Building State Capacity for Environmental Protection?
Lessons from an Environmental Politics Model for Authoritarian States

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Abstract: A significant proportion of the world's population today live under some forms of authoritarian rule. In this paper, we present a model of environmental politics in the authoritarian world acknowledging the theme in the recent literature that authoritarian states differ from each other as much as they do from democracies. We start with the basic assumptions that rulers want to stay in power; and in order to achieve this, they need to deliver benefits to their key constituencies. Therefore, on average, the larger the size of the key constituencies, the more pressure there is for the ruler to deliver. For countries that lack ready access to revenue (domestic non-tax revenues and/or foreign aid), this often requires higher state capacity for more extensive resource extraction from the society, which is often at the expense of the environment, by limiting the efforts of the private sector and civil society to protect the environment. Large key constituencies plus strong state capacity, as our theoretical model predicts, are associated with bad environmental outcomes in authoritarian regimes. We test our theory by modelling three types of major air and water pollutants (SO_2, CO_2, and Biological Oxygen Demand or BOD) in authoritarian states as a function of regime types (which we use to proxy the size of key constituencies), the extractive capacity of the state, and a battery of relevant variables. The results strongly support our theory. State capacity is associated with higher levels of all three types of pollutants. Single-party regimes, which we assume to have the largest key constituencies among four types authoritarian regimes, are positively associated with SO_2 emissions. We also find strong evidence that the time horizon of the ruler (measured by regime duration) reduces SO_2 and CO_2 emissions.

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Introduction

Does political regime type matter for environmental performances? This is an important question for students of political science. Previous research suggest that democracies are often associated with more stringent environmental regulations and sometimes better environmental outcomes (Barret and Graddy 2000; Esty and Porter 2005; Bernauer and Koubi 2008). However, given the fact that a significant amount of the world population today live under some forms of authoritarian rule and that different kinds of authoritarianism differ from each other as much as they differ from democracy (Geddes 1999), we need to further investigate the dynamics of environmental politics in the authoritarian world.[2] Our understanding of environmental politics in authoritarian systems is much more limited than that of democratic systems. Recent literature on authoritarianism has been focusing on classification of authoritarian regimes (Geddes 1999, Lai and Slater 2006, Cheibub and Gandhi 2004, Cheibub, Gandhi and Vreeland 2009) and the links between these regime types and various phenomena such as regime survival (Geddes 2003), democratic transition and consolidation (Svolic 2008), and economic development (Gandhi 2008, Wright 2008). Though there is an abundant case study literature about environmental regulations and outcomes in authoritarian systems, unfortunately little systematic theoretical work has been carried out, and we lack systematic studies of how outcomes are related to variance among authoritarian systems.

In this paper, we present a model of environmental politics in the authoritarian world starting with the basic assumptions that rulers want to stay in power, and in order to achieve this, they need to deliver benefits to their key constituencies. Therefore, on average, the larger the size of these key constituencies, the more pressure there is for the ruler to deliver. For countries that lack easy revenue (domestic non-tax revenues and/or foreign aid), this often requires higher state capacity (often acquired over time) for more extensive extraction of resources from the society. Heavy resources extraction from the society by the state is often at the expense of the environment, because it lowers the incentives of the private sector and civil society to implement environmental regulations and to react to public demand, whilst also limiting their capabilities. Large key constituencies plus strong state capacity, as our theoretical model predicts, are associated with bad environmental outcomes in the authoritarian regimes.

We test our theory by modelling three types of major air and water pollutants, SO_2, CO_2, and Biological Oxygen Demand (BOD) in authoritarian states as a function of regime types (which we use to proxy the size of key constituencies), extractive capacity of the state, and a battery of relevant variables, for 1980-1999. The results strongly support our theory. State capacity is associated with higher levels of all three types of pollutants. Single-party regimes, which we assume to have the largest key constituencies among four types authoritarian regimes (single-party, military, personalistic, and monarchy), is positively associated with SO_2 emissions. This is indeed a strong indication of the size effect of the key constituencies, because state capacity, often acquired over time as a function of constituency demand, can picks up at least part of this size effect. We also find strong evidence that the time horizon of the ruler, as measured by regime duration, reduces SO_2 and CO_2 emissions. The rest of the paper describes our theoretical model, presents data and variable operationalization, and discuss the empirical findings and direction of future research at the end.

A Simple Model of Environmental Politics in Authoritarian States

Authoritarian Ruler and Key Constituencies: Like many studies of authoritarian politics (Geddes 1999 and 2006), the basic assumption of our authoritarian environmental politics model is that rulers in authoritarian states want to stay in power. Only when they manage to stay in power, can they collect private benefits. Our secondary assumption is also uncontroversial: in order to stay in power,

[2] For example, for year 1980, 55.9% of the world population live under some form of authoritarian rule: single-party, military, personalistic, monarchy, and their hybrid regimes; by 2000, after waves of democratization, this number is still as high as 42.04%.

authoritarian rulers have to satisfy their key constituencies without which they will lose the office.[3] It is therefore important for us to define key constituencies in the context of authoritarian states.

To do this by looking at specific groups in each individual country can reveal rich information about authoritarian politics. However, groups identified by this case-by-case approach are often hard to generalize across countries. We therefore choose a more theoretical approach.[4] Following Bueno de Mesquita et al. 2003, we divide the population in an authoritarian state into two components: the selectorate and the disenfranchised. The disenfranchised population refers to those who do not have influence over the leadership selection process. They are, in most of the authoritarian polities, the majority of the population. The selectorate is defined as individuals who can theoretically be part of the leadership selection process --- this 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" (Bueno de Mesquita et al. 2003, p 42). Typical characteristics that might serve as criteria for inclusion to the selectorate often include personal origin and lineage, special skills, proficiency, or knowledge, wealth, and gender and age. Furthermore, among the selectorate, there is a subset called the winning coalition "who control enough instruments of power to keep the leader in office" (Bueno de Mesquita et al. 2003, p 51).

It is empirically difficult to draw a clear line between the disenfranchised, the selectorate, and the winning coalition, especially given the diversity of authoritarian regime types. However, we can still get a sense of who are more likely to fall into each category based on their theoretical definitions. For instance, in a political regime dominated by a single party (e.g., China and Vietnam), the majority of the people do not have influence over the leadership selection process: they simply do not have the right to vote; these are the disenfranchised population. Leaders are selected within the party. Therefore, we can think of the distinction between the disenfranchised and the selectorate as approximately the difference between no-party and party members. Moreover, within this selectorate, there is the winning coalition: often time, this is a faction or a coalition of a few factions within the party that control the office.[5] Similarly, in the context of a monarchy, the selectorate might include all members of the extended royal family and the winning coalition the close allies (a few princes and their families) around the king. In a military regime, the selectorate might include the whole military apparatus while the winning coalition includes the Junta or military council as a whole.[6] Finally, for a personalistic regime, the winning coalition often includes a small group of cronies who benefit from the dictator's largess while the selectorate is much more difficult to identify, because this might

[3] Indeed, the same assumptions also work for democratic polities as Geddes points out that "Standard theories of politics begin with two simplifying assumptions: (a) Politicians want to achieve office and remain there; (b) the best strategy for surviving in office is to give constituents what they want." (Geddes 1999)

[4] Here, we depart from Geddes' view that the identification of these key constituencies cannot be achieved at an abstract level: "... in the absence of routine ways for citizens to remove leaders from office, questions of who exactly the constituents of authoritarian leaders are, how satisfied they have to be, and what factors besides satisfaction with regime performance affect their level of acquiescence require empirical investigation and cannot be answered in the abstract or assumed, as in the study of democratic politics." (Geddes 1999, p6)

[5] We follow Geddes' classification (updated to include monarchies) of authoritarian states in this paper. Single-party regimes are defined by Geddes as "regimes in which the party has some influence over policy, controls most access to political power and government jobs, and has functioning local-level organizations" (Geddes, 1999, 20).

[6] Military regimes are defined as governed "by an officer or retired officer, with the support of the military establishment and some routine mechanism for high-level officers to influence policy choice and appointments" (Geddes, 1999, 20). Military regimes often share the following characteristics: relationships within the Junta and or military council are relatively egalitarian; the regime has some kind of institutions for deciding succession questions, and for routine consultation between the leader and the rest of the officer corps; the military hierarchy remains intact; and the security apparatus is controlled by the military.

depend on specific stages of a personalistic regime and how the leader came to power. Geddes defines personalistic regimes as those whose leaders usually came to power as an officer in a military coup or as the leader of a single-party government: the leader has consolidated control over policy and recruitment in his own hands and is in the process marginalizing other officers' influence and/or reducing the influence and functions of the party. In so far as the leader still needs support from the military or party, the military or party that are being marginalized might be part of the selectorate in addition to the few close cronies.

In selectorate theory, the key theoretical variation comes from the size of the winning coalition (W) and/or the loyalty ratio (W/S) between the size of the winning coalition (W) and that of the selectorate (S) as they affect the choice between private and public good provisions by the ruler (Bueno de Mesquita et al. 2003). Public goods benefit everyone in the society and private goods often go to members of the winning coalition, especially when the size of the winning coalition (and/or the loyalty ratio) is small. The most significant predictions from the theory are about the level of public good provisions. The central point is that the larger the size of the winning coalition the higher the relative cost of building winning coalition using private goods: because 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 being equal, the level of provision of public goods increases with W; decreases with S;[7] and decreases as W/S falls.[8]

Empirical and theoretical criticisms of the selectorate theory can be found in the recent literature. Gallagher and Hanson 2009 argue that the preferences of the disenfranchised have little role in the selectorate theory, therefore the model rules out an important range of policy responses that combine repression with measures to enhance economic welfare. Moreover, selectorate theory assumes that all members of the selectorate have identical preferences, rendering the composition of the winning coalition irrelevant. Knack 2005 criticizes Bueno de Mesquita et al. 2003 for neglecting the time horizons of leaders: the theory only works in cases of leaders with short time horizons because in the long run, revenues for the leader to steal or purchase support will increase if the government provides broad public goods that promote growth.

Our theoretical argument also departs significantly from selectorate theory. We argue that in the context of authoritarian states, the key constituencies include not only the winning coalition, but also the majority, if not the whole, of the selectorate. The rationale of selectorate theory is that the ruler and a potential challenger bid for support from those in the selectorate in order to create a winning coalition (the ruler has incumbent advantage when W is small). The competition largely happens within the selectorate. This is a reasonable assumption in a democratic setting when the selectorate includes most of the adult population. In authoritarian states, the existence of a large disenfranchised population often changes the dynamics of the game. Public discontent and potential revolutionary threat also pose serious challenges to the ruler (Acemoglu and Robinson 2006). However, what eventually kills an authoritarian regime is often a split within the elites, with one or a few factions seizing the opportunity of such social unrests. Indeed, many studies in the literature observe that within-elite competition is the key to understanding authoritarian politics (O'Donnell and Schmitter 1986; Geddes 1999). Bueno de Mesquita et al. 2003 take loyalty as exogenous and have an essentially one-period focus. In their model, support is a function of current tax and spending offers, whereas

[7] Because spending falls with S for fixed W while the ratio of private to public good provision remaining the same.

[8] 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.

there are good reasons why members of S might make judgements retrospectively on the basis of past performance (just as voters often do in democracies). One reason for treating members of S not in W reasonably well is so as to retain a degree of support based on retrospective performance among groups that might be important to you in staving off future challenges, even if they are not in your current coalition. Doing so prevents grievances among groups that challengers could exploit. Therefore, it is in the interest of the ruler to distribute private goods to other elites (and their close allies) which are often not in the winning coalition.

The implication for this is that private goods not only go to the members of the winning coalition (e.g., the faction or the coalition of a few factions within the party that control the office in the context of single-party regimes), but also go to other members of the selectorate (party members for single-party regimes).[9] Private goods provisions might be at a much lower rate for the non-winning coalition part of the selectorate, but it does exist in authoritarian states: for example, party members in single-party regimes and royal family members in monarchies often occupy public offices which come with work benefits that often cannot not be found in the private sector;[10] these jobs also often come with opportunities for perks and bribes. The groups that obtain these benefits are often not members of the dominant existing faction or coalition. However, private goods do not go to the disenfranchised population who can only benefit from public goods provisions.[11]

In sum, we conceptualize the population in an authoritarian state as composed of the disenfranchised, the selectorate, and the winning coalition. We argue that key constituencies for the ruler potentially include all members of the selectorate. The ruler provides public and private goods. Private goods go to the members of the winning coalition and (often at a lower rate) members of the selectorate; public goods benefit the whole population including the disenfranchised.

Demand Side: Size of the Selectorate. In order to stay in power, the ruler must satisfy the key constituencies --- the selectorate. Here, we further assume that members of the key constituencies generally prefer private goods over public goods.[12] For example, they would prefer that the ruler provide them with material benefits which enable them to send their children to private schools or abroad than money spent to improve public education which is available for everyone in the society. There is considerable evidence suggesting that grievances leading to rebellion can arise as the result of relative deprivation (Østby 2008; Regan and Norton 2005; Walder 2009). Support derives from the feeling that you are doing better than some comparator group. To the extent to which relative deprivation matters and some members of the selectorate compare themselves with the disenfranchised, rulers should emphasise providing private goods to the selectorate based on surplus extracted from the disenfranchised, because pure public goods do not create relativities. The danger with such a strategy is rebellion among the disenfranchised, but a ruler who feels secure in his ability to repress such dissent need not be too concerned. (We will discuss the role of the repressive capacity of the state in following sections.) The ruler therefore has strong incentives to provide private goods to these constituencies. The final amount of resources devoted, among many other factors, should be a function of the size and demand intensities of these constituencies. Because it is very hard to measure demand intensities and it actually should vary across different members of the constituencies (those in the winning coalition might in a better position to demand more than average members of the selectorate), in this paper, we choose to focus on the size aspect of the constituencies. We expect that:

[9] Otherwise, why join the party which often incurs non-trivial cost?

[10] Single-party systems routinely require party membership for most government jobs, even at the local level (Perceny and Butler 2004).

[11] They can also benefit from lower taxes if we consider Bueno de Mesquita et al. 2003's utility function for to the disenfranchised population.

[12] They might also prefer club goods such as welfare entitlements associated with certain government positions.

> Everything else equal, the larger the size of the key constituencies (selectorate), the higher is the amount of resources that the ruler has to provide in order to stay in power.

The size of the key constituencies (selectorate) is the key variable on the demand size of the theory. However, it is hard to empirically measure this directly, especially across countries. Bueno de Mesquita et al. 2003 use index variables that they themselves describe as crude. These indexes are created using general characteristics of political systems that are assumed to be correlated with the sizes of the selectorate (and winning coalition), but they are also highly correlated with other important concepts such as the level of political competition and the level of political rights. Their efforts to separate the effects of S and W from measures of these other concepts have drawn criticism (Hanson 2007; Gallagher and Hanson 2009). For example, Clarke and Stone 2008 present a detailed analysis of the statistical findings in Bueno de Mesquita et al. 2003 and argue that the empirical evidence does not support the theory because the effects ascribed to winning coalition size are indeed attributable to democracy. Moreover, Chang and Golden 2010 argue that the lack of direct correspondence between the concepts of selectorate and winning coalition with political institutions that are observed in real-world polities is an evident weakness of selectorate theory. They turn to Geddes's classification of authoritarian regimes (which they consider intuitively more meaningful, thereby generating results that are easier to interpret), rank authoritarian regime types by the size of winning coalition and selectorate, and use regime type dummy variables to test the effects of the size of the winning coalition on corruption. Recent studies following this strategy of using regime types to test the effects of winning coalition (W) and/or loyalty ratio (W/S) also include Peceny and Butler 2004 and Pickering and Kisangani 2010.

However, this approach is not without controversy. Scholars seem to have different rankings of authoritarian regime types by the size of winning coalition and selectorate. For example, Chang and Golden 2010 assume that W is more or less the same in all polities and the variation comes from S in the following order: military juntas and monarchies < single-party dictatorships < personalistic regimes.[13] But in Pickering and Kisangani 2010's study on autocracies' propensities to use and benefit from military force, the authors argue that the selectorate is roughly the same (the citizenry) and variation of W follows the order of personalistic<=military<=single-party (Geddes 2006; Peceny and Butler 2004).[14] Interestingly, Bueno de Mesquita et al. tend to see single-party regimes and personalist dictatorships as fundamentally similar and they consider both of these types of regimes to have large selectorates and small winning coalitions. Military regimes, on the other hand, have a small selectorate as well as a small winning coalition (Bueno de Mesquita et al. 2003).

We follow the same approach as in Peceny and Butler 2004, Chang and Golden 2010, and Pickering and Kisangani 2010, and we use regime types to test the effects of the size of the key constituencies after assuming some ranking order of regime types by the size of the selectorate. Note that the selectorate refers to individuals who can theoretically be part of the leadership selection process and whose endowments include the qualities or characteristics institutionally required to gain access to private benefits doled out by the government's leadership (Bueno de Mesquita et al. 2003, p 42). As we discussed earlier, in a single-party regime, the distinction between the disenfranchised and the selectorate might be the difference between party members and others. Moreover, the whole military machinery is likely to be included in the selectorate because authoritarian rulers need to reply on the repressive capacity of the military to deal with potential revolutionary threats from the disenfranchised (or from coup attempts from rival factions within the selectorate). Indeed, it is likely to be true that in all four types of authoritarian regimes, the military is included into the selectorate and receives private goods distributed by the ruler. Therefore, in addition to the military, the

[13] So if W is constant, the loyalty ratio (W/S) is in the reverse order: military juntas and monarchies > single-party dictatorships > personalistic regimes.

[14] In the context of authoritarian states, the existence of disenfranchised population seems to cast serious doubt on Pickering and Kisangani's (2010) assumption that the selectorate is roughly the whole citizenry.

selectorate of the single-party regime would include party members;[15] in addition to the military, the selectorate of a monarchy might include all members of the extended royal family; in a military regime, the selectorate is the military apparatus itself. Thus, it seems that on average the ranking for these three types of regimes by size of the selectorate is roughly: single-party regime >= monarchy >= military regime.

The reason why we assume that single-party regimes are associated with larger selectorates than monarchies is that with some exceptions such as Taiwan and Mexico, most single-party states have been socialist regimes; communist/socialist parties in these states are often large.[16] For example, the are about 77.9 million (in 2009) current members of the Chinese Communist Party, which is roughly 6% of the population; the Communist Party of Vietnam has 3. 6 million members: roughly 4% of the population. It is hard to estimate the exact size of the extended royal family in a monarchy; however, it is unlikely that this will be 4%-6% of the population: this would mean 1 to 1.5 million for Saudi Arabia (which has a total population of 25.7m).

The case of personalistic regimes is more complicated because this might depend on the way that the leader came to power: Geddes argues that they do so often as an officer in a military coup or as the leader of a single-party government, and they are in the process marginalizing other officers' influence and/or reducing the influence and functions of the party after having consolidated control (Geddes 1999). Therefore, if the leader came into power from a single-party, the selecorate is the military plus a marginalized party; if the leader came to power as an officer in a military coup, the selectorate is more like to be a marginalized military. For the former case, the size of the selectorate would be somewhere between the single-party regime and the military regime: whether the size is larger than that of a monarchy depends on the extent of marginalization of the party. For the latter case, the size of the selectorate would be more likely to the smallest among all regime types: smaller than the military regime because the military has been marginalized. Therefore, there are three possible rankings for all of which single-party regimes are expected to have the largest selectorate:

1). single-party regime >=personalistic>= monarchy >= military regime;
2). single-party regime>= monarchy >=personalistic >= military regime;
3). single-party regime >= monarchy >= military regime>=personalistic.

In sum, we argue that on average, single-party regimes should have the largest selectorate (mainly party members plus the military). This is consistent with Bueno de Mesquita et al. 2003's observation that associates single-party regimes with large selectorates.[17] Therefore, if our demand-side theoretical expectation is true --- that the larger the size of these constituencies, the higher is the amount of resources that the ruler has to provide in order to stay in power --- single-party regimes require more resources for the ruler to spend on private goods for key constituencies compared to other types of authoritarian regimes. This theoretical prediction has its implication for the environment. Assume a given the amount of resources available to the ruler. (The amount of resources is likely to vary in the real world depending on non-tax revenues and extractive state capacity of the state; we discuss this supply-side theoretical story in the following section.) Then single-party regimes spend more to satisfy the selectorate often by private good provisions and this leave less for public goods provision, including environmental public goods.

[15] However, there is often overlapping between the party, the military, and the bureaucracy: the party often penetrates even the ranks and files of the military; and it often requires party membership not only for important posts of the bureaucracy, but also average "civil servant" jobs.

[16] Notoriously, the PRI in Mexico included quite large groups of farmers and trade-unions in the movement, so maybe it had quite big S as well.

[17] They also consider personalistic dictatorships having large selectorates. We think this is likely the case if the dictator in a personalistic regime came to power as a leader of a party.

So far, we have assumed that the ruler's only option is to provide private goods to the key constituencies because these constituencies prefer private goods. However, similar to the *Logic* of political survival (Bueno de Mesquita et al. 2003), if the selectorate gets too big, it might makes economic sense for the ruler to also provide public goods. However, providing members of the selectorate only with public goods is not able to keep the constituencies happy because it creates no relativities between the selectorate and the disenfranchised.[18] In reality, rulers will be likely to provide private and public goods in different combinations, but even with selectorates as large as those in single party systems they are likely to prioritise private goods highly unless public goods provision affects the size of the surplus they can extract and they expect to be around long enough to reap the benefits.

Characteristics of the public goods differ.[19] Indeed, we can measure public goods by their implications for economic growth. Many studies argue for the positive connections between environmental protection and productivity (Porter and van der Linde 1995).[20] For example, Repetto et al. 1996 have shown that in the US, such efficiency gains as a function of more stringent regulations boost productivity by reducing the cost of pollution on health, materials, forests and crops.[21] However, more stringent environmental regulations often incur high production costs (or is perceived to be so by policy-makers), at least (and often) in the short run (Simmons 2010). This is especially the case if the national economy is not characterized by quality production and lacks necessary technologies and funding. This would include most authoritarian systems because they are generally not highly developed countries.

Therefore, when simply providing private goods is too expensive, it is in the benefit of the ruler to provide public goods that are more directly related to productivity increases such as building roads, dams, and schools, and providing some basic public health care for the working force. The goal is to increase production which is the basis of resource extraction by the ruler to pay the key constituencies. The implication of choosing these types of public goods is first, a negative externality for environmental public goods --- money for environmental protection is used in other production-related public goods: again, we implicitly assume that environmental protection does not increase productivity at least in the short-run or is perceived to be so by rulers. Second, the increasing level of economic production increases environmental burden. Therefore, everything else equal, large key constituencies (selectorate) in authoritarian states have negative impacts on the environment.

> Single-party regimes, by having the largest selectorate among all four regime types, should be associated with worse environmental outcomes compared to monarchies, military, and personalistic regimes.

However, as we will see in the following discussion on the supply side of the story, at least part of these negative impacts leave their footprint on the environment indirectly due to extraction of surplus by the state.

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[18] Indeed, the conceptualization provided by Bueno de Mesquita et al. for the selectorate --- 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" (Bueno de Mesquita et al. 2003, p 42) --- suggests being a member of the selectorate is a necessary condition to receive private goods.

[19] Gallagher and Hanson differentiate between public goods that enhance economic productivity (e.g., education, health care, and infrastructure) and public goods that provide greater government transparency and a range of political freedoms (e.g., the freedoms of speech and the press, and assembly).

[20] See Ambec and Lanoie 2008 for an overview of the literature.

[21] For example, electric utilities now produce twice as many kilowatt hours per ton of emissions as they did when the Clean Air Act was passed in 1972. The pulp and paper industry produces seven times as much paper per ton of water pollution as it did before the Clean Water Act was passed.

Supply Side: ***Extractive Capacity of the State.*** Ruler need to find money to buy support in order to stay in power; this includes financing private good provisions to key constituencies and some provision of ding public goods to the selectorate (and the disenfranchised). Money generally comes from two sources: non-tax and tax revenues.[22] Non-tax revenues can include income from raw material extraction (for example, oil, natural gas, and diamond), state-owned enterprises (SOE), and foreign aid. Different components of non-tax revenue might have different effects on the environment. For example, foreign aid with environmental components is likely to improve the environmental. However, in our theoretical story, we consider non-tax revenue as a whole without further differentiating the effects of each component because of a common causal mechanism connecting them to the environment: they replace part of the resource extraction from the society that the ruler has to engage in order to buy out the key constituencies.[23] Indeed, recent literature has shown that the particular source of nontax revenue often does not make a difference, for example, with regard to regime stability (Morrison 2009). We also treat non-tax revenue as exogenous because it is often a function of natural endowment and historical legacies.

On the other hand, tax revenue is a function of the extractive capacity of the state which measures the extent to which the state can extract resources from the society. We will use the term state capacity and state extractive capacity inter-changeably in the paper even though there are other types of state capacity such as administrative and repressive capacities (Hendrix 2010). State capacity is often acquired over time. For example, for many European countries, tax capacity was developed as a result of financing large wars in the historical past (Tilly 1975 and 1990). Here, we argue that the extractive capacity of the state in authoritarian states is likely to be a function of the size of the demand from the key constituencies the ruler is expected to extract more resources with increasing demand. Those regimes that cannot meet this demand by developing this capacity and/or relying on non-tax revenues cannot exist for long. Of course, the extractive capacity of the state is also of a function of many other factors such as the structure of the governing organization: for example, communist parties often have an advantage in their ability to penetrate society and extract more resources because of an organizational structure reaching every corner of the society.

One implication of high extractive capacity of the state is that even in the absence of non-tax revenue, the demand from key constituencies is likely to be met and ruler is more likely to stay in power. More importantly in terms of the environmental impact, high level of resource extraction from the society by the ruler means, for private firms, high taxation and other hidden fees which create negative externalities for (most likely the enforcement of) environmental protection. Simmons argues that compliance with environmental law involves regulations that attempt to change the behaviors of private actors, in particular commercial entities. Competitive factors are important here as firms want to reduce costs to be competitive (Simmons 2010). For private firms, money lost to high government taxation is likely to be compensated by negligence of environmental standards because compliance with environment regulations can be expensive for industry, at least initially.

Finally, environmental protection is a regulatory policy that involves a broad array of nongovernmental actors. Recent research has stressed the importance of civil society and interest aggregation. For example, Bernhagen finds that greater participation by NGOs (and corporatist forms of interest mediation) contribute to higher compliance with multilateral environmental agreements in general, and the 1992 United Nations Framework Convention on Climate Change in particular (Bernhagen 2008; see also Gulbrandsen and Andresen 2004).[24] High levels of resource extraction by the state often leave civil society with fewer resources left to act in the interest of public demand for

[22] So for now, we don't consider international borrowing by the government; but we can control for this if we have the data.

[23] In the empirical analysis, we do differentiate between domestic non-tax revenues and foreign aid.

[24] Bernhagen's research is based on 35 advanced industrialized countries and only for the year 2000 though.

better environment. (We assume that average citizen prefers better environment.). Therefore, we expect that in authoritarian states:

The higher is the level of extractive state capacity, the worse the environmental outcomes.

Non-tax revenue, insofar as it replaces part of the state resource extraction from the society, should have positive effects on the environment. However, as we discussed earlier in relation to different components of non-tax revenue, this might also depend on the nature of different components such as resource extraction, state-owned enterprises, and foreign aid. Also note that here extractive state capacity might capture part of the negative impacts of the size of the key constituencies, because the former could be a function of the latter as high demand from large key constituencies force authoritarian rulers to acquire high capacity overtime. However, not all the negative impact of the size of key constituencies would be captured by state capacity. This is because there are potentially ways that the ruler might use to appease the key constituencies without directly paying them, for example, if part of the key constituencies control industrial production, policy concessions in the form of less environmental regulations might be an alternative.

Finally, if we assume that the majority of the disenfranchised population prefers better environment and the ruler prioritize other objectives --- satisfying key constituencies so as to stay in power and keeping the rest of the resources for himself, the repressive capacity of the state should be a factor that affects the extent to which the ruler can ignore the popular demands of the disenfranchised. Indeed, Gallagher and Hanson show that rulers, at least in many East Asian authoritarian states, favour a combination of repressive politics in conjunction with public goods (e.g., infrastructure and education) that provide welfare-enhancing economic growth (Gallagher and Hanson 2009). The disenfranchised population is intimidated by the repressive capacity of the state and at the same time, benefits from rapid economic growth. The higher the repressive capacity, the more the ruler can afford to ignore the green demand from the public, and therefore the worse the environmental outcomes. It is also important for us to consider the repressive capacity of the state in the empirical analysis because if it is highly correlated with extractive capacity of the state, we might be just picking up this repressive mechanism and mistaking it for one related to the extractive capacity of the state.

Data and Measurement

Air and Water Pollution: In order to test the impacts of the size of the selectorate and the extractive capacity of the state on the environment, we choose to focus on three major types of air and water pollution with available data covering enough countries and years: Sulphur dioxide (SO_2), carbon dioxide (CO_2), and bio-chemical oxygen demand (BOD).[25] Sulphur dioxide is a serious air pollutant, implicated in: i) ground-level smog and haze, particularly in urban areas; ii) associated damage to human health; iii) reduced agricultural productivity and; iv) acid-deposition, which damages vulnerable aquatic and forest ecosystems and buildings (Hill 2004). Around two-thirds of emissions result from fossil fuel-burning electricity generation. In developed countries the trend has been towards reductions in emissions due to changes to less sulphurous fossil fuels, deindustrialization, domestic legislation such as the US Clean Air Act of 1973, pollution control technologies encouraged by regional arrangements like the 1988 EU Large Combustion Plant Directive, and the international Convention of Long-Range Transboundary Air Pollution. However, emissions are still increasing in

[25] We do not choose environmental policies and regulations because recent studies have shown that even with stringent laws on the books, governments can and often cut enforcement budgets, reduce penalties for enforcement violations, and adopt administrative policies, all of which undermine enforcement effectiveness of policies (Cao and Prakash 2011). And we expect that the gap between law on paper and environmental outcomes is likely to be large, especially for developing countries.

rapidly growing developing countries many of which are authoritarian regimes. We used Stern's data on sulphur dioxide emissions, in kilograms per-capita per year (*so2pc*).[26]

Carbon dioxide is the most significant anthropogenic forcing factor for climate change.[27] Hence it is also implicated in an enormous range of problems, including potential food scarcity, health, development, security, and loss of biodiversity. It has been under intense discussion since the late 1980s, primarily under the umbrella of the 1992 Framework Convention on Climate Change. Despite the entering into force of the 1997 Kyoto Protocol in 2005, regional action such as the EU Emissions Trading Scheme, and action at state and local scales, policy has had little impact to date. We use CO_2 emissions in metric tonnes per capita (*co2pc*) from the World Bank's Development Indicators. Emissions have fallen in some countries since the 1980s partly as a consequence of shifts in fuel or closing polluting heavy industry.

Bio-chemical oxygen demand (BOD) is an important indicator of water pollution and it measures the amount of oxygen required to decompose a given amount of organic pollutant. 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 (*bodpdpc*). This is, then, a measure of anthropogenic organic pollution of waterways.[28]

Authoritarian Regime Type: We rely on Wright 2008's extension of Geddes' typology of authoritarian regime types (Geddes 1999). Note that Geddes originally offers a straightforward classification of regimes as military, personalist, and single-party: in military regimes, a group of officers decides who will rule and influence policy; in single party regimes, one party dominates access to political office and controls policy; in personalist regimes, access to office and the fruits of office depends on the discretion of an individual leader. The original data spanned from 1950 to 2000, but did not include monarchies and only included data on regimes that endured more than three years. Wright 2008 updated the Geddes data to include monarchies, such as Saudi Arabia, Morocco, and Kuwait. The data have also been updated to include all regimes from 1946 to 2003, regimes that lasted less than 4 years, and new regimes from the old Soviet bloc such as the Central Asian republics and Belarus.

There are some hybrid regimes coded in the data including military-personalist, single-party-military, single-party-military-personalist, and single-party-personalist regimes. These hybrid regimes might exhibit characteristics of two or more than two pure regime types. Therefore, in this study, we choose to focus on the four pure types of authoritarian regime types to capture the effects of the size of the key constituencies/selectorate on the environment. Between 1946 and 2003, among the 4180 country-years coded, there are 938 observations that are hybrid regimes, roughly 22% of the total observations.

Extractive State Capacity: In order to capture the concept of the extractive capacity of the state, we use two different fiscal measures of state capacity from Arbetman-Rabinowitz and Johnson (2007): the state's tax revenue as a percentage of GDP (*Tax ratio*) and relative political capacity (*RPC*).[29] Tax

[26] See Stern 2005 for data sources.

[27] Even though other pollutants have greater forcing potential *per-unit*.

[28] Inorganic pollution, for instance, that due to run-off of nitrates and phosphates from agriculture, may also deplete oxygen by generating algal blooms, but BOD is not a direct measure of this, and we know of no internationally comparable data.

[29] Other measures of state capacity are also often used in the literature, such as government consumption and government total revenue. However, we think these alternative measures are problematic for our purposes.

ratio measures state's ability to extract resources from individuals and groups in society; it is the conventional gauge of the state's extractive capacity (Campbell 1993; Cheibub, 1998; Centeno, 2002; Thies, 2005 and 2010). Relative political capacity (RPC) further conceptualizes state's relative political capacity as the "the ability of a government to extract resources from a population given their level of economic development" (Arbetman-Rabinowitz and Johnson 2007, 2). It is a measure of the strength of the state compared to other states with similar levels of development and resource endowments.

RPC is an index that compares the actual level of tax revenue extraction to a predicted level of extraction. Predicted revenues are estimated as a function of per capita income, the share of agriculture in the economy, the share of mining in the economy, and major oil production. A state that scores 1 on the RPC indicator is extracting exactly as one would expect compared to other states with similar conditions, while those that score higher than 1 are extracting more than expected and those that score lower than 1 are extracting less than expected. The relative political capacity score was originally developed by Organski and Kugler (1980) as a proxy for states' relative ability to wage war, and has proven useful in conflict studies (Ties 2010) and in recent work on carbon emissions (Sprinz et al. 2009).

***Non-tax Revue and Repressive State Capacity*:** It is important for us to control for the effects of non-tax revenue, because given the same level of demand from the key constituencies, non-tax revenue can replace part of the resources that the ruler has to extract from the society in order to stay in power. Therefore, our theory predicts that non-tax revenue, by lowering ruler's resource extraction from the society, should have a positive effect on environmental quality in authoritarian states. However, this positive impact might be weaker or stronger depending on other effects associated with different components of non-tax revenue. Non-tax revenues can include income from raw material extraction, state-owned enterprises (SOE), and foreign aid. In addition to the "tax-replacing" impact predicted by our theory, raw material extraction often has negative impacts on the environment; state-owned enterprises (SOE) often engage in industrial production which is also often associated with higher level of pollution (compared to agriculture and service); foreign aid, on the other hand, if granted with conditionality on environment protection or in the form of environmental aid, might have additional positive impact on the environment ("additional" to the positive impact caused by replacing ruler's tax extraction).[30]

Indeed, the domestic components of non-tax revenue (by definition, domestic sources of revenue that are not levied as taxes) include more than income from SOEs and royalties from corporations engaged in natural resource exploitation: for example, revenue (including interest or profit) from investment funds, sovereign wealth funds, or endowments; revenues from sales of state assets, and licensing fees. Data are often not available for these different components. Therefore, we only control for the total amount of *Domestic non-tax revenue* (% of GDP).[31] Detailed data on foreign environmental aid are indeed available at project level.[32] However, aggregating to the unit of country-year is not easy,

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Government consumption is a measure of the amount of a society's resources consumed by government. It measures expenditures, rather than revenue gathering activity. Total government revenue is a measure of the government's income that includes both tax and non-tax revenue. It is not typically seen as the best measure of revenue extraction, since it contains non-tax revenue.

[30] We control for energy production (% of GDP) and fuel exports (% of exports) in the empirical analysis that might be able to capture the non- "tax-replacing" impact of raw material extraction; moreover, we also control for industrial production (% of GDP) in order to capture state-owned enterprises' non- "tax-replacing" impact on the environment.

[31] Data are from the replication data of Thies 2010, with original data from Johnson and Rabinowitz 2007.

[32] See Project-Level Aid and AidData at: http://irtheoryandpractice.wm.edu/projects/plaid/, accessed on February 23, 2011. See also Hicks et al. 2008.

because it is hard to determine in a given country-year, how much money of the total commitment is implemented. We leave this further data aggregation exercise to future research. In the current paper, we use WDI's data on net development assistance and aid which measure official development assistance (ODA) and official aid flows, net of repayments, in current US dollars. We calculate this as a percentage of GDP (*Foreign aid*).

As we discussed in the theoretical section, a combination of repressive politics with welfare-enhancing public goods might be a dominant strategy for the ruler to deal with the disenfranchised population (Gallagher and Hanson 2009). Public demand for a better environment is more likely to be ignored by the ruler if he has enough repressive capacity ("stick") to crush potential protest and rebellion and can offer economic benefits ("carrot") to the population. It is therefore important for us to control the repressive capacity of the state. Moreover, if the repressive capacity is correlated with extractive capacity of the state, we risk picking up this repressive mechanism and mistaking it for the extractive capacity of the state.[33] We use two indicators for repressive capacity of the state: military personnel per capita and military expenditure as a percentage of GDP.[34] Data are from Singer et al. 1972.

Time Horizon*:* We have argued that ruler is more likely to provide both public and private goods to their constituencies, especially when the size of these constituencies is so large that it becomes too expensive to only provide private goods. However, public goods differ in multiple dimensions and in the short run, environmental public goods are unlikely greatly to increase productivity. Indeed, one characteristic of many environmental regulations and investment in environmental protection in general is that it requires a long period of time for the investment to show its effects. This, in turn, implies that everything else equal, it is more likely for the ruler to provide environmental public goods if he has a long time horizon. We use two indicators often seen in the literature to measure the time horizon of the ruler: predicted probability of regime failure and actual regime duration. We borrow both the concept and data from Wright 2008 on predicted probability of regime failure which assumes that autocratic rulers themselves are attuned to the same predictors of leadership survival as researchers. These predicted probabilities, based on the observable causes of regime failure, give us a measure of how likely an autocrat is to be replaced in any given year.[35] The greater the perceived probability of failure is, the shorter the time horizon.

The second way to operationalize the ruler's time horizon is to use actual regime duration. We use the variable DURABLE from the Polity IV data set. Conceptually, this variable captures the notion of regime durability. More concretely, the DURABLE variable provides a running measure of the durability of the regime's authority pattern for a given year. Empirically, it measures the length of time since a three point change in the Polity score over a three year period (Marshall, Gurr, and Jaggers 2010).

Socialist/Communist Legacies: Communist regimes have often adopted a progressivist perspective based on Marx and Engels' idea that the road to communism lies through the development of the forces of production. In practice, communist regimes tended to develop forces of production by

[33] Military expenditure (% GDP) is indeed positively correlated to RPC (0.05) and tax ratio (0.18) measures for the extractive capacity of the state. Military personnel per capita's correlations with RPC and tax ratio are -0.09 and 0.09 respectively.

[34] Military expenditure per capita, on the other hand, might be misleading because it is often a function of GDP per capita of the country.

[35]The explanatory variables used in the model, according to the web appendix from Wright 2008, include GDP per capita, GDP growth, civil war, Islam, cold war, Geddes regime dummies (single party, military, monarch, single party/military/personalist, military/personalist, single party/military, single party/personalist), and region dummies (Sub-Saharan Africa, North Africa, Middle East, Central Asia, Central East Europe, East Asia, South America, and West Europe).

investment in heavy industry, mining, and massive irrigation and hydro-electric projects. While the case-study literature on communist regimes finds it difficult to disentangle this ideology from other variables such as relative under-development, it is frequently held to be one factor lying behind such problems as heavy air and water pollution in the Soviet Union (Oldfield 2005, 21-42). Beside ideology, it is commonly held that Soviet central planning was wasteful of resources, because inputs and use of pollution sinks came un-priced to enterprises bent on plan fulfilment, and led to under-investment in cleaner plant, because of short-term pressures to maximize production (Ericson 1991). Another reason to control for communist legacies is that many single-party regimes are associated with communist/socialist experience; we need to tease out the effect of communist legacies in order to make it a convincing case that it is the size of the constituencies (and state capacity) that impact the environment.[36] We therefore add a dummy variable indicating whether a country has ever been a communist or socialist regime.[37]

Further Control Variables: We include both *GDP per capita* (in purchasing power parity) and its squared term in the model to capture the curvilinear relationship between wealth and environmental protection. This is to test the Environmental Kuznets Curve argument that there is a U shape relationship between economic development and environmental protection. Moreover, rapid economic growth may generate forms of environmental damage that are hard to cope with in the short-term. We therefore include *GDP growth rate*. Our model also includes the share of industrial production in GDP (*Industry*) because the industrial production is often associated with higher levels of pollution in relation to service and agricultural sectors. We further control for *Fuel exports* (as a percentage of merchandise exports) given the negative environmental impacts associated with the exploration, drilling, and extraction of fossil fuels (O'Rourke and Connolly 2003).

We include two demographic variables, *Population density* (population divided by land area) and *Urban population* (as a share of total population) to control for demographic influences on pollution levels. Countries with high population density might prioritize development at the expense of environmental protection. Large urban population might also increase environmental burden of the country; but urban population is also likely to be associated with environmental activism and protection.[38] We controls for *Trade openness* (the sum of imports and exports as a percentage of GDP) which has been used extensively in the trade-environment research to capture the effect of overall trade *openness* (de Soysa and Neumayer 2005).

Finally, any account of environmental politics will be incomplete without taking into account societal demands for more/less environmental protection. We, like many previous studies, have implicitly assumed that the public demands better environment. However, how strong that demand is and to what extent people are willing to give up part of their income for environmental protection is largely unknown, especially for many authoritarian states. It is therefore important to control for relative demand for environmental public goods. However, data on public opinion concerning environmental demand are limited, especially for developing countries.[39] Income is probably the best available proxy. Indeed, this is another justification for including GDP per capita and its square term.

[36] The correlation between communist legacies and single-party regime is indeed 0.45.

[37] Countries that have been coded 1 for this dummy variable and potentially enter the empirically analysis after deletion of missing data are Albania, Bulgaria, China, Hungary, Mongolia, Poland, Laos, Mozambique, Angola, Cambodia, Vietnam, Somalia, and Afghanistan.

[38] Data on GDP per capita, GDP growth rate, industrial production, oil exports, population density, and urban population are from the World Development Indicators (World Bank 2008).

[39] The World Values Survey and European Value Survey are to our knowledge the best sources for public opinion data on environmental demand. These surveys have a number of questions relating to the environment, depending on wave and country concerned. The most prevalent question across four waves and across countries has been "I would agree to an increase in taxes if the extra money were used to prevent environmental pollution"

Another important societal demand is associated with the energy intensive sectors and the common assumption is that these sectors prefer less stringent environmental regulations. For example, Ward and Cao forthcoming have shown that in the OECD context, the larger the size of the sectors, the lower the level of environmental taxation in a country. Energy intensive sectors can be identified, for instance by reference to those included in the EU's CO2 emissions trading scheme such as electricity generation, cement production, and glass making. In principle, the power of such sectors could be measured by their contribution to GDP, but available breakdowns of GDP are not fine enough to make this practicable. Things are more straightforward on the production side. We used World Development Indicators (WDI) data on national energy production in ktonnes of oil equivalent and divided by real GDP. This gives energy production per unit of real gross domestic product (*Energy production*). Table 1 presents the correlation statistics for the variables used in the paper.

Insert Table 1 about here.

Empirical Findings

We model air and water pollution in a country random effects model with a first-order autoregressive process to capture the within-country serial correlation of the data. While the random-effects in our model are conceptually analogous to the country- fixed effects usually employed in Time-Series-Cross-Sectional data (TSCS) analyses, they have certain statistical advantages. Unlike random effects models, fixed effects models use one degree of freedom for each unit. Such loss of information inflates the standard errors and makes the estimates of the coefficients less precise. This is important for our analysis because missing data (on RPC and Tax ratio, for example) already reduce the number of countries to 38-46 and the number of observations 262-374 (time period 1980-1999). More importantly, the authoritarian regime type variables are often slow-moving or even time-invariant. It is well known that estimating country fixed effects with slow-moving and time-invariant variables is often problematic.[40]

The model can be written as $y_{i,t} = \beta_0 + \beta_i + X\beta + \xi_{i,t}$, where β_0 is the population intercept, β_i represents mean-zero random unit intercepts and is normally distributed. Xβ is the linear covariates and an estimate of their impact on the dependent variable. Residuals are further decomposed as $\xi_{i,t} = \rho\xi_{i,t-1} + \epsilon_{i,t}$, where ρ is the first order autoregressive correlation term (AR1), and $\epsilon_{i,t}$ follows the normal distribution $N(0, \sigma^2)$. We also include year fixed effects to control for common trend and region dummy variables to control any potential regional effects that might not be captured by the explanatory variables.[41]

We present the empirical findings in Table 2-7 with two tables for each type of pollutant; for each pollutant, we present eight model specifications: we have two measures for state extractive capacity, time horizon, and state repressive capacity each. Each model specification includes basic social-economic control variables from GDP per capita to Energy production, domestic non-tax revenue, foreign aid, communist/socialist legacies, and region variables. The results from SO_2 regressions (Table 2-3) best support our theoretical expectations. With military regime as the baseline regime type,

(World Values Survey 2009). However, countries and years covered by these surveys are very limited for the authoritarian states included in this study.

[40] Even though recent literature has proposed statistical tools to deal with this (Plümper and Troeger 2007), there is still debate on whether the proposed estimators indeed solve the problem or which estimator(s) outperform the others (Plümper and Troeger 2011; Greene 2010).

[41] The region dummies are East Asia, Eastern Europe & post-Soviet, Latin America, North Africa & Middle East, South-East Asia, South Asia, and Sub-Saharan Africa.

single-party regimes are associated with higher levels of SO_2 per capita emission. Not only is the association statistically significant across all model specifications, but also the magnitude of the association is substantively important. A coefficient around 0.8 suggests that a single-party regime on average emits 0.8 kilograms per-capita in logarithm of SO_2 per capita per year --- the average of SO_2 per capita emission in the sample is 1.474 kilograms per-capita in logarithm. (We take the logarithm of all three dependent variables to rescale extreme values and approximate a normal distribution.) State extractive capacity, either measured by *RPC* or *Tax ratio*, is also associated with a higher level of SO_2 per capita emission. Moreover, among the two measures for the time horizon of the ruler, regime duration reduces SO_2 per capita emission. Therefore, the longer the durability of the regime is, the lower the level of emissions. The other measure, predicted probability of regime failure, is not associated with SO_2 emission.

Insert Table 2-3 about here.

However, we find no evidence that state repressive capacity (measured either by military personnel or spending) affects SO_2 emission. Similarly, the associations between domestic non-tax revenue, foreign aid, socialist/communist legacies on the one hand, and emission on the other are not statistically significant. The lack of impacts of domestic non-tax revenue and foreign aid on SO_2 emission are hardly surprising given the diversity in their components. For example, income from raw material extractions might ease the pressure for the leader to further squeeze the society and therefore have positive impacts on the environment. However, raw material extraction itself often damages the environment.

GDP per capita and its square term are significantly associated with emission and the signs of coefficients indicate an inverted U-shaped environmental Kuznets curve: per capita emission goes up with wealth until reaching a threshold after which increasing wealth decreases emission.[42] Urban population and energy production are also positively associated with SO_2 emission.

Insert Table 4-5 about here.

Table 4-5 presents the empirical findings for CO_2 emission. Different from the case of SO_2 emission, we do not find evidence for an inverted U-shaped environmental Kuznets curve even though the negative impacts of urban population and energy production are still statistically significant. In terms of the effects of regime types, the relationship between single-party regimes and emission is not significant. This might be because the effects of single-party regime run causally through state extractive capacity to affect CO_2 emission, so we would not expect the former to be significant when we control for state capacity. Indeed, when we look at the correlation statistics in Table 1, unlike the other three types of regimes (that are all negatively correlated with both RPC and Tax ratio), single-party regime is positively correlated with both measures of state extractive capacity.

Moreover, similar to the case of SO_2 emission, both RPC and Tax ratio increase CO_2 emission. Ruler's time horizon as measured as regime duration also reduces CO_2 emission. Unlike the case of SO_2 emission, there is some evidence that t the repressive capacity as measured as military spending (% GDP) is positively associated with emission (model 6 and 8 in Table 5). Foreign aid has negative coefficients in all model specifications, but only achieves some level of significance in model 8 of Table 5. In terms of the regional effects, with the baseline region being East Asia, we find that South Asia and Sub-Sahara Africa emit significantly less CO_2.

[42] The estimated threshold is over $30000, which is quite extreme. But this is under authoritarian regimes and chances are that countries would have democratized before such level of economic development.

Insert Table 6-7 about here.

Different from findings of two major air pollutants, those from BOD regressions suggest that few covariates in our model actually have any impact on this type of water pollution. GDP growth reduces and urban population increases BOD per capita. However, state extractive capacity as measured as Tax ratio still increases BOD per capita (model 5-8, Table 7). We also find that domestic non-tax revenue is negatively associated with BOD per capita, but the significance level is always around 0.11. We might simply need better quality data for BOD discharges: for the same time period and same set of countries, the available observations for the BOD regressions are one third lower than those in the SO_2 and CO_2 regressions.

Conclusion and Discussion on Future Research

In this paper, we present a simple model of environmental politics in the authoritarian world. Starting with the basic assumptions that rulers want to stay in power, and in order to do so, they need to deliver benefits to their key constituencies, we argue that on the demand side, the larger the size of these key constituencies, the more pressure there is for the ruler to deliver. For countries that lack easy revenue (domestic non-tax revenues and/or foreign aid), this often requires higher state capacity (often acquired over time) for more extensive extraction of resources from the society. Heavy resources extraction from the society by the state is often at the expense of the environment, because it lowers the incentives and abilities of the private sector to implement environmental regulations; it also limits the efforts and abilities of civil societies to act on public environmental demand. Large key constituencies plus strong state capacity, as our theoretical model predicts, are associated with bad environmental outcomes in the authoritarian regimes.

We test our theory by modelling three types of major air and water pollutants (SO_2, CO_2, and BOD) in authoritarian states as a function of regime types (which we use to proxy the size of key constituencies), extractive capacity of the state, and a battery of relevant variables, for 1980-1999. We find that state capacity is associated with higher levels of all three types of pollutants. Single-party regimes, which we assume to have the largest key constituencies among four types authoritarian regimes (single-party, military, personalistic, and monarchy), are positively associated with SO_2 emissions. We also find strong evidence that the time horizon of the ruler, as measured by regime duration, reduces SO_2 and CO_2 emissions.

However, there are many assumptions in our model that require further investigation. For example, we assume that the disenfranchised population generally prefers more state investment to protect/improve the environment. In our theory, the ruler deals with the disenfranchised by carrots (economic development) and sticks (direct repression or the threat/ability to do so). This is the reason why we predict the higher repressive capacity the ruler has, the more he can ignore the public environmental demand, and therefore the worse the environmental outcomes. We indeed have some empirical support for this prediction but only for the CO_2 case when using military spending (% GDP) as measure of repressive capacity. However, whether the public would prefer environment over economic development or whether in some developing countries, people are willing to give up the environment for economic welfare are open questions, largely because of the lack of data covering many developing countries. If there is no such public demand, then there is no need for the ruler to use repression to deal with this type of demand, and our prediction is invalid. We simply need further research to collect public opinion data on this.

Moreover, we need to better understand the differences between different types of pollutants. We test our theory for three types of pollutants. The results indeed vary across pollutant types. What explains these differences in addition to data quality? Industries and activities that generate one type of pollutant might be different from those generating other types of pollutants, and politics connecting these groups to authoritarian rulers' calculation might be different. Cao and Prakash 2011 have shown that the effects of trade competition and domestic political constraints on pollution intensity indeed vary across pollutants, more likely as a function of visibility associated with each pollutant (which in

turn affects the level of mobilization of pro-environmental groups). In the context of authoritarian states, whether it is visibility or some other factors that can explain these differences across pollutant types, we need more detailed studies on this in the future.

Finally, we use regime types to approximate the size of key constituencies. Our ranking of regime types by the constituency sizes is largely based on the expectations derived from the theoretical definitions of the selecorate. Also based on anecdotal evidence, we are confident that single-party regimes tend to have the largest selectorate than other three types of regimes. However, it is always an empirically challenge to measure the winning coalition and selectorate directly in the real world. (Indeed, this is the most serious empirical challenge for the Selectorate theory as problematic proxies of W and S limit the validity of any test associated with the theory.) In this case, we think comparative case studies might help us to better establish the causal relationships. For example, many authoritarian governments have the tendency to include more and more people into the selectorate (often by giving them public employment) either intentionally in order to buy out support or as a function of the "natural" growth of bureaucracy and party organizations. Future research might be able to take advantage of such comparative cases (over time) to see whether differences in size of the key constituencies make a difference in environmental outcomes.

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TABLE 1. Correlation among covariates

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1: RPC	1.00	0.86	-0.07	0.24	-0.05	-0.17	-0.15	0.09	-0.18	0.20	0.16	-0.09	0.05	-0.16	-0.02	-0.04	-0.05	-0.12	0.10	0.09	-0.07
2: Tax ratio (% GDP)	0.86	1.00	-0.15	0.25	-0.09	-0.04	-0.20	0.24	-0.03	0.03	0.11	0.09	0.18	0.05	0.35	-0.04	0.04	0.19	0.31	0.30	0.05
3: Personalist	-0.07	-0.15	1.00	-0.57	-0.26	-0.31	0.23	-0.01	-0.19	0.24	-0.23	-0.15	-0.09	-0.29	-0.25	-0.11	-0.09	-0.19	-0.09	-0.15	-0.13
4: Single party	0.24	0.25	-0.57	1.00	-0.29	-0.34	-0.36	0.05	-0.01	-0.02	0.43	-0.04	-0.03	-0.07	0.01	0.04	0.15	-0.02	0.05	-0.14	-0.21
5: Military	-0.05	-0.09	-0.26	-0.29	1.00	-0.16	0.52	-0.19	-0.09	-0.13	-0.13	-0.04	-0.09	-0.05	-0.04	0.02	-0.02	0.02	-0.24	-0.06	-0.07
6: Monarchy	-0.17	-0.04	-0.31	-0.34	-0.16	1.00	-0.28	0.11	0.35	-0.18	-0.16	0.28	0.25	0.51	0.36	0.08	-0.07	0.26	0.30	0.41	0.48
7: Probability of regime failure	-0.15	-0.20	0.23	-0.36	0.52	-0.28	1.00	-0.10	-0.17	0.09	-0.12	-0.15	-0.13	-0.24	-0.18	-0.14	-0.08	-0.07	-0.26	-0.21	-0.18
8: Regime duration	0.09	0.24	-0.01	0.05	-0.19	0.11	-0.10	1.00	0.07	-0.05	0.19	0.23	0.15	0.23	0.32	0.02	0.03	0.24	0.23	0.20	0.18
9: Non-tax revenue (% GDP)	-0.18	-0.03	-0.19	-0.01	-0.09	0.35	-0.17	0.07	1.00	-0.12	0.01	0.18	0.22	0.28	0.45	0.03	0.08	0.35	0.26	0.40	0.45
10: Foreign aid (% GDP)	0.20	0.03	0.24	-0.02	-0.13	-0.18	0.09	-0.05	-0.12	1.00	0.13	-0.13	-0.03	-0.32	-0.38	-0.02	-0.10	-0.33	0.08	-0.28	-0.15
11: Socialist/Communist legacies	0.16	0.11	-0.23	0.43	-0.13	-0.16	-0.12	0.19	0.01	0.13	1.00	0.25	0.22	-0.09	0.11	0.02	-0.03	-0.03	-0.03	-0.04	-0.03
12: Military personnel (per capita)	-0.09	0.09	-0.15	-0.04	-0.04	0.28	-0.15	0.23	0.18	-0.13	0.25	1.00	0.39	0.59	0.45	0.07	0.15	0.53	0.22	0.24	0.27
13: Military spending (% GDP)	0.05	0.18	-0.09	-0.03	-0.09	0.25	-0.13	0.15	0.22	-0.03	0.22	0.39	1.00	0.24	0.28	0.02	0.00	0.28	0.18	0.30	0.32
14: GDP per capita	-0.16	0.05	-0.29	-0.07	-0.05	0.51	-0.24	0.23	0.28	-0.32	-0.09	0.59	0.24	1.00	0.55	0.03	0.29	0.66	0.25	0.32	0.50
15: Industry (% of GDP)	-0.02	0.35	-0.25	0.01	-0.04	0.36	-0.18	0.32	0.45	-0.38	0.11	0.45	0.28	0.55	1.00	0.06	0.03	0.58	0.42	0.59	0.61
16: GDP growth rate	-0.04	-0.04	-0.11	0.04	0.02	0.08	-0.14	0.02	0.03	-0.02	0.02	0.07	0.02	0.03	0.06	1.00	0.07	-0.00	0.05	0.06	0.04
17: Population density	-0.05	0.04	-0.09	0.15	-0.02	-0.07	-0.08	0.03	0.08	-0.10	-0.03	0.15	0.00	0.29	0.03	0.07	1.00	0.31	-0.12	-0.03	-0.14
18: Urban population (% pop.)	-0.12	0.19	-0.19	-0.02	0.02	0.26	-0.07	0.24	0.35	-0.33	-0.03	0.53	0.28	0.66	0.58	-0.00	0.31	1.00	0.26	0.37	0.23
19: Trade openness	0.10	0.31	-0.09	0.05	-0.24	0.30	-0.26	0.23	0.26	0.08	-0.03	0.22	0.18	0.25	0.42	0.05	-0.12	0.26	1.00	0.21	0.32
20: Fuel export (% of exp)	0.09	0.30	-0.15	-0.14	-0.06	0.41	-0.21	0.20	0.40	-0.28	-0.04	0.24	0.30	0.32	0.59	0.06	-0.03	0.37	0.21	1.00	0.73
21: Energy production (% GDP)	-0.07	0.05	-0.13	-0.21	-0.07	0.48	-0.18	0.18	0.45	-0.15	-0.03	0.27	0.32	0.50	0.61	0.04	-0.14	0.23	0.32	0.73	1.00

TABLE 2. Models on SO2 per capita emission: using RPC as state capacity.

	Model 1:			Model 2:			Model 3:			Model 4:		
	Coef.	$\hat{\sigma}$	p(>|t|)	*Coef.*	$\hat{\sigma}$	p(>|t|)	*Coef.*	$\hat{\sigma}$	p(>|t|)	*Coef.*	$\hat{\sigma}$	p(>|t|)
(Intercept)	-8.9161	3.364	0.009	-9.1337	3.340	0.007	-7.3318	3.293	0.027	-7.6409	3.266	0.020
GDP per capita	2.0938	0.760	0.006	2.2118	0.740	0.003	1.7345	0.744	0.021	1.8834	0.724	0.010
GDP per capita^2	-0.1007	0.045	0.025	-0.1088	0.043	0.012	-0.0848	0.044	0.054	-0.0946	0.042	0.027
Industry (% of GDP)	-0.0012	0.004	0.781	-0.0007	0.004	0.863	-0.0002	0.004	0.954	0.0002	0.004	0.964
GDP growth rate	-0.0015	0.002	0.359	-0.0015	0.002	0.354	-0.0013	0.002	0.445	-0.0013	0.002	0.432
Population density	-0.0009	0.163	0.996	-0.0034	0.163	0.983	-0.0025	0.157	0.987	-0.0031	0.157	0.984
Urban population (% pop.)	0.0144	0.009	0.099	0.0148	0.009	0.090	0.0183	0.009	0.033	0.0185	0.009	0.031
Trade openness	-0.0050	0.081	0.951	0.0009	0.081	0.991	-0.0047	0.082	0.954	0.0029	0.081	0.972
Fuel export (% of exp)	-0.0123	0.009	0.189	-0.0121	0.009	0.200	-0.0145	0.009	0.126	-0.0141	0.009	0.138
Energy production (% GDP)	0.1568	0.094	0.096	0.1621	0.094	0.086	0.1644	0.094	0.082	0.1703	0.094	0.071
Regime (baseline: Military):												
Monarchy	0.9450	0.536	0.088	0.9493	0.534	0.086	0.7358	0.511	0.161	0.7462	0.509	0.154
Personalist	0.0837	0.408	0.839	0.1072	0.406	0.794	0.0237	0.393	0.952	0.0544	0.390	0.890
Single party	0.7916	0.379	0.046	0.8211	0.375	0.037	0.6969	0.367	0.068	0.7390	0.362	0.051
State Capacity:												
RPC	0.1287	0.047	0.007	0.1292	0.047	0.006	0.1197	0.047	0.012	0.1204	0.047	0.011
Tax ratio (% GDP)												
Time Horizon:												
Regime duration	-0.0038	0.002	0.082	-0.0038	0.002	0.085						
Probability of regime failure							-0.8155	0.592	0.169	-0.7362	0.592	0.215
Repressive Capacity:												
Military personnel (per capita)	-0.0590	0.071	0.404				-0.0699	0.071	0.325			
Military spending (% GDP)				-0.0228	0.035	0.515				-0.0221	0.035	0.532
Non-tax revenue (% GDP)	0.0493	0.243	0.839	0.0651	0.243	0.789	0.0524	0.244	0.830	0.0700	0.244	0.775
Foreign aid (% GDP)	0.0033	0.005	0.471	0.0036	0.005	0.423	0.0032	0.005	0.486	0.0035	0.005	0.441
Socialist/Communist legacies	-0.1939	0.710	0.787	-0.2419	0.704	0.734	-0.1837	0.684	0.790	-0.2436	0.678	0.722
Region (baseline: East Asia):												
East Europe & post-Soviet												
Latin America	-0.9158	0.832	0.280	-0.9401	0.831	0.267	-0.7636	0.803	0.349	-0.7913	0.802	0.332
North Africa & Middle East	-0.9678	0.834	0.255	-1.0111	0.830	0.233	-0.8424	0.801	0.302	-0.8931	0.797	0.271
South-East Asia	-0.9130	0.790	0.257	-0.9339	0.787	0.245	-0.7953	0.759	0.303	-0.8214	0.756	0.286
South Asia	-2.4635	1.195	0.048	-2.4064	1.188	0.052	-2.2924	1.148	0.055	-2.2176	1.140	0.062
Sub-Saharan Africa	-1.0207	0.795	0.209	-0.9928	0.791	0.220	-0.9653	0.765	0.217	-0.9272	0.761	0.233
AR1:			0.973			0.973			0.971			0.971
$StdDev(Intercept_i)$			0.035			0.035			0.036			0.036
$StdDev(Residual)$			0.764			0.762			0.737			0.734
Log-Lik			-5.367			-6.205			-0.334			-1.322
N of countries			39			39			39			39
N of Observations			347			347			347			347

Note: Year fixed effects (1980-1999: 1980 is the baseline year) are estimated for all models but not reported because of space limit.

TABLE 3. Models on SO2 per capita emission: using tax ratio as state capacity.

	Model 5:			Model 6:			Model 7:			Model 8:		
	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)
(Intercept)	-8.0907	3.301	0.015	-8.2124	3.277	0.013	-6.8624	3.255	0.036	-7.0622	3.228	0.029
GDP per capita	1.7344	0.755	0.022	1.8049	0.735	0.015	1.4570	0.745	0.051	1.5629	0.725	0.032
GDP per capita^2	-0.0860	0.045	0.054	-0.0913	0.043	0.035	-0.0742	0.044	0.093	-0.0816	0.043	0.057
Industry (% of GDP)	-0.0011	0.004	0.789	-0.0007	0.004	0.870	-0.0001	0.004	0.986	0.0004	0.004	0.931
GDP growth rate	-0.0011	0.002	0.509	-0.0011	0.002	0.526	-0.0008	0.002	0.646	-0.0008	0.002	0.655
Population density	0.1283	0.149	0.389	0.1207	0.149	0.418	0.1256	0.146	0.390	0.1194	0.145	0.412
Urban population (% pop.)	0.0230	0.008	0.006	0.0234	0.008	0.005	0.0261	0.008	0.002	0.0264	0.008	0.002
Trade openness	0.0142	0.081	0.861	0.0157	0.081	0.846	0.0061	0.082	0.941	0.0105	0.082	0.897
Fuel export (% of exp)	-0.0104	0.009	0.255	-0.0100	0.009	0.271	-0.0120	0.009	0.193	-0.0114	0.009	0.213
Energy production (% GDP)	0.1762	0.096	0.068	0.1787	0.096	0.063	0.1828	0.096	0.058	0.1862	0.096	0.053
Regime (baseline: Military):												
Monarchy	0.7415	0.495	0.143	0.7479	0.493	0.138	0.5782	0.481	0.237	0.5893	0.477	0.225
Personalist	0.1326	0.384	0.732	0.1474	0.382	0.702	0.0538	0.376	0.887	0.0789	0.373	0.833
Single party	0.8681	0.365	0.023	0.8834	0.361	0.020	0.7879	0.359	0.035	0.8177	0.354	0.027
State Capacity:												
RPC												
Tax ratio (% GDP)	0.0072	0.003	0.012	0.0073	0.003	0.010	0.0072	0.003	0.013	0.0073	0.003	0.012
Time Horizon:												
Regime duration	-0.0038	0.002	0.097	-0.0037	0.002	0.100						
Probability of regime failure							-0.7469	0.608	0.220	-0.6672	0.607	0.273
Repressive Capacity:												
Military personnel (per capita)	-0.0381	0.069	0.584				-0.0537	0.070	0.446			
Military spending (% GDP)				-0.0317	0.035	0.371				-0.0298	0.036	0.405
Non-tax revenue (% GDP)	0.0329	0.252	0.896	0.0516	0.252	0.838	0.0326	0.253	0.898	0.0539	0.253	0.831
Foreign aid (% GDP)	0.0002	0.005	0.969	0.0005	0.004	0.917	0.0001	0.005	0.985	0.0004	0.005	0.935
Socialist/Communist legacies	0.0438	0.689	0.950	0.0231	0.682	0.973	0.0249	0.675	0.971	-0.0132	0.666	0.984
Region (baseline: East Asia):												
East Europe & post-Soviet	-0.1609	0.793	0.840	-0.1920	0.787	0.809	-0.0544	0.774	0.944	-0.0977	0.767	0.899
Latin America	-0.5591	0.800	0.489	-0.6015	0.798	0.456	-0.4237	0.786	0.593	-0.4699	0.783	0.552
North Africa & Middle East	-0.4914	0.788	0.537	-0.5214	0.783	0.510	-0.3964	0.770	0.610	-0.4388	0.763	0.569
South-East Asia	-0.6439	0.766	0.406	-0.6626	0.763	0.391	-0.5388	0.749	0.477	-0.5650	0.744	0.452
South Asia	-1.4985	0.893	0.102	-1.4793	0.884	0.103	-1.4312	0.872	0.110	-1.3870	0.861	0.116
Sub-Saharan Africa	-0.6083	0.757	0.427	-0.6083	0.753	0.425	-0.5671	0.741	0.449	-0.5553	0.735	0.455
AR1:			0.970			0.970			0.968			0.968
$StdDev(Intercept_i)$			0.0003			0.0003			0.0004			0.0003
$StdDev(Residual)$			0.751			0.748			0.736			0.731
Log-Lik			-18.516			-18.247			-13.874			-13.821
N of countries			46			46			46			46
N of Observations			373			374			372			373

Note: Year fixed effects (1980-1999: 1980 is the baseline year) are estimated for all models but not reported because of space limit.

TABLE 4. Models on CO2 per capita emission: using RPC as state capacity.

	Model 1:			Model 2:			Model 3:			Model 4:		
	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)
(Intercept)	-1.5924	2.539	0.531	-1.5724	2.481	0.527	-0.5435	2.450	0.825	-0.4489	2.388	0.851
GDP per capita	-0.0596	0.552	0.914	-0.0739	0.524	0.888	-0.2775	0.530	0.601	-0.3101	0.501	0.536
GDP per capita^2	0.0352	0.033	0.286	0.0365	0.031	0.242	0.0452	0.032	0.158	0.0474	0.030	0.116
Industry (% of GDP)	-0.0037	0.004	0.314	-0.0031	0.004	0.383	-0.0028	0.004	0.430	-0.0022	0.004	0.536
GDP growth rate	-0.0001	0.002	0.962	-0.0002	0.002	0.929	0.0001	0.002	0.962	-0.0000	0.002	0.999
Population density	0.0081	0.152	0.957	0.0391	0.151	0.796	-0.0052	0.150	0.972	0.0270	0.149	0.856
Urban population (% pop.)	0.0127	0.006	0.039	0.0126	0.006	0.040	0.0140	0.006	0.020	0.0138	0.006	0.020
Trade openness	0.0874	0.063	0.165	0.0926	0.062	0.134	0.0917	0.062	0.139	0.0976	0.061	0.108
Fuel export (% of exp)	0.0067	0.009	0.438	0.0080	0.009	0.355	0.0061	0.009	0.481	0.0074	0.009	0.393
Energy production (% GDP)	0.2366	0.088	0.007	0.2308	0.087	0.009	0.2335	0.087	0.007	0.2275	0.086	0.009
Regime (baseline: Military):												
Monarchy	0.2563	0.509	0.618	0.2337	0.503	0.645	0.1356	0.501	0.789	0.1075	0.494	0.829
Personalist	-0.2467	0.398	0.540	-0.2388	0.391	0.546	-0.2712	0.394	0.497	-0.2677	0.387	0.495
Single party	0.2763	0.372	0.464	0.2966	0.365	0.423	0.2418	0.371	0.520	0.2526	0.363	0.492
State Capacity:												
RPC	0.1081	0.042	0.011	0.1098	0.042	0.009	0.1142	0.042	0.006	0.1156	0.041	0.006
Tax ratio (% GDP)												
Time Horizon:												
Regime duration	-0.0033	0.002	0.087	-0.0032	0.002	0.093						
Probability of regime failure							-0.1243	0.564	0.826	-0.2309	0.565	0.683
Repressive Capacity:												
Military personnel (per capita)	-0.0049	0.070	0.944				-0.0020	0.069	0.977			
Military spending (% GDP)				0.0527	0.035	0.135				0.0556	0.035	0.116
Non-tax revenue (% GDP)	-0.1131	0.254	0.656	-0.1181	0.253	0.641	-0.1019	0.254	0.688	-0.1082	0.253	0.669
Foreign aid (% GDP)	-0.0045	0.004	0.275	-0.0051	0.004	0.218	-0.0056	0.004	0.174	-0.0061	0.004	0.134
Socialist/Communist legacies	-0.3171	0.681	0.645	-0.3499	0.669	0.605	-0.3601	0.673	0.597	-0.3896	0.661	0.560
Region (baseline: East Asia):												
East Europe & post-Soviet												
Latin America	-1.4033	0.799	0.090	-1.2815	0.793	0.117	-1.3668	0.791	0.094	-1.2288	0.784	0.128
North Africa & Middle East	-0.7680	0.802	0.346	-0.7326	0.792	0.362	-0.7206	0.792	0.371	-0.6831	0.781	0.389
South-East Asia	-0.9029	0.767	0.249	-0.8713	0.757	0.259	-0.8624	0.758	0.265	-0.8288	0.748	0.277
South Asia	-3.3654	1.122	0.006	-3.2194	1.100	0.007	-3.2588	1.108	0.006	-3.1187	1.084	0.007
Sub-Saharan Africa	-1.8475	0.767	0.023	-1.7549	0.754	0.027	-1.8525	0.759	0.021	-1.7604	0.745	0.025
AR1:			0.357			0.354			0.323			0.317
$StdDev(Intercept_i)$			0.711			0.702			0.704			0.694
$StdDev(Residual)$			0.178			0.177			0.176			0.175
Log-Lik			-16.467			-16.030			-12.111			-11.546
N of countries			39			39			39			39
N of Observations			347			347			347			347

Note: Year fixed effects (1980-1999: 1980 is the baseline year) are estimated for all models but not reported because of space limit.

TABLE 5. Models on CO2 per capita emission: using tax ratio as state capacity.

	Model 5:			Model 6:			Model 7:			Model 8:		
	Coef.	$\hat{\sigma}$	p(>|t|)	*Coef.*	$\hat{\sigma}$	p(>|t|)	*Coef.*	$\hat{\sigma}$	p(>|t|)	*Coef.*	$\hat{\sigma}$	p(>|t|)
(Intercept)	-1.6857	2.396	0.482	-1.4665	2.356	0.534	-0.7197	2.308	0.755	-0.4123	2.263	0.856
GDP per capita	-0.0199	0.533	0.970	-0.0984	0.509	0.847	-0.2201	0.513	0.668	-0.3185	0.487	0.514
GDP per capita^2	0.0316	0.032	0.323	0.0367	0.030	0.227	0.0406	0.031	0.190	0.0467	0.029	0.112
Industry (% of GDP)	-0.0030	0.003	0.381	-0.0027	0.003	0.420	-0.0022	0.003	0.528	-0.0017	0.003	0.612
GDP growth rate	-0.0001	0.002	0.957	-0.0001	0.002	0.932	0.0001	0.002	0.955	0.0001	0.002	0.971
Population density	0.0183	0.134	0.891	0.0445	0.133	0.739	0.0073	0.132	0.956	0.0349	0.131	0.790
Urban population (% pop.)	0.0148	0.006	0.012	0.0146	0.006	0.012	0.0161	0.006	0.005	0.0159	0.006	0.005
Trade openness	0.0757	0.061	0.212	0.0797	0.060	0.183	0.0778	0.060	0.198	0.0820	0.059	0.166
Fuel export (% of exp)	0.0093	0.008	0.230	0.0102	0.008	0.189	0.0089	0.008	0.251	0.0097	0.008	0.210
Energy production (% GDP)	0.2240	0.085	0.009	0.2190	0.085	0.010	0.2195	0.084	0.010	0.2142	0.084	0.011
Regime (baseline: Military):												
Monarchy	0.0565	0.455	0.902	0.0447	0.451	0.922	-0.0504	0.447	0.911	-0.0694	0.442	0.876
Personalist	-0.1023	0.359	0.777	-0.1080	0.355	0.762	-0.1388	0.354	0.698	-0.1514	0.349	0.667
Single party	0.2728	0.344	0.433	0.2738	0.339	0.424	0.2395	0.341	0.487	0.2309	0.335	0.496
State Capacity:												
RPC												
Tax ratio (% GDP)	0.0065	0.002	0.006	0.0065	0.002	0.005	0.0069	0.002	0.003	0.0069	0.002	0.003
Time Horizon:												
Regime duration	-0.0031	0.002	0.097	-0.0031	0.002	0.101						
Probability of regime failure							-0.1771	0.547	0.746	-0.3064	0.547	0.576
Repressive Capacity:												
Military personnel (per capita)	0.0220	0.065	0.735				0.0250	0.065	0.701			
Military spending (% GDP)				0.0594	0.034	0.078				0.0638	0.034	0.060
Non-tax revenue (% GDP)	-0.1263	0.248	0.611	-0.1358	0.246	0.582	-0.1170	0.248	0.638	-0.1272	0.246	0.606
Foreign aid (% GDP)	-0.0051	0.004	0.197	-0.0058	0.004	0.139	-0.0060	0.004	0.126	-0.0067	0.004	0.086
Socialist/Communist legacies	-0.2708	0.637	0.674	-0.2791	0.628	0.659	-0.3140	0.628	0.620	-0.3219	0.617	0.605
Region (baseline: East Asia):												
East Europe & post-Soviet	-0.3588	0.735	0.628	-0.3098	0.726	0.672	-0.3065	0.722	0.674	-0.2567	0.713	0.721
Latin America	-1.3883	0.739	0.069	-1.2724	0.735	0.092	-1.3439	0.730	0.074	-1.2076	0.726	0.105
North Africa & Middle East	-0.6485	0.733	0.382	-0.6106	0.725	0.405	-0.6063	0.721	0.406	-0.5667	0.712	0.432
South-East Asia	-0.8886	0.718	0.224	-0.8550	0.711	0.237	-0.8445	0.707	0.240	-0.8078	0.699	0.256
South Asia	-2.4555	0.825	0.005	-2.4083	0.809	0.005	-2.3886	0.811	0.006	-2.3461	0.794	0.006
Sub-Saharan Africa	-1.7581	0.707	0.018	-1.7008	0.699	0.020	-1.7543	0.697	0.017	-1.6967	0.687	0.019
AR1:			0.371			0.369			0.339			0.333
$StdDev(Intercept_i)$			0.667			0.661			0.657			0.650
$StdDev(Residual)$			0.176			0.174			0.174			0.172
Log-Lik			-10.754			-9.297			-6.948			-5.309
N of countries			46			46			46			46
N of Observations			373			373			372			373

Note: Year fixed effects (1980-1999: 1980 is the baseline year) are estimated for all models but not reported because of space limit.

TABLE 6. Models on BOD per capita emission: using RPC as state capacity.

	Model 1:			Model 2:			Model 3:			Model 4:		
	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)
(Intercept)	-3.1520	4.283	0.463	-3.2839	4.250	0.441	-3.0198	4.264	0.480	-3.2027	4.236	0.450
GDP per capita	-1.1083	1.027	0.282	-1.0614	1.000	0.290	-1.1427	1.020	0.264	-1.0846	0.993	0.276
GDP per capita^2	0.0869	0.063	0.167	0.0844	0.061	0.167	0.0883	0.062	0.158	0.0851	0.061	0.162
Industry (% of GDP)	-0.0078	0.007	0.259	-0.0068	0.007	0.333	-0.0077	0.007	0.267	-0.0065	0.007	0.354
GDP growth rate	-0.0063	0.003	0.040	-0.0063	0.003	0.040	-0.0063	0.003	0.041	-0.0063	0.003	0.040
Population density	0.2005	0.170	0.240	0.2333	0.172	0.177	0.2041	0.170	0.232	0.2397	0.173	0.167
Urban population (% pop.)	0.0217	0.009	0.022	0.0214	0.009	0.023	0.0223	0.009	0.019	0.0219	0.009	0.020
Trade openness	-0.0609	0.134	0.650	-0.0597	0.134	0.656	-0.0552	0.135	0.683	-0.0524	0.134	0.697
Fuel export (% of exp)	-0.0047	0.022	0.835	-0.0053	0.022	0.812	-0.0052	0.022	0.812	-0.0057	0.022	0.794
Energy production (% GDP)	-0.1175	0.184	0.523	-0.1334	0.184	0.469	-0.1136	0.184	0.537	-0.1305	0.184	0.479
Regime (baseline: Military):												
Monarchy	-0.8571	0.547	0.128	-0.8809	0.542	0.115	-0.9165	0.530	0.095	-0.9376	0.526	0.086
Personalist	-0.5777	0.396	0.156	-0.5717	0.389	0.152	-0.5948	0.397	0.146	-0.5914	0.390	0.141
Single party	-0.0196	0.372	0.958	0.0101	0.363	0.978	-0.0517	0.378	0.892	-0.0258	0.369	0.945
State Capacity:												
RPC	0.1225	0.079	0.124	0.1222	0.079	0.125	0.1221	0.079	0.125	0.1211	0.079	0.128
Tax ratio (% GDP)												
Time Horizon:												
Regime duration	-0.0009	0.004	0.825	-0.0006	0.004	0.886						
Probability of regime failure							-0.3550	0.963	0.713	-0.4579	0.970	0.637
Repressive Capacity:												
Military personnel (per capita)	-0.0262	0.120	0.827				-0.0250	0.120	0.835			
Military spending (% GDP)				0.0542	0.071	0.443				0.0593	0.071	0.403
Non-tax revenue (% GDP)	-0.5930	0.376	0.116	-0.6014	0.375	0.111	-0.5922	0.376	0.117	-0.6025	0.375	0.110
Foreign aid (% GDP)	-0.0007	0.007	0.924	-0.0011	0.007	0.882	-0.0005	0.007	0.947	-0.0008	0.007	0.913
Socialist/Communist legacies	-0.1098	0.713	0.879	-0.1300	0.693	0.853	-0.1083	0.713	0.880	-0.1267	0.694	0.856
Region (baseline: East Asia):												
East Europe & post-Soviet												
Latin America	-0.8578	0.813	0.301	-0.7001	0.827	0.404	-0.7975	0.818	0.338	-0.6213	0.834	0.463
North Africa & Middle East	-0.8510	0.820	0.308	-0.7863	0.813	0.342	-0.8252	0.814	0.319	-0.7609	0.807	0.354
South-East Asia	-0.1066	0.751	0.888	-0.0509	0.747	0.946	-0.0845	0.748	0.911	-0.0295	0.744	0.969
South Asia	0.1478	1.176	0.901	0.3412	1.174	0.773	0.1979	1.164	0.866	0.3899	1.160	0.739
Sub-Saharan Africa	-1.1147	0.778	0.163	-0.9654	0.783	0.228	-1.0906	0.775	0.170	-0.9347	0.780	0.241
AR1:			0.827			0.826			0.823			0.823
$StdDev(Intercept_i)$			0.559			0.552			0.563			0.556
$StdDev(Residual)$			0.454			0.452			0.449			0.449
Log-Lik			-103.717			-103.978			-98.247			-98.445
N of countries			38			38			38			38
N of Observations			262			262			262			262

Note: Year fixed effects (1980-1999: 1980 is the baseline year) are estimated for all models but not reported because of space limit.

TABLE 7. Models on BOD per capita emission: using tax ratio as state capacity.

	Model 5:			Model 6:			Model 7:			Model 8:		
	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)	$Coef.$	$\hat{\sigma}$	p(>|t|)
(Intercept)	-2.5915	4.025	0.520	-2.6077	4.000	0.515	-2.6013	3.978	0.514	-2.6594	3.959	0.503
GDP per capita	-1.1200	0.962	0.246	-1.1153	0.939	0.236	-1.1240	0.950	0.238	-1.0896	0.929	0.242
GDP per capita^2	0.0868	0.059	0.140	0.0865	0.057	0.131	0.0853	0.058	0.142	0.0831	0.056	0.143
Industry (% of GDP)	-0.0103	0.007	0.116	-0.0097	0.007	0.143	-0.0096	0.007	0.145	-0.0088	0.007	0.186
GDP growth rate	-0.0068	0.003	0.020	-0.0067	0.003	0.021	-0.0063	0.003	0.032	-0.0063	0.003	0.034
Population density	0.1605	0.150	0.285	0.1739	0.151	0.250	0.1654	0.148	0.266	0.1830	0.150	0.223
Urban population (% pop.)	0.0199	0.009	0.024	0.0198	0.009	0.024	0.0208	0.009	0.017	0.0206	0.009	0.018
Trade openness	-0.0298	0.124	0.810	-0.0269	0.124	0.828	-0.0439	0.126	0.727	-0.0399	0.125	0.751
Fuel export (% of exp)	0.0019	0.019	0.919	0.0009	0.018	0.962	0.0003	0.018	0.986	-0.0004	0.018	0.981
Energy production (% GDP)	-0.1292	0.171	0.450	-0.1387	0.171	0.417	-0.1212	0.170	0.477	-0.1308	0.170	0.443
Regime (baseline: Military):												
Monarchy	-0.6697	0.485	0.177	-0.6820	0.481	0.166	-0.7101	0.468	0.139	-0.7215	0.465	0.131
Personalist	-0.6263	0.363	0.094	-0.6295	0.357	0.088	-0.6580	0.361	0.078	-0.6573	0.355	0.074
Single party	-0.0681	0.349	0.847	-0.0611	0.341	0.859	-0.0946	0.350	0.789	-0.0814	0.342	0.813
State Capacity:												
RPC												
Tax ratio (% GDP)	0.0075	0.004	0.100	0.0074	0.004	0.106	0.0082	0.004	0.076	0.0081	0.004	0.081
Time Horizon:												
Regime duration	-0.0015	0.004	0.720	-0.0013	0.004	0.754						
Probability of regime failure							-0.2493	0.926	0.788	-0.3264	0.934	0.727
Repressive Capacity:												
Military personnel (per capita)	-0.0008	0.112	0.994				-0.0146	0.113	0.897			
Military spending (% GDP)				0.0340	0.065	0.604				0.0417	0.066	0.527
Non-tax revenue (% GDP)	-0.5828	0.366	0.112	-0.5938	0.365	0.106	-0.5826	0.366	0.113	-0.5935	0.366	0.106
Foreign aid (% GDP)	-0.0009	0.007	0.890	-0.0013	0.007	0.851	-0.0008	0.007	0.912	-0.0010	0.007	0.882
Socialist/Communist legacies	-0.1558	0.671	0.818	-0.1557	0.652	0.813	-0.1565	0.664	0.815	-0.1738	0.647	0.790
Region (baseline: East Asia):												
East Europe & post-Soviet	0.2395	0.769	0.758	0.2710	0.756	0.722	0.2728	0.755	0.720	0.2895	0.742	0.699
Latin America	-0.9682	0.756	0.210	-0.8860	0.765	0.255	-0.9049	0.753	0.239	-0.7992	0.765	0.304
North Africa & Middle East	-1.0848	0.748	0.157	-1.0462	0.738	0.166	-1.0339	0.736	0.169	-1.0051	0.726	0.176
South-East Asia	-0.1934	0.707	0.786	-0.1630	0.702	0.818	-0.1464	0.696	0.835	-0.1171	0.692	0.867
South Asia	-0.5937	0.831	0.480	-0.5292	0.824	0.525	-0.5814	0.816	0.481	-0.4900	0.809	0.549
Sub-Saharan Africa	-1.2465	0.713	0.090	-1.1802	0.714	0.108	-1.2295	0.703	0.090	-1.1435	0.705	0.115
AR1:			0.837			0.838			0.833			0.832
$StdDev(Intercept_i)$			0.514			0.506			0.509			0.504
$StdDev(Residual)$			0.459			0.459			0.453			0.453
Log-Lik			-104.878			-105.282			-99.271			-99.615
N of countries			43			43			43			43
N of Observations			284			284			283			283

Note: Year fixed effects (1980-1999: 1980 is the baseline year) are estimated for all models but not reported because of space limit.