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WORKING PAPER

The EKC for SO_2: does firm size matter?

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Abstract

The environmental Kuznets curve hypothesis (EKC) predicts and inverse U-shaped relationship between environmental pollution and per capita income. The literature with respect to the EKC is vast but far from conclusive. This paper adds firm size to the standard EKC reduced form regression and analyses whether firm size matters once income and composition are controlled for. Results suggest that countries whose average firm is larger are initially associated with higher levels of environmental damage. However, as economies develop, large firm countries find it easier to adopt environmental legislation. Environmental damage starts to decrease at lower levels of income and the decrease is much larger compared to countries whose firms are on average small.

Key words

Environmental Kuznets Hypothesis, Firm size

1. Introduction

Empirical literature with respect to the inverse U-shaped relationship between environmental damage on the one hand and per capita income on the other (*aka* the environmental Kuznets curve hypothesis (EKC)) is vast but far from conclusive. The empirical strategy focuses on reduced form regressions (Stern (1996); De Bruyn et al. (1998)) and tries to explain the level of environmental pollution through per capita income, per capita income squared and/or cubed and time or country specific effects (Holtz-Eakin and Selden (1992), Selden and Song (1994), Shafik (1994), Grossman and Krueger (1995), Stern and Common (2001) or Harbaugh et al. (2002)). The income and income-squared variables capture the so-called scale, composition and income effect. At initial stages of economic development, the increasing scale of economic activity as well as the changing composition from agricultural towards industrial activities generates more pollution. Therefore the slope of the income-environment relation is positive. However, as income rises, demand for environmental quality increases and more stringent environmental regulation leads to the replacement of old technologies by environmentally less harmful ones. This technique or income effect together with the changing composition away from industrial towards post-industrial economic activities puts downward pressure on pollution. Eventually, as income passes some threshold level, income and composition effects outweigh the scale effect and the income-environment relationship becomes downward sloping. The empirical evidence with respect to the EKC is, however mixed. Stern and Common (2001) for instance find that income turning points are not stable across income groups. Harbaugh et al. (2002) show that the empirical evidence is not robust for small changes in the data or covariates. The above notwithstanding, the EKC is a valuable framework within which one can analyse the various channels that affect the income-environment relationship.

This paper adds firm size to the standard EKC reduced form regression and analyses whether firm size matters. Firm size has been the topic of quite some discussion in environmental and development literature (Schumacher (1989), Beckerman (1995), Revell and Rutherfoord (2003)). The EKC-literature, however, has largely ignored firm size as a possible determinant of the composition-channel or the cost/benefit ratio of environmental policy. In one study, Dasgupta et al. (2002) find that small plants are on average more (air-) pollution intensive per employee. However, large plants account for most of the industry-related air pollution deaths in Brazil. This seems to suggest that although small firms are on average more polluting per employee (and most probably per unit of output), large firms produce larger volumes of both output and emissions. The evidence presented in Dasgupta et al. (2002) however is limited to 2 countries, Mexico and Brazil. To our knowledge, there is little empirical evidence with respect to the impact of firm size on environmental damage in a large cross section.

We find that firm size matters. Empirical results suggest that countries whose average firm is large, experience higher levels of environmental degradation than comparable countries whose average firm is small, but only in the initial stages of economic development. Once per capita income exceeds a threshold, the large firm country seems to be better off in terms of environmental pollution.

The remainder of this paper is organised as follows. Section 2 explores the issue while section 3 presents the data and the empirical strategy. The fourth section discusses the major results. Section 5 proposes a number of robustness tests and the last section concludes.

2. Income, environment and firm size

The EKC literature has identified a number of channels through which income affects the environment. The average firm size could affect 2 of these channels: the composition channel and the cost/benefit ratio of environmental policy.

With respect to the composition-channel, variables such as the share of manufacturing activities in GDP or exports of manufactured goods (Suri and Chapman (1998), Alpay (2000), Cole (2000)) investment in non-residential capital (Panayotou et al. (2000) or endowment data (Gale and Mendez (1998)) have been used to study the impact of the composition of economic activity on levels of environmental damage within an EKC framework. The evidence with respect to the composition variables suggests that the composition of economic activity influences environmental damage. Cole (2000) for instance finds that the share of manufacturing output has a positive effect on 8 out of 10 environmental indicators he uses and is significant for 4 out of these 8. Panayotou et al. (2000) conclude from their results that structural economic change plays an important role as a mechanism driving the EKC. They find that the accumulation of non-residential capital results in rising emissions as a country industrialises but contributes to lower emissions in the post-industrial stage. Gale and Mendez (1998) report evidence that suggests that greater relative capital abundance is generally conducive to more polluting production whereas land and labour abundance is associated with environmentally less harmful economic activities.

Within an EKC framework the income channel assumes that marginal benefits of better environmental quality increase with income. Literature that focuses on other variables that affect the cost/benefit ratio of environmental policy includes Kaufman et al. (1998) and Munasinghe (1999). Kaufman et al. (1998) argue that income is not sufficient as an explanatory variable within the EKC. These authors assume that the effect of country or city characteristics that affect the cost/benefit ratio of environmental policies could overwhelm the effect of increased demand for environmental quality. Their evidence suggests that spatial intensity, as a proxy for environmental damage is a highly significant variable. Their results support the hypothesis that higher levels of environmental damage are associated with decreasing concentrations of sulphur dioxide emissions because marginal costs of environmental policy are lower, while marginal benefits increase as higher damage levels are reached. Munasinghe (1999) is another example of an author who points at specific characteristics of a country that could have an impact on the cost/benefit ratio of environmental policy. The author argues that knowledge on environmental issues for instance, could affect the way in which environmental damage responds to changes in per capita income.

How does firm size fit into these channels? With respect to the influence of firm size on the composition channel, Dasgupta et al. (2002) argue that some of the most pollution intensive industries are also characterized by important scale economies. This suggests that we could expect a relatively high share of pollution intensive firms among the largest firms in any particular country. From the evidence presented in Gale and Mendez (1998) it follows that if capital abundance correlates with capital-intensive production methods, one could assume that capital abundance and firm size are correlated and hence, firm size and environmental damage. It follows that one could expect that larger firms are associated with more pollution intensive activities.

With respect to the cost/benefit argument, Andreoni and Levinson's (2001) evidence suggests that there are returns to scale in abating pollution at the plant level. They argue that "*larger industrial boilers cost less to control per unit of abatement than smaller boilers*" (p. 281), i.e. larger firms are faced with lower marginal abatement costs. This is in line with Kaufmann et al. (1998) who argue that the point at which the costs of non-adoption of environmental policies outweigh those of adoption will be reached sooner if firms are large on average. Furthermore, Beckerman (1995) argues that small firms are difficult to monitor and regulate. It follows that one could expect that countries whose economy counts a small number of large firms would find it easier to meet certain environmental standards both from an administrative point of view as well as from a marginal abatement cost point of view.

Through the inclusion of firm size in the EKC framework, this paper adds a variable that reflects marginal abatement costs. However, lower marginal abatement costs for large firms are only relevant if these firms are actually required to abate emissions. The latter will be the result of environmental policies that are designed to meet demand for better environmental quality by the general public.

The composition and the cost/benefit channels work their way from firm size to environmental damage along an opposite route. Since it is not possible to argue that one of them is certain to dominate the other, the net effect of firm size seems to be an empirical question. However it is possible to distil some testable hypotheses from the previous discussion:

Hypothesis 1: In poor countries where environmental policies are absent, firm size is positively related to emissions.

Hypothesis 2: Since large firms face lower marginal abatement costs and the EKC predicts that marginal benefits of higher levels of environmental quality rise with income, large firm countries' marginal benefits will outweigh marginal abatement costs at lower levels of income. Hence, large firm countries will enact environmental policies sooner, i.e. at lower levels of income. Furthermore, marginal benefits of environmental policy will continue to outweigh marginal costs for higher levels of abatement in large firm countries.

3. Data and empirical strategy

We have used data on environmental damage, income, openness, investment and democracy that were used by Harbaugh et. al (2002) (HLW-dataset).[1] This dataset reports yearly mean ambient pollution levels of sulphur dioxide (SO_2), total suspended particulates

[1] We are grateful to W. Harbaugh, A. Levinson and D. Wilson for making their dataset graciously available.

(TSP) and smoke collected by the Global Environmental Monitoring System (GEMS). The data are maintained by the U.S. Environmental Protection Agency in its Aerometric Information Retrieval System (AIRS). These pollution levels are recorded in various monitoring stations in selected cities around the world and are reported for the 1971-1992 timeframe although data-availability differs across countries and cities. AIRS-data also include variables indicating whether a monitoring station is located in an industrial or a residential area, in a city centre or along the coast. Income (measured as per capita GDP in 1985 USD), openness (ratio of imports plus exports to GDP), investment (measured as a fraction of GDP), relative GDP (per capita GDP relative to the mean), city population density and political equality data were also taken from the HLW-dataset. Column 1a-1c in table 1 presents summary statistics.

Firm size data were derived from the UNIDO Industrial Statistics Database. This database supplies data on the number of employees and on the number of establishments for 4-digit ISIC manufacturing sectors for the years 1981 - 1992. For each country, we have taken the total number of employees and establishments to calculate the average firm size as the ratio between the total number of employees and the total number of establishments. Ideally, we would like to add other statistics with respect to firm size to our database. However, as UNIDO ISIC manufacturing sectors are not uniform across countries, we could not calculate average firm size in separate industries such as iron and steel or pulp and paper or the standard deviation of firm size within one country.

Due to data availability, the total number of observations for the sulphur dioxide sample dropped from 2381 in the HLW-dataset to 614 in our set. These observations come from 144 monitoring stations in 62 cities located in 24 countries whereas the HLW-dataset contains observations for 285 stations in 102 cities located in 45 countries. Columns 2a-2c of table 1 report summary statistics for the observations that were available after adding firm size data.

Comparing these statistics with those for the full HLW-dataset reveals that the observations that were dropped do not have a sizeable effect on the overall distribution of the various variables. Although both the mean and maximum level of mean SO_2 concentration is somewhat lower in our dataset compared to the HLW-dataset, per capita GDP variables, investment as a share of GDP, trade intensity, democracy and relative GDP variables seem to be quite comparable. Also note that the average values for the variables indicating whether a monitoring station is located in an industrial, residential, coastal are or a city centre are comparable. This seems to suggest that our observations with respect to SO_2 share quite some of the characteristics of the full HLW-dataset and cannot be seen as a particular sample from that larger dataset.

With respect to TSP, the number of monitoring sites was reduced to 81 (from 149 in HLW-dataset) in 29 cities (53 in HLW-dataset) in 20 countries (30 in HLW-dataset). Although the distribution of the TSP dataset was not significantly different from the HLW dataset for most variables, our dataset did not include any observation from an industrial city area and almost all of our observations came from residential areas in city centres. For this reason, we have chosen not to use the TSP sub sample. With respect to smoke, the total number of available observations dropped to 136 and these observations came from residential areas in city centres. This is why we also dropped the smoke observations from our dataset.

We also collected data on the industrial sectors from the World Bank World Development Indicators 2001. The importance of industrial activities is measured as a percentage of GDP. Summary statistics can also be found in table 1. Table 2 reports correlation coefficients between per capita GDP, firm size, investment, openness, relative per capita GDP and the democracy index. Firm size seems to be positively associated with open countries and correlates negatively with most other variables in our dataset. However, correlation coefficients seem to be small. This seems to suggest that our measure of firm size is not a substitute for other variables and especially per capita GDP, investment or the importance of industry in GDP.

[Insert table 1 and 2 around here]

In line with the EKC literature, we estimate a model of the following form:

$$m_{ljit} = \beta_1 y_{it} + \beta_2 y_{it}^2 + \beta_3 y_{it}^3 + \beta_4 s_{it} + \beta_5 y_{it} s_{it} + \boldsymbol{\beta}_6 \mathbf{x_{it}} + \mu_l + \varepsilon_{ljit} \quad [1]$$

where m_{ljit} the is the yearly mean level of SO_2 concentration recorded in monitory station l, in city j located in country i at time t, y_{it} is the income of country i at time t, x_{it} contains control variables such as a time trend and population density, μ_l is a fixed or random monitoring station specific effect and ε_{ljit} is an independent and identically distributed random error term. Finally s_{it}, the average firm size in country i at time t, is added to the explanatory variables. We have used a Hausman test to determine whether the random or fixed effects model is preferred. This test reveals that the fixed effects estimator is preferred. Accordingly, we have dropped the random effects estimates from the tables reporting the results. The last row in each table reports the Hausman Chi^2 as well as its significance. Due to the dominance of the cross-section dimension, we can estimate [1] in levels without worrying about the time series properties of the variables (Stern and Common (2001), Perman and Stern (2003)).

From our hypotheses it follows that we expect:

<u>Hypothesis 1:</u> $\beta_4>0$ and $\beta_5<0$ with $-(\beta_4/\beta_5)$ within a reasonable range in terms of per capita GDP

<u>Hypothesis 2:</u> $\beta_1>0$, $\beta_2<0$, $\beta_3>0$ and $\beta_5<0$

If firm size is relevant in terms of environmental damage, hypothesis 1 requires that initially, i.e. at lower levels of income, firm size is positively associated with environmental damage. With $\beta_4 > 0$ and $\beta_5 < 0$, this will be the case as long as per capita GDP is lower than $-(\beta_4/\beta_5)$. If $\beta_5 < 0$ and the standard EKC results ($\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 > 0$) remain valid, large firm countries' initial turning point will be located at lower levels of income compared to the one for small firm countries. The second turning point will be located at higher levels of income in large firm countries.

4. Results

Table 3, panel A reports results for various specifications of [1], panel B presents the implied turning points and slopes. As a benchmark, column 1 confirms for our sample the standard results from the empirical EKC literature.[2] Initially, income is associated with an increase in the mean ambient SO_2 concentrations until it reaches $1985 6,654 and then starts to decline until a level of $1985 15,492 is reached. Beyond this income level, environmental damage increases again. With respect to the slope of the EKC at various income levels, our evidence suggests that the upward sloping part at $1985 2,000 and $1985 20,000 are more of less equal. The trend variable is negative and significant; population density is not, however.

[Insert table 3 around here]

Adding size (column 2) reveals that our measure for average firm size is positively associated with higher level of yearly mean ambient SO_2 concentrations. A 1 standard

[2] Although some EKC regressions use 3-year lagged levels of per capita GDP as well as current values of per capita GDP, we have chosen not to include them here. As Grossman and Krueger (1995) point out, "*lagged and current GDP per capita are highly correlated, so including just current (or lagged) GDP per capita does not qualitatively change the results*" (p. 361). This conclusion also applies to our results.

deviation increase in the size of the average firm is associated with an increase of 61.68 μg/m^3, which equals 1.88 times the standard deviation of mean SO_2 in our sample. Firm size is thus not only a significant variable in statistical terms, but is also very relevant from an environmental point of view.

Column 3 of table 3 adds the interactions of size and per capita GDP to the explanatory variables. The interaction between size and the level of per capita GDP is negative and significant. The product between size and per capita GDP squared and cubed is not. If we drop the latter from the specification, column 4 in table 2 shows that the results are unaffected. The size-per capita GDP interaction term affects the peak and through income turning points. Using the average firm size, column 4 suggests that mean ambient SO_2 concentration reaches a peak at $1985 5,712 while it reaches a trough at $1985 15,600. With firm size equal to 1 standard deviation below its sample average, peak and trough income levels equal $1985 6,640 and $1985 14,670 respectively. With firm size equal to 1 standard deviation above its sample mean, these income levels reach $1985 4,930 and $1985 16,380.

The implied peak and trough income turning points are fairly close to those reported in Grossman and Krueger (1995). As can be seen from table 3, both the sign of the estimate as well as the magnitude of the turning points and slopes are quite comparable across various specifications of [1]. Including 3-year average lags of per capita GDP does not alter these turning points (not reported).

In view of the estimated coefficients of the size and per capita GDP variables in table 3, the negative slope between peak and trough will be steeper the larger the average firm size. This can be seen from figure 1 that plots 3 EKC curves. Our benchmark, the standard EKC is based on the estimated parameters presented in column 1 of table 3. Environmental damage is rescaled to equal 100 at zero income for the standard EKC. The other 2 EKC-curves are based on the data in column 4 of table 3 and were drawn for firm sizes equal to 1 standard deviation below and above the sample average (i.e. 16.46 and 98.16). These curves are indicated with 'EKC Small Firms' and 'EKC Large Firms'.

[Insert Figure 1 about here]

What does the evidence suggest in terms of the channels through which firm size affects environmental degradation? The data presented in column 4 of table 2 and shown in figure 1 indicate that countries whose per capita GDP is low, experience higher environmental pollution as income increases whether their average firm is large or small. The estimates however seem to suggest that countries with a larger average firm initially suffer much higher levels of environmental damage. This supports hypothesis 1. Since the difference in the upward slope of the large firms and small firms EKC is small, the pollution level remains higher throughout initial stages of development. From Dasgupta et al. (2002) and Gale and Mendez (1998), this seems to indicate that the large firm countries are most probably characterised by an industrial structure whose firms are specialised in capital- and/or pollution-intensive manufacturing activities. As demand for environmental policy is low due to low levels of both per capita income as well as low levels of damage from environmental pollution, an increase in economic activity translates into more environmental pollution, as there is no need to introduce environmental legislation.

As mean ambient SO_2 concentrations increase, public demand for better environmental quality strengthens. Once income approaches about $1985 5,000, large firm country governments are first to respond with environmental policies. Whether this is due to the fact that these firms are easier to regulate from a governance point of view or whether it is due to their lower marginal abatement costs cannot be determined from the data. In the small firm country, it takes about $1985 1,600 more before the threshold level of income is reached were environmental policies that lower environmental degradation are introduced.

The slope of the EKC in the large firm country seems to suggest that these country's governments are able to introduce environmental policies that are more stringent than those adopted by the decision-makers in small firm countries as both the depth and the length of the decline in environmental degradation is much larger. As a matter of fact, environmental degradation in the small firm country declines much less peak to trough than in the large firm country. Furthermore, in the large firm country, environmental degradation drops below the level in the small firm country if per capita income exceeds $1985 9,600. This can be interpreted as evidence in favour of hypothesis 2.

5. Additional robustness tests

Table 4 reports a number of robustness tests we performed. First, we add the percentage of GDP going to investment to the variables in column 4 of table 3. As such we test whether average firm size is not simply capturing an investment effect. Results are presented in column 1. A higher percentage of GDP going to investment results in a higher pollution level. The inclusion of investment does not alter the results with respect to the other variables.

[Insert table 4 about here]

Column 2 further adds a number of covariates to the specification. To the variables in column 1, we add a number of variables that have been suggested in the EKC literature. These are: national trade intensity (Alpay (2000)), an index of democratic government (Torras and Boyce (1998), Scruggs (1998)) and relative GDP (national GDP divided by the average of all countries' GDP). With the exception of relative GDP, all are statistically significant and correctly signed. Though the magnitude of the other coefficients is affected, the general EKC pattern is not changed and turning points do not drastically change.

Although table 2 suggests that firm size is not a substitute for the importance of industrial activities, we tested for robustness by adding the importance of industrial activities in GDP both to the variables in column 2 of table 4 and column 4 of table 3. This reduces the sample size from 614 to 364 when all covariates are used (column 3) or 393 when industrial activities are added to column 4 of table 3 (column 4, table 4). Industrial activities itself is not significant in either case. The implied EKC is not totally unaffected as both peak and trough are shifted to a higher level of GDP per capita and the slope at $1985 2,000 is still quite steep. Clearly the change in sample size might be responsible. With respect to the size variable, earlier results are confirmed.

To allow for a more flexible time pattern, the random effects estimation in column 5 uses year dummies rather than a time trend. Conclusions with respect to the impact of average firm size are unaffected. Finally column 6, compared to column 4 in table 3 leaves out GDP per capita. The size effect again is robust to this change in specification.

With respect to slopes and turning points, one can infer from panel B in table 3 and 4 that they are not unaffected by changes in the specification. The general EKC pattern is always preserved, however, and differences with respect to peak, trough and slope are small. Although Harbaugh et al. (2002) have argued that turning points are not robust to small changes in the data, empirical model or covariates, our evidence suggests that, at least in our sample, they are.

6. Conclusion

This paper addresses the question whether firm size matters in an Environmental Kuznets Curve framework. Our results suggest that firm size is important and that the way in which it influences mean ambient SO_2 concentrations depends to a large extent on the question whether environmental policies have been enacted or not. If they have not been enacted, countries whose average firm is large seem to suffer higher levels of environmental pollution compared to small firm countries. Large firms, however, do seem to allow countries to introduce more stringent environmental policies sooner than countries whose average firms are small. The latter result is in line with the hypothesis that larger firms face lower marginal abatement costs and governments face lower governance costs in the presence of a small number of large firms. On the other hand, the higher peak of mean ambient SO_2 concentrations in the large firm country may work out badly, since it increases the probability that this country suffers irreversible harm (Arrow et al. (1995)).

Our results seem to be robust for additional covariates. However, other work with respect to the EKC seems to suggest that this should not be the case if new observations are available and can be added to the dataset. We also did not have the opportunity to look at firm size in particular sectors, as the data did not allow us to calculate average firm sizes for comparable manufacturing sectors. If there were a difference between countries whose large firms are pollution-intensive or capital intensive and countries where this is not the case, this would be a valuable exercise. Finally, a measure of 'dispersion' was not available to enrich our analysis. This leaves open the question whether the results would still hold if one were able to control for dispersion and compare countries with a lot of small firms and one huge firm and countries with a lot of reasonably large firms.

Concluding, our paper suggests that the question of firm size can be addressed in a panel-framework and that firm size might be an important variable affecting both the composition-channel and the cost/benefit channel of the income-environment relationship. Although further evidence is required before one can argue that the results of this paper can be generalized, firm size and the income-environment relationship seems to be a promising avenue for further research.

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Table 1 – Summary statistics SO_2-sample

	HLW			Size-dataset		
	Obs.	Mean	S.D.	Obs.	Mean	S.D.
Mean SO_2 Conc.	2401	49.4	50.9	614	37.06	32.80
GDP per capita	2381	9.43	5.73	612	11.08	5.47
Year	2401	1983	5.17	614	1986	3.43
Population density	2401	2.75	3.99	614	3.67	5.07
Size	-	-	-	614	57.31	40.85
% of industry in GDP	-	-	-	395	32.39	5.39
Industrial dummy	2401	0.09	0.28	614	0.06	0.23
Residential dummy	2401	0.82	0.38	614	0.88	0.32
Centre city dummy	2401	0.86	0.35	614	0.90	0.30
Coastal dummy	2401	0.57	0.50	614	0.62	0.49
Investment as %GDP	2381	23.1	5.49	612	22.64	6.84
Trade intensity	2381	42.5	32.9	612	47.54	38.81
Democracy index	2322	7.23	4.16	585	8.72	2.93
Relative GDP	2381	1.12	0.91	612	1.33	0.84
# sites	285			144		
# cities	102			62		
# countries	45			24		

Table 2 – Correlation matrix (583 observations)

	Mean	GDPpc	Size	Inv	Trade	Rel. GDP	Demo
Mean SO_2 Conc.	1						
GDP per capita	-0.094	1					
Size	-0.083	-0.425	1				
Investment as %GDP	0.271	0.417	-0.383	1			
Trade intensity	-0.346	-0.177	0.293	-0.004	1		
Relative GDP	-0.050	0.948	-0.454	0.480	-0.035	1	
Democracy index	-0.048	0.666	-0.522	0.386	-0.059	0.688	1
% industry in GDP*	0.204	0.175	-0.193	0.519	0.050	0.269	0.145

* 364 observations

Table 3A – Results for mean Sulfur Dioxide (standard errors in brackets)

	(1)	(2)	(3)	(4)
GDP	32.464**	24.395*	49.803**	24.819*
	(10.829)	(10.965)	(15.083)	(10.862)
GDP^2	-3.487**	-2.915**	-4.919**	-2.625**
	(0.945)	(0.950)	(1.514)	(0.945)
GDP^3	0.105**	0.092**	0.144**	0.082**
	(0.027)	(0.027)	(0.047)	(0.027)
GDP*size			-0.421*	-0.050**
			(0.166)	(0.016)
GDP^2*size			0.034	
			(0.021)	
GDP^3*size			-0.001	
			(0.001)	
Size		0.151**	1.653**	0.483**
		(0.044)	(0.407)	(0.115)
Year	-1.887**	-1.813**	-2.074**	-2.273**
	(0.456)	(0.451)	(0.476)	(0.470)
Density	9.179	9.759	12.635	3.863
	(18.752)	(18.541)	(18.462)	(18.462)
# obs.	612	612	612	612
# groups	144	144	144	144
R^2 (within)	0.14	0.16	0.20	0.18
Hausman Chi^2	23.54**	42.50**	80.51**	45.71**

** significance at 1%

* significance at 5%

Table 3B – Implied turning points and slopes (standard errors in brackets)

	(1)	(2)	(3)	(4)
Turning points for average firm size (if applicable)				
Peak	6654.6	5746.5	5925.5	5712.6
	(981.9)	(1268.4)	(1299.3)	(1428.3)
Trough	15492.0	15388.4	15478.3	15600.7
	(497.9)	(510.3)	(1062.3)	(638.0)
Turning points for large firms (average firm size + 1 s.d.)				
Peak			3126.5	4934.0
Trough			15743.8	16379.3
Turning points for small firms (average firm size – 1 s.d.)				
Peak			7227.6	6639.3
Trough			15301.7	14674.0
Slopes for average firm size				
At $2000	19.78	13.84	14.81	12.44
	(56.54)	(7.64)	(9.77)	(7.58)
At $10000	-5.79	-6.32	-6.25	-5.91
	(3.71)	(1.91)	(2.62)	(2.16)
At $20000	18.94	18.13	17.82	15.48
	(25.57)	(5.01)	(11.48)	(4.96)

Table 4A – Effects of variations in specification and functional form

	(1)	(2)	(3)	(4)	(5)	(6)
GDP	25.267*	52.674**	91.033**	41.311**	13.294**	
	(10.814)	(13.273)	(20.521)	(15.368)	(4.195)	
GDP^2	-2.923**	-5.367**	-7.309**	-3.501**	-1.173**	
	(0.950)	(1.061)	(1.529)	(1.339)	(0.456)	
GDP^3	0.092**	0.156**	0.190**	0.099**	0.031*	
	(0.027)	(0.029)	(0.042)	(0.039)	(0.015)	
GDP*size	-0.055**	-0.047**	-0.125**	-0.118**	-0.030**	
	(0.016)	(0.018)	(0.040)	(0.038)	(0.011)	
Size	0.513**	0.435**	0.883**	0.885**	0.280**	0.149**
	(0.115)	(0.121)	(0.243)	(0.236)	(0.089)	(0.043)
Year	-1.880**	-0.422	1.818	-1.866**		-1.803**
	(0.499)	(0.591)	(0.991)	(0.615)		(0.260)
Density	14.583	-133.460	-472.295**	-9.111	-0.131	-14.206
	(18.963)	(111.705)	(168.698)	(22.625)	(0.773)	(17.837)
Investment	0.981*	1.656**	2.850**			
	(0.428)	(0.448)	(0.718)			
Trade		-0.472**	-1.126**			
		(0.177)	(0.327)			
Democracy		-10.261**	-4.702			
		(3.943)	(5.366)			
Relative GDP		-35.617	-101.815**			
		(26.086)	(39.198)			
Industry as			1.477	-0.867		
%GDP			(0.944)	(0.601)		
# obs.	612	612	364	393	612	612
# groups	144	144	80	83	144	144
R^2 (within)	0.18	0.24	0.23	0.08	0.23	0.12
Hausman Chi^2	45.39**	43.90**	34.08**	22.71**	RE	-

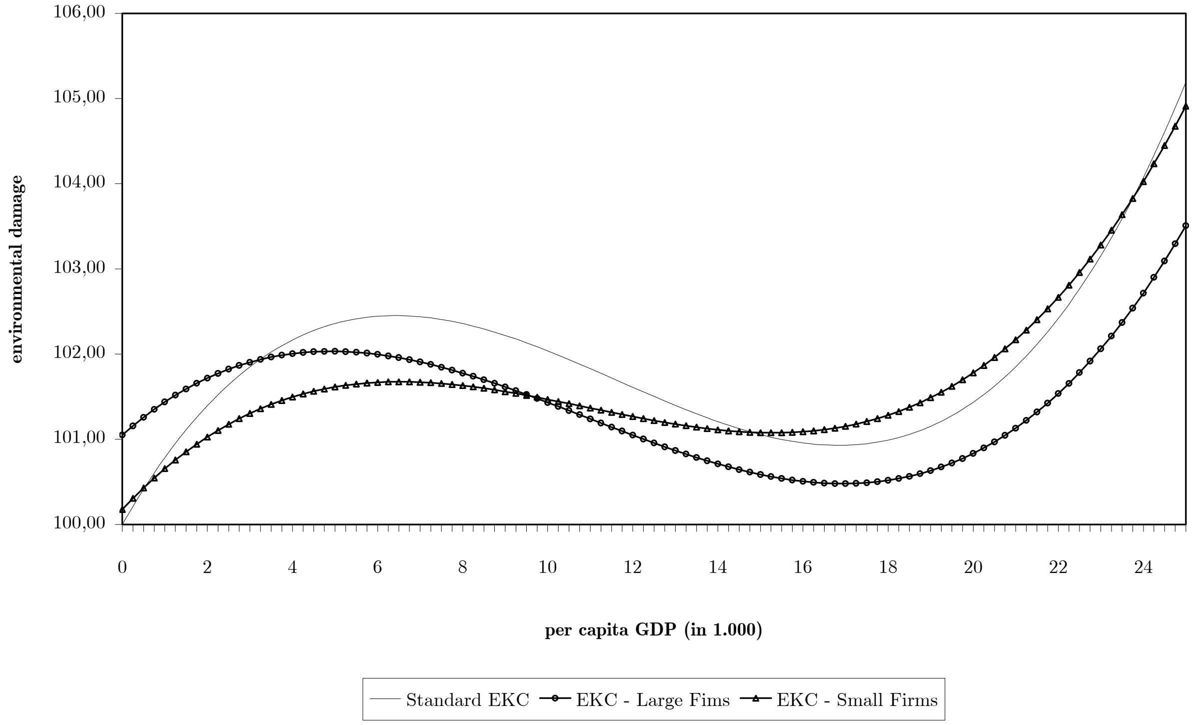
** significance at 1%

* significance at 5%

Table 4B - Implied turning points and slopes (standard errors in brackets)

	(1)	(2)	(3)	(4)	(5)
Turning points for average firm size (if applicable)					
Peak	4934.2	6490.4	8640.4	7057.0	6714.3
	(1329.3)	(1087.7)	(1508.2)	(1531.9)	(917.0)
Trough	16288.3	16493.0	17067.8	16416.9	18503.0
	(587.2)	(529.3)	(940.6)	(1185.2)	(2491.2)
Turning points for large firms (average firm size + 1 s.d.)					
Peak	4260.8	6097.5	7681.4	5569.6	5678.8
Trough	16961.7	16885.9	18026.8	17904.3	19538.5
Turning points for small firms (average firm size – 1 s.d.)					
Peak	5699.0	6917.0	9895.6	9335.2	7975.7
Trough	15523.5	16066.4	15812.6	14138.7	17241.7
Slopes for average firm size					
At $2000	11.55	30.40	56.89	20.09	7.24
	(7.55)	(9.78)	(15.62)	(10.67)	(2.65)
At $10000	-8.77	-10.64	-5.46	-2.97	-2.60
	(2.43)	(3.92)	(6.49)	(3.13)	(1.09)
At $20000	15.40	22.13	18.94	10.94	1.85
	(4.94)	(5.06)	(8.74)	(8.40)	(3.90)

Figure 1 – EKC for large and small firm countries



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