Greenery and Subjective Well-being: Assessing the Monetary Value of Greenery by Type

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ABSTRACT

This study shows the monetary value of greenery in Tokyo by type, based on the relationship between greenery types and well-being indices. We use multiple measures to measure well-being, including the Cantril ladder, life satisfaction, subjective happiness, affect balance, and mental health, as each of these measures may capture a different aspect of well-being. We utilize QuickBird satellite images with a pixel resolution of 61 cm, which have not been used in previous studies. This allows us to extract greenery data at the tree level, which is a method we expect to contribute to a more reliable evaluation of greenery. Our estimation results show that the valuations of greenery change depending on the choice of index used to measure well-being and the type of greenery.

1. Introduction

Along with economic development, there have been changes in land use, and this is resulting in forests, green space, and agricultural land giving way to residential and industrial/commercial areas in many cities.[1] Due to this reduction in green space, efforts have been made in urban planning to restore greenery around residential neighborhoods for many metropolitan areas.

The importance of efforts to restore greenery has also been substantiated in research using subjective well-being. Studies showing the relationship between question-based subjective well-being indices and the surrounding natural environment have recently emerged (e.g., Ambrey and Fleming, 2011, 2014; MacKerron and Mourato, 2013; Tsurumi and Managi, 2015). These studies use life satisfaction or subjective happiness as subjective well-being indices, and demonstrate a positive relationship between subjective well-being and greenery.

In this study, we use the following well-being indices: the General Health Questionnaire (GHQ-12) as a medical/health index, "affect balance" as a psychological index, and life satisfaction, subjective happiness, and the Cantril ladder as subjective well-being indices to measure the marginal willingness to pay (MWTP) for green spaces. The first purpose of the current study is to compare the well-being indices in terms of their relationship with greenery, which we expect to provide us with a greater

understanding of the value of greenery. In addition, we need to consider that there is a diversity of greenery in urban areas, and the impact on people may vary by type. There are many types of green spaces in urban areas, including those within residential areas, trees lining streets, greenery in industrial/commercial areas, parks and green spaces by rivers, etc., and each of these represent categories of urban planning. The second purpose of this study is to categorize urban greenery in a detailed fashion, verify it, and then evaluate the detailed categories.

The remainder of the paper is organized in the following way. Section 2 reviews prior research and the originality of this paper, Section 3 covers data and analytical methods and Section 4 contains the results of the analysis. The discussion and conclusions are found in Section 5.

2. Literature

Studies showing the relationship between subjective well-being indices and the surrounding natural environment include those by Ambrey and Fleming (2011, 2014), MacKerron and Mourato (2013), and Tsurumi and Managi (2015). Ambrey and Fleming (2011) perform a regression analysis to explore the relationship between life satisfaction and the distance from people's residences to parks in Australia. They find a positive relationship between parks and life satisfaction. Ambrey and Fleming (2014) use green coverage data obtained from

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[1] For example, as shown in Appendix A, when looking at the changes in the extent of green areas (city parks, forest areas, and agricultural land) in the Tokyo metropolitan region, even though the total land mass of city parks increased by about 16,000 ha between 1965 and 2005, farmland and forest areas decreased by about 219,000 ha. This has led to a decrease of approximately 22% in total green coverage.

geographic information systems (GIS) as an objective measure of the amount of green space. In urban areas of Australia, the authors find a positive relationship between the percentage of public greenspace within a 750 m radius of an individual's residence and their self-reported life satisfaction. MacKerron and Mourato (2013) find that, on average, subjective happiness is higher when individuals are in locations surrounded by greenery compared to urban environments. Tsurumi and Managi (2015) show that people's MWTP for green space decreases as the current amount of green space increases. Individuals' MWTP increases in proportion with their affection for green spaces, the amount of interaction they have with green spaces, their knowledge of green spaces' multiple functions, and the quality of greenery with which they normally come into contact; there are also various MWTP values for green spaces in terms of distance from respondents' houses.

We note that previous studies that investigate the relationship between subjective well-being and greenery have tended to rely on a general definition of green spaces. In this study, we assume that the value of greenery varies based on greenery type, which enables us to provide evidence-based proposals for future land use policy. The effects exerted on people by greenery in parks versus greenery in farmland, for example, are assumed to differ. It is also possible that the values of these types of greenery depend on the extent of contact that people have with each type of greenery. Thus, in this study, we seek to produce monetary valuations of various types of greenery using subjective well-being indices, which has not been attempted in previous studies.

To achieve this, detailed data on greenery are required. For example, estimating the value of roadside greenery requires street-level data on vegetation, while estimating the value of greenery on private lands requires individual premise-level data on vegetation. In short, tree-level data are required. We obtain satellite imagery data that has become available in recent years. Specifically, we use QuickBird satellite images with a pixel resolution of 61 cm. Images with this resolution allow extraction of data at the tree level. Trees are present only in some sections of land. Thus, this study compiles greenery data using high-resolution satellite imagery, which includes items that cannot be extracted from conventional data sets. Previous studies have not utilized tree-level greenery data, and, to our knowledge, no studies have estimated the monetary valuations of specific types of greenery using various indices of well-being. Although Li et al. (2015) highlight the advantages of using high-resolution land-cover data over moderate resolution NDVI data, our study uses both high-resolution land-cover data and high-resolution NDVI data. The main purpose of this study is thus to reveal more detailed and reliable values of greenery by using high-resolution satellite images. While previous studies use relatively rough green data, such as land-use maps, we use "tree-level" greenery data. By extracting greenery from satellite images with tree-level accuracy, we expect to obtain more reliable values of greenery.

3. Data and Estimation Method

3.1. Survey

We conducted an online survey between September 24, 2014 and October 6, 2014 targeting a sample of approximately 5057 individuals in the eight selected Tokyo wards. We obtain the sample by "ward level" strata for gender and age distributions, which resulted in 3124 responses.[2] We set several trap questions, which are different questions

that should obtain the same answers. To improve the quality of the data, we then excluded inconsistent responses from the sample. We finally obtained 2758 responses.[3] To minimize the respondents' burden, we used multiple-choice questions, and the average length of time taken to complete our questionnaire was 21.2 min.

3.2. Data on Subjective Well-being

The concept of cost-benefit is considered central to local policy in relation to taxes, so that monetary values of greenery are expected to be applied to policy, particularly in budgeting for land use planning. Our estimation strategy is in line with the "experienced preference method," which is discussed by Welsch and Ferreira (2014). The "experienced preference method" corresponds to the method of evaluating non-market values with several indices for well-being, which is related to "experienced utility." The concept of "experienced utility" is distinguished from conventional utility or "decision utility" (see Kahneman et al. (1997) for the detailed distinction between "experienced utility" and "decision utility.") In this study, we thus use the term "well-being" as a synonym for "utility."[4]

The relationship between people's well-being and greenery may differ depending on the well-being indices applied. Considering this difference, we include several indices related to well-being in our survey questions. The specific questions are provided in Table 1.

According to the *OECD Guidelines on Measuring Subjective Well-being*, two main types of indices measure subjective well-being. These include those related to "life evaluation," in which the individual evaluates his or her own life experience or life as a whole (e.g., degree of life satisfaction, degree of subjective happiness, and the Cantril ladder), and indices related to "affect" (affect balance), which measure an individual's feelings or psychological state at a certain point in time or during a period (OECD, 2013).[5] The latter is related to a psychological evaluation index. In addition to life evaluation and affect, several studies have incorporated mental health concepts, which are related to medical/health literature. Powdthavee and van den Berg (2011) include the GHQ-12 and degrees of life satisfaction as measures of well-being. The GHQ-12 is widely used in the medical literature as a measure of psychological stress and pain (Guthrie et al., 1998) and measures well-being, or particular effects, at a point in time. Recent studies that utilize the GHQ-12 include Clark and Oswald (2002), Pevalin and Ermisch (2004), Robinson et al. (2004), Oswald and Powdthavee (2007), and Powdthavee and Vignoles (2008).

The correlations among the well-being indices are shown in Table 2. The table implies that each index captures a different aspect of well-being.

3.3. Data on Greenery

In this study, green spaces are classified in accordance with the land classifications of the 2011 Tokyo Land Use Survey (Ward Areas). These include greenery in residential areas, roadsides, commercial areas, industrial areas, farmland, forests and wilderness, waterfronts, parks, public facilities, and railroads. Table 3 shows the details of the land-use classifications adopted in this study.

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[2] The survey was conducted as follows: first, an invitation is emailed from the internet survey company to relevant cohorts from their one million plus registered monitors in Japan. To obtain a random sample, e-mails were sent to selected monitors based on prefectural demographics, such as population, gender, and age, and basic attributes, such as income level, and education.) To avoid respondent bias, the research objectives (i.e., identifying the value of green space) were not disclosed to the research monitors before they decided to answer the questionnaire. About 62% of the individuals who were contacted completed the survey.

[3] We show the relationship between our survey sample and population in Appendix B, which demonstrates that our sample is almost the same as the population in terms of age, gender, and income.

[4] Benjamin et al. (2014) discuss various indices of well-being and show the theoretical background in terms of economic literature. D'Acci (2014) discusses various monetary evaluation methods, including studies using subjective well-being indices.

[5] There is some debate as to whether the three types of life evaluation—life satisfaction, subjective happiness, and the Cantril ladder—signify the same thing (Helliwell et al., 2012). For example, subjective happiness is easily influenced by feelings (Diener et al., 2010), and the Cantril ladder is more strongly correlated with income compared to other life evaluation indices. Meanwhile, the OECD (2013) has argued that affect should be considered a complement to the principal indices of life evaluation.