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Analysis

Subjective Well-being and Environmental Quality: The Impact of Air Pollution and Green Coverage in China

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ABSTRACT

Rapid environmental degradation is a well-publicized issue, particularly in rapidly developing countries. This study examines the impact of air pollution and green coverage on people's subjective well-being (SWB) in China using self-reported life satisfaction (LS) from survey data combined with the city-level air quality index (AQI) and green coverage data. The results show that air pollution and green coverage are significantly negatively and positively correlated with LS, respectively. The total effect of green coverage on life satisfaction constitute of a direct effect of green space itself and indirect effects through improving air pollution and health. The implicit monetary valuations of a 1-unit reduction in the AQI and a 1% increase in green coverage according to the respondent's annual gross individual income are approximately 239–280 USD (1.7%–2.0%) and 420–444 USD (3.0%–3.2%), respectively. The results also indicate that the average benefit from a 1% change in green coverage for people with a poor subjective health evaluation is almost 2 times higher than that for their counterparts.

1. Introduction

Rapid economic growth and environmental degradation are environmental challenges. In order to assess the impact of environmental issues, non-market evaluations, conventional methods, and the life satisfaction (LS) approach that are also known as experienced preference methods, have received increased attention in the environmental economics literature (Welsch, 2007; Welsch, 2009; Welsch and Ferreira, 2014), and often have been used in environmental evaluations (Frey et al., 2010; MacKerron, 2012; Welsch and Ferreira, 2014). The LS approach has been used to investigate the environmental determinants of subjective well-being (SWB), which refers to an overall evaluation of one's life and is broader than "happiness" (Helliwell and Putnam, 2012; Welsch and Kühling, 2009). Previous studies have shown that the environmental surroundings, including biodiversity (Ambrey and Fleming, 2014b), noise (van Praag and Baarsma, 2005), water pollution (Israel and Levinson, 2003), air pollution (Smyth et al., 2011), environmentally friendly goods (Welsch, 2009) and green areas (Ambrey and Fleming, 2014c) influence residents, businesses, governments, and ecosystems.

In China, environmental degradation is a crucial issue given its well-known severity. In the *Environmental Performance Index: 2016 report* published by Yale University, the air quality score for China ranked second to last (see "*Global Metrics for the Environment*" (2016)). According to the *World Bank report*, 16 of the world's 20 most polluted cities are in China (World Bank, 2006). In 2015, only 21.6% of Chinese cities met the Ambient Air Quality Standards (GB3095-2012), which is set by the Chinese Ministry of Environmental Protection (MEP). The Chinese president, Jinping Xi,[2] said that "Air quality has directly affected the Chinese people's happiness" in an official statement in 2014. The air pollutants in China diffuse across the country's border and affect neighboring countries. Hence, the air pollution in China is both a domestic and international problem.

Moreover, the demands for urban greenery to abate environmental problems have increased with an increasing awareness of various environmental problems (Cai et al., 2002; Chen and Jim, 2008a, 2008b; Jim and Chen, 2009). Introducing urban forests in China has been discussed since the 1990s; however, green coverage has only recently received attention in the public area (Li et al., 2005). China's State Council has addressed the importance of urban greening and the recent

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[2] The report is available at http://www.gov.cn/xinwen/2914-03/07/content_2632820.htm.

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plans for the world's first pollution-eating "forest city" is a part of the government's efforts to address the negative externalities of rapid urbanization (Yu and Padua, 2007).

Previous studies have extensively examined the impact of air pollution on SWB in China (Li et al., 2014; Smyth et al., 2008; Smyth et al., 2011; Zhang et al., 2017a, 2017b). However, previous researches have not examined the relationship between green coverage and SWB in China, combined with air pollution. Ambrey et al.'s (2014) recent analysis uses data from South East Queensland, Australia to examine the relationship between air pollution, green coverage and SWB. Nevertheless, the authors used the green coverage as a control variable and focused their discussion on the relationship between air pollution and SWB.

This study contributes to the literature by providing additional evidence of the impact of air pollution and urban green coverage on LS using recent Chinese data, and provides detailed assessment of the relationship between environment and SWB. The analysis examines the possible interaction between air pollution and green coverage (i.e., green coverage may partially increase LS through reducing air pollution). In addition, we also consider the interaction effect of environmental determinants and health status on respondents' LS.

We use originally collected data from a social survey that was conducted in 2016 and includes 281 major Chinese cities. To the best of our knowledge, this is the most recent SWB survey that was conducted in China with relatively complete coverage, especially at the city level. We use the air quality index (AQI) as the pollution measure (Zhang et al., 2017a, 2017b), which is calculated based on a health risk assessment that is associated with six major pollutants and is used by many countries to communicate with the public (Ferreira et al., 2013; MacKerron et al., 2009). To provide an extensive analysis on the relationships among air quality, green coverage and SWB, we also assess the interaction effects of pollution and green coverage as well as the interaction effects of both of these variables with the respondent's health condition. In addition, we provide implicit willingness-to-pay estimates for air quality and green coverage using the results from a regression analysis and compute the marginal rate of substitution of individual gross equivalised household income for air quality improvement as well as expanded green coverage.

The remainder of this paper is organized as follows. Section 2 provides background and hypotheses and Section 3 provides a description of the data. Section 4 describes the estimation model. Section 5 provides the empirical results and discussion. Section 6 presents the conclusion.

2. Background and Hypotheses

The impact of environmental degradation, e.g., air pollution, is an important policy issue and research area in the literature (MacKerron and Mourato, 2009; Ambrey et al., 2014; Cuñado and de Gracia, 2013; Li et al., 2014; Zhang et al., 2017a, 2017b). Overall, the empirical evidence indicates that air pollutants, including NO_2 and Pb (Welsch, 2006), SO_2 (Ferreira et al., 2013; Luechinger, 2010), PM_{10} (Levinson, 2012) and $PM_{2.5}$ levels (Du et al., 2018), has a significant negative impact on people's SWB. However, the magnitude of the impact varies by the specific pollutant type and the geographical region in each study.

In contrast, green coverage has relatively limited evidence for its relationship with SWB. Previous studies have found that the biodiversity increases the psychological benefits that are associated with the "green" experience (Fuller et al., 2007); more access to greenspace is associated with higher levels of life satisfaction (Ambrey and Fleming, 2012; Ambrey and Fleming, 2014c; Carrus et al., 2015; Fleming et al., 2016; Krekel et al., 2016). On the other hand, some studies have found building green areas can induce negative feelings among the users (e.g., Gobster, 1994; Henwood and Pidgeon, 2001; Nassauer, 1995; Thayer, 1989),[3] and some urban dwellers have ambivalent attitudes toward the urban green spaces (e.g., Bonnes et al., 2011; Carrus et al., 2004).

In addition to reduce the negative sensorial perception, harmful ultraviolet radiation and noise, urban forests and trees also act as excellent filters of air pollution (Nowak et al., 2014). Urban green vegetation can absorb carbon and air pollutants that originate from three primary processes: wet deposition (e.g., the transfer of pollutants by falling rain/snow), chemical reactions (e.g., gas phase reactions in the atmosphere), and dry deposition (e.g., the transfer of gaseous and particulate pollutants to several surfaces, including trees) (Rasmussen et al., 1975). Given the challenges of a central government in imposing "top down" directives to reduce air pollution or to resolve other environmental problems (Economy, 2006), individual/community efforts to increase urban greening are highlighted as an effective measure to improve air quality (Manes et al., 2014; Bottalico et al., 2016a, 2016b).

Moreover, the results of previous related studies suggest that air pollution may have a negative effect on LS through deteriorating the health (Mabahwi et al., 2014; Zhang et al., 2017a, 2017b); green space may have a positive influence on LS through health, which is a positive determinant of SWB (van den Berg et al., 2016). Also, previous studies found that the exposures to pollutants are associated with increases in mortality and hospital admissions due to respiratory and cardiovascular disease (Pope and Dockery, 2006; Brunekreef and Holgate, 2002). On the other hand, viewing nature through a window (Ulrich, 1984; Honold et al., 2014), living in environments with high share of green spaces (Maas et al., 2006) and having access to nearby green areas and parks (Cohen-Cline et al., 2015) are positively associated with the residents' health.

Based on the abovementioned previous results, this study examines four hypotheses regarding the direct, indirect and interaction effects of AQI, green coverage and subjective health status on individuals' well-being.

1. Air pollution has a negative impact on LS; green coverage has a positive impact on LS.
2. Green coverage partially increases LS through reducing air pollution.
3. Part of the effect of air pollution and green coverage on LS occurs through deteriorating and ameliorating subjective health status, respectively.
4. Poor subjective health status aggravates the effect of air pollution and enhances the effect of green coverage on LS.

3. Data and Variables

3.1. Survey

This study uses a web-based social survey that was conducted during January and February 2016 in China; the respondents were recruited by posting the survey link on several websites, and the payment amount varied depending on the expected targeted respondent for each website. We constructed the matrix of age group (20s, 30s, 40s, and over 50s) and gender that reflected the general population and continued to recruit and collect responses until each cell was complete. Internet surveys can prevent interviewer biases that are caused by arbitrary factors, such as the appearance or gender of interviewer (Welsch

[3] Henwood and Pidgeon (2001) reported that some people have 'modern' feelings and fears (such as fears of wildness, threats of darkness and ancient cultural meanings) toward trees and forests. Both Nassauer (1995) and Thayer (1989) argued that "the appearance of natural habitats transgresses American cultural norms for the neat appearance of landscapes. In this social context, natural ecosystems may be viewed as messy and untended." Additionally, through his examination of children, Gobster (1994) observed that the spatial configurations that are preferred by humans "are consistent with the visual characteristics of vegetation of poor ecological quality."