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Environmental Degradation and Public Opinion: The Case of Air Pollution in Vietnam

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Abstract

Air pollution is a pressing problem of public health for developing countries, but governments have few incentives to abate air pollution without public awareness of the issue. Focusing on the case of Vietnam, we examine the determinants of public awareness of air pollution. Using representative survey data for the entire country from 2017, we find that local exposure to air pollution increases public awareness and reduces satisfaction with governments but does not provoke opposition to coal-fired power generation. In contrast, education leads people to oppose coal-fired power plants. These results suggest that while local air pollution contributes to awareness and dissatisfaction with the government, support for effective policy measures depends on education levels.

Keywords

air pollution, public opinion, Southeast Asia, education, Vietnam

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Air pollution is a serious threat to public health and the environment (Nel, 2005). The problem is particularly severe in developing countries, with more than 90% of air pollution-related deaths occurring in low- and middle-income countries (World Health Organization, 2018). The problem is expected to worsen in the future. In Southeast Asia, for example, emissions from coal are expected to increase threefold by 2030 at current rate (Koplitz, Jacob, Sulprizio, Myllyvirta, & Reid, 2017). From a political perspective, governments can choose to promote clean energy and reduce emissions, but such initiatives require support from the public (Wüstenhagen, Wolsink, & Bürer, 2007).

Public demand for action against air pollution is more likely when the public is aware of the problem, understands that it can be addressed with government actions, and is willing to hold elected officials accountable. Political scientists have found that public awareness of environmental problems fluctuates considerably (Brulle, Carmichael, & Jenkins, 2012; Downs, 1972; Dunlap, 2013) and that citizens have difficulty distinguishing between natural and man-made problems (Achen & Bartels, 2016). Furthermore, holding governments accountable for specific policy issues is difficult in both democratic and authoritarian settings (Ashworth, 2012; Healy & Lenz, 2014). That said, Alkon and Wang (2018) reveal that air pollution in Beijing does contribute to dissatisfaction with the government, suggesting that under some conditions people respond to worsening air quality.

We explore the factors that relate to awareness in the case of Vietnam. Vietnam was ranked as 161 out of 180 countries in the air pollution category of the 2018 Environmental Performance Index (Wendling, Emerson, Esty, Levy, & de Sherbinin, 2018). Among Southeast Asian countries, Vietnam is expected to be most affected by pollution due to coal plant emissions, with 188.8 excess deaths per million people by 2030 (Koplitz et al., 2017). Vietnam plans to increase the amount of generated electricity from renewable sources, but such initiatives are colored by the fact that the country is also planning to build 26 additional coal power plants after 2020 (VnExpress International, 2018).

We begin by examining the determinants of individuals' awareness about air pollution and their opposition to coal-fired power plants in Vietnam. In exploring these two dimensions, we focus on (a) the degree of exposure to air pollution and (b) the role of education. We expect local air quality to be an important determinant of one's perception about air pollution. Yet, its effects on opposition to coal are unclear as individual citizens may not associate such plants with air pollution. However, we expect that individuals with higher education would be more aware of air pollution and more opposed to coal plants. We further explore whether exposure to air pollution lowers satisfaction with the government.

To test our expectations, we combine our ward-level estimates of air pollution and public opinion data from the 2017 Vietnam Provincial Governance and Public Administration Performance Index (PAPI) (UNDP, CECODES and VFF, 2017a,b). We use two indicators for ward-level air pollution. First, we use satellite measures of an important air pollutant, nitrogen dioxide (NO_2) as an indicator for overall pollution. Second, we use a Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model to simulate particle pollution from all coal plant locations in Vietnam, providing an estimate on the intensity of pollution specifically from coal plants.[1] With these derived measures of pollution and public opinion data collected from more than 13,000 Vietnamese citizens, we explore how ward-level air quality is associated with (a) public perception about air pollution, (b) opposition to coal plants, and (c) satisfaction with the government.

Our analysis finds a positive association between exposure to air pollution and awareness of it, but no clear relationship exists between such exposure and opposition to coal plants. Substantively, one standard deviation increase in the intensity of NO_2 in one's ward is associated with more than 10% increase from the average level of negative perception of air quality and about 2% increase in the use of face masks due to air pollution. We find similar results from our estimates of pollution from coal plants. One standard deviation increase in the intensity of coal-related pollution is associated with 11% increase in the negative evaluation of air quality, although we find no statistically significant effects on mask use. For one's opposition to coal plants, we find no evidence of the effects of exposure to air pollution on attitudes toward coal plants.

We instead find that education level is associated with opposition to coal-fired power plants as well as awareness of air pollution. According to our base model, individuals with high school degree, on average, tend to negatively evaluate air quality (4% increase from the average level of negative evaluation), tend to perceive current air quality more negatively than past (13% increase from the average level of negative evaluation), and tend to wear mask due to concerns about air pollution (14% more likely than the average). Importantly, education also appears substantive and statistically significant for explaining one's opposition to coal plants. Individuals with high school education are about 6% more likely to oppose to coal-fired power plants.

Furthermore, we find that the intensity of air pollution is systematically related with satisfaction with government. Individuals living in more polluted areas tend to be less satisfied with the national government, local committees, and the national assembly. This finding is closely related to Alkon and Wang's (2018) analysis on how air pollution is associated with satisfaction with government in the case of China. Yet, our analysis differs in that we examine subnational variation in the intensity of air pollution and its effects on government satisfaction. While Alkon and Wang (2018) demonstrate that citizens respond to short-term temporal changes in the level of pollution focusing on the survey of Beijing residents, our findings further demonstrate how geographical variation in air pollution is associated with satisfaction in the government.

This study joins a small but growing body of research on the relationship between actual and perceived air pollution. Earlier studies have examined the public perception of air pollution and support for air quality policy by focusing on one or a few selected subregions (e.g., Huang, Andersson, & Zhang, 2017; Lubell, Vedlitz, Zahran, & Alston, 2006), without providing systematic evidence drawing from a representative sample. An exception is Peng, Zhang, Evans, Zhong, and Yang (2019) that presented a rigorous analysis on the relationship between actual and perceived air pollution and the moderating effect of environmental transparency on this relationship in China. We join this effort by documenting how geographical variation of actual air pollution is related with perception about air pollution from another developing country.

Our findings provide an important policy implication on how environmental groups can increase government incentives for mitigating air pollution. The lack of strong association between air quality and support for costly measures suggests that the public should be provided with more information on the detrimental effects of air pollution on health, sources of air pollution, and benefits of different policy options. While the public directly experience air pollution, it is important to emphasize the link between policy and air quality. Our findings on the impact of education are in line with this implication. Individuals with higher education are likely to be more knowledgeable about causes of air pollution and potential benefits from reducing reliance on coal-fired power plants. Environmental groups can provide this type of information to the public so that they develop an understanding about consequences of specific policies and become more strongly opposed to the causes of air pollution and hold governments accountable for their policy choices.

Awareness of Air Pollution and Satisfaction With the Government

We emphasize two factors as the key determinants of the public perception about air pollution: (a) air quality in one's locality and (b) education. First, individuals develop awareness of air pollution through direct experience, which is largely determined by air quality in one's locality. We also expect exposure to air pollution to reduce satisfaction with the government. Second, individuals indirectly acquire knowledge about air pollution. One's level of awareness is closely linked with education, which is our second focus. While we consider both direct experience and indirect learning as equally important determinants of perceptions of air pollution, we posit that is a more important factor in accounting for one's opposition to coal plants.

Exposure to Air Pollution, Policy Preferences, and Satisfaction With Government

Air pollution is a pressing problem in many countries. Yet, the multifaceted causes of air pollution (e.g., power generation, industrial activity, and transportation) are linked with economic benefits and create a trade-off between economy and environment. In other words, individuals or regions more heavily exposed to air pollution may also economically benefit from the sources of air pollution, such as energy access and transportation. A government would be incentivized to implement a strong air pollution policy when these individuals are aware of air pollution and willing to pay the costs associated with pollution-related activities that they economically benefit from.

However, not everyone is equally aware of and concerned about poor air quality. Previous empirical studies report a wide variation in the public perceptions of air pollution (Bickerstaff & Walker, 2001; Johnson, 2002). One strand of research examines how actual and perceived air pollution correlate with each other. While one's exposure to actual air pollution is found to form a basis of one's subjective evaluation of air quality (e.g., Atari, Luginaah, & Fung, 2009), a number of studies also report a gap between objective and subjective air quality (e.g., Graves, 2003). To explain the gap, another strand of research focuses on the social contexts that influence how individuals process and interpret information related to air quality. For instance, Bickerstaff and Walker (2001) note that a negative social environment generates a tendency to dislike the neighborhood and to form a negative evaluation of one's local air quality. Also, the media's focus on negative news may explain the mismatch between actual and perceived air pollution (Graves, 2003). All in all, the way individuals perceive air pollution depend on a range of individual- and local-level factors that cannot be reducible to one or two factors.[2]

Among different sources of the public perception of air pollution, we focus on the effects of actual air pollution. This question has not been much explored in the context of developing countries, where the problem of air pollution is severe. While the perception of air quality is complex and influenced by a variety of factors, we expect that actual air quality would be one of the key determinants that shape the public perception about it.

Most important, individuals can experience polluted air through sensory and health cues. Individuals can easily assess air quality through reduced visibility and dust, all of which are noticeable signs of air pollution. Also, individuals may experience negative effects of air pollution on their health even in the short term through various respiratory irritation. Individuals also learn about air pollution through secondary sources (Brody, Peck, & Highfield, 2004), but such nonvisceral exposure is not necessary and not likely as impactful as direct exposure. For instance, Bickerstaff and Walker (2001) find that only 3.4% of people identified media as the source of their awareness of air pollution, while 51.1% of people pointed its health effects, visible indicators, smell, or taste as the sources of their awareness. We thus expect that the degree of air pollution in one's locality is an important determinant of the residents' perception about air pollution.

With respect to one's attitudes toward coal plants, however, the expected effect of local air quality is ambiguous. On one hand, one's exposure to air pollution may increase opposition to its sources. On the other hand, one needs to recognize power plants as a source of air pollution and consider the benefits from improved air quality to outweigh the costs of reducing reliance on coals. Yet, one's exposure to air pollution does not automatically lead to the understanding of its sources. Moreover, the public in developing countries tend to have weak preferences for environmental quality due to trade-off between economic and environmental benefits (Dinda, 2004; Gelissen, 2007). For these reasons, air pollution in one's locality would not necessarily lead one to oppose coal plants, which are cheap sources of energy, even when one perceives air pollution.

In understanding the effect of air pollution on satisfaction with government, one need not assume that citizens know the specific causes of air pollution and the details of potential policy trade-offs. In line with Alkon and Wang's (2018) discussion, we expect air pollution to have a negative externality on the incumbent government for two reasons.

First, exposure to air pollution lowers subjective well-being of individual citizens. A series of empirical studies find that air pollution decreases one's subjective well-being and happiness while increasing the rate of depressive symptoms (e.g., Zhang, Zhang, & Chen, 2017). This is also consistent with Zheng, Wang, Sun, Zhang, and Kahn's (2019) finding that high levels of air pollution lead to low levels of expressed happiness on social media in China. Several mechanisms may account for the findings. For one, air pollution is reported to induce oxidative stress, a potential cause of depression (Lim et al., 2012). Also, impaired visibility and negative health effects of air pollution would also affect individuals' moods and general life satisfaction. When individuals become less satisfied with their quality of life in general due to air pollution, they in turn will tend to think more about the issue focusing on the link between pollution and government, which may lead to lower satisfaction with the government.

Second, the public is likely to blame the government for its incapacity to tackle the air pollution problem (Per & Svensson, 2003). Also, the public is likely to understand the connection between industrial policies and environmental outcomes when the government publicly claims credit for economic growth and industrial policies. In their analysis of the effect of air pollution on support for the Chinese government, Alkon and Wang (2018) show that government efforts to lower pollution improved citizens' evaluation of the regime. This mechanism is likely to hold in other contexts if the public understands the role of government in affecting air pollution.

The Role of Education

We next discuss the role of education in affecting the public perceptions of air pollution and the public opposition to coal plants. Building on Inglehart's (1995) insights, we posit that education is an important factor that can explain the variation in public opinion of air pollution. Specifically, we expect that education increases the public awareness about air pollution and the public opposition to coal plants for two main reasons.

First, individuals with higher education would be more capable of acquiring and processing information related to air pollution. While individuals can directly experience air pollution, there are other information sources that highlight the issue of air pollution. For instance, individuals exposed to only a moderate level of air pollution in their localities may read news articles on a serious level of air pollution at the national level. Then, the issue of air pollution would become more salient for those who read news articles, and they may become more aware of the issue without directly experiencing a serious level of air pollution. For a similar reason, they might be able to better interpret health cues related to air pollution. Those individuals who are more informed about air pollution issue in general would be more likely to attribute their respiration irritation to air pollution.

Second, education can foster environmental consciousness among individuals. More educated individuals are better aware of the potential damage of environmental destruction. This could be through education on environment-related subjects. Even when the curriculum does not specifically address the issue of air pollution, learning environmental-related subjects would increase an overall level of environmental consciousness. There is indeed evidence from empirical studies in different contexts to suggest that education can increase awareness, with higher levels leading to more extensive knowledge about environmental issues (Aminrad, Zakaria, & Hadi, 2011; Centre for Community Support and Development Studies [CECODES], Centre for Research and Training of the Viet Nam Fatherland Front [VFF-CRT], & United Nations Development Programme [UNDP], 2017). A recent PAPI report finds that highly educated individuals are more likely to decrease their support for coal plants in response to the provision of information on the effects of coal plants on greenhouse gas emissions, compared with individuals with lower level of education (CECODES et al., 2018).

Summary of Hypotheses

We summarize our hypotheses in Table 1. First, we hypothesize that one's exposure to air pollution increases one's awareness of air quality due to its highly visible nature. Yet, we do not expect that local-level air pollution would be clearly related with one's opposition to coal plants in any direction. As for satisfaction with government, we hypothesize that a higher level of air pollution would negatively affect one's level of satisfaction with government. Second, we draw another set of hypotheses concerning the effect of education. We hypothesize that education would be positively associated with one's awareness of air pollution as well as opposition to coal plants.

Table 1. Summary of Hypotheses.

IV	DV	Expectation
Air pollution	Awareness of air pollution	+
	Opposition to coal plants	?
	Satisfaction with government	–
Education	Awareness of air pollution	+
	Opposition to coal plants	+

Note. Our expectation on the association between each IV and each DV is summarized in the last column, where + indicates positive effect, – indicates negative effect, and ? indicates no clear expectation on the direction of the association. DV = dependent variable; IV = independent variable.

Air Pollution and Coal-Fired Power Generation in Vietnam

Vietnam faces a serious air pollution problem. Major cities such as Ho Chi Minh City and Hanoi suffer from high levels of air pollution that in turn contribute to public health problems (Phung et al., 2016). In 2017, the capital city Hanoi experienced only 38 days during which air quality would be considered healthy by the World Health Organization (Taylor, 2018).

Vietnam's Air Pollution Problem

Vietnam's air pollution problem has multiple causes. Power generation, industry, residential buildings, and transportation all contribute to poor air quality and smog, with traffic and industrial activity contributing to NO_2 emissions at about the same rate, traffic accounting for more than 85% of carbon monoxide and volatile organic compound emissions, and industrial activity producing 70% of sulfur oxides pollution in 2015 (Hoang, Chu, & Van Tran, 2015). Due to rapid growth in energy demand, air pollution levels have increased over time. Between 1990 and 2013, the population-weighted average particulate matter $(PM)_{2.5}$ concentration increased from below 20 to about $25\,\mu g/m^3$ (Brauer et al., 2015). These high air pollution levels have caused respiratory diseases, as evidenced by increased numbers of hospitalization at times of poor air quality (Phung et al., 2016).

Coal-Fired Power Generation in Vietnam

Current coal consumption in Vietnam is about 43.8 million tons with power plants accounting for more than 50% of this consumption (Danish Energy Agency, 2017). The country has planned to expand its coal generation capacity in the coming years with the total installed capacity reaching 115 GW by 2030, an annual rate of 8%, and coal-fired capacity is expected to account for 75%

of future capacity additions by 2010 (International Energy Agency, 2016). In sum, coal is expected to play a critical role in the country's power sector in the coming decades.

We illustrate the distribution of coal-fired power plants in Vietnam in Figure A1 in the online appendix. The map shows that most of coal-fired power plants are located in the coastal area in the East. These plants are largely concentrated in the northern east region, with the presence of coal-fired power plants with varying levels of capacity. However, it is also notable that coal-fired power plants are in operation in other regions as well. In particular, there are a few coal-fired power plants with large capacity in the southern east region.

Research Design

Our empirical analysis draws on the 2017 PAPI survey of more than 13,000 randomly selected Vietnamese citizens of all demographic backgrounds from all provinces. The PAPI survey is Vietnam's largest nationwide annual policy monitoring survey that started with a pilot survey in 2009. The 2017 survey was conducted through face-to-face interviews from July 12, 2017 to October 31, 2017, in 828 villages in 414 communes of 207 districts. The survey includes questions related to citizen perceptions of governance and public administration performance (e.g., control of corruption, public administration performance, and public service delivery). The survey also includes questions on perceived local air and water quality and attitudes toward coal plants. Our analysis draws on responses to the questions on air quality, attitudes toward coal plants, and satisfaction with local and national governments. We combine this survey data set with our ward-level estimates of air pollution.

With a series of dependent variables on public opinion, we estimate the following model:

$$Y_{ijk} = \alpha + \beta_1 \, \text{Air Pollution}_{ijk} + \beta_2 \, \text{Education}_i + \theta \, \text{Demographic Controls}_i + \mu_k + E_{ijk}$$

where Y_{ijk} is a measure of perception about air quality, opposition to coal-fired power plants, or satisfaction with government performance for an individual i in ward j in region k. We have a different set of dependent variables that are continuous, ordered, or binary.

We estimate linear regression models for all dependent variables for simplicity and ease of interpretation.[3] Our primary parameters of interest are β_1, the coefficient on *Air Pollution*, and β_2, the coefficient on *Education*. The model also includes *Demographic Controls*, a vector of individual characteristics (gender, age, and income). Some of our models also include μ, a vector of region fixed effects.[4] We do not include fixed effects for districts or provinces due to little variation in air pollution levels within each district or province. The ratio of between group to within group is far above the standard threshold (1.7) for different measures of air pollution levels at both districts and provinces.

It should be noted that our data set is cross-sectional, which does not allow us to explore any overtime variation in public responses to the change in air quality. Instead, our analysis focuses on examining the correlation between local air quality and individual-level attitudes toward air quality, coal-fired power plants, and local and national governments. Also, our analysis on satisfaction with government can be subject to a concern of endogeneity because the regional-level support for government might be correlated with the government's decision in allocating polluting industries across regions. With these caveats, we next describe our construction of key variables.

Dependent Variables

We have three sets of dependent variables: (a) evaluation of air quality, (b) opposition to coal-fired power plants, and (c) satisfaction with governments. We examine how an objective level of air pollution is associated with one's perception about air quality and one's opposition for coal-fired power plants. We further explore whether air pollution level in the area is associated with one's evaluation of government performance.

For one's perception of air quality, we use various measures to ensure that our findings are not particularly contingent on the way questions are phrased in the survey. First, the survey asked respondents to rate the air quality in the area as (a) good, (b) good on most days, (c) poor on most days, or (d) poor. Second, the survey also asked them to indicate whether the current quality is (a) better, (b) same, or (c) worse, compared with 3 years ago. Last, the survey asked whether they wear face masks for air quality. By examining their actual behavioral responses to air pollution, this binary measure can assess to what extent individuals are concerned about air pollution in their everyday environment. These questions were originally developed by CECODES et al. (2018). We describe exact question wordings in Table A3 in the online appendix.

Figure 1 summarizes the distribution of responses. Overall, the respondents have positive perceptions of air quality in their areas. The majority of surveyed respondents rated the air quality as good (68%) or good on most days (17.3%), while only a small fraction rated it as poor (9.5%) or poor on most days (5.2%). When asked to compare the current air quality with 3 years ago, the most frequent answer was "better" (37.4%), followed by "worse" (34.9%) and "same" (26.4%). This overall positive perception may seem surprising, given the problem of air pollution in Vietnam, but a wide variation exists in the level of air quality across regions with the northern area experiencing more serious air pollution than the southern part (see Figure 2). Even among those who rated air quality as good in the first question, more than 50% reported that they wear masks due to air quality. This may suggest that many individuals are actually

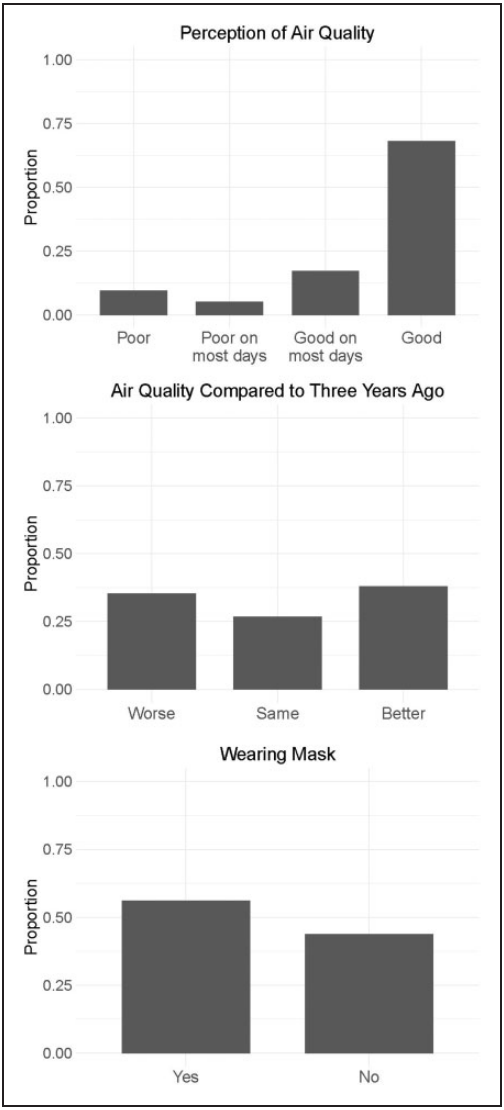

Figure 1. Distributions of perceptions of air pollution issues. Perception of current air pollution (top), perception of current air pollution relative to the past (middle), and mask use (bottom).

concerned about air pollution in their everyday environment, even when they perceive their area's air quality "relatively good" compared with other areas. This response is indeed only weekly correlated with individual perceptions of current and past air quality ($r = .16$ and $r = .08$ respectively), as shown from the correlation matrix presented in Table A2 in the online appendix.

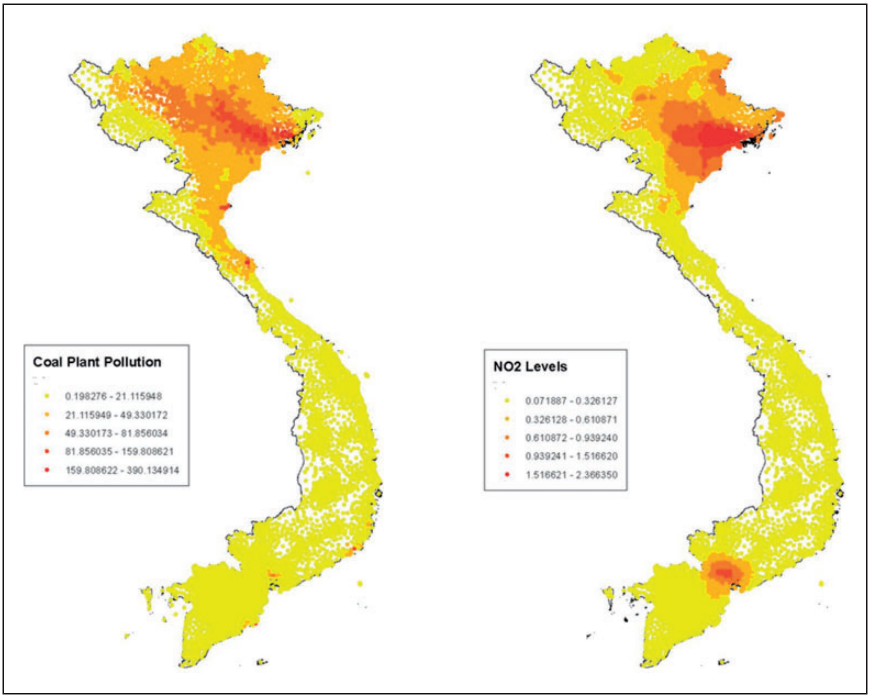

Figure 2. Maps of pollution prevalence in Vietnam. The left graph is the HYSPLIT-derived measure of coal pollution. The right graph is NO_2 concentration.
Note. NO_2 = nitrogen dioxide; HYSPLIT = Hybrid Single-Particle Lagrangian Integrated Trajectory.

Our next dependent variable is one's opposition to coal-fired power plants. We rely on responses to the question asking whether they support the construction of coal-fired power plants, to which respondents answered either yes or no.[5] For the question on coal-fired power plants, only 29.1% appeared to support for coal-fired power plants. The majority (60.6%) answered "no" to the question, while 10.3% did not answer the question.

Last, we have another set of dependent variables that measure one's evaluation of government performance. We use responses on the level of satisfaction with the performance of five different institutions. The survey asked to give a mark between 0% (*very unsatisfied*) and 100% (*very satisfied*) to show one's degree of satisfaction with different institutions. We focus on responses related to one's evaluation of the national government, local committees, and the national assembly.

Explanatory Variable: Air Pollution

To estimate air pollution levels, we use satellite observations and derive ward-level estimates of pollution. We focus on one particular type of pollution: NO_2.

It is produced as a byproduct of burning coal in power plants. It is linked with a range of adverse health effects, including irritating airways, and exacerbating respiratory diseases such as asthma. For NO_2 estimates, we use the spatial pollution grids developed by Geddes, Martin, Boys, and van Donkelaar (2016) that estimates surface NO_2 mixing ratio a 0.1×0.1 degree resolution from satellite-observed tropospheric densities and a global chemical transport model. We estimate the grid value at the centroid of the ward.

NO_2 is a particularly important pollutant to track not only because of its role in producing visible air pollution and adverse health effects, but it is also an important precursor for both $PM_{2.5}$ and ground-level ozone pollution, both of which are easily perceived by the public. Satellite measurements of this pollutant are also generally complete and accurate at monthly to annual level with 20% uncertainty (Lamsal et al., 2014). $PM_{2.5}$ is another pollutant for which there is satellite data available. However, satellite-derived $PM_{2.5}$ has substantial geographic gaps and are subject to various sources of uncertainties (Jin et al., 2019), especially over regions with sparse ground-based measurements such as Vietnam. Where $PM_{2.5}$ data are reliably measured in Vietnam, however, there is a reasonably strong correlation between it and NO_2 ($r = .60$).

Attributing Air Pollution to Coal

To estimate exposure to pollution specifically emanating from coal plants, we use the HYSPLIT model (Stein et al., 2015). The HYSPLIT model uses detailed information about wind speed and direction, temperature, humidity, and precipitation to estimate the position of a particle's movement in three dimensions over time. In this case, we start each particle at the latitude/longitude point for all the unique power plants in Vietnam. To measure the pollution burden from these coal plants in the different wards of Vietnam, we created a 0.1 degree grid, counting the number of weighted particles that passed through each square of the grid. Ward-level data were collected by extracting the sum of weighted particles passing through the grid square in which the centroid of the ward is located.[6]

In general, there is a reasonably strong relationship between pollution measures and our derived measure of coal plant emissions. The weighted number of plant particles from the HYSPLIT model correlates with NO_2 at $r = .76$. Given that coal plants are expected to be a primary source of this pollutant, this is consistent with what we would expect from a valid coal plan pollution measure. Summary statistics and correlation matrix with other key variables are presented in Tables A1 and A2 in the online appendix.

Figure 2 presents the maps of HYSPLIT-derived measure of coal pollution and NO_2 concentration. The maps show that the level of pollution measured in coal pollution and NO_2 concentration is highly correlated. According to both maps, coal plants pollution and NO_2 are concentrated in the northern east region. Other areas show a relatively minor level of air pollution, except in Ho Chi Minh City in the south, where NO_2 levels appear to be as high as the northern east region. Yet, the level of coal plant pollution is not high in this area, implying that air pollution in Ho Chi Minh City is mainly driven from sources other than coal plants.[7]

For both NO_2 and air pollution emanating from coal plants, we matched the calculated value of ward-level estimate to survey respondents based on their ward of residence, which is the most microlevel geographic information available in the survey data. For exposure to coal plants, we also examine the distance to coal plants as an alternative measure (the distance between the centroid of ward and the nearest coal plants) as presented in Tables A9 to A11 in the online appendix.

Explanatory Variable: Education

Another key variable we are interested in is education. We expect that highly educated individuals might be more aware and conscious about air pollution problems in their localities than those with less education. They are also more likely to pay attention to related information disseminated by environmental organizations.

We describe the distribution of education level among the respondents in Figure A5 in the online appendix. The figure demonstrates that nearly 65% of respondents did not complete high school education. While about 29.4% completed secondary school education, 20.1% only completed primary school education, and 14.1% did not complete primary school education. In our analysis, we use a binary indicator for high school education, coded 1 for those who completed high school education (23.2%), hold university degree (12.0%), and postgraduate degree (0.7%) and 0 otherwise. To simplify the regression and avoid an incidental parameters problem from too many discrete categories, we collapse our education measure into an indicator variable for high school completion. By doing so, we distinguish between respondents that might have been introduced to the science behind air pollution in high school or college education. Yet, we also estimate the same models with a more refined set of categories of education levels as presented in Tables A6 to A8 in the online appendix. The main findings on the effect of education remain substantively similar.

Control Variables

We include a series of control variables to account for individual characteristics that might be correlated with air pollution level in different communes. First, we include a binary indicator for female. Women are generally found to be more concerned about environmental issues than men (Bord & O'Connor, 1997).

Second, we control for age, which has been found to be an important determinant of individual perception of environmental issues, with younger people expressing more environmental concerns (Baldassare & Katz, 1992). Last, we include income, which is generally positively associated with environmental concern. Individuals with higher income can prioritize environmental values as the basic material needs are satisfied (Liere & Dunlap, 1980). Also, citizens with higher incomes tend to have more education. Because education and income are highly correlated, we need to control for income to examine the effects of education, given the same level of income. We construct two binary indicators: *High Income* is coded 1 for those whose income is more than 10 million VND (31.8% of respondents) and 0 otherwise; *Middle Income* is coded 1 for those who earn more than 7 million VND but less than 10 million VND and 0 otherwise.[8]

Results

This section presents the results. To foreshadow our results, we find that one's exposure to air pollution increases one's perception of air pollution, but this is not associated with one's opposition to coal-fired power plants. Air pollution measures are also found to be negatively associated with one's satisfaction with governments. Last, we find that education consistently appears to be an important determinant for one's perceived air quality and opposition to coal-fired power plants.

Air Pollution and Perception of Air Quality

We present the results on perceived air quality in Table 2. The first two models focus on one's perception of current air quality, the next two focus on one's evaluation of current air quality compared with past, and the last two models focus on one's use of mask. All dependent variables are coded such that a higher value indicates a negative perception of air quality. We estimate the models separately for different measures of air pollution to avoid the issue of multicollinearity because these pollution measures are highly correlated.

Beginning with the effects of air pollution, we find that the coefficient on NO_2 increases the probability that one negatively evaluates air quality at a statistically significant level. We find a substantively similar result from the coefficient on coal plants pollution. Given that these measures are standardized ones, we can directly compare the substantive effects of different measures of air pollution levels. Specifically, one standard deviation increase in the intensity of NO_2 is associated with more than 10% increase in one's negative evaluation of air quality from the average level, and one standard deviation increase in the intensity of coal-related pollution is similarly associated with about 11% increase in one's negative perception.

Table 2. Air Pollution Level and Perceptions of Air Quality.

	(1)	(2)	(3)	(4)	(5)	(6)
	Perception of air quality		Air quality compared with past		Mask use	
NO_2						
NO_2	0.163***	0.084***	0.119***	0.061***	0.010*	0.018*
	(0.008)	(0.015)	(0.008)	(0.013)	(0.004)	(0.007)
High school degree	0.061**	0.046*	0.262***	0.257***	0.080***	0.084***
	(0.019)	(0.019)	(0.017)	(0.017)	(0.009)	(0.009)
Female	–0.019	–0.016	0.172***	0.176***	–0.286***	–0.284***
	(0.016)	(0.016)	(0.015)	(0.015)	(0.008)	(0.008)
Age	0.001*	0.002*	–0.005***	–0.005***	–0.003***	–0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
High income	–0.098***	–0.076***	0.046**	0.044*	0.020*	0.011
	(0.019)	(0.020)	(0.017)	(0.018)	(0.010)	(0.010)
Middle income	–0.062**	–0.047*	–0.002	0.000	0.045***	0.036**
	(0.023)	(0.023)	(0.021)	(0.021)	(0.012)	(0.012)
Observations	12944	12944	12958	12958	13092	13092
Coal-fired power plants						
Coal plants	0.165***	0.080***	0.096***	0.033*	–0.004	0.013
	(0.009)	(0.018)	(0.008)	(0.016)	(0.004)	(0.009)
High school degree	0.052**	0.050**	0.260***	0.260***	0.082***	0.084***
	(0.019)	(0.019)	(0.017)	(0.017)	(0.009)	(0.009)
Female	–0.027	–0.019	0.165***	0.174***	–0.287***	–0.284***
	(0.016)	(0.016)	(0.015)	(0.015)	(0.008)	(0.008)
Age	0.002**	0.002*	–0.004***	–0.004***	–0.003***	–0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
High income	–0.057**	–0.073***	0.077***	0.047**	0.023*	0.011
	(0.019)	(0.020)	(0.017)	(0.018)	(0.010)	(0.010)
Middle income	–0.036	–0.046*	0.017	0.003	0.047***	0.037**
	(0.023)	(0.023)	(0.021)	(0.021)	(0.012)	(0.012)
Observations	12944	12944	12958	12958	13092	13092
Region FE	No	Yes	No	Yes	No	Yes

Note. The dependent variable is 4-point scale ordinary variable in Models 1 to 4. Higher values indicate more negative perception of air quality. The dependent variable is a binary indicator for mask use in Models 5 and 6. All models use survey weights. Standard errors in parentheses. NO_2 = nitrogen dioxide; FE = fixed effect.

*$p < .10$. **$p < .05$. ***$p < .01$.

As to one's evaluation of current air quality compared with past, both measures of air pollution again appear to be positive and statistically significant. This suggests that the higher the level of air pollution in the area, the more negative one's evaluation of current air quality relative to the past. We also examine one's behavioral response to air pollution. If one is more aware of air pollution problems in the area, one would be more likely to wear mask to protect oneself from air pollution. This allows us to examine whether one actually adjusts her behavior in their daily lives in response to air pollution. As presented in Models 5 and 6, a higher level of concentration of NO_2 is positively associated with the variable on wearing mask. But the effect of coal-fired power plants appears less substantial, and the sign of coefficient is inconsistent across the models.

As for the effects of education, we find that those with high school degrees hold a more negative perception of air quality and are more likely to wear masks due to concerns about air quality. The coefficients are statistically significant across the models. According to the base model without regional fixed effects, individuals with high school degree, on average, tend to more negatively evaluate air quality (4% increase from the average level), tend to perceive current air quality more negatively than past (13% increase from the average level of negative evaluation), and tend to wear mask due to concerns about air pollution (14% more likely than the average).

Among control variables, we find that the effects of gender and age are substantive and statistically significant in explaining one's use of perceived air quality relative to the past and one's use of face masks. While age is associated with a negative evaluation of current air quality, the older people tend to have less negative evaluation of air quality compared with the past and tend not to use face masks. Also, women tend to have a more negative perception of current air quality compared with the past, but they in general are far less likely to use face masks. This points to the importance of further investigating how one's perceived air quality is related with actual behavioral response to air pollution.

Table 3 presents the results on one's opposition to coal-fired power plants. Both measures of air pollution appear to be negatively associated with opposition to coal-fired power plants although none of them are statistically significant at the conventional level with the inclusion of region fixed effects. Two mechanisms may account for this lack of significant association. First, areas more heavily exposed to pollution from coal plants are more likely to economically benefit from those plants (e.g., employment benefits). Thus, individuals may have ambiguous attitudes toward coal plants considering both environmental benefits and economic costs. Second, individuals may not have much information on the sources of air pollution especially when they live farther from coal plants. We investigate this possibility by examining the effects of distance from coal plants (Table A11 in the online appendix) and indeed find that those living

Table 3. Air Pollution Level and Opposition to Coal Plants.

	(1)	(2)
	Opposition to coal plants	
NO_2		
NO_2	–0.019***	0.011
	(0.004)	(0.008)
High school degree	0.060***	0.060***
	(0.010)	(0.010)
Female	–0.001	0.000
	(0.009)	(0.009)
Age	–0.000	–0.000
	(0.000)	(0.000)
High income	0.012	0.016
	(0.010)	(0.010)
Middle income	0.028*	0.032**
	(0.012)	(0.012)
Observations	11893	11893
Coal-fired power plants		
Coal plants	–0.017***	0.006
	(0.004)	(0.009)
High school degree	0.060***	0.061***
	(0.010)	(0.010)
Female	–0.000	–0.000
	(0.009)	(0.009)
Age	–0.000	–0.000
	(0.000)	(0.000)
High income	0.007	0.016
	(0.010)	(0.010)
Middle income	0.025*	0.032**
	(0.012)	(0.012)
Observations	11893	11893
Region FE	No	Yes

Note. The dependent variable is a binary variable coded 1 for those who oppose the construction of coal-fired power plants. All models use survey weights. Standard errors in parentheses. NO_2 = nitrogen dioxide; FE = fixed effect.
*$p < .10$. **$p < .05$. ***$p < .01$.

Table 4. Air Pollution Level and Satisfaction With Governments.

	(1)	(2)	(3)	(4)	(5)	(6)
	National government		Local committees		National assembly	
NO_2						
NO_2	–2.227***	–1.196***	–1.771***	–0.402	–2.069***	–1.839***
	(0.183)	(0.315)	(0.201)	(0.346)	(0.188)	(0.324)
High school degree	–3.886***	–3.585***	–0.633	–0.048	–2.364***	–2.248***
	(0.401)	(0.404)	(0.439)	(0.441)	(0.408)	(0.412)
Female	0.101	0.009	–1.508***	–1.666***	1.004**	0.920*
	(0.361)	(0.360)	(0.397)	(0.394)	(0.370)	(0.369)
Age	0.115***	0.110***	0.073***	0.062***	0.136***	0.132***
	(0.016)	(0.016)	(0.017)	(0.017)	(0.016)	(0.016)
High income	0.324	0.113	1.320**	0.778	0.171	0.139
	(0.422)	(0.434)	(0.463)	(0.475)	(0.431)	(0.442)
Middle income	0.059	–0.120	1.817**	1.572**	0.546	0.493
	(0.512)	(0.513)	(0.567)	(0.566)	(0.525)	(0.527)
Observations	9879	9879	7936	7936	9746	9746
Coal-fired power plants						
Coal plants	–2.054***	–1.197**	–2.385***	–1.546***	–1.621***	–1.312***
	(0.188)	(0.374)	(0.208)	(0.408)	(0.193)	(0.383)
High school degree	–3.750***	–3.624***	–0.332	–0.044	–2.298***	–2.311***
	(0.402)	(0.404)	(0.439)	(0.441)	(0.410)	(0.412)
Female	0.162	0.030	–1.542***	–1.686***	1.077**	0.957**
	(0.362)	(0.360)	(0.396)	(0.394)	(0.371)	(0.369)
Age	0.104***	0.109***	0.069***	0.065***	0.123***	0.130***
	(0.016)	(0.016)	(0.017)	(0.017)	(0.016)	(0.016)
High income	–0.206	0.090	0.930*	0.848	–0.308	0.062
	(0.420)	(0.434)	(0.458)	(0.475)	(0.429)	(0.442)
Middle income	–0.218	–0.126	1.654**	1.614**	0.289	0.459
	(0.512)	(0.514)	(0.564)	(0.566)	(0.526)	(0.528)
Observations	9879	9879	7936	7936	9746	9746
Region FE	No	Yes	No	Yes	No	Yes

Note. The dependent variable is a continuous variable ranging from 0 (*very unsatisfied*) to 100 (*very satisfied*). All models use survey weights. Standard errors in parentheses. NO_2 = nitrogen dioxide; FE = fixed effect.
*$p < .10$. **$p < .05$. ***$p < .01$.

farther from coal plants are less opposed to coal plants. Coal plants are not likely to be a visible source of air pollution for those living farther from the plants, and thus, this may explain why the effects of air pollution emanating from coal plants is close to zero in Model 2.

Education is also a strong predictor of one's opposition to coal plants. Individuals with high school degrees are more opposed to coal plants, which remains robust to controlling for gender, age, income, and region fixed effects. Substantively, individuals with high school education are more likely to oppose to coal-fired power plants by 6 percentage points than are those with lower levels of education.

Air Pollution and Public Opinion on Government Performance

We next present the results on satisfaction with governments in Table 4. The first two models focus on one's satisfaction with national government, and the next two focus on one's satisfaction with subnational governments, from provincial people's committee and district people's committee to commune/ward people's committee. We take an average level of satisfaction with these three types of subnational governments as the value for dependent variable in these models. We also have the two models on satisfaction with the performance of national assembly.

Beginning with the models without region fixed effects, the level of NO_2 and the level of air pollution from coal sources appear to be negatively associated with one's satisfaction with all three types of institutions. Across the models, the coefficients on NO_2 and coal plants all appear to be negative and statistically significant at the conventional level, except for the coefficient on NO_2 for the satisfaction with local committees in Model 4.

The findings show that actual air pollution is strongly associated with the citizens' evaluation of government performance. This is in line with our expectation that individuals more heavily exposed to air pollution are more likely to understand the government's responsibility over the environmental problem. Also, this association might be reinforced by social or political movements over air pollution. Indeed, there is an emerging view that environmental problems are likely to pose a political risk to the Vietnamese government, as evidenced by an increasing number of protests on environmental issues (Nguyen, 2018). Hutt (2017) further notes that "without elections and any meaningful public engagement, the government's legitimacy depends on economic growth. But environmental concerns are severely testing this legitimacy." Individuals more heavily exposed to air pollution are more likely to join those environmental protests, which may again create a feedback effect on generating the public consensus over the government's responsibility over environmental issues.

Conclusion

The aforementioned results provide both good and bad news about air pollution and government accountability. Good news is that individuals tend to have a *correct* understanding of air pollution. A pattern of individual awareness of air pollution is consistent with geographical distribution of air pollution. Given that the public awareness of the problem is foremost necessary for holding governments accountable to air pollution, the strong association between actual and perceived air pollution shows that the first hurdle of government accountability is passed. The findings on government satisfaction also suggest that governments may have to pay political costs due to air pollution.

Bad news is that one's exposure to air pollution does not translate into one's opposition to coal-fired power plants. This underscores the importance of discounting and cost-benefit distribution in understanding policy support of individuals. The public may not support policy that imposes short-term costs especially when they discount future policy benefit. Moreover, the public may recognize the trade-off between economy and environment and may not be willing to give up the economic benefits of coal-fired power plants even at the environmental costs. The lack of public support for policy implies that governments would have little incentives to implement stringent pollution abatement policies. Although the public may express dissatisfaction with governments due to air pollution, governments would still weigh the cost of implementing policy not strongly supported by the public.

There is one key area that future research should address. Our analysis does not allow us to delineate the mechanism behind the association between air pollution and dissatisfaction with government. A few complementary mechanisms might be at work. Namely, individuals might understand the consequences of government (in)actions on air quality and express their dissatisfaction with inadequate policy measures. Or individuals might be simply unhappy with the quality of life in general due to air pollution and become dissatisfied with different types of political institutions irrespective of their responsibility. They are not contradictory, and future research should explore which of the mechanisms appear relatively stronger depending on the context, information environment, and individual characteristics. Possible approaches include more detailed surveys, mediation analysis, and exploration of heterogeneous effects of air pollution across individual characteristics.

Another area for further exploration is an analysis of overtime variation in local-level air quality and government satisfaction of the residents. Our data do not contain the measures of air quality for different years or months. Our work therefore cannot explore whether and how quickly the public responds to improvement or deterioration of air quality or whether the public is willing to reward or punish the national or subnational governments for their air quality policy decisions. Our work is also not free from an endogeneity problem in that support for government, measured as citizens' satisfaction, might be correlated with other factors that determine the government's decision to allocate polluting industries across regions. An exploration of overtime data will be an important step for addressing this potential problem.

Air pollution is a pressing concern especially for developing countries that are projected to rely more on coal-fired power plants to meet a rapid increase in demand for energy. Yet, the determinants and political consequences of public awareness of air pollution have received limited attention so far in the prior literature, and the few studies on the topic mostly focus on advanced economies such as the United States and the United Kingdom (e.g., Gerber & Neeley, 2005). The only country that received relatively more attention among developing countries is China (Alkon & Wang, 2018; Huang et al., 2017). Our work expands the geographical scope of empirical studies on public opinion on air pollution and calls for further exploration of the topic.

Authors' Note

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Supplemental Material

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Notes

1. Developed by the National Oceanic and Atmospheric Administration Air Resources Laboratory, the HYSPLIT model provides relatively accurate simulations of particle transport based on a range of atmospheric conditions and has proven its accuracy in a wide range of studies (e.g., Stein et al., 2015). For our purposes, HYSPLIT provides the best estimates of pollution transport, given the relatively limited information we have on particular plant characteristics.

2. For more on the existing literature on the public perception of air pollution, see Peng et al.'s (2019) study that provides a comprehensive summary of the existing literature.
3. For ordered/binary indicators, we respectively estimate ordered/binary probit models (presented in Tables A4 and A5 in the online appendix).
4. We classify provinces into eight regions: Northwest, Northeast, Red River Delta, North Central, South Central Coast, Central Highlands, Southeast, and Mekong River Delta.
5. This question was originally prepared as a part of survey experiments by CECODES et al. (2018). Prior to the first question, different types of information ranging from coal plant licensing to their role in greenhouse emissions and health risks were provided to the respondents. Because our study is primarily interested in examining the effects of exposure to air pollution and education on one's opposition to coal plants, we do not use the experimental component of the survey. The CECODES et al. (2018) team also plans to use the survey experiments for other purposes, and we have committed to not using this part of the survey as part of a data sharing agreement.
6. See Section A2 in the online appendix for more technical details on this procedure.
7. These observations find further support in Section A1 in the online appendix, which breaks down the distribution of pollution by population, population density, and income quintile. The distribution suggests higher levels of NO_2 in areas with higher population and population density.
8. The original income variable ranges from 1 (less than 500,000 VND) to 21 (more than 10 million VND). The original survey contains as many has 20 income categories, complicating interpretation and risking an incidental parameters problem. We thus collapse our income measure into three levels.

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