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Analysis

Valuing Air Quality Using Happiness Data: The Case of China☆

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ABSTRACT

This paper estimates the monetary value of cutting PM2.5, a dominant source of air pollution in China. By matching hedonic happiness in a nationally representative survey with daily air quality data according to the dates and counties of interviews in China, we are able to estimate the relationship between local concentration of particulate matter and individual happiness. By holding happiness constant, we calculate the tradeoff between the reduction in particulate matter and income, essentially a happiness-based measure of willingness-to-pay for mitigating air pollution. We find that people on average are willing to pay ¥258 ($42, or 1.8% of annual household per capita income) per year per person for a 1% reduction in PM2.5.

1. Introduction

Air pollution poses a substantial physical and social threat to human beings.[1] As such, government agencies are often called upon to implement environmental regulations to reduce air pollution. When introducing more stringent regulations, governments need to gauge the monetary value of better air quality so as to compare it with the cost of environmental regulations (Greenstone and Jack, 2015). However, because air quality is not a standard good for sale, evaluating its value is a great challenge.

There are three major approaches to valuing air quality: the hedonic approach (Smith and Huang, 1995; Chattopadhyay, 1999; Chay and Greenstone, 2005; Bayer et al., 2009; Yusuf and Resosudarmo, 2009), the contingent valuation method (CVM) (Alberini and Krupnick, 1998; Kwak et al., 2001; Zhai and Suzuki, 2008; Vasquez et al., 2009; Wang et al., 2010, 2013), and the happiness approach.

Each method is associated with its own advantages and disadvantages. The hedonic approach infers the value of air quality from the differences in property values across regions with varying air quality after controlling for many observable factors. The main problem with this approach is location sorting: those who are more concerned about air pollution may move into less polluted areas in the first place, rendering the locational choice endogenous and causing biased estimates on the value of air quality.

The CVM directly surveys people regarding their willingness to pay for better air quality. However, this approach is subject to strategic responses, the ways of questions being framed, and the initial hypothetical monetary value adopted to start the survey. Consequently, estimates based on CVM often yield a wide range of willingness to pay for better air quality. For example, in China, the estimates of willingness to pay for smog mitigation range from ¥428 (Wang et al., 2015) to as large as ¥1590 per year (Sun et al., 2016).

It has been well documented in the literature that happiness is positively associated with household annual income at a given time (Knight et al., 2009; Knight and Gunatilaka, 2010, 2011) but negatively affected by air pollution (Welsch, 2007; Rehdanz and Maddison, 2008;

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[1] For example, cognitive test scores (Bharadwaj et al., 2014; Ham et al., 2014; Marcotte, 2016), human capital formation (Ebenstein et al., 2016), productivity of indoor workers (Chang et al., 2014; He, Liu and Salvo 2016), mental health and subjective well-being (Zhang et al., 2015).

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MacKerron and Mourato, 2009; Luechinger, 2010; Ferreira et al., 2013). There is a tradeoff between income growth and worsening air pollution. Based on the findings in the literature, our happiness approach computes willingness to pay based on the average marginal rate of substitution between air pollution and annual income, holding happiness constant in regressions of happiness (stated well-being) on air quality. Since this approach relies on surveys evaluating peoples' stated well-being and does not directly ask about their valuations on public goods per se, strategic responses are largely avoided. In addition, this approach, often based on large representative surveys, can be used to assess heterogeneities in valuations across different subgroups. The happiness approach is not without its own weaknesses. For example, it treats stated well-being as a proxy for utility and makes interpersonal comparisons among respondents. Moreover, this approach only applies to public goods, such as air pollution, which vary across individuals in any given location and time.[2]

There is a burgeoning body of studies valuing air quality based on the happiness approach. However, most studies rely on aggregated air quality data spanning a rather long period, such as one year (Welsch, 2006; Luechinger, 2009, 2010; Menz and Welsch, 2010; Menz, 2011; Chen and Shi, 2013; Ambrey et al., 2014). Consequently, the aggregated long-term air pollution used in analyses may not reflect the actual exposure at the time of interview faced by survey subjects, resulting in measurement errors.

Moreover, the literature primarily uses life satisfaction as a measure of happiness (Welsch, 2006; MacKerron and Mourato, 2009; Luechinger, 2009, 2010; Menz and Welsch, 2010; Menz, 2011; Ferreira et al., 2013; Ambrey et al., 2014). Life satisfaction, an evaluative happiness measure, reflects one's overall assessment of life in the long term. While hedonic happiness, on the other hand, refers to moment-to-moment experienced utility and has a more direct link to immediate emotions and affections. It is necessary to test both evaluative and hedonic happiness as these two measures could yield different results (Deaton and Stone, 2013). Our paper employs hedonic happiness, which has been less studied in the literature, and links it to daily air quality data.[3]

Furthermore, most existing studies focus only on a single air pollutant. In this study, we simultaneously estimate the willingness to pay for several major air pollutants, including but not limited to particulate matter with a diameter smaller than 2.5 μm (PM2.5). Because nationwide PM2.5 monitoring data was not released in China until 2014, our study is among the first to assess the monetary value of reducing PM2.5 in China. Previous studies have shown that finer particulate matter, such as PM2.5, tends to be more detrimental to health than larger particulates, such as those with a diameter smaller than 10 μm (PM10) (Stanek et al., 2011; Cao et al., 2014; Pal et al., 2016). PM10 is usually trapped in the upper airways and can be cleared by mucociliary mechanisms. However, due to its miniature size, PM2.5 can penetrate lungs at the alveolar level, translocate directly through the alveolar capillaries into the circulatory system, and leave toxic substances in the blood, causing cumulative damage to the body (Stanek et al., 2011). Exposure to PM2.5 may affect human development in the long run (Ebenstein et al., 2016). We focus on PM2.5 because it is in high concentrations and associated with greater public awareness in China.

Air pollution is generally worse in some developing countries (Chen et al., 2013; Greenstone and Hanna, 2014; Tanaka, 2015). For example, almost half of the Chinese population is exposed to PM2.5 at a level beyond the highest hazard threshold in the United States. Recently, the choking smog has galvanized public opinion in China, calling for more stringent environment regulations (The Economist, 2015). Given that air pollution is ubiquitous in some developing countries such as Bangladesh, India and Nepal, the study on China may shed some light for other developing countries as well.[4]

We merge a nationally representative survey – the China Family Panel Studies (CFPS) – with newly released daily air quality data that contain rich information on six main pollutants and weather conditions at the time and county of each interview. The well-matched air quality measure precisely captures environmental amenities that interviewees were exposed to. A key assumption for our identification strategy is that day-to-day fluctuations of air quality in a given county have little to do with the characteristics of individual respondents. More generally, under the assumption that sorting in response to air pollution occurs more slowly than changes in happiness, high-frequency variations in air pollution over a short period of time in conjunction with local area fixed effects are literally random to survey subjects.[5]

We find that the concentration of particulate matter is negatively associated with people's hedonic happiness. People on average are willing to pay ¥539 ($88, or 3.8% of annual household per capita income) for a 1 μg/m^3 reduction in PM2.5 per year per person.[6] In other words, a one SD decline in PM2.5 raises an average person's happiness by an amount worth ¥49 ($8) per day. Our estimates are robust and consistent with comparable studies and may provide the first estimate of WTP for PM2.5 in China.

The rest of the paper is organized as follows. Section 2 describes the data. Section 3 lays out the empirical strategy. Section 4 presents our main findings, including robustness checks and heterogeneous tests. Finally, Section 5 concludes.

2. Data

For happiness measures, we rely on the China Family Panel Studies (CFPS), a nationally representative survey of Chinese communities, families, and individuals. The CFPS is funded by Peking University and carried out by the Institute of Social Science Survey of Peking University. Respondents in the third wave of the CFPS survey conducted in year 2014 were asked to report the extent to which they felt it was difficult to be cheered up in the past month, ranging from 0 (*almost every day*) to 4 (*never*). The answer to this question forms the basis for the dependent variable. The higher the number, the happier the respondents were. In addition to happiness measures, the CFPS survey collects rich information at multiple levels, allowing us to control for a wide range of covariates to be introduced in the next section. Moreover, the CFPS contains information about geographic counties and dates of interviews for all respondents, which enables us to precisely match individual happiness measures in the survey to local air quality data.

The air pollution measures come from the daily air quality report published by the Ministry of Environmental Protection of China (MEP). The report, which was not released until 2014, covers 947 monitoring stations including longitude and altitude information for each station. Six pollutants, including PM2.5, PM10, carbon monoxide (CO), nitrogen dioxide (NO_2), daily maximum ozone (O_3) and sulfur dioxide (SO_2), are used in our analysis. Figs. A1 and A2 indicate that particulate matters (PM2.5 and PM10) are highly concentrated and are dominant sources of air pollution on most days in China.

We also include rich weather data in our analysis to help isolate the impact of air pollution from other weather patterns. The weather data come from the National Climatic Data Center under the US National Oceanic and Atmospheric Administration. The dataset contains consecutive daily records of rich weather conditions from 402 monitoring stations in China, such as temperature, precipitation, wind speed, and an

[2] See an excellent discussion about advantages and disadvantages of these approaches by Levinson (2012).

[3] As noted in Zhang et al. (2015), the level of short-term air pollution is negatively associated with hedonic happiness, while it has little to do with life satisfaction.

[4] According to the 2016 Environmental Performance Index published by the Yale University, the world's top five most air polluted countries are Bangladesh, China, India, Nepal and Laos.

[5] Several studies have made such assumption in their analyses, e.g. Levinson (2012) and Currie et al. (2014) provide an excellent review of this approach.

[6] ¥539 corresponds to $87.74 using the average 2014 exchange rate 1 USD = 6.1434 CNY.