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The Internationalization of National Lead Reduction Regulations: Do International Factors Affect National Decisions to Phase-out Lead from Gasoline?

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1. Introduction

Most theorists agree that in light of growing institutional and economic integration into the international arena it is no longer possible to understand the making of environmental policy in strictly national terms. For two main reasons, these international factors, i.e. international economic and institutional interlinkage, could be relevant for explaining the domestic policy decision to phase-out lead from gasoline. Firstly, limit values for lead in gasoline are standards which regulate a product that is traded on international markets. Reducing the lead content of gasoline increases production costs and therefore yields repercussions on a country's competitiveness. Most importantly, the necessary measures are less expensive in the beginning but increase as the lead content is further reduced until the complete phase-out (Busch 2007: 5). On the other hand, trade accelerated the cleanup of automobile emissions in the United States because the threat of cleaner cars from imports advanced the introduction of catalytic converters in the 1970s (Barbour 1980). In consequence, it is reasonable to hypothesize a causal relationship between a country's stringency of lead regulation and its trade dependence (Hilton 1999: 152).

Secondly, the limitation of the lead content in gasoline has been subject to activities, recommendations and agreements of numerous international institutions, such as the World Bank, the United Nations Commission for Sustainable Development, or the Organization for Economic Cooperation and Development (OECD) (Lovei 1997: 35; Busch 2007: 3). Accordingly, one could hypothesize that countries participating in these international structures are more likely to follow the corresponding regulatory recommendations on lead reduction. In light of these considerations, it is the aim of this analysis to respond to the following research question: Do international institutional or economic factors affect the decision of national governments to phase-out lead from gasoline?

This analytical focus appears appropriate for three theoretical reasons. Firstly, the relationship between lead phase-out and international institutional variables has not been addressed in quantitative studies yet. Secondly, the empirical evidence on the causal link between international economic factors and the level of the gasoline lead content has been mixed, and the results presented in the pertinent research literature therefore inconclusive. Thirdly, this design allows for testing the effect of international variables against national explanatory factors, i.e. the strength of environmental non-governmental organizations (ENGOs), the level of democratic participation and competition, and the level of per capita income. Therefore, my second research question is: Do national variables possess a higher explanatory power for the phase-out of lead from gasoline than international factors?

In addition to its contribution to the existing scientific literature, this analysis is also motivated by the relevance of that topic for the "real world" (see King et al. 1994: 14-19). Lead is a cumulative neurotoxin and thus poses a serious threat to public health (Lovei 1997: 1). It causes grave social and economic costs, which are given by medical expenditures, lost workdays due to lead poisoning, and a general lowering of the standard of living. Lead has harmful implications for the brain development of children, entailing a lowering of their intellectual performance. As concerns adults, their exposure to atmospheric lead can cause cardiovascular problems (for an overview of studies see Nriagu 1990). Hence, policies targeting the phase-out of lead in gasoline should be given high priority in every country.

The remainder of the paper is structured as follows. In the first section, I develop the theoretical framework and derive testable hypotheses on the relationship between lead phase-out and international and national factors. In the second chapter, I present details on the research design. In chapter three, I discuss the data and measures underlying the analysis. In the fourth section, I give an outline of my estimation strategy. In chapter five, I present a description of the statistical results. The final section discusses the findings, points to limitations of this analysis, and concludes.

2. Theoretical Framework

The "classic" theories of environmental regulation mainly focus on a variety of domestic factors for explaining policy outputs. In this regard, one central approach refers to the power resources of competing societal actors. The underlying assumption of this lobby group model is that politics is conflictual, i.e. a certain policy benefits one group whereas another benefits different individuals. According to Hahn (1990), the competing actors in environmental policy are industry and environmental groups, with the first preferring low standards and the latter asking for advanced standards. From this follows that the actual policy output is located closer to the ideal position of the more "powerful" actors, while this power may not only stem from material resources but also from the number of such organizations. Fredriksson et al. (2005) support this view by present evidence that an increase in the number of environmental groups tends to lower the lead content of gasoline.

Related to the lobby group model are approaches that explore that link between the stringency of environmental protection standards and the characteristics of the democratic process in a country. Though mainly focusing on the general differences between democracies and autocracies, Payne (1995) provides the most comprehensive theoretical discussion about this relationship. According to this, firstly, democracies support individual political rights and a free flow of information. This implies that citizens in democratic systems are better informed and can better express their concerns and demands. Secondly, democracies are more responsive than non-democracies, meaning that emerging organizations of environmental interests can exert pressure on policy entrepreneurs operating in a competitive political system to respond positively to these demands. Thirdly, democracies are better learners than authoritarian systems. Thereby, the possibility of transnational communication is of crucial importance (see Holzinger/Knill 2005: 782-783). Fourthly, democracies participate more willingly in global environmental cooperation. They are expected be more sensitive to rule and norm compliance than authoritarian systems and thus be more likely to adjust to the standards and rules agreed on in environmental treaties and decisions by international organizations. Fifth, an open market economy, which is a feature of any democracy, is presumed to provide sufficient incentives for responsible environmental policies. In fact, a considerable number of studies have revealed a positive relationship between some environmental outcome measures and the level of democracy (see Shafik/Bandyopandhyay 1992; Shafik 1994; Didia 1997; Murdoch/Sandler 1997; Midlarsky 1998; Scruggs 1998; Torras/Boyce 1998; Barrett/Graddy 2000; Gleditsch/Sverdrup 2002; Fredriksson et al. 2005).

Environmental standards are further often associated with a country's socio-economic conditions, mainly its income per capita. The corresponding theoretical concept, the Environmental Kuznets Curve, hypothesizes an inverted U-shaped curve which indicates that pollution increases at the beginning of the development process, but declines after a certain level of income is reached (see Grossman/Krueger 1995). The reason for this decline of pollution is an increase in the political demand for a better environmental quality, and hence for sound environmental policies, which is assumed to augment simultaneously with growing income (see also Inglehart 1997). Though numerous studies exist, the empirical findings on the existence of inverted U-shaped relationship between economic growth and the reduction of environmental degradation is mixed (see Beghin/Potier 1997; Bhattarai/Hammig 2001; Gallagher 2004).

The final group of domestic variables is derived from a more functional understanding of environmental policy-making as a response to problem pressure. One can assume that low population density causes less environmental problems since these are often related to agglomeration, entailing less pressure on a government to address degradation. The same should hold true if the overall level of environmental pollution is rather low (Heichel et al. 2008). From these theoretical considerations, I derive the first set of hypotheses on the relationship between domestic variables and the phase-out of lead from gasoline:

H1: The higher the number of environmental groups in a country, the more likely the government will eliminate lead from gasoline.

H2: The more democratic a country's system is, the more likely the government will eliminate lead from gasoline.

H3: The higher the per capita income of a country, the more likely the government will eliminate lead from gasoline.

CVs: Further, I include population density and pollution intensity as control variables in my estimation models.

Recalling Payne's (1995) treatise on the positive effects of a consolidated democratic system, I now refer to three of these aforementioned aspects when discussing the theoretical relationship between national environmental standards and international factors, namely cross-national learning, international cooperation, and trade openness. The first theoretical approach refers to the burgeoning role of international organizations in environmental policy-making and directly addresses policy learning and cooperation. Since the 1970s, the lead content in gasoline has been subject to numerous activities, non-binding recommendations, and agreements of a number of international institutions. On the one hand, this international cooperation may stimulate learning and thus lead to more ambitious legislation (see Meseguer Yebra 2006). On the other hand, this kind of international policy promotion should increase the stringency of environmental standards through legitimacy pressures that may emerge in light of "international scrutiny" (Holzinger/Knill 2005: 785). Empirically, this perspective has not received much attention yet. In accordance with the findings of Holzinger et al. (2008), I hypothesize that there is a positive relationship between the participation in these international structures and the prospect of a lead phase-out.

The second international variable is about economic interlinkage, which is generally associated with the theory of regulatory competition. It predicts that countries adjust policy instruments and regulatory standards in order to cope with competitive pressures emerging from international economic integration. The more exposed a country is to competitive pressures following from high economic integration, the more likely its policies will be affected. This way, regulatory competition among governments may at least theoretically lead to a race to the bottom in environmental policies (Holzinger/Knill 2005: 789-790). Empirically, however, this prediction is a "non-phenomenon" (Bhagwati 2002).

Therefore theoretical refinements have been developed that distinguish between product and production process standards (Scharpf 1997; Holzinger 2003; Murphy 2004). In the case of process standards, we find a widely shared expectation that states will gravitate towards the policies of the most laissez-faire country (Drezner 2001). If the regulation of production processes implies an increase in the costs of production, potentially endangering the international competitiveness of an industry, regulatory competition will generally exert downward pressures on economic regulations (Scharpf 1997: 524). Expectations are less homogeneous for product standards. Often industries in both low-regulating and high-regulating countries have a common interest in harmonization of product standards to avoid market segmentation, which may lead to a mutual increase in the regulatory level.

For two reasons, I expect a positive relationship between economic integration and the phase-out of lead from gasoline. Firstly, this is due to the fact that lead in gasoline is a product standard. Thus, increased trade interlinkage should trigger an upward harmonization of standards. Secondly, trade openness may also raise the regulatory standard through importations of modern vehicles with catalytic converters. Cars equipped with catalytic converters require unleaded gasoline as lead destroys important technical components for its operation. Hence, the import of these cars might motivate governments to adopt measures targeting at the reduction and removal of lead in gasoline (Busch 2007: 3, see also Lovei 1997: 15).

In addition to the previous set of hypotheses, I formulate the following expectations regarding the relationship between lead phase-out and international variables:

H4: The more a country participates in institutional structures targeting the limitation and phase-out of lead in gasoline, the more likely the government will eliminate lead from gasoline.

H5: The more a country is economically integrated in international markets, the more likely the government will eliminate lead from gasoline.

3. Research Design

As the literature review already hinted, environmental policy has been a frequent subject to exploration. As a consequence, the theoretical contributions to this topic have been numerous, whereas the empirical testing of the resulting hypotheses has been problematic due to lacking reliable output data, i.e. data based on legislation (Esty/Porter 2005: 393). Thus, most studies have relied on outcome data (i.e., data on emission loads or pollution rates) or other proxies that are gathered and published by international organizations, e.g. the World Bank. Yet, this data is often problematic in terms of its overall quality, and even more gravely concerning the underlying causal relationship that the researchers seek to establish (Neumayer 2002: 144).

Given this unsatisfactory data situation, I decided to base my analysis on the data set used by Fredriksson et al. (2005), which has the clear advantage that the dependent variable – in their case the level of gasoline lead content – is directly taken from national legislation as reported by Lovei (1997). Accordingly, this analysis relies on cross-national data from 109 developing and developed countries. I further extended and modified the original data set through additional sources, i.e. the World Development Indicators (World Bank 1999), the Polyarchy data set, data from the Polity IV project and the Freedom House organization, Lovei (1997), and Busch (2007).[1] Hence, the data is secondary in nature (i.e., not collected by myself via questionnaires etc.) and the units of observation are countries. Generally, these information are gathered via national official statistics and qualitative or quantitative content analysis. Due to lacking alternatives, the use this kind of data is rampant in quantitative cross-national research in environmental policy. Nonetheless, we should keep in mind that we do not know how this data has exactly been collected, and we cannot preclude errors from the processing of the data. All this to a certain extent reduces the data's quality in terms of validity and reliability. In consequence, the relationships modeled in this paper are subject to several replications.

Most of the variables included in this study – such the three democracy indices, measures of trade openness, international institutional interlinkage, income, or problem pressure – are theoretically also available as times series data. But since the dependent variable is measured at one point of time only, that is 1996, the dataset used in this analysis is cross-sectional. However, I also included an additional measurement for some explanatory variables prior to 1996 in order to give consideration to the tediousness of political decisions. In the subsequent chapter, I offer a more detailed discussing of the data.

4. Data and Measures

The statistical analysis is based cross-sectional data from 82 developing and 27 OECD countries. Whereas the entire population comprises 211 countries, I had to drop 102

[1] As of these – partly substantive – modifications, this analysis cannot be considered as a replication of the Fredriksson et al. (2005) article.

observations due to missing values for the dependent variable, which reduced the size of the sample notably. Table 1 below provides summary statistics of the focal variables together with a short description of the data and information on the sources.

Table 1: Description of focal variables

Variable	Obs	Mean	Std.Dev	Min	Max	Description	Source
phaseout	109	.146789	.3555301	0	1	1 if lead content = 0, else 0	Lovei (1997); Fredriksson et al. (2005)
lnengos1993	95	1.898234	1.28309	0	5.605802	Log of ENGOs in 1993	Fredriksson et al. (2005)
lnengos1996	97	2.095624	1.257567	0	5.56452	Log of ENGOs in 1996	Fredriksson et al. (2005)
comp	107	41.19224	23.59289	0	70	% smaller parties' votes in 1996	Polyarchy dataset
part	107	34.37776	19.66991	0	66.95	% population that voted in 1996	Polyarchy dataset
democracy	107	1694.657	1347.802	0	4274.512	comp * part in 1996	Polyarchy dataset
FHpolrights	106	3.471698	2.191792	1	7	Categories: 1 (not free) to 7 (free) in 1996	Freedom House
FHcivillib	106	3.773585	1.888729	1	7	Categories: 1 (not free) to 7 (free) in 1996	Freedom House
Polity	101	2.772277	7.106168	-10	10	Continuous: 10 (democracy) to –10 (autocracy)	Polity IV
lngdp1993	107	8.492794	1.127971	6.173786	10.27505	Log of GDP per capita in 1993	Fredriksson et al. (2005)
lngdp1996	108	7.92902	1.668397	4.70048	10.71936	Log of GDP per capita in 1996	Fredriksson et al. (2005)
openness1993	101	73.05524	50.07944	14.4066	348.79	imports + exports / GDP in 1993	World Development Indicators (1999)
openness1996	96	75.03836	43.29902	16.3009	284.56	imports + exports / GDP in 1996	World Development Indicators (1999)
lnintagreement	106	1.124005	.6254	0	2.302585	Log of agreements in 1996	Busch (2007); Global Lead Network; LEAD Group Inc.

I calculated the dependent variable of the study PHASEOUT on the basis of the continuous variable leadcontent from the data set used by Fredriksson et al. (2005).[2] The binary variable takes on the value 1 if the maximum permissible limit for the lead content in gasoline in 1996 was smaller than 0.013 gram per liter (see von Storch et al. 2003: 158), and

2 To this end, I checked the data and made two corrections on the basis of the original data of Lovei (1997).

otherwise it equals 0. At that year, of the 109 countries analyzed here, merely 16 states had phased-out leaded gasoline.

The data on the number of ENGOs in 1993 and 1996 is also taken from Fredriksson et al. (2005). Here I used the logarithm of ENGOS due to a highly skewed distribution. The variation in the (log) number of ENGOs across countries is rather impressive. Whereas the number of environmental interest groups surpassed 200 in the United States and the United Kingdom, many developing countries, e.g. Algeria, did not even have one ENGO at the two points of measurement.

The variables COMPETITION, PARTICAPTION, DEMOCRACY, FHPOLRIGHTS, FHCIVILIB, and POLITY are all measurements of democracy. I abstained from including measurements at different points of time as systemic variables generally tend to be rather stable for such a short period. COMPETITION, PARTICAPTION and DEMOCRACY are compounds of Vanhanen's democracy index. Although they are also reported in the Fredriksson et al. (2005) data set, I took the data directly from the corresponding Polyarchy data set that aims at measuring democracy.[3] To this end, it uses two indicators, namely competition and participation as well as their interaction term. Competition measures the smaller parties' share of the votes cast in parliamentary or presidential elections, or both. It is calculated by subtracting the percentage of votes won by the largest party from 100. The percentage of the population which actually voted in the same elections is used to measure the degree of participation.

There is an ongoing debate in scientific literature about the advantages and disadvantages of different measures of democracy (see e.g. Bollen 1993). Therefore, I decided to include two more frequently used measures of democracy. The first ones are FHPOLRIGHTS and FHCIVILIB of the Freedem House Organization. Based on expert evaluations, they measure the strength of political rights and civil liberties, in categories

3 Fredriksson et al. (2005) centralized the variables by a factor that I could not find out.

ranging from 1 (= not free) to 7 (= free).[4] The second alternative measurement is the POLITY variable from the Polity IV Project, which is also based on expert assessments. It compares the aspects of institutionalized democracy and autocracy and locates a country on a scale between 10 (= democracy) to –10 (= autocracy) (see also Neumayer 2002: 145-146). Though these measures do not correlate perfectly, the degree of correlation is still strong, ranging from 0.62 to even 0.92.[5] Consequently, I do not use them jointly when fitting the model but rather include them individually for checking the robustness of a potential "democracy effect".

The final focal domestic variables are LNGDPPC1993 and LNGDPPC1996, that is the logarithm of per capita income for the years 1993 and 1996. The transformation of the variable also results from its skewed distribution.

OPENESS1993 and OPENESS1996 is the sum of a state's imports and exports divided by its GDP in the years 1993 and 1996, respectively, which I calculated from the the World Development Indicators (World Bank 1999). This measurement of trade openness is rampant in political science literature (see e.g. Andonova et al. 2007: 792).

Finally, I counted the number of international agreements ratified by a country that focus on lead reduction on the basis of Busch (2007) as well as information from the Global Lead Network and the LEAD Group Inc. Due to skewed distribution, I generated the variable LNINTAGREEMENT, that is the logarithm of the number of international agreements signed by each country until 1996. Surprisingly, all the countries included in the sample signed at least one pertinent international agreement.

Besides the focal variables, I have identified three more control variables, of which the summary statistics are given in table 2 below.

[4] I reversed the original order of the Freedom House scores for a better comparison with the other measures.
[5] FHPOLRIGHTS and FHCIVILIB even correlate 0.9224. But the elimination of either of the two variables does not substantially change the coefficients of the logistic regression.

Table 2: Description of control variables

Variable	Obs	Mean	Std.Dev	Min	Max	Description	Source
lnpopden1993	107	3.972649	1.553602	.5752642	8.692926	Population density per capita/km²	Word Development Indicators
lnpopden1996	107	4.025921	1.545089	.6537305	8.760093	Population density per capita/km²	Word Development Indicators
lnco2pc1993	105	.7064396	1.799332	-4.22263	3.898046	Log of CO2 emissions in 1993	Word Development Indicators
lnco2pc1996	105	.736368	1.777196	-4.25029	3.738193	Log of CO2 emissions in 1996	Word Development Indicators
oecd	109	.2477064	.4336743	0	1	dummy variable	Own assignment

The variables LNPOPDEN1993 and LNPOPDEN1996 are the logarithm of the measurement of population per km² in 1993 and 1996 as reported by the World Development Indicators (World Bank 1999). LNCO2PC1993 and LNCO2PC1996 are the logarithm of the carbon dioxide emissions per capita in both years and serve as a proxy for air pollution intensity. Finally, the table contains the variable OECD which aims at controlling whether there are systematic differences between developing and developed countries. An alternative way of evaluating this would have been given by splitting the sample and estimating the models separately for each group (see Fredriksson et al. 2005). But given the small size of the country sample, I argue that the inclusion of this dummy variable is more reasonable.

5. Analytic Strategy

Given the binary nature of the dependent variable PHASEOUT, I use logistic regression models in my main estimation. The logit model has an S-shaped relationship between the independent variables and the probability of an event. I assume that this functional form is appropriate for modelling the research questions posed here.

Further requirements for being able to run logistic regressions refer to the model specification assumption. Most importantly, the model should be specified with the correct independent variables. To this end, I selected the independent variables on the basis of the relevant scientific literature. In this way, I reduce – though surely not eliminate – the potential source of bias from omitted variables. Secondly, there should be no autocorrelation. In this particular analysis, this is no problem as the data is cross-sectional. Thirdly, the independent variables must not be exactly multicollinear. I tested for this requirement by calculating the mean variance inflation factor (VIF) for both full models with 1996 and 1993 variables. I can rule out multicollinearity as both mean VIF values of 4.73 and 5.07, respectively, are well below 10 (see annex).

I run five logistic estimation models in total. Model (1) contains all independent variables; model (2) is the first reduced model containing the domestic and control variables; model (3) is the second reduced model that only includes the international as well as control variables; models (4) and (5) are replications of the full model with different measurements of democracy.

Logit (Phaseout) = ß0 + ß1*lnengos + ß2*comp + ß3*part + ß4*democracy + ß5*lngdp + ß6*openness + ß7*lnintagreement + ß8*lnco2pc + ß9*lnpopden1996 + ß10*oecd **(1)**

Logit (Phaseout) = ß0 + ß1*lnengos + ß2*comp ß3*part + ß4*democracy + ß5*lngdp + ß6*lnco2pc + ß7*lnpopden1996 + ß8*oecd **(2)**

Logit (Phaseout) = ß0 + ß1*openness + ß2*lnintagreement + ß3*lnco2pc + ß4*lnpopden1996 + ß5*oecd **(3)**

Logit (Phaseout) = ß0 + ß1*lnengos + ß2*FHcivilib + ß3*FHpolrights + ß4*lngdp + ß5*openness + ß6*lnintagreement + ß7*lnco2pc + ß8*lnpopden1996 + ß9*oecd **(4)**

Logit (Phaseout) = ß0 + ß1*lnengos + ß2*polity + ß3*lngdp + ß4*openness + ß5*lnintagreement + ß6*lnco2pc + ß7*lnpopden1996 + ß8*oecd **(5)**

This proceeding allows for comparing the explanatory power of both sets of variables, i.e. national and international ones. I will compare the different model by using Akaike's Information Criterion (AIC), which is provided by Long and Freese's (2005) SPost software, and additional state-of-the-art goodness of fit measurements. The inclusion of different indicators for democracy results from the ongoing debate in the research literature and is useful for assessing the robustness of the overall model. As of the small size of the sample checking the robustness of my findings is key. Hence, I repeat the logistic regression with variables from 1993 because of possible time lag involved with the enactment of laws.

I provide a final robustness test by running the models again by using a probit and a linear probability model (LPM). Logit and probit regressions are very similar to one another. Principally, they only differ regarding the assumptions of the distribution of the error terms. Accordingly, the logit coefficients are usually about 1.6 to 1.8 times larger than the corresponding probit coefficients (Long 1997: 49). By contrast, the use of LPM is controversial and in fact the (incorrect) assumption of linearity may result in biased estimates. Nevertheless, it is a good way of replicating the analysis for checking the robustness of the estimates.

The core problem of the data set is the relatively small number of observations. Logistic regression models use Maximum Likelihood equations, which are yet risky to use with samples smaller than 100 (Long 1997: 54). Another conceivable problem relates to the coding of the dependent variable. To recall, I computed PHASEOUT by transforming the continuous variable LEADCONTENT from the Fredriksson et al. (2005) data set into a binary one. This proceeding implies an information loss, and might lead to inefficient estimates. Nevertheless, it is theoretically reasonable to distinguish between the determinants of lead reduction and complete phase-out since the latter causes disproportionately high costs (Busch 2007: 5). Having said all this, the results of the analysis should be taken with a pinch of salt.

6. Results

Tables 2 and 3 report the empirical results of various model specifications, with LEADCONTENT as the dependent variable and explanatory variables from the years 1996 and 1993, respectively. In the following, I will first discuss the model fit and turn then to the interpretation of the coefficients. [6]

Table 3: Logistic estimation with 1996 variables

	(1) Full model	M.E.	(2) Reduced model national	M.E.	(3) Reduced model international	M.E.	(4) Full model FH	M.E.	(5) Full model Polity	M.E.
lnengos1996	.794 (.443)*	.044	.982 (.398)**	.047	-	-	.798 (.424)*	.062*	.644 (.464)	.032
comp	.083 (.091)	.005	.065 (.078)	.003	-	-	-	-	-	-
part	.057 (.136)	.003	.027 (.108)	.001	-	-	-	-	-	-
democracy	-.001 (.002)	-.000	-.000 (.002)	-.000	-	-	-	-	-	-
FHcivilib	-	-	-	-	-	-	.145 (.652)	.011	-	-
FHpolrights	-	-	-	-	-	-	-.411 (.456)	-.032	-	-
polity	-	-	-	-	-	-	-	-	.243 (.157)	.012**
lngdp1996	1.380 (.669)**	.076	1.412 (.644)**	.068	-	-	1.225 (.764)	.095	1.433 (.720)**	.071
openness1996	-0.002 (.011)	-.000	-	-	-.013 (.011)	-.001	-.003 (.012)	-.000	-.003 (.011)	-.000
lnintagreement	1.107 (1.021)	.061	-	-	1.732 (.969)*	.175*	.970 (.931)	.075	.881 (.934)	.043
lnco2pc1996	-1.053 (.711)	-.058	-1.234 (.677)*	-.059	.364 (.301)	.037	-.845 (.618)	-.066	-1.009 (.629)	-.050
lnpopden1996	-.439 (.273)	-.024	-.476 (.261)*	-.023	-.309 (.237)	-.031	-.393 (.280)	-.031	-.526 (.279)*	-.026
oecd	-2.688 (1.512)*	-.111	-1.898 (1.295)	-.069	-1.189 (1.099)	-.100	-2.678 (1.546)*	-.158	-3.131 (1.626)*	-.115
Constant	-17.146 (7.539)**	-	-16.065 (6.687)**	-	-1.789 (1.399)	-	-11.066 (6.850)	-	-13.696 (5.747)**	-
N	84	-	91	-	89	-	83	-	82	-
LR chi2	24.41 (df=10)	-	25.42 (df=8)	-	12.90 (df=5)	-	22.92 (df=9)	-	26.82 (df=8)	-
Prob > chi2	.0066	-	.0013	-	.0243	-	.0064	-	.0008	-
Pseudo R²	.3097	-	.3120	-	.1598	-	.2922	-	.3436	
AIC	.910	-	.814	-	.897	-	.910	-	.844	

Notes: Standard errors in parentheses. *p < 0.10, **p < 0.05, ***p < 0.01.

[6] I also checked for multicollinearity (see chapter 5), examined residuals and influential observations (see annex), but due to space limitation I do not discuss the results here.

Table 4: Logistic estimation with 1993 variables

	(1) Full model	M.E.	(2) Reduced model national	M.E.	(3) Reduced model international	M.E.	(4) Full model FH	M.E.	(5) Full model Polity	M.E.
lnengos1993	.615 (.389)	.029	.844 (.367)**	.046	-	-	.669 (.381)*	.40	.387 (.412)	.016
comp	.065 (.075)	.003	.045 (.071)	.002	-	-	-	-	-	-
part	.020 (.117)	.001	.003 (.104)	.000	-	-	-	-	-	-
democracy	-.001 (.002)	-.000	-.000 (.002)	.000	-	-	-	-	-	-
polity	-	-	-	-	-	-	-	-	.227 (.163)	.010*
FHcivilib	-	-	-	-	-	-	.337 (.632)	.020	-	-
FHpolrights	-	-	-	-	-	-	-.502 (.484)	-.030	-	-
lngdp1993	2.983 (1.197)**	.141*	2.572 (1.078)**	.139*	-	-	3.022 (1.334)**	.180**	2.967 (1.243)**	.126
openness1993	-.007 (.013)	-.000	-	-	-.019 (.013)	-.002	-.007 (.013)	-.000	-.008 (.013)	-.000
lnintagreement	1.748 (1.140)	.083	-	-	1.871 (.969)*	.165**	1.494 (1.004)	.089	1.372 (.987)	.058
lnco2pc1993	-1.325 (.712)*	-.063	-1.349 (.675)**	-.073 *	.334 (.292)	.029	-1.435 (.760)*	-.085*	-1.350 (.711)*	-.057
lnpopden1993	-0.497 (.280)*	-.024	-.462 (.256)*	-.025	-.322 (.240)	-.028	-.530 (.302)*	-.031*	-.607 (.301)**	-.026
oecd	-3.418 (1.617)**	-.119	-1.787 (1.175)	-.075	-1.243 (1.108)	-.089	-3.296 (1.686)*	-.145	-3.590 (1.694)**	-.112
Constant	-29.634 (10.775)***	-	-25.042 (9.299)***	-	-1.691 (1.406)	-	-26.520 (11.622)**	-	-26.521 (10.128)***	-
N	86	-	89	-	94	-	85		83	-
LR chi2	28.64 (df=10)	-	26.20 (df=8)	-	14.31 (df=5)	-	27.39 (df=9)	-	30.09 (df=8)	-
Prob > chi2	.0014	-	.0010	-	.0138	-	.0012	-	.0002	-
Pseudo R²	.3598	-	.3246	-	.1734	-	.3457	-	.3837	-
AIC	.848	-	.815	-	.853	-	.845	-	.799	

Notes: Standard errors in parentheses. *p < 0.10, **p < 0.05, ***p < 0.01.

For assessing the model fit, the Likelihood Ratio (LR) Chi-square value, pseudo R-squared and AIC are the most straightforward measures. In terms of all three measurements, model (3) is the most poorly fitted one, whereas model (5) performs best. The POLITY variable seems to be a better estimator than the other democracy measures. This holds true for the estimations with both the 1996 and 1993 data. The relatively poor fit of model (5) is further undermined by LR Chi-square value and the corresponding test statistic, which allows us to dismiss the null hypothesis on the intercept-only model just at the 5% level, while for the other specifications, we can reject it at the 1% level. And finally, the pseudo R-squared values and the relatively high AIC value confirm this picture. In addition to the goodness of fit assessments provided here, I also ran Pearson's Chi-square, Hosmer and Lemeshow and LR tests[7] for model (1). Further I calculated the Count R-squared and practiced graphical diagnostics via the Receiver Operating Characteristic (ROC) curve.[8] By and large, the model fit is fair. Yet, remarkably, all the models estimated with 1993 data reveal a higher goodness of fit. This observation hints that modeling a time-lagged relationship between the dependent and independent variables is justified.

With logistic regressions, the interpretation of the estimated coefficients is tricky. While with linear regression models the slope coefficients indicate the rate of change in the dependent variable as an independent variable changes, with logistic regressions the slope coefficient signals the rate of change in the "log odds" as the independent variable changes. Since this interpretation is not very intuitive, it is better to rely on the marginal effect of an independent variable on the probability of an event. Accordingly, for one unit increase in the log per capita income, the probability of lead phase-out increases by 7.6%, and for a unit increase in the number of ENGOs it increases by 4.4% (see model 1 in table 3). Across all models, the significant effect of income per capita is most robust finding, followed by the effect of the number ENGOs. Except for POLITY, the democracy variables are never significant. As concerns the international variables, of these only the log number of international agreements signed by a country turns out to be weakly significant. Also the control variables have significant effects in some models. All three controls have negative signs, which in case of the OECD dummy is contra-intuitive. Hence, OECD countries seem to be less likely than developing countries to phase-lead. However, we should be careful with the interpretation of these findings. In fact, the varying significance levels between the logit

[7] Due to differing numbers of observation, the LR test is not overtly useful in this context.
[8] See annex for the corresponding Stata output.

coefficients and the marginal effects could be taken as a hint that the estimations are imprecise.

Table 5: Probit estimation with 1996 variables

	(1) Full model	(2) Reduced model national	(3) Reduced model int.	(4) Full model FH	(5) Full model Polity
lnengos1996	.475 (.261)*	0.573 (0.232)**	-	0.487 (0.248)**	0.407 (0.282)
comp	.047 (.054)	0.036 (0.047)	-	-	-
part	.034 (.080)	0.014 (0.063)	-	-	-
democracy	-.001 (.001)	-.000 (.001)	-	-	-
FHcivilib	-	-	-	.062 (.358)	-
FHpolrights	-	-	-	-.211 (.254)	
polity	-	-	-	-	.130 (.083)
lngdp1996	.758 (.369)**	.776 (.350)**	-	.654 (.405)	.811 (.396)**
openness1996	-.001 (.007)	-	-.007 (.006)	-.001 (.007)	-.001 (.007)
lnintagreement	.634 (.587)	-	.943 (.526)*	.579 (.531)	.483 (.544)
lnco2pc1996	-.598 (.408)	-.698 (.391)*	.214 (.163)	-.480 (.344)	-.599 (.364)
lnpopden1996	-.247 (.158)	-.273 (.150)*	-.159 (.132)	-.218 (.160)	-.300 (.161)*
oecd	-1.519 (.874)*	-1.060 (.741)	-.686 (.622)	-1.508 (.893)*	-1.767 (.944)*
Constant	-9.676 (4.406)**	-8.927 (3.867)**	-1.075 (.795)	-6.135 (3.689)*	-7.782 (3.214)**
Observations	84	91	89	83	82
LR chi2	24.57 (df=10)	25.73 (df=8)	12.80 (df=5)	23.06 (df=9)	26.95 (df=8)
Prob > chi2	.0062	.0012	.0254	.0061	.0007
Pseudo R^2	.3117	.3158	.1585	.2941	.3453
AIC	.908	.810	.898	.908	.842

Notes: Standard errors in parentheses. *p < 0.10, **p < 0.05, ***p < 0.01.

But as table 5 above shows, the probit regressions confirm the findings of the logistic models. Again the logarithm per capita income yields of the strongest and most consistent effect, followed by the logarithm of the number of ENGOs. And these findings are further substantiated by the LPM, which I do not report here due to limitation in space (but see annex).

7. Discussion and Conclusion

As the various statistical analyses revealed, the only independent variable with a robust significant effect on lead phase-out is the level of per capita income. Further, the second independent variable that turned out to be significant in some model specifications is the number of ENGOs. For the research questions underlying this analysis, the implications of these findings are straightforward. Although theoretically plausible, international economic and institutional interlinkage have no robust significant effects on the phase-out of lead from gasoline. Whereas the number of international agreements turned out to be weakly significant in the reduced models, the degree of trade openness constantly failed to produce significant effects. Therefore, the answer to my first research question must be "no".

As regards the weak effect of international agreements, there may be two explanations. First, international agreements strongly vary in their degree of bindingness, and in fact most of the more compulsory agreements were just signed after 1996, e.g. Resolution 99/6 "Phasing out Lead in Petrol" by the European Conference of Ministers of Transport. Second, signing such an agreement may indeed not have any substantive effect since especially developing countries often tend to pay mere lip service in these instances. The non-significance of the trade variable might further point to an omitted variable problem. To be sure, I argued that trade openness may enhance the importation of cars equipped with catalytic converters and therefore yield a positive effect on lead phase-put. Probably this link was too indirect. In fact, analysis would have benefited from a direct measurement of a country's share of cars with catalytic converters. Yet, such data was not at hand, but should ideally be gathered for future analysis. Nevertheless, the international variables still seem to be somehow relevant for the estimation models as the LR test rejected the null hypotheses that they equal zero (see annex). Here theoretical refinements are needed.

Turning to the explanatory power of the domestic factors, the varying democracy also performed poorly. Only POLITY turned out to be significant. In consequence, it can be questioned whether the different democracy measures are interchangeable as it is often assumed by comparative analysts. This observation is moreover surprising since there is indeed broad empirical evidence in support of this relationship. Since most of these studies are based on often crude proxies for environmental regulations, Neumayer's (2002) methodological critique on these kind of studies seems hold. Accordingly, of the sets of domestic variables, we can only surely confirm the hypothesis on the positive effect of income and with a higher portion of caution also the hypothesis on the impact of ENGOs. But overall the explanatory power of the domestic factors included in the models presented here is not overtly high. Accordingly, we can merely give a careful "yes" to the second research question.

Regarding the control variables, the OECD dummy has the most pronounced effect, yet with the "wrong" sign. According to the estimation results, OECD countries are less likely to phase-out lead from gasoline. This finding runs against common theoretical expectations. The other controls (except in model 3) also have a negative sign, which was not anticipated by theory neither. Hence, the higher population density and pollution intensity in a country, the less likely a government eliminates lead from gasoline.

An additional interesting finding refers to the replication of the first logit models with data from 1993. As the statistical results show, the entity of estimation models benefits from the using 1993 data. This outcome shows that it is reasonable to hypothesize a time-lagged relationship between the variables, especially when it comes to controversial issues such as the phasing-out of lead.

The overall quality of the estimation models is surely improvable. A serious limitation to the study is given by the small size of the country sample and the resulting problems for the use of Maximum likelihood procedures. In fact, the diverging significance levels of the logit coefficients and the marginal effects might be caused by problems related to the degrees of freedom. Therefore, it could be worthwhile to replicate this study with a larger country sample. An even more promising undertaking would be a re-analysis with times series data. Despite all limitations, however, this study represents a step into the right direction as it does not use proxies for exploring the determinants of environmental policy decisions.

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9. Annex

1. Correlation democracy measures

	FHpolr~s	FHcivi~b	polity	comp	part	democr~y
FHpolrights	1.0000					
FHcivilib	0.9224	1.0000				
polity	-0.9034	-0.8591	1.0000			
comp	-0.7625	-0.7534	0.8282	1.0000		
part	-0.6155	-0.6576	0.6377	0.6184	1.0000	
democracy	-0.7731	-0.8019	0.7929	0.8542	0.8315	1.0000

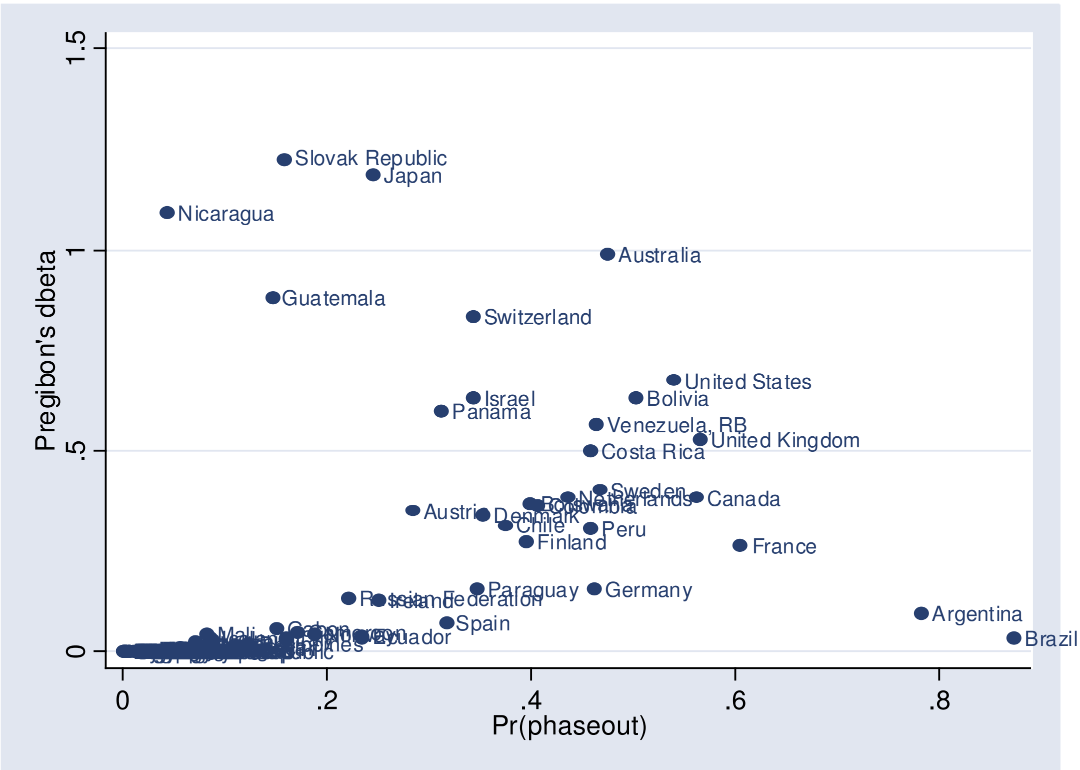
2. Testing for multincollinearity

Variable	VIF	1/VIF
democracy	14.66	0.068224
lngdp1996	6.52	0.153404
lnco2pc1996	5.34	0.187236
comp	5.26	0.190104
part	4.69	0.213326
oecd	3.61	0.276821
lnintagree~t	2.59	0.386785
lnengos1996	2.10	0.476651
openness1996	1.43	0.698978
lnpopden1996	1.06	0.941241
Mean VIF	4.73	

Variable	VIF	1/VIF
democracy	16.01	0.062446
lngdp1993	8.10	0.123470
lnco2pc1993	5.78	0.173076
comp	5.68	0.176101
part	4.94	0.202245
oecd	3.43	0.291277
lnintagree~t	2.50	0.399954
lnengos1993	1.82	0.548689
openness1996	1.36	0.736228
lnpopden1993	1.08	0.923215
Mean VIF	5.07	

3. Checking model assumptions for model 1 in tables 2 and 3

```
Model 1, table 2

Comparing standardized residuals (rs) with unstandardized ones


   Variable |       Obs        Mean    Std. Dev.       Min        Max
-------------+--------------------------------------------------------
          r |        84    -.005263    .8737244  -1.236292   4.704001
         rs |        84   -.0148907    .9499809  -1.325389   4.813469



                      Pearson residual
-------------------------------------------------------------
      Percentiles      Smallest
 1%    -1.236292     -1.236292
 5%    -.9247729      -1.13792
10%    -.7733986     -.9498049       Obs                  84
25%    -.3966495     -.9280943       Sum of Wgt.          84

50%    -.1515262                     Mean           -.005263
                       Largest       Std. Dev.      .8737244
75%    -.0370469      1.754529
90%     1.088664      2.312487       Variance       .7633943
95%     1.592258      2.426968       Skewness       2.566443
99%     4.704001      4.704001       Kurtosis       12.44952
```

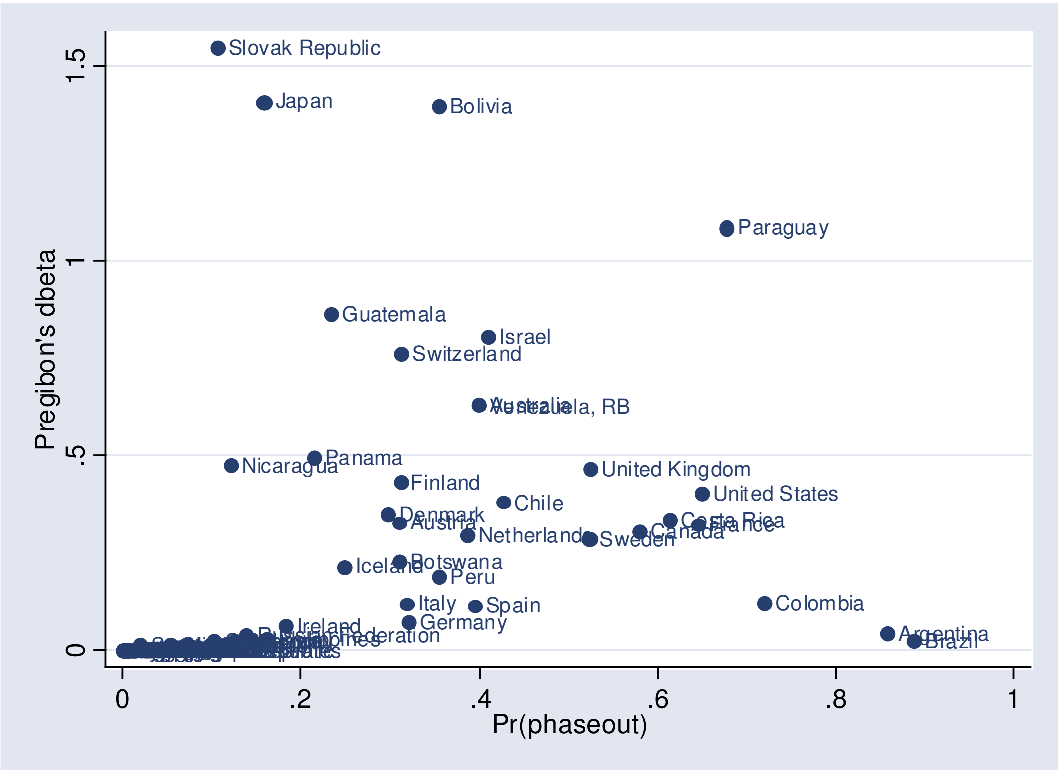


Model 1, table 3

Variable	Obs	Mean	Std. Dev.	Min	Max
r2	86	-.0195416	.7716394	-1.44864	2.901639
r2s	86	-.0295426	.8549161	-1.699468	3.123312

Pearson residual

	Percentiles	Smallest		
1%	-1.44864	-1.44864		
5%	-.8335184	-1.346779		
10%	-.7937771	-1.048124	Obs	86
25%	-.3597202	-.8625247	Sum of Wgt.	86
50%	-.1208988		Mean	-.0195416
		Largest	Std. Dev.	.7716394
75%	-.0268658	1.813535		
90%	.9550603	2.307428	Variance	.5954273
95%	1.535567	2.701496	Skewness	1.756145
99%	2.901639	2.901639	Kurtosis	6.806357



In both specifications, the Slovak Republic is the most pronounced outlier. A good way of replication the analysis would now be to eliminate this observation.

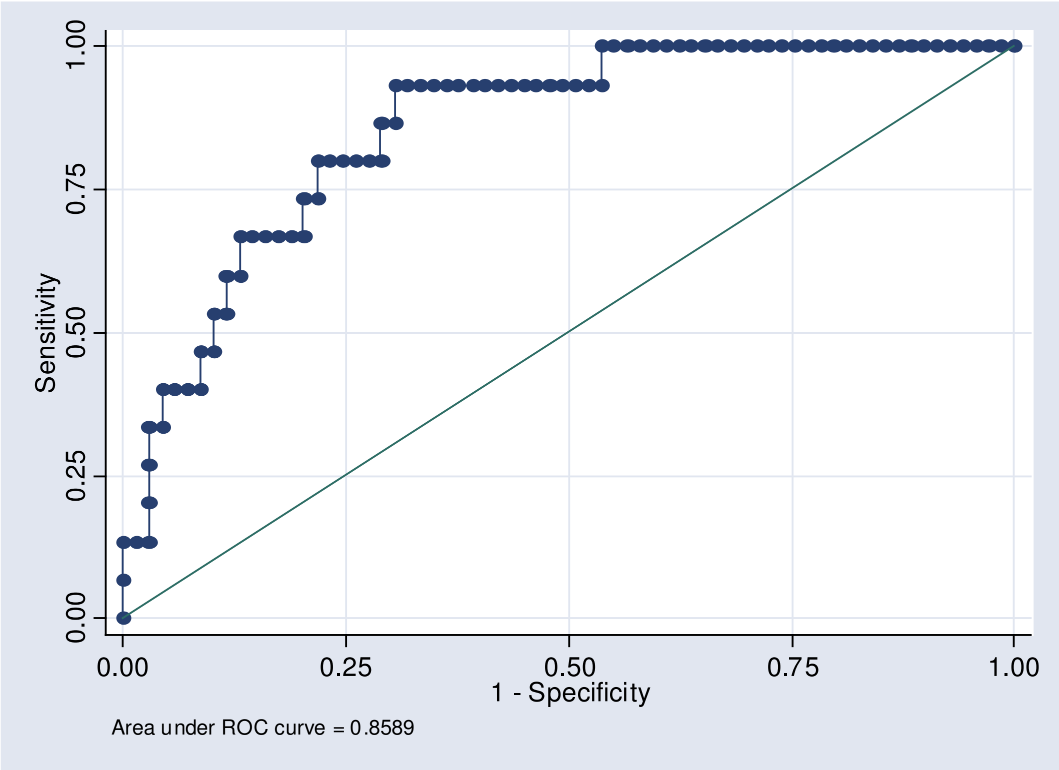
4. Goodness of fit of logistic regression model 1

With 1996 data

```
Logistic model for phaseout, goodness-of-fit test

       number of observations =        84
 number of covariate patterns =        84
             Pearson chi2(73) =        63.36
                  Prob > chi2 =         0.7822


. lfit, group (10)

Logistic model for phaseout, goodness-of-fit test

  (Table collapsed on quantiles of estimated probabilities)

       number of observations =        84
             number of groups =        10
      Hosmer-Lemeshow chi2(8) =         3.17
                  Prob > chi2 =         0.9234


. lfit, group (15)

Logistic model for phaseout, goodness-of-fit test

  (Table collapsed on quantiles of estimated probabilities)

       number of observations =        84
             number of groups =        15
     Hosmer-Lemeshow chi2(13) =         4.45
                  Prob > chi2 =         0.9854
```

In all of these tests we can accept the null hypothesis that predicted and observed values match. This is a very good result!

```
              -------- True --------
Classified |         D            ~D  |      Total
-----------+--------------------------+-----------
     +     |         5             2  |          7
     -     |        10            67  |         77
-----------+--------------------------+-----------
   Total   |        15            69  |         84

Classified + if predicted Pr(D) >= .5
True D defined as phaseout != 0
--------------------------------------------------
Sensitivity                     Pr( +| D)   33.33%
Specificity                     Pr( -|~D)   97.10%
Positive predictive value       Pr( D| +)   71.43%
Negative predictive value       Pr(~D| -)   87.01%
--------------------------------------------------
False + rate for true ~D        Pr( +|~D)    2.90%
False - rate for true D         Pr( -| D)   66.67%
False + rate for classified +   Pr(~D| +)   28.57%
False - rate for classified -   Pr( D| -)   12.99%
--------------------------------------------------
Correctly classified                        85.71%
--------------------------------------------------
```



With 1993 data

```
Logistic model for phaseout, goodness-of-fit test

       number of observations =        86
 number of covariate patterns =        86
             Pearson chi2(75) =        50.64
                  Prob > chi2 =         0.9861

. lfit, group (10)

Logistic model for phaseout, goodness-of-fit test

  (Table collapsed on quantiles of estimated probabilities)

       number of observations =        86
             number of groups =        10
      Hosmer-Lemeshow chi2(8) =         7.76
                  Prob > chi2 =         0.4573

. lfit, group (15)

Logistic model for phaseout, goodness-of-fit test

  (Table collapsed on quantiles of estimated probabilities)

       number of observations =        86
             number of groups =        15
```

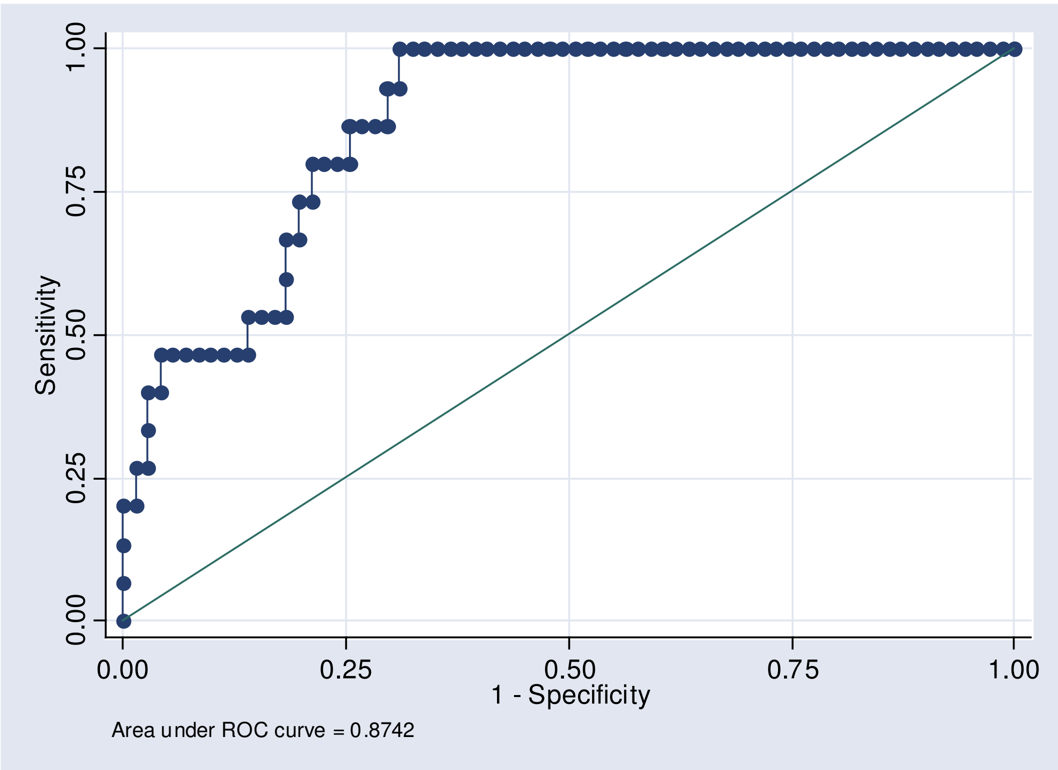
```
     Hosmer-Lemeshow chi2(13) =        10.29
                  Prob > chi2 =         0.6697
```

In all of these tests we can accept the null hypothesis that predicted and observed values match. This is again a very good result!

Classified	True D	True ~D	Total
+	7	3	10
-	8	68	76
Total	15	71	86

Classified + if predicted Pr(D) >= .5
True D defined as phaseout != 0

Sensitivity	Pr(+| D)	46.67%
Specificity	Pr(-|~D)	95.77%
Positive predictive value	Pr(D| +)	70.00%
Negative predictive value	Pr(~D| -)	89.47%
False + rate for true ~D	Pr(+|~D)	4.23%
False - rate for true D	Pr(-| D)	53.33%
False + rate for classified +	Pr(~D| +)	30.00%
False - rate for classified -	Pr(D| -)	10.53%
Correctly classified		87.21%



6. LPM

	(1) Full model	(2) Reduced model national	(3) Reduced model int.	(4) Full model FH	(5) Full model Polity
lnengos1996	.086 (.047)*	.106 (.038)***	-	.089 (.046)*	.057 (.051)
comp	.002 (.004)	.001 (.004)	-	-	-
part	.001 (.005)	-.000 (.003)	-	-	-
democracy	-.000 (.000)	.000 (.000)	-	-	-
FHcivilib	-	-	-	.030 (.065)	-
FHpolrights	-	-	-	-.036 (.047)	-
polity	-	-	-	-	.010 (.008)
lngdp1996	.131 (.061)**	.126 (.053)**	-	.135 (.068)*	.137 (.061)**
openness1996	-.000 (.001)	-	-.001 (.001)	-.001 (.001)	-.001 (.001)
lnintagreement	.106 (.110)	-	.152 (.097)	.094 (.106)	.089 (.105)
lnco2pc1996	-.079 (.056)	-.090 (.047)*	.039 (.030)	-.080 (.057)	-.076 (.054)
lnpopden1996	-.037 (.029)	-.040 (.026)	-.035 (.028)	-.042 (.030)	-.052 (.031)*
oecd	-.254 (.163)	-.149 (.132)	-.083 (.131)	-.254 (.162)	-.285 (.157)*
Constant	-.925 (.475)*	-.846 (.405)**	.233 (.170)	-.858 (.621)	-.779 (.475)
Observations	84	91	89	83	82
R-squared	.23	.23	.12	.24	.25
F	2.19 (dfs=10, 73)	2.98 (dfs=8, 82)	2.34 (dfs=5, 83)	2.51 (dfs=9, 73)	3.09 (dfs=8, 73)
Prob > F	.0278	.0056	.0488	.0147	.0046
Adj R-squared	.1253	.1497	.0707	.1420	.1713
Root MSE	.36034	.34403	.36291	.35859	.3541

Notes: Standard errors in parentheses. *p < 0.10, **p < 0.05, ***p < 0.01.

7. LR Test

Testing full model 1 against reduced model without international variables

Logistic Model (1) with 1996 variables

```
likelihood-ratio test                                 LR chi2(2)  =       1.63
(Assumption: . nested in myfull1)                     Prob > chi2 =     0.4431
```

Logistic Model (1) with 1993 variables

```
likelihood-ratio test                                 LR chi2(2)  =       3.57
```

```
(Assumption: . nested in myfull2)                         Prob > chi2 =    0.1681
```

Probit Model (1) with 1996 variables

```
likelihood-ratio test                                     LR chi2(2)  =      1.48
(Assumption: . nested in myfull3)                         Prob > chi2 =    0.4778
```

Probit Model (1) with 1993 variables

```
likelihood-ratio test                                     LR chi2(2)  =      3.36
(Assumption: . nested in myfull4)                         Prob > chi2 =    0.1862
```

In all versions of the LR test we can reject the null hypothesis that the effect of the eliminated independent variables is zero.