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Valuing sunshine

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ABSTRACT

Sunlight influences people's housing decisions, but city intensification may reduce sunlight exposure for neighboring properties, causing a negative externality. There are hitherto no rigorous estimates of the cost of this externality. Using over 5000 observations on house sales in Wellington, New Zealand, we derive the willingness to pay for an extra daily hour of sunlight, on average, across the year. After controlling for locational sorting and other considerations in an hedonic regression, we find that each extra daily hour of sunlight exposure is associated with a 2.6% increase in house sale price. This estimate is robust to a variety of alternative specifications in which we test for non-linearities and amplifying factors by interacting sunlight with a range of other influences. Our results can be used to price negative externalities caused by new development, so replacing or augmenting regulations designed to address impacts of development on neighbors' sunshine.

The history of architectural material … has been the endless struggle for light.[1]

1. Introduction

Humans overwhelmingly like to live and work near daylight (Aries et al., 2015). This observation implies that dwellings that are situated with good exposure to sunlight should be preferred, *ceteris paribus*, to dwellings with poor sunlight. Intensification of cities, however, may lead to urban canyons or other forms of overshadowing by neighbouring buildings, reducing sunlight for existing dwellings. Negative externalities are therefore likely to be incurred through intensification where this process reduces sunlight exposure for neighbouring sites. Planning authorities, in practice, either ignore this externality or deal with it through (often inflexible) regulatory rules that specify allowable building parameters. Economists typically prefer to use price-based instruments to deal with externalities but, to date, the urban economics literature has not found a rigorous way to price this negative externality. Indeed, in his survey of hedonic house price indices, Hill (2013) identifies sunlight as an omitted variable across all the hedonic models that he surveyed.[2]

We address this gap in knowledge, employing an hedonic framework to estimate the value that house purchasers place on each daily hour of sunlight received by a residential dwelling. We use Wellington, New Zealand, as our focus, being a city in which nearby houses exhibit considerable variation in received direct sunlight hours due to natural and man-made features. We are able to undertake this analysis by utilising modelled sunlight data for every house in the core metropolitan area of the city, where the modelling takes account of the sun's angle above the horizon, the building envelope and the natural features of the (very hilly) landscape within the city. The modelling enables us to measure the average daily sunlight received by each dwelling separately for each month of the year. We link the sunlight data to other characteristics of each house (including location, elevation and viewspan) and to the market sales price of each house.

The hedonic analysis follows standard procedures and the characteristics vector includes a standard set of variables. It is the estimates enabled by the addition of the sunlight (and also the viewspan) variable, together with the interactions of sunlight with other influences to test for non-linear effects, that provide the distinctive contribution of our paper. We find, *ceteris paribus*, that each extra hour of sunlight received per day by a house (on average through the year) leads to a 2.6% increase in house price. This estimate remains virtually constant when we test sunlight across seasons and suburb types, and interact its value with a range of influences that conceptually may augment or diminish sunlight's impact on property values.

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[1] Statement by Swiss-French architect, Le Corbusier, in 1929; cited by Aries et al. (2015), page 21.
[2] Hill's survey appeared initially as OECD Statistics Working Paper, 2011/01.

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Our estimates can be used by city authorities to value the externalities caused by a prospective new building within a city that crowds out sunlight to neighbouring sites. This value can be used as part of a price-based mechanism for developers (e.g. through payment of compensation to neighbours who lose sunlight) which may replace less flexible regulatory approaches to site coverage and building heights.[3] Our estimates may be city-specific. Nevertheless, our approach can be used to value sunlight in other cities where there is reason to believe that circumstances would yield a different valuation of sunshine than that estimated here.

In the next section we examine findings of related literature, noting that there are no directly comparable studies to ours given the lack of prior hedonic valuation of sunlight hours. Section 3 details our data, including our construction of the sunlight and viewspan variables. Section 4 outlines our estimation approach and presents our results. We present these results both across our full sample, and then testing for several potential sources of non-linearity in the effect of sunlight on house prices, which demonstrate the robustness of our estimates. Section 5 discusses implications of the findings and concludes.

2. Sunlight and real estate

Despite the cited view of Le Corbusier on the importance of sunlight for building design, we could not find any published research in the economics or property literature that rigorously estimates the value accorded to sunshine in the residential property market. There are, nevertheless, four related areas of research that are relevant to the topic, each of which provides insights as to how and why sunshine may be valued by prospective house purchasers.

First, the hedonic literature on the determinants of property values provides evidence that the availability of natural and man-made amenities can have a positive effect on property values. Attributes such as views,[4] proximity to open spaces,[5] and proximity to street trees[6] are associated with higher property values within cities. In addition, a number of papers investigate variations in prices within high-rise apartment buildings, including the degree to which prices vary by storey and outlook.[7] These studies generally find evidence of a price premium for apartments on upper storeys. It is likely that apartments on upper storeys have greater access to sunshine than those on lower storeys. However, storey and outlook also affect other outcomes, such as the quality of views and audibility of traffic noise. As a result these findings cannot be interpreted as a price premium that relates solely, if at all, to access to sunshine.[8]

Second, the urban economics literature investigates determinants of variations in property values and population growth rates between cities. Evidence from the United States indicates that a better climate, often proxied by mean annual sunshine hours or average winter temperatures, tends to be associated with higher property prices and faster population growth rates.[9] Evidence from other jurisdictions tends to show similar patterns in terms of climatic factors having positive effects on growth rates of urban areas, at least within countries.[10] An underpinning for these patterns can be traced to the observed relationship between quality of life (life satisfaction) and sunshine exhibited, for instance, through higher reported life satisfaction on sunnier survey days (Kämpfer and Mutz, 2013).

Third, several studies investigate the impact of built form on energy costs (for example, in relation to home heating and air conditioning). These studies are relevant to the relationship of sunshine and house prices since high energy costs, *ceteris paribus*, should be reflected in a lower house price. The research suggests that shade or access to sunshine may have different effects on energy costs depending upon climate. Strømann-Andersen and Sattrup (2011) model residential energy consumption in Copenhagen. They find that narrow 'urban canyons' raise modelled residential energy consumption by approximately 19% relative to areas with open horizons. By contrast, Donovan and Butry (2009) find that shading from street trees in Sacramento, California tend to lower summer cooling costs, while Kolokotroni et al. (2007) observe a "heat island" effect in intensely developed areas such as central London, which raises summer cooling costs while lowering winter heating costs. Separately, energy costs may be affected by access to rooftop photovoltaic cells to generate electricity, with the premium paid for such access reflecting sunlight exposure for the house.[11] Thus, to the extent that access to sunshine affects house prices through energy costs, the effect of sunshine hours on house prices may be context dependent.[12]

Fourth, many studies investigate the link between access to sunshine and health outcomes, especially in relation to depression and mood disorders. If a relationship between sunshine and health exists, we can again expect this to be reflected in the price paid for a house. Aries et al. (2015) identify 47 studies on the impact of sunshine on a range of human health outcomes, concluding that there is only limited evidence of a link between daylight and health outcomes. The Cochrane Database of Systematic Reviews has no reviews on the link between sunshine and health but includes two reviews[13] on the impact of bright light therapy on non-seasonal and seasonal depression. (Artificial light may act as a substitute for sunshine.) While finding some evidence to support modest benefit of light treatment for non-seasonal depression, the reviewers considered that limited data and heterogeneity of studies mean the results need to be interpreted with caution. Furthermore there were too few studies to draw a conclusion on whether light therapy is effective in treating seasonal depression.

Overall, the surveyed literature suggests a number of channels through which the benefits of increased access to sunshine for a residential dwelling may accrue: (i) increased sunshine may be treated as a natural amenity which is valued for its own sake – and this may influence location choices both within and between cities; (ii) increased sunshine may reduce energy costs, at least in some contexts; and (iii) increased sunshine may improve some aspects of health. We note here that the cited studies often measure sunshine indirectly by its converse: e.g. by examining the negative effects on dwellings that are overshadowed by tall buildings. Unlike many of these prior studies, our analysis measures hours of sunshine directly while fully incorporating the effects of the building envelope (and of natural features) on the hours of sunshine that a dwelling receives.

[3] We note that a developer in Boston USA has recently been required to pay $US3million for a new development that will block sunlight to local churches (Logan, 2017); however there is no indication that this figure was derived using any formal economic approach.

[4] See Bourassa et al. (2004), Filippova (2009), Rohani (2012), Nunns et al. (2015).

[5] See Crompton (2001), Morancho (2003), Bourassa et al. (2005) Brander and Koetse (2011), Nunns et al. (2016).

[6] See Donovan and Butry (2009), (2010), Li and Saphores (2012), Anderson and Cordell (1988), Kestens et al. (2004), Willis and Garrod (1993), Pandit et al. (2013), Macdonald and Franco (2016).

[7] Wong et al. (2011) summarize a number of prior studies on this topic. In addition, see Chau et al. (2007), Hui et al. (2012), Jim and Chen (2006), Glaeser et al. (2005).

[8] One unpublished paper using a small dataset for Auckland, New Zealand (Nunns and Denne, 2016) finds a 17% price premium for north-facing apartments (i.e. those on the sunny side of the building in the southern hemisphere) relative to other apartments, indicative of a sunshine premium.

[9] See Glaeser et al. (2001), Rappaport (2007), Partridge (2010).

[10] See, for instance, Cheshire and Magrini (2006) for Europe, Ferguson et al. (2007) for Canada, and Grimes et al. (2016) for New Zealand.

[11] Dastrup et al. (2012) show that the price premium is also affected by the socio-economic status and preferences of residents.

[12] In this respect, Wellington (the subject of our study) is more similar to the cited European cities than to Sacramento for summer temperatures but more similar to Sacramento for winter temperatures. The monthly average (of daily high) temperatures range from 12–21 (degrees Celsius) for Wellington, 2–21 for Copenhagen, 6–22 for London, and 12–34 for Sacramento.

[13] See http://www.cochrane.org/CD004050/DEPRESSN_light-treatment-for-non-seasonal-depression and http://www.cochrane.org/CD011269/DEPRESSN_light-therapy-prevention-winter-depression.