

Vertical gentrification: A 3D analysis of luxury housing development in New York City

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Abstract: New York City has experienced a boom in elite ‘luxury’ housing development. With large apartments and expansive amenity spaces, luxury buildings offer uncrowded living in an otherwise densely populated landscape. However, making space for these luxuries requires novel engineering, especially high-rise development. The paper maps the expanding footprint of luxury real estate in three dimensions, analyzing 943 housing projects built between 2000 and 2020. It assesses how construction of taller buildings with larger footprints increased height and volume of the built environment, and how these landscape changes interact with social changes related to gentrification. On average, new build luxury development increased height by 6.8 stories and more than doubled building volumes. Building heights and volumes are also significantly larger than neighboring structures. The resulting intensification of land investment leads to new kinds of displacements, especially middle class displacement. Vertical development is closely associated with super-gentrification, the further intensification of gentrification processes in already gentrified or otherwise middle class neighborhoods.

Keywords: gentrification, built environment, 3D GIS, New York City

Introduction

In recent decades New York City has experienced a boom in elite ‘luxury’ housing development, a phenomenon observed in many global cities (Atkinson 2019, Forrest et al. 2017, Pow 2017). Luxury buildings are physically different from more ordinary forms of residential land use, by offering “world class” architecture, ostentatious building materials, and expansive floorplans and amenity spaces. Making space for these luxuries requires novel forms of engineering through vertical development: building up into the skyline with a new generation of super-tall skyscrapers (over 300 meters), building down into subterranean infrastructure like multi-story “mega-basements” (Burrows et al. 2021), and building outward onto engineered landforms (like the 10-acre platform that sits beneath Manhattan’s Hudson Yards mega-project). Vertical development goes hand-in-hand with political economic change in the city, as the housing market is transformed through financialization by elite capital (Fernandez et al., 2016) and public policies that subsidize gentrification (Busà 2017, Stein 2019).

This paper interprets the relationship between vertical development and gentrification. It analyzes where luxury housing development changed the vertical geography of New York, using 3D GIS analysis of 943 luxury buildings constructed between 2000 and 2020. It compares vertical development to gentrification trends, using statistical analysis of Census data on racial and class demographics. The central argument is that vertical development intensifies gentrification processes in already-gentrified places, by allowing an intensification of land investment within those already-desirable neighborhoods. This is consistent with “super-gentrification” (Lees 2003), the further intensification of development and displacement in neighborhoods that have already experienced prior waves of middle-class led gentrification (Halasz 2018). Vertical development should be conceptualized along a continuum of gentrification processes (Shaw 2008, Halasz 2018,

Lawton 2020). At the extreme end of the continuum (i.e. super-gentrification), neighborhoods experience more dramatic changes in the built environment – demolition and new-build development, with extreme engineering to enclose previously unbuilt vertical spaces – and new kinds of displacements – especially middle class displacement by elite capital. Thus verticality is a visible symptom of super-gentrification. But it also plays a constitutive role by intensifying land investment.

The paper contributes at the intersection of scholarship on vertical geographies and gentrification. It uses a novel empirical approach to show statistically significant relationships between vertical development and gentrification. It advances theory on the political economy of vertical space in super-gentrified neighborhoods. While gentrification involves re-investment in undervalued land markets (Smith 1996), super-gentrification involves *over*-investment in already saturated land markets. In the rarefied neighborhoods where super-gentrification occurs, developers turn to “air mining” (McNeill 2020, 823), building vertically to squeeze further value from landscapes where most buildable land has already been built upon. Verticality allows a spatial intensification of land investment – more capital can be fixed three dimensionally atop the same two-dimensional area of land. It establishes new, vertical gentrification frontiers defined by high rise spatial fixes (Nethercote 2018) and three-dimensional rent gaps (Yang and Chang 2018). This enclosure of the skyline is often accomplished through extra-legal means, a sort of “space grabbing” akin to land grabbing (Liong et al. 2020, 1072). In this case, the enclosures are facilitated by a byzantine system of tax abatements, zoning incentives, lax building code enforcement, and creative interpretations of land use law. Building taller structures with larger volumes alters the architectural character and spatial aesthetic of the landscape, while allowing wealthy homeowners to monopolize public goods associated with the skyline (e.g. light, air flow, scenic views).

Vertical geographies of gentrification

There is a growing literature exploring the relationship between the spatial process of vertical development and the social process of gentrification (Lawton 2020, Nethercote 2018, Troy et al. 2020). Verticality helps distinguish degrees of gentrification intensity within a neighborhood. “Ordinary” gentrification involves middle class migration into working class neighborhoods (Lees et al. 2013). Its physical impact on the build environment is relatively modest, with minimal new development. In the traditional “gentrification frontier” (Smith 1996, 187) renovation is more common than new construction, reflecting a transition from “areas of disinvestment” with blighted or otherwise undervalued housing stock to “areas of reinvestment” experiencing gentrification-related upgrades (the key idea being *reinvest* rather than demolish-and-replace). Indeed, given the predominance of renovation over new construction, there is some debate over whether new-build redevelopment should even be called gentrification (Davidson and Lees 2010). Displacement effects are generally concentrated among low income households, especially renters living in properties that could be renovated and sold to owner occupants (Newman and Wyly 2006, Zapatka and Beck 2021). In US cities displacements are often racialized, with Black and Hispanic households disproportionately impacted (Raymond et al. 2021, Rucks-Ahidiana 2020).

In contrast, super-gentrification involves middle class neighborhoods transforming into more expensive and socially exclusive places (Lees 2003). It tends to occur in “already gentrified” places (Halasz 2018) that have experienced prior waves of middle-class migration and which are now experiencing further upgrading by elite capital. Its impact on the built environment is far more disruptive. The process involves the demolition of older structures and replacement with (typically taller) new buildings. Indeed, vertical development should be conceptualized as a physical marker of super-gentrification: at the extreme end of a gentrification continuum (Shaw 2008, Halasz

2018), it reshapes not only the social structure but also the built environment of a neighborhood. That physical disruption leads to new kinds of social displacement patterns, as older and more affordable housing is replaced, and new architecture encloses vertical space in new ways. While low income households remain vulnerable, the middle class also increasingly experiences displacement. In the US context, Black and Hispanic middle class households (Sutton 2020) and middle class renters (Woldoff et al. 2016, Shakespeare 2020) and are particularly vulnerable to this sort of displacement. Potential reasons include racial wealth gaps between different segments of the middle class (Rucks-Ahidiana 2021), and gaps in federal and local housing policies that “squeeze” the middle class (Quart 2018). In New York, for example, many middle income renters earn too much to qualify for affordable housing programs, but not enough to pay market rate rents.

While gentrification involves a move from disinvestment to reinvestment in a local land market (Smith 1996), super-gentrification is a transition to *over*-investment: pouring even more capital into already gentrified, already affluent, already “reinvested” neighborhoods. There are, of course, limits to such investment because neighborhoods eventually run out of disinvested land. A neighborhood has only so many dilapidated houses to flip, or vacant lots to infill. But those limits can be overcome through vertical development. At the extreme end of a gentrification continuum, a dearth of re-investable land can be remedied by extending investment space along a vertical axis. Thus “over” investment is both literal – building additional layers of space over the same area of land – and conceptual – new kinds of rent gaps (Yang and Chang 2018) can be established by redefining ground rent to include development rights on airspace above the ground. Borrowing McNeill’s (2020, 823) metaphor, vertical development enables “air mining”, such that

the development of large tradable buildings is part of the extractive processes of contemporary capitalism...A key issue here is the relationship between earth and air, between a plot of land and the extrusion of its value

through height, where air space – which could be defined as any buildable space that exists along a vertical axis – is colonized through the mechanism of stacking floors, the repetition of land or surface multiple times.

This metaphor helps illustrate the relationship between vertical development and super-gentrification, in three ways. First, the “repetition of land” (McNeill 2020, 823) transforms the skyline and the subterranean into new kinds of gentrification frontiers. Building vertically creates new three-dimensional spaces of investment opportunity atop the same two-dimensional area of land, enabling a high-rise spatial fix for elite and institutional investors (Nethercote 2018). It also creates additional space for in-building amenities not typically available in densely-populated cities. The result may range from “luxified skies” (Graham 2015) through high-rise development, down to “luxified troglodytism” (Burrows et al. 2021) as the wealthy construct subterranean infrastructure like basement swimming pools or underground garages.

Second, the “extrusion of value through height” (McNeill 2020, 823) reflects the economics of high-rise living. Elite investors favor luxury real estate in part because of its verticality. Residential height and social class have long been viewed as correlated in New York (Plunz 2016, Gregory 2020). A similar relationship has been observed in other global cities like Buenos Aires (Hölzl and Verwiebe 2020), London (Atkinson 2019), and Sydney (Troy et al. 2020), though of course this trend does not necessarily translate across all cultural contexts. And height is only part of the equation. Equally important is the kind of lifestyle enabled by vertical construction. Life in high-rise towers is managed in elite-friendly ways, for example with amenities like private entrances or VIP rooms to ensure privacy (Atkinson 2016), design and surveillance that keeps classes segregated (Rosenberger 2020), in-building technologies to manage relations with the neighbors and staff (Shilon and Eizenberg 2021), and specialized forms of housing tenure that appeal to absentee investors, most notably condominium associations (Lippert

2019). Collectively, these characteristics enhance the liquidity of luxury real estate by rendering it relatively homogenous (Fernandez et al. 2016): a high-rise luxury tower in New York is not that dissimilar from high-rise luxury towers in other global cities, in terms of design, amenities, and management. This homogeneity is important when the primary clientele are transnationally-mobile elites (Brash 2011, Pow 2017) who may use apartments as investment properties or second homes rather than primary residences (Atkinson 2019).

Third, air mining is made possible through forms of enclosure, a sort of space grabbing akin to land grabbing (Liong et al. 2020) or vertical accumulation by dispossession (Sonn and Shin, 2020). The intensification of capital fixing made possible through vertical development has displacement effects, both directly (as erstwhile open space in the skyline is enclosed) and indirectly (by increasing land prices, and thus housing costs). Vertical development strategies often stretch the letter and spirit of land use law, sometimes even violating it outright. Analyzing this requires a volumetric perspective toward public space, focusing on open spaces in the skyline. These volumetric spaces are a communal resource which provide public goods including sunlight, air flow, or the right to view and (not) be viewed. They also shape the architectural character of the landscape, contributing to new spatial aesthetics of gentrification (Berglund and Gregory 2019, Summers 2019). The skyline is, for many cities, a symbolic representation of the urban community; vertical enclosures by luxury developers remake that representation to fit the preferences of elite capital.

Methodology

Comparing the relationship between vertical development and (super-)gentrification requires two levels of analysis: of the built environment, and of social change. Changes in the built environment are assessed by comparing the new construction to that which it replaced, and to nearby land use. This establishes a baseline measurement of where and to what degree vertical development has occurred. Physical change can then be compared to social change, analyzing racial and class transitions in affected areas. This assesses the degree to which vertical development is correlated with gentrification and displacements. Vertical development does not directly *cause* displacements, since of course the space being enclosed was previously uninhabited open space in the skyline. But height and displacement are nonetheless intertwined. Building taller allows the over-investment that unleashes displacements unique to super-gentrification, especially middle class displacement.

Building data are derived from four large datasets maintained by the City of New York: real estate property sales records (available from 2003-present), building permit records (1995-present), parcel-scale land use data (released semi-annually since 2002), and building footprint and height data (released every 4-5 years based on aerial photographs and lidar surveys; the earliest version is based on imagery from 1996). Luxury properties were identified by sampling over 50,000 residential sales which closed at over \$2 million per unit (inflation adjusted to 2019 USD) between 2003 (when the public data first became available) and 2020. This definition of luxury housing was chosen because it is the minimum threshold for a local “mansion tax” on real estate transactions. The sales records were cross referenced with land use data and building permit records to identify properties that were newly constructed between 2000 and 2020 (n=943 buildings).

The physical changes associated with luxury development were assessed by analyzing building characteristics including floor area, the number of stories (a proxy for height), and floor area ratio (a proxy for volume, defined as the ratio of built floor space to the size of the lot). These variables are based on commonly-used urban volumetrics (Bruyns et al., 2021), adapted like other recent studies using New York City's data on the built environment (e.g. Bonczak and Kontokosta 2019). Paired-sample t-tests were used to compare these variables temporally before and after luxury development, and geographically to nearby buildings within a 100 meter buffer zone (roughly one city block). This technique allows a building-by-building analysis, quantifying how much vertical change occurred on each lot, and how new buildings compare to nearby structures.

The relationship between luxury development and gentrification was assessed using linear regression, comparing changes in building height and volume to social changes in the census block groups where each building is located. Data are derived from the 2000 Decennial Census and 2019 American Community Survey five-year estimates, drawn from the National Historical GIS to standardize across census boundaries over time (Manson et al. 2021) and based on variables used in other recent quantitative studies of super-gentrification (Halasz 2018) and displacement (Sutton 2020) in New York City. The dependent variables are the change in each building's number of stories (model 1, assessing height) and floor area ratio (model 2, assessing volume). Independent variables include the percent of local populations identifying as Asian, Black or African American, or White; median household income (in inflation-adjusted dollars); the percentage of residents with a bachelor's degree or higher level of education; and the percentage of renters. Each of the latter variables is assessed both by its 2019 value (assessing correlations between present-day markers of gentrification and vertical development), and by its change from 2000 to 2019

(assessing correlations between gentrification-related change and vertical development during the study period).

Luxury development in three dimensions

The most recent boom in New York City's luxury housing market can be traced to the entrepreneurial urban governance policies of the Giuliani (late 1990s) and Bloomberg (early 2000s) mayoral administrations (Smith 1996, Busà 2017). Under Bloomberg in particular, the city supported luxury development as a way to attract transnational capital (Brash 2011), often leveraging luxury housing as an anchor for broader investment within gentrifying neighborhoods (Stein 2019). Projects started in the 2000s came to fruition by the 2010s, and during that time the luxury housing market more than doubled in capitalization to an annual average of \$18.1 billion in sales. Buildings constructed between 2000 and 2020 accounted for \$76 billion in home sales, approximately 31% of the overall luxury market. While a relatively small slice of the market, these new buildings are important because they expanded luxury housing in new directions, both architecturally through more ostentatious structures and geographically into areas that, even a couple decades earlier, were largely avoided by elite investors.

The geographic expansion of the luxury market followed two spatial patterns: intensification and expansion (Lauermann 2021). Intensification occurred in already-affluent neighborhoods through infill development (e.g. building on parking lots, or replacing rowhouses with taller structures). This form of development was most common in super-gentrified Manhattan neighborhoods on the lower west side (e.g. SoHo, Chelsea) and around the edges of historically elite neighborhoods (e.g. neighborhoods on the periphery of the Upper East Side). Expansion

occurred in still-gentrifying neighborhoods through development that differs more dramatically – in verticality and cost – from surrounding structures. This was most pronounced in northern and central Brooklyn, in neighborhoods that were historically working class (e.g. Williamsburg) and/or majority-Black (e.g. Fort Greene, Crown Heights), but which have experienced substantial racial displacement due to gentrification (Chronopoulos 2020).

The development did indeed enclose vertical space, as new construction significantly increased height and volume in the built environment (Table 1). New luxury buildings are, on average, 6.8 stories taller than the land use they replaced. They also increased the volume of built space by 210% based on floor area ratio. While there was no significant growth in the number of residential units per lot, the average amount of residential area per unit increased. This suggests luxury development produces more living space – bigger apartments, amenity spaces – but not necessarily more households. It signals a displacement effect, as less affluent households living in smaller apartments are replaced by more affluent households living with more spacious arrangements.

Table 1: Comparing new-build luxury development to previous and surrounding land use

	New luxury buildings	Buildings they replaced	Nearby buildings within 100m
<i>Number of floors</i>	9.67	2.89***	5.28***
<i>Floor area ratio</i>	4.93	1.59***	3.59***
<i>Building area (m²)</i>	6257	3989***	4637***
<i>Residential area (m²)</i>	4884	1197***	2490***
<i>Commercial area (m²)</i>	1017	2744***	1900***
<i>Garage area (m²)</i>	270	353	148***
<i>Residential units</i>	39.04	20.71	23.93***
<i>Residential area per unit (m²)</i>	229	40***	121***

Notes: Mean differences assessed with paired-sample t-tests, equal variances not assumed. Asterisks indicate a significant difference from new luxury buildings. * (p <.05); ** (p<.01), ***(p<.001)

The enclosure of vertical space also matters in relative terms. Relative height is important because unobstructed views of the skyline are often a selling point for luxury properties. That relative height is often achieved through extra-legal means, as developers leverage loopholes and zoning incentives to build taller than what is formally allowed on a lot (MASNYC 2017). This was assessed by comparing the characteristics of luxury buildings to those of surrounding buildings within a 100 meter buffer – a distance roughly equivalent to one city block. New-build projects are significantly taller and have larger volumes than neighboring buildings. These are not isolated concerns in a densely populated city like New York, where nearby construction can shroud formerly well-lit apartments in perpetual gloom. In this way, new construction could reduce the value of nearby properties – or, perhaps, appropriate a portion of their value through enclosure of public space in the skyline.

New vertical development – measured both in terms of height (change in number of stories) and volume (change in floor area ratio) – is significantly correlated to gentrification-related displacements (Table 2). Compared to the city at large, the luxury market is concentrated in areas that are predominantly (upper) middle class: more affluent, highly educated, and majority white, characteristics closely associated with gentrification in the New York context (Lauermann 2021). The vertical development assessed here follows a similar class geography. It is significantly and positively related to household income and educational attainment (and negatively related to their change, suggesting that gradual class upgrading [e.g. upper-middle to upper income] is more common than dramatic class upgrading [e.g. low to middle income]). Distinctive displacement patterns emerge. Vertical development is significantly related to a decline in Black residents, an increase in White residents, and a decrease in renters. This is broadly consistent with recent

research suggesting middle class households – especially middle class households of color – are vulnerable to displacement in super-gentrified neighborhoods (Sutton 2020, Woldoff 2016).

Table 2: Comparing vertical development to local demographics

	Model 1 $\beta(t)$	Model 2 $\beta(t)$
Dependent variable	Δ number of floors	Δ floor area ratio
Median household income, 2019	.474 (5.36***)	.253 (2.80**)
Δ Median household income, 00-19	-.314 (-5.23***)	-.151 (-2.48*)
% Bachelor's degree, 2019	.096 (1.31)	.246 (3.26**)
$\Delta\%$ Bachelor's degree, 00-19	-.070 (-1.32)	-.172 (-3.19**)
% Asian, 2019	.314 (4.67***)	.264 (3.81***)
$\Delta\%$ Asian, 00-19	.022 (.43)	-.027 (-.50)
% Black, 2019	.164 (1.95)	.167 (1.92)
$\Delta\%$ Black, 00-19	-.089 (-2.21*)	-.115 (-2.80**)
% White, 2019	.185 (1.88)	.137 (1.35)
$\Delta\%$ White, 00-19	.126 (2.36*)	.151 (2.76**)
% Renters, 2019	.398 (6.81***)	.333 (5.60**)
$\Delta\%$ Renters, 00-19	-.151 (-3.07**)	-.092 (-1.84)
F	16.49***	14.68***
R ²	.263	.244
n	568	559

Notes: OLS regressions comparing vertical changes at each luxury building to characteristics of the census block groups in which the buildings are located. Boundaries standardized to 2019 census geographies. Currency values are inflation-adjusted to 2019 USD. * (p <.05); ** (p<.01), ***(p<.001)

Overall, these patterns are consistent with super-gentrification theory. The new buildings are disruptions in the built environment, with heights and volumes that are out of place with the surrounding neighborhood. Vertical development is more closely associated with middle-to-upper class transitions typical of super-gentrification, rather than working-to-middle class transitions typical of conventional gentrification. This lends credence to the idea that vertical development indicates extreme degrees along a gentrification continuum: by crowding additional capital into already-desirable neighborhoods, it enables concentration of wealth and further class upgrading. This intensification also introduces new kinds of displacement effects. Displacement could be

experienced by both the last remaining members of the pre-gentrification working class, and newer generations of middle class residents, displacement patterns previously observed in neighborhoods like Brooklyn's Park Slope (Halasz 2018) or Manhattan's Stuyvesant Town (Woldoff et al. 2016).

Conclusion

To summarize, luxury construction involves significant vertical growth compared to the land use it replaced, this growth is out of context with surrounding land use, and it is spatially correlated with gentrification-related displacements. There is ample evidence to support the central argument of the paper: that vertical development contributes to super-gentrification, the further upgrading of already gentrified places which unleashes both old and new forms of displacement as gentrified neighborhoods transform into more exclusive enclaves. It does so by facilitating over-investment in already affluent neighborhoods, a “repetition of land” (McNeill, 2020, p. 823) made possible by stacking layers of real estate atop each other. This process encloses previously unbuilt skyline and subterranean spaces, and unleashes new forms of displacement by concentrating so much capital in atop a relatively small area of land (e.g. middle class displacements).

Such enclosures often entail extra-legal tactics, forms of “space grabbing” (Liong et al. 2020) that commodify the open space of the skyline. In the New York context, vertical development often bends the letter and spirit of land use law, in three ways. First, there are a number of *legal but socially questionable* tactics, like the ironic appropriation of benefits for affordable housing by luxury developers. These include: the 421(a) tax abatement for including affordable units in new buildings; the 80/20 Program which allows developers to issue tax-exempt bonds if 20% of units are set aside for low income housing; and Inclusionary Housing Program

zoning incentives which allow developers to increase floor area ratio beyond zoning regulations, in exchange for building affordable housing. New luxury buildings thus often include a small amount of low income housing, though the new supply is simply insufficient to replace the broader loss of modestly-priced housing stock. One recent study estimates that for each affordable unit built in recent years, 314 eligible households applied (Smith et al., 2020).

Second, enclosure is facilitated by *loopholes* in building codes and land use regulations (MASNYC 2017). The most relevant is that the technical definition of a building story is loosely regulated. Developers can build taller structures by adding higher ceilings or mechanical stories, non-residential floors for elevator equipment, air conditioning units, or completely empty “wind shear” spaces that reduce wind pressure on super-tall structures. Another key loophole is the zoning lot merger, which allows developers to purchase unused air development rights from neighboring lots, often gerrymandering together a series of mergers from lots that are only tangentially connected.

Third, *illegal* enclosure tactics include building beyond the maximum size and then daring authorities to force a demolition. A recent example of this is a luxury project at 200 Amsterdam Avenue, which may have as many as 20 illegal stories (Chen 2020). A content analysis of the *New York Times* archive suggests that luxury developers have employed this practice since at least the 1970s (e.g. a 1973 conflict over illegal stories on a luxury building at 614 Second Avenue). Another illegal tactic is ignoring building code citations and stop-work orders. One recent study estimates that developers have dodged at least \$31 million in unpaid fines for building façade violations alone, much of it related to illegally built scaffolding on sidewalks and public streets (Haag 2020).

By way of conclusion, the geographies of vertical gentrification merit further research, especially work that explores its implications for everyday life in gentrifying neighborhoods (exploring concepts like those proposed by Atkinson [2019] or Shilon and Eizenberg [2021]). Promising threads include the political economy of vertical sprawl, in particular the role of financialization in enclosing and extracting value from skyline space (building on ideas from, among others, Nethercote [2018] and Pow [2017]). Another is the development of geospatial tools for assessing urban morphology, in particular by leveraging tools like lidar to create building height and volume data in the many places where such data are scarce (engaging with technical procedures like those used by Bonczak and Kontokosta [2019] or Bruyns et al. [2021]). A final promising area for future research is the interaction of vertical development and the often racialized aesthetics of gentrification (in conversation with recent work like Berglund and Gregory [2019] or Summers [2019]).

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