Winning Coalition Size, State Capacity, and Time Horizons: An Application of Modified Selectorate Theory to Environmental Public Goods Provision

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Abstract. Selectorate theory proposes that authoritarian regimes supply less public goods than democracies because, with small winning coalitions, it is relatively less costly for them to maintain support among critical groups by providing private goods. In contrast, in democracies with large winning coalitions providing public goods is the cheaper option. We argue that the effect of winning coalition size on public good provisions is conditional: many public goods require considerable state capacity to plan, legislate, and implement; moreover, leaders with short time-horizon are unlikely to invest in public goods that take considerable time to provide. Therefore, our modified selectorate theory suggests that public goods will be provided if the size of the winning coalition is large enough, state capacity is great enough, and a-priori regime durability is long enough. We test our theory on air and water pollution. While selectorate theory is not empirically supported, modified selectorate theory receives support. In particular, core democracies, defined as those with large winning coalition, considerable state capacity, and high regime stability, perform better than autocracies in controlling air pollution.

Introduction

Bueno de Mesquita, Smith, Siverson, and Morrow's selectorate theory (2003) argues that as the size of the coalition that rulers have to build to stay in power increases, they provide more public goods, because the relative price of doing so falls compared to buying support with private good transfers. This size argument follows because in principle all can benefit from the provision of any unit of a pure public good without diminishing the enjoyment that others derive from the same unit. The theory predicts that democracies will typically provide more public goods, because they have large winning coalitions. We argue that selectorate theory needs to be modified in two key respects. First, many public goods require considerable state capacity to plan, legislate and to implement if they are to be provided. Second, leaders who face potential shocks which are likely to change the rules of the political game will hardly invest in public goods that take considerable time to provide, because the expected benefits to them will be too low. Thus we suggest that all else equal, public goods will be provided if the size of the winning coalition is large enough, state capacity is great enough, and a-priori regime durability is long enough.

Bueno de Mesquita et al (2003) test selectorate theory on a variety of public goods. In their response to Clarke and Stone (2008), 31 types of public goods (or the lack of) are included in the tests, ranging from income, government spending and taxation, numerous indictors of public education and public health, to civil liberties and political rights, and to war and conflicts (Morrow et al. 2008). In principle we could test modified selectorate theory on a wide range of public goods, but for three reasons we focus on certain environmental public goods. First, complex political processes govern provision of each type of public good, which implies that more variables need to be controlled as we expand the range of public goods considered. More importantly, the effects of political processes and social economic conditions are likely to vary across different public goods.[1]

[1] In the main empirical models in Bueno de Mesquita et al. 2003 and in Morrow et al. 2008, in addition to variables directly related to the selectorate theory (winning coalition size W, selectorate size S, and loyalty ratio W/S) and the control for democracy (either by the residualization of the

We feel that in a first test of modified selectorate theory it is better to deal with a single class of public goods where an existing literature suggests what needs to be controlled for and where political processes are relatively similar, as should be the case with environmental regulation.

Second, the size argument implicitly assumes pure public goods that are fully non-rival and non-excludable. Yet, in reality, many public goods suffer from a degree of rivalness and some crowding effects. Examples include infrastructure, education, health and social welfare, considered in the existing literature testing selectorate theory. Because enjoyment of a unit of such an impure public good goes down with the number consuming it, it is not clear on purely theoretical grounds whether they actually are a relatively cheap way of maintaining support with large winning coalitions, although this might still be true empirically. Our specific focus is on air and water pollution where cleanup is not subject to crowding or rivalness, so the size argument clearly applies.[2]

Our third reason for focussing on environmental public goods is substantive. A vital question for our time is what sort of political system is best able to provide environmental public goods. There is a considerable literature, reviewed below, on whether democracies are better at providing

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Polity score or by executive constraints (*XCONST)*), a few additional variables are controlled, for example, per capita income and population size. Fixed country effects are also included for some of the model specifications. But it is unlikely that fixed effects are able to deal with all the potential omitted variable biases.

[2] Both modified and unmodified selectorate theory assume a public versus private goods trade-off while some might conceptualize environmental protection as a trade-off between two types of public goods: economic growth vs. environmental protection. Economic growth is not, in any simple sense, a public good. Much of what a given quantum of growth provides is private goods. Second, there is a direct trade-off between the environment and private goods: if the government stops an economic agent generating a negative environmental externality, for instance, by making him change his activities or pay a tax, his profit and/or consumption is reduced. Therefore, a public versus private goods trade-off is a valid theoretical framework to model environmental protection.

such goods, but consensus has not been achieved. Our paper seeks to clarify some issues by arguing that it is not democracy, *per se*, that counts. Besides having large winning coalitions, core democracies have considerable state capacity and high a-priori regime durability. We show that the environmental performance of core democracies is distinctively better for two forms of air pollution than that of other systems.

Because modified selectorate theory should apply generally over time and space, we seek observations for as many country and years as possible. Our empirical analysis follows those who have used a range of environmental indicators and a pooled research design (e.g., Li and Reuveny 2006). Another reason that we choose to focus on measures of air and water pollution is that there is good quality and relatively abundant data.

Modified Selectorate Theory and the Environment

Selectorate Theory and Public Good Provisions. Bueno de Mesquita *et al* argue that underlying observed variation between autocracies and democracies in providing a range of public goods is the size of the coalition that leaders have to build in order to continue to hold power. Based on this idea, they provide a parsimonious, unified account spanning all types of political systems over the millennia. They picture incumbent leaders and challengers vying for office by attempting to build winning support coalitions by offering tax and spending packages. Only incumbents can enjoy rents deriving from the difference between what they spend and their tax revenue. Leaders aim to maximise expected rents, which requires getting power. The selectorate is the subset of the population "whose endowments include the qualities or characteristics institutionally required to choose the government's leadership and necessary for gaining access to private benefits doled out by the government's leadership" (2003, 42). Furthermore, the winning coalition is a subset of the selectorate "who control enough instruments of power to keep the leader in office" (2003, 51). Beside the selectorate there is the disenfranchised part of the population which has no influence over the leadership selection process. Winning coalitions are of size W, drawn from a selectorate

constituted by potential members of winning coalitions, size S. S is, in turn, a subset of the populace. The values of W, S, and the 'loyalty ratio' W/S tend to vary between systems: in democracies both W and S are large; among autocracies, single party systems have small W, but may have relatively large S (Bueno de Mesquita et al. 2003); monarchies and military regimes often have small W and small S.

The theory's most significant predictions concern the level of public good provisions. The larger the size of the winning coalition the higher the relative cost of building it using private rather than public goods: public goods are jointly supplied and non-excludable, in principal everyone can enjoy the benefits from any unit provided, whereas only one citizen can enjoy a unit of a private good. The prediction is that other things equal the level of provision of public goods: increases with W; decreases with S;[3] and increases with W/S.[4] As we have already noted, it is unclear whether these predictions hold for impure public goods.

Motivating Modified Selectorate: The Case of Environmental Public Goods. Critical attention has largely focussed on whether Bueno de Mesquita *et al* convincingly demonstrate the key variable *W* performs better than standard measures of democracy in empirical tests. We return to this issue in the empirical section, focussing here on theoretical underpinnings, to which relatively little attention has been given (Gallagher and Hanson 2009). We use environmental public goods as a motivating example to develop the theory, following suggestions in the existing literature (Bernauer and Koubi 2009; Ward 2008). There is a great deal of empirical work and anecdotal evidence that this might be

[3] Spending falls with S for fixed W while the ratio of private to public goods remains constant.

[4] In equilibrium incumbents spend less both on public and private goods as W/S falls, because their existing supporters become more loyal. Challengers may *promise* better tax and spending packages to entice away some of the incumbent's supporters, but these promises are not credible because, after the transition, they are liable to build a winning coalition based on their *real* allies; and who these are is a largely unknown factor. The smaller W/S is the lower the a-priori probability any member of the incumbent's coalition would *actually* be rewarded.

fruitful. Selectorate theory implies that regimes with small winning coalitions will be especially prone to cronyism and corrupt practises as a way of transferring private goods to key supporters (Bueno de Mesquita *et al* 2003, 164-168). On theoretical grounds, when corruption is high, environmental regulation will be lax, although the effect of corruption will be less when political instability is high, because there is less incentive to bribe a government that is unlikely to survive (Fredriksson and Svensson 2003). Case studies also suggest that leaders of personalist and military regimes (typically small W systems) often directly exploit forest resources for personal gain, or corruptly benefit from others doing so. Cambodia is a classic example, where Pol Pot's regime and its successor under former Kymer Rouge general Hun Sen cooperated with Thai and Chinese logging concerns, forcing many forest inhabitants off their land (McCargo 2005). There is also strong evidence from a large-n research design for a positive relationship between corruption and deforestation (Koyuncu and Yilmaz 2009).

While selectorate theory has considerable face validity for environmental public goods, it has limitations. While private goods can be delivered to the selectorate at relatively low transaction cost through close personal ties, party apparatuses, and other connections between the ruler and key constituencies, such costs are generally higher for environmental public goods, and can become infeasible without the requisite state capacity. Providing environmental public goods requires sophisticated forms of regulation and, most notably, enforcement. Many countries that have significant bodies of environmental law on the statute book largely fail to implement the law, because of lack of regulatory capacity. For instance, this has been a notable problem in China, even though the regime has higher capacity than many developing countries (Economy 2004; Schwartz 2003). While ideas about efficient environmental regulation diffuse through international networks (Ward and Cao forthcoming), states need a degree of sophistication to make use of this information. Enforcement is the Achilles' heel of many international environmental treaties (Young 1999), and may be a particular problem for low-capacity states even if signing the treaty signals intent (Simmons 2010). Ecological modernization means uncoupling economic growth from further

environmental damage, then reversing damaging trends. *Inter alia* this requires high degrees of policy integration, sophisticated forms of environmental planning, and market intervention to provide information to consumers. If state infrastructural investment is to bear fruit in terms of environmental improvement, policies must be correctly targeted. In short, the state must have considerable scientific, bureaucratic, and implementational capacity, as well as the ability to tax (Jänicke 2002; Weale 2002; Weidner 2002).

Selectorate theory is largely a static model in which rulers maximise rents over the short-run. Bezley and Persson (2010) argue that rulers must make optimal choices about how much rent to rake off in the short run versus investment in state capacity. It would be futile for a ruler to propose a package including environmental public goods unless such investment had been made in the past, because the package could not credibly be delivered. Moreover relevant forms of state capacity are often acquired over a long period of time. (Therefore, we can treat state capacity, at least in the short-run, as exogenous.) Thus we expect that environmental public goods will be provided if W is large enough *and* state capacity is high enough. Conversely, if state capacity is low, the size of W should not affect the level of provision of public goods.

Bueno de Mesquita and Smith (2009) extend selectorate theory to allow for the possibility of revolutionary ruptures changing the rules of the game, but they maintain the assumption that supply of public goods can be altered at will and instantaneously.[5] This might be considered a modelling simplification, capturing the idea that supply can be changed rapidly compared to the potential rate

[5] In equilibrium if W is small enough the possibility of rebellion leads to reduction in public good provision, which is assumed to undercut the potential of revolutionary groups, while increasing the loyalty of the incumbent's coalition; if W is large enough public goods provision increases, which may buy out revolutionary opposition. As selectorate theory treats human and democratic rights as public goods provision, the second equilibrium rules out the combination of increased public good provision with increased repression that has often been used by autocracies in Asia (Gallagher and Hanson 2009).

of political change. Short of a full transition, when the chances of successful rebellion by a challenger are high enough, authoritarian rulers may reduce rent extraction, or even co-opt the opposition within limited forms of democracy (Gandhi and Przeworski 2006). When one part of the ruling block appeals for support outside the selectorate, negotiation may lead to relatively rapid formal institutional change, though full 'extrication' from autocracy takes time (Casper and Taylor 1996; Przeworski 1992). It is questionable whether levels of provision of complex packages of public goods can be altered as fast as rent extraction, taxation, or even some aspects of formal institutional change. It may take a considerable period of time to provide any increment in infrastructural public goods and to deliver environmental improvement. For instance it has taken decades for developed democracies to start to get to grips with air pollution, and progress is by no means uniform over pollutants and across all countries (Economic Commission for Europe 2007). A ruler will be less likely to offer public goods if she places a high probability on the rules of the game changing, which would put the possibility of future tenure into question. Rather than invest in long-run returns, she would be likely to emphasise the short-term.

Besides legitimacy we should also consider production. In selectorate theory public goods do not enter the production function, implying that rulers have no long-run incentive to invest in them due to improved future revenues (Knack 2005). Yet a range of public goods relating to public health, education, and environmental quality clearly do increase national productivity (Ambec and Lanoie 2008; Porter and van der Linde 1995). Again a ruler with short time horizons would be less responsive to increasing productivity in the long-term. Therefore, in addition to state capacity, the time horizon of the ruler is an important factor that affects her decision to invest in environmental public goods. In summary we expect that:

Hypothesis: pollution emissions will decrease with the size of winning coalition so long as state capacity and regime durability are high enough.

Modified Selectorate Theory, Democracy, and the Environment. It is widely believed outside the academic community that democracies are better placed to deal with environmental problems than

autocracies and that further democratization is a necessary condition for saving the environment. A notable proponent of this position is former US Vice President Al Gore (1992). Concern for broad democratic participation over environmental issues is built into key international statements, such as principle 10 of the 1992 Rio Declaration on Environment and Development. Over recent years a number of mechanisms have been proposed in the academic literature linking a country's regime type to its environmental performance (Li and Reuveny 2006; Ward 2008). The bulk of the proposals favour democracy. The principle reason is that democracy allows citizens to have greater influence. In a liberal democracy, environmentally concerned citizens have multiple channels to influence political outcomes through the ballot box, pressure groups, social movement activity, the free media, and local political structures (Payne 1995). Moreover, environmental pressure groups will have significant influence (Binder and Neumayer 2005), if there is enough political competition for office (Fredriksson et al, 2005). Autocracies' failure to protect human rights, on the other hand, disables environmental social movements (Barrett and Graddy 2000). Democratisation also gives a political voice to the poor, and if this helps to alleviate poverty, it may aid sustainability (UNDP, 2003, 17). Democracies educate citizens better, which may increase demand for a clean environment (Binder and Neumayer 2005). Finally, if failures of environmental policy arise, democratic politicians may be called to account (Payne 1995).

While the literature favours democracy on theoretical grounds, the evidence is much more ambiguous. Results depend on the particular performance indicators used, choices of control variables, how democracy and liberal freedoms are measured, the sample chosen, whether levels or rates of change are considered, and how outliers and special cases are dealt with (Barrett and Graddy 2000; Binder and Neumayer 2005; Bättig and Bernauer 2009; Bernauer and Koubi 2009; Congleton 1992; Fredriksson *et al* 2005; Gallagher and Thacker 2008; Grafton and Knowles 2004; Midlarsky 1998; Scruggs 2009). While a consensus exists that democracies are more prone to make international environmental commitments (Bernauer *et al* 2010), it is questionable whether this always translates into improved environmental outcomes (Bättig and Bernauer 2009).

The ambiguities may partly arise from the close to total neglect of supply-side factors in this literature (but see Congleton 1992). According to our hypothesis it is core democracies with large winning coalitions, considerable state capacity and regime stability that should perform better than other systems, other things equal. These factors reflect supply-side considerations. Of course supply side and demand side arguments cannot be rigidly separated, because it would be irrational for rulers to provide public goods for which demand is relatively weak. If democracy delivers what the average voter wants most, it may deliver unsustainable economic growth (Midlarsky 1998), so wise democratic leaders might attempt to change citizens' views so the environment becomes a higher priority (Gore 1992). However, supply-side considerations should still intervene. It would not be rational for leaders to attempt to create demand if it is costly to meet it. Our theoretical and empirical focus is on the supply side, unlike the bulk of the literature on autocracy, democracy and the environment, although we do also consider demand side factors.

Measurement and Estimation Strategy

Size of Winning Coalition. Bueno de Mesquita *et al* (2003, 134-135) assign the lowest score to military regimes on the assumption that military regimes have particularly small *W*. The value of *W* goes up by a fixed amount if the executive is not chosen by heredity or in rigged or in unopposed elections. An additional increment is added if the executive is not recruited from a group based on heredity. If there are relatively stable groups that regularly compete for political influence, W is also increased. Their data on *W* only extends to 1999. We extend it to 2005 using Cheibub, Gandhi, and Vreeland's (2009) coding of military regimes and Polity IV data (Marshall, Gurr, and Jaggers 2010). We recalculated *W* using Cheibub, Gandhi, and Vreeland's coding throughout, for consistency. Over the cases where the two measures of *W* are available the correlation between them is .94 (n = 5875).[6]

[6] To make sure that the empirical support for our theory is not a function of an extension of the winning coalition size data, we re-ran all our models based on Bueno de Mesquita *et al.'s* original

Table 1 and 2 provide basic descriptive statistics and correlations for the variables used in the main text of the paper.[7]

Table 1 and 2 about here

State Capacity. There are several alternative measures of state capacity in the literature, but all of them tend to focus on tax or government expenditure data to ensure wide coverage and comparability (Ties 2010). Arbetman-Rabinowitz and Johnson (2007) view states' relative political capacity as the 'the ability of a government to extract resources from a population given their level of economic development' (2007, 2). The capacity measure is accordingly the ratio of the actual level of tax extraction to a predicted level of extraction. A government is relatively efficient if it can extract more than might be predicted. Predicted levels are a function of per-capita GDP and the size of extractive industries like oil production and mining which are relatively easy to tax. For poor countries the size of the agricultural sector is also deemed to affect predicted ability.[8] The measure *capacity* depends on the size and the sign of residuals: large positive residuals betoken relative efficiency.

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data. The results are almost the same (both short-term and long-term effects). These results are available upon request.

[7] Selectorate theory makes some distinct predictions for the ratio of the size of the winning coalition and the selectorate. We focus on the size of the winning coalition because the correlation between *W* and *W/S* is so high that it is not possible to distinguish the effects empirically: with our extended coding the correlation is .9968 (n = 7246); with Bueno de Mesquita *et al.'s* original coding it is .9963 (n = 5784).

[8] The specific variable we use is *rpc2*, which controls for agriculture and energy production but not mining, for which data is lacking for many authoritarian systems.

At first sight states' relative capacity to extract is not the most obvious proxy for their relative ability to plan and to execute programmes to provide public goods. However, Besley and Persson's (2010) model indicates investments in fiscal capacity and legal capacity, within which they include the capacity to make infrastructural investment, will be positively correlated, because they are compliments in producing greater expected returns to office holding. Besley and Persson discuss much evidence that broadly supports this correlation. So we expect on theoretical grounds that fiscal capacity will be a good proxy for states' ability to provide public goods. Empirically, the bureaucratic and administrative capacity of the state, which we think is the key to states' ability to provide public goods, is often measured either by using surveys relying on estimates of states' revenue-generating capacity (Hendrix 2010). Survey-based approaches suffer from low temporal and spatial coverage compared to relative political capacity. Measures of capacity such as the total tax to GDP ratio and the total revenue to GDP ratio are often endogenous to other factors such as the level of economic development and economic structure.

Regime Durability. We argue that, in general, leaders will not provide public goods if they place a high a-priori probability of being out of power by the time that the public goods or their beneficial knock-on effects are provided. Further, we suggest that this probability will increase if the rules of the game have changed substantially and recently. To capture this we use the Polity IV regime durability measure which captures the length of time since a three point change in the Polity score over a three year period (Marshall, Gurr, and Jaggers 2010). Clearly *durability* does not capture the chances of losing power *within* a fixed set of rules of the game.[9] Bueno de Mesquita *et al.*'s models predict that the average tenure of leaders will go up with *W/S*, and they provide evidence supporting

[9] It is difficult to measure leader's time horizon directly. We use regime durability based on the assumption that for leaders, the chances of being kicked out of the office tend to increase if the rules of the game have changed substantially and recently. Democratic leaders risk losing office every few years, but the fact that the rules of the game stay the same increases their time horizon given the chance of re-election (of their parties if not themselves).

this contention. If tenure is endogenous, it is methodologically advantageous to focus on something distinct: regime durability.

Two and Three Way Interactions. Our hypothesis is that provision of environmental public goods will increase with *W* as long as regime capacity and regime durability are high enough. To test this we need to include interactions between *W* and *capacity* and *W* and *durability* in the model, alongside each of these three variables. We also include the three-way interaction between these terms, as we expect the modifying effect of *capacity* and *durability* on *W* to be synergistic. In fact we employ a fully interactive model (Kam and Franzese 2007) also including the interaction between *capacity* and *durability*, given the possibility that these variables count *independent of* the level of W: actors like bureaucrats may have some influence over public good provision independent of the logic of survival facing leaders, relating to their own interests, capacity to deliver, and likely tenure.

Control Variables. The Environmental Kuznets' curve posits that the environment is a relatively low priority for citizens in the early stages of development, but it becomes a higher priority as they become better off (Grossman and Krueger 1995). The evidence suggests that this argument does not hold for all pollutants, for all types of political system, or for all regions (Cole and Neumayer 2005). Where it does, a combination of demand factors and changing industrial structure is probably at work. Nevertheless it is important to control for relative demand for environmental public goods, even if is not really possible to proxy the level of demand among the selectorate. Because of lack of cross nationally comparable data on demand, income is the best available proxy.[10] We include real

[10] Given that it rests on demand-side theoretical arguments, it is notable that the empirical literature on autocracy, democracy and the environment mostly fails to control for the level of demand and for the interaction between demand and measures of democracy (Ward 2008). To test demand-side arguments we need data on whether the public is willing to sacrifice economic development and personal income for environmental improvement across a sample of cases. The World Values Survey (WVS) is the best available source, but country and temporal coverage is limited, and it has proven difficult to trace demand-side effects using this data (Ward 2008). Where WVS data is

GDP per-capita calculated using the Laspeyres method from Penn World Tables version 6. 2 (Heston, Summers and Aten 2006). We took the natural log of this variable. To allow for possible non-linearities, we also included the square term, $GDP\ per\ capita^2$. Rapid economic growth may generate forms of environmental damage that are hard to cope with in the short-term, e.g., the current situation in China (Economy 2004). We include *GDP growth* – the annual rate of growth of GDP from the World Bank's World Development Indicators.

Several air pollutants are generated by burning fossil fuels, e.g. sulphur dioxide (SO_2) is generated from burning coal and oil containing sulphur. Other things equal the higher the price of fossil fuels the lower emissions ought to be. It is hard to get consistent time series data on coal and natural gas prices, but changes in these correlate with changes in oil prices because they are partial substitutes. The longest consistent time series data on oil prices is an index of the 2010 dollar price of Illinois crude oil at the production pump, *Real oil price*.[11] This correlates strongly with other series that exist for shorter time periods such as the real price of Saudi Arabian crude.

Selectorate theory adopts a parsimonious approach in which rulers' only motive is to maximise the expected surplus they can extract from society, though allowance is made for idiosyncrasies such as spending parts of the surplus they extract in public-spirited ways. Yet rulers' motives could systematically intervene in the logic of political survival in ways that have consequences for important choices like going to war (Weeks 2011). Such preferences also influence the relative provision of different public goods. We focus on communist regimes, where our theoretical priors

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available, it suggests that those willing to sacrifice their personal income for a better environment no longer necessarily constitute a majority, even in developed countries, and that support has weakened in many countries. For instance in Austria this percentage dropped from 48.5% to 37.0% between 1990 and 1999 and in Canada it dropped from 62.8% to 57.0% between 1990 and 2000 (WVS 2009).

[11] See www.ioga.com/Special/crudeoil_Hist.htm, downloaded December 2010.

are strong.[12] Communist regimes have often adopted a progressivist perspective based on Marx and Engels' idea of the road to communism as represented by Lenin's (1965 [1920]) dictum that "Communism is Soviet power plus the electrification of the whole country." In practice, communist regimes tended to construe development of the forces of production as building heavy industry, mining, and massive irrigation and hydro-electric projects. The case-study literature finds it difficult to disentangle this ideology from other variables such as relative under-development, yet it is frequently held to be one factor lying behind such problems as heavy air and water pollution in the Soviet Union (Oldfield 2005). Beside ideology, it is commonly held that Soviet central planning was wasteful of resources because inputs and use of pollution sinks came unpriced to enterprises bent on short-term plan fulfilment, which also led to under-investment in cleaner plant (Ericson 1991). We generally found little reason to include other controls in a fixed-effects estimation framework. However, we provide an online appendix mainly devoted to robustness checks.[13]

[12] We suspect that leaders' preferences also vary across other authoritarian regime types in ways consequential for public good provision. For instance, if military regimes are less stable and their leaders are prone to short-term personal aggrandizement (Geddes 2004), they may over-exploit renewable and non-renewable resources, as in the case of military regime's exploitation of gemstones and forests in Myanmar (Myint 2007). If they prefer high spending on military activities, this impacts the environment as the carbon footprint of the military is high (Jorgenson, Clark, and Kentor 2010). We provide models controlling for these regime types in an online appendix.

[13] Here we report models controlling for the effect of democracy by including Polity scores because Clarke and Stone (2008) argue that the empirical power of selectorate theory largely evaporates once democracy is properly controlled for (see Morrow *et al* 2008 for a rejoinder; also Kennedy 2009). Note that selectorate theory also predicts *W* will vary systematically with regime type. We therefore control for different regime types (e.g., single party, monarchy, military, and personalist regimes). None of these specific regime types systematically affects pollution and the Polity score only

Estimation Strategy. We estimate models with fixed country effects. Though this leads to lower efficiency, it is a conservative strategy when there is a possibility of estimation bias due to uncontrolled institutional factors correlated with independent variables. For instance, the rule of law may correlate with W, but it is doubtful whether commonly used measures such as Transparency International's specifically capture environmental enforcement; so country fixed effects are necessary to avoid biased inferences. We include lagged dependent variables. Our dependent variables are likely to take years to respond to changes in political structure, because of the time taken to build and implement programmes (Gallagher and Thacker 2008). Thus dynamics are of central interest here. In effect, including the lagged dependent variable results in the estimation of a geometric lag on our central variables *W*, *durability*, c*apacity* and their interactions so that observations become less influential with time.[14]

Models with both fixed effects and a lagged dependent variable might be problematic: the lagged dependent variable is correlated with the error term by its correlation with the time-invariant component of the error term. When country fixed effects are included, "Nickell bias" results because the lagged dependent variable is still correlated with the error term. However, Kiviet (1995) shows that panel data models that use instrumental variable estimation often lead to poor finite sample efficiency and bias. Adolph, Butler, and Wilson (2005) show that Nickell bias is often negligible and suggest that all remedies (e.g., Anderson-Hsiao or Arellano-bond) are worse than the original problem. As the number of years gets larger, this bias becomes less of a problem. We have data with relatively large T: 43 years for sulphur dioxide, 15 years for particulates, and 23 years for bio-chemical oxygen demand.

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predicts SO2 emission levels. Our basic findings on the conditional effects of state capacity and regime duration do not change.

[14] Gallagher and Thacker (2008) use a democracy stock variable (the sum of annual observations of Polity 2 scores) after applying a fixed time discount parameter. Other specifications might involve lagging the political variables then allowing influence to decay.

Statistical Results

Even if the logic is for the ruler to provide more public goods, the question is what sort of public goods? Specifically the relative demand for different public goods among members of actual or potential winning coalitions, S, ought to matter. Besides attempting to control for demand by including real income, we can bring to bear what we know about the immediacy of environmental problems. Rulers should be relatively disinclined to use scarce resources on problems like climate change where action in one country is not sufficient to bring about marked change in outcomes and benefits are long-term and uncertain, although they might adopt relatively low-cost policies. This is the theoretical reason why we do not choose to model greenhouse gas emissions (for example, CO2) despite the existence of data with good quality and coverage. We focus on major air and water pollutants with potentially grave and immediately perceptible health effects and for which relatively abundant data exist: sulphur dioxide (SO2) and particulates for air pollution and bio-chemical oxygen demand (BOD) for water pollution.[15]

Sulphur dioxide emissions. SO2 is a serious air pollutant, implicated in: i) ground-level smog and haze; ii) associated damage to human health; iii) reduced agricultural productivity and; and iv) acid deposition (Hill 2004). Around two-thirds of emissions result from fossil fuel-burning electricity generation, particularly from burning of high-sulphur content coal. In developed countries the trend has been towards reductions in emissions due to changes to less sulphurous fossil fuels, deindustrialization, domestic legislation (e.g., the US Clean Air Act of 1973), pollution control

[15] Some have used aggregated sustainability measures (Li and Reuveny 2006; Jorgenson *et al* 2010) which have the advantage of addressing broader questions, but at the cost of considerable measurement problems and dangers with aggregation bias. The advantage of considering international commitments (Bättig and Bernauer 2009) or specific policies (Ward and Cao forthcoming) is that we are more likely to observe clear differences between regimes. However, international commitments are often undemanding and policies fail to get implemented as rulers see no advantage in going beyond political symbolism.

technologies encouraged by regional arrangements (e.g., the 1988 EU Large Combustion Plant Directive), and the international Convention of Long-Range Transboundary Air Pollution. However emissions are still increasing in rapidly growing developing countries like China and India. We use Stern's (2005) data on SO2 emissions, in logged kilograms per-capita, per year.

The first two specifications in Table 3 present estimates from models for SO2 emissions. Model 1 tests for unconditional effects of the winning coalition size (*W*), thus it excludes interaction terms. The mean estimate of the coefficient is positive, suggesting that larger *W* is associated with greater emissions – the opposite of what selectorate theory predicts. But this estimate is far from being statistically significant (indicated by its p-value). In the second model we added interaction terms to test whether modified selectorate theory is supported. Before discussing the conditional effects of state capacity and regime duration, it is worth noticing that in both models, there is quite strong evidence for an Environmental Kuznets' Curve (*GDP per capita* and its square term). Moreover, *GDP growth* is associated with higher emissions while urbanization (*Urban population (% of total)*) seems to reduce emissions. Interestingly, the communist regime dummy variable has a significant positive coefficient in the first model; but this result is not robust to the inclusion of state capacity, regime duration, and the interactive effects in the second model.

Table 3 about here

In models with interaction terms, it is well known that not only the marginal effect but also the associated standard errors vary with the value of other lower-order variables. In other words, it is hard to get a sense of the conditional effects by looking at coefficients and standard errors only. In Figure 1(a), we show the marginal effects of winning coalition size and associated 95% confidence intervals, conditional on regime duration, across four different levels of state capacity – the 20^{th}, 40^{th},

70th and 90th percentiles based on the full sample values of state capacity.[16] The vertical lines correspond to 10 and 20 year durability. The four sub-figures look similar: for the first three where state capacity is at low/medium levels, the effect of winning coalition size on SO2 emissions is only positive at the very low end of regime duration, and then only barely so. Detailed inspection of 95% confidence intervals show that once the regime lasts more than 2 years, any positive effect becomes undetermined. For countries with high state capacity (e.g., the fourth sub-figure), the effect of *W* on SO2 emissions is never both positive and significant. For all four sub-figures, once the regime lasted more than 20 years, the effect of *W* is negative and also statistically significant; the longer the regime has lasted, the greater the negative effect of *W*. These findings illustrate the strong conditional effect of regime duration on winning coalition size's relationship with SO2 emissions.

Figure 1 about here

Figure 1(b) shows the marginal effects of winning coalition size conditional on state capacity across four different levels of regime duration, respectively the 20th, 40th, 70th and 90th percentiles. Vertical lines correspond to political capacity of 1 and 2. The four sub-figures clearly demonstrate that the conditional effect of state capacity changes across different levels of regime duration. For regimes that have not lasted long (the first (2 years) and the second (8 years) sub-figures), *W* has no statistically significant effect on emissions regardless of the level of state capacity. However, for relatively long lasting regimes such as those represented by the third (24 years) and the last (53 years) sub-figures, we see statistically significant and negative associations between *W* and emissions up to relative political capacity values of around 2 or 3. Note, however, that relative political capacity rarely exceeds 2 (See Table 1: the mean of relative political capacity is 1 with a standard deviation of 0.52); and the lack of observations beyond this value explains why the 95%

[16] We follow Brambor, Clark and Golder (2006) in displaying the marginal effects in interaction models.

confidence intervals include 0 for high levels of state capacity in these two sub-figures. Moreover, the slopes of the dark lines (i.e., the mean coefficients estimated) suggest that this negative effect becomes more important with increasing state capacity: for regimes that last relatively long, large winning coalition size reduces emissions and this negative effect becomes stronger with increasing state capacity. In sum, for SO2 emissions, Figure 1 lends support to our first hypothesis that the effect of the winning coalition size on pollution is conditional on state capacity and regime duration. Moreover, the conditional effect of regime duration seems to be more dominant than that of state capacity as suggested by Figure 1(a): for non-extreme values of state capacity (20^{th} to 90^{th} percentiles), as long as the regime lasted more than 20 years, winning coalition size (*W*) always reduces emissions.

As Scruggs (2009) argues, much of the environmental political economy literature fails to go beyond consideration of immediate effects. The models estimated here include the lagged dependent variable, because we do not think that shocks to the political variables are likely to have their full impact in one year. If changes in the nature of the political system are to have an effect, we would not expect this to occur within a single year; therefore, to fully appreciate the effects of winning coalition size, regime duration, state capacity, and their interactions, we need to look at least at the medium term. However, the mean coefficient estimate of an independent variable, say, $\hat{\beta}$, in a model with lagged dependent variable only captures the short-term effect. The mean long term effect is $\frac{\hat{\beta}}{1-\hat{\varphi}}$, where $\hat{\varphi}$ is the mean coefficient estimate for the lagged dependent variable (De Boef and Keele 2008). It is hard though to calculate the confidence intervals for the long-term effect directly, especially in our case where 3-way full interaction terms are involved. To investigate dynamics, we carried out simulations of predicted values as advocated by Williams and Witten (2008). To make the results graphic, it is best to think in terms of more familiar categories rather than three interval level variables (W, state capacity and time horizon). We use four categories of political system designed to speak to the debate on democracy, autocracy and the environment. In scenario 1 we set

W, *capacity*, and *durability* at their 80th percentile level among democracies in our overall sample. We call these cases core democracies (large *W*, durable and high in state capacity, e.g. the UK and Sweden). In scenario 2 we set the three main variables at their mean values across democracies (average democracies). In scenario 3 we set the three main variables at their mean value among autocracies (average autocracies). Finally in scenario 4 we set the three main variables at the 20th percentile level for autocracies: these are fragile autocracies with small winning coalition, subject to recent regime change and with low state capacity (e.g., Myanmar and the Republic of the Congo for some years).[17] We set values of other variables at their sample mean among valid cases, with the exception of communist regime variable where values reflect the scenarios.[18] In particular, we construct scenarios to hold the level of economic development constant. In all four simulations we set the starting value of the lagged dependent variable at its mean value in the valid sample.

Results are shown in Figure 4(a). The central estimates (solid dark dots) and 95% confidence intervals (vertical lines) are shown for predicted values under all four scenarios.[19] We see in all scenarios emissions slowly decline and stabilize around year 20. In scenarios 3 and 4, emissions are barely statistically distinguishable, so fragile autocracies do not perform significantly worse than average autocracies. In scenario 2, emissions fall to a lower level than those in scenarios 3 and 4, but the 95% confidence intervals overlap. What stands out is scenario 1, core democracies, whose performance is significantly better than average democracy after the first decade. The idea that democracies perform better in relation to SO2 pollution is often found in the literature (Barret and

[17] We define democracies and autocracies by their Polity2 scores as follows: democracies ≥ 6 and autocracies ≤ -6 (Marshall, Gurr, and Jaggers 2010).

[18] In scenarios 1 and 2 communist = 0; in scenarios 3 and 4 communist is set at their mean values (i.e. frequency among autocracies in the valid sample).

[19] Notice that with predicted values the uncertainty surrounding the lagged value of the dependent variable is not carried forward when calculating confidence intervals (Williams and Witten 2008), as would be the case if we reported forecasts.

Graddy 2000; Esty and Porter 2005). But our simulation suggests that it is the core democracies that behave significantly differently from other regimes, including average democracies.

Particulates. Particulates may comprise mixtures of a number of substances including sulphates, nitrates, metals, dust, and biological matter. Major sources are dust from farms, mines and roads. Burning fossil fuels contributes most to smaller, more damaging particulates (Hill 2004). Particulates are implicated in a number of problems: ground-level smog and haze, especially in urban areas; damage to human health, especially from the smallest particles lodging in lungs and even reaching the bloodstream, associated with exacerbation of heart-disease and with lung cancer. There has been considerable regulatory action, e.g. 1997 measures by the US Environmental Protection Agency under the Clean Air Act and measures under EU directives in 1996 and 1999. We focus on the density of suspended particulates less than 10 microns in diameter, in logged micrograms per cubic metre, *pm10*. We use data taken from World Bank Development Indicators for 1990-2005.

We also present two model specifications in Table 3, one to test the unconditional effect of *W* and the other for the modified selectorate theory. For both models, we find that *GDP growth*, *Real oil price*, and *Urban population (% of total)* are associated with lower emissions. Again, *Communist regime* is associated with higher levels of emissions, but the relationship is not robust to the inclusion of the interactive effects in the second model specification. We also only find evidence for an Environmental Kuznets' Curve in the first model specification. Figure 2(a) shows the marginal effects of winning coalition size conditional on regime duration across four different levels of state capacity chosen at the 20^{th}, 40^{th}, 70^{th} and 90^{th} percentiles. For all four sub-figures, the mean estimates of the effect of W on particulates become more negative with increasing levels of regime duration. These negative effects become statistically significant in the last sub-figure where state capacity reaches a relatively high level: only when state capacity is high (e.g., in last sub-figure where *Relative state capacity* = 1.65), does winning coalition size reduces emissions after the regime

lasted more than about 45-50 years;[20] moreover, this negative effect gets stronger as the regime lasted longer. Figure 2(b) looks at the interactive effects from the other angle: the marginal effects of winning coalition size conditional on state capacity across levels of regime duration also chosen at the 20th, 40th, 70th and 90th percentiles. The four sub-figures clearly demonstrate that the conditional effect of state capacity changes across different levels of regime duration. When the regime is very short-lived, as in the first sub-figure when regime duration =2 years, *W* is associated with greater emissions once state capacity reaches a relative high level, and this positive association between *W* and particulates becomes stronger with higher level of state capacity. One explanation might be that for short-lived states, leaders with short time horizon might only care about current gains; strong state capacity helps them to extract resources from the society as quickly and as extensively as possible, so the incentive to provide environmental public goods would be very small. However, the mean effects of *W* on particulates shift from positive to negative with increasing regime duration (moving from the first to the last sub-figure). Ultimately for relatively long lasting regimes such as those represented by the last (53 years) sub-figure, we see a statistically significant and negative association between *W* and emissions; moreover, the negative association becomes stronger with increasing level of state capacity even though this relationship loses its statistical significance after capacity reaches around 4. In sum, we find that the case of particulates strongly supports our hypothesis that *W* only reduces pollution when both state capacity and regime duration are high enough.

Figure 2 about here.

[20]Examples of countries with relative political capacity larger than 1.65 and with a political regime that has lasted more than 45 years include Belgium, Ireland, Israel, Italy, New Zealand, and United Kingdom.

Figure 4(b) further illustrates the long-term effects of *W*, state capacity, and regime duration by comparing the four scenarios discussed in the previous section: core and average democracies as well as average and fragile autocracies. We see in all scenarios emissions increase in the first few years and stabilize after around year 10. In scenarios 3 and 4 emissions are barely statistically distinguishable: fragile autocracies do not perform significantly worse than an average autocracy. In scenarios 2, emissions do not rise to as high as in scenarios 3 and 4, but 95% confidence intervals still largely overlap. Core democracies, on the other hand, perform significantly better than average and fragile autocracies. Core democracies also seem to do better than average democracies, but there is a little overlap between their 95% confidence intervals. The simulation exercise seems to suggest that the core democracies behave differently from other regimes, especially when compared with autocracies.

Bio-chemical oxygen demand. Organic matter entering rivers and lakes is decomposed by micro-organisms, and their activity depletes the oxygen dissolved in the water. Beside natural flows of organic matter, there are flows from sewage discharge and from industrial processes like paper production. These flows push up bio-chemical oxygen demand, and in the extreme can lead to the water becoming hypoxic and unable to support life (Hill 2004). The measure we draw from World Bank Development Indicators is based on the standard test for this form of environmental stress, bio-chemical oxygen demand in kilograms per-day, per-capita (BOD, also logged). This is, then, a measure of anthropogenic organic pollution of waterways.[21] Besides putting stress on eco-systems, the discharges may be a problem for human health, as is the case when pathogenic organisms are discharged in untreated sewage in water-courses which poorer people depend on for drinking water. These forms of water pollution have long been a target for environmental regulation in most countries, but investment in secondary sewage treatment is expensive even for developed countries.

[21] Inorganic pollution, e.g., run-off of nitrates and phosphates from agriculture, may also deplete oxygen, but we know of no internationally comparable data.

Figure 3 about here.

Looking at the last two model specifications of Table 3, there is some evidence for an environmental Kuznets' curve, but only for the model without the interactive effects. We also find that *GDP growth* and *Communist regime* are positively associated with BOD discharges. There is no evidence for the unconditional effect of *W*. Figure 3 displays the way the coefficient on *W* changes for different values of *capacity* and *durability*. The coefficient on *W* is not significant for any combination of the conditioning variables in the figure. The coefficient decreases with regime durability and with state capacity when regime duration is low (first and second sub-figures of Figure 3(b)) but *increases* with state capacity when regime last relatively long (the last two sub-figures). But none of the effects are statistically significant. There is little support for our hypothesis here. Figure 4(c) shows a dynamic simulation for per capita BOD over our four standard scenarios. Levels under the four scenarios are not statistically distinguishable at conventional levels. Other things equal, core democracies do not differ significantly.

Figure 4 about here.

Conclusion and Discussion

Selectorate theory is derived from a well-specific formal model, is very parsimonious in terms of the number of key variables, and is in principle able to explain variance in the provision of a wide range of public goods. Despite the power of this approach, we argue that selectorate theory needs to be modified by furthering modelling the conditional effects of state capacity and time horizon, to the extent that the public good requires strong state capacity to provide and can only be provided with long lead times. Without undue additional theoretical complexity this should extend the empirical domain of application of the approach, as we have demonstrated here. Over the pollutants we consider, our theory outperforms unmodified selectorate theory and receives empirical support from

analyses of both sulphur dioxide and particulate pollutions. Simulation exercises demonstrate that core democracies --- those with large winning coalition, considerable state capacity, and high regime stability, can be predicted to perform better in the medium and long term in relation to these two pollutants.[22] This result will be of considerable interest to those concerned with the debate about democracy, autocracy and the environment.

We find no evidence for modified selectorate theory in the case of water pollution, though there is no empirical support for the unmodified selectorate theory, either. One possible explanation is that demand for cleaning up water pollution is not necessarily as strong as that for cleaning up air pollution. Given adequate facilities, clean drinking water and good sanitation can be provided even if rivers and lakes are highly polluted. While air pollution is difficult to avoid, richer members of the selectorate may be able to get access to clean water and sanitation. Moreover, the difference in the ways that governments finance water vs. air pollution regulation also affects the incentives of the selectorate and eventually of rulers. Selectorate theory assumes that public goods provision is funded out of taxation. While the bulk of the costs of environmental regulation will eventually fall on citizens, much of this may not be in the form of taxation. For instance, consumers paying a higher price for electricity because of air-pollution regulation will not necessarily be aware what proportion of the price they pay is due to regulation (they may not even be aware of the legislation). Where costs to citizens mostly do not take the form of taxes or charges by the state, as in the case of air pollution, the *political* costs to rulers will be lower. On the other hand, despite some movement towards privatization of the water industry since the late 1980s, the bulk of it is still state owned.[23] If

[22] These basic findings are robust to the further inclusion of regime type variables (see the online appendix) and to the exclusion of the Northern European countries such as Norway, Sweden, Denmark, and Finland (detailed results available upon request from authors).

[23] In the 20th century the water industry was predominantly publicly owned. Starting in the late 1980s there were a handful of out-and-out sales of the industry to the private sector; but a far commoner pattern was public-private partnerships (PPPs) whereby state-owned capital assets were

charges increase because the industry cleans up sewage before it enters watercourses, it is more likely in the case of water pollution that citizens will attribute those costs to state actions and perceive themselves as paying for the cost; so other things equal, rulers are less likely to regulate in the case of water pollution. The lesson we draw from the water pollution case is that selectorate theory would be strengthened by systematic thinking both about cost incidence and relative demand. While it is likely to prove difficult to obtain comparable data on these factors across countries, headway may still be made using variance over-time within countries, or by choosing a range of dependent variables which, on theoretical grounds, can be assumed to differ across these dimensions.

As the first study to modify selectorate theory to allow for state capacity and time horizon, we feel we were justified in examining a relatively narrow range of public goods in depth, especially as environmental public goods have not been considered before in the selectorate literature. However, it is important that future research should go beyond this to consider other types of public goods. To carry things further, we think more thought will be required to establish that for impure public goods relative costs of buying support compared to private transfers do fall with coalition size. This will require simultaneous consideration of crowding and externalities, the technology of supply of the good concerned, and economies of scale in its provision (Sandler 1992). Selectorate theory could also consider the advantages to rulers of providing club goods, in joint supply but only to specific members of the selectorate to whom the ruler wants to grant access, e.g. national parks in developing countries yielding profits to elites through tourism at the cost of displacing poor people (Adams and Hutton 2007). Another possibility is spatial targeting of public goods when key members of the selectorate are located in identifiable areas, e.g. the Chinese government tends to clean up industrial air pollution where there is a significant local protest in important cities (Tilt 2007). Finally co-production of public and private goods (Sandler 1992) provides potential

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run by private corporations (Marin 2009). It is difficult to put a precise figure on the spread of PPPs, but one recent estimate is about 10% of the market in cities of over 1 million people (Hall and Lobina 2008).

additional leverage to rulers by weakening the trade-off between supplying public and private benefits, e.g. corrupt placement of contracts with cronies to build public roads (Kenny 2006).

Our results focus on "bottom line" impact on the biosphere. Behind this impact there should be a traceable causal chain of government decisions and induced changes in behaviour (Underdal 2002). We do not drill down into the causal mechanism linking regime type with overall supply of environmental public goods. Lack of impact may disguise action by rulers, because of lags in "bottom line" response and because aggregation may render particular policies invisible. To fully test the credibility of modified selectorate theory, future empirical research should do more to access these causal mechanisms, both for environmental and for other public goods.

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TABLE 1. Summary statistics based all available observations.

	N. obs	Mean	SD	Min	Max
SO2 per capita (kilograms, after taking logarithm)	6447	1.84	1.68	-5.41	6.74
PM10 per M^3 (micrograms, after taking logarithm)	2775	3.91	0.69	1.87	6.12
BOD per capita (kilograms, after taking logarithm)	2266	0.47	1.14	-5.74	2.56
Winning coalition size	7264	0.58	0.31	0.00	1.00
Regime durability (years)	6121	21.52	28.06	0.00	196.00
Relative political capacity	5934	1.00	0.52	0.00	6.95
GDP per capita (constant $, after taking logarithm)	6821	8.43	1.13	5.03	11.62
GDP per $capita^2$ (constant $, after taking logarithm)	6821	72.41	19.34	25.33	135.09
GDP growth (% of GDP)	6546	3.84	6.56	-51.03	106.28
Real oil price (constant $)	8924	35.84	19.32	15.93	99.11
Urban population (% of total)	8924	46.58	24.59	2.00	100.00
Population density (people per sq. km)	8486	206.70	975.09	0.10	16317.80
Communist regime	8924	0.13	0.34	0	1

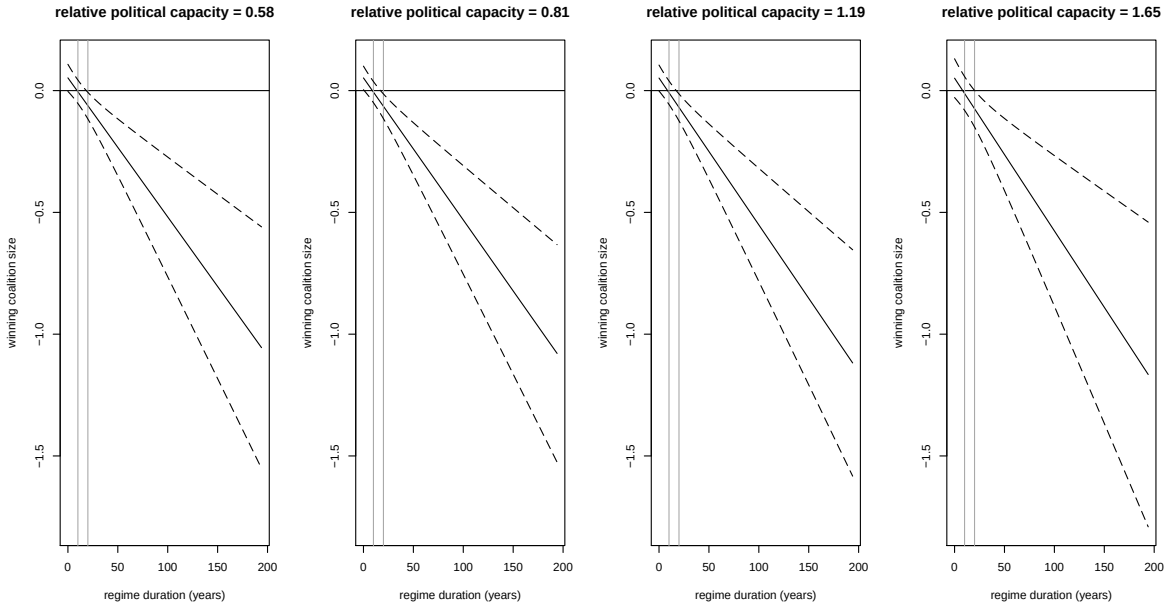
TABLE 2. Correlation statistics based all available observations.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1: SO2	1.00	-0.20	0.55	0.30	0.22	0.19	0.42	0.60	-0.04	0.06	0.49	-0.10	0.12
2: PM10	-0.20	1.00	-0.49	-0.35	-0.24	-0.09	-0.29	-0.37	-0.04	-0.09	-0.24	-0.01	0.13
3: BOD	0.55	-0.49	1.00	0.56	0.31	0.23	0.56	0.72	-0.05	-0.05	0.61	0.17	0.11
4: Winning coalition size	0.30	-0.35	0.56	1.00	0.32	0.20	0.30	0.46	-0.03	-0.04	0.36	0.08	-0.13
5: Regime durability	0.22	-0.24	0.31	0.32	1.00	0.08	0.45	0.47	-0.00	0.04	0.34	0.01	0.00
6: Relative political capacity	0.19	-0.09	0.23	0.20	0.08	1.00	0.12	0.16	-0.04	0.08	0.15	-0.05	0.01
7: GDP per cap	0.42	-0.29	0.56	0.30	0.45	0.12	1.00	0.86	-0.00	0.05	0.62	0.11	-0.11
8: $GDP\ per\ cap^2$	0.60	-0.37	0.72	0.46	0.47	0.16	0.86	1.00	0.01	0.05	0.79	0.14	-0.13
9: GDP growth	-0.04	-0.04	-0.05	-0.03	-0.00	-0.04	-0.00	0.01	1.00	-0.06	-0.03	0.05	-0.05
10: Real oil price	0.06	-0.09	-0.05	-0.04	0.04	0.08	0.05	0.05	-0.06	1.00	0.05	0.00	0.08
11: Urban population	0.49	-0.24	0.61	0.36	0.34	0.15	0.62	0.79	-0.03	0.05	1.00	0.26	-0.02
12: Population density	-0.10	-0.01	0.17	0.08	0.01	-0.05	0.11	0.14	0.05	0.00	0.26	1.00	-0.05
13: Communist regime	0.12	0.13	0.11	-0.13	0.00	0.01	-0.11	-0.13	-0.05	0.08	-0.02	-0.05	1.00

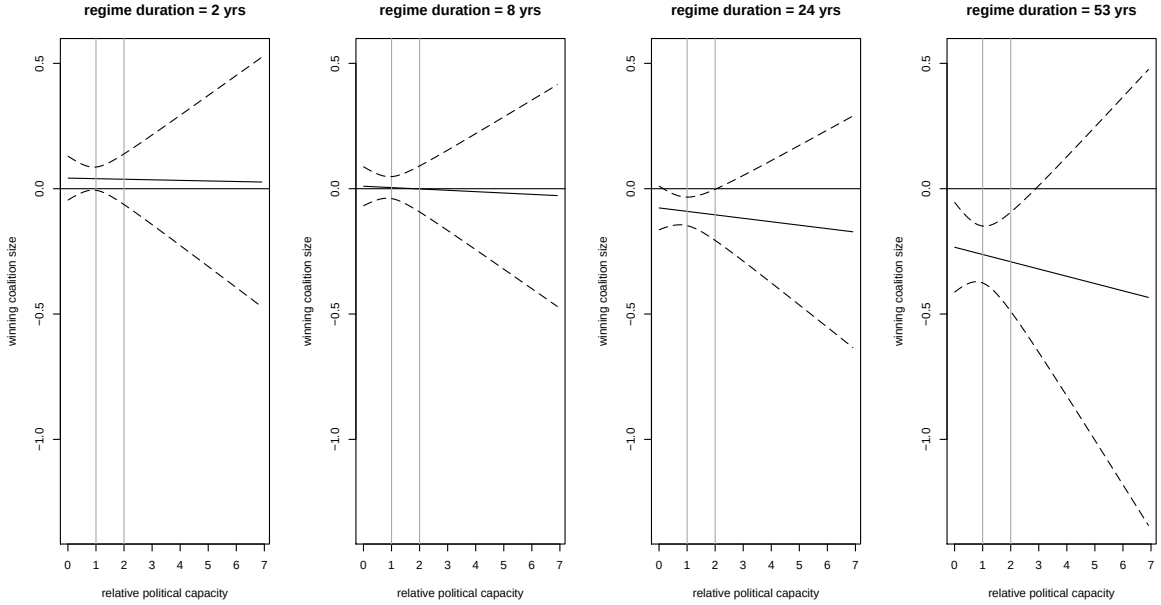
TABLE 3. Models with winning coalition size unconditioned and with full three-way interactions of winning coalition size, regime duration, and state capacity. Country fixed effects are estimated but not reported because of space limit.

	SO2				PM10				BOD			
	$Coef.$	$\hat{\sigma}$ ($p>\|t\|$)	$Coef.$	$\hat{\sigma}$ ($p>\|t\|$)	$Coef.$	$\hat{\sigma}$ ($p>\|t\|$)	$Coef.$	$\hat{\sigma}$ ($p>\|t\|$)	$Coef.$	$\hat{\sigma}$ ($p>\|t\|$)	$Coef.$	$\hat{\sigma}$ ($p>\|t\|$)
Intercept	-2.552	0.461 (0.00)	-1.932	0.512 (0.00)	0.620	0.313 (0.05)	1.594	0.364 (0.00)	-3.190	1.149 (0.01)	-1.949	1.373 (0.16)
Lagged dependent variable	0.905	0.006 (0.00)	0.891	0.007 (0.00)	0.788	0.011 (0.00)	0.790	0.015 (0.00)	0.807	0.015 (0.00)	0.784	0.018 (0.00)
Winning coalition size (w)	0.011	0.023 (0.62)	0.053	0.049 (0.28)	-0.010	0.014 (0.46)	-0.038	0.026 (0.15)	0.020	0.034 (0.55)	0.055	0.078 (0.48)
Regime durability (durable)			0.001	0.002 (0.64)			-0.001	0.001 (0.48)			0.004	0.003 (0.29)
Relative political capacity (rpc)			0.019	0.031 (0.53)			-0.011	0.019 (0.57)			0.023	0.052 (0.66)
w × durable			-0.005	0.002 (0.01)			0.001	0.002 (0.48)			-0.005	0.004 (0.16)
w × rpc			-0.001	0.046 (0.98)			0.051	0.026 (0.05)			-0.023	0.074 (0.76)
durable × rpc			0.000	0.002 (0.84)			0.001	0.001 (0.16)			-0.001	0.003 (0.72)
w × durable × rpc			-0.000	0.002 (0.78)			-0.002	0.001 (0.03)			0.002	0.003 (0.51)
GDP per cap	0.661	0.106 (0.00)	0.414	0.120 (0.00)	0.133	0.073 (0.07)	0.010	0.082 (0.90)	0.696	0.257 (0.01)	0.422	0.307 (0.17)
$GDP\ per\ cap^2$	-0.038	0.006 (0.00)	-0.020	0.007 (0.01)	-0.011	0.004 (0.01)	-0.003	0.005 (0.57)	-0.040	0.014 (0.00)	-0.026	0.017 (0.13)
GDP growth	0.003	0.001 (0.00)	0.003	0.001 (0.00)	-0.001	0.000 (0.00)	-0.001	0.000 (0.00)	0.003	0.001 (0.00)	0.004	0.001 (0.00)
Real oil price	0.000	0.000 (0.84)	-0.000	0.000 (0.77)	-0.001	0.000 (0.00)	-0.001	0.000 (0.00)	0.000	0.000 (0.34)	0.000	0.000 (0.27)
Urban population (% of total)	-0.002	0.001 (0.02)	-0.001	0.001 (0.08)	-0.007	0.001 (0.00)	-0.009	0.001 (0.00)	0.002	0.002 (0.23)	0.003	0.002 (0.05)
Population density	-0.000	0.000 (0.16)	-0.000	0.000 (0.07)	0.000	0.000 (0.59)	0.000	0.000 (0.72)	0.000	0.000 (0.48)	0.000	0.000 (0.57)
Communist regime	0.072	0.034 (0.03)	0.059	0.045 (0.19)	0.061	0.020 (0.00)	0.031	0.040 (0.45)	0.207	0.033 (0.00)	0.390	0.098 (0.00)
Adjusted R^2		0.967		0.968		0.988		0.989		0.976		0.976
N. of observations/Countries		4622/154		3899/110		2352/165		1652/113		1773/130		1403/95
Time period		1961-2003		1961-2003		1991-2005		1991-2005		1981-2003		1981-2003

FIGURE 1. Testing the short-term effects of the modified selectorate theory, SO2.



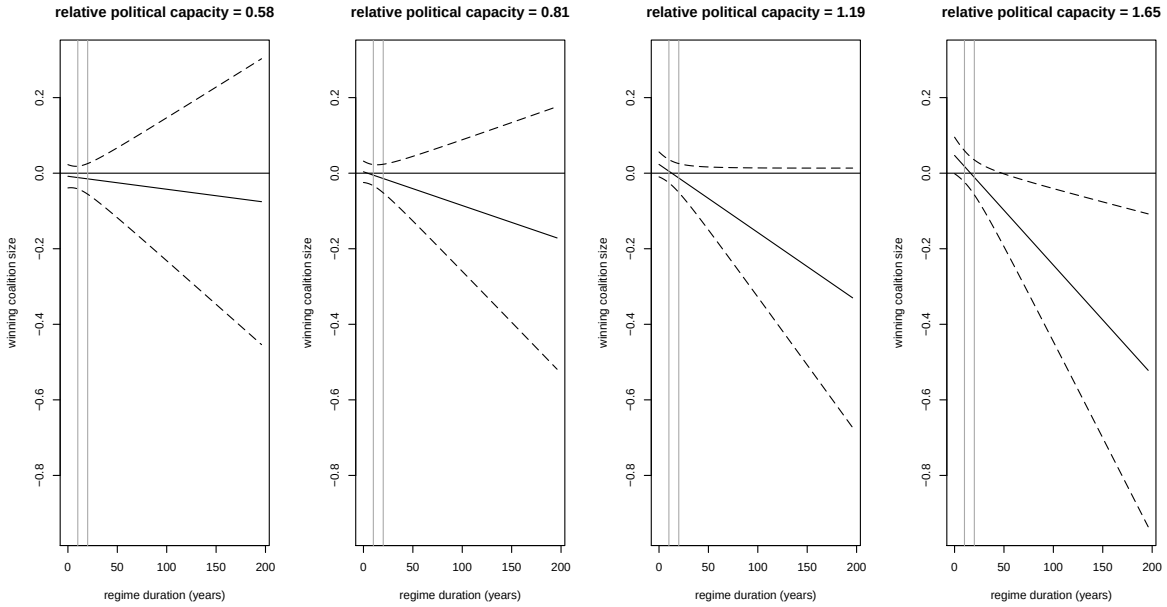
(a) Effects of winning coalition conditional on time horizon for different levels of state capacity.



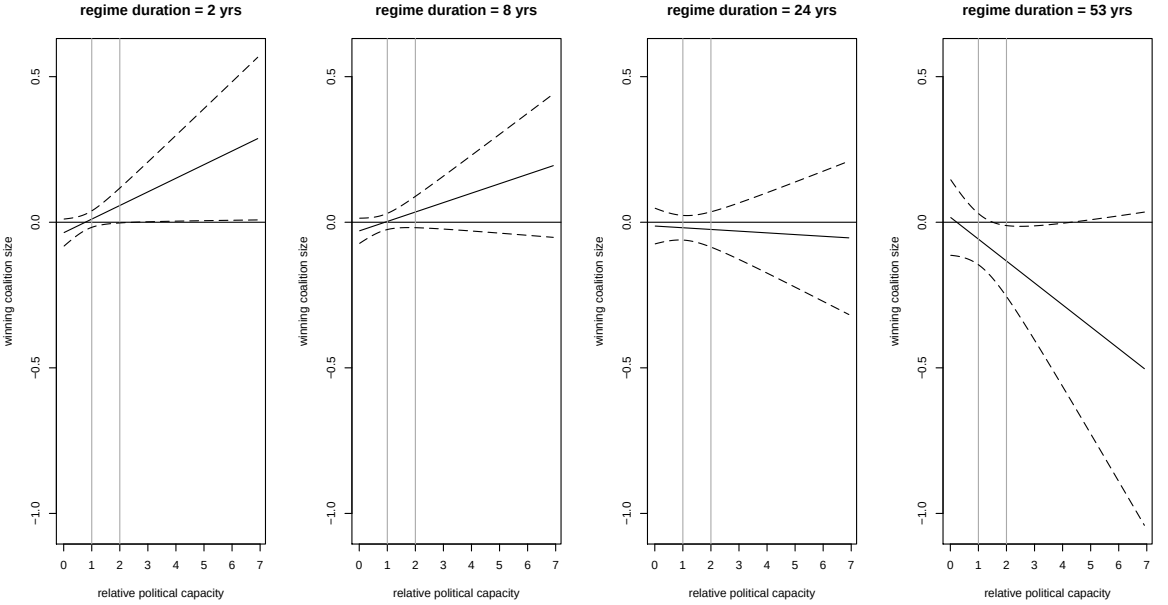
(b) Effects of winning coalition conditional on state capacity for different levels of time horizon.

Note: The four different levels of state capacity and time horizon are chosen at the 20th, 40th, 70th, and 90th percentiles of the full sample.

FIGURE 2. Testing the short-term effects of the modified selectorate theory, pm10.



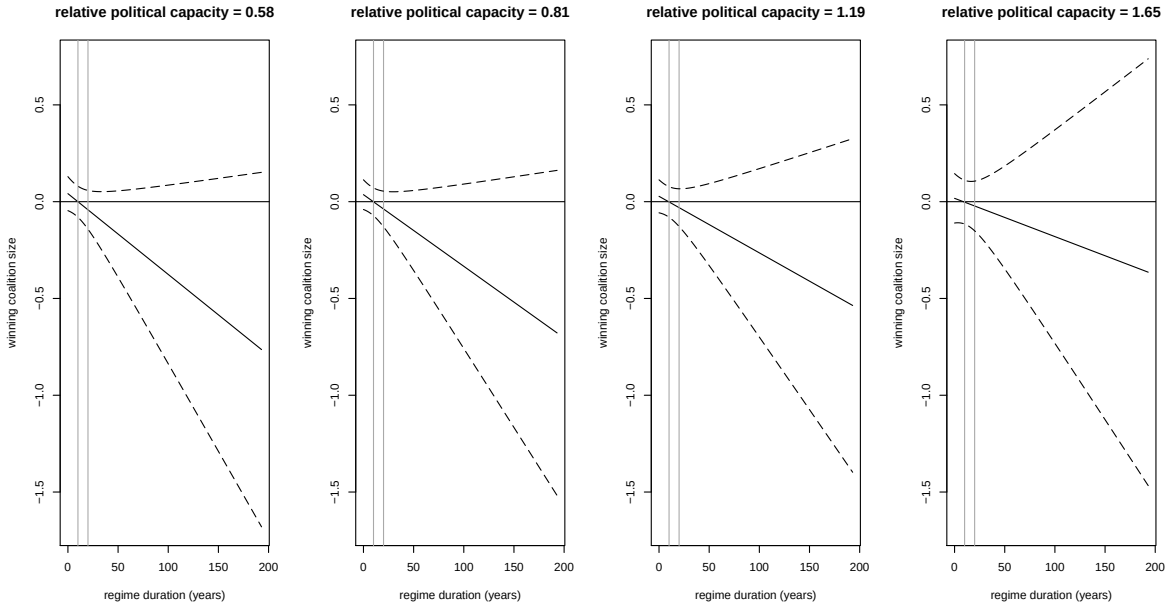
(a) Effects of winning coalition conditional on time horizon for different levels of state capacity.



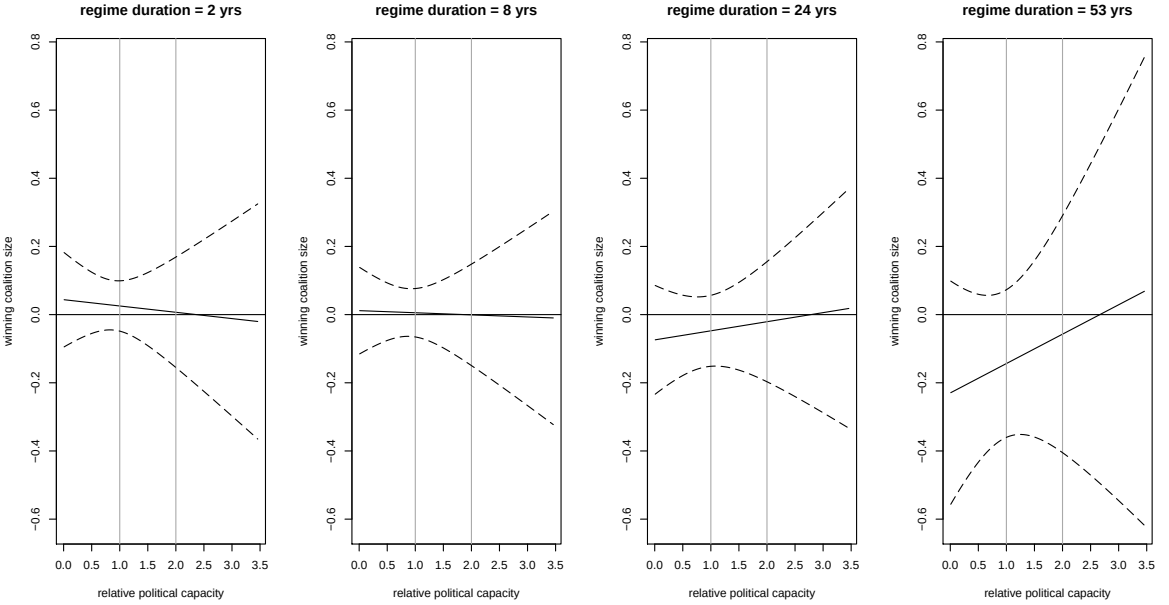
(b) Effects of winning coalition conditional on state capacity for different levels of time horizon.

Note: The four different levels of state capacity and time horizon are chosen at the 20th, 40th, 70th, and 90th percentiles of the full sample.

FIGURE 3. Testing the short-term effects of the modified selectorate theory, BOD.



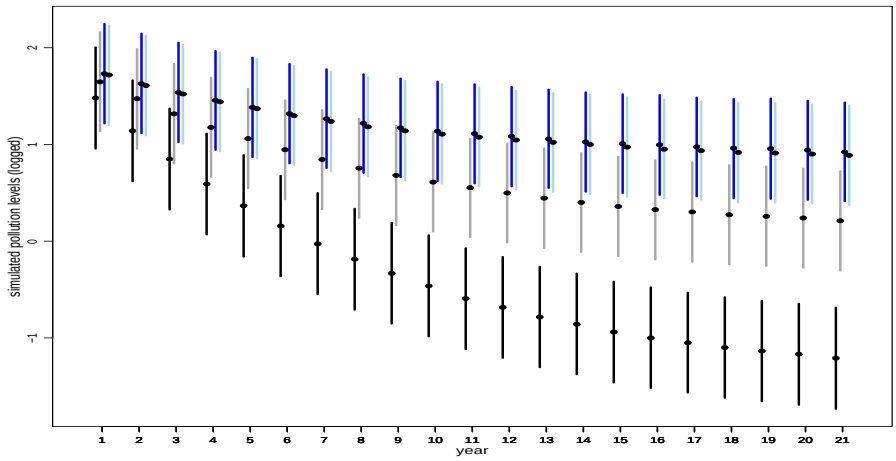
(a) Effects of winning coalition conditional on time horizon for different levels of state capacity.



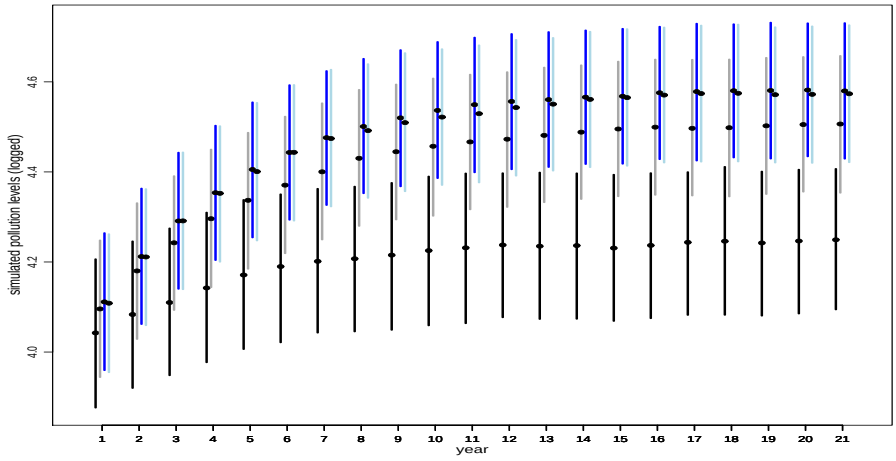
(b) Effects of winning coalition conditional on state capacity for different levels of time horizon.

Note: The four different levels of state capacity and time horizon are chosen at the 20th, 40th, 70th, and 90th percentiles of the full sample.

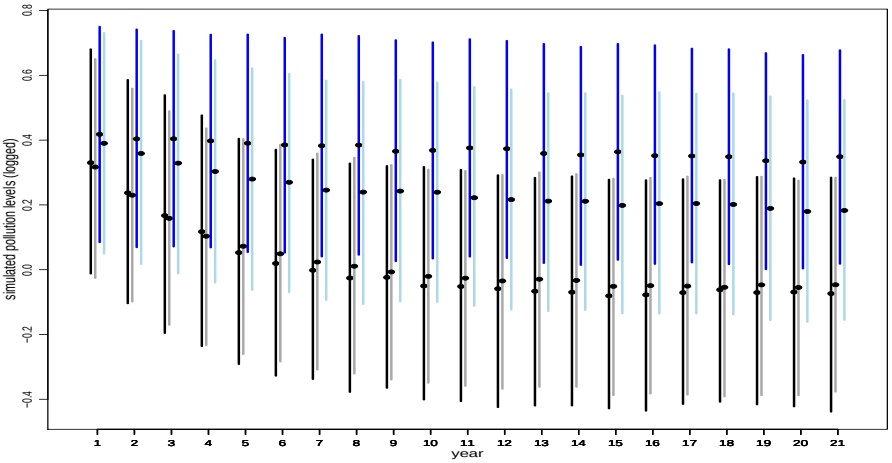
FIGURE 4. Simulating the long-term effects: 4 different colors represent results for 4 scenarios. We use black for core democracies (the values of w, capacity, and durability set at the 80th percentile among democracies), dark gray for average democracies (w, capacity, and durability at the mean level among democracies), blue for average autocracies (w, capacity, and durability at the mean level among autocracies), and light blue for fragile autocracies (w, capacity, and durability at the 20th percentile among autocracies). 95% confidence intervals and mean values for each year are indicated by vertical lines and solid dots. We jittered the vertical lines to avoid overlap.



(a) SO2



(b) pm10



(c) BOD