambient Particulate Matter Concentrations in Residential and Pollution Hotspot Areas of World Cities: New Estimates Based on the Global Model of Ambient Particulates (GMAPS)," World Bank, Development Research Group and Environment Department (2006).

Real interest rate (%) - is the lending interest rate adjusted for inflation as measured by the GDP deflator. Source: International Monetary Fund, International Financial Statistics and data files using World Bank data on the GDP deflator.

Per capita income PPP (current international $) - GDP per capita based on purchasing power parity (PPP). PPP GDP is the gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over the GDP as the U.S. dollar has in the United States. The GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources. Data are in constant 2000 international dollars. Source: World Bank, International Comparison Programme database.

TABLE A1

RESULTS OF REGRESSIONS (OLS) – DEPENDENT VARIABLE CO2

Variables	(1)	(2)	(3)	(4)
Constant term				199510.1 [70695.7] (2.8221)*
Dummy 1	199510.1 [70695.7] (2.822)*	457692.4 [154292.5] (2.9664)*	-62258.5 [105309.8] (-.59119)	
Dummy 2	-137195.9 [68132.5] (-2.0137)**	32343.7 [144547.8] (.22376)	-328940.1 [118247.5] (-2.7818)*	-336706.0 [37545.8] (-8.9679)*
Market capitalization companies	-.029324 [.026396] (-1.1109)	-.082449 [.029927] (-2.7550)*	-.053352 [.036393] (-1.4660)****	-.029324 [.026396] (-1.1109)
Real interest rate (%)	-.019852 [.14033] (-1.14146)	1.6255 [.64453] (2.5220)*	-.20692 [.13760] (-1.5037)****	-.019852 [.14033] (-1.14146)
Gross domestic savings	1.0964 [.25770] (4.2545)*	.57586 [.27045] (2.1239)**	-.18327 [.53399] (-.3432)	1.0964 [.25770] (4.2545)*
Foreign direct investment	.23437 [.26824] (.87375)	.14823 [.22030] (.67284)	6.1742 [.98027] (6.2984)*	.23437 [.26824] (.87375)
Exports of goods and services	-.62898 [.21251] (-2.9598)*	-.59242 [.17918] (-3.3062)*	.63824 [.58761] (1.0862)	-.62898 [.21251] (-2.9598)*
Imports of goods and services	.25991 [.22502] (1.1551)	-.046179 [.013065] (-3.5347)*	-.42960 [.56818] (-.75609)	.25991 [.22502] (1.1551)
Per capita income PPP	36.0479 [1.9446] (18.5372)*	33.9649 [4.2812] (7.9335)*	72.1960 [10.0054] (7.2157)	36.0479 [1.9446] (18.5372)*
GDP growth	.90642 [.53866] (1.682)***	1.5808 [.79996] (1.9762)**	.94140 [.63244] (1.4885)****	.90642 [.53866] (1.682)***
R^2	.60433	.58642	.54064	.60433
Log LH	-5422.9	-2765.0	-2579.3	-5422.9
Observations	384	200	184	384

(1) All the countries in the sample. (2) High per capita income countries. (3) Low per capita income countries (4) All the countries in the sample, with only one dummy variable and constant term. Standard errors in brackets and t-values in Parentheses. *, **, ***, ****, indicate statistical significance at the 1%, 5%, 10% and 15% levels, respectively.

TABLE A2

RESULTS OF REGRESSIONS (OLS) – DEPENDENT VARIABLE PM10

Variables	(1)	(2)	(3)	(4)
Constant term				8703630
				[687220]
				(12.6650)*
Dummy 1	8703630	4001122	10200000	
	[687220]	[636359.4]	[1511166]	
	(12.6650)*	(6.2875)*	(6.7296)*	
Dummy 2	7667048	4189628	7799982	-1036582
	[662089.6]	[595239.8]	[1696819]	[364768.9]
	(11.5801)*	(7.0386)*	(4.5968)*	(-2.8417)
Market capitalization companies	-.58919	.040174	-1.0516	-.58919
	[.25651]	[.12338]	[.52223]	[.25651]
	(-2.2970)*	(.32562)	(-2.0136)**	(-2.2970)*
Real interest rate (%)	2.7285	2.6869	3.3176	2.7285
	[1.3638]	[2.6549]	[1.9746]	[1.3638]
	(2.0007)**	(1.1021)	(1.6801)***	(2.0007)**
Gross domestic savings	-2.0425	2.6765	-.27686	-2.0425
	[2.5046]	[1.1155]	[7.6627]	[2.5046]
	(-.81551)	(2.3994)**	(-.0361)	(-.81551)
Foreign direct investment	-.20759	-.46124	-36.4673	-.20759
	[2.6068]	[.90842]	[14.0667]	[2.6068]
	(-.079633)	(-.50773)	(-2.5925)*	(-.079633)
Exports of goods and services	.29752	-1.6265	-3.5248	.29752
	[2.0653]	[.73886]	[8.4321]	[2.0653]
	(.14406)	(-2.2014)**	(-.41802)	(.14406)
Imports of goods and services	-.51186	2.1831	2.1207	-.51186
	[2.1869]	[.80627]	[8.1532]	[2.1869]
	(-.23406)	(2.7077)*	(.2611)	(-.23406)
Per capita income PPP	-163.3774	-88.3231	-85.2311	-163.3774
	[18.8650]	[17.6019]	[143.5752]	[18.8650]
	(-8.6604)	(-5.0178)*	(-.59363)	(-8.6604)
GDP growth	-.82157	2.4377	1.7490	-.82157
	[5.2351]	[3.2977]	[9.0753]	[5.2351]
	(-.15693)	(.73922)	(.19272)	(-.15693)
R^2	.30566	.24030	.17426	.30566
Log LH	-6296.1	-3048.4	-3069.5	-6296.1
Observations	384	200	184	384

(1) All the countries in the sample. (2) High per capita income countries. (3) Low per capita income countries (4) All the countries in the sample, with only one dummy variable and constant term. Standard errors in brackets and t-values in Parentheses. *, **, ***, ****, indicate statistical significance at the 1%, 5%, 10% and 15% levels, respectively.

TABLE A3

RESULTS OF REGRESSIONS (OLS) – DEPENDENT VARIABLE WASTE

Variables	(1)	(2)	(3)	(4)
Constant term				46500000 [3057358] (15.1951)*
Dummy 1	46500000 [3057358] (15.195)*	1977581 [2817098] (.70199)	71700000 [5044860] (14.2149)*	
Dummy 2	33200000 [2945556] (11.2705)*	4420433 [2635066] (1.6775)***	48500000 [5664641] (8.5617)*	-1330000 [1622812] (-8.1703)*
Market capitalization companies	-2.9350 [1.1412] (-2.5719)*	1.6774 [.54618] (3.0711)*	-2.1086 [1.7434] (-1.2095)	-2.9350 [1.1412] (-2.5719)*
Real interest rate (%)	-7.3959 [6.0673] (-1.2190)	-3.1121 [11.7529] (-.26479)	9.8055 [6.5920] (1.4875)****	-7.3959 [6.0673] (-1.2190)
Gross domestic savings	-15.7722 [11.1426] (-1.4155)****	15.9852 [4.9381] (3.2371)*	-36.4549 [25.5810] (-1.425)****	-15.7722 [11.1426] (-1.4155)****
Foreign direct investment	8.6544 [11.5973] (.74625)	2.3637 [4.0215] (.58777)	-56.5456 [46.9600] (-1.2041)	8.6544 [11.5973] (.74625)
Exports of goods and services	15.2064 [9.1881] (1.6550)***	-2.7578 [3.2709] (-.84315)	36.6773 [28.1495] (1.3029)	15.2064 [9.1881] (1.6550)***
Imports of goods and services	-23.2037 (9.7293) [-2.3849]**	-2.3072 [3.5693] (-.64640)	-53.4423 [27.2186] (-1.9634)**	-23.2037 (9.7293) [-2.3849]**
Per capita income PPP	-951.9636 [83.9280] (-11.3426)*	-71.9877 [77.9219] (-.92384)	3578.4 [479.3097] (-7.4658)*	-951.9636 [83.9280] (-11.3426)*
GDP growth	-31.2871 [.23.2905] (-1.3433)	-1.9246 [14.5986] (-.13183)	-8.4447 [30.2970] (-.27873)	-31.2871 [.23.2905] (-1.3433)
R^2	.44253	.18631	.62869	.44253
Log LH	-6869.3	-3346.0	-3291.3	-6869.3
Observations	384	200	184	384

(1) All the countries in the sample. (2) High per capita income countries. (3) Low per capita income countries (4) All the countries in the sample, with only one dummy variable and constant term. Standard errors in brackets and t-values in Parentheses. *, **, ***, ****, indicate statistical significance at the 1%, 5%, 10% and 15% levels, respectively.

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