Does Social Capital Have a Role in Environmental Kuznets Curve Estimation?

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This study examines if social capital has a role to play in environmental Kuznets curve estimation. It uses information from the World Values Survey to extract the variables representative of the social capital to develop an index using a principal component analysis. Estimation involves the use of parametric and semiparametric panel models to examine the role of social capital in the EKC behavior.

Keywords: Social capital, Environmental Kuznets Curve, Water pollution, Air pollution

JEL classification: C23, Q53

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Environmental Kuznets Curve (EKC) is a hypothetical relationship that purports to explain how income and pollution relate to each other. It states that as a country traverse through the path of economic growth, pollution increases as income rises. However, as income further rises, pollution level reaches a peak and then begins to decrease. As a result, there exists an inverted-U shaped relationship between economic growth and pollution. It is reasonable to assume that at the beginning of growth, population tolerates increased pollution levels as they focus attention of economic development, jobs, and income. After reaching a critical level of welfare and economic growth, people treat environmental quality as a luxury good and hence invest money to clean air, water and their environment.

Researchers have tested EKC hypothesis and found mixed results. A few studies have supported inverted U-shape curve for the EKC (Paudel *et al.*; Selden and Song). However, Grossman and Kruger found water quality declined monotonically with income. Stern's review of the empirical EKC literature with respect to air and water quality concluded the inverted-U curve relationship applies only to certain types of pollution. This inconsistency in the shape of the EKC has been a motivation to continue studying the income pollution relationship. Some empirical studies incorporated variable that suggest external factors cause economic-environmental relationship (Bhattarai and Hammig; Dasgupta *et al.*). For example, Dasgupta *et al.* found governance and geographic vulnerability influenced the EKC estimation.

The recent trend has been to include several other variables in addition to per capita income as explanatory variables. However, the choice to include additional variables has been random. We use social capital variables to find if we can standardize additional variable inclusions in the EKC regression model. Therefore, we propose to expand traditional EKC analysis using a cross-country social capital variable to determine if this variable can explain pollution income relationship in a better way. Our hypothesis in this case is that a country with stronger civic solidarity may be more aggressive on implementing pollution control measures because collective vigilant in that country against pollution emitting industries is higher. Cross-country panel data is more robust to estimate EKC which explains better pollution-income relationship. We explore whether social capital enhances our understanding of pollution dynamics by utilizing cross-country panel data obtained from world value survey. The objectives of this study are to:

i. use world value survey to develop a social capital index, and
ii. test the impact of social capital index on ambient water and air quality under an EKC framework using parametric panel models.

Social Capital

The term social capital is popularized by Putnam. His version of social capital is identified with "those features of social organization, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions" (Putnam). A number of definitions is attached to the concept; as a result, confusion exists for what constitutes social capital. For example, Fukuyama focuses on trust. He defines the social capital a community capability arising from the prevalence of trust in a society or in a certain part of it. Woolcock focuses on collective action for mutual benefit. He equates high stocks of social capital with increased civic engagement, organizational plurality, and democracy. Similarly, Bebbington and Farrington define social capital as organizational plurality. To the World Bank, social capital encompasses

"The institutions, relationships and norms that shape the quality and quantity of a society's social interactions."

Social Capital, Environment and Economic Performance

After a thorough literature survey from developing and developed world, Pretty and Ward claim that during the past decade some 408,000-478,000 groups with 8.2-14.3 million members in the area of watershed, irrigation, microfinance, forest and integrated pest management and farmers' research are self evidence of growing social capital associated with better managed natural resources.

As for the link between economic performance and social capital, the nexus is not clear. Sabatini points out a number of issues. The first one is measurement issue. There is no universal method of measuring social capital. The second one is that empirical studies show conflicting association between social capital and economic growth. The third one is issue of the direction of causality. Whether social capital cause economic growth or economic growth cause social capital? Another issue could be that whether social capital is directly related to income or not? Despite these challenges, we find some degree of association between social capital and economic development. Sabatini argues that social capital is multidimensional as well as contextual. For example, he found that strong family ties causes negative human development and economic performance because it blocks the opportunity of knowledge sharing among the members of different community and reduce cross community trust.

Zak and Knack found 15% point increases in trust is associated with 1% point increase in economic growth. They also found that 7% point increase in trust is associated with 1% point increase in investment/GDP share.

Categorizing group membership into Putnam vs. Olsan and active vs. passive, Beugelsdijk and van Schaik found that only active membership matters for the growth in Europe. They estimate that one standard deviation change in active membership raises growth by .03% points.

Following Putnam's distinction between bonding (networks of family and friends) and bridging (intercommunity network) social capital, Beugelsdijk and Smulders found that one percent change in standard deviation in bridging capital raises growth by 0.03% points. They also found that bonding social capital is negatively associated with economic growth.

Using voters' turnout rate in Italy's provinces and voluntary blood donation as measure of social capital, Guiso *et al.* found that higher level of social capital is associated with increased probability of using check and decrease investment in cash together with increase investment in deposit and stock. Their result shows that one standard deviation increase in social capital is associated with 1) 12% point increase in probability of using check; 2) 7% point decrease in investment in cash; 3) 14% point increase in the proportion of wealth invested in stock.

Model

To understand the role of social capital in pollution, we adopted a similar approach used by Paudel *et al.* (2005a). Many data points were missing for variables chosen to create a social capital index; therefore, we used a SAS imputed procedure to generate missing values. We used a factor analysis method to create an index of social capital from data. The indexing procedure is given by Jha and Murthy (2003).

Social Capital Indexing

To create a composite social capital index and relate it to individual air and water pollutants in the EKC framework, we chose few essential variables and determined the relative weights to form a single index. Social capital index is developed using principal component analysis. Principal component analysis (PCA) is an appropriate methodology because it maximizes the variance rather than minimizes the least square distance. PCA is capable of providing the original set of variables into a smaller set of uncorrelated variables containing most of the information. PCA is capable of providing the original set of variables into a smaller set of uncorrelated variables containing most of the information. The transformation of original variable to new index is presented as

$$SC_1 = a_{11}x_1 + a_{12}x_2 + ...+ a_{1p}x_p = \sum_{i=1}^{p} a_{1i}x_i \qquad (1)$$

PCA determines the optimal vector of weights (a_{11}, a_{12}, ….. , a_{1p}) and the associated variance of SC_1 which is denoted by   .

We identified the number of factors to uniquely represent social capital variables using an Eigen value criterion. Once the number of factors is identified, we used weight variable in the regression based on the weight shown in the factor pattern. Following this procedure, we define the social capital for the ith country as $SC_i = \sum w_j x_{ji}$, where w_j is the jth component score and x_{ji} is the value of the jth variable for the ith country given j equal to variable used in the regression. Social capital index is calculated by dividing each SC value thus calculated with the highest SC value. Therefore SCINDEX ranges from 0 to 1.

Parametric Panel Data Model

Environmental Kuznets Curve models have been estimated either in quadratic or in cubic specifications between pollutant concentration and per capita income. We adopt both of these specifications in our analysis. The general form of the panel data model used to describe the relationship between pollution and income in this study is given in equation (2).

$$p_{it} = a + \sum_{k=1}^{m} b_k Y_{it}^k + b_{m+1} SC_{it} + b_{m+2} D + u_{it} \qquad (2)$$

Here, p is a water pollutant (nitrogen, phosphorus or dissolved oxygen), Y is a GNI adjusted in terms of a purchasing power parity of US dollar 1982-84, SC is a social capital index in a given country, i and t represent indices of country and time, respectively. Population density (persons per square mile) is accounted by D. We estimated the model with quadratic and cubic specifications so m=2 when Y and pollution concentration is specified as quadratic and m=3 if pollution-income relationship is specified as cubic. Population density is used in the model as a proxy for human behavior on water pollution. The hypothesis underlying this variable is that the more populated parishes are likely to be more concerned about reducing water pollution. Hence, population density is expected to have a negative sign[1].

The error components, u_{it}, can take different structures. The specification of error components can depend solely on the cross section to which the observation belongs or on both the cross section and time series. If the specification depends on the cross section, then we have $u_{it} = v_i + e_{it}$; and if the specification is assumed to be dependent on both cross section and time series, then the error components follow $u_{it} = v_i + e_t + e_{it}$. The term v_i is intended to capture the heterogeneity across individual parishes and the term e_t is to represent the heterogeneity over time. Furthermore, v_i and e_t can either be random or nonrandom, and e_{it} is

[1] Relationship between population density and water pollution may be positive or negative depending on where the data come from. The hypothesis is open to an empirical testing.

the classical error term with zero mean and homoscedastic covariance matrix. The nature of the error structures leads to different estimation procedures depending on the specification. For this study, we estimated the models fixed and random effects models. Goodness of fit of alternative formulations is assessed by comparing the log likelihood and AICC values.

Semiparametric Model

Various studies (Paudel *et al.* 2005b; Millimet *et al.* 2002) contest using quadratic or cubic functional forms in EKC framework to show how income exerts its effect on pollution. Instead, these authors suggest an alternative formulation where functional form of variables other than the income is identified. This formulation can be presented as:

$$P_{it} = f(Y) + a_1 SC_{it} + a_2 D_{it} + e_{it} \qquad (3)$$

Here f(Y) enters in a regression model as unknown functional form, thus making the model a semi-parametric form.

Data

Measuring Social Capital

Social capital variables are obtained from World Value Survey (WVS). The survey asks a variety of attitudinal questions to samples of individuals from different countries. WVS sample include 22 countries for 1981, 44 countries for 1990-91, 55 countries for 1995-97 and 68 countries for 2000. Two categories of social capital variables are used from the WVS; the first category include TRUST variable, and the second category includes the people's reported belongingness to four types of associations such as trade unions, political parties, environment groups, youth work and professional organizations.

To measure the trust as a one measure of social capital, we utilize the WVS response on "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?" After deleting "don't know" option, we measure TRUST for a country as the proportion of respondents who agree with this statement. A second category of social capital variables is measured as the proportion of people belonging to trade union, political parties, environment groups, youth work and professional organizations. WVS asked the individual respondents whether they belong to certain organization/association. Although there are many other similar indicators in more recent WVS, to maintain uniformity for all four years we chose only five types of associations such as trade unions, political parties, conservation, youth work and professional organization.

Measuring pollution

Cross country pollution data are obtained from the World Bank. Country specific water pollution is measured by the production of organic water pollutants (kilogram per day per worker). We use one water pollution variable and four air pollution variables. The first variable is water pollution variable (BOD) which is organic pollutant estimated through biochemical oxygen demand. Its unit of measurement is kilograms per day per workers. As a standard water-treatment test, it is the total emissions of organic water pollutants, divided by the number of industrial workers. The rest variables related to air pollution are carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen dioxide (NO2) and total suspended particulate (PARTICULATE). CO2 is the total amount of carbon dioxide emitted by a country as a result of human activities especially consumption of fuels, cement production and gas flaring, divided by the population of the country. Remaining three air pollution variables are estimated from average city pollution of each country. All of these three variables are measured in microgram per cubic meters. Variables used, measured unit, number of observations and source where these variables are collected are provided in Table 1.

Results

The descriptive statistics of the results are presented in Table 2. Results for both quadratic and cubic formulations for each fixed and random effects models are shown in Tables 3 to 7. Similarly, to illustrate the turning point for these different air and water pollutants, figures are presented. Figures were developed (Figures 1 – 5) for both fixed and random effects models and for both quadratic and cubic specifications using information from the regression models using all four panel years.

Principal component analysis indicated that there is only one dominant factor for these six variables. The highest weight was assigned to variable membership in professional organization and lowest to the trust variable. These weights are used in developing the index of social capital variable which is then used in regression models.

For CO2, overall speaking, a cubic specification seemed to be superior compared to the quadratic model. Coefficients of cubic model were significant although turning point indicated them to be all in complex number range. Population density variable was found to be positively affecting CO2 pollution. Coefficient associated with population density was found to significant only when data use was restricted for last two panel years. Social capital was found to be positive and insignificant in most of the specification, panel data model use (fixed vs random) and number of observation included in the analysis. Most of the turning points were beyond the present range of GNI range. In some cases, the turning points values were complex numbers.

SO2 is one pollutant where most of the regressors were found to be nonsignificant. The upper turning point lies in the income range of 2.4 -4.5 K GNI. Figures 2.1 and 2.2 show the turning point for SO2. Social capital index was found to be negatively related to SO2 concentration. NO2 also show similar results described for SO2 although social capital index were found to be negatively significant in few models. Coefficients associated with population density were consistently found to have negative sign. The upper turning point for NO2 is in the range of 1.0 -4.5 K GNI.

For PM, coefficients associated with income were found to be significant although the turning points were mostly in the negative ranges. Coefficients associated with population density and social capital index were positive in most of the cases. When social capital coefficient was significant, it had a positive sign indicating that increase in social capital increases PM in the environment. It is likely that highly agricultural society exhibit this kind of behavior.

For the only one indicator of water pollution in this study (i.e. BOD), we found that population density has significant negative effect. Income was found to be significant in a few different situations although it did not have consistent sign throughout. Social capital was found to be insignificant and signs also varied based on the model and functional forms chosen.

Summary and Conclusions

Social capital variable did not have consistent sign across the pollutant indicating the fact that it is uncertain to point out the exact effect of social capital in reducing pollution. Even with in one pollutant, it changes sign based on the data and model utilized. This was true for CO2, particulate matter and BOD. In SO2, the sign associated with social capital in regression model was consistently negative but it was not significant. In NO_2, signs were consistently negative and significant in many cases.

Income variable represented by GNI was significant across different models in CO_2. Income was also found to be significant when regressed against particulate pollutant. In SO_2 and NO_2, variable representing income did not come out to be significant. Therefore, it looks like regional pollutants such as SO_2 and NO_2 were not significant but global pollutant, CO_2, was significantly related to income. BOD, a measure of water pollution, was found to be significantly related to income when income was entered in a quadratic formulation but not significant in a cubic formulation.

Turning points of different pollutant showed that CO_2 reached the turning point at the high level of income ranging from 51 to 336 K GNI. Considering the fact that the highest GNI value is only 29 K GNI, CO_2 concentration seems to continue to increase in future. In case of SO_2, the upper turning point is at the range of 2.4- 4.5 K GNI which means most of the countries have already crossed the higher point of SO_2 and are in the declining portion of the EKC. Similarly for water pollutant BOD, the turning point was 0.7 K GNI which mean that all the countries have increased their water quality with income. Turning point for particulate matter did not come out to be in the valid range.

The results of this study were inconclusive on whether social capital is a significant negative factor in impacting pollution. This indicates a need to increase the number of observations used in analysis and replications of the analysis with more inclusive number of countries.

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Table 1. Summary of Statistics of Sample Data

Variable	Unit of measurement	Source	Year
Water pollution			
BOD	Kilogram/day/workerr	World Bank	1980, 1990, 1993, 2001
Air pollution			
CO2_Capita	metric tons per capita	World Bank	1981, 1990, 1995, 2000
CO2_PPP	kg per 2000 PPP $ of GDP	World Bank	1981, 1990, 1995, 2000
PARTICULATE	microgram per cu.m.		1981,1990, 1995, 1999
SO2	microgram per cu.m	World Bank	1982, 1990, 1995, 1999
NO2	microgram per cu.m	World Bank	1985, 1990, 1995, 1999
Social Capital			
Trust	proportion	WVS	1981, 1990, 1995, 2000
TRADEUNI	proportion	WVS	1981, 1990, 1995, 2000
POLITICAL	proportion	WVS	1981, 1990, 1995, 2000
ENVIRON	proportion	WVS	1981, 1990, 1995, 2000
YOUTHWORK	proportion	WVS	1981, 1990, 1995, 2000
PROFESSIONAL	proportion	WVS	1981, 1990, 1995, 2000
Other Variable			
GNI	GNI per capita, PPP (current international $)	World Bank	1981, 1990, 1995, 2000
DENSITY	Persons/sq. kilometer (land area)	Calculated using World Bank data	1981, 1990, 1995, 2000

Table 2. Descriptive Statistics

Variable	N	Mean	Std Dev	Minimum	Maximum
year	170	1994.12	6.230487	1981	2000
CO2GDP	159	0.575405	0.379375	0.051835	2.338018
CO2capita	160	6.387975	4.440457	0.065558	19.84774
BOD	150	0.1726	0.038642	0.07	0.31
particulate	95	66.0607	61.83439	6.673333	343.3333
so2	102	34.82906	35.12695	1	209
no2	98	53.0591	31.21346	5	248
Population	170	77416579	1.99E+08	228000	1.26E+09
GNI	167	7.812419	5.58257	0.296	29.582
density	139	187.4655	528.7528	1.9	5997
factor1	170	0.276427	0.154897	0.042306	1.034445
gni2	167	92.01236	112.9762	0.087616	875.0947
gni3	167	1309.22	2491.09	0.025934	25887.05

Table 3: CO_2 - Fixed and Random Effects

Variables	All Data				No 1981 data				No 1981 and 1990 data			
	Fixed		Random		Fixed		Random		Fixed		Random	
	Q	C	Q	C	Q	C	Q	C	Q	C	Q	C
Intercept	0.4376	-0.6822	0.6955	-1.5181	0.7293	-0.4636	0.1604	-1.6059	0.5857	-0.4466	0.6991	-0.9788
GNI	0.7314*	1.2406*	0.754*	1.6602*	0.6352*	1.1488*	0.7666*	1.5575*	0.6523*	1.0927*	0.734*	1.5292*
GNI Square	-0.00514	-0.05531*	-0.00765	-0.0949*	-0.00141	-0.05128*	-0.00749	-0.08437*	-0.00097	-0.0434	-0.00562	-0.08252*
GNI cube		0.001263*		0.002122*		0.001235*		0.001889*		0.001027		0.001859*
Density	0.000512	0.000585	0.00079*	0.00083*	0.000618	0.000691	0.000754*	0.000802*	0.000625	0.000686	0.000723*	0.000771*
Social Capital Index	1.183	1.6087	0.6746	1.5611*	0.6487	1.4248	0.9557	1.829*	0.3547	1.1792	-1.1048	-0.2625
-2 Log L	681.8	690.7	558.6	561.5	578.1	587.3	482.4	486.1	425.8	436.3	373.6	378.7
Turning Point ($)	71.14786	CN	49.28105	CN	225.2482	CN	51.1749	CN	336.23	CN	63.2	CN

Note: Q and C stand for quadratic and cubic specifications respectively. CN indicates a complex root.
* indicates values are significant at 5% level.

Table 4: SO_2 – Fixed and Random Effects

Variables	All Data				No 1981 data				No 1981 and 1990 data			
	Fixed		Random		Fixed		Random		Fixed		Random	
	Quad	Cubic	Q	C	Q	C	Q	C	Q	C	Q	C
Intercept	76.2834*	62.7413*	80.489*	55.0525	79.7375	59.0414*	86.4896	71.1103	69.3645*	50.686*	60.161	23.6409
GNI	-2.5711	3.9306	-3.4947	7.9919	-5.2878	4.5192	-14.0126	-6.7733	-6.3668	2.3485	-3.5047	12.6596
GNI Square	0.06361	-0.6993	0.1289	-1.1773	0.1087	-1.073	0.1746	-0.6382	0.05637	-1.1683	-0.111	-2.3077
GNI cube		0.02594		0.04248		0.0402		0.02657		0.04367		0.0758
Density	-0.00153	-0.00159	-0.00174	-0.0017	-0.00038	-0.00031	0.004393	0.004317*	0.001182	0.00174	0.001379	0.002511
Social Capital Index	-0.00497	-0.00471	-0.00726	-0.00691	-0.00628	-0.00607	-0.00647	-0.00633	-0.00458	-0.00459	-0.00688	-0.00626
-2 Log L	908.4	912.7	883.1	886.6	788.4	792	761.3	765.6	549.6	553	525.6	527.6
Turning Point ($)	20.21		13.56		24.32		40.13		56.47		-15.79	

Table 5: NO2 Pollutant – Fixed and Random Effects

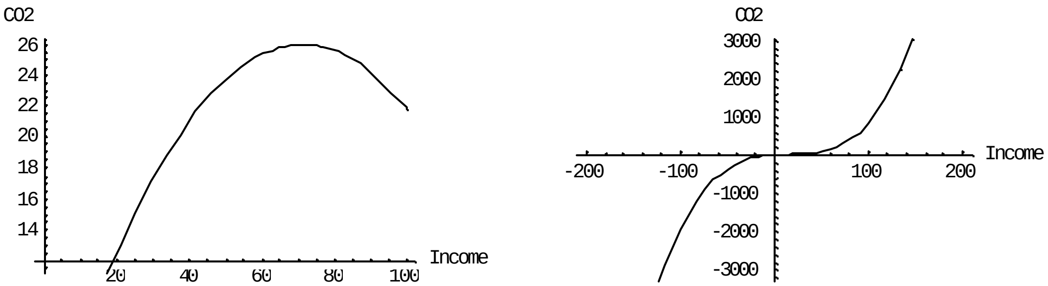
Variables	All Data				No 1981 data				No 1981 and 1990 data			
	Fixed		Random		Fixed		Random		Fixed		Random	
	Quad	Cubic	Q	C	Q	C	Q	C	Q	C	Q	C
Intercept	84.3722*	71.47*	67.2719*	68.7624*	89.2754*	74.353*	78.273*	70.67	91.2431*	69.7346*	71.9335	78.1647
GNI	-3.094	2.363	-1.3631	-1.9777	-3.0012	3.3107	-2.8196	0.4946	-2.7623	6.6559	-1.1947	-3.8044
GNI Square	0.1146	-0.4915	0.02015	0.08368	0.1161	-0.5855	0.1013	-0.254	0.1076	-0.9691	0.03173	0.296
GNI cube		0.01935		-0.0019		0.02237		0.01099		0.0348		-0.00767
Density	-0.00488	-0.00439	-0.00487	-0.0049	-0.00586	-0.00527	-0.0051	-0.0049	-0.00653	-0.00547	-0.0052	-0.00529
Social Capital Index	-45.8745*	-44.288*	0.6827	0.8293	-70.8038*	-68.52*	-25.4057	-26.3806	-71.9877	-67.2129	-6.9785	-6.6899
-2 Log L	865.6	870.4	824.7	830	754.6	759.2	725.6	730.5	529	532.8	483	488.8
Turning Point ($)	13.50		33.82		12.93		13.92		12.84		18.83	

Table 6: Particulate Pollutant – Fixed and Random Effects

Variables	All Data				No 1981 data				No 1981 and 1990 data			
	Fixed		Random		Fixed		Random		Fixed		Random	
	Quad	Cubic	Q	C	Q	C	Q	C	Q	C	Q	C
Intercept	168.47*	231.23*	186.68*	237.88*	166.59*	227.55*	180.48*	232.38*	169.43*	217.53*	183.64	228.1
GNI	-20.797*	-50.5866*	-21.9064*	-47.3737*	-21.4732*	-50.4041*	-21.7364*	-47.2971*	-23.9614*	-47.1939*	-23.3321*	-44.9714*
GNI Square	0.7228*	4.1696*	0.8244*	3.7823*	0.7466*	4.1019*	0.8062*	3.7818*	0.8257*	3.6035*	0.8534*	3.4388*
GNI cube		-0.1126*		-0.09707*		-0.1098*		-0.09779*		-0.09245		-0.08606
Density	0.006083	0.003499	0.007452	0.005267	0.006608	0.004006	0.007855	0.005531	0.007822	0.005078	0.008223	0.00566
Social Capital Index	45.3778	39.5462	-8.1201	-3.5085	65.897	59.6051	6.5703	8.4111	108.75*	97.5652	28.0592	19.3508
-2 Log L	894.8	892.9	880	879.5	809.9	808.5	799.2	798.7	592	593.2	585.1	586.4
Turning Point ($)	14.39		13.29		14.38		13.48		14.51		13.67	

Table 7: BOD Water Pollutant - Fixed and Random Effects

Variables	All Data				No 1981 data				No 1981 and 1990 data			
	Fixed		Random		Fixed		Random		Fixed		Random	
	Quad	Cubic	Q	C	Q	C	Q	C	Q	C	Q	C
Intercept	0.1908*	0.1862*	0.198*	0.1925*	0.1955*	0.1908*	0.1979*	0.1902*	0.1939*	0.1785*	0.1992*	0.1883*
GNI	-0.00505*	-0.00305	-0.00401*	-0.00143	-0.00495*	-0.00307	-0.00369*	-0.00021	-0.00561*	0.000558	-0.00519*	-0.00042
GNI Square	0.000184*	-0.00001	0.000145*	-0.00011	0.000182*	1.97E-06	0.00013	-0.0002	0.000189*	-0.0004	0.00018*	-0.00027
GNI cube		4.84E-06		6.49E-06		4.41E-06		8.16E-06		0.000014		0.000011
Density	-0.00002*	-0.00002*	-0.00002*	-0.00002*	-0.00002*	-0.00002*	-0.00002*	-0.00002*	-0.00002*	-0.00002*	-0.00002*	-0.00001*
Social Capital Index	0.02901	0.03067	-0.00797	-0.0093	0.004628	0.008542	-0.01263	-0.00941	0.03504	0.05303	0.002449	0.01068
-2 Log L	-440.1	-418.9	-534.4	-513.4	-363.6	-342.5	-422.3	-401.6	-255.4	-236.2	-280.2	-260.1
Turning Point ($)	13.72		13.83		13.60		14.19		14.84		14.42	



A B

Figure 1.1. CO2 and Income Relationship in Fixed Effects Models (A. Quadratic model, B Cubic Model)

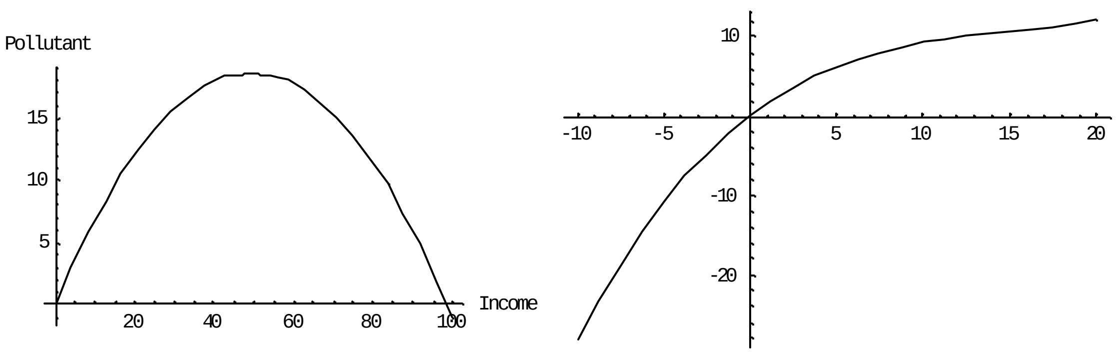


Figure 1.2. CO2 and Income Relationship in Random Effects Models (A. Quadratic model, B Cubic Model)

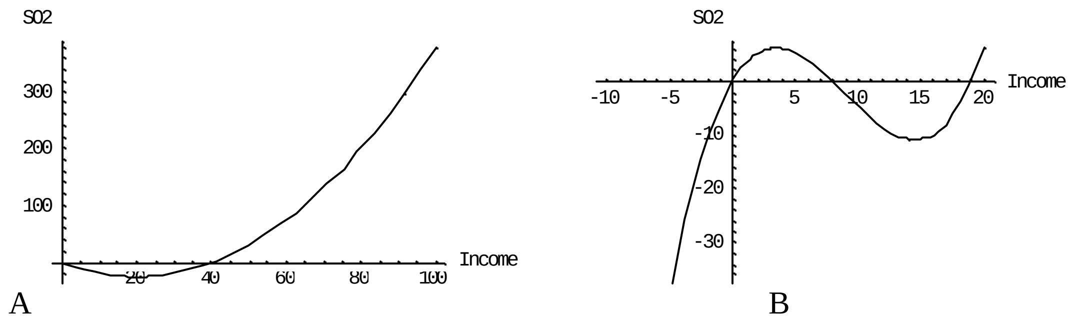


Figure 2.1. SO2 and Income Relationship in Fixed Effects Models (A. Quadratic model, B Cubic Model)

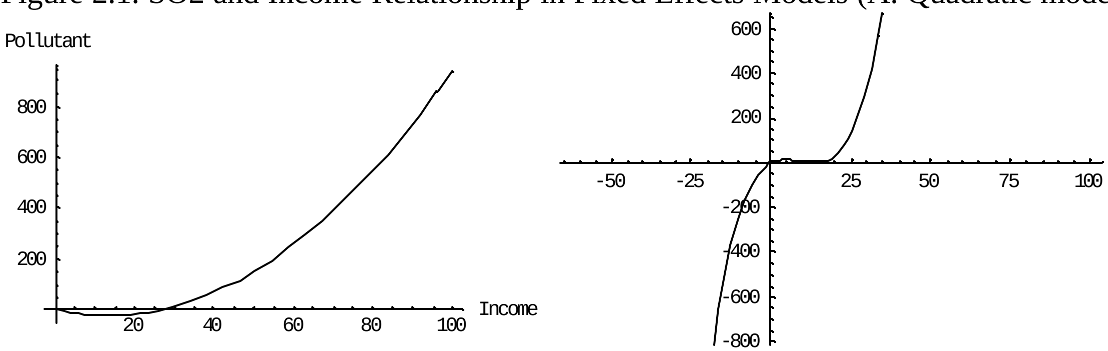
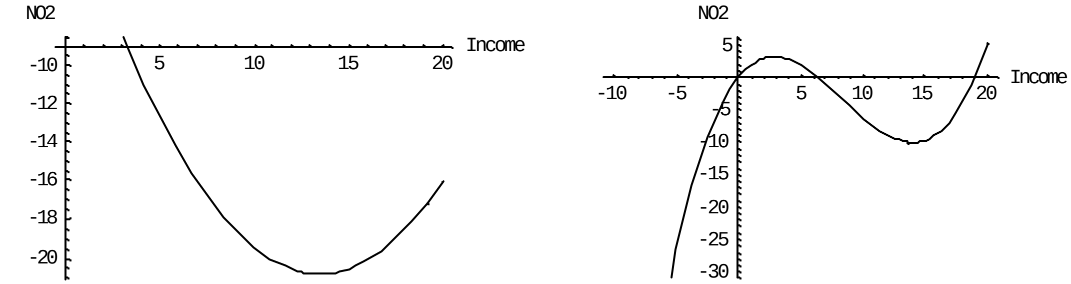


Figure 2.2. SO2 and Income Relationship in Random Effects Models (A. Quadratic model, B Cubic Model)



A B

Figure 3.1. NO2 and Income Relationship in Fixed Effects Models (A. Quadratic model, B Cubic Model)

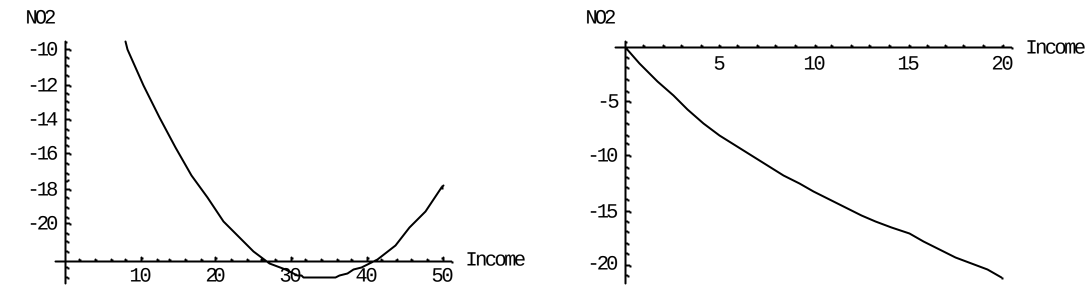
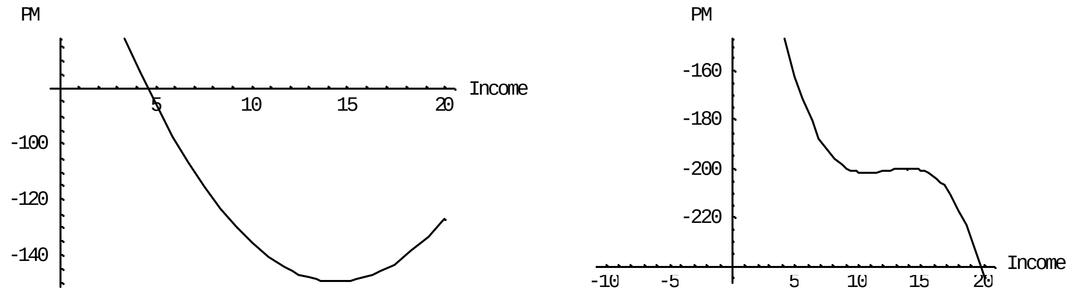
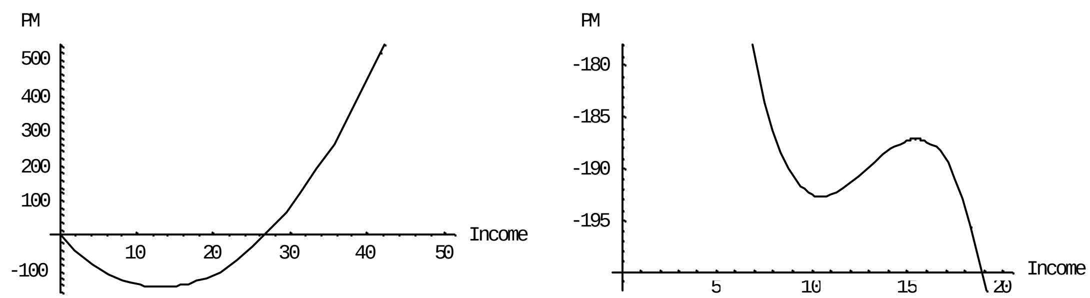


Figure 3.2. NO2 and Income Relationship in Fixed Effects Models (A. Quadratic model, B Cubic Model)



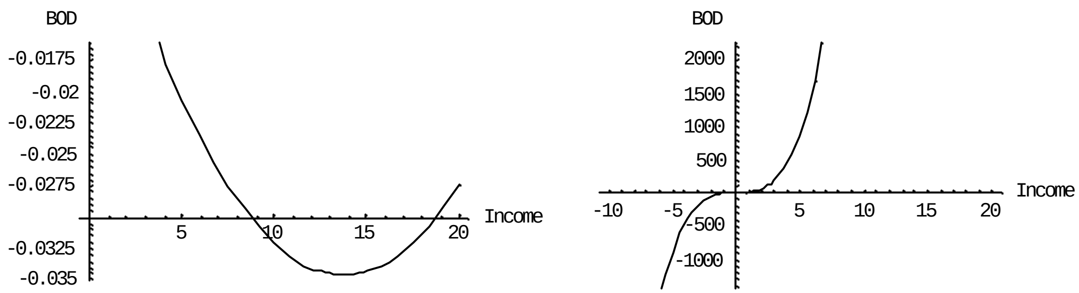
A B

Figure 4.1. NO2 and Income Relationship in Fixed Effects Models (A. Quadratic model, B. Cubic Model)



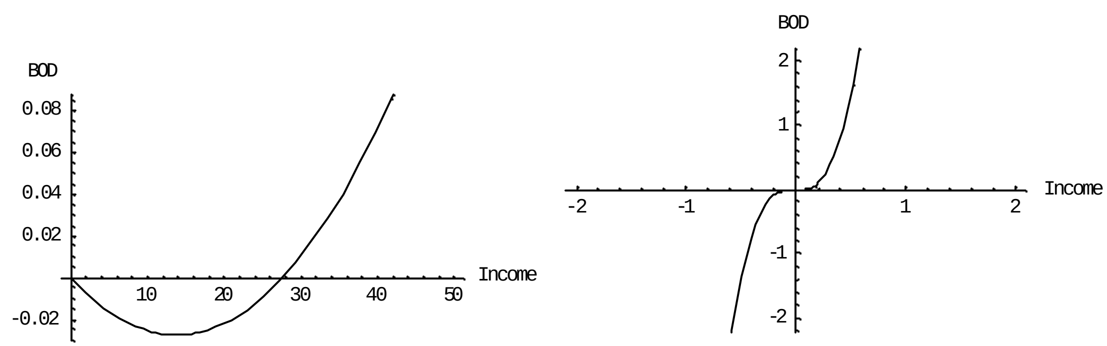
A B

Figure 4.2. NO2 and Income Relationship in Random Effects Models (A. Quadratic model, B. Cubic Model)



A B

Figure 5.1. BOD and Income Relationship in Fixed Effects Models (A. Quadratic model, B. Cubic Model)



A B

Figure 5.2. BOD and Income Relationship in Random Effects Models (A. Quadratic model, B. Cubic Model)