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Do high-rise buildings influence melanoma? Tall buildings as positive externalities

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ABSTRACT

Population growth, urban densification and shortage of available land make the construction of tall buildings increasingly prevalent. Given the world population growth, the volume of high-rise construction is steadily rising. Previous literature identifies skyscrapers as a potential source of negative externalities due to their high carbon footprints, and negative environmental features (reduction of sun light and wind-tunnel effects). The current study is the first to provide evidence supporting the notion that skyscrapers may also be considered a source of a positive externality. Based on data from 50 US states over a 19-year period (1999–2017), we demonstrate projected connection between the prevalence of melanoma and high-rise construction per state. This result might be attributed to the shadier environment created by these structures. Findings suggest that the annual projected increase in melanoma cases may be offset by approximately 53 additional high-rise buildings per state. Research findings may be of assistance to city planner. Potential saving associated with reduction of melanoma prevalence in terms of lost productivity and life lost should be considered. In addition, Caucasians with above 50 nevi as well as those with a personal or family history of melanoma should be encouraged to live in urban environments with tall buildings.

1. Introduction

Population growth, urban densification and shortage of available land make the construction of tall buildings increasingly prevalent. In 2008, one-half of the world's population lived in cities and the United Nation projects population growth by another 50 %, to 5 billion people, by 2030 (Glaeser, 2011). Consequently, a steady rise in the volume of tall buildings is anticipated.

Tall buildings, historically known as skyscrapers,[1] stand at the heart of the classical urban monocentric model (e.g., O'Sullivan, 2012: Chapter 7). Two interesting features of skyscrapers are the classical economic perspective, namely, the substitution of capital for expensive land - the market's response to dramatic variations in relative land prices (Mills, 1967: 197–199), and the non-economic perspective. This is manifested, for instance, in the competition among entrepreneurs, for the title of the tallest building. This competition dates back to the early 30s of the twentieth century, between financier Walter P. Chrysler and John Jakob Raskob, along with Coleman du Pont, Pierre S. du Pont and

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[1] [1]The definition of skyscrapers employed in this study is buildings above 125 m (see, MapPorn, https://www.reddit.com/r/MapPorn/comments/9c86s5/number_of_skyscrapers_in_each_us_state_oc/). Nevertheless, there is no consensus in the literature regarding the definition of skyscrapers. This definition was modified over time following the changes in construction technology (for a review see, for example, O'Sullivan, 2012: 175–176). Previously, skyscrapers were defined as buildings above 50 m, and subsequently above 100 m. As construction technology evolves, further modifications in this definition are anticipated.

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others, where the respective skyscrapers are the Chrysler vs. the Empire State Building in New York (Helsley & Strange, 2008; for a different application of the game theory approach in the context of tall buildings, see, for example Ben-Shahar et al., 2009). As Helsley and Strange demonstrate, each firm places a value on having the tallest building. Yet, instead of constructing an 80-floor building, the firm can construct a 51-story building, closer to an optimal number of 50 floors, which maximizes profit (O'Sullivan, 2012: 186–188).[2]

This example identifies a source of inefficiency in the construction of skyscrapers. Other sources of inefficiencies emanate either from positive or negative externalities (e.g., the amount of space dedicated for "non-revenue" infrastructure such as elevators). There is a debate in the literature which source of externality prevails. On the one hand, the reduction of commuting length with higher population density has the potential to make denser cities more environmentally sustainable (Borck, 2016; Gaigné et al., 2012; Glaeser & Kahn, 2010). On the other hand, residential land use, as opposed to open space such as forests and other natural vegetation areas generates elevated CO2 emissions (Borck, 2016; Seto et al., 2012).[3]Moreover, there are forces that attenuate agglomeration effects within cities following, for instance, spatial relocation of economic activity (Liu et al., 2020; Rosenthal & Strange, 2020).

The objective of this study is to investigate a new potential source of positive externality associated with high-rise construction, namely, the reduction of melanoma prevalence in US States. Given that taller buildings cast a longer shadow on pedestrians, they, in turn, may reduce the impact of sun radiation in the creation of new melanoma cases.

Indeed, melanoma has the potential to result in significant years of lost productivity and life lost. In the United States, the average lifetime risk of developing melanoma has increased from one person in 1500 in 1935 to one person in 30 in 2009 (Guy & Ekwueme, 2011). In Europe, mortality and incidence of malignant melanoma of the skin is increasing at an annual rate of between 3 % and 7 % (Østerlind, 1992). According to Gordon et al. (2022), the steady growth in the incidence of skin cancer, including melanoma in white populations around the world, imposes a large and growing burden on health systems and individuals. Avoiding harmful exposure to ultraviolet (UV) radiation, mostly solar UV, is the simplest way to reduce skin cancer risk and mortality.

The novelty of this research lies in the argument that high-rise buildings generate a positive health externality, and not a negative one, as formerly discussed in the literature. To the best of our knowledge, this possibility was not considered previously. The positive externality, and our novel research hypothesis is that high-rise buildings influence melanoma prevalence. The risk of melanoma is expected to decrease with elevated number of skyscrapers. One possible interpretation for this phenomenon is that the construction of high-rise buildings may limit exposure to the harmful UV radiation, by casting shadow on pedestrians, and may, in turn, reduce skin cancer risk and mortality.[4]

To address our research hypothesis, we use a panel dataset at the US statewide level. The panel includes the prevalence of new melanoma cases adjusted for age during the period 1999–2017. In addition, we use information on the number of skyscrapers in each US state.

The results demonstrate, on the one hand, an annual rise in the projected prevalence of melanoma adjusted for age over time, where the number of skyscrapers by state is held constant. On the other hand, a reduction in the projected melanoma prevalence adjusted for age with additional skyscrapers is indicated when time is held constant. Moreover, to offset the annual rise in projected melanoma prevalence, 53 additional skyscrapers are required per state.

The remainder of this article is organized as follows. Section 2 gives the descriptive statistics. Section 3 provides the empirical model and Section 4 – the results. Finally, Section 5 presents a summary and conclusion.

2. Descriptive statistics

The data of this study refer to prevalence of melanoma from 1999 to 2017 in 50 US States. Table 1 provides the descriptive statistics of variables subsequently incorporated in the regression model. The average number of annual new melanoma cases adjusted for age is 20.4506 cases and the standard deviation is 5.5438 per 10,000 persons. The minimum prevalence of melanoma cases is 5.5 and the maximum is 42.7 cases per 10,000 persons (AgeAdjustedRate).

Fig. 1 provides the histogram of the variable AgeAdjustedRate. Based on the Kolmogorov-Smirnov test for normality, the *p*-value for rejection of the null hypothesis is 0.03. Consequently, the null hypothesis of normal distribution is not rejected at the 1 % significance level.

Referring to skyscrapers, the average number of skyscrapers in each state is 15.4232 and the standard deviation is 42.3986. The 99 % confidence interval is 11.78–19.06. The implication is a 99 % likelihood that the average number of skyscrapers in the population of US states is above zero.

Appendix A provides the number of skyscrapers stratified by US states. While the minimum number of skyscrapers is zero (Maine, New-Hampshire, Vermont, West Virginia, Alaska, Hawaii, Mississippi, Idaho, Montana, Wyoming, North Dakota, South Dakota, Rhode Island, Arizona, New Mexico, Utah, Kansas, District of Columbia) the maximum figure is 267 skyscrapers (New York State).

3. Methodology

Consider the following random-effect empirical model:

$$AgeAdjustedRate = \beta_0 + \beta_1(Year - 1999) + \beta_2 Skyscrapers + D\overrightarrow{\delta} + \epsilon \tag{1}$$

Where *AgeAdjustedRate* is the prevalence of melanoma adjusted for age[5];

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[2] Without detracting from what is stated in the presented theoretical model, and in light of the steady technological development over the years, it should be noted that in real life: 1) Construction of buildings taller than 50 stories might achieve the maximum profit. 2) A marketing icon value associated the prestige of occupying the tallest building might be also influence profit maximization. 3) Rents and sales price per square meter generally rise with the floor, due to a better landscape view without the concealment of other buildings and other reasons. This outcome is obtained despite the rise in the cost per square meter with higher floor. 4) The objective of a theoretical model is to isolate and focus on one effect. In real life, each floor has different attributes, that affect price.

[3] It should be noted in this context that examining the differences between high and low population densities particularly in developed cities, might prove to be important. Nevertheless, the conventional approach in the literature is that the construction of tall buildings promotes higher population densities.

[4] 4As demonstrated in previous literature, the negative externalities discussed are: The enjoyment of people from access to sunnier offices with more natural light (This is the logic behind construction of glass-facade skyscrapers). Unlit, dark streets can be a "breeding ground" for crime and may, more broadly, diminish the quality of urban life. Reduced sunlight also is known to hinder vegetative growth and can block light on rooftops that might otherwise be useful for solar panels (Barr, 2016)).

[5] Note that this variable controls the age of the population in the state. Consequently, this provides an additional implicit confounder to the empirical model.

Table 1

Descriptive statistics.

Variables	Description	Obs.	Mean	Std.	Min	Max
AgeAdjustedRate	Prevalence of Melanoma Adjusted for Age.	905	20.4506	5.5438	5.5	42.7
Skyscrapers	Number of Skyscrapers by State	905	15.4232	42.3986	0	267

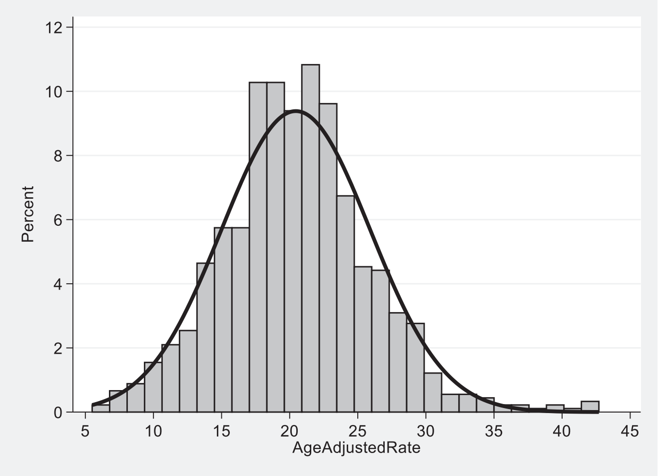

Fig. 1. Histogram of Melanoma prevalence adjusted for age
Note: According to the Kolmogorov-Smirnov test for normal distribution, the p-value for rejection of the null hypothesis is 0.03.

Year is the year in which the measure took place ($Year = 1999, 2000, \cdots, 2020$)[6]; *Skyscrapers* is the number of skyscrapers in each state; β_0, β_1, β_2 are parameters; D is a matrix of dummy variables, where each column vector receives 1 for the state and zero otherwise; $\overrightarrow{\delta}$ is the corresponding column vector of parameters; and ϵ is the classical random disturbance term.

Table 2

Regression analysis.

	(1)	(2)
Variables	AgeAdjustedRate	AgeAdjustedRate
Constant	16.60***	16.60***
	(<0.01)	(<0.01)
(Year-1999)	0.438***	0.438***
	(<0.01)	(<0.01)
Skyscrapers	−0.00822***	−0.00822**
	(0.0014)	(0.0324)
Observations	905	905
Number of Year	19	19
$-\frac{b[Year-1999]}{b[Skyscrapers]}$	53.35	53.35
	[19.83, 86.86]	[3.93, 102.76]

Notes: Based on the random effect regression. Robust p-values are given in parentheses in column (1). P-values are given in parentheses in column (2). 95 % confidence intervals are given in square brackets.
** $p < 0.05$.
*** $p < 0.01$.

4. Results

Table 2 reports the regression outcomes, where column (1) gives the robust p-values and column (2) the p-values of non-robust standard errors. The outcomes reveal a steady rise in the projected prevalence of melanoma with time. While the baseline is 16.60 new melanoma cases per 10,000 persons in 1999, in the absence of skyscrapers, the model predicts $16.60 + 0.438 \times 20 = 25.36$ new melanoma cases per 10,000 persons until 2020, a $\frac{25.36}{16.6} - 1 = 52.27\%$ rise within 20 years.

Yet, this rise is offset in the presence of additional skyscrapers. The calculation at the bottom of Table 2 reveals that 53 additional skyscrapers have the potential to offset the annual rise in the projected prevalence of melanoma cases adjusted for age. The 95 % confidence interval is 20–87 additional skyscrapers. These outcomes demonstrate the positive externalities associated with tall buildings with regard to the prevalence of melanoma.

Fig. 2 provides further evidence based on the regression outcomes. A shift from states without skyscrapers to those with 165 skyscrapers reduces the projected number of new melanoma cases by 7.076 % – from

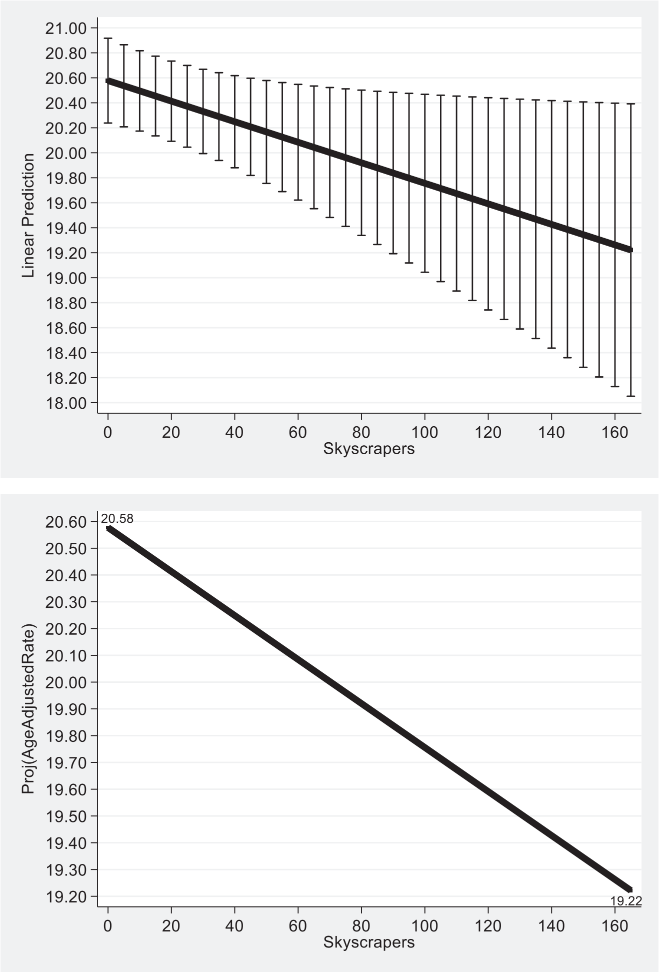

Fig. 2. Projected prevalence of Melanoma vs. number of Skyscrapers
Note: Based on the regression analysis in Column (1) of Table 2. The upper (lower) figure includes (excludes) 95 % confidence intervals.

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[6] It may be readily verified that the transformation ($Year - 1999$) makes the constant term the baseline projected new melanoma cases adjusted for age at states without skyscrapers in 1999. For a formal derivation of this outcome, see, for example, Ramanathan, 2002: 147–148.

20.58 to 19.22 new cases per 10,000 persons adjusted for age.

5. Summary and conclusions

Externalities are directly associated with urban economics. There is a consensus that pollution discharges to air and water result in resource misallocation (Mills and Hamilton, 1994: 169). Congestion externality is an additional source of inefficiency, which is closely related to urban sprawl and suburbanization. Compared to other urban areas (cities) in the world with similar education and income levels, U.S. urban areas are substantially less densely populated (Nivola, 1998; O'Sullivan, 2012: 181). According to the Texas Transportation Institute, the typical 2003 waste in traffic congestion is about 47 h (O'Sullivan, 2012: 260). A similar example of external diseconomy is related to the labor market. The outcome of the decision to hire another worker is associated with more traffic in urban areas, which, in turn, increases the travel time of truck drivers (McDonald & McMillen, 2011: 51–52).

An interesting negative externality of urban sprawl emanates from health risk factors, such as obesity (Arbel et al., 2020; Ewing et al., 2014; Zhao & Kaestner, 2010). The objective of the current study is to reveal a new source of positive externality associated with densely populated regions and tall buildings, namely, the reduction of melanoma prevalence in US states. Given that taller buildings cast a longer shadow on pedestrians, they, in turn, may reduce the impact of sun radiation on the creation of new melanoma cases.

The outcomes demonstrate, on the one hand, a reduction in the projected melanoma prevalence adjusted for age with additional skyscrapers when time is held constant. On the other hand, results exhibit an annual rise in the projected prevalence of melanoma adjusted for age with time, where the number of skyscrapers in the state is held constant. One could argue that this is the outcome of the world climatic crisis in recent years (United Nation). Finally, 53 additional skyscrapers have the potential to offset the annual rise in projected melanoma prevalence over time.

Public policy repercussions of our study are threefold. First, city and public policy planners should consider the potential saving associated with reduction of melanoma prevalence in terms of lost productivity and life lost (Guy & Ekwueme, 2011). Second, at the personal level, people who are more susceptible genetically to sun radiation and more inclined to develop melanoma (e.g., white populations with above 50 nevi; and those with a personal or family history of melanoma), should be motivated to live in urban environments with tall buildings. Finally, tax benefits associated with neighborhoods with high-rise buildings should be considered to susceptible populations.

An open question for future research is the potential reduction of melanoma prevalence in light of the proximity, type, and design of skyscrapers. This question is beyond the scope of the current study. One limitation of this article emanates from the fact that high-rise construction is not dichotomous but rather continuous. The analysis in this article focuses on buildings above a certain height but ignores those below this threshold. Buildings that are 40 m high may cast almost as large a shadow on pedestrians, but this effect was not examined in the current research.

In sum, City and public policy planners should also account for health considerations (melanoma), including:

1) Formation of national planning teams and outlining urban policy for reduction of melanoma morbidity and mortality.
2) Neighborhood design that accounts for melanoma prevalence (e.g., circumferential ring of high-rise buildings).
3) Architectural design of structures (e.g., height and size) that reduces the prevalence of melanoma.
4) Formation and publication of standardized international urban index that considers melanoma prevalence. The index reflects the risk associated with melanoma prevalence at a city level.
5) Allowing city and urban planners the use of accepted urban design tools (e.g., air rights), so as to reduce the prospects of melanoma morbidity in that city.

While recommendations 2, 3 and 5 stress the local perspective, recommendations 1 and 4 emphasize the international aspect.

Ethics approval and consent to participate

This research does not require an IRB approval since it does not involve any experiment or manipulation of subjects. All authors read and approved the final manuscript for submission.

Consent for publication

All authors agreed to submit to Cities.

Availability of data and materials

After acceptance of the manuscript, full Information and replication instructions in Stata software package will be given upon request.

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CRediT authorship contribution statement

Yuval Arbel: Study conception and design, data collection and analysis, the first draft and comments on previous versions of the manuscript.

Yifat Arbel: Study conception and design, data collection and analysis, the first draft and comments on previous versions of the manuscript.

Amichai Kerner: Study conception and design, data collection and analysis, the first draft and comments on previous versions of the manuscript.

Miryam Kerner: Study conception and design, data collection and analysis, the first draft and comments on previous versions of the manuscript.

Declaration of competing interest

None of the authors have potential conflicts of interest, financially or non-financially, directly, or indirectly related to this work.

Data availability

Data will be made available on request.

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Appendix A. Number of Skyscrapers per State

No.	State	Number of Skyscrapers
(1)	Maine	0
(2)	New Hampshire	0
(3)	Vermont	0
(4)	Massachusetts	18
(5)	New York	267
(6)	Pennsylvania	23
(7)	New Jersey	11
(8)	Connecticut	3
(9)	Virginia	1
(10)	West Virginia	0
(11)	Kentucky	2
(12)	Maryland	3
(13)	Ohio	11
(14)	Michigan	7
(15)	California	49
(16)	Nevada	17
(17)	Washington	18
(18)	Oregon	4
(19)	Texas	64
(20)	Florida	61
(21)	Louisiana	4
(22)	Illinois	114
(23)	Alaska	0
(24)	Hawaii	0
(25)	Mississippi	0
(26)	Alabama	2
(27)	Georgia	18
(28)	Tennessee	2
(29)	Kentucky	2
(30)	Idaho	0
(31)	Montana	0
(32)	Wyoming	0
(33)	North Dakota	0
(34)	South Dakota	0
(35)	Minnesota	8
(36)	Iowa	1
(37)	Wisconsin	3
(38)	Missouri	6
(39)	Arkansas	1
(40)	Rhode Island	0
(41)	Arizona	0
(42)	New Mexico	0
(43)	Colorado	8
(44)	Utah	0
(45)	New Mexico	0
(46)	Oklahoma	6
(47)	Kansas	0
(48)	Nebraska	1
(49)	Indiana	3
(50)	District of Columbia	0

Source: MapPorn, available at: https://www.reddit.com/r/MapPorn/comments/9c86s5/number_of_skyscrapers_in_each_us_state_oc/ (Last accessed on August 26, 2022).

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