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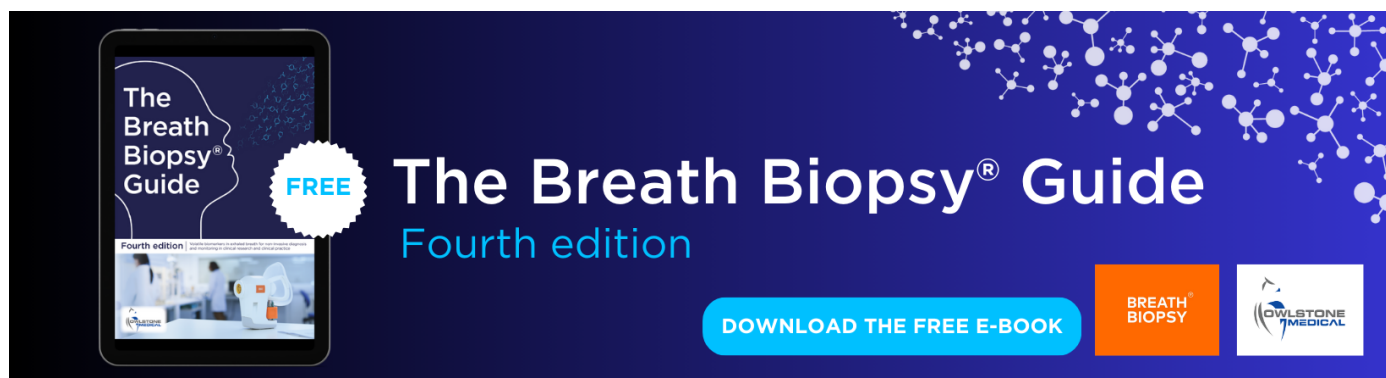
Climate gentrification: from theory to empiricism in Miami-Dade County, Florida

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Abstract

This article provides a conceptual model for the pathways by which climate change could operate to impact geographies and property markets whose inferior or superior qualities for supporting the built environment are subject to a descriptive theory known as ‘Climate Gentrification.’ The article utilizes Miami-Dade County, Florida (MDC) as a case study to explore the market mechanisms that speak to the operations and processes inherent in the theory. This article tests the hypothesis that the rate of price appreciation of single-family properties in MDC is positively related to and correlated with incremental measures of higher elevation (the ‘Elevation Hypothesis’). As a reflection of an increase in observed nuisance flooding and relative SLR, the second hypothesis is that the rates of price appreciation in lowest the elevation cohorts have not kept up with the rates of appreciation of higher elevation cohorts since approximately 2000 (the ‘Nuisance Hypothesis’). The findings support a validation of both hypotheses and suggest the potential existence of consumer preferences that are based, in part, on perceptions of flood risk and/or observations of flooding. These preferences and perceptions are anticipated to be amplified by climate change in a manner that reinforces the proposition that climate change impacts will affect the marketability and valuation of property with varying degrees of environmental exposure and resilience functionality. Uncovering these empirical relationships is a critical first step for understanding the occurrence and parameters of Climate Gentrification.

Introduction

This article provides a conceptual model for the pathways by which climate change could operate to impact geographies and property markets whose inferior or superior qualities for supporting the built environment are subject to a descriptive theory known as ‘Climate Gentrification’ (hereinafter, ‘CG’). To provide empirical resolution to a theory of CG, this article utilizes Miami-Dade County, Florida (‘MDC’) as a case study to explore the potential existence of consumer preferences that are based, in part, on perceptions of flood risk and/or observations of flooding. These preferences would be anticipated to be amplified by climate change in a manner that reinforces the proposition that climate change will affect the marketability and

valuation of property with varying degrees of exposure and resilience functionality. It is speculated that comparatively high- and low-elevation properties in MDC will be more or less valuable overtime by virtue of a property’s capacity to support habitation in the face of nuisance flooding and relative sea level rise (‘SLR’).

This article tests the hypothesis that the rate of positive price appreciation in MDC from 1971–2017 is positively related to and correlated with incremental measures of higher elevation of the underlying properties (the ‘Elevation Hypothesis’). As a reflection of an increase in observed tidal nuisance flooding and SLR since 2000 (Southeast Florida Regional Climate Change Compact 2015), the second hypothesis is that the rates of price appreciation in the lowest elevation cohorts are below the rates of appreciation of higher elevation

cohorts since 2000 (the ‘Nuisance Hypothesis’). Both hypotheses are evaluated across MDC, as well as within various jurisdictions within MDC.⁵ If validated, these hypotheses would provide partial evidence that market preferences reward and penalize properties with higher and lower elevations, respectively. While a validation of these hypotheses is by no means definitive in establishing a link between the perception of flood risk and consumer preferences, the inference of such a relationship would highlight one of multiple pathways by which CG may manifest to disrupt economically vulnerable communities.

The relevance of a theory of CG is defined by the need to promulgate a broader awareness of the processes shaping socioeconomic vulnerabilities and not just physical environmental exposure (Füssel 2007, O’Neill *et al* 2014). Likewise, it highlights the dynamic and dependent relationships of elements of the built environment (e.g. housing, transportation, public facilities) that may either exacerbate vulnerabilities associated with climate change impacts or are themselves exacerbated by such impacts (Räsänen *et al* 2016, Walker *et al* 2016). As climate adaptation planning internalizes the implications of resource constraints (North and Longhurst 2013) and due process (Sovacool and Linnér 2016) within the context of distributive and procedural justice (Bulkeley *et al* 2013, Shi *et al* 2016), the onus of the public sector is to contextualize existing institutional parameters that define both the vulnerability and exposure of sensitive populations (Anguelovski *et al* 2016, Chu *et al* 2017). In this case, understanding the institutional and economic mechanisms of property markets are arguably critical for long-term planning. Whether it is land use or affordable housing planning, the common denominator is the relative availability and price of property and real estate. If CG proves to be an accurate description of economic processes and behaviors, high-elevation property, shaded or wind-cooled property, fresh water resourced property, geologically stable property, ecologically diverse property, pollution-free property, and property with resiliently design buildings will all provide attributes of market valuation that complicate the existing capacities of society to house and shelter its most vulnerable populations.

Climate gentrification

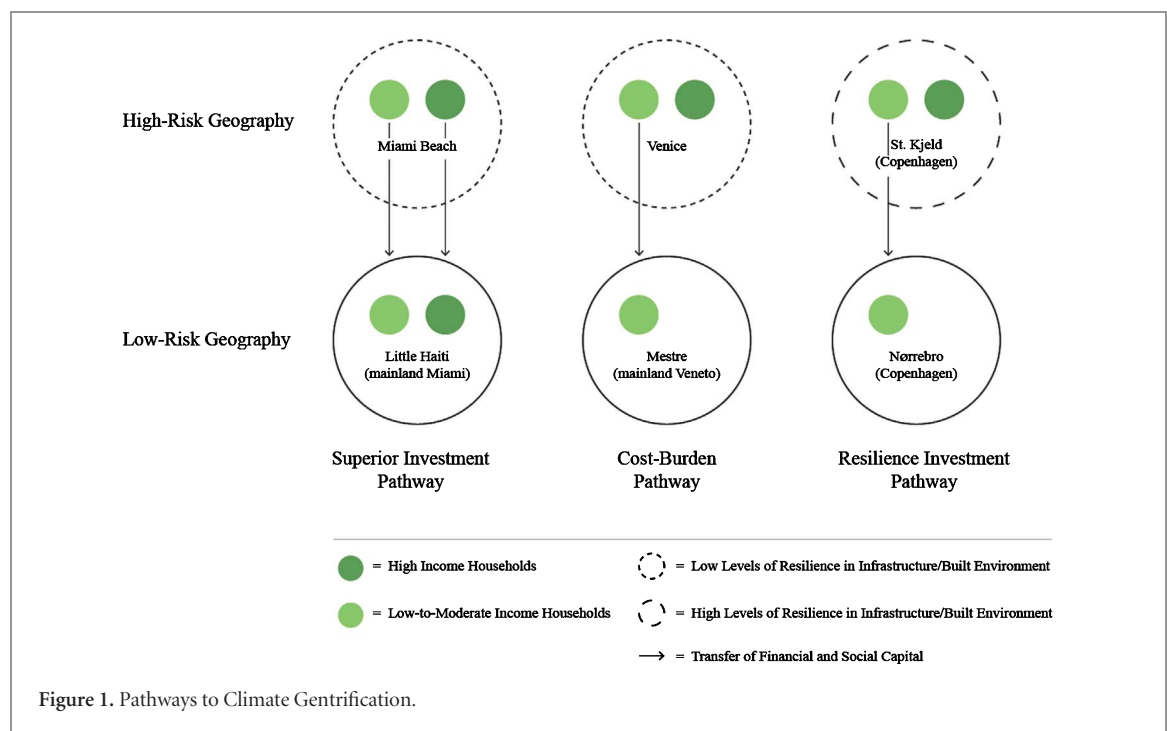
While CG has been popularized in the media (Flavelle 2016, Bolstad 2017), there has been limited scholarship defining the parameters of this emerging theory (Keenan and Weisz 2017). CG is based on a simple proposition: climate change impacts arguably make some property more or less valuable by virtue of its

capacity to accommodate a certain density of human settlement and its associated infrastructure. The implication is that the price volatility associated with rent seeking, speculative investment, or superior purchasing power is either a primary or a partial driver of the patterns of urban development that lead to displacement (and sometimes entrenchment) of existing populations consistent with conventional framings of gentrification (Slater 2006, Lees *et al* 2013). While geographic exposure of property is a primary locational and environmental attribute of CG, the relative degree of engineered resilience within buildings and infrastructure systems on such property may also provide a secondary axis of analysis that may explain why two equally exposed property markets of similar constructed attributes may perform differently over the long-term in the face of climate change (Hollnagel 2014).

CG may arguably manifest in one of several pathways, as represented in figure 1. The first pathway is what primarily frames this article. It relates to the substitution of property from an inferior to a superior location. This may also be viewed as a selection of properties with superior locational and environmental attributes among alternative investment options with inferior qualities. For purposes of representational simplification in figure 1, it is assumed that there are only two local options for settlement and investment, and it is assumed that there are two population wealth cohorts—high-income (i.e. rich) and lower-to-moderate income (i.e. not rich). Superiority of one option to another is adjudicated by a property’s comparatively lower level of physical environmental exposure or its high level of constructed attributes for engineered resilience and/or hazard mitigation. In this article, superiority is informally hypothesized to be high-elevation geographies (e.g. Little Haiti in Miami) who are less vulnerable to flooding, in part, because of a known reliance on gravitational flows to manage water in MDC. More fundamental to the theory, it describes a behavior of moving financial capital to a geography that offers superior risk-adjusted returns for accommodating real estate and infrastructure. It may also offer superior attributes for accommodating communities and not just assets. This pathway comes with the caveat that some households may otherwise be trapped for a lack of resources to relocate (de Sherbinin *et al* 2011, Black *et al* 2013) or because of outstanding mortgage liabilities (Bricker and Bucks 2016). This pathway is collectively referenced as the ‘Superior Investment Pathway.’

As represented in figure 1, the Superior Investment Pathway is shown within the context of two options. In reality, there may be many local and non-local options. It is conceptualized that households—particularly low-to-moderate income households—would gradually move from the coastal barrier islands (e.g. Miami Beach) to the mainland of MDC where elevations are significantly higher. However, as economic

⁵ In the US, not all portions of a county are part of a municipal jurisdiction. As such, unincorporated portions of a county are entirely governed and serviced by the county.



productivity and jobs may be undermined by SLR, populations may leave MDC altogether (Hauer *et al* 2016). As such, CG may operate across multiple scales (i.e. neighborhoods, municipalities, states, regions, countries). For instance, SLR impacts in MDC may lead to CG in central Florida, which is much less physically exposed. Likewise, Atlanta may be subject to CG stemming from coastal SLR on the east coast of the US because of its superior labor and housing opportunities (Hauer 2017). While these networks, transfers and transitions are difficult to model, emerging research in demographics suggests that CG may operate at multiple scales beyond those simplified representations in figure 1 (Curtis and Schneider 2011, Neumann *et al* 2015). Interview data suggests that speculative property investors are already hedging on south Florida's gradual exodus to central and north Florida.

The second pathway for CG relates to the deterioration of environmental conditions such that the overall cost of living can only be feasibly borne by wealthier and wealthier households, as climate change impacts manifest in greater frequency and intensity. Gentrification happens inversely by the fact that vulnerable populations are unable to afford to live *in situ*. This would be primarily due to the increased costs of insurance, property taxes, special assessments, property repairs, transportation and consumer goods, as well as a loss in overall productivity (e.g. sitting in traffic in water-clogged streets). For comparatively wealthy households, prior research has suggested that the 'risk of coastal flooding seems inconsequential in determining property values due to the substantial premiums that appear to be associated with proximity to coastal water' (Bin and Kruse 2006, p 137). For those households who are more sensitive to the carrying costs

associated with such hazards, there may be no alternative but to relocate. Those that remain are those who are either trapped or have invested speculative capital that they can 'afford' to lose. An example of this is in Venice, Italy where environmental conditions, including relative SLR and unabated tourism, have resulted in a total cost-burden that has undermined class diversification (Moretti 2012). This pathway is collectively referenced as the 'Cost-Burden Pathway.'

It would be anticipated that over time such a phenomenon would occur on the barrier islands of MDC, such as Miami Beach. However, research models suggest that adaptation investments in risk mitigation likely have a threshold by which even informed (and comparatively wealthy property owners) will eventually abandon their investments (McNamara and Keeler 2013, Treuer *et al* 2018). As such, it should be qualified that the pathways to CG are limited in their duration and intensity, as threshold dynamics are highly unpredictable (Haer *et al* 2017). Eventually, in the face of SLR, it can be argued that even the most-wealthy will likely have to abandon Venice and Miami Beach.

The third pathway relates to the unintended consequences of making public investments in the engineered resilience of buildings and infrastructure (Ayyub 2014, Cerè *et al* 2017). As a consequence of these investments, the underlying property increases in value by virtue of the fact that the positive externalities associated with performance of the resilience investments represents a superior outcome to the status quo—even when netted-out by any costs associated with the taxes for building and maintaining the resilience infrastructure (Bunten and Kahn 2017). Therefore, any tax consequences associated with the investments would be absorbed by increases in

property valuation and/or rent payers. This pathway is a derivative of the well-developed concept of ‘Green Gentrification,’ wherein investments in sustainability amenities and infrastructure are unevenly distributed or otherwise associated with gentrification (Checker 2011, Curran and Hamilton 2012, Bryson 2013, Sandberg 2014, Curran and Hamilton 2017, Gould and Lewis 2017, Anguelovski *et al* 2018). Although not widely studied, the exemplar case for this pathway is the St. Kjeld Climate District in Copenhagen where a broader resilience strategy to revitalize a neighborhood led to some displacement from increased rents (Kjaer 2015) and the marginalization of existing homeowners (Baron and Petersen 2016). This pathway is referenced as the ‘Resilience Investment Pathway.’

However, there is an alternative hypothetical scenario wherein resilience investments operate to reduce risk and exposure to such an extent that it reduces long-term tax and insurance liability. In Copenhagen, the resilience investment brought the neighborhood real estate up to ‘market rate.’ However, in this alternative-scenario, the market value becomes more competitive among alternative substitutes because of the comparatively lower carrying costs (e.g. taxes and insurance).

Each of the three pathways represent possible behaviors that may lead to CG. They do not independently represent deterministic conditions, as exogeneity in property markets often defy current methodologies for pinpointing long-term valuation trends or preferences. CG is referenced as a descriptive theory for understanding emerging trends otherwise referenced as conventional gentrification. Climatic impacts should be understood within a broader array of influences driving gentrification, including historic racial segregation, income inequality, and the spatial distribution of jobs, transportation, and housing. However, with CG, it can be argued that climatic influences will increasingly play an important role in the weighted factors driving investment and locational decisions of households, investors, and financiers. The empirical portion of this article seeks to identify potential methodologies and measurements that may validate the underlying behaviors inherent in the Superior Investment Pathway.

Research design and methodology

The research design of this article is based on a mixed-methods approach undertaken in two distinct phases: (i) theory development and (ii) empirical data analysis and hypothesis testing (Creswell 2013). In the first phase, exploratory research was undertaken in MDC as it relates to vulnerability assessment and the identification of existing resilience activities and capacities. MDC was selected as a case study based on its popular and scientifically determined vulnerability to climate change impacts, including increased nuisance

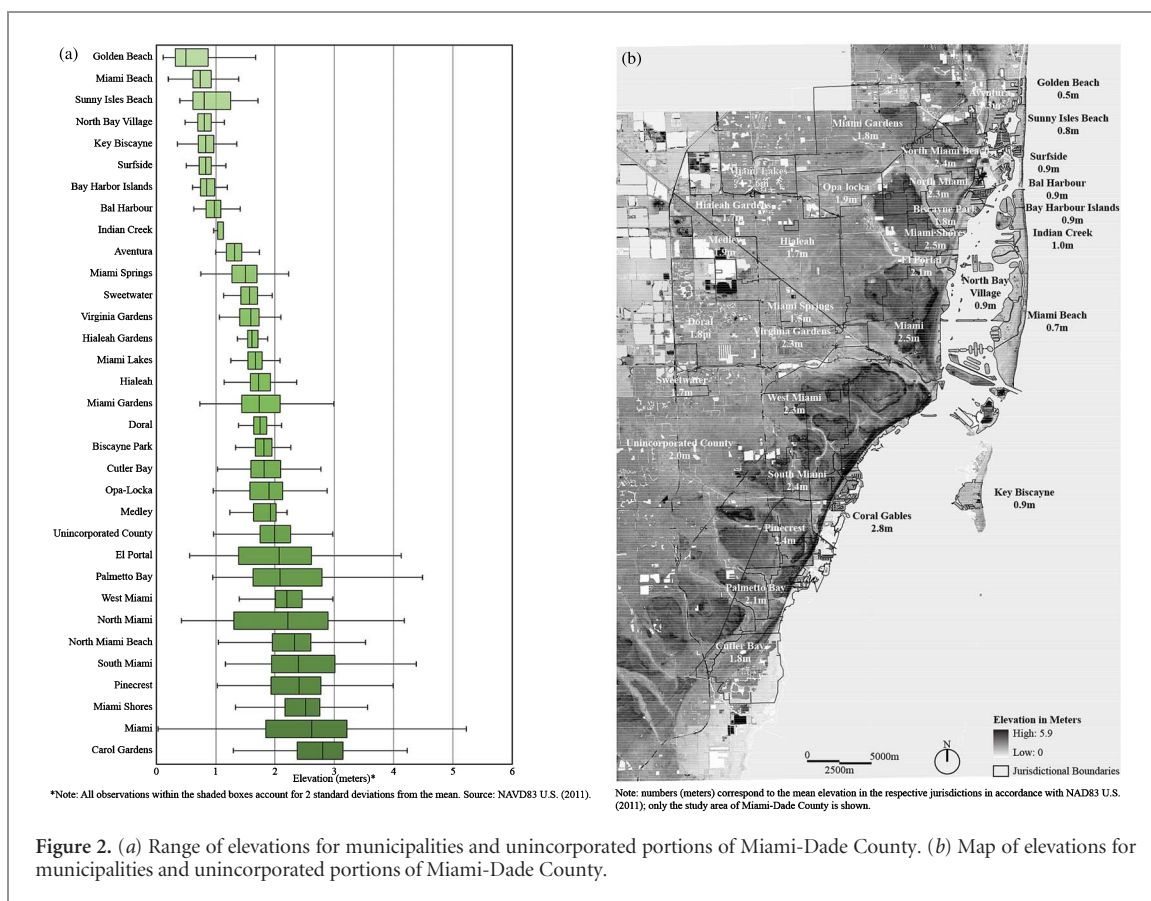
flooding and SLR inundation (Yin 2013). As part of the theory development phase, semi-structured interviews were conducted with numerous ($n = 48$) local officials, researchers, real estate developers, investors, financiers, residents and activists. Interviews suggested a consensus that high-elevation property would increase in value over the long-term with SLR and that preferences relating to flood risk (climate change related or not) were increasingly being recognized among consumers and real estate actors. Interviews confirmed that speculative investment in certain high-elevation communities is well underway. The empirical aspects of this article seek to identify whether a validation of the hypotheses could partially explain behaviors consistent with a Superior Investment Pathway.

Detailed property sales information was obtained from the Miami-Dade County Property Appraiser’s Office. The dataset contained approximately 800 000 properties and included records for property type, unit count, lot and building size, property and building values, year-built, bed and bath counts, market and property tax assessment values, exemptions, owner name, address, zoning, and the last three transactions (the ‘Property Dataset’). Property records with incomplete or misregistered values were culled. In order to understand how patterns might be conditioned or contextualized by elevation, the analysis involved combining the Property Dataset with elevation data (1/9th arc-second) for Miami-Dade County sourced by the United States Geological Survey (‘Elevation Dataset’) (USGS 2017).

The economic analysis comprised of two principle steps. First, a price index was constructed to allow a comparison of price appreciations of properties across the entire Property Dataset. This normalization of price appreciation allowed for a more resolute apples-to-apples comparison of price appreciation by and between different property characteristics. Second, a linear mixed effects model was constructed and coded to understand how the relationship between elevation and price appreciation varied across jurisdictions—holding various other explanatory variables constant (i.e. square footage, sale date, and construction year). Both the price indexing and the regression analysis were conducted in parallel using the programming languages R and Python.

Empirical modeling and findings

From the cleaned Property Dataset, properties containing single-family homes were isolated. The resulting Property Dataset was reduced to 107 984 properties. Single-family homes were selected to the exclusion of condominium and cooperative properties because these properties are arguably less sensitive to the nuisance and risk of loss from intermediate flooding because of their varied base floor elevations and insurance structures. Second, condominium development



patterns were spatially concentrated and did not offer much insight for patterns across time and elevation. Commercial real estate was also removed because valuations are largely dependent on net operating income and investment cycles (Geltner 2015).

Figure 2 represents the range of elevations found in each of the selected municipalities and the unincorporated portions of MDC. Not all municipalities in MDC were selected for analysis because certain municipalities did not have either a meaningful internal variation in elevation or a robust level of data. With the revised Property Dataset and the Elevation Dataset, two computational strategies were deployed. As is discussed in the Supplemental Methodology, the first was to construct a multiplicative price index (Bailey *et al* 1963, Hill 2013) and the second was to conduct a linear mixed effects regression on modified samples within the subject datasets (Peng and Lu 2012, Reddy 2015).

Rate of appreciation and elevation findings

Figure 3 represents a range of jurisdictions wherein the indexed valuation multiple was decomposed for elevation cohorts measured in 1 meter increments. Measurement anomalies below sea level (< 0 meter) were spot-checked and either culled or grouped into the lowest elevation cohort. The values on the y-axis are multiples indexed to 1971. The total sample size of properties broken down by elevation cohort is found in supplemental table 1 available at stacks.iop.org/ERL/13/054001/mmedia. For all subject

properties, figure 3(a) demonstrates that properties in the 2–3 meter and 3–4 meter cohorts have had slightly higher rates of price appreciation relative to the 1–2 and 0–1 meter cohorts. This finding would be consistent with a validation of the Elevation Hypothesis. While properties in the 4–5 meter and 5–6 meter elevation cohorts have lagged the group, this finding is less relevant or impactful because these properties represent just 1.41% ($n = 1518$) of the entire sample. This marginal distribution holds true across all of the evaluated jurisdictions. As such, elevation cohorts above 4 meters can generally be ignored.

Figure 3(b) highlights a similar pattern for unincorporated parts of MDC, which accounts for 58% ($n = 58\ 804$) of the sample. Unincorporated portions of MDC suggest a slightly stronger relationship to elevation than the entire sample represented in figure 3(a). As a general observation, the 3–4 meter cohort has slightly outperformed the 2–3 meter cohort. The 2–3 meter cohort has slightly outperformed the 1–2 meter cohort and the 1–2 meter cohort has outperformed the 0–1 meter cohort. This spread has been particularly pronounced since approximately 2000. Specific to the City of Miami, figure 3(c) represents a similar but less conclusive pattern to those found of figures 3(a) and (b). While the 0–1 meter cohort has lagged the group for most of the time period, the relationships between cohorts are less clear than unincorporated MDC. In particular, there has been a recent increase in rates of appreciate in the 0–1 meter

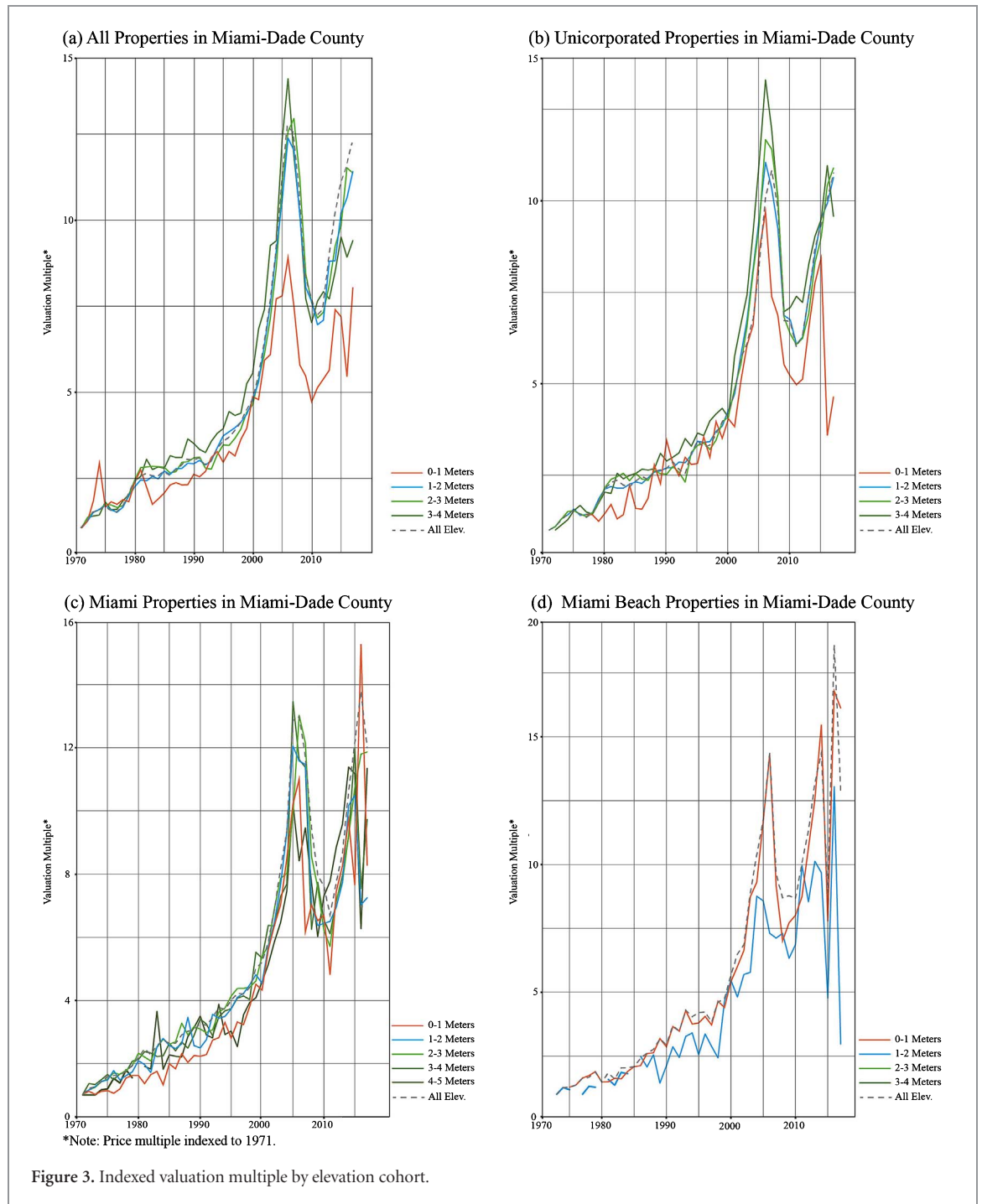


Figure 3. Indexed valuation multiple by elevation cohort.

cohort. This might be explained by properties benefiting from their proximate location to a recent boom in luxury coastal high-rise properties. Overall, the City of Miami accounts for just 6.70% ($n = 7234$) of the sample.

Consistent with a validation of the Nuisance Hypothesis, the 0–1 meter cohort has significantly lagged the group since approximately 2000 for all properties in MDC in figure 3(a). A similar pattern is found among unincorporated properties in figure 3(b), with a precipitous drop in price appreciation in approximately 2015 for the 0–1 meter cohort. In addition,

7 of the 12 jurisdictions represented in supplemental figure 1 all demonstrated a similar pattern wherein the lowest elevation cohorts (i.e. either 0–1 or 1–2 elevation cohorts) tracked the general group until approximately 2000, at which point they begin to underperform relative to the general track of the elevation cohorts.

As represented in figure 3(d), properties in the City of Miami Beach have expressed a notably negative relationship between elevation and price appreciation. This is likely explained by the proposition that spatial proximity to the water has a positive impact on both valuation and rate of appreciation, at least as long as those

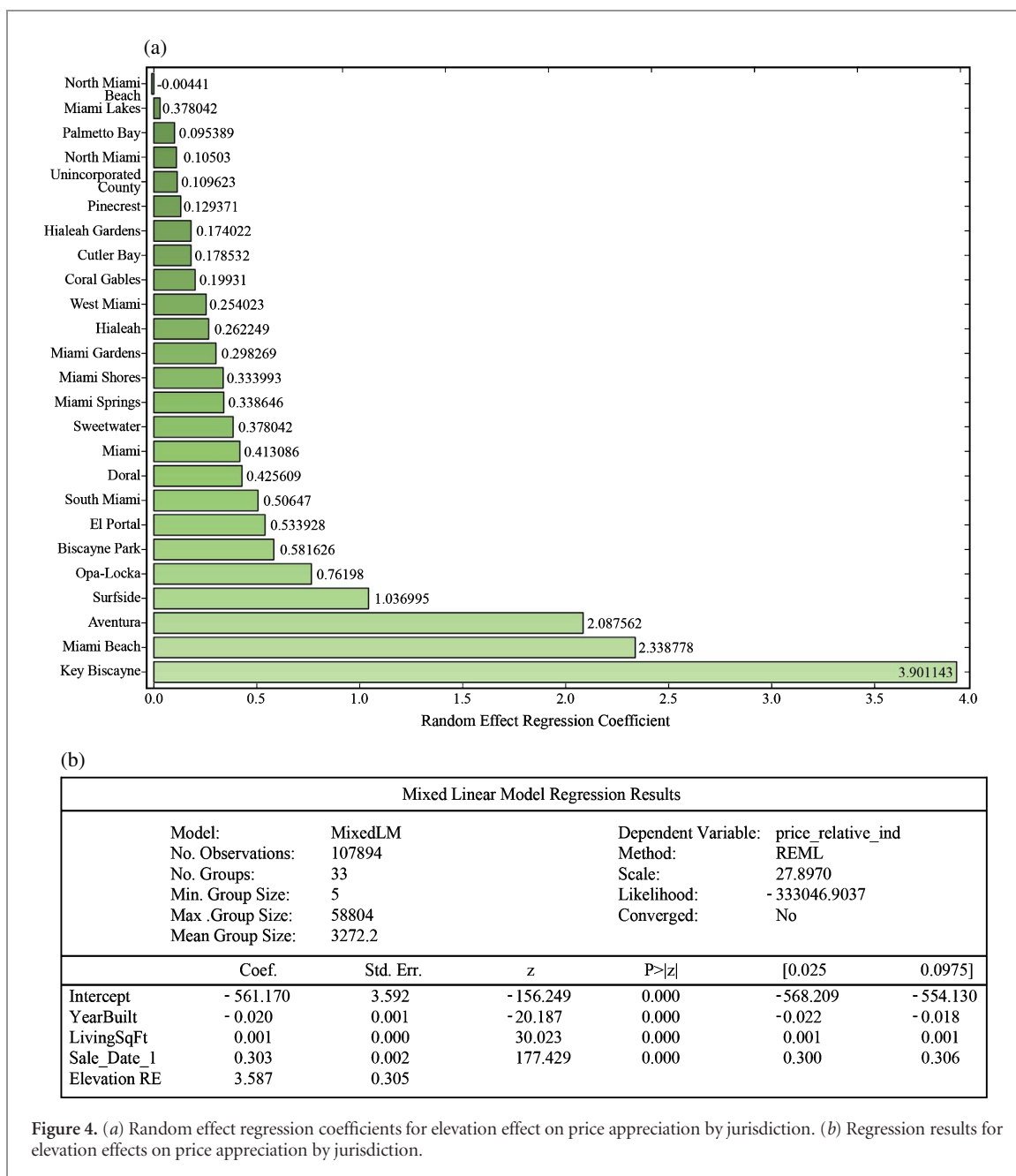


Figure 4. (a) Random effect regression coefficients for elevation effect on price appreciation by jurisdiction. (b) Regression results for elevation effects on price appreciation by jurisdiction.

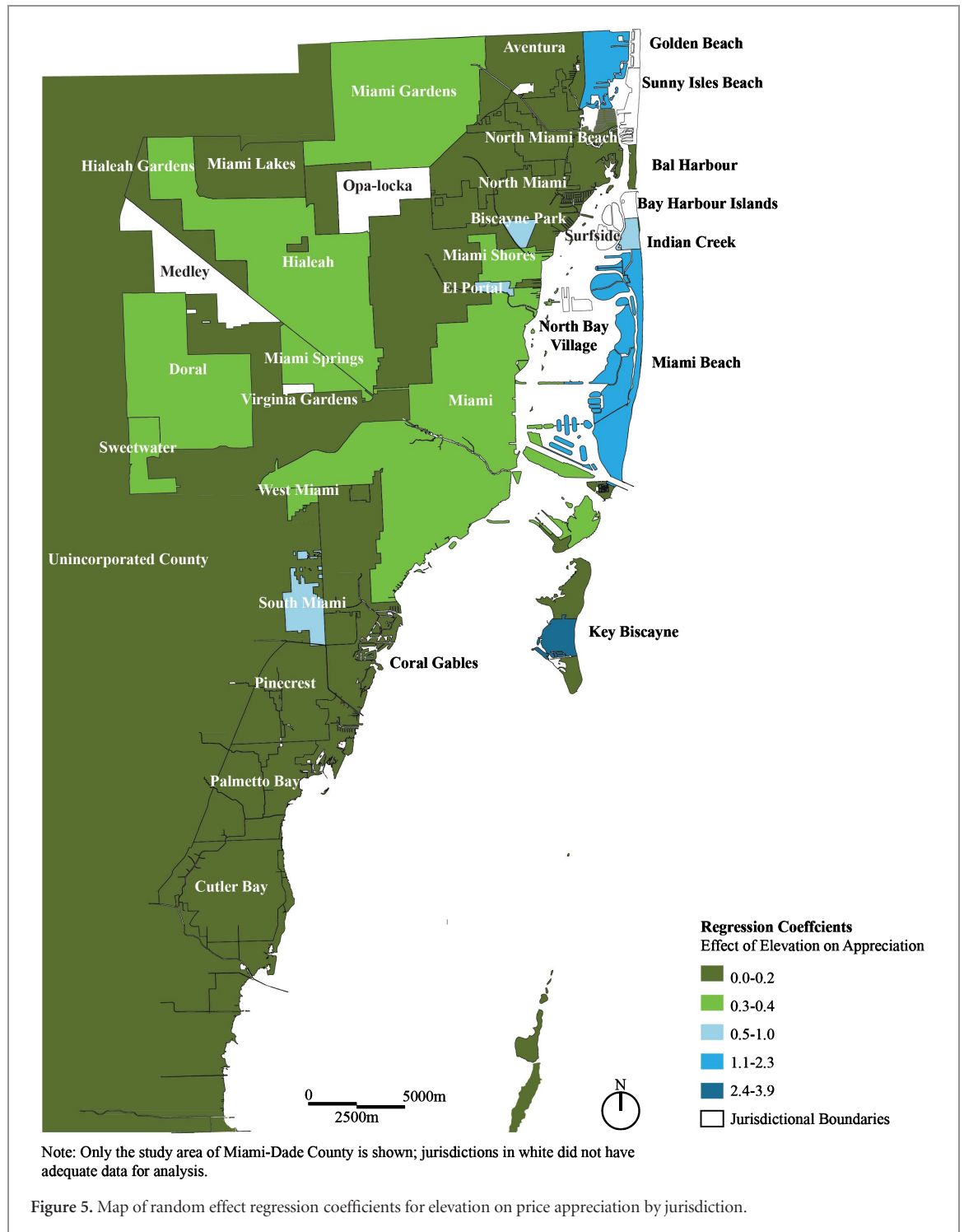
bodies of water are deemed to be amenities (McNamara *et al* 2015). Supplemental figures 1 and 2 contains sets of figures for those municipalities that demonstrated varying degrees of positive and negative relationships between price appreciation and elevation. Overall, 11 jurisdictions accounting for 76% ($n = 82\,068$) of the overall sample demonstrated some measure of positive relationships. By contrast, 5 jurisdictions accounting for 13% ($n = 14\,014$) of the sample were founded to have some negative relationship. While 17 jurisdictions had either inadequate elevation granularity or inconclusive relationships, these jurisdictions accounted for 11% ($n = 11\,798$) of the sample.

Regression findings

Utilizing a linear mixed effects model, the price appreciation index was regressed for elevation, construction

year, date of sale, and square footage, within each of the jurisdictions and the unincorporated portions of MDC with each variable representing a different group. Thereafter, the method sought to obtain the specific effect of elevation on price appreciation for each of these jurisdictions, excluding municipalities ($n = 6$) with less than 200 single-family units ($n = -672$). Elevation was found to have a positive effect on price appreciation in 24 of the 25 jurisdictions under study. Those 24 jurisdictions represent 98.1% of the 107 312 properties subject to the regression. Only North Miami Beach exhibited a negative relationship between elevation and price appreciation, albeit a weak one.

Figure 4 highlights the regression results and the range of elevation regression coefficients for the subject jurisdictions. As figure 5 represents, the 3 jurisdictions



with the strongest coefficients are all on the coast. Overall, 13 (54%) of the 24 jurisdictions with positive coefficients are land-locked, although nearly all of the land-locked jurisdictions have significant collections of lakes and drainage canals. The largest single jurisdiction represented in the sample, unincorporated MDC ($n=58\ 804$; 54%), showed a positive correlation. Overall, the sample of all subject properties showed a positive correlation between elevation and appreciation when controlling for the aforementioned variables.

Discussion

It is difficult to identify the effect of elevation on price appreciation independent of other variables and locational factors. There are many spatial qualities that cannot be easily controlled for. The historical development patterns of MDC are complex, and uneven patterns at different elevations runs in contradiction to many American cities where the historical patterns of development dictated concentrations of wealth on high elevations. Since elevation was the only locational

factor, it is possible that the results simply demonstrate a correlation between location and price appreciation. However, the jurisdictions that exhibit a positive relationship between elevation and price appreciation represent the vast majority of all housing units in MDC.

This overall positive correlative effect provides evidence in support of validating the Elevation Hypothesis. This evidence is in addition to the observations of positive relationships between price appreciation and elevation cohorts in jurisdictions accounting for 76% ($n = 82\,068$) of the sample population. However, inferential connections between the results of the two modes of analysis is inconclusive for some jurisdictions. In the case of Miami Beach, there was an observed negative relationship between price appreciation and elevation cohorts, yet the city had the second highest regression coefficient. This could be explained by the two different analytical methods, wherein elevation breaks in the regression were more precise than the coarse 1 meter cohorts. However, more precise elevation measurements may be inconsequential in the real world wherein the path of water may not be obstructed by such nuances in elevation. Future research will need to find resolution between observations and meaningful breaks and location of elevation. That is to say that not all elevation represents equal units of risk or nuisance given the underlying bathymetry and surface water management capacities of MDC.

There is robust evidence supporting a validation of the Nuisance Hypothesis. The logic behind the formulation of the Nuisance Hypothesis was based on the proposition that increased nuisance flooding may have been negatively impacting low elevation properties in the market. Interviews with real estate brokers suggested a certain intelligence about high nuisance portions of MDC among the brokers. While the findings support the hypothesis, they do not necessarily speak to a validation of the causal logic. However, in some areas, lower elevation properties are grossly underperforming relative to other elevation cohorts. Likewise, this trend appears to have accelerated in and around 2000. While measurements of SLR on the East Coast of the US were observed to accelerate in the 1990s (Miami-Dade Sea Level Rise Task Force 2014, Davis and Vinogradova 2017), observed incidents of increased flooding in MDC appear to have accelerated just after 2000 (Wdowski *et al* 2016). This pattern of acceleration was observed not just in a majority of the sample, as represented in figures 3(a) (All Properties), figure 3(b) (unincorporated MDC), and, to a lesser extent, in figure 3(c) (Miami), but also in areas such as El Portal, Miami Shores, and North Miami Beach, which are subject to ongoing tidal flooding and King Tides (see supplemental figures 1(b), (d) and (e), respectively).

The evidence supports a validation of the Elevation Hypothesis with the broader inference that higher elevation properties may have a slight advantage in terms of higher rates of price appreciation that may

be increasing with time. By contrast, the evidence supporting a validation of the Nuisance Hypothesis suggests that the lowest elevation properties may be at a price disadvantage. In relating these findings to a theory of CG, the Elevation Hypothesis provides support for the long-term occurrence of the Superior Investment Pathway. Over time, it could be argued that higher elevation properties in MDC will become more attractive because of their superior rates of appreciation.

This may also be viewed within the context of the Nuisance Hypothesis wherein the lowest elevation properties are not appreciating at the same rate and therefore are inferior investments—assuming that rate of appreciation is a significant factor for investment. The heuristics of real estate investment suggest that this rational maximization through long-term appreciation does not always hold (Salzman and Zwinkels 2017). If investors/owners see a relative disadvantage or opportunity cost to their lower elevation properties, then this may be one of many other factors that lead to spatial relocation or the disposition of a particular asset. Arguably, this may reinforce a Cost-Burden Pathway if lower-to-moderate income households have more at stake in terms of their overall net-wealth. The cost burden may be increased by virtue of a cycle of declining tax rolls and fewer and fewer tax payers. In all cases, this article provides support for the proposition that climate change impacts could exacerbate environmental and locational effects and qualities in property that may already be reflected to a certain extent in the housing market.

Uncovering these effects and qualities is a critical first step for monitoring the incremental occurrence of CG. What can the public sector do to mitigate the negative consequences? Land use regulators will be tasked with evaluating the consequences of relocation and densification, particularly on higher-elevations (e.g. inclusionary zoning). As previously theorized, resilience investments will also have socioeconomic consequences that should be accounted for. The challenge for the public sector is to build a sensitivity to the economic effects of climate change and climate change adaptation on property markets within existing policy regimes.

Conclusions

Whether it is through a superior investment among substitutes; a function of being driven-out through increased consumer cost-burdens; or, a matter of public resilience investments that drive up the value of property, a theory of CG gives recognition to the various pathways by which climate change impacts may drive investment and settlement patterns. In MDC, CG has been speculated in popular discourse to already explain gentrification patterns. This article has demonstrated that the elevation of one's home in MDC could matter in terms of long-term price appreciation. The findings

would suggest that a consumer preference may exist in favor of higher elevation properties. Likewise, lower elevation properties may be subject to lower rates of appreciation due to flooding concerns. In light of accelerated SLR, these preferences may become more robust and may lead to more widespread relocations that serve to gentrify higher elevation communities.

Future research will be tasked with understanding preferences and heuristics among relevant households and investors. In particular, there is a need to understand threshold dynamics that shape investment and relocation decision-making. As such, a diagnostic understanding of CG provides another step in a long journey of adaptation that seeks to refine our understanding of vulnerability in the name of protecting our most vulnerable populations from long-term maladaptation in human settlements.

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