Policy Responsiveness and Feedback without Democracy

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Abstract

Scholarship has found a dynamic relationship between public opinion and government action in settings with strong democratic features—namely, electoral mechanisms, independent media, and clear lines of accountability. Under these conditions, public opinion affects policy, which then feeds back on public opinion. Less is known about this dynamic when democratic features are weak or absent. What little research there is has identified limited responsiveness, but it remains unclear whether it is sufficient to yield meaningful outcomes, and feedback has received scant attention. We propose a dynamic responsiveness model for nondemocratic polities in which outcomes feature, particularly for the public when it lacks credible information about government action. Our analysis looks at air pollution, which has objectively measurable outcomes, in 274 localities from 2013-2015 in a nondemocratic setting: China. We find that without democracy, meaningful responsiveness exists but the public reacts directly to outcomes—not government action itself.

Keywords: Public concern, policy representation, policy outcomes, local government, authoritarianism, air pollution

A large body of scholarship has identified a dynamic relationship between public opinion and government action in settings with strong democratic characteristics—namely, electoral mechanisms, independent media, and clear lines of accountability for government actors. Public opinion generally affects the level of government action directed at an issue, which then affects public opinion through a feedback effect (Bonafont and Palau 2011; Jennings 2009; Jones, Larsen-Price, and Wilkerson 2009; Jones and Baumgartner 2005, 249-274; Pacheco 2013; Soroka and Wlezien 2010; Wlezien 1995; Wlezien and Soroka 2012). The extent to which this dynamic exists when democratic features are weak or nonexistent is unclear. As will be discussed in the next section, studies have identified limited responsiveness in many nondemocratic settings but have done little to determine how substantively meaningful it is. That is, we do not know whether the outcomes of this responsiveness are large enough to be perceptible to the public and affect its welfare. This scholarship has also mostly ignored the possibility that nondemocratic responsiveness is a dynamic process with feedback effects.

Our poor understanding of responsiveness dynamics in nondemocratic circumstances has far-reaching consequences, as many of the settings in which governments' policies are formed and implemented lack strong democratic features. Much of the world's population lives in countries that severely restrict independent media and elections. Even mature democracies often have a dearth of independent media coverage and overlapping jurisdictions that obfuscate accountability at the local level.

To address this imbalance in scholarly focus, we propose a model of responsiveness and feedback for settings where democratic features are weak or absent. A novel feature of this model is that it brings together public opinion, government action, and outcomes into a single dynamic system. The relationships between each pair of these variables has

been well studied, especially in democracies. However, looking at each relationship in isolation weakens causal inference because variables in a system tend to correlate even if they lack a direct causal link. For instance, a correlation between public opinion and government action could be caused by policy responsiveness or both variables reacting to outcomes. Problems like this have been empirically demonstrated (Soroka and Wlezien 2010, 107-124).

Our model posits that responsiveness under nondemocratic conditions is meaningful—i.e., the responsiveness yields outcomes large enough to be perceptible to the public and affect its welfare—when outcomes are visible. We hypothesize that (1) nondemocratic governments respond to public concern on a limited basis, and (2) that the limited government action prompted by public concern is highly imperfect, with many individual actions failing to achieve their objectives, but nevertheless meaningfully affects outcomes in the aggregate. The model applies to policy areas in which salience and the public's preference for more government action are closely correlated; we refer to public opinion in these issue areas as *public concern*.[1]

Regarding feedback, we hypothesize that (3) public concern reacts primarily to outcomes, not government action. This hypothesis represents a key difference between our model and the extant responsiveness-feedback scholarship, which is based on evidence from democratic settings. This literature finds that the public reacts to increases and decreases in government action and not the action's outcomes (Jennings 2009; Pacheco 2013; Soroka and Wlezien 2010, 107-124; Wlezien 1995; Wlezien and Soroka 2012). The logic underlying our model's feedback pattern is that the public reacts primarily to the most convenient, seemingly reliable indicator of how well an issue is being addressed by

[1]For a diagram of the model, see Figure 1 in the theory section (page 8).

the government. By this logic, the literature's findings make sense in a liberal system with robust media coverage; it is reasonable for the public in such circumstances to base its preferences for more (or less) government action in an issue area on its perception of the action itself and not the outcomes—particularly when the outcomes are far removed from people's everyday lives. We argue, however, that when the public lacks credible information about how much the government is doing about an issue (perhaps due to censorship or government opacity), people base their opinions on outcomes they can directly observe. Indeed, this logic is consistent with existing evidence that public opinion is influenced by what people see in their day to day lives (Ansolabehere, Meredith, and Snowberg 2014).

To test our model, we look at an important issue with objectively measurable outcomes in a nondemocratic political environment: air pollution in Chinese cities. Due to China's virtually nonexistent electoral mechanisms, lack of independent media, and murky lines of accountability, it represents a most difficult case for the responsiveness aspect of our model, and an ideal case for examining feedback in the absence of democratic features. Estimating the relationships between public concern, government action, and outcomes is done using structural equation models (SEM's), which allow us to account for the error correlation that can be caused by feedback dynamics. To measure public concern, we use the Baidu Internet search index,[2] which reflects an issue's salience by indicating the proportion of Internet searches related to air pollution in each locality. For air pollution outcomes, we use satellite-derived concentrations of two ubiquitous pollutants: nitrogen dioxide (NO_2) and fine particulate matter ($PM_{2.5}$). For government action, we use the goals municipal governments set out in their annual work reports and the contents of

[2]Baidu is China's dominant Internet search engine. The Baidu Internet search index is comparable to Google Trends.

their official newspapers. Of course, policy goals and announcements by state-run media do not necessarily reflect governments' actual efforts, so we also use changes in cities' air pollution to infer shifts in the level of government action. Our analysis includes all observations for which data are available: 274 prefecture level cities from 2013 to 2015. We map the locations of each year's observations in Appendix H.

The results support both the responsiveness and feedback components of our model, allowing us to make two major contributions. The first is finding evidence of substantively meaningful responsiveness in a nondemocratic setting. Our analysis suggests that the limited responsiveness scholarship has found aggregates into outcomes large enough to significantly affect the general public within this issue domain. Until now, there has been no clear evidence that substantive responsiveness exists within *any* domain in nondemocratic political environments. Thus, this finding advances our understanding of policy responsiveness across regime types and may apply across issues with visible outcomes. Whether the magnitude of this responsiveness is smaller than in democratic settings is an empirical question for future study. The second contribution is finding evidence of an outcomes-based feedback dynamic in a political system with minimal independent media coverage and opaque government. Taken together with the existing literature, these findings suggest that the relationship between what the public wants and what it gets is dynamic in both democratic and nondemocratic settings, but that feedback follows a different pattern when democratic features are absent.

What We Know

Literature on nondemocratic political systems has found that government responsiveness to public concern is limited and ad hoc. Governments monitor public sentiment across

issue areas and respond to the extent they believe is necessary to avoid social upheaval (Cai 2010; Chen, Pan, and Xu 2016; Gandhi and Przeworski 2006; Li, Liu, and Li 2012; Manion 2014; Malesky and Schuler 2010; Meng, Pan, and Yang 2017; Miller 2015; Truex 2016). Of course, authoritarian regimes can (and do) respond to high levels of concern with repression, but repression is costly—often more costly than minimally meeting citizens' demands. Government officials therefore tend to accede to the public's demands when the cost of doing so is low relative to the cost of repression (Cai 2010; Chen, Pan, and Xu 2016; Li, Liu, and Li 2012).

In a decentralized political system, responsiveness can occur across multiple levels of government. Upper levels may respond to public concern by pressuring lower level officials to better address issues it perceives to be fueling civil strife. Local level officials may also respond directly to the concerns of their own publics to minimize social tumult that embarrasses them in front of their superiors or even endangers them directly. In China's case, the regime's formal cadre evaluation system facilitates both mechanisms (Cai 2010; Chen, Pan, and Xu 2016; Li, Liu, and Li 2012; Manion 2014; Meng, Pan, and Yang 2017; Truex 2016). Cadres' promotions are largely based on their annual performance reviews of how well they achieved the various goals set by the national government, and—to an even greater extent—their apparent success maintaining social stability (Edin 2003). Thus, local level cadres face strong incentives to respond to their own publics' concerns enough to avoid unrest and to pursue the priorities set by upper levels of government, which are themselves influenced by popular pressure.

How can government officials gauge public sentiment without electoral mechanisms and independent media? In any polity with high state capacity, their tool set is extensive. It includes advisory bodies representing various societal interests (Manion 2014; Malesky

and Schuler 2010; Truex 2016), the volume of complaints and threatening emails received from citizens (Chen, Pan, and Xu 2016), occurrences of protests (Cai 2010; Li, Liu, and Li 2012), and interviews and surveys conducted by state actors (Brady and Juntao 2009).

A key question left unanswered by this literature is whether the limited responsiveness it has found matters to the general public. Our hypothesis that it aggregates to yield outcomes that are perceptible and meaningful to the public's welfare is consistent with these findings, but it is also possible that this responsiveness is too irregular and narrowly targeted to produce such outcomes.

Feedback without Democracy

Feedback has received minimal attention in nondemocratic settings. In democracies, studies have found that changes in the amount of government action in an issue domain has a negative effect on the public's desire for additional action. That is, when the government does more (or less) about an issue, the public's preference for further increases (or decreases) goes down (Jennings 2009; Pacheco 2013; Soroka and Wlezien 2005; Soroka and Wlezien 2010; Wlezien 1995; Wlezien and Soroka 2012). It finds that, while government action and outcomes tend to be correlated, public opinion reacts directly to government action, not outcomes (Soroka and Wlezien 2010, 107-124).

Whether the same pattern exists when democratic features are absent is not addressed by this literature. As noted earlier, we hypothesize that public opinion reacts primarily to outcomes in nondemocratic settings because it lacks other credible indicators of government action. However, this is by no means a forgone conclusion based on what we know from the literature. We cannot dismiss out of hand the possibility that the public reacts to the level of government action depicted in the media, regardless of the media's

independence and the accuracy of its reporting.

Theory

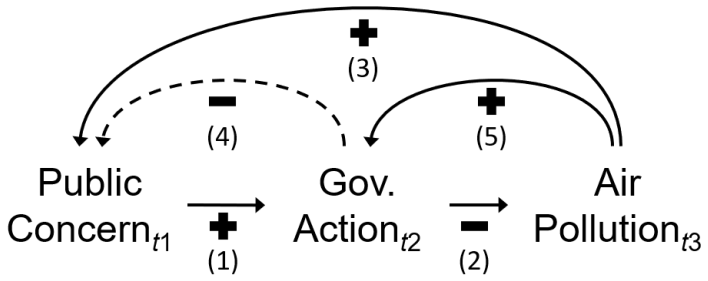
Here we lay out our theoretical model of responsiveness and feedback for nondemocratic settings as it pertains to air pollution. It consists of three variables—public concern, government action, and air pollution outcomes—and five causal relationships (see Figure 1). The relationships of interest are 1-4. By itself, relationship 5 is not important for our purposes, but we must account for it to accurately estimate the other relationships and properly test our hypotheses.

Relationship 1 represents (limited) policy responsiveness and simply expresses the scholarly consensus discussed in the previous section. Relationship 2 is the substantive outcomes of the responsive government action. This relationship remains poorly understood. It is well known that government action can—broadly speaking—achieve outcomes like mitigating air pollution. The relationship, however, is imperfect. While some policies achieve their goals, many others fail and can even be counterproductive (see, for example, McDermott et al. 2019). Thus, we cannot infer from extant scholarship that the limited government action prompted by public concern is sufficient to meaningfully affect outcomes—i.e., we do not know whether the outcomes of policy responsiveness are large enough to be noticed by the public and affect its well-being, particularly over short time periods of just a few years.

For feedback, we hypothesize that the public reacts primarily to air pollution outcomes and not directly to government action. Thus, we expect that worsening (improving) air pollution severity will lead to increases (decreases) in public concern (Relationship 3). If more government action has any calming effect on public concern (Relationship 4), we

expect it to be far weaker than air pollution's effect (Relationship 3).

Figure 1: Theoretical Model Overview



Note: The arrows with plus (+) and minus (−) signs represent theorized positive and negative causal relationships respectively. The dashed arrow signifies that we expect relationship 4 to be weak relative to relationship 3. $t1$, $t2$, and $t3$ represent time periods. The arrows pointing from right to left (arrows 3, 4, and 5) represent a variable's effect on another in the following period.

Public Concern

Public concern refers to an issue's salience and the public's preference for the government to do more about it. We use this term because salience and preferences move together in this domain; for environmental matters like pollution emissions, public attention to the issue and the degree to which it prefers the government to do more about it go hand in hand (Oehl, Schaffer, and Bernauer 2017). This is a special case, as salience and preferences do not reliably move together in all issue areas.

If democratic features like independent media are weak or absent, we hypothesize that the public lacks credible indicators of government action itself and therefore can only react to directly observable outcomes. Studies have shown that this hypothesis is plausible, for people can directly perceive air pollution's absolute level and change over time (Amundsen, Klæboe, and Fyhri 2008; Lo and Leung 2000). Scholarship that has examined the effect of outcomes on public opinion is also consistent with our expectations. Air pollution severity has a positive relationship with public concern in China (Chen et

al. 2013), and even in liberal democracies, public opinion is partially informed by people's day to day experiences (Ansolabehere, Meredith, and Snowberg 2014). These studies do not include government action as an explanatory variable for public opinion, so they do not rule out the possibility that the public is actually reacting directly to government action that is correlated with the outcomes. Even so, these findings are consistent with our theory.

We expect that any direct soothing effect government action has on public concern is small relative to air pollution's effect. Our theory assumes that the public regards indicators of government action itself, such as state-run media coverage, as non-credible and therefore mostly ignores them in favor of outcomes it can directly observe. This is not to say that the effect from state-run media and perhaps other information sources is entirely absent, only that it is comparatively minor. The other determinants of public concern we control for are discussed in Appendix N.

Government Action

Government action refers to the aggregation of governments' activities that mitigate air pollution in a given location. It is, in effect, a very broad conception of policy (Kingdon 1995). For the purposes of this study, government action can be conceptualized as having two aspects. One is the pre-implementation stages of policymaking, which include the local political leadership's search for policy solutions, deliberation, and the formation of official policies, goals, and priorities. The other is the government's implementation efforts. This refers primarily to the activities of the leadership's subordinates—particularly street-level bureaucrats and other low-level officials—that affect local air pollution emissions. Recognizing these two aspects of government action is important because they may

not closely correspond. Policies can be announced by political leaders but never meaningfully carried out, and subordinates can vary the amount of effort they put into mitigating air pollution without explicit directives from the leadership.

The distinction between these two aspects of government action is especially relevant here because there is abundant evidence that the implementation of air pollution-related policy is far more sensitive to public concern than official policy is. Case studies, interviews with local environmental protection bureau (EPB) officials, and quantitative assessments have found that citizens' demands for more air pollution enforcement greatly increase the effort low-level city officials put into mitigating air pollution (Lo and Leung 2000; Lo and Fryxell 2005; Van Rooij and Lo 2010). Furthermore, in one of the few nation-wide studies on this subject in China, Zheng and Shi (2017) find that official environmental policies and public complaints have independent effects on polluting firms' decisions to leave a province. This pattern of disinvestment by polluting firms suggests that both official policy *and* public pressure have sizable impacts on how well air pollution emissions are regulated in practice. It also implies that much of the public's effect on government implementation efforts is direct and not mediated through official policy.

Government action responds to public concern on a limited basis for the reasons discussed in the previous section; officials face strong incentives to respond to public concerns to at least the minimum extent they feel is necessary to avoid social instability. This has been shown to be the case across issue areas, including environmental degradation (Li, Liu, and Li 2012).

Officials cannot use air pollution levels as a reliable proxy for public concern. This is because air pollution is not the only determinant of public concern and its effect is mediated by other factors, such as the public's knowledge of air pollution's health

consequences and the other issues competing for the public's attention (Lo and Leung 2000). We discuss these in Appendix O. Thus, air pollution levels by themselves are only a very rough indicator of public concern. Government officials must therefore use the various other tools at their disposal to monitor concern if they want to minimize unrest.

Air Pollution

Air pollution refers to the average concentration of air pollutants at ground level within a given locality. It is a function of government action. When governments do more to mitigate air pollution, air pollution will be lower than it would otherwise be. The opposite is also true. It is important to note that while air pollution is a function of government action, government action is *not* the primary determinant of a city's air pollution level—at least not in the short to medium term. The main driver of local air pollution is local economic output (Chan and Yao 2008; Jiang, Lin, and Lin 2014). Conceptually, one can think of government action as a force that pushes air pollution levels above or below a "natural" level that is determined by the local economy.

Actions that affect air pollution within a locality come from all levels of government and take a variety of forms; any action that reduces a city's automobile traffic or reliance on coal for electricity, heating, or cooking would reduce pollution emissions to some degree. Many of the most conspicuous actions—such as investments in clean energy—come from the national and provincial governments. There are also important ways through which local governments affect air pollution levels. Most notably, they often use discretionary regulatory enforcement to pressure polluting firms to relocate to other cities. In a case study based on site visits and interviews with city EPB officials and senior firm managers in Shangyu, Zhu, He, and Liu (2014) found that many local firms were relocat-

ing to other cities in China because of increasing environmental regulation enforcement by the local government. Large-N studies have corroborated Zhu et al.'s finding that environmental enforcement by local governments is a major factor causing polluting firms to relocate. Pollution-intensive industries are more likely to leave cities which claim to strictly enforce air pollution regulations and are more likely to enter cities that do not (Zheng and Shi 2017; Zhou, Zhu, and He 2017). Foreign direct investment for polluting industries also gravitates towards areas that report having looser anti-pollution enforcement (Zhang and Fu 2008). We discuss other determinants of local air pollution and how we account for them below and in Appendix P.

Data

To test our model, we must measure its dependent and control variables as well as consider their reliability. The latter is especially important for the measures from government sources and has implications for how we interpret our empirical results.

Public Concern

Our public concern measure is the Baidu index of Internet searches in the air pollution topic area. The index represents the annual number of air pollution-related searches relative to the total search volume in each city going back to 2011. Baidu is China's dominant search engine and its search index is functionally identical to Google Trends (Vaughan and Chen 2015). Fundamentally, a search index reflects an issue's salience (Mellon 2013); it does not necessarily indicate public preferences for government action on a given issue. However, as discussed earlier, air pollution's salience corresponds with the public's preference for the government to do more to mitigate the problem (Lo and

Leung 2000). Indeed, Internet search indices have been found to be reliable indicators of public preferences for government action on environmental issues cross-nationally (Oehl, Schaffer, and Bernauer 2017).

Government censorship of the Internet is pervasive in China but unlikely to bias this measure. The specific topics targeted by China's online censors are constantly shifting and notoriously difficult to track. Nevertheless, Chinese censorship generally takes the form of blocked websites as opposed to blocked search terms, meaning that people's pollution-related searches should be reflected in the index regardless of which websites are easily accessible. To whatever extent blocked search terms do bias the measure, the likely result would be to under-represent increases in public concern, for censorship of a topic is presumably most prevalent in the face of surging public attention. Thus, even if censorship biases the measure, the result would be to make the key statistical relationships in our analysis *less* significant.

The search index does not reflect a perfectly representative sample of the population, as Internet users are disproportionately young, educated, non-poor, and urban. Even so, it reflects a very large portion of society. China's Internet penetration was roughly 34 percent in 2011 and 48 percent in 2015 (China Internet Network Information Center 2011, 2015).

Government Action

Our primary government action measure is derived from city governments' work reports. Work reports are published by nearly all city governments (as well as the other levels of the political system) within the first two months of each year. Though they are publicly available, their writing style implies their intended audience is rank and file government

officials. The first section of the reports highlights the governments' accomplishments over the previous year, while all subsequent sections lay out their broad goals for the new year.[3] Our measure is the proportion of each report's prospective section that discusses topics directly related to air pollution. To calculate this proportion, we identify all paragraphs that include one or more keywords and then divide the combined length of those paragraphs by the length of the report's entire prospective section (see Appendix F for the keywords and how we calculate length).

The reports are a *partial* indicator of government action. They are indicative of the local leadership's policy priorities, which reflect one aspect of government action; there is qualitative evidence that governments put substantial effort into writing the reports and following through with their stated goals (Wang 2017). However, the reports are not a *comprehensive* indicator of government action, for they are unlikely to reflect many factors that directly influence implementation efforts. As noted earlier, extant scholarship suggests that much of the public's impact on government action is directly on low-level officials' implementation efforts and not mediated through responsive official policy (Lo and Leung 2000; Lo and Fryxell 2005; Van Rooij and Lo 2010; Zhan, Wing-Hung Lo, and Tang 2014; Zheng and Shi 2017).

As a secondary measure, we use the attention to air pollution in each city's flagship, party-controlled daily newspaper. This measure is the number of articles containing at least one air pollution-related keyword each year (see Appendix G). The newspapers are general interest daily publications run by the local governments. While their readership tends to be low, they are an indicator of the attention allocation of a government's

[3]At the start of a new five-year plan, section two focuses exclusively on five-year goals while subsequent sections discuss goals for the year. We exclude the section twos from our analysis in these cases.

propaganda apparatus as a whole. Newspaper coverage of air pollution is essentially coterminous with coverage of the government's actions to address it. Nearly every article on this topic emphasizes how hard the local government is working to mitigate air pollution or the successes of its ongoing efforts.

The reports and newspapers are fundamentally measures of how much governments *claim* to be doing about air pollution. As such, they are well suited to test the feedback effect we hypothesize. In an environment with no independent media coverage and heavy censorship, the most viable way for the public to gauge government action without relying on visible outcomes is to trust what the government says it is doing. These measures allow us to estimate the degree to which public concern reacts to the government's claims relative to visible outcomes.

One cannot reasonably assume that a government's claims are a frank depiction of its efforts. When facing pressure from above or below to do more about air pollution, officials have obvious incentives to exaggerate how much they are doing. The likely bias of these already incomplete measures means that we cannot rely on them to estimate responsiveness. We therefore use changes in air pollution levels to infer government action.

Air Pollution

Our two measures for air pollution are satellite-derived concentrations of cities' tropospheric (i.e., ground level) NO_2 and $PM_{2.5}$. NO_2 and $PM_{2.5}$ are ubiquitous air pollutants in China and around the world, and are indicative of a city's overall level of air pollution. NO_2, $PM_{2.5}$, and most other major air pollutants are produced primarily by the same types of local human activities: combustion processes like those in automobile engines, electricity generation, and heavy industry (Chan and Yao 2008; Jiang, Lin, and Lin 2014).

As a result, NO_2 and $PM_{2.5}$ typically have correlations of over 0.8 with other major air pollutants, including course particulate matter (PM_{10}), carbon monoxide (CO), and sulfur dioxide (SO_2) (Guo, Wang, and Zhang 2017). In our sample, NO_2 and $PM_{2.5}$ have a correlation of 0.78 with each other.

We calculate each city's annual NO_2 level using the DOMINO (version 2) and TM4NO2A (version 2.3) datasets provided by the European Space Agency, which are derived from the daily overpass measurements of the OMI, MetOp-A and MetOp-B sensors. We combine these datasets to achieve near-total spatial coverage of China by a process we describe in Appendix I. The $PM_{2.5}$ values are from the Global Annual $PM_{2.5}$ Grids provided by NASA's Socioeconomic Data and Applications Center, which are derived using measurements from the MODIS, MISR, and SeaWiFS sensors.

City boundaries are defined as level two administrative units (known as prefectures in China), which we take from GADM's map (version 3.6). We crosschecked the GADM map with its counterpart in the GAUL maps provided by the United Nations' Food and Agricultural Organization and made several corrections (see Appendix Q).

Using satellite data allows us to avoid biased measurements from China's ground sensors. Local officials have strong incentives to manipulate the pollutant concentrations they report, and the country's pollution data show extensive evidence of tampering (Ghanem and Zhang 2014). Any measurement error in the satellite data should be effectively random and not introduce bias.

Controlling for Economic Output

As discussed in the previous section, local economic output is the primary determinant of an area's air pollution level. Thus, inferring government action from shifts in local air

pollution levels requires that we control for changes in the area's output. Our measure for each city's output (i.e., gross regional product—GRP) is derived from the data reported in China's official Statistical Yearbook. The Yearbook values are nominal, so to account for regional purchasing power variation, we use the estimates of Brandt and Holz (2006) for price differences between provinces. We then use the official consumer price index of each province to account for inflation.

China's reported economic indicators are famously suspect and there is overwhelming anecdotal evidence that official economic output measures are inflated. Even so, we are confident that official GRP statistics are valid measures for our purposes because this study depends on accurate measurement of *change* in GRP from one year to the next. Satellite images of changes in China's nighttime brightness, which correspond to changes in economic output (Henderson, Storeygard, and Weil 2012), imply that China's reported output statistics are either not greatly inflated or (more likely) inflated consistently over time (Landry, Lü, and Duan 2018). To whatever extent GRP values are not inflated consistently, the error terms in our models will increase, but we see no reason to think that the additional error would bias our results.

Controlling for Pollution Spillover

While an overwhelming majority of air pollution in cities is locally produced, some is blown in from neighbors. The amount blown in varies by pollutant. Compared to most pollutants, NO_2 breaks down quickly and does not travel very far; non-local sources account for roughly 10 percent of a city's NO_2 (Jeong et al. 2017). $PM_{2.5}$ tends to have a substantially longer lifetime and travels farther than most other pollutants. 20 to 40 percent of a city's $PM_{2.5}$ is from non-local sources (Chan and Yao 2008).

Air pollution's movement in the atmosphere is complex; there is no ideal method for controlling for pollution spillover (Chan and Yao 2008). We therefore demonstrate that our results are robust across a range of methods to rule out the possibility that spillover is biasing our results. For the models in this paper, we include a control variable for the average pollution level of a city's upwind neighbors and compare those results with models that ignore spillover (see Appendix J for how we calculate each city's upwind air pollution). We use two more approaches in the appendix: controlling for air pollution in a city's neighborhood regardless of prevailing wind direction and using lagged spatial autoregression (SAR) models, which account for endogeneity caused by spillover (see appendixes K and L).

Other Controls

We use several methods to control for the factors we discuss in appendixes N, O, and P. To control for top-down pressure on local governments to mitigate air pollution, we use the national and provincial government work reports. The proportions are derived using the same method we used for the city work reports.

To help account for miscellaneous factors that may influence our results, such as variation in cities' overall economic development levels, we use a measure of per capita GRP. The values for each city are taken from the Statistical Yearbook and adjusted for inflation and regional purchasing power variation the same way the ΔGRP values are.

The remaining unmeasured factors discussed in the appendix are accounted for using a combination of lagged dependent variables (LDV's) and province fixed effects. They account for any unmeasured factors that do not vary meaningfully over the three-year period of this study, such as geography, industrial composition, climate, and culture.

Model Specifications

The three equations in our SEM that use the NO_2 air pollution measure are as follows. The models using the $PM_{2.5}$ measure substitute each instance of NO_2 with $PM_{2.5}$ but are otherwise identical. The α's are the intercepts, the β's are the coefficient estimates, the e's are the error terms, and ζ_P is a fixed effect for each city's province (P). $Reports_{P,t}$ and $Reports_{Nat,t}$ are the provincial and national reports for each city i in year t. *Reports* in Eqn. 3 are not lagged because they are published at the beginning of year t and express goals for that year.

These specifications are relatively simple because SEM estimation tends to fail in the presence of multiple closely related variables and lags, such as $X_{i,t\text{-}2}$ and $\Delta X_{i,t\text{-}1}$ (see Wothke 1993). We therefore supplement our SEM's with original least square (OLS) estimated models with more intricate lag structures and comparisons of absolute and change values for all variables of interest (see Table 2 in the next section).

Equations 1 and 3 do not include national and provincial reports measures because their priorities are reflected in the lower level reports of the same year (Wang 2017). As a robustness check, we run models with the upper level reports and find similar results to what we show in the next section (see Appendix C).

$$\begin{aligned} Search\ index_{i,t\text{-}1} = \alpha_{1,0} + \beta_{1,1} Search\ index_{i,t\text{-}2} + \beta_{1,2} NO2_{i,t\text{-}1} + \beta_{1,3} \Delta NO2_{i,t\text{-}1} \\ + \beta_{1,4} Reports_{i,t\text{-}1} + \beta_{1,5} GRP\ percap_{i,t\text{-}1} + \zeta_P + e_{1,i,t\text{-}1} \end{aligned} \tag{1}$$

$$Reports_{i,t} = \alpha_{2,0} + \beta_{2,1} Reports_{i,t\text{-}1} + \beta_{2,2} NO2_{i,t\text{-}1} + \beta_{2,3} \Delta NO2_{i,t\text{-}1} + \beta_{2,4} Search\ index_{i,t\text{-}1} + \beta_{2,5} Reports_{P,t} + \beta_{2,6} Reports_{Nat,t} + \zeta_P + e_{2,i,t} \quad (2)$$

$$NO2_{i,t} = \alpha_{3,0} + \beta_{3,1} NO2_{i,t\text{-}1} + \beta_{3,2} Reports_{i,t} + \beta_{3,3} Search\ index_{i,t\text{-}1} + \beta_{3,4} \Delta GRP_{i,t} + \beta_{3,4} Reports_{i,t} + \beta_{3,5} GRP\ percap_{i,t} + \zeta_P + e_{3,i,t} \quad (3)$$

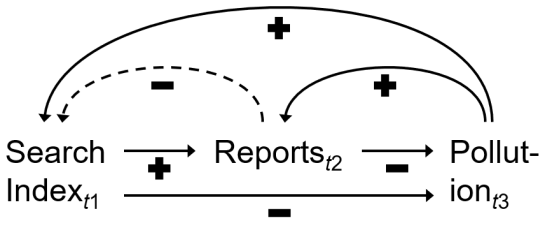
Analysis

Figure 2 shows our theoretical expectations for the relationships among the three dependent variables (DV's) next to the standardized coefficients for models with NO_2 and $PM_{2.5}$ pollution measures. Figure 2b's values correspond to the nonstandardized coefficients of Model 4, Table 1. Those for Figure 2c are from Table A.2's Model 4 in the appendix.

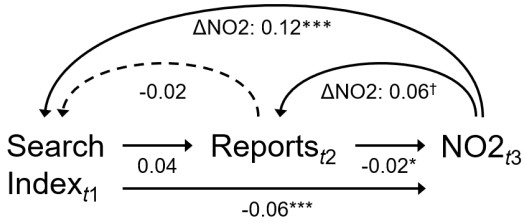
Most of the expected relationships in the operationalized model match their Figure 1 counterparts in the theory section (see page 8). The one exception is that we also expect the search index to have a direct negative effect on pollution severity in the empirical analysis. We theorize that public concern's effect on air pollution is mediated through government action. However, as already discussed, the reports are not a comprehensive measure. They are unlikely to reflect much of the effect public concern has on implementation efforts, which is where scholarship has found public concern to have the greatest influence on government action (Lo and Leung 2000; Lo and Fryxell 2005; Van Rooij and Lo 2010; Zheng and Shi 2017). Thus—if we can discount other plausible explanations for the estimated relationship—we can infer the level of unmeasured government action prompted by public concern with the search index's "direct" effect on air pollution.

Figure 2: Theoretical Expectations and Results Summary

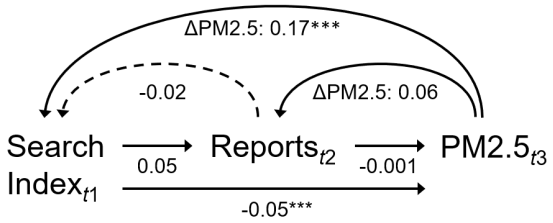
(a) Theoretical Expectations



(b) Results with NO_2 (Standardized)



(c) Results with $PM_{2.5}$ (Standardized)



Note: The arrows with plus (+) and minus (−) signs represent theorized positive and negative causal relationships respectively. The dashed arrows signify that we expect the relationship to be weak relative to air pollution's effect on the search index. The coefficients correspond to Model 4 in tables 1 and A.2. †p<0.1; *p<0.05; **p<0.01; ***p<0.001.

Responsiveness

The search index's estimated effect on pollution the following year is consistent with the substantive responsiveness we theorize. If unobserved aspects of government action—such as the implementation efforts of low-level officials—are responding to public concern, a robust negative effect of the search index on NO_2 and $PM_{2.5}$ is what we should see.

The same is true of the relative sizes of the search index's effects on NO_2 and $PM_{2.5}$. A higher proportion of NO_2 than $PM_{2.5}$ is from local sources (Chan and Yao 2008; Jiang, Lin, and Lin 2014; Jeong et al. 2017). The search index having a larger effect on NO_2 therefore implies that whatever phenomenon accounts for this estimate is, to a significant

degree, local.[4] This result is consistent with the responsive local government action we theorize and is evidence against a major unmeasured exogenous event causing a spurious relationship between the search index and air pollution. If, for instance, the relationship were due to a dramatic environmental catastrophe that shocked government officials into action and drew public attention nationwide, the search index's estimated effects on NO_2 and $PM_{2.5}$ should not be significantly different.

While these relationships match our model's expectations, they are also consistent with a competing explanation: government action may be responding directly to local air pollution severity and not public concern. In this scenario, public concern and government action would correlate because they would be responding to the same signal, and—assuming the government action were effective—the search index would be negatively associated with air pollution the following year despite the absence of a causal link.

The relationships between the reports and the air pollution measures help to discount this possibility. These relationships suggest that government action is driven only to a small extent by air pollution severity; ΔNO_2's effect on the reports is just above the 0.05 significance threshold in models 1-4. Moreover, if government action were responding only to air pollution, the reports' effect on NO_2 and $PM_{2.5}$ should wipe out—or at least substantially reduce—the search index's estimated effect on pollution in our model. What we actually see is that the search index remains highly significant even with the reports' measure included as an explanatory variable for NO_2 and $PM_{2.5}$. In fact, the inclusion of reports has only a negligible impact on the search index's estimated effect.[5]

[4]We use a Z-test to determine that the difference is significant.

[5]See Appendix B for model estimates that exclude the reports' effect on pollution.

Table 1: Summary Results for SEM's with NO_2 Pollution Measure

	(1)	(2)	(3)	(4)
DV: Search index$_{t\text{-}1}$				
$NO_{2,t\text{-}1}$	0.031***	0.031***	0.031***	0.031***
	(0.006)	(0.006)	(0.006)	(0.006)
$\Delta NO_{2,t\text{-}1}$	0.090***	0.114***	0.090***	0.106***
	(0.015)	(0.015)	(0.015)	(0.015)
Reports$_{t\text{-}1}$	-0.002	-0.003	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
DV: Reports$_t$				
$NO_{2,t\text{-}1}$	0.147	0.101	0.144	0.137
	(0.106)	(0.106)	(0.106)	(0.106)
$\Delta NO_{2,t\text{-}1}$	0.468†	0.495†	0.470†	0.477†
	(0.273)	(0.273)	(0.273)	(0.273)
Search index$_{t\text{-}1}$	0.316	0.274	0.316	0.317
	(0.305)	(0.305)	(0.305)	(0.305)
DV: $NO_{2,t}$				
Upwind $NO_{2,t}$			0.231***	0.227***
			(0.020)	(0.020)
Search index$_{t\text{-}1}$	-0.340***	-0.418***	-0.217***	-0.268***
	(0.039)	(0.046)	(0.037)	(0.044)
Reports$_t$	-0.008*	-0.008*	-0.008*	-0.008*
	(0.004)	(0.004)	(0.004)	(0.004)
Feedback	No	Yes	No	Yes
Comp. Fit Index (CFI)	0.99	0.99	0.99	0.99
Akaike (AIC)	28321	28314	28196	28192
R^2 (Eqn. 1)	0.83	0.83	0.83	0.83
R^2 (Eqn. 2)	0.26	0.26	0.26	0.27
R^2 (Eqn. 3)	0.96	0.96	0.97	0.97

Note: N = 731. Control variables not shown. See Table A.1 for the complete results. Estimated using lavaan v0.6-2 in R Open 3.5.1. †p< 0.1; *p<0.05; **p<0.01; ***p<0.001.

Extant scholarship also rules out the possibility of a spurious relationship from unmeasured forms of government action reacting directly to air pollution. Interviews and surveys of local EPB officials designed to identify what drives their implementation efforts have not found air pollution severity to be a significant factor while they have found the public to have a major effect (Lo and Fryxell 2005; Zhan, Wing-Hung Lo, and Tang

Table 2: Alternative Lag Structure

	(1)	(2)	(3)		(1)	(2)	(3)
DV: Search index$_{t\text{-}1}$				**DV: NO2$_t$**			
$NO2_{t\text{-}2}$	0.03***		0.05***	$Search_{t\text{-}2}$	-0.21***		-0.21***
	(0.01)		(0.01)		(0.05)		(0.05)
$\Delta NO2_{t\text{-}1}$		0.09***	0.14***	$\Delta Search_{t\text{-}1}$		-0.22**	-0.24***
		(0.02)	(0.02)			(0.07)	(0.07)
$Reports_{t\text{-}1}$	-2.34		-22.63	$Reports_{t\text{-}1}$	27.54		-33.80
	(17.20)		(20.99)		(38.02)		(45.50)
$\Delta Reports_t$		-20.76	-26.69	$\Delta Reports_t$		-85.04**	-103.29**
		(15.00)	(17.89)			(32.08)	(38.04)

Note: This table shows an alternative lag structure for the key explanatory variables (EV's) of the search index and NO_2. This structure avoids EV's that are functions of other EV's, which can lead to misleading estimates; X_t is a function of ΔX_t, but $X_{t\text{-}2}$ is not. These estimates are consistent with the SEM results we focus on in this section. The estimator is OLS. Only EV's of interest are shown. Control variables not shown. See Appendix M for the full results.

2014).

It is of course impossible to definitively prove there are no other factors causing a spurious relationship between the search index and both pollution measures, but the possibility is extremely remote. We are aware of no plausible alternative explanations for this relationship that we have not already addressed, and our model explains around 97 percent of NO_2's and 95 percent of $PM_{2.5}$'s variation. These high R^2 values are due mostly to the models' LDV's, which account for any otherwise unmeasured factors that do not change significantly from one year to the next. Explaining nearly all of the pollutants' variation implies that our models are not missing any important variables that could potentially bias our results and cause spurious correlations.

How substantively meaningful is this responsiveness? Based on Model 4 in tables 1 and A.2, a one standard deviation increase in the search index would reduce local NO_2 by 29.4 $\mu g/m^3$ the following year, which is a 4.7 percent change for the average observation. For $PM_{2.5}$, the reduction would be 0.9 $\mu g/m^3$, a 2.4 percent change. China's air pollution

levels are so far above what is generally considered to be healthy that no amount of public concern is likely to bring about safe air in the near future.[6] Even so, the effect is sufficient to affect the public in the short term. A reduction in NO_2 and $PM_{2.5}$ levels of around 29.4 and 0.9 $\mu g/m^3$ is enough to decrease people's self-reported levels of discomfort (Amundsen, Klæboe, and Fyhri 2008). The effect size also suggests near-term impacts on public health. An annual decrease of this magnitude would likely lead to a small but significant reduction in mortality rates even within the three years of this study. Over longer periods of time, the health impacts would be profound (He, Fan, and Zhou 2016).

Feedback

ΔNO_2 and $\Delta PM_{2.5}$ have positive, robust effects on the search index while the reports' effect is insignificant. This set of relationships suggests that public concern reacts directly to air pollution outcomes and mostly ignores indicators of government action itself. The main competing explanation for ΔNO_2 and $\Delta PM_{2.5}$'s apparent feedback effect on the search index is that the public is reacting to unmeasured forms of government action that are negatively correlated with air pollution. After all, such an explanation would be consistent with the feedback pattern in democratic settings (Soroka and Wlezien 2010, 107-124).

The reports help to rule out this scenario because they are fundamentally a measure of how much governments *claim* to be doing about air pollution. The extent to which they reflect actual government action remains unclear. Nevertheless, in an environment with no independent media and heavy censorship, the government's claims are one of the few

[6]The average NO_2 and $PM_{2.5}$ levels for the cities in our sample are 627 and 38 $\mu g/m^3$ respectively. For comparison, the World Health Organization considers annual average exposures over 40 $\mu g/m^3$ of NO_2 and 10 $\mu g/m^3$ of $PM_{2.5}$ to be dangerous.

indicators of government action (other than outcomes) that the public could potentially react to. If, as the reports' insignificant effect implies, the public mostly ignores the government's claims, it is difficult to imagine how else it could react directly to government action. To be clear, government claims are not the *only* signals of government action nondemocratic publics are exposed to aside from outcomes. For instance, upper level government action receives some coverage in foreign media that motivated individuals can access, and rumors can spread by word of mouth and slip past censors online. Such signals, however, are *extremely* noisy. It is implausible that they could account for the robust estimated effects of ΔNO_2 and $\Delta PM_{2.5}$ on the public concern measure.

To further test whether public concern is reacting to governments' claims, we look at the effect state media coverage of government action has on our public concern measure. As shown in Table 3, state media's coefficient estimates are *positive* and significant. Even a cursory look at its content and tone makes clear that state media coverage of this issue is intended to minimize public concern, so the positive relationship is likely not causal. Rather, the positive sign implies that local governments allocate their media coverage strategically in anticipation of rising public concern; that is, when the government senses public concern is beginning to swell, it starts preemptively hyping its actions to mitigate air pollution in an effort to ameliorate public anger. We cannot statistically estimate the extent to which state media coverage successfully assuages public concern without a counterfactual. Even so, its positive coefficients combined with the robustness of NO_2 and ΔNO_2 suggest that any calming effect state media has on public concern is small relative to air pollution's effect. As a robustness check, we also aggregate the local, provincial, and national state media and find similar results (see Appendix E). Taken together, the estimated effects of the reports and state media coverage on the search index provide strong

support for our hypothesis that public concern reacts primarily to visible outcomes—and not government action—in nondemocratic settings.

Table 3: Local State Media and Public Concern

	(1)	(2)	(3)
DV: Search index$_{t\text{-}1}$			
$NO2_{t\text{-}2}$	0.025***		0.039***
	(0.005)		(0.005)
$\Delta NO2_{t\text{-}1}$		0.083***	0.124***
		(0.013)	(0.014)
State media$_{t\text{-}2}$	0.009		0.125†
	(0.069)		(0.066)
ΔState media$_{t\text{-}1}$		0.611***	0.610***
		(0.081)	(0.079)
F Statistic	213.41	228.28	229.59
Resid. Std. Error	44.31	43.02	41.70
R^2	0.85	0.86	0.87
N	1105	1100	1100

Note: Control variables not shown. See Appendix D for full results. Estimated using OLS. †p< 0.1; *p<0.05; **p<0.01; ***p<0.001.

The contrast between the NO_2 and $PM_{2.5}$ model estimates lends further credence to the feedback pattern we hypothesize. Of the two pollutants, ΔNO_2 is the better indicator of changes in government action within a locality because a higher proportion of NO_2 concentrations are from nearby sources. $PM_{2.5}$, however, is more easily observed by the public. Compared to NO_2, $PM_{2.5}$ exposure tends to cause more physical discomfort (Amundsen, Klæboe, and Fyhri 2008, 7684). $PM_{2.5}$ is also more salient; it is explicitly mentioned on Chinese social media and other forums far more than any other pollutant. Thus, if air pollution's estimated effects on public concern are spurious, and the public is instead—through unknown mechanisms—accurately perceiving and reacting to shifts in unmeasured government action, the search index should appear to be more sensitive to ΔNO_2 than $\Delta PM_{2.5}$. What we see, though, is that the public reacts (significantly)

more strongly to $\Delta PM_{2.5}$. This difference is yet more evidence that the public is reacting primarily to the outcomes it directly observes and not to indicators of government action itself.

Model Performance and Error Correlation

The extent to which error correlation from feedback presents a practical problem for model estimation is unclear, particularly in the presence of lagged effects (see, for example, Hermida 2015). Still, comparing the models that assume correlated errors from feedback to those that do not provides additional support for our model as a whole. Unmeasured shocks that affect pollution levels and persist over time—a change in the quality of coal used in a city's power plants, for instance—will tend to push both air pollution and the search index in the same direction if, as we hypothesize, pollution levels have a positive effect on the search index. The search index's estimated effect on air pollution is therefore likely to be biased in the positive direction if feedback is present. Given that we expect the search index to have a negative effect on pollution, the bias should make the estimate smaller (i.e., closer to zero).

Tables 1 (and A.2) compare the variables of interest in models that account for feedback to otherwise identical models that ignore it. While models 2 and 4 assume the search index and air pollution have correlated errors, models 1 and 3 assume each equation is an independent regression. The results are supportive of the feedback dynamic we theorize in two key respects. First, the search index's estimated effect on NO_2 (and $PM_{2.5}$) is smaller in the models that ignore feedback, which is consistent with the bias we expect feedback to cause. Second, the models that assume correlated errors have better relative fit than their counterparts, as can be seen by their lower Akaike Information Criteria (AIC).

Discussion

We find strong support for our model of dynamic responsiveness and feedback under nondemocratic conditions. Our findings suggest that the limited responsiveness scholars have found in nondemocratic settings is indeed meaningful for the general population; it aggregates into outcomes large enough to be noticeable to the public and affect its welfare even in the short term. The extent to which this holds true across issue areas is a question for future studies, but the logic of this finding should extend to any issue domain with visible outcomes that the public perceives as important. Such issues may include local school performance, the quality of local infrastructure, and other forms of environmental degradation.

Outcomes-based feedback when democratic features are absent is perhaps our more striking finding. Scholarship has consistently found that public opinion reacts directly to shifts in government action and not outcomes in democratic systems. We find that in nondemocratic circumstances, the public reacts directly to observable outcomes and mostly ignores indicators of government action itself. In the context of the existing literature, our findings imply that the public consistently reacts to the most accessible, seemingly credible indicator of how well a problem is being handled. Which indicator meets this criterion appears to depend in large part on the presence or absence of democratic features.

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