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Freedom, growth, and the environment

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ABSTRACT. A number of recent papers have found that certain measures of pollution worsen and later improve as income per head increases. It is widely believed that the downhill portion of this inverted-U curve reflects an induced policy response; that, as incomes rise, citizens demand improvements in environmental quality, and that these demands are delivered by the political system. In this paper we find that, for a number of pollution variables, an increase in civil and political freedoms significantly improves environmental quality. For other pollution variables, however, we find that freedoms have no effect. The former finding suggests that political reforms may be as important as economic reforms in improving environmental quality worldwide. The latter finding hints that the observation that pollution levels fall with income, once income becomes high enough, may *not* always reflect an induced policy response.

Introduction

Is economic growth good or bad for the environment? Recent empirical evidence points to a pattern reminiscent of the Kuznets curve: for a number of indicators of environmental quality (but not all), economic growth seems to be accompanied by a deterioration in environmental quality at low income levels and an improvement in environmental quality at high income levels.[1] This is a striking result; but, as we demonstrate in this paper, it is also a partial result.

We are grateful to Gene Grossman and Alan Krueger for supplying us with their computer programs and data. We also thank Freedom House for making their data available to us. Our research was partly funded by a MacArthur Foundation grant to the Global Environment and Trade Study. We have learned much about the topic of this paper from Partha Dasgupta, Paul Ehrlich, and Karl-Göran Mäler. Jagdish Bhagwati, Robert Deacon, Charles Perrings, and Todd Sandler provided helpful comments on an earlier draft, as did participants at the June 1998 World Congress of Environmental and Resource Economists, the NBER's 1998 Summer Institute, and the GETS / MacArthur Foundation Workshop on Trade and Environment.

[1] See the special issue of this journal, Volume 2, Part 4, October 1997. See also Cropper and Griffiths (1994), Grossman and Krueger (1993, 1995), Hilton and Levinson (1998), Holtz-Eakin and Selden (1995), Selden and Song (1994), Schmalensee, Stoker, and Judson (1998), Shafik (1994), and World Bank (1992).

Though the estimated models are in a reduced form, and so cannot tell us why the inverted-U might exist, there is a kind of consensus on the principal mechanism at work. This is that there is an induced policy response: as nations become richer, their citizens demand that the non-material aspects of their standard of living be improved. But if this reasoning is correct, then the observed levels of environmental quality will depend on more than a nation's prosperity. They will depend also on citizens being able to acquire information about the quality of their environment, to assemble and organize, and to give voice to their preferences for environmental quality; and on governments having an incentive to satisfy these preferences by changing policy, perhaps the most powerful incentive being the desire to get elected or re-elected. In short, they will depend on civil and political freedoms. These vary widely, however, both across countries and over time. So the omission of these variables could be important. In this paper we re-estimate the relations estimated by Grossman and Krueger (1995; hereafter, G–K), including as explanatory variables certain measures of civil and political freedoms. In essence, we ask a different question from the one that introduced this paper. We ask: Is more freedom good or bad for the environment?

For a number of measures of environmental quality, we find that our freedom variables are jointly highly significant.[2] Inclusion of the freedom variables does not affect the qualitative nature of the relationship between pollution and per capita income or the associated turning points; we find no evidence that the results reported by G–K are biased. But our results do show that, for a number of different measures, environmental quality is increasing in the extent of civil and political freedoms. In this sense, our results suggest that more freedom is good for the environment. Moreover, the effect is quantitatively and not just statistically significant. In the case of sulfur dioxide the effect is especially strong: we find that a low freedom country, with an income level near the peak of the inverted-U, can reduce its pollution at least as much by increasing its freedoms as it can by increasing its income per head. This is policy relevant if, as we argue, freedoms can be controlled independently of incomes.

Levels of some measures of environmental quality, however, seem not to depend on freedoms, even when the underlying relationship exhibits a strong inverted-U, and this hints that the downhill portion of the inverted-U

[2] After writing this paper, we learned that Torras and Boyce (1998) also used the Freedom House data to estimate similar relationships. They use a different transformation of these data and a somewhat different model to determine the effect of the 'distribution of power' on pollution levels but obtain broadly similar results. Congleton (1992), Murdoch and Sandler (1997), Murdoch, Sandler, and Sargent (1997), and Fredriksson and Gaston (1998) also test for links between democracy and environmental policy. However, these papers are concerned with transboundary environmental damage—a very different situation than examined in this paper. Bohn and Deacon (1997) examine the connections between investment in natural resource industries and measures of both political stability and the type of government (distinguishing, for example, between parliamentary and non-parliamentary democracies). This again is a different kind of analysis using different data.

may not always result from an induced policy response. True, even dictatorships have to please *some* constituency to remain in power (see Olson, 1993). So, even if our freedom variables were not significant, a kind of induced policy response could still underly the inverted-U. But it does strike us as peculiar that freedoms would show up as being very significant in some cases and not at all significant in others. We comment on possible reasons for these results, and their implications for future research, later in the paper.

Before proceeding with the substance of the paper, we wish to emphasize that our results are not immune to the criticisms that have been levelled against the environmental Kuznets curve literature.[3] Like previous studies, we consider a selected number of pollutants only; our results imply nothing about optimality; and the models from which they are derived ignore system-wide linkages. What we add in this paper is a perspective that has not been expressed previously. We believe that our results are important, but they are important only in this context.

Section 1 discusses the data used in our study, while sections 2 and 3 present our econometric results for air and water pollution, respectively. Section 4 extends these results, by controlling for country fixed effects. The final section of the paper discusses the implications of our work, both for the literature on growth and environment and the literature on trade and environment.

1. Data

With the exception of our freedom variables, we rely entirely on the data used by G–K. The pollution data were gathered by the Global Environmental Monitoring System and have two great virtues: they are comparable across different countries; and they are direct measures of environmental quality (as opposed to, say, pollution emission levels), and so are measures that citizens will have preferences over—preferences that can find expression at the ballot box or otherwise.[4] Air quality is measured in selected urban areas; water quality in selected river basins. The income data are from Summers and Heston (1991), and adjust for differences in purchasing power. Note that these data are country averages, whereas the pollution readings are local.[5] Time and physical features of the pollution sites (like mean annual water temperature) are also included in our regressions as independent variables. For a more detailed description of these data, see Grossman and Krueger (1995).

Our measures of civil and political freedoms are constructed from indices developed by Freedom House, which have been used widely in the

[3] See in particular the policy forum in this journal, volume 1, part 1, February 1996.

[4] Shafik (1994) and the World Bank (1992) also examine a number of direct indicators of environmental quality.

[5] Grossman and Krueger (1995, p. 361) note that the use of country-level GDP is appropriate since 'environmental standards are often set at a national level'. This statement is correct, but there are also variations. For example, in the United States, some regions have not attained the standards that were set for them. Furthermore, environmental standards are not always uniform, even if they are set at the national level. In the United States, for example, regions with superior air quality have been protected from any significant deterioration in air quality.

literature.[6] The civil freedoms index reflects constraints on the freedom of the press, and on the rights of individuals to debate, to assemble, to demonstrate, and to form organizations, including political parties and pressure groups. The political freedoms index reflects whether a government came to power by election or by the gun, whether elections, if any, are free and fair, and whether an opposition exists and has the opportunity to take power at the consent of the electorate.

The Freedom House indices of freedoms are on a scale from 1 to 7, where 7 is the lowest level of freedom. Following Barro (1996), we convert these indices to a scale of from 0 to 1, where 0 now corresponds to the lowest level of freedom. Since the ranking of freedoms by Freedom House is ordinal, it might seem natural to represent each of the seven index numbers by dummies. However, there are two reasons for not doing so: there are too few observations in some freedom categories, and the inclusion of many dummies would result in a loss in degrees of freedom. This second reason is especially important if one believes, as we do, that current pollution levels should depend not just on current freedoms but on the recent history of freedoms. We therefore employ two different representations of the freedom data. The first enters the converted indices directly, and therefore on a linear scale. The second uses grouped dummies. In creating these dummies, we again follow Barro by defining a low freedom country as having an index number between 0 and 0.33, and medium and high freedom countries as having index numbers of from 0.33 to 0.67 and from 0.67 to 1, respectively. The low political (civil) freedom dummy takes on a value of 1 if the country is a low political (civil) freedom country and zero otherwise. The other dummies are calculated in a similar fashion. All freedom variables enter our regressions as a moving average of the current year and the previous three years to reflect the expected lag between changes in freedoms and changes in environmental quality.

For the primary regressions, we use the same basic regression model as G–K.[7] Of course, one might explore alternative specifications, such as including income–freedom interactive terms. However, G–K include many income variables and we use different freedom variables. It is not obvious which variables should be interacted or whether different variables should be constructed for this purpose. Nor is it obvious that richer specifications would be appropriate, given the data limitations. Perhaps more importantly, our ambition for this paper is modest. We only want to determine whether politics can be shown to intermediate between income and pollution, as is so often supposed without any supporting evidence. If the link really does exist, it should show up in our model; and if our model can show this while making only the smallest deviation from G–K's, which is now a standard in this literature, so much the better. There is, however,

[6] See Barro (1996), Dasgupta (1993), Helliwell (1994), Murdoch, Sandler, and Sargent (1997), and Perotti (1996).

[7] As in G–K, we estimate the model using generalized least squares and employ a random effects estimator that takes into account the unbalanced nature of the panel (see G–K for details). Note that the peak of the inverted-U can be sensitive to the functional form used in estimation (see Hilton and Levinson, 1998).

one specification change that does seem warranted, if only as a test for robustness, and this is to control for fixed effects. These results are reported separately, toward the end of the paper.

2. Results for air pollutants

Table 1 presents the summary statistics for three different air pollutants. A number of observations follow from these. First, incomes and freedoms are positively correlated. In particular, the high freedom countries are rich; the low and medium freedom countries are poorer. Second, pollution levels are negatively correlated with freedom with one small exception: sulfur dioxide concentrations are about the same for countries with low and medium political freedoms. Finally, the correlations between freedoms and income and freedoms and pollution are very similar for both political and civil freedoms. This is because civil and political freedoms are very highly correlated. The correlation coefficients between the linear transformations of the civil and political freedom indices are about 0.95 for the data corresponding to each of the three pollutants.

Table 2 presents the regressions for the three measures of air pollution

Table 1. *Summary statistics by freedom indices for urban air pollutants (means and standard deviations)*

	Political freedoms			*Civil freedoms*		
	Low	*Medium*	*High*	*Low*	*Medium*	*High*
Sulfur dioxide						
Median daily observed level	48.81 (41.34)	51.53 (42.93)	25.95 (25.72)	53.66 (41.91)	34.08 (36.18)	26.07 (25.63)
Income	2.60 (1.24)	3.82 (1.17)	9.69 (4.36)	2.65 (1.27)	2.85 (1.61)	10.23 (3.95)
No. of obs.	348	81	889	305	182	831
No. of countries	15	7	25	11	14	25
Smoke						
Median daily observed level	73.86 (53.39)	57.67 (26.79)	30.32 (36.00)	88.94 (55.68)	49.40 (33.11)	30.01 (34.99)
Income	3.43 (0.77)	3.86 (1.29)	8.12 (2.57)	3.70 (0.50)	3.43 (1.18)	8.32 (2.41)
No. of obs.	94	49	323	65	90	311
No. of countries	5	4	13	3	6	13
Heavy particles						
Median daily observed level	252.62 (134.32)	146.23 (85.34)	94.81 (90.45)	267.39 (133.79)	169.11 (108.20)	83.36 (73.50)
Income	2.28 (1.32)	3.62 (1.20)	11.51 (5.16)	2.41 (1.37)	2.42 (1.55)	12.26 (4.49)
No. of obs.	310	78	621	281	149	579
No. of countries	10	6	16	10	10	16

Table 2. *The determinants of urban air pollution (random effects estimation). Dependent variable is annual median concentration*

Variable	*Sulfur dioxide*			*Smoke*			*Heavy particles*		
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Income (1000s)	−3.53	−9.76	−7.87	37.52	33.96	33.35	23.18	29.17	9.83
	(9.31)	(9.37)	(9.52)	(21.55)	(21.40)	(21.27)	(22.33)	(22.75)	(22.33)
Income squared	0.79	1.39	1.27	−10.59	−10.07	−9.99	−1.87	−2.37	−0.21
	(1.14)	(1.14)	(1.16)	(3.77)	(3.73)	(3.73)	(2.84)	(2.89)	(2.84)
Income cubed	−0.03	−0.05	−0.04	0.60	0.58	0.57	0.05	0.06	−0.01
	(0.04)	(0.04)	(0.04)	(0.18)	(0.18)	(0.18)	(0.10)	(0.10)	(0.10)
Lagged income	19.91	25.03	25.40	−16.93	−14.37	−24.46	−66.32	−74.40	−45.54
	(9.89)	(10.02)	(10.20)	(24.55)	(24.64)	(24.45)	(24.01)	(24.60)	(24.27)
Lagged income squared	−3.36	−3.65	−3.66	9.53	9.49	11.87	5.26	6.21	3.45
	(1.28)	(1.29)	(1.31)	(4.52)	(4.52)	(4.56)	(3.25)	(3.30)	(3.25)
Lagged income cubed	0.13	0.13	0.13	−0.63	−0.64	−0.77	−0.15	−0.18	−0.10
	(0.05)	(0.05)	(0.05)	(0.23)	(0.23)	(0.23)	(0.12)	(0.12)	(0.12)
Low political freedom dummy		−2.02			10.82			38.45	
		(5.94)			(9.99)			(18.04)	
Low civil freedom dummy		26.99			24.89			19.29	
		(5.66)			(9.10)			(14.97)	
Medium political freedom dummy		8.24			1.82			67.82	
		(5.61)			(8.01)			(18.32)	
Medium civil freedom dummy		1.45			6.03			−19.24	
		(3.70)			(6.56)			(9.41)	
Political freedoms (linear scale)			−17.68			−19.71			−104.96
			(11.65)			(18.87)			(30.81)

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Civil freedoms (linear scale)			−15.24 (13.87			−47.27 (26.73)			−8.09 (36.79)
Coast	−12.44 (3.82)	−7.62 (3.63)	−10.15 (3.85)	−35.23 (8.27)	−36.34 (8.18)	−37.77 (8.33)	−21.31 (12.19)	−29.07 (11.31)	−23.72 (11.98)
Desert				0.85 (11.25)	−4.13 (11.08)	−4.89 (11.38)	162.82 (26.35)	135.89 (25.89)	114.65 (27.54)
Central city	3.05 (4.39)	4.72 (4.11)	3.50 (4.33)	4.78 (8.82)	2.75 (8.80)	−0.51 (8.85)	25.60 (14.67)	24.54 (13.22)	20.19 (14.40)
Industrial	−0.32 (5.38)	−1.13 (5.02)	−1.32 (5.29)	−13.61 (10.84)	−12.77 (10.56)	−14.53 (10.70)	22.52 (17.80)	12.74 (16.03)	13.02 (17.52)
Residential	−11.16 (4.94)	−10.85 (4.63)	−11.14 (4.86)	−16.47 (9.36)	−14.33 (9.14)	−14.77 (9.34)	6.87 (16.67)	−3.95 (15.24)	−1.79 (16.41)
Popluation density (pop/sq mile)	1.12 (1.32)	1.14 (1.32)	1.18 (1.33)	4.37 (1.34)	4.02 (1.33)	3.03 (1.39)	−1.57 (1.97)	−.179 (1.79)	−1.03 (1.95)
Year	−1.55 (0.22)	−1.66 (0.22)	−1.51 (0.23)	−0.86 (0.37)	−0.70 (0.39)	−0.27 (0.40)	0.68 (0.64)	−0.03 (0.67)	0.75 (0.67)
No. of observations	1318	1318	1318	466	466	466	1009	1009	1009
P-value (combined freedom variables)		<0.0001	0.0004		<0.0001	0.0006		<0.0001	<0.0001
P-value (combined income variables)	<0.0001	<0.0001	<0.0001	<0.0001	0.001	<0.0001	<0.0001	<0.0001	<0.0001
P-value (combined freedom and income variables)		<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Note: Regressions also include a constant, a dummy variable to indicate that the type of area is unknown, and a dummy to indicate that the measurement device is a gas bubbler.

(here and elsewhere standard errors are shown in parentheses). Regressions 1, 4, and 7 replicate the G–K regressions with the exception that freedoms data for Hong Kong are unavailable and so this territory is excluded. The omission of Hong Kong does not affect the qualitative nature of the relationship between pollution and income but it does affect the turning point in the case of smoke. This rises from $6,151 in the G–K study to $7,286 (the turning point for sulfur dioxide rises from $4,053 in the G–K study to just $4,202; both regressions reveal that heavy particles decrease monotonically with income).

Regressions 2, 5, and 8 add the freedom dummies. In all three regressions, the freedom dummies are jointly significant at the 1 per cent level, as is income. There are, however, some surprising results. These include the low coefficient on the low political dummy in the sulfur dioxide regression and the high and low coefficients on medium political and civil freedoms in the heavy particles regression. However, as noted earlier, political and civil freedoms are highly correlated. Countries with high civil freedoms also have high political freedoms, and countries with low civil freedoms have low political freedoms. Thus, while the different definitions of freedom may have different effects, the data indicate that they are not (and, possibly, that they cannot be) controlled separately. We therefore combine these freedom variables for the purposes of making predictions. The combined effect of political and civil freedoms—something we call democratic freedoms—is striking: pollution levels are monotonically decreasing in the extent of democratic freedoms.

The combined effect of freedoms is shown more clearly in figures 1a, 2a, and 3a. Following G–K, these graphs were constructed by assuming that current and lagged income take on the same values.[8] All other variables, excluding freedoms, take on their mean values. The low democratic freedoms curve was obtained by setting the low political and low civil freedom dummies equal to 1 and by setting all the other freedom dummies equal to 0. The medium and high democratic freedoms curves were calculated in a similar manner. The number of the shapes in these graphs indicate the number of observations for each income level in the panel data set.[9] The vertical ranges of these graphs represent four standard deviations in the dependent variables.

Figure 1a shows that the relationship between sulfur dioxide concentrations and freedoms is nearly linear. This is not true for the other pollutants. For smoke, as figure 2a shows, a move from low to medium democratic freedoms has the biggest effect. For heavy particles, however, figure 3a shows that the move from medium to high democratic freedoms has the more substantial effect.

For comparison, regressions 3, 6, and 9 measure civil and political freedoms on the linear scale. Of course, the results reported above suggest

[8] G–K construct the variable by multiplying GDP, GDP squared, and GDP cubed by the sum of the estimated coefficients for current and lagged GDP.

[9] Note that the rising portion of the relation for sulfur dioxide at the higher income levels only includes data for Canada, Switzerland, and the United States. It is for this reason that G–K discount this portion of the relation.

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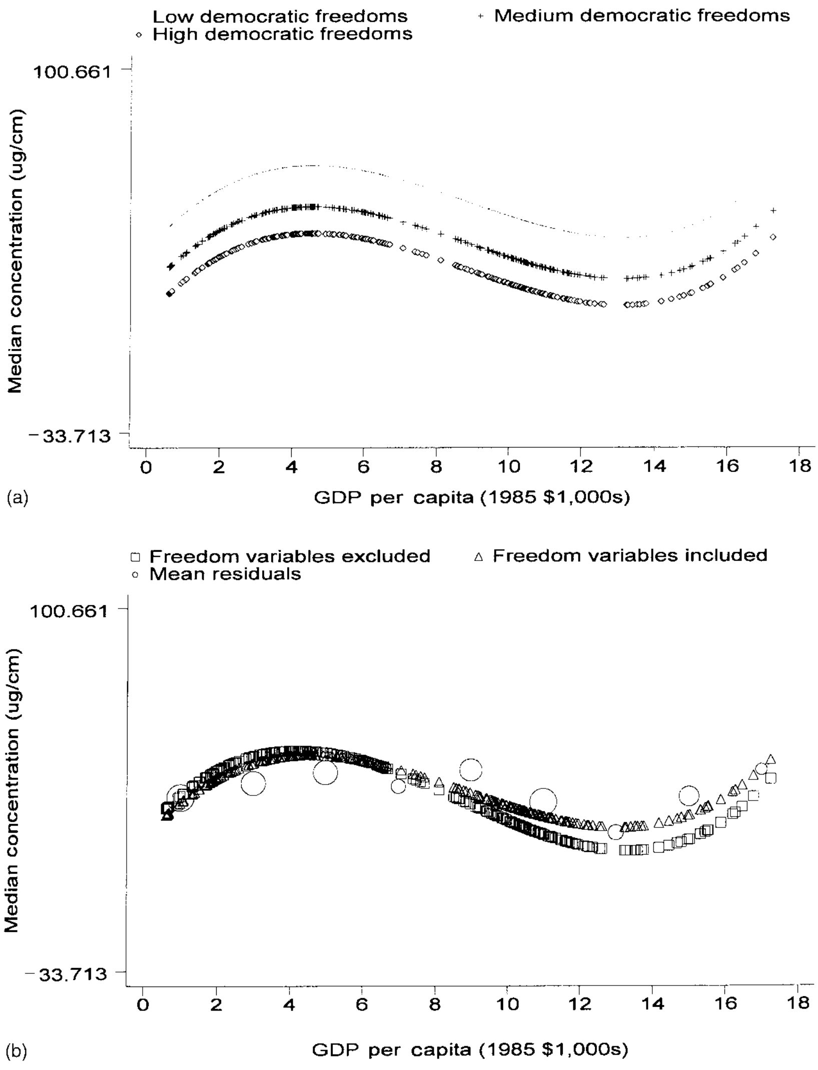

Figure 1. *GEMS/AIR: Sulfur dioxide in cities*

that, at least for smoke and heavy particles, the linear specification is a very rough approximation. However, it must be remembered that the dummy specification aggregates over different raw index numbers. So both representations of freedoms—the linear form and the dummies—impose restrictions, and neither is obviously the more superior. We note, however, that the coefficients on both the civil and political freedom variables are negative in all three regressions.

Figures 1b, 2b, and 3b depict the relationship between income and pollution with the freedom variables excluded (as in G–K) and included, where in the latter case the freedom dummies are set equal to their mean

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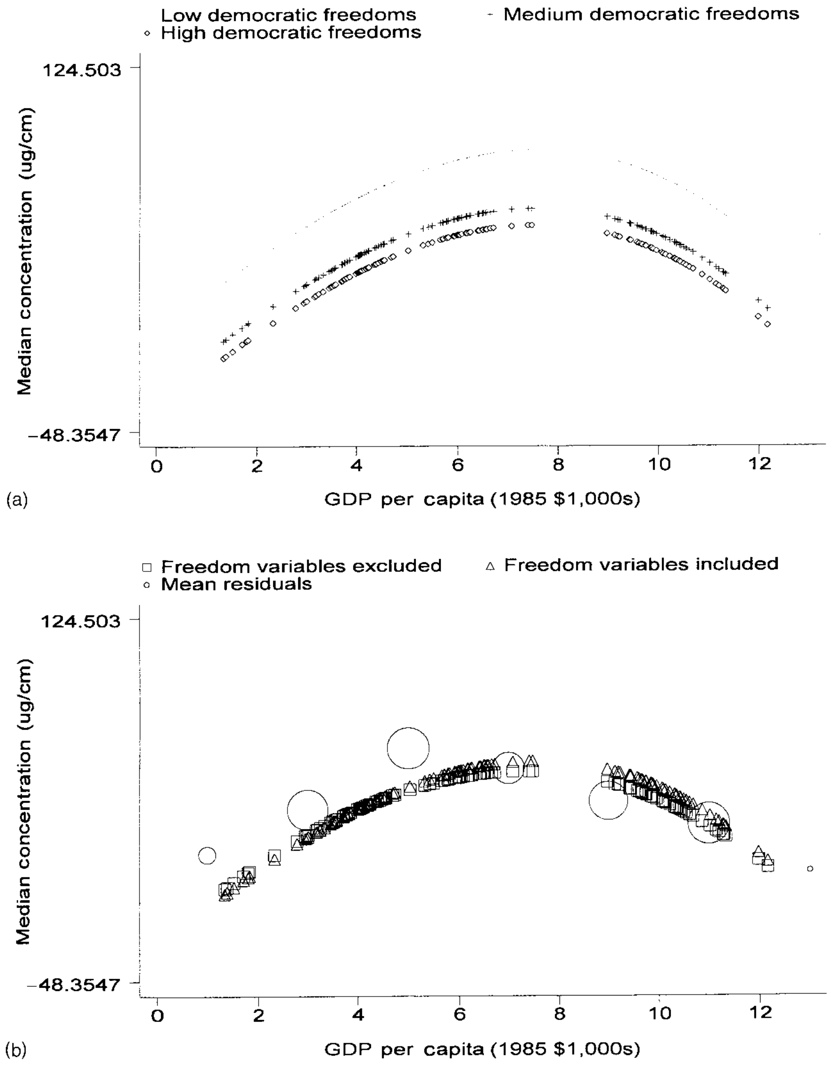

Figure 2. *GEMS/AIR: Smoke in cities*

values. In all three cases, the former regression predicts a higher concentration of pollution than the latter at low incomes (if only very slightly) and a lower concentration of pollution than the latter at high incomes. This is to be expected. Recall that freedoms and incomes are positively correlated (the correlation coefficients between the linear freedom variables and income range between 0.72 and 0.84 for the three data sets). Low income countries tend to have fewer freedoms than the average, and our regressions indicate that they should therefore have higher pollution levels. High income countries tend to have more freedoms than the average and so should have lower pollution levels.

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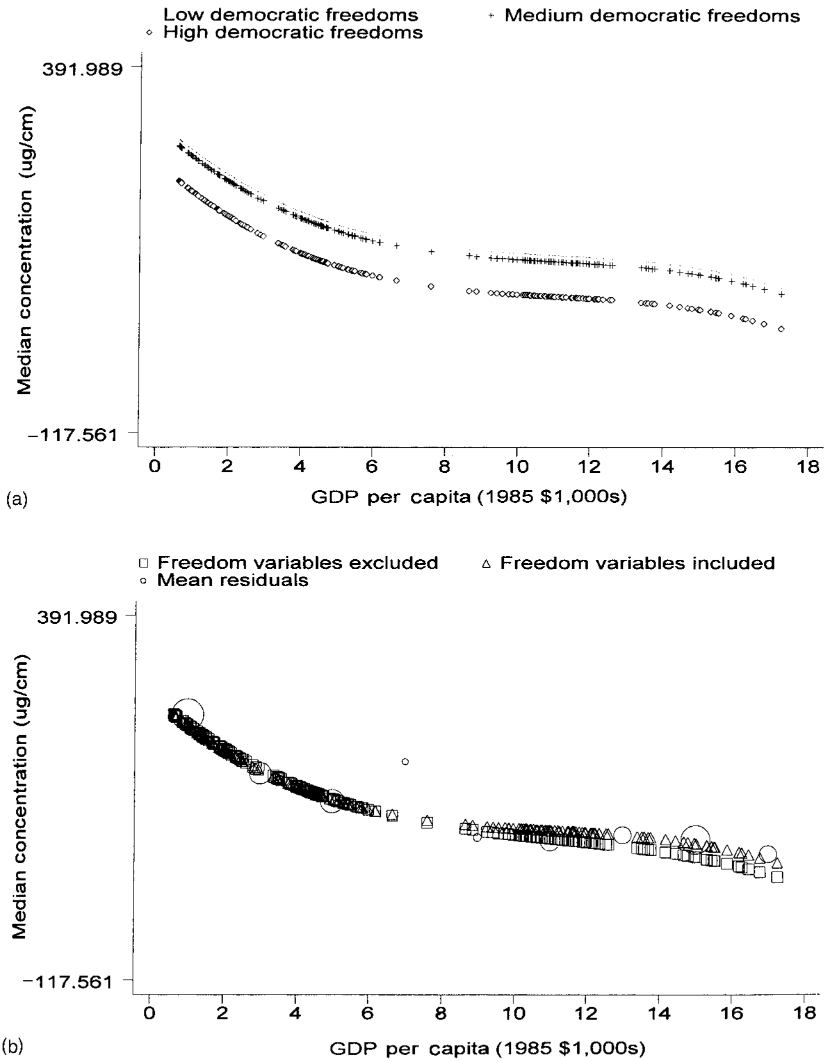

Figure 3. *GEMS/AIR: Heavy particles in cities*

Note, finally, that the circles in figures 1b, 2b and 3b show the mean residual for the fitted regressions including the freedom variables for each $2,000 income interval, with the size scaled to reflect the number of observations in each interval. A comparison with G–K reveals a very close correspondence. There is thus no indication that the G–K estimates are biased.

3. Results for water pollutants

Table 3 presents the summary statistics for 11 different measures of water pollution (but note that dissolved oxygen is a measure of water quality, not pollution). These confirm a general positive association between income and freedom. However, in contrast with the data for air pollutants, the

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Table 3. *Summary statistics by freedom indices for water pollutants (means and standard deviations)*

	Political freedoms			*Civil freedoms*		
	Low	*Medium*	*High*	*Low*	*Medium*	*High*
Dissolved oxygen						
Mean daily observed level	7.72 (2.82)	6.90 (5.13)	8.60 (2.46)	7.75 (2.93)	6.92 (4.22)	8.88 (2.43)
Income	2.51 (1.49)	4.07 (1.57)	8.60 (5.20)	2.51 (1.42)	2.97 (2.03)	9.92 (4.42)
No. of obs.	296	296	1007	273	466	860
No. of countries	22	20	31	21	21	26
Biological oxygen demand						
Mean daily observed level	3.32 (3.89)	7.99 (19.02)	7.34 (27.50)	3.58 (4.43)	7.19 (19.01)	7.55 (29.11)
Income	2.51 (1.49)	4.06 (1.56)	6.62 (4.69)	2.51 (1.41)	2.97 (2.02)	8.11 (4.10)
No. of obs.	269	293	722	251	459	574
No. of countries	21	18	27	20	18	23
Chemical oxygen demand						
Mean daily observed level	18.36 (16.17)	59.32 (102.72)	51.14 (136.60)	18.92 (16.08)	48.56 (84.48)	57.86 (158.14)
Income	1.97 (1.21)	4.54 (1.34)	6.00 (4.91)	1.95 (1.10)	2.99 (2.14)	8.00 (4.36)
No. of obs.	120	200	530	123	346	381
No. of countries	10	9	19	9	12	18
Nitrates						
Mean daily observed level	0.88 (1.25)	1.21 (1.47)	1.79 (4.63)	1.04 (1.35)	0.84 (1.31)	2.07 (5.12)
Income	2.67 (1.61)	3.70 (1.66)	7.97 (5.54)	2.65 (1.55)	2.31 (1.89)	9.79 (4.72)
No. of obs.	210	131	676	187	292	538
No. of countries	18	13	21	15	18	18
Fecal coliforms						
Mean daily observed level	218370 (788312)	67967 (210883)	80584 (609272)	237319 (819458)	107919 (450290)	59701 (585941)
Income	2.65 (1.49)	4.09 (1.60)	8.78 (5.36)	2.51 (1.41)	3.02 (2.04)	10.20 (4.53)
No. of obs.	224	227	810	206	368	687
No. of countries	17	14	27	15	18	23
Total coliforms						
Mean daily observed level	25050.70 (99607.51)	106294.40 (263936.40)	203578.10 (1059427.00)	60051.24 (206218.10)	187972.80 (901880.50)	182737.00 (1031001.00)
Income	2.70 (1.53)	4.24 (1.32)	4.54 (4.68)	2.66 (1.34)	2.05 (1.91)	6.73 (4.65)
No. of obs.	25	82	387	27	223	244
No. of countries	5	9	14	7	11	11

Table 3. *Continued*

	Political freedoms			*Civil freedoms*		
	Low	*Medium*	*High*	*Low*	*Medium*	*High*
Lead						
Mean daily observed level	0.071 (0.099)	0.031 (0.067)	0.013 (0.028)	0.073 (0.098)	0.026 (0.064)	0.013 (0.029)
Income	2.46 (1.51)	4.21 (0.80)	11.44 (2.92)	2.26 (1.17)	4.30 (0.87)	11.46 (2.88)
No. of obs.	43.68	499	44	68	498	
No. of countries	4	8	14	5	7	12
Cadmium						
Mean daily observed level	0.021 (0.063)	0.003 (0.007)	0.050 (0.179)	0.023 (0.066)	0.003 (0.007)	0.050 (0.179)
Income	2.47 (1.51)	4.10 (1.07)	11.33 (2.83)	2.18 (1.20)	4.12 (1.17)	11.31 (2.84)
No. of obs.	43	62	544	39	64	546
No. of countries	5	8	19	4	9	17
Arsenic						
Mean daily observed level	0.007 (0.008)	0.010 (0.011)	0.005 (0.006)	0.005 (0.006)	0.010 (0.011)	0.005 (0.006)
Income	2.14 (0.76)	4.44 (0.70)	11.63 (2.94)	1.96 (0.38)	4.45 (0.69)	11.61 (2.96)
No. of obs.	17	49	302	16	49	303
No. of countries	3	4	12	3	5	11
Mercury						
Mean daily observed level	0.345 (0.238)	0.176 (0.344)	0.297 (0.832)	0.335 (0.261)	0.153 (0.306)	0.301 (0.832)
Income	2.72 (1.77)	4.29 (0.82)	11.29 (2.81)	3.25 (1.55)	4.31 (0.95)	11.28 (2.80)
No. of obs.	17	62	558	14	64	559
No. of countries	5	8	21	5	8	19
Nickel						
Mean daily observed level		0.010 (0.010)	0.009 (0.011)	0.010 (0.011)		0.009 (0.011)
Income		4.22 (0.67)	12.05 (2.58)	4.26 (0.72)		12.01 (2.64)
No. of obs.		14	336	12		338
No. of countries		3	8	3		8

relationship between water pollution levels and freedom is not always negative. Levels of biological and chemical oxygen demand, nitrates, total coliforms, and cadmium generally increase with the extent of freedom.[10]

[10] For nickel, there is only one observation for low political freedoms (the Philippines in 1982) and no observations for low civil freedoms. Hence, we cannot include these dummy variables in our regression. Instead, we include the single observation for low political freedoms in the medium political freedoms dummy.

Table 4. *The determinants of water pollution (random effects estimation). Specification with dummy political and freedom variables*

Variable	*DO*	*BOD*	*COD*	*NIT*	*FEC*	*COL*	*LEAD*	*CAD*	*ARS*	*MERC*	*NICKEL*
Income (1000s)	1.33475 (0.70284)	1.81421 (4.58019)	−21.93143 (37.32588)	−0.84600 (1.35881)	−0.87940 (0.62440)	−2.41657 (2.17754)	−0.00746 (0.03539)	−0.01626 (0.12283)	0.00599 (0.00366)	0.11420 (0.57727)	−0.02791 (0.02101)
Income squared	−0.12514 (0.08136)	0.30271 (0.62089)	0.64788 (4.78137)	0.14556 (0.17316)	0.13732 (0.07169)	0.27832 (0.33371)	−0.00032 (0.00315)	0.01020 (0.01082)	−0.00047 (0.00032)	−0.02906 (0.05160)	0.00242 (0.00170)
Income cubed	0.00376 (0.00277)	−0.02101 (0.02469)	0.01167 (0.18542)	−0.00529 (0.00602)	−0.00497 (0.00240)	−0.00818 (0.01435)	0.00004 (0.00009)	−0.00046 (0.00032)	0.00001 (0.00001)	0.00129 (0.00154)	−0.00007 (0.00005)
Lagged income	−1.37902 (0.7449)	−0.63921 (4.84620)	35.44237 (41.23138)	0.49990 (1.41613)	0.82265 (0.66378)	3.73928 (2.44551)	0.01076 (0.03613)	−0.00828 (0.13492)	−0.00107 (0.00302)	0.12265 (0.56977)	0.02705 (0.02228)
Lagged income squared	0.13380 (0.09232)	−0.35877 (0.69723)	−1.71738 (5.61768)	−0.01599 (0.18175)	−0.08117 (0.08157)	−0.59082 (0.40726)	−0.00079 (0.00344)	−0.00598 (0.01258)	−0.00007 (0.00029)	−0.00807 (00.05440)	−0.00258 (0.00196)
Lagged income cubed	−0.00348 (0.00338)	0.02005 (0.02936)	−0.00117 (0.22985)	−0.00210 (0.00704)	−0.00112 (0.00296)	0.02659 (0.01011)	0.00001 (0.00011)	0.00027 (0.00039)	0.00000 (0.00001)	0.00019 (0.00173)	0.00008 (0.00006)
Low political freedom dummy	−0.07768 (0.41642)	−0.03412 (2.27928)	0.81459 (18.12813)	−0.43365 (0.68836)	0.68480 (0.41618)	−0.93394 (0.91966)	−0.01829 (0.02384)	−0.01001 (0.07552)	0.00672 (0.00291)	−0.05999 (0.38424)	−0.00657 (0.00683)
Low civil freedom dummy	0.24015 (0.39912)	0.53444 (2.09985)	−9.26354 (15.30474)	−0.54396 (0.59890)	0.97323 (0;40379)	−1.65061 (0.67011)	0.02834 (0.02357)	0.00847 (0.04523)	−0.00227 (0.00416)	−0.1115 (0.39208)	−0.00145 (0.00647)
Medium political freedom dummy	−0.04876 (0.33225)	1.29264 (1.78904)	−6.70940 (14.82417)	−0.01457 (0.61382)	0.48174 (0.32173)	0.83057 (0.47620)	−0.00292 (0.01240)	0.03103 (0.08304)	0.00656 (0.00157)	−0.03621 (0.20405)	
Medium civil freedom dummy	0.09901 (0.25443)	0.10938 (1.32926)	−2.28055 (7.65207)	−0.54963 (0.39387)	0.08340 (0.24156)	−0.90901 (0.27945)	0.02585 (0.01517)	0.00423 (0.04829)	−0.00037 (0.00235)	−0.11713 (0.24830)	
No. of observations	1599	1284	850	1017	1261	494	610	649	368	637	350
P-value (combined freedom variables)	0.9795	0.8899	0.9488	0.3629	<0.0001	0.0004	0.2292	0.9915	0.0001	0.9702	0.1873
P-value (combined income variables)	0.0007	0.0771	0.2269	0.0023	<0.0001	0.1796	0.3891	0.0176	0.0012	0.6305	0.1066
P-value (combined freedom and income variables)	0.0048	0.2352	0.5410	0.0009	<0.0001	<0.0001	0.0077	0.1065	<0.0001	0.9189	0.2213

Note: The dependent variable in all regression equations except for fecal and total coliforms is annual mean concentration. For fecal and total coliforms the dependent variable is 1 + log annual mean concentration. All equations include mean temperature, year and an intercept as covariates.

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Freedom data were available for all the countries and years for which G–K had water pollution data, and so we were able to replicate exactly the G–K results for these measures of water pollution. For this reason, we only report here the regression results with the freedoms variables included. These are shown in tables 4 and 5.

The regressions show that freedoms do not significantly affect the oxygen regime of rivers, as measured by dissolved oxygen (DO), biological oxygen demand (BOD), or chemical oxygen demand (COD). The concentration of nitrates (NIT) is significantly affected by freedoms, but only when freedoms are entered in the linear form. Even then, the coefficients on political and civil freedoms cancel each other out. An increase in democratic freedoms thus has no discernible quantitative effect on nitrate levels. The income variables are jointly significant in the dissolved oxygen and nitrates regressions, however, and the estimated relationships closely resemble those estimated by G–K: dissolved oxygen follows the U-shaped relationship and nitrates the inverted-U. That freedoms do not affect these pollution levels suggests that the negative relationship between pollution and income at higher income levels may not reflect an induced policy response. This may seem surprising, but oxygen loss does not threaten human health directly and nor are nitrates especially dangerous.[11]

Fecal coliform is different. It is a direct health hazard. Fecal contaminated water carries infectious diseases like cholera and typhoid and is implicated in many cases of diarrheal disease, roundworm infection, and schistosomiasis. We should expect levels of this pollution to depend on freedoms, and this is confirmed by our regressions. An increase in freedom, however measured (civil or political, entered either in linear form or as dummies), reduces fecal contamination (denoted FEC in tables 4 and 5). Figure 4a illustrates our results, and one can confirm that, as in the case of the various air pollution measures, the underlying relationship is nearly identical to the G–K result. For the same income level, countries with higher freedoms have lower pollution readings, but increases in income do seem to be needed to bring these readings down to very low levels.

Our results for total coliform are also highly significant, but the signs on the freedom variables are the wrong way round (see also figure 5a). G–K also obtain unexpected results for total coliform—results which they describe as 'baffling'.[12] But unlike fecal coliform, total coliforms are not necessarily disease producing. So at one level our results should not cause much concern. However, it is also possible that our results reflect a sample bias: the regressions for total coliform rely on a much smaller number of observations. To see whether sample bias may be a problem, we re-esti-

[11] Nitrates may cause 'blue baby syndrome' in newborns, but the condition is very rare.

[12] Specifically, G–K find that total coliforms increase sharply with incomes at high income levels. Note, however, that Shafik (1994) obtains a very similar relationship for measures of fecal coliform. Shafik also finds that dissolved oxygen decreases monitonically with income. These differences can probably be traced to the use of different data, but they are nonetheless worrying. Neither Shafik nor G–K comment on these different results.

Table 5. *The determinants of water pollution (random effects estimation). Specification with linear political and freedom variables*

Variable	*DO*	*BOD*	*COD*	*NIT*	*FEC*	*COL*	*LEAD*	*CAD*	*ARS*	*MERC*	*NICKEL*
Income (1000s)	1.31259	1.39026	−26.73734	−1.22271	−0.91624	−3.56248	−0.01915	−0.02764	0.01277	−0.04976	−0.02501
	(0.70041)	(4.55544)	(36.79164)	(1.36506)	(0.62583)	(2.19439)	(0.03531)	(0.11685)	(0.00364)	(0.55981)	(0.02125)
Income squared	−0.12652	0.34340	0.85064	0.21910	0.13306	0.40355	0.00026	0.01115	−0.00100	−0.01592	0.00222
	(0.08114)	(0.61937)	(4.71049)	(0.17436)	(0.07215)	(0.33825)	(0.00313)	(0.01048)	(0.00031)	(0.05045)	(0.00173)
Income cubed	0.00385	−0.02233	0.01151	−0.00786	−0.00471	−0.01217	0.00003	−0.00048	0.00003	0.00095	−0.00006
	(0.00276)	(0.02466)	(0.18307)	(0.00607)	(0.00242)	(0.01459)	(0.00009)	(.00032)	(0.00001)	(0.00152)	(0.00005)
Lagged income	−1.36917	0.16698	39.28706	0.89654	0.79082	6.58642	0.02696	0.00737	−0.00419	0.17147	0.01673
	(0.73310)	(4.77277)	(39.70717)	(1.40516)	(0.65636)	(2.40355)	(0.03505)	(0.12701)	(0.00320)	(0.54239)	(0.02303)
Lagged income squared	0.13469	−0.46312	−1.84324	−0.08439	−0.06795	−1.06495	−0.00198	−0.00758	0.00022	−0.01377	−0.00180
	(0.09110)	(0.68916)	(5.39802)	(0.18998)	(0.08101)	(0.39921)	(0.00339)	(0.01202)	(0.00030)	(0.05284)	(0.00203)
Lagged income cubed	−0.00354	0.02400	−0.00557	0.00028	0.00059	0.04897	0.00004	0.00032	0.00000	0.00037	0.00006
	(0.00334)	(0.02911)	(0.22180)	(0.00696)	(0.00295)	(0.01860)	(0.00011)	(0.00038)	(0.00001)	(0.00170)	(0.00006)
Political freedoms	−0.61956	0.36574	−36.55645	6.44489	−1.14736	1.19741	−0.10388	0.13526	0.00126	0.37155	0.01672
	(0.92550	(5.11923)	(31.72748)	(1.48118)	(0.88336)	(1.79587)	(0.04607)	(0.12897)	(0.00456)	(0.73180)	(0.02178)
Civil freedoms	0.72506	−0.73887	65.41566	−6.88875	−0.66206	3.39459	0.08698	−0.15639	−0.02410	0.46803	0.02655
	(1.14017)	(6.16151)	(42.76095)	(1.94052)	(1.07770)	(1.91052)	(0.04558)	(0.12254)	(0.00594)	(0.73128)	(0.02206)
No. of observations	1599	1284	850	1017	1261	494	610	649	368	637	350
P-value (combined freedom variables)	0.7909	0.9918	0.3108	0.0001	0.0066	0.0015	0.0633	0.4409	0.0001	0.3912	0.0449
P-value (combined income variables)	0.0036	0.0790	0.1431	0.0003	<0.0001	0.0008	0.2831	0.0167	<0.0001	0.4797	0.0426
P-value (combined freedom and income variables)	0.0014	0.1654	0.2242	0.0000	<0.0001	<0.0001	0.0012	0.0276	<0.0001	0.6569	0.0935

Note: The dependent variable in all regression equations for fecal and total coliforms is annual mean concentration. For fecal and total coliforms the dependent variable is 1 + log annual mean concentration. All equations include mean temperature, year and an intercept as covariates.

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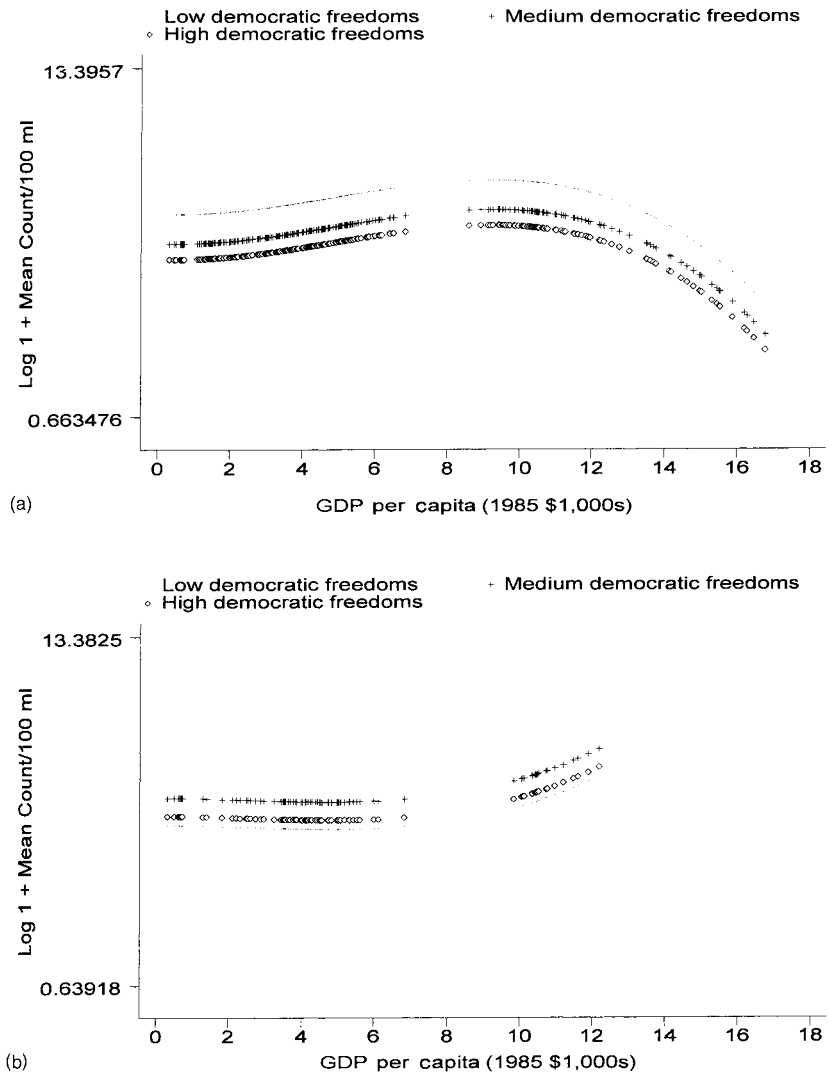

Figure 4. *GEMS/WATER: Fecal coliforms in rivers*

mated the relationships for both measures of coliform for a consistent set of data. The results are given in table 6 and illustrated in the figures 4b and 5b. The fecal and total coliform regressions are now fairly consistent with each other. Moreover, both the combined freedom variables and the combined income variables are no longer significant in the fecal coliform regressions. We conclude from this exercise that, as a result of the much larger data set, the fecal coliform relationships estimated in tables 4 and 5 are the more reliable.

We turn finally to the results for heavy metals. Freedoms are jointly sig-

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Table 6. *Selected sample regressions for fecal and total coliforms (random effects estimation). Dependent variable is 1 + log annual mean concentration*

Variable	*Fecal coliforms*		*Total coliforms*	
Income (1000s)	0.316 (2.519)	−0.972 (2.543)	−1.027 (2.250)	−2.064 (2.268)
Income squared	−0.054 (0.384)	0.100 (0.390)	0.105 (0.343)	0.223 (0.347)
Income cubed	0.004 (0.016)	−0.002 (0.017)	−0.002 (0.015)	−0.006 (0.015)
Lagged income	−0.316 (2.872)	2.009 (2.844)	1.495 (2.565)	3.690 (2.535)
Lagged income squared	0.035 (0.477)	−0.325 (0.470)	−0.256 (0.425)	−0.613 (0.419)
Lagged income cubed	−0.001 (0.022)	0.016 (0.022)	0.013 (0.020)	0.029 (0.019)
Low political freedom dummy	0.010 (1.209)		−0.416 (1.078)	
Low civil freedom dummy	−0.333 (1.053)		−0.795 (0.940)	
Medium political freedom dummy	1.267 (0.579)		0.829 (0.517)	
Medium civil freedom dummy	−0.610 (0.339)		−0.707 (0.303)	
Political freedoms (linear scale)		−0.367 (2.322)		−0.058 (2.067)
Civil freedoms (linear scale)		0.737 (2.359)		2.453 (2.100)
No. of observations	431	431	431	431
P-value (combined freedom variables)	0.181	0.945	0.106	0.048
P-value (combined income variables)	0.730	0.450	0.135	0.203
P-value (combined freedom and income variables)	0.181	0.479	0.003	0.005

Note: All equations include mean temperature, year and an intercept as covariates.

nificant only in the case of arsenic (denoted ARS in tables 4 and 5). When freedoms are entered in linear form, an increase in democratic freedoms reduces arsenic concentrations. When entered as dummies, arsenic levels increase slightly and then decrease with democratic freedoms. These results are broadly consistent with the hypothesis of an induced policy response, but we note that these regressions rely on a small sample and may not be reliable. Interestingly, we find that the relationship between

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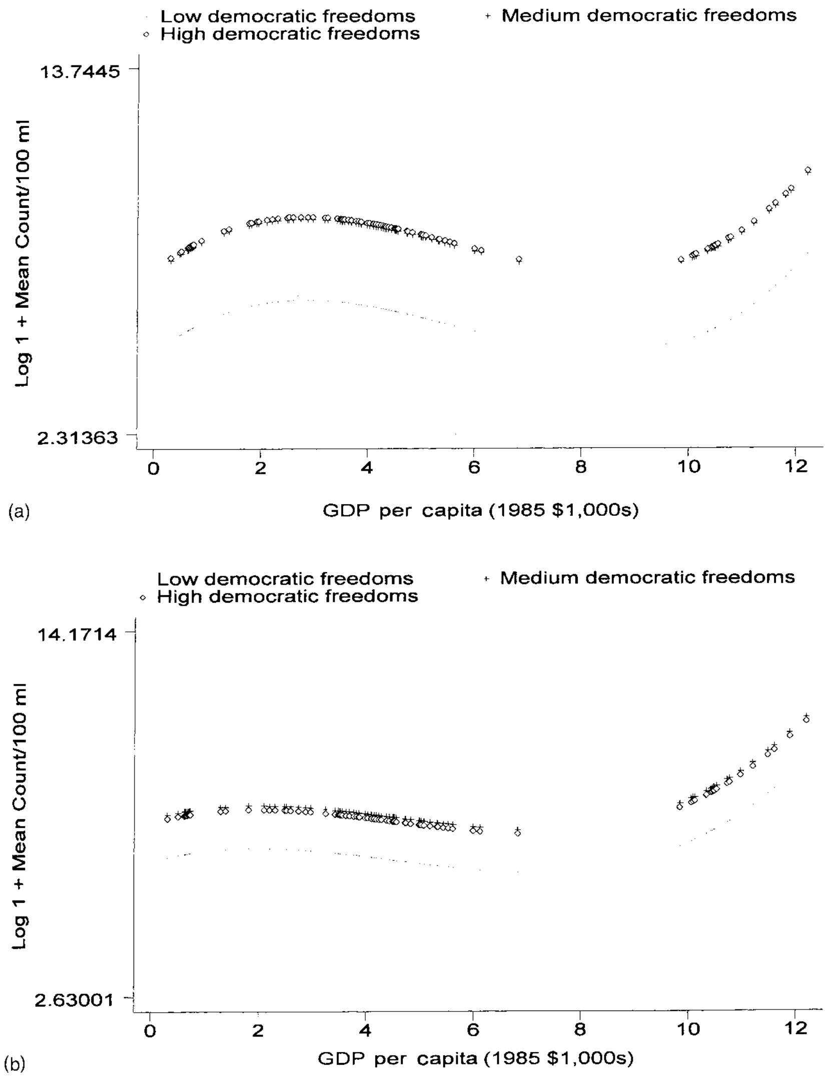

Figure 5. *GEMS/WATER: Total coliforms in rivers*

lead levels (LEAD) and income is not significant when freedoms are included as independent variables (the relationship between lead levels and income is significant in G–K's regression). However, the combined effect of income and freedom is very significant. This suggests that the generally negative relationship between incomes and lead levels detected by G–K may indeed result from an induced policy response. As for the other heavy metals, G–K found a statistically significant relationship between concentrations of cadmium (CAD) and income, but the relationships for nickel (NICKEL) and mercury (MERC) were not significant.

Table 7. *The determinants of pollution (country fixed effects) Specification with dummy political and freedom variables*

Variable	*SO2*	*Smoke*	*H.Part.*	*DO*	*BOD*	*COD*	*NIT*	*FEC*	*COL*	*LEAD*	*CAD*	*ARS*	*MERC*	*NICKEL*
Income (1000s)	−18.39567	39.84781	71.95218	0.14131	3.77388	−42.49774	−0.09249	−2.64295	−5.71509	0.07622	0.00195	0.01452	0.08053	−0.03611
	(9.24979)	(21.71658)	(21.15618)	(0.82016)	(5.20027)	(43.2195)	(1.56464)	(0.69059)	(2.56909)	(0.04260)	(0.20186)	(0.00515)	(0.77917)	(0.03629)
Income squared	1.75833	−9.88130	−4.42766	−0.01397	0.10692	2.19049	−0.01994	0.28179	0.71891	−0.00713	0.00732	−0.00106	−0.01971	0.00324
	(1.11652)	(3.77838)	(2.65969)	(0.09092)	(0.67966)	(5.27734)	(0.18662)	(0.07679)	(0.38580)	(0.00368)	(0.01713)	(0.00043)	(0.06725)	(0.00290)
Income cubed	−0.05411	0.54370	0.09658	0.00062	−0.01531	−0.02530	0.00128	−0.00879	−0.02579	0.00021	−0.00033	0.00002	0.00100	−0.00009
	(0.03825)	(0.18059)	(0.08940)	(0.00301)	(0.02636)	(0.19941)	(0.00634)	(0.00253)	(0.01655)	(0.00011)	(0.00048)	(0.00001)	(0.00192)	(0.00008)
Lagged income	28.99138	−16.14333	11.09994	−2.30027	1.02451	10.36041	−0.45809	−0.45352	−2.25904	−0.03655	−0.04443	−0.00100	0.36043	0.01583
	(10.29683)	(26.55506)	(23.34081)	(0.89302)	(6.78312)	(76.97612)	(1.81907)	(0.75708)	(4.29734)	(0.03538)	(0.17003)	(0.00347)	(0.63971)	(0.03052)
Lagged income squared	−5.05515	10.97839	0.43922	0.18329	−0.56164	0.49379	0.09522	−0.00413	0.12330	0.00274	−0.00359	−0.00006	−0.01559	−0.00152
	(1.29354)	(4.854357)	(3.12159)	(0.11082)	(1.06327)	(11.85985)	(0.23573)	(0.09224)	(0.69990)	(0.00332)	(0.01555)	(0.00032)	(0.05975)	(0.00263)
Lagged income cubed	0.18719	−0.73021	−0.02834	−0.00340	0.02669	−0.12861	−0.00300	−0.00029	−0.00066	−0.00009	−0.00026	0.00000	0.00043	0.00005
	(0.04690)	(0.24165)	(0.11177)	(0.00425)	(0.04811)	(0.53693)	(0.00870)	(0.00345)	(0.03208)	(0.00011)	(0.00048)	(0.00001)	(0.00189)	(0.00007)
Low political freedom dummy	0.16016	0.48910	−50.48287	−0.33031	2.13231	11.94408	−0.09322	0.86889	1.84166	−0.04217	−0.00636	0.02722	−0.13945	−0.00887
	(9.70882)	(12.50615)	(50.94196)	(0.53656)	(2.79515)	(28.17388)	(1.00371)	(0.49079)	(1.57049)	(0.02609)	(0.11450)	(0.01361)	(0.47033)	(0.00884)
Low civil freedom dummy	18.31376	20.91897	42.23579	0.48105	−0.41577	−11.86618	−0.54050	1.15279	−1.58031	0.01910	0.04639	−0.00463	−0.98710	0.00384
	(5.97914)	(9.20029)	(14.52888)	(0.42961)	(2.26640)	(16.27007)	(0.64770)	(0.41679)	(0.70258)	(0.02427)	(0.12279)	(0.00525)	(0.47082)	(0.00783)
Medium Political freedom dummy	6.38624	−5.89065	−9.85155	−0.27199	2.82724	−1.45473	0.34143	0.47769	0.93199	0.00524	0.01117	0.00875	−0.03845	
	(7.11051)	(8.54818)	(48.97682)	(0.40836)	(2.10275)	(21.85618)	(0.85361)	(0.37875)	(0.61643)	(0.01331)	(0.06394)	(0.00170)	(0.24553)	
Medium civil freedom dummy	4.16575	6.51922	−10.67042	0.27307	−0.67711	−6.31023	−0.49672	0.23668	−0.85480	0.01423	0.03290	−0.00112	−0.07295	
	(3.56992)	(6.56373)	(8.87939)	(0.26901)	(1.40411)	(8.24274)	(0.41496)	(0.25099)	(0.31949)	(0.01662)	(0.07198)	(0.00349)	(0.30727)	
Country dummies	40	16	27	50	45	30	39	41	21	19	26	14	27	9
P-value	<0.0001	<0.0001	<0.0001	<0.0001	0.1890	0.0878	<0.0001	<0.0001	0.0004	<0.0001	<0.0001	0.0005	<0.0001	0.0071
P-value (combined freedom variables)	0.0076	0.1224	<0.0001	0.8244	0.7437	0.8863	0.5673	0.0001	0.06840	0.24610	0.97180	0.00000	0.99330	0.09420
P-value (combined income variables)	<0.0001	<0.0001	<0.0001	0.0008	0.0990	0.1902	0.9256	<0.0001	0.0223	0.2621	0.3359	0.0198	0.3439	0.4107
P-value (combined freedom and income variables)	<0.0001	<0.0001	<0.0001	0.0062	0.3257	0.5150	0.8488	<0.0001	<0.0001	0.313	0.7186	0.000	0.735	0.361

Note: The dependent variable in all regression equations except for fecal and total coliforms is annual mean concentration. For fecal and total coliforms the dependent variable is 1 + log annual mean concentration. Unreported, included covariates and numbers of observations are as in previous tables.

4. Fixed effects

Because political and civil freedoms vary little within countries over time, we have tested our results for robustness by including separate country dummy variables. Essentially, our fixed effects regressions test whether our results might reflect omitted country characteristics like geography that just happen to be correlated with freedoms.

As shown in table 7, we find that our main results hold up surprisingly well. The relationship between freedom and pollution is still highly significant for SO_2, heavy particles, and fecal coliforms. While the direction of the effect for heavy particles appears somewhat ambiguous in these regressions, if we include only a combined low civil and political freedoms dummy, the essence of our earlier results is still supported (the coefficient on the low freedoms dummy is 33.272 with a standard error of 12.680). Similarly, while the combined political and civil freedom variables are no longer significant at the 5 per cent level in the smoke regression, the combined civil freedom variables on their own are significant.

We wish to stress that the fixed effects model provides an overly strong test of the effect of freedoms on pollution levels. A country is what it is partly because of the political and civil institutions it embraces. Countries with more repressive regimes may also subsidize energy consumption or concentrate industrial production, so that in our earlier regressions the effects of the subsidies and planning decisions may be reflected in the freedom variables. But of course it is partly because freedoms are low in these countries that such subsidies and central planning decisions can be sustained. For this reason, it is best to consider the random and fixed effects models as alternatives, each with its own advantages and disadvantages.

5. Implications

Effective environmental protection requires both economic reforms, as Arrow *et al.* (1995) and the World Bank (1992) have emphasized, and—as we have shown—political reforms. Which type of reform ought to come first? We cannot say, but our results do clash with a related literature which is less equivocal on this question. Barro (1996) argues that political freedoms in poor countries should not be promoted directly but that economic freedoms should be. One reason for this is that Barro finds that an increase in political freedoms has a small adverse effect on growth, for countries that have already attained a medium level of freedom. We find, however, that some measures of environmental quality are monotonically increasing in the extent of freedoms. If GDP per head were synonomous with welfare, then one might still agree with Barro that political freedoms ought not be promoted (ignoring, of course, the direct contribution that freedom makes to well-being). But we know that GDP per head is an inadequate measure of welfare, not least because it excludes the benefits of environment improvements (Dasgupta and Mäler, 1995). To the extent that freedoms are instrumental in correcting for market failures, they may increase welfare, even if at the expense of growth.

Barro's recommendation that economic reforms should precede political reforms is also supported by his finding that political freedoms tend to erode over time if they get out of line with a country's standard of living. The implication is that freedoms cannot be controlled independently of incomes. But Barro's estimates only reveal that democratic freedoms *tend* to increase with incomes; they do not indicate that a country cannot increase freedom by more than the average for its income level, and one can point to a number of countries that have increased freedoms rapidly (Barro might say prematurely) without ever sliding back: in our sample alone, these include Argentina, Spain, Portugal, Greece, and Brazil, not to mention a number of the former Communist countries of Eastern Europe. As Dasgupta (1993: 116) has put it, 'the claim that the circumstances that make for poverty are also those that make it necessary for governments to deny their citizens political and civil liberties is simply false'. This means that our results do have real implications for policy. If the environmental Kuznets curve suggests that growth need not harm the environment, our results show that an expansion of freedoms may lead to an improvement in environmental quality.

Data for Brazil provide an anecdotal illustration of this contention. Between 1977 and 1987, per capita income increased, decreased, and then increased again. It was less than 10 per cent greater at the end of the period than at the beginning and averaged around $4,000 over this period, a level near the peak of the inverted-U for the sulfur dioxide curve (figure 1a). Such small changes in income, especially near the peak of the inverted-U, should have translated into small changes in pollution levels. However, sulfur dioxide concentrations in Brazil fell by half over this period. At the same time, freedoms increased. The raw score of political and civil freedoms fell from 4 and 5, respectively in 1977 to 2 and 2 in 1987, enough to lift Brazil from being a medium to a high freedom country. Of course, this is only an illustration, but it supports our interpretation of the statistical evidence that freedoms can change independently of incomes, and have a demonstrable effect on environmental quality.

This conclusion has important implications for the trade and environment debate. Environmentalists and protectionists claim that weaker environmental standards in developing countries should be brought into alignment with the higher standards found in industrialized countries. As Bhagwati has repeatedly emphasized, however, diversity is usually to be cheered.[13] Certainly, in a model in which environmental standards are chosen by governments to maximize the welfare of their citizenry, diversity is beneficial. The hole in this argument is that only textbook governments choose standards in this way. Actual standards are chosen by a political process. Of course, we know that no form of government can be sure of sustaining first-best outcomes every time. However, there is reason to believe that countries with greater civil and political freedoms will do a better job at supplying public goods (see Olson, 1993). The point is that, to the extent that the interests of the citizens of some countries are poorly represented, the appropriate remedy is not to impose an outcome (a harmonized standard) but rather to promote a move toward greater freedoms. As Bhagwati and Srinivasan (1996: 170) put it:

[13] See, for examples, Bhagwati (1993, 1996).

> even if one argues that the decisions made undemocratically by a dictatorship or an oligarchy are vitiated, there is no reason to believe that the higher standards being pursued by a foreign country representing the competitive interests of a foreign industry or labor union in an industry are what a more democratic process would yield. The correct approach should rather to be encourage a shift to more democratic procedures in arriving at social and economic legislation, including environmental policy. Process, not outcomes (especially outcomes sought by self-serving groups elsewhere), is what we should aim at in countries that lack democratic ways.

This paper shows that the promotion of freedoms will in many cases actually lead to improvements in environmental quality. That is, promotion of a more democratic process is not the only 'right' thing to do but it will also lead to the changes in outcomes desired by the environmental and protectionist lobbies.

The mystery in our results is why freedoms should affect some measures of environmental quality and not others. With the exception of heavy metals and total coliforms, which may suffer from small sample problems, freedoms significantly affect environmental quality measures that relate directly to human health: all three of our air pollution measures in addition to fecal contamination. But they do not affect DO, BOD, COD, or nitrates. Our results for the oxygen-related measures of water quality are especially surprising, because sewage treatment intended to reduce fecal coliform would tend to increase DO and reduce BOD and COD in the bargain. The results seem to hint that something other than an induced policy response may lie behind the inverted-U relationships for these measures of water quality. The distinction is important, for if the relationship is determined by, say, fixed factors, it may not be stable; growth in the middle income countries may not be accompanied by reductions in pollution, as suggested by the inverted-U.

The latter explanation is at least plausible in the case of nitrates. To reduce nitrates in rivers would require reductions in the use of fertilisers, or more specifically in fertiliser run-off, and changes in cropping techniques. The richer countries have done little to regulate these activities (occasionally, nitrates are removed from drinking water). Moreover, the release of both unused fertiliser and organic nitrogen into rivers varies with the type of crop that is planted as well as climatic conditions. So something other than an induced policy response may explain the inverted-U, at least in this case. Research that links the inverted-U to actual policies would seem to be badly needed.

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