The Value of Vertical Status: Evidence from the Real Estate Market

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Abstract

Economists typically assume an individual utility as a function of own consumption. Yet, the pursuit of status, as defined as one's own standing relative to others in a relevant preference group, appears to be nearly as fundamental an aspect of human behavior. With conspicuous consumption, it is insufficient to own or consume a product, but rather that the consumption is visible to others. Drawing from linguistics and psychology literature, in this paper, we examine vertical status as it manifests one's apartment height relative to the height of others in the same building. We explore the value of status based on the price of apartment units in mid and high-rise condominium structures, controlling among others, for actual height and view. Based on extensive data from Vancouver (Canada), we find that there is a significant price premium for being higher up *compared to others* in the building. Specifically, *ceteris paribus*, moving from the bottom to the top floor of a building generates an average status premium of about 8 percent of the average transaction price. Further, the marginal value of status increases as one climbs to higher floors, especially in taller buildings. Results are robust to a series of model and sample specifications.

1 Introduction

Status is accepted as a fundamental characteristic and metric of hierarchy and power within organizations and societies (Weber 1922). For Polanyi 1944, economics does not exist separate from the social forms that acknowledge status. Within economics, status has long been recognized as a motivating factor for consumer and producer actions (see Smith 1759 and Marshall 1890). Analysis of status as an ingredient of the utility function is perhaps most associated with Veblen 1899 and Duensberry 1949. However, status itself is multi-facted. Heffetz and Frank 2010 present three main aspects of status: ”positionality”, position (or rank) in relation to others; “desirability”, the resources that status brings along; and “non-tradability and visibility”, that status is granted by society, cannot be directly purchased, and it is attained by visible consequences.

Verticality is an expression of status in both absolute and relative sense. In their seminal work on metaphors in language and the mind, Lakoff and Johnson 1980 show that the use of metaphors that utilize the vertical dimension ties “up” and “down” to positive and negative associations, respectively.[1] But positionality or relative position also matters. In Dr. Suess’s Yertle the Turtle (Geisel 1950) the imperative for Yertle is not how high he is per se, but that he is higher than all he can see. He is furious that the moon “dares to be higher than Yertle the King.” In this paper we address positionality in the vertical dimension of status using a novel framework—one’s relative (compared to others) vertical location in a condominium building. By exploiting the variation in condominium apartment transaction prices attributable to relative vertical (i.e., by height) differentiation within a given building, we estimate the shadow price of relative status as expressed in this vertical up-down paradigm.

The analysis of the marginal price of relative status here uses a data set with more than 55,000 transactions in nearly 320 condominium towers in the Vancouver (Canada) downtown peninsula over the period 1992–2016. These occur in a fairly small geographic area

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[1] Among the examples in Lakoff and Johnson 1980 are “control” is up, whereas “lack of control” is down, as in “I am on top of the situation” versus “he is under my control; “virtue” is up and “lack of virtue” is down, e.g. “she is an upstanding citizen” versus “that was a low-down thing to do”; and “happy” is up whereas “sad” is down – e.g., “I am feeling up” versus “He is low these days”.

– about 2.1 by 3.1 kilometers – because of the density of high-rise residential development in Vancouver's core. We estimate the status that is associated with the vertical position (height) of each condominium unit relative to its reference group – other unit's in the same building – by observing the unit's floor level relative to the total number of stories in its building. We assess the value of status controlling for a series of factors such as unit's physical characteristics, actual floor in the building, view, and building and temporal fixed-effects. By employing GIS, we derive and control for continuous measures of view—quantified by total airspace (hyperplane), uninterrupted by other buildings, out to a fixed distance at the unit's height in each compass quadrant.

We find a significant value for relative status in the price of housing. *Ceteris paribus*, the average price difference between the top and bottom floors of a building that is attributed to the status measure is about 8% of a unit's price (equal to 92,900 CAD or 78,700 USD – deflated to July 2018 values) controlling for unit characteristics (including actual floor and view) and building fixed-effects. Put differently, the price of an $i - th$ floor unit in a N-storey building is on average about a 3.5% (46,000 CAD or 39,300 USD) higher than a unit in a $2N$-storey building. This difference reflects the status that corresponds to the vertical positioning relative to others in the building. Moreover, we find evidence that, on average, people weight more heavily the disutility from having people positioned above them than the utility from having people below them. This pattern is accentuated among those occupying higher floors and more so in taller buildings. Finally the marginal value of status rises convexly in the building; that is, the disadvantage associated with being behind the Joneses net of the advantage of being ahead of them is greater for those occupying relatively higher floors.

Our study contributes to the literature in several ways. First, unlike previous empirical studies of status, our assessment of the utility from status is not built on survey-based measures of subjective happiness or well-being related to income and job satisfaction. Instead we use market measures-the market transaction price that is associated with the relative vertical position (floor) of the housing unit in the building. Second, following studies in linguistics and psychology Lakoff and Johnson 1980; Schubert 2005, and Dorfman, Ben-Shahar, and Heller 2018; we believe that our work is the first that rigorously estimates and quantifies status in the context of relative vertical position. As we discuss more fully in Section 2, Nase, van Assendelft, and Remoy 2019 and Nase and Barr 2022 include a status measure based on relative positioning, but their treatment of relative status is more cursory as their primary estimation focus lies elsewhere. Further, they do not find a statistically different than zero effect of relative status. Finally, Boyce, Brown, and Moore 2010 present evidence that people weight upward social comparison (i.e., comparing their own income to those with higher income) more than they care about the downward comparison. Our findings extend this insight beyond the income-related regime, generalizing this phenomenon as a more primal feature of human perception and behavior. Specifically, we find that on the physical vertical axis, people place greater (smaller) weight on the negative (positive) effect of being below (above) others and that this pattern amplifies among those locating higher up.

The paper follows the standard format. In Section 2 we review the relevant literature of relative status and the work on vertical features of buildings (the vertical rent/price gradient premia for height and views). We present our methodology for measuring relative status and the estimating equation in Section3. The data are described in Section 4. We present our results in Section4 and then conclude with a summary. The appenidx provides detail on data construction (Appendix A), distribution of the measures of relative status (Appendix), estimates of the vertical gradient. i.e. the price-vertical height function (Appendix C), and a detailed description of our methodology for constructing the view measures (Appendix D).

2 Literature Review

2.1 Status Literature

There is an extensive literature across multiple social science fields that explores the role of status as a factor in individual well-being. Within economics, in addition to seminal analysis by Veblen 1899 and Duensberry 1949, theoretical work that addresses social comparison and status in utility functions includes citeBecker1974, Gilboa and Schmeidler 2001, Samuelson 2004, Rayo and Bcker 2007, and Rablen 2008. Heffetz and Frank 2010 survey the extant empirical and experimental work on the preference for status. Rather than a general empirical analysis of status broadly defined as in these works, we study an aspect of status that lends itself to our data: positionality or relative status, a factor that is highlighted by Weiss and Fershtman 1998 in their integration of economic and sociology approaches to status.

Easterlin 1995 has established that relative income - in addition to the absolute level of income - is fundamental in the indirect utility function, showing that while income is associated with happiness, increasing everyone's income has no significant effect on happiness. Much of the work, however, that measure what is referred to as positionality, relative positioning, or relative status (and we will use the latter here) is either experimental or uses income ordering within a workplace as the indicator of position and associates it with measures of well-being. For example, Brown et al. 2008 find that satisfaction and well-being depend on individual wage ordinal rank within the comparison group; Boyce, Brown, and Moore 2010 present evidence that rank-income overpowers both reference-income and absolute income in predicting life satisfaction; and Blanchflower and Oswald 2004 and Groot and Van den Brink 1999 find that happiness and satisfaction from wage income is associated with relative rather than absolute wages.[2] While these studies indicate the imperative effect of status on individual utility, income alone may ignore other factors that determine job satisfaction (and are likely correlated with current income and wage structure) such as future income growth, non-wage benefits, work environment, and professional opportunities.

Bursztyn et al. 2018 use a quasi-field experiment to document the preference for status, separating it from other features that increase utility and are normally correlated with status.[3] Employing a credit card market setting in Indonesia they show that adding the premium label to the credit card almost doubles its uptake, as compared to the control card, despite no change in fees or benefits. They also find that holders of the "status" premium card are more likely to use the card in social situations, where it serves as a status signaling mechanism. Correspondingly, in our framework, locating in a unit on a higher floor of the building generates this representation of the status effect as it is visible by the reference

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[2] Other work that highlights relative income includes the Clark and Oswald 1996 finding that reported job satisfaction is negatively correlated with comparison earnings levels and Luttmer 2005 who demonstrates that self-reported happiness is negatively associated with neighbors' earnings.

[3] E.g., a Lamborghini, while generating high status, is also fast, handles well, an offers an excellent sound system.

groups (e.g., other tenants in the building and those visiting the unit's owner). Unlike their work, our analysis, not only explores the status effect in a setting that associates it to the vertical axis of the built environment, but also explicitly prices its value.

Our use of building height and residential properties as a mechanism to express status is not unique. In psychology, based on a series of behavioral experiments, Dorfman, Ben-Shahar, and Heller 2018 find a bi-directional causality between a subject's social power and her/his presumed apartment's floor in a fictional building.[4] In urban economics, by modelling the evolution of high-rises in a game-theoretic setting, Helsley and Strange 2008 model developers who compete to construct the tallest building. Their model finds support in empirical evidence in Barr 2012 height competition among developers in New York City and Ahlerldt and McMillen 2018 analysis of land values and development in Chicago.

Our measure for vertical status focuses on the relationship between floor i and the number of stories in the building, which can be immediately expressed – under certain assumptions – by the ratio of the two. Two previous studies examine floor level effect on real estate prices and use this measure as a control variable in their analysis. Specifically, Nase, van Assendelft, and Remoy 2019 examine commercial real estate leases, finding a statistically insignificant effect of status on the price of commercial leases (rent). Similarly, Nase and Barr 2022 study the effect of height in residential towers in New York and Rotterdam, controlling for a relative status measure. They also find a statistically insignificant status-price effect. Importantly, however, both studies are based are a fairly small sample size.[5]

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[4] Also the context of housing, Tower-Richardi et al. 2014 show that people associate a subject's social status with living in a higher residential location (hilltop) and Meier et al. 2011 find that people associate a northern (associated with "up") versus southern (associated with "down") residential location with high versus low socioeconomic status individuals, respectively. ellet 2019 find that new construction at the top of the house size distribution lowers the satisfaction that neighbors derive from their own house size.

[5] In Nase, van Assendelft, and Remoy 2019, the sample size includes 627 transactions in 33 buildings widely distributed in Amsterdam (and controls are limited, especially given the heterogeneity in the unobserved components of their commercial lease data and the lack of information on whether tenants occupy multiple floors. In Nase and Barr 2022, the sample includes 1,271 transactions over 20 years in 200 residential towers in Rotterdam, and 2,095 transaction over 9 years in 28 high-rise residential buildings in Manhattan; i.e., about 3 and 8 transactions per building per year, respectively. This small sample if particularly meaningful in the presence of building and time fixed-effects in the empirical model.

2.2 Building Height and View Literature

In estimating the vertical status effect, we control, among other things, for height and view. While these variables are not the primary focus of our work, to accurately measure the effect of relative vertical status on price we must adequately control for these characteristics of the housing unit. Consequently, our paper also contributes to these literatures. Assessing agglomeration effects through estimating a vertical rent gradient in commercial space, Liu, Rosenthal, and Strange 2018 identify a convex vertical commercial rent gradient of approximately 0.13% per floor below the 30th floor that increases to over 1% above the 60th floor. As they do not control for view, this estimate is arguably a mix of height and view effects. The previously noted Nase, van Assendelft, and Remoy 2019 paper decomposes this type of general height premium into height, firm, industry, and view effects and generates a vertical gradient that is also convex but slightly smaller in magnitude compared to that of Liu, Rosenthal, and Strange 2018.

For residential properties the positive height-price correlation is well documented. For example, for rents, Danton and Himbert 2018 find a substantial ground floor premium and that rents increase by 1-2% per floor, controlling for unit characteristic but not for view. Including a control for view, Nase and Barr 2022 find lower linear price gradients: 0.75% and 0.33% per floor in Manhattan and Rotterdam, respectively. Finally, pricing views has long been part of the real estate literature—e.g., see Bourassa, Hoesli, and Sun 2004 for a review of empirical estimates of the value of view. The papers cited by Bourassa, Hoesli, and Sun 2004 mostly use a dummy variable to indicate the presence of a view, so the range in reported point estimates reflects variation in both quality and quantity. More developed measures of view such as those in Hamilton and Morgan 2010, Nase, van Assendelft, and Remoy 2019, Dai, Felsenstein, and Grinberger 2021 (whom we follow), and Nase and Barr 2022 use GIS software and developed databases of topographic features and urban forms to generate continuous measures of views from individual buildings. Among these papers Nase and Barr 2022 stands out as they have data that allows for testing floor to floor variation in units that face the same direction with identical layouts, offering the best controls of estimates of view values and vertical gradients.

3 Methodology

Following works by Brown et al. 2008 and Boyce, Brown, and Moore 2010 on income-related utility from rank position, we express relative status (RS) from locating on floor i in an N-story building by:

$$RS_{iN} = 0.5 + \frac{(i-1) - \eta(N-i)}{2[(i-1) + \eta(N-i)]} \tag{1}$$

where the first and second terms in the numerator of the ratio on the right-hand side of (1) are, respectively, the number of floors below i, $(i-1)$, and the number of floors above i, $(N-i)$, multiplied by the parameter η, where $0 \leq \eta < \infty$. The parameter η captures the degree of upward comparison, i.e., the extent to which the measure of relative status is driven by those who are above (and below) i. The greater (smaller) η is, the more one is concerned by the disutility (utility) generated by the those above (below) her.

We simplify (1) to:

$$RS_{iN} = \frac{(i-1)}{(i-1) + \eta(N-i)} \tag{2}$$

Note from (2) that when $\eta > 1$, one's status is more heavily driven by the disutility from others being higher than her than the utility of being above others. For example, $\eta = 2$ implies that people weight the disutility generated by those locating above two times more than the utility from those locating below. Instead, when $\eta = 0.5$ implies that status is twice more heavily determined by the utility from being higher than others as compared to disutility from being below others. When $\eta = 1$, the same weight is put on those locating above compared to those below. Note that when η approaches 0 then RS becomes a dichotomous variable that approaches a value of 0 for units on the bottom floor and approaches 1 for all units above them, i.e. all that one considers is that there are units below her. Similarly, when η approaches ∞, RS becomes a dichotomous variable that approaches a value of 1 for top-floor units and approaches 0 for all units below them, i.e. all that one concerns is that there are units above her. Also, note that when $\eta = 1$, equation (2) reduces to

$$RS_{iN} = \frac{(i-1)}{(N-1)} \approx \frac{i}{N} \tag{3}$$

We begin our empirical investigation of relative status with the base characterization in which $\eta = 1$, as in (3). We then allow η to vary in order to examine whether relative status is driven differently by the disutility of others being higher (i.e., $\eta > 1$) and the utility of being higher than others (i.e., $\eta < 1$).

Formally, consider a standard semi-log hedonic specification for the log transaction price per square foot, lnP, of condominium apartment unit j on floor i in building m sold at time period (month-year) t:

$$lnP_{jimt} = \beta_0 + \beta_1 X_j + \beta_2 RS_{im} + \beta_3 F_i + \beta_4 Z_m + \beta_5 V_{ijmt} + \beta_6 Y_t + \epsilon_{imt} \tag{4}$$

The right-hand side of (4.1) includes a unit and time controls comprise of X_j, a vector of unit characteristics, including floor area, year built, number of bedrooms, number of bathrooms, and a dummy for whether the unit has been renovated; F_i, a set of building floor fixed-effects for height;Z_m, building fixed-effects; V_{ijmt}, location and time specific view measure; and Y_t, month-year time fixed-effects. Also, β_0, β_2, and β_5 are standrad coefficients, while β_1, β_3, β_4, and β_6 are vectors of coefficients and ϵ_{jmt} is a random disturbance term. In estimating (4.1) our primary parameter of interest is the coefficient on relative status β_2. The coefficients for height (vertical gradient) and view (β_3 and β_4, respectively) are also of interest as they relate to the existing literature, however, their roles here are as controls in a clean estimation of the value of relative status (β_2), rather then to specifically identify the magnitude of the capitalized consumption benefit from height in a building (estimated in the vector X) or of views (estimated in the vector Y).

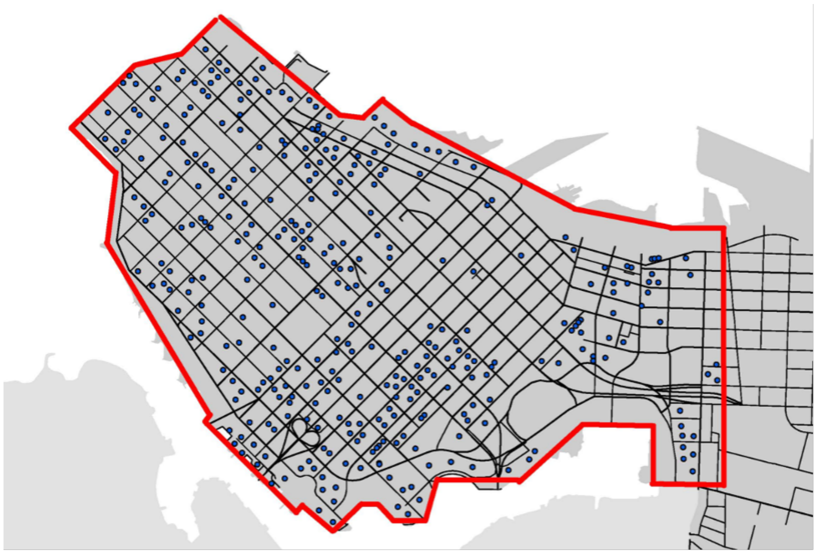

Figure 1: **Building Locations**

4 Data

Our data includes that universe of condominium apartment transactions that occurred in downtown Vancouver, British Columbia over the period 1992–2016 – a total of 76k observations. Vancouver provides a natural framework for our analysis as it has a relatively small share of single-family detached housing units while populating a large percentage of units in buildings over five stories.[6] While multi-family rental and condominium buildings are present in many different areas of the city, they are especially concentrated in the downtown peninsula. Figure 1 shows the location of the 318 condominium buildings in our dataset within the approximately 2x3 km downtown peninsula.

Our transaction information and building and unit characteristics data are drawn from BC Assessment, the Province's assessment authority, and the City of Vancouver building databases.[7] The unit data come with a standard set of hedonic characteristics, including

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[6] According to the 2021 Canadian census, 14.5% and 29.3% of households in the City of Vancouver respectively live in single detached housing and buildings of 5 stories or more (as opposed to 29.4% and 16.7% of households, respectively, in the Vancouver Census Metropolitan Area). In comparison, according to the 2019 American Housing Survey, in the New York-Newark-Jersey City MSA the share of households in single family units was 40.9% and the share of units in buildings of 4 or more stories was 33.7%.

[7] See the City of Vancouver's open data site `https://opendata.vancouver.ca/pages/home/`, where we

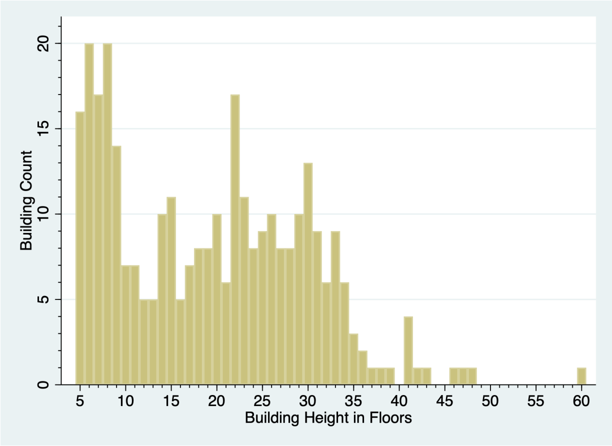

Figure 2: **Building Count by Building Height**

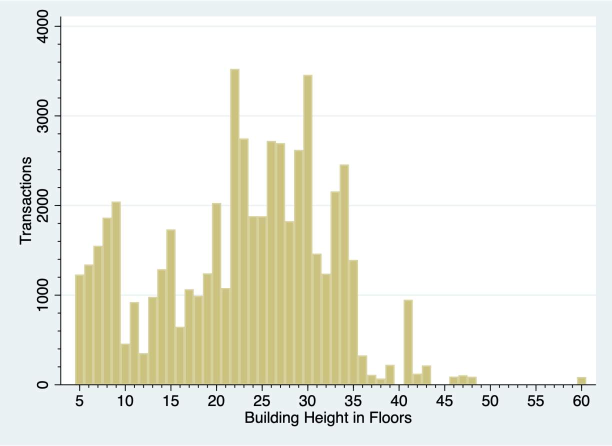

Figure 3: **Transactions by Building Height**

floor area, year built, number of bedrooms, number of bathrooms, and year of any renovation. Our final dataset includes 55,274 observations across 318 residential buildings, all of which are five floors or higher. Appendix A includes an accounting of the derivation of our sample from the universe of sales.[8].

Figures 2 and 3 show the distribution of the data by building height. As shown, there is considerable representation by building height across the distribution through buildings with 35 stories in height, both in individual buildings and by transactions. In contrast, above 37 floors, with one exception, the sample gets sparse in ways that introduce considerable noise into estimates of a vertical gradient. However, are primary results are robust to dropping buildings above 35 floors or above 45 floors.

In order to estimate the effect of relative status in our hedonic specification, we control for building height and amenities (building fixed-effects) and apartment unit characteristics, including floor (floor fixed-effects) and view. Following Dai, Felsenstein, and Grinberger 2021, we use geographical information software (GIS) to derive a continuous measure of view based on the total area of a plane of unobstructed lines of sight up to one kilometer, which

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use the property tax report and GIS building footprint and parcel map data sets.

[8] Nearly all of the reduction in the count from the universe is from units in buildings with four or fewer floors, dropping pre-sales, transactions that are flagged as not suitable for data analysis by BC Assessment

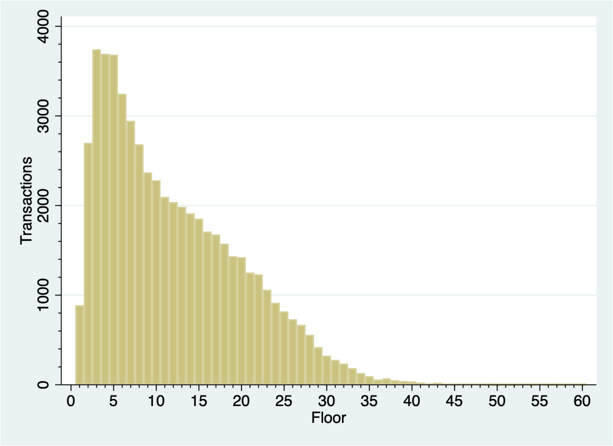

Figure 4: **Transactions by Floor**

we describe more fully in Appendix (Appendix D).[9] The view measure is floor-building-year-compass quadrant specific. As a floor variable, all units on a floor receive the same values, hence we refer to this measure as an "average floor view". Assuming all units on a floor have an equal probability of selling, then estimated coefficients for the values of these views will be unbiased estimates of the mean individual unit view effect on a given floor. The distribution of view values are shown below in Figure 5. Most units have a very limited view; namely, they face an adjacent building. Given our lack of priors on the shape of the view valuation function, we treat view non-linearly, converting the view values in each direction into deciles for each quadrant (four quadrants by nine dummies per quadrant). For robustness we also estimate unit specific views and report results for both the average floor and estimated individual unit view measures in our base set of regressions in Table 2. In Appendix D we present a full description of our methodology for estimating the unit specific views for each condominium unit in our sample from the floor average values.

Table 1 presents descriptive statistics of the regression variables. As indicated in the table, the typical housing unit is a 1- to 2-bathroom, 882-square-foot condominium apartment located in an 8-year-old structure. For convenience, we show price variables in nominal

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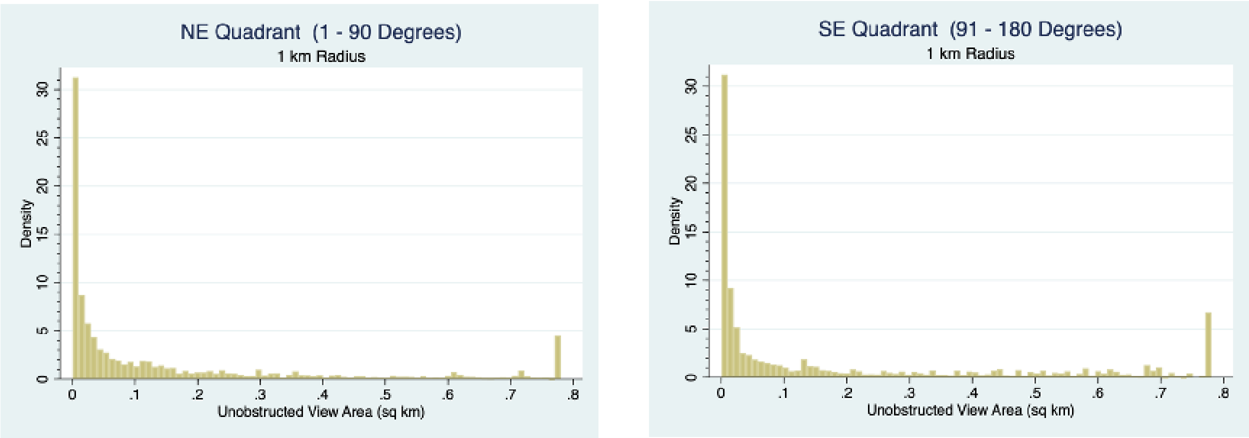
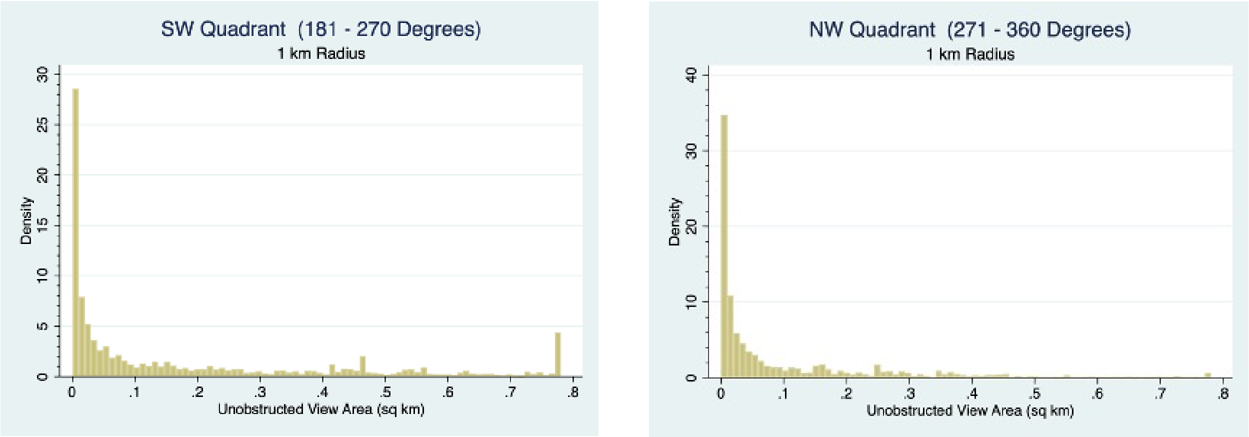
[9] We report view measures with a 1 km radius, but our results are robust to using a 5 km view radius measure). See, Yu, Han, and Chai 2007 and Baranzini and Schaerer 2011 for comprehensive descriptions of the GIS technique and its use of modelling of the existing urban building massings.



((a)) NE Quadrant ((b)) SE Quadrant



((c)) SW Quadrant ((d)) NW Quadrant

Figure 5: Distribution of View Values by Quadrant

terms as well as indexed to July 2018 Vancouver CMA condo prices—both total price and per sqft.[10] Notably, the mean indexed price is \$C 1.15M (where in July 2018 \$C 1.00 = \$US 0.76) with standard deviation equal to about \$C 902K reflecting the high cost of real estate in Vancouver. We show relative status for $\eta = 1$, our starting parameter value, as calculated using equation (2).

			(1)		
	count	mean	sd	min	max
Transaction price	55274	434947	432351.4	65000	1.50e+07
price per sq ft	55274	468.177	249.8523	93.56538	13691.64
ln sales price per sq ft	55274	6.024822	.495412	4.538661	9.524541
Real price - condo price index 7/18=100	55274	1146964	880629.1	304142	2.75e+07
Real price per sf - condo price index 7/18=100	55274	1243.514	349.9701	339.18	27653
Floor area	55274	.8795179	.3890218	.305	4.469
Floor area - sq	55274	.9248869	1.030679	.093025	19.97196
Floor area - cube	55274	1.191898	2.835128	.0283726	89.25468
Floor area - fourth	55274	1.917697	9.156341	.0086537	398.8792
# of Bedrooms	55274	1.548667	.7564196	0	4
# of baths (full+part)	55274	1.495875	.6161746	1	4
Unit age	55274	7.907624	8.252206	0	88
Unit age - sq	55274	130.6282	287.4864	0	7744
Unit was renovated, dummy	55274	.0315519	.1748054	0	1
Unit is a penthouse, dummy	55274	.0069291	.0829532	0	1
Relative Status, $\eta = 1.0$	55274	.5044494	.2762962	0	1
unit floor in bldg - calculated	55274	12.07012	8.240589	1	60
Highest residential floor in building	55274	22.83327	9.389515	5	60
Floor average view (sq km) NE quadrant	55274	.1502232	.2210233	.000071	.780326
Floor average view (sq km) SE quadrant	55274	.1995143	.261329	.000103	.780502
Floor average view (sq km) SW quadrant	55274	.1807022	.2335436	.000512	.78065
Floor average view (sq km) NW quadrant	55274	.1047762	.1579714	.000107	.780636
Estm unit specific view in NE quadrant	55274	.0812138	.1658972	0	.780326
Estm unit specific view in SE quadrant	55274	.1055159	.1961742	0	.780502
Estm unit specific view in SW quadrant	55274	.0868737	.1671448	0	.78065
Estm unit specific view in NW quadrant	55274	.0615936	.120923	0	.780636

Table 1: **Summary Statistics**

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[10] To deflate to July 2018 condominium prices, we use a repeat-sales index for condominium transactions in the Vancouver Census Metropolitan Area (CMA) but exclude those in the downtown peninsula. These data are sourced from BC Assessment, using the assessment roll and their database of registered transactions deemed suitable for valuation. We windsorize using these deflated prices.

sectionResults

4.1 Value of Relative Status

We begin with estimating equation 4.1, where we assume (following equation 3] that $\eta = 1$ so that relative status is roughly equal to the ratio of unit floor to the number of floors in the structure. Results from the estimation of this specification for the full sample are presented in Table 2. Specifications (1)-(6) in Table 2 differ by whether we omit view controls (column 1), include control for view with either the floor average view measure (column 4, and 5) or the estimated unit-specific view measure(column2).[11] Additional differences across regressions are whether we control for whether a unit is a penthouse (columns 4 and 6), and whether we treat bedroom and baths count as linear or not (columns 1-4) or introduce bedroom and bath room fixed-effects (columns 5-6). All regressions in Table 2 and all subsequent regressions include floor fixed-effects, building fixed-effects, and year-month fixed-effects. Standard errors are clustered at the building level.

As indicated in Table 2, under all specifications, relative status is associated with a price premium. The relative status variable is statistically different from zero and economically meaningful, with a maximum marginal effect on unit price of 7.8%-9.4%; implying that, *ceteris paribus* (and specifically controlling for the amenities associated with height, including floor fixed-effect and view) a unit on the top floor would sell for about 7.8%-9.4% more (at the sample mean \$C 91,300 or \$US 69,400) than the same unit on the bottom floor of the building. Put differently, a unit on the 7th floor of a 10 storey building sells for 2.7% (\$C 30,000 \$US 23.400) more than the same unit would sell for if it were on the 7th floor of a 20 storey building.

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[11] The view controls are quadrant-view decile dummies, based on average floor values or estimated unit specific values.

	(1) est1	(2) est2	(3) est3	(4) est4	(5) est5	(6) est6
status, η=1	0.091^{***}	0.087^{***}	0.077^{***}	0.094^{***}	0.081^{***}	0.076^{***}
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Unit floor area	-1.31^{***}	-1.25^{***}	-1.31^{***}	-1.34^{***}	-1.35^{***}	-1.29^{***}
	(0.13)	(0.11)	(0.13)	(0.14)	(0.14)	(0.12)
Unit floor area - sq	1.12^{***}	1.06^{***}	1.12^{***}	1.13^{***}	1.13^{***}	1.07^{***}
	(0.13)	(0.12)	(0.13)	(0.14)	(0.14)	(0.12)
Unit floor area - cubed	-0.36^{***}	-0.34^{***}	-0.36^{***}	-0.35^{***}	-0.36^{***}	-0.33^{***}
	(0.050)	(0.046)	(0.049)	(0.052)	(0.051)	(0.047)
Unit floor area to 4th	0.039^{***}	0.036^{***}	0.039^{***}	0.038^{***}	0.038^{***}	0.035^{***}
	(0.0065)	(0.0061)	(0.0063)	(0.0066)	(0.0064)	(0.0061)
# of bedrooms	0.011^{*}	0.011^{*}	0.011^{*}			
	(0.0052)	(0.0042)	(0.0052)			
# of bathrooms	0.021^{***}	0.023^{***}	0.021^{***}			
	(0.0051)	(0.0045)	(0.0050)			
Unit effective age	-0.026^{***}	-0.026^{***}	-0.026^{***}	-0.026^{***}	-0.026^{***}	-0.026^{***}
	(0.00079)	(0.00080)	(0.00079)	(0.00079)	(0.00079)	(0.00080)
Unit effective age - sq	0.000047^{*}	0.000041	0.000045	0.000047^{*}	0.000045	0.000039
	(0.000023)	(0.000023)	(0.000023)	(0.000023)	(0.000023)	(0.000023)
Unit was renovated, dummy	0.028	0.028	0.028	0.028	0.027	0.027
	(0.015)	(0.014)	(0.015)	(0.015)	(0.015)	(0.014)
Unit is penthouse, dummy			0.093^{***}		0.094^{***}	0.098^{***}
			(0.015)		(0.014)	(0.014)
Floor Avg View	Yes	No	Yes	Yes	Yes	No
Unit Specific View	No	Yes	No	No	No	Yes
of Bedroom and Baths FE	No	No	No	Yes	Yes	Yes
N	55274	55274	55274	55274	55274	55274
adj. R^2	0.944	0.947	0.944	0.944	0.944	0.947

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
All regressions include floor, building, and month-year fixed effects. Effective age is age adjusted for renovations. Standard errors are clustered at the building level.

Table 2: **Relative Status - Baseline Regressions**

In our base specification in equation (4.1) and estimated in Table 2, we assume that marginal relative status (β_2) is constant among floors and across buildings. A natural conjecture, however, is that people have different preferences for relative status. If so, this can result in a separating equilibrium with regards to apartment choice: those with stronger preferences for relative status occupy higher floors while those with weaker preferences occupy the lower floors.[12] Below in Table 3 we relax the assumption on the constant relative status parameter. In columns (1) and (2) we stratify the sample by units below the median floor of the transactions in the sample and those above (lower and upper), respectively. In columns (3) and (4) we stratify the sample by units in buildings that are below and above the median building height among the transactions in the sample, which are designated as short versus tall, respectively.[13] The results provide indications of differences in preferences that affect prices. The point estimate for the marginal effect of relative status is approximately three times as high for units that are above the median floor (regression (2)) as for those below the median floor (regression (1)) in the sample, though the standard error is considerably higher for the latter. The difference between units in shorter and taller buildings (columns (3) and (4)) is much smaller in magnitude and not statistically different than zero.

As a further extension of the results in Table 3, we segregate the sample to test if there is a difference in the status parameter between units located on the upper floors of taller buildings versus those in shorter buildings. Table 4 stratifies the sample into four categories: lower (vs. upper) floors of shorter (vs. taller) buildings. Result are presented in Table 4. As indicated in the table, the results emphasize the separation of consumer types. Indeed, those occupying units in the upper floors of taller buildings particularly value relative status, whereas those occupying units on the lower floors of the same buildings are especially agnostic to the status of their floor level relative to others in the building. Similarly, individuals in shorter buildings also exhibit separation around relative status, the differences in which are

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[12] While we do not formally show separation in equilibrium, intuitively, the required single-crossing property required for separation maintains, as the net cost of occupying higher floors (i.e. the price net of the benefit associated with status) is lower, the stronger are the preferences for the relative vertical status.

[13] The median unit in the entire sample is on the 10th floor. The median building height, by transactions, is 23 floors.

	(1) Low	(2) High	(3) Bottom	(4) Top	(5) Short	(6) Tall
Relative Status,	0.094^{***}	0.27^{***}	0.070	0.59^{***}	0.087^{***}	0.11
$\eta = 1.0$	(0.018)	(0.070)	(0.038)	(0.11)	(0.021)	(0.076)
N	28233	27041	26504	28770	27096	28178
adj R^2	0.944	0.945	0.946	0.945	0.946	0.944

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
All regressions include the controls from Table 2 specification (5) with floor, building, and month-year fixed effects and building specific average floor views. Low are units on or below the 10th (median) floor. High are those above. Bottom are units below their building mid-point. Top are units above the mid-point in their building. Short are units in buildings at or below the median height of 23 stories. Tall are units in buildings above this height. Medians are determined by the total number of transactions not by building. View is estm. avg floor view. Standard errors are clustered at the building level.

Table 3: **Relative Status - Sub-Samples: Lower vs Upper Floors Shorter vs. Tall Buildings**

smaller in magnitude, as compared to those in taller buildings.

	(1)	(2)	(3)	(4)
Relative Status,	0.0016	0.12	0.63^{***}	0.74^{***}
η= 1.0	(0.053)	(0.11)	(0.15)	(0.18)
	Bottom/Short	Bottom/Tall	Top/Short	Top/Tall
N	12953	13551	14143	14627
adj R^2	0.949	0.948	0.946	0.945

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
All regressions include the controls from Table 2 specification (5) with floor, building, and month-year fixed effects and building specific average floor views. and month-year fixed effects. Bottom/Short are units in the bottom half of short buildings (≤ 24 stories). Bottom/Tall are units in the bottom half of tall buildings (> 24 stories). Top/Short are units in the top half of short buildings. Top/Tall are units in the top half of tall buildings. View is estimated avg floor view. Standard errors are clustered at the building level.

Table 4: **Relative Status - Sub-Samples: Lower Floors in Short Buildings vs Upper Floors in Tall Buildings**

Recall that in the results in the tables in estimating equation , we assumed that $\eta = 1$; namely, that all people weight the disutility generated by those locating above them the same way that they weight the utility from locating above others. We now relax that assumption, recalling that when $\eta > 1$ ($\eta < 1$), people weight more heavily the utility (disutility) generated from being (below) above others, as compared to the disutility (utility) from being below (above) others.[14] A greater disutility from being below others is analogous to a greater weighting in the measure of status on being on the top floor, so no one is above you. Similarly a greater utility from being above others is analogous to a greater weighting on not being on the bottom floor, where no one is below you. We present the distribution of relative status for different values of η in Appendix B.

Below we re-estimate equation 4.1 with values of η for RS from equation 2 varying from 0.5 to 5.0.[15] The results of estimating equation with varying η are presented in Table 5. The coefficient on the status variable remains statistically different than zero for all values of η. However, the estimated coefficient on relative status declines in magnitude as η increases in size, ,with the size of these declines becoming smaller as η rises. While not offering guidance to the "right" measure of η these regressions to confirm that the significance of relative status is robust to different characterizations of how buyers assess a unit's status.

To generate insights on how regression estimates vary with values of the parameter η, and by extension an understanding the nature of relative status, we plot the variation in regression output measures as η varies in size. In Figure 6, we plot the estimated coefficient on relative status against η, which flattens in the range of $\eta = 3$ to $\eta = 5$. Figure 7 plots another perspective on this, matching the change in the estimated coefficient on relative status in units of standard deviations against η. Consistent with Figure 6 the magnitude of the change in the estimated coefficient on relative status essentially becomes zero in the same range of η values. Similarly, adjusted-Rsq in 8 reaches a maximum in the same range. These outcomes suggest the appropriate value for η in high-rise housing is greater than one, so that relative status is weighted towards being at the top, a disutility to being below others. This is consistent with a higher marginal value of relative status for units above the median floor

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[14] As η approaches 0 equation 2 becomes dummy with a value of zero for the bottom floor and one for all floors above the bottom. Conversely, as η approaches ∞ the status measure because a dummy variable with a value of one for the top floor unit and zero for all lowers floors.

[15] standard deviations are similar across these measures but the mean relative status value declines as the value of η rises: from 0.62 for $\eta = 0.5$ to 0.25 for for $\eta = 5.0$.

	(1)	(2)	(3)	(4)	(5)
Relative status, $\eta = 0.5$	0.098^{***} (0.026)				
Relative status, $\eta = 0.75$		0.088^{***} (0.019)			
Relative Status, $\eta = 1.0$			0.081^{***} (0.017)		
Relative Status, $\eta = 2.0$				0.071^{***} (0.013)	
Relative Status, $\eta = 3.0$					0.069^{***} (0.012)
N	55274	55274	55274	55274	55274
adj R^2	0.944	0.944	0.944	0.944	0.944

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
All regressions include the controls from Table 2 specification (5) with floor, building, and month-year fixed effects. Standard errors are clustered at the building level.

Table 5: **Relative Status - Allowing variation in η**

and those at the top of taller buildings in the earlier sub-samples.[16]

In Figure 9 we combine the assessment of the effect of varying η with the implications from Tables 3 and 4 that the marginal effect of relative status varies across floors and building height. Figure 9 presents the variation in the estimated coefficients on relative status for units on floors below or above the median floor as η varies in value. At every value of η, the marginal effect of relative status on prices is higher for units on upper floors than on lower floors. While the estimated coefficient for upper floors stabilizes, that for lower floors does not. This is possibly an artifact of the model: for lower floors, as η increases the spread between min and max values (and similarly for inner decile range) becomes quite small.

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[16] As a check, we did include a top floor dummy in the empirical specification, the coefficient on relative status remained positive and statistically different from zero, indicating that relative status is not specifically generated from being on top.

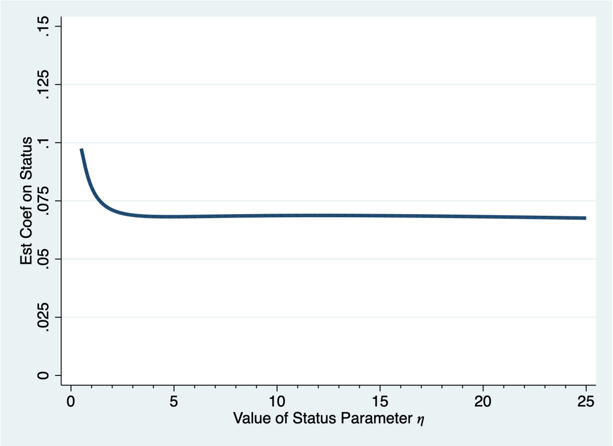

Figure 6: Status Coefficient by η

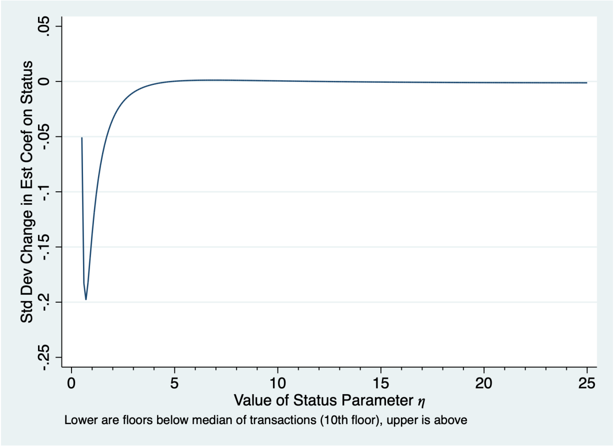

Figure 7: Standard Deviation Change in Coefficent with η

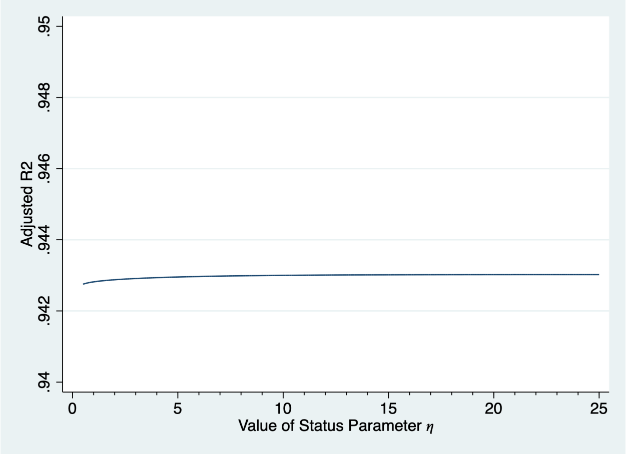

Figure 8: **Adjusted R-Sq by** η

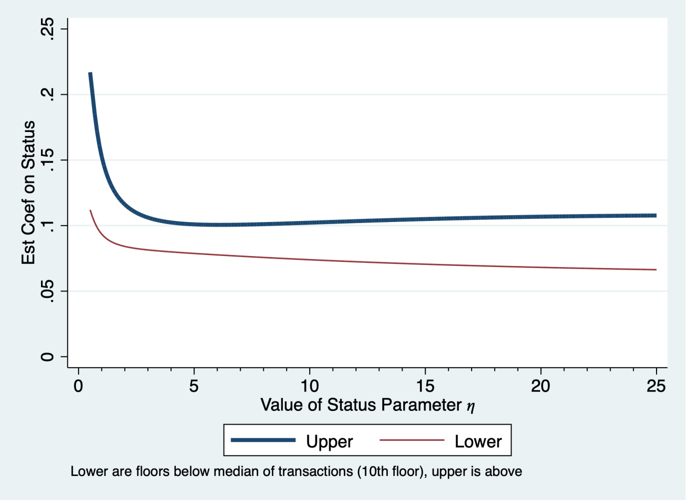

Figure 9: figure
Upper vs Lower: Status Coef. by η

Finally, we relax the constraints on the value of relative status by allowing it to vary non-parametrically. Specifically, we divide the relative status measure into 10 bins (of equal number of observations) by value. We then re-estimate our preferred hedonic specification, regression (6) from Table 2, replacing the continuous measure of relative status with the nine dummies for the bins (first bin being the base-group). Figure 10 presents a plot of the point estimates and 95% confidence error bars for $\eta = 3$. As shown, the relative status is quite low in magnitude and flat for lower status deciles, higher and at a plateau for the mid-range, and then clearly convex for the top third of the deciles. These findings reinforce the separating patterns we document above in the sub-sample regressions in Tables 3 and 4, where individuals with high preferences for vertical status select into higher floors and more steeply bid for marginal gains in relative positioning, while individuals with weaker preferences for vertical status both select into lower floors and are more indifferent to differences in relative positioning.

Up to this point we have used one's own building as the primary reference point for determining relative status. It also reasonable to believe that status might also come from one's position relative to other neighbouring buildings. On a building by building basis, any relative status effects that are shared among all units will be subsumed in the building fixed

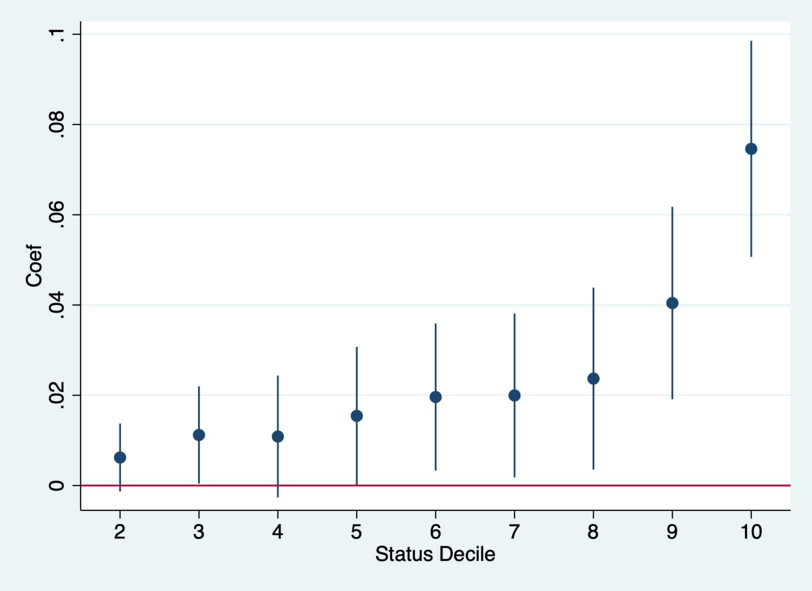

Figure 10: figure
Non-Linear Status, η=3

effects controls. Here we test for the height of one's own unit, compared to the heights of buildings in a 100m and 250m ring around one's own building. In Appendix B we describe the calculation of this measure, which like our relative status measure is [0,1] but is based one own's unit elevation, the total number of buildings in a ring and then number of buildings that are higher than one's own unit's elevation. Appendix B also shows distributions of the variable for different values of η and different ring radius's. Table 6 shows the results for $\eta = 1$ and $\eta = 3$ and for 100m and 250m rings around the transacting unit's building. Including the area relative status measure does not meaningfully change the point estimates for relative status from Table 5 of 0.81 for $\eta = 1$ and 0.69 for $\eta = 3$. The marginal effect of area (ring) relative status is smaller, but still statistically different from zero for $\eta = 3$ in regressions (2) and (4). As the mean and variance are similar to our relative status measure for one's own building, these differences in point estimates for the two relative status measures reflects the difference in economic magnitude, that own building relative status is twice to three times as impact full on unit price as is the area relative status measure.

	(1) 100m Ring	(2) 100m Ring	(3) 250m Ring	(4) 250m Ring
Rel. Status, η =1	0.075***		0.080***	
	(0.017)		(0.016)	
Area Relative Status, η =1	0.020		0.013	
	(0.011)		(0.017)	
Rel. Status, η =3		0.065***		0.066***
		(0.012)		(0.012)
Area Relative Status, η =3		0.024*		0.034*
		(0.011)		(0.017)
N	55274	55274	55274	55274
adj R^2	0.944	0.944	0.944	0.944

Standard errors in parentheses
All regressions include the controls from Table 2 specification (5) with floor, building, and month-year fixed effects. View is themean floor view measure. Standard errors are clustered at the building level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: **Status Relative to Neighbouring Buildings**

5 Summary

In this paper we provide rigourous empirical estimation of the value buyers place on relative status, as measured vertically in height in a building. We find that premiums for relative status both exist and are economically meaningful, composing up to a 7% premium for the highest status unit relative to the lowest status unit. Introducing variation in the marginal effect of relative status by allowing for the effect to vary within a building between lower and higher floors and across building between short and tall buildings demonstrates that the marginal effect of status is highest among upper floors in tall buildings and lower in bottom floors of all buildings. The convexity of marginal status is consistent with sub-groups of individuals who re not status conscious - and live on low floors - and those who are who live on high floors, especially in tall buildings. This is consistent with how our estimates vary as we change the parameter η that identifies preferences for being above versus distaste at being below others. We find for our context of relative status in a vertical dimension there are individuals with a strong distaste for having others above and others for whom there is little willingness to pay for gains in relative status. Many of us are Yertle the Turtle, but many are also like Mack at the bottom of the stack.

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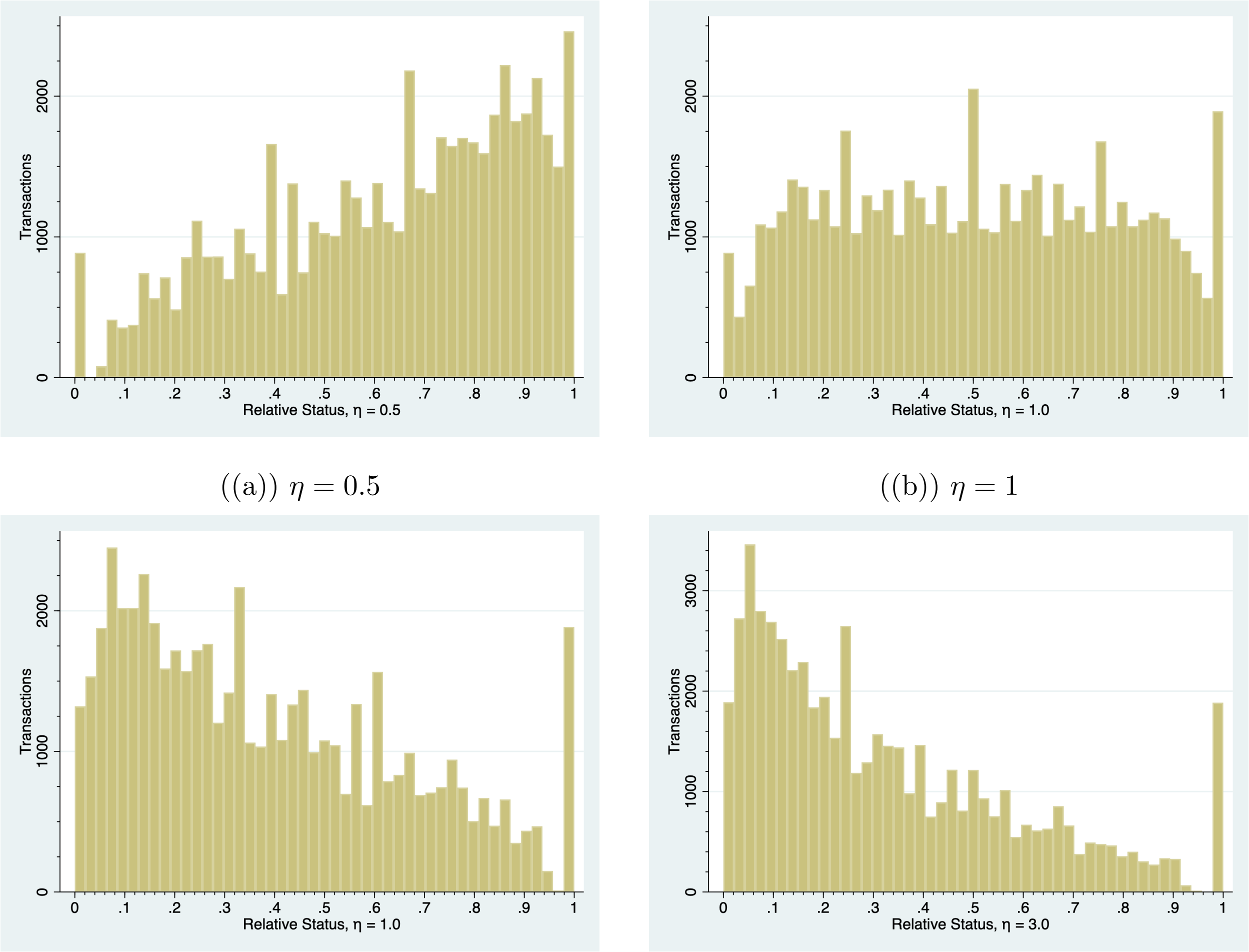
A Data Set Construction

BC Assessment reports 76,799 transactions registered in the Land Title Office between 1992-2016 with a reported price. These transactions are limited to one per day, so if multiple transactions are recorded on the same day we use the highest price. Of these, 3,950 are in buildings that are four stories or lower and are dropped from the sample. We also reject sales that are not fee-simple or BC Assessment deems invalid for statistical appraisal, removing another 5,515 observations. We drop transactions that likely reflect the price of a pre-sales contract, all transactions on the first three days of occupancy, which removes another 5,197 transactions. Missing data for control variables reduces the sample by a further 6,804 observations, of which 5,521 are because we do not have a bedroom count (we still include studios of the bedroom count is zero). We windsorize on price (using real house prices) dropping the the top and bottom 0.05% of the sample (prices under \$C30,412 and over \$C10,800,000). Other outliers are units with more than four bedrooms or more than four bathrooms, which removes another 50 transactions. This leaves a sample of 55,274 transactions.

B Measuring Own Building and Area Relative Status

As we note in the main body of the text, changing η has both meaning, but it also effects the distribution of the values for stats, even as they remain distributed [0,1]. Below in Figure 11 we present the distributions of relative status for η=0.5, η=1.0, η=3.0, which highlight the moving of the mass of the distribution to 0 or 1 as the value of η is smaller or larger. The figures how for values of $\eta < 1$ mass of the distribution is moved to the right such that in the extreme ($\eta = 0$) relative status would have the value of 0 for units on the bottom floor and 1 for all units above. Symmetrically when $\eta > 1$ the mass is moved to the left, and in the extreme ($\eta = \infty$) relative status would be a top floor dummy variable.

For the measure of area relative status we cannot use own floor compared to the floors in neighbouring buildings because of the different heights of nearby buildings. Comparing to only the height of the tallest building in the ring would assume that lots of other taller



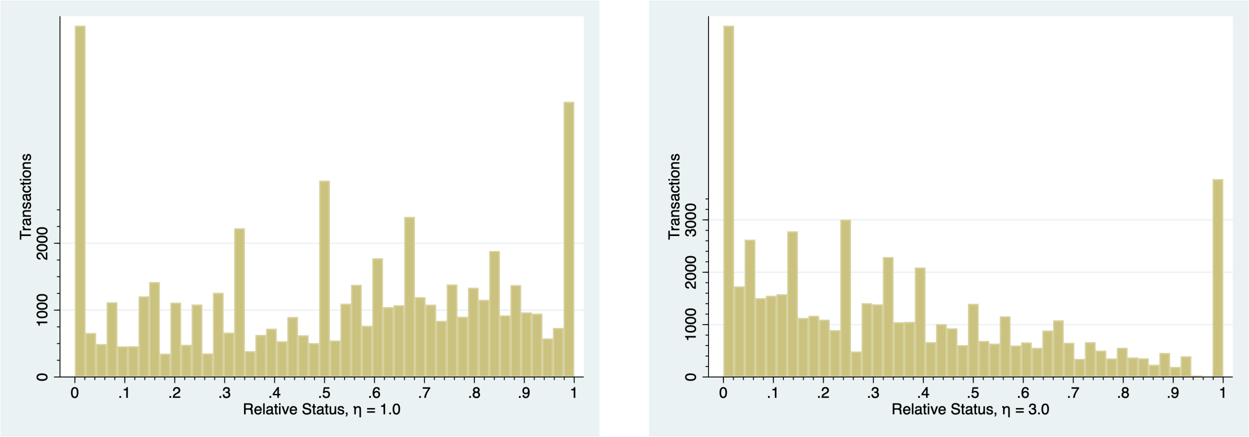
((a)) $\eta = 0.5$

((b)) $\eta = 1$

((c)) $\eta = 2$

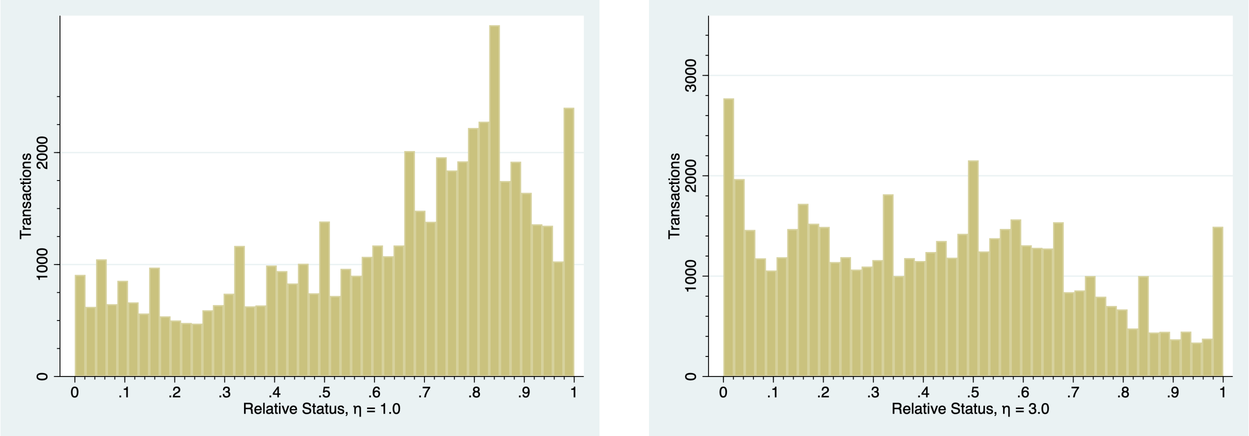
((d)) $\eta = 3$

Figure 11: Distribution of Relative Status by η



((a)) $\eta = 1$, 100m ring

((b)) $\eta = 3.$ 100m ring



((c)) $\eta = 1$, 250m ring

((d)) $\eta = 3$, 250m ring

Figure 12: Distribution of Area Relative Status by η and Ring Radius

building are of no consequence. We choose to measure area relative status using equation 2 and for i using the number of buildings whose maximum elevation above sea level is below the reference unit's elevation and for N the total number of buildings in the ring. If your unit is higher In Figure 12 below, we show these distributions for $\eta = 1$ and $\eta = 3$ and for rings of 100m and 250m in radius. Relative to the within building relative status measure the area relative status measures have more mass at the $0, 1$ endpoints and are not distributed as yuniformly for $\eta = 1$.

Finally, we present summary statistics for the within building and area ring relative status measures. These are shown in Table 7. Though the distributions shown above in Figures 11 and 12 differ clearly, these differences are not significantly in the first and second moments for the 100m radius measures. However, for the 250m ring we do observe differences in the mean value, but the standard deviations remain close in magnitude.

	(1)				
	count	mean	sd	min	max
100m ring					
Relative status, $\eta = 0.5$	55274	.6230381	.2632185	0	1
Relative status, $\eta = 1$	55274	.5044494	.2762962	0	1
Relative status, $\eta = 2$	55274	.3865194	.2709157	0	1
Relative status, $\eta = 3$	55274	.322634	.2605884	0	1
Area relative status, η =0.5	55274	.6203758	.3143183	0	1
Area relative status, η =1	55274	.519949	.3144354	0	1
Area relative status, η =2	55274	.4146257	.3057439	0	1
Area relative status, η =3	55274	.3557647	.2972283	0	1
# of bldgs in ring	55274	18.13202	11.83221	2	57
# of bldgs in ring above unit	55274	7.702356	7.493265	0	52
250m ring					
Relative Status,$\eta = 0.5$	55274	.6230381	.2632185	0	1
Relative Status, $\eta = 1$	55274	.5044494	.2762962	0	1
Relative Status, $\eta = 2$	55274	.3865194	.2709157	0	1
Relative Status, $\eta = 3$	55274	.322634	.2605884	0	1
Area relative status, η =.5	55274	.7133542	.2609168	0	1
Area relative status, η =1	55274	.6099121	.2782326	0	1
Area relative status, η =2	55274	.4936675	.2793126	0	1
Area relative status, η =3	55274	.4240882	.2722704	0	1
# of bldgs in ring	55274	96.28281	50.98931	6	264
# of bldgs in ring above unit	55274	35.05929	33.39722	0	259

Table 7: **Summary Statistics - Relative Status Measures**

C Vertical Gradient

The focus of this paper is the effect of relative status. But our rich data set of geographically concentrated condominium apartment transactions with good controls for views offers an

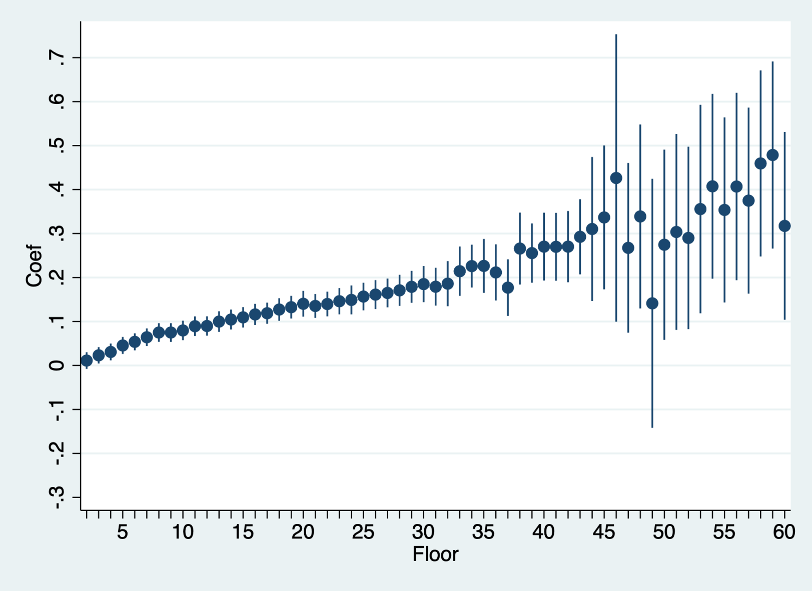


Figure 13: **Floor Fixed Effects, η=3**

opportunity to investigate the residential vertical rent gradient. In Figure 13 we plot the values of the floor fixed effect coefficients. As in other papers in the literature, the small number of transactions and likely higher unobserved heterogeneity of high floors yields dramatically greater volatility in the point estimates for higher floors.[17]. The plots in Figure 13 suggest breaks at the 9th floor, 21st floor, and 31st floors, so below we parameterize floors into our base specification to identify the form of the vertical rent gradient.

The sample choice around including or excluding the highest buildings does not effect are estimates of the effect of relative status. Table 8 presents regressions with both types of view measures for all buildings (columns 1 and 2), dropping the right hand tail of buildings above 41 floors (columns 3 and 4), and limiting the sample to where we have at least 5 buildings for each maximum height (columns 5 and 6). The relative status coefficient is stable, varying only by view measure.

The regressions in Table 9 provide linear and linear spline estimates of the vertical price

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[17] In our sample there are 1.421 observations on the 20th floor, 807 on the 25th, 314 on the 30th, 175 on the 33rd, and 86 on the 35th. Above the 40th there are fewer than 20 observations per floor.

	(1)	(2)	(3)	(4)	(5)	(6)
status, η=3	0.069***	0.063***	0.069***	0.063***	0.073***	0.066***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Sample	All Bldg	All Bldg	<45 Floors	< 45 Floors	<36 Floors	<36 Floors
Floor Avg View	Yes	No	Yes	No	Yes	No
Unit Specific View	No	Yes	No	Yes	No	Yes
# of Bedroom and Baths FE	Yes	Yes	Yes	Yes	Yes	Yes
N	55274	55274	54902	54902	52887	52887
adj. R^2	0.944	0.947	0.943	0.946	0.942	0.945

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
All regressions include floor, building, and month-year fixed effects and the controls from regression (5) in Table 2. Standard errors are clustered at the building level.

Table 8: **Robustness: Building Height**

gradient for residential buildings. In regressions (1) and (2) floor enters linerally into the hedonic price equation. For regressions (3) and (4) we allow for a linear spline with two breaks and limit the sample to units on the 30th floor or lower. Regressions (5) and (6) expand to all floors and the spline function has three breaks. The odd numbered regressions use the floor average view measure, while the even numbered regressions use the estimated unit specific floor view (the methodologies for both are in the appendix). Our results differ somewhat from the findings for commercial rent gradients. First, the estimated vertical price gradient coefficients in Table 9 are smaller (flatter gradient) 0.51 - 0.63% per floor in the linear in (1) and (2) and no spline coefficients above 1.0%. With the spline, we get a concave gradient, but Liu, Rosenthal, and Strange 2018 and Nase, van Assendelft, and Remoy 2019 both report convex gradients. There is some evidence of this above the 30th floor in Nase and Barr 2022 for Manhattan condominium units, but their small sample size yields noisy point estimates.

The estimated effect of height directly (coefficient on floor measure) is affected by how we measure views. The vertical gradients are lower at all levels when we use the estimated unit specific view measure instead of floor average view. As we explain in the Appendix,

	(1)	(2)	(3)	(4)	(5)	(6)
Relative Status,	0.080^{***}	0.084^{***}	0.083^{***}	0.068^{***}	0.072^{***}	0.068^{***}
$\eta = 3.0$	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)
Floor	0.0062^{***}	0.0057^{***}	0.0043^{***}			
	(0.00056)	(0.00053)	(0.00051)			
Floor, for				0.0099^{***}	0.0093^{***}	0.0088^{***}
Floors 1-8				(0.00095)	(0.00086)	(0.00085)
Floor, for				0.0055^{***}	0.0048^{***}	0.0039^{***}
Floors 9-20				(0.00059)	(0.00058)	(0.00056)
Floor, for				0.0059^{***}	0.0048^{***}	0.0020
Floors 21-34				(0.00086)	(0.0010)	(0.0010)
Floor, for				0.015^{**}	0.011^{*}	0.0075
Floors 35-45				(0.0053)	(0.0054)	(0.0066)
Floor, for				0.0074^{***}	0.0083^{***}	0.0075^{***}
Floors $\geq$46				(0.0013)	(0.0016)	(0.0015)
Floor Avg View	No	Yes	No	No	Yes	No
Unit Specific View	No	No	Yes	No	No	Yes
Observations	55274	55274	55274	55274	55274	55274
Adjusted R^2	0.943	0.944	0.947	0.943	0.944	0.947

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
All regressions include unit characteristics from Table 2 specification (5) and floor, building, and month-year fixed effects. Standard errors are clustered at the building level.

Table 9: **Vertical Gradient**

the former is upper bound on the contribution of views to value, but it does clearly indicate that much of what is assigned to height is likely to be because of views.[18]

D View Estimation

D.1 Floor Average View Measure

For the GIS 3-D modelling, floors in each building are identified in meters of elevation. The City of Vancouver property footprint database includes the elevation of a building's base, its massing, and the height of its highest point of the structure. Heights are allocated to floors with an assumption of a lobby height of 4.7m, a mechanical floor every 30 floors with a height of 4.65m, and a roof and equipment height of 6.2m. Remaining height is allocated evenly by floor. View level is assumed to be 1.7m above the floor height.

The same database allows us to construct the massing of all other buildings in a given year, based on year of completion. We make the following assumptions for the temporal variation in the city's built form: 1) prior to construction of the building currently on a parcel, all lots have three story buildings; 2) for tower and podium forms we use the building tower footprint and assume any podium is 3 stories tall, 3) a building's massing is completed one year prior to the year of completion, and 4) all completions are July 1.

This approach should yield an unbiased estimate of views, but with higher standard errors, as all units on a floor in a given building in a specific year are given the same view. However, there are reasons to worry that the point estimated may still be biased. First, if lower quality view units (i.e. less expensive) turn over more frequently than we do not have a random sample of units on a floor. Additionally, building fixed effects can absorb view values when all units on a floor get the same view value, irrespective of direction, and many floors share the same view. To understand this, imagine that all buildings in Vancouver's downtown peninsula are exactly 20 stories high. In this simple extreme example, the only

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[18] The difference between having no view and a complete 360 degree unobstructed view with the estimated unit specific measure adds about 26% to a unit's price. In the linear specification in regression (2) this is equivalent to being on the 52nd floor.

units that have unobstructed views are those in the buildings that are on the edge of the downtown, and facing the water (north and south), Stanley Park (west), or lower density residential and non-residential neighborhoods (east). In these buildings, the buildings have a side with unobstructed views, while the other three sides have views of adjacent buildings behind or to the side and are thus obstructed. However, all units on each floor get the same view values because we don't know in which direction they face. And on any side all floors have the same view. In this case, building fixed effects capture all of the view effects, where the fixed effects are much larger for buildings on the edge with the view and lower elsewhere. While the example is extreme, it is not implausible. Most of the units with the full views are on the edge of the downtown peninsula facing the water to the north or south, and in this case, the view is the same for all units facing a given direction, not varying by floor. In order to address this, we estimate unit specific views per floor.

D.2 Unit Specific View Measure

To generate an estimate of unit specific views from the average floor views we use as the motivating assumption that the unobserved differences in prices among units on a given floor in a given building are a function of view differences and not of other unobserved unit characteristics. Based on building alignment, the number of units per floor, and view values for each quadrant we rank estimated views for units on a floor from highest to lowest and then assign these to units in the same ordinal ranking based on residuals from a first stage regression. The view values are generated in a first stage regression using mean floor view and with census tract rather than building fixed-effects. As we assign high view value to high residuals, this is likely to yield upward biased unit specific view coefficients and should be understood as an upper bound. For each unit we estimate the amount of view in each quadrant a unit might have. This will depend on i) the building's alignment relative to 0 degrees due north, ii) the number of units on a floor, iii) how view is then allocated among the units on the floor, and iv) an estimation of the arc of view that a unit has.

- *The building's alignment.* If the building alignment is due north (0 degrees) and a unit facing that direction had a 180-degree arc of view, then they would have a view equal to 100% of the N.W. and N.E. quadrant view values for its floor. If the alignment was 45 degrees, then said unit would have 50% of the N.W., 100% of the N.E., and 50% of the S.E. view quadrants. The building alignment has to be in 0-89 since buildings are assumed to have 4 90-degree corners. For simplicity, we restrict these to 0, 25, 45, and 70, as 82 percent of units are within 3 degrees of each of these, with 72 percent of units aligned between 42 and 48 degrees.

- *The number of units on the floor.* The number of units on a floor will define their potential view arcs. For instance, one unit on a floor would get 100% of the views in all directions. 2 units we would assume get half each, subject to an assumption is the floor divided N-S or E-W. Translating these shares into degrees of view depends on the number of units per floor, and whether the unit is a corner unit or not. Roughly: i) a unit that occupies the entire floor – 360 degrees of view, ii) a unit on a corner - 250 degrees of view, iii) unit that just faces single direction – 160 degrees of view. In the data 78% of transactions are for units on a floor with six or more other units, with the mode of eight units per floor.

- *View arc.* Discussions with an architect suggests that one would lose 10 degrees of angle of view because when looking out a window one does not see along the building's edge. So facing one direction implies a 180-degree arc of view, but you lose 10 degrees from each side. Hence, if facing due east (90 deg orientation), the view is 10-170. For a corner unit this generates 250 degrees (170 + 80). The problem is estimating for a unit that occupies half a floor because of the blind spot created by the building mass is larger than just the 20-degree arc loss (by the system above used for a corner unit, a building on half a floor is like two corner units and would be 180 (not 170 because of the second corner) + 80 + 80 = 340, but the building mass seems much larger). We assume that it is the midpoint between a corner unit (250) and a whole floor (360) rounded to 300. This yields the following view arcs based on the number of units per floor: i) 1 unit per floor, 360 degrees, ii) 2 units per floor, 300 degrees, iii) 3 units – a $\frac{1}{2}$ floor unit and two corner units, iv) 4+ units per floor, corner unit, 250 degrees, v) 4+ units per floor, one direction, 160 degrees

Combining the buildings angle with the number of units on a floor we can generate the set of possible views for each unit on the floor. This requires one additional assumption, which is for floors with 2,3, and 5+ units is the division in the building aligned N-S or E-W, i.e. in which direction is the axis separating one half of units from the other half. We test for both and there is no meaningful; quantitative difference in results, so we report using the E-W alignment

The first stage generates estimated view coefficients that we use to rank view values among transacting units on an individual building floor. For this we use coefficients for the maximum view value in a particular direction, i.e., the estimated coefficient for the top decile of view quantity, typically an unobstructed view in a direction. For any unit, their estimated view value would be their amount of view in each direction, as estimated above based on alignment and number of units per floor, times this estimated coefficient value.[19]. We match estimated view values to regression residuals also from the same type of the first stage regression used above to estimate view value. For a floor on a building, the unit with the largest residual gets the 1st ranked view, the unit with the second highest view gets the second highest residual and so on. If there are six units on a floor, the unit with the lowest residual gets the lowest estimated view value. This approach assumes that the primary missing variable and source of error is the value of the view. The lowest possible view type is the 6th highest (just 6 unit types for views in a building with 6+ units), so if there are more than 6 units on a floor, all units from 6th down in residual value receive the same view value.

The bias that this introduces is to force all unexplained variation onto view. As such, this should be an upper bound on the value of view as we correlate view value with residual. In aggregate, with this approach using building fixed-effects, a unit with the top decile view in every direction has a 21% higher value than one with the lowest decile.

Figure 14 shows the difference in view values between the average floor view (panel *a*) and the estimated unit specific view (panel *b*). For presentation, the view effects in a decile are summed across all four quadrants so that we present the estimated effect of view on value for a unit with 2nd decile view values across all quadrants. Estimated view effects are substantially larger with the unit specific estimates: a unit with top decile views in each direction would have an 11% higher value than a units with

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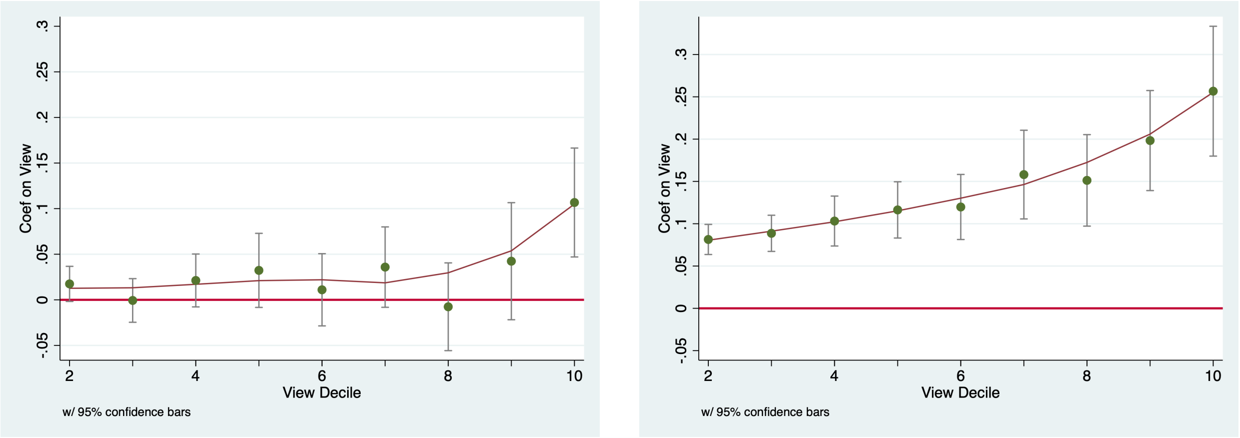
[19] While we generate different estimates based on whether the first stage uses census tract or building fixed effects, We also test with and without the four buildings over 44 stories and with 1 and 5 km rings. The final results in the hedonic regressions are robust across these different criteria



((a)) Avg Floor View

((b)) Est Unit Specific View

Figure 14: Comparing View Coefficients