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The Catalyst Effect of Historic Preservation: A Spatial Analysis of the Impact of Historic District Designation on Housing Renovations in New York City

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The Catalyst Effect of Historic Preservation: A Spatial Analysis of the Impact of Historic District Designation on Housing Renovations in New York City

by

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Contents

1 Introduction

The benefits ascribed to historic preservation are manifold in terms of linking the past with the present. Historic resources [1] embody environmental and psychological value that generates social and economic benefits (Sable & Kling, 2001). From a social standpoint, many perceive that historic designation confers honorific status or prestige (Noonan, 2007; Noonan & Krupka, 2011). Moreover, designation status is an amenity that improves both neighborhoods and surrounding areas (Ahlfeldt & Maennig, 2010; Zahirovic-Herbert & Chatterjee, 2012). The communal effort to preserve these assets fosters social cohesion (Sable & Kling, 2001), thereby establishing the fabric of designated communities (Rose, 1981, p. 480; Noonan, 2007, p. 18; Ahlfeldt & Maennig, 2010). Historic districts often receive credit for providing economic benefits to property owners and the overall community by spurring investment and development (Wojno, 1991; Listokin, Listokin, & Lahr, 1998; Sable & Kling, 2001). Various accounts show that historic designation raises property values (Ford, 1989; Clark & Herrin, 1997; Coulson & Leichenko, 2001; Leichenko, Coulson, & Listokin, 2001; Coulson & Lahr, 2005; Noonan, 2007; Zahirovic-Herbert & Chatterjee, 2012), generates tourism, and creates jobs (Wojno, 1991; Listokin et al., 1998; Sable & Kling, 2001).

These benefits, both tangible and intangible, spill over into adjacent undesignated neighborhoods (Wojno, 1991; Listokin et al., 1998; Zahirovic-Herbert & Gibler, 2014). The constraints on property use along with the economic merits of historic districts are critical points in the debate over preservation policies. Although preservationists acknowledge the impact of preservation laws on property use (Rypkema, 2000), they assert that these policies serve the public interest (Noonan, 2007, p. 27; Ahlfeldt & Maennig, 2010).

1.1 Early Beginnings and Ongoing Controversies

Preservation statutes were initially based on architectural and aesthetic considerations (Loflin, Rankin, Marcus, & Goldstone, 1971; Rose, 1981). Early efforts entirely depended on raising private funds to protect buildings of historic distinction from demolition (See Boge & Boge, 1993, chap. 2). Relying solely on acquisition, this endeavor proved difficult to achieve prompting the legislative efforts of the movement (Loflin et al., 1971, p. 363).

Historic preservation remains a controversial subject that raises ethical [2] as well as legal concerns over ownership, maintenance, and availability of designated properties (Rose, 1981; Warren, 1999; Uzdavinis, 2007; Lindsay, 2012; Matthes, 2016). The effect on ownership by preservation depends on whether the policy is based on an incentive or regulatory framework (Asabere, Huffman, & Mehdian, 1994). In cities, the regulatory approach to initiate preservation policies typically occurs in the form of historic districting (Ford, 1989, p. 354). A recurring argument made by critics is that these regulations intentionally infringe on property rights and undermine both improvements and investment within designated districts (Asabere & Huffman, 1994b, p. 397; Heintzelman & Altieri, 2013, p. 546).

[1] Historic resources encompass all assets having cultural, historical, and architectural significance. These assets can include physical structures, natural scenery, and other tangible or intangible attributes of a community.

[2] These issues arise over what to preserve and whether preservation should trump access and property rights.

1.2 Who Benefits?

Serious disagreement exists regarding which segment of the public actually benefits from preservation policies. Critics have characterized historic preservation as having vaunted benefits that are inimical to low-income and elderly households (Rose, 1981; Schneider, 2001; Uzdavinis, 2007; Glaeser, 2010). Edward Glaser, prominent urban economist, describes the preservationists of New York City as "[t]he well-heeled denizens of historic districts convincing the Landmarks Preservation Commission to stop taller structures have become the urban equivalent of those restrictive suburbanites who want to mandate five-acre lot sizes in order to keep out the riffraff" (cited in Byrne, 2012, p. 668). Furthermore, historic designation may impose obligatory structural maintenance standards on property owners. [3] The preservation ordinance usually requires that alteration plans are approved prior to the commencement of any work on the structure. The enforcement of the ordinance typically seeks restitution by imposing civil penalties on property owners. Homeowners that are susceptible to displacement may find the cost of complying with maintenance obligations too burdensome (Schneider, 2001; Coulson & Leichenko, 2004). [4] Similarly, the benefit of higher building and land valuations stemming from historic designation can increase property taxes, which may further displace homeowners (Leichenko et al., 2001; Zahirovic-Herbert & Chatterjee, 2012) and cause inauspicious neighborhood change (Glaeser, 2010).

Preservationists have also received criticism for prioritizing the protection of certain heritages over others [5] (Newsom, 1971; Bell, 2013). Newsom (1971) writes that historic preservation has had a detrimental effect on black households in Georgetown, Washington D.C., and their historic contributions to the area. In this regard, historic preservation is comparable to gentrification for adversely affecting minorities (Newsom, 1971) and households of lower socioeconomic status (Rose, 1981; Schneider, 2001).

1.3 Preservation Laws and Property Use Restrictions

The first requisite of any preservation policy is coherently specifying the criteria that would establish "historical significance" (Robinson, 1981; Byrne, 2012). Herein lies the challenge of drafting preservation laws. Legislators must properly define the legal notion of "historic", along with a procedure to identify such assets (Rose, 1981; Robinson, 1981). Upon designation, the property owner is instantly subject to regulations that guide future use and renovation decisions.

Land-use controls, which typically follow historic designation, restrict demolition and any alteration [6] that may compromise the architectural integrity of the designated structure. The restrictions that follow designation encumber efficient use of the property within designated areas, thereby hampering the growth of the housing supply (Glaeser, 2010). The argument is that the best use of a property today may not be its best use in the future (Asabere & Huffman, 1994a). Hence, owners of designated buildings must

[3] These obligations vary by jurisdiction.

[4] Provided that these property owners were neither offered nor qualified to receive tax breaks or other subsidies.

[5] Bell (2013) discusses the general politics of heritage preservation in several countries.

[6] The terms "alterations" and "improvements" will be used interchangeably.

accept functional and physical quiescence (Asabere, Hachey, & Grubaugh, 1989, p. 183). Allen Greenough, the then-president of the Pennsylvania Railroad Company, expressed this sentiment in 1962 via a letter to the *New York Times*: "Does it make any sense to attempt to preserve a building merely as a 'monument' when it no longer serves the utilitarian needs for which it was erected?" [7] (Wood, 2008, p. 312).

The regulatory part of preservation policies finds public justification in the threat that the free market poses to historic structures (Coulson & Leichenko, 2001; Rypkema, 1994, cited in Noonan, 2007). Advocates have since touted the economic benefits of historic districts to bolster their legislative efforts (Sable & Kling, 2001). Likewise, these benefits give policymakers a rationale to employ historic preservation as a policy tool in urban development initiatives (Wojno, 1991; Listokin et al., 1998; Slaughter, 1997, cited in Coulson & Leichenko, 2001).

Improving the existing stock of housing is a substantial economic activity and a significant part of the nation's overall construction industry. In addition to new construction, alterations form a vital source of housing supply affecting both the quantity and quality of the existing housing stock (DiPasquale, 1999). The Joint Center for Housing Studies (2017) of Harvard University reports that nominal expenditures on improvements, maintenance, and repairs have increased annually since 2009, with an estimated $221 billion spent in 2015. [8] Private ownership constitutes the majority of the housing stock; hence, property owners have great influence over the quality and quantity of the supply (Fallis, 1985, p. 62; DiPasquale, 1999, p. 1). Given a time of rising inequality, sustained efforts must take place to ensure affordable housing. Better insight into the housing supply adjustment mechanism would aid in formulating an astute policy (Mendelsohn, 1977, p. 469). If historic districts are indeed a stimulus for urban development and investment (Noonan, 2007), then it would certainly aid efforts to succor this emerging global crisis (See Wetzstein, 2017). While the environmental value of historical assets is broadly recognized, the empirical merit of these economic externalities is more disputatious (Coulson & Leichenko, 2001). Particularly, research concerning its impact on the renovation decisions of nearby homeowners has received little attention.

1.4 The Catalyst Effect of Historic Preservation

Government commitment to enforce the preservation ordinance reduces investment risk and ensures owners that homes in districts will not deteriorate (Ford, 1989). This provision increases renovation and investment within designated districts (Lockard & Hinds, 1983; Listokin et al., 1998). The amenity of neighborhood stabilization may give nearby homeowners an incentive to invest in their properties, on the other hand, it may induce other courses of action.

For homes within districts, preservation is beneficial for homeowners so long as it is unsurpassed by the loss incurred from the restrictions of the ordinance. The effect of

[7] This letter was written in response to the campaign that was formed to preserve the original Pennsylvania Station. This significant event will be discussed in the next section.

[8] The Leading Indicator or Remodeling Activity (LIRA) was designed to estimate current and future home-improvement expenditures. Readers are encouraged to visit `http://www.jchs.harvard.edu/sites/default/files/n07-1_bendimerad_0.pdf` for more information on LIRA (last visited June 16, 2017).

historic districts on nearby undesignated homes, however, is not as straightforward as these externalities can be capitalized through an entirely different mechanism. Zahirovic-Herbert & Gibler (2014) highlighted that designation may affect both property values as well as the buying process. Also, Byrne (2012) has noted that the aesthetics of preserved neighborhoods spread development to new areas just outside their boundary. Simply by the delineation of the historic district boundary, homeowners in surrounding neighborhoods experience improved conditions as a result of their proximity to that boundary. These property owners are essentially free-riding off a public good since they are under no regulatory obligation to maintain the structure and can reap the benefits of the amenity without incurring the regulatory costs (Coulson & Leichenko, 2001; See Sable & Kling, 2001). The claim of historic districts catalyzing rehabilitation is prevalent in the preservation literature. This strongly motivates new research into the external effect of historic districts on renovation decisions of homeowners both in and outside the historic district boundary.

The purpose of this study is to present an empirical cross-sectional analysis of the relationship between historic district designation and renovation activity of single-family homes in New York City. Preservationists describe the catalyst effect of historic preservation as a positive spillover to the renovation activity of adjoining neighborhoods (Wojno, 1991; Rypkema, 1994, cited in Listokin et al., 1998; Coulson & Leichenko, 2001). However, existing research has not sufficiently addressed either the existence or the strength of this relationship. Instead, only anecdotal observations support the proposed phenomenon (Listokin et al., 1998, p. 440).

The results of the analysis found that historic preservation does not inhibit the renovation activity of single-family homeowners. However, contrary to the claims made by proponents, it does not give a powerful incentive. The results suggest that urban development or renewal initiatives can incorporate historic preservation, but the effects on the improvement of the housing stock and renovation activity among residential homeowners are overstated by preservation advocates, at least as it relates to owners of single-family homes.

2 Background

The historic preservation movement established an active presence across the United States in the early part of the 20th century.[9] During the post-WWII economic boom, the demolition of several architectural treasures by urban renewal projects and federally funded initiatives triggered an increase in activism. The release of the seminal report created by the Special Committee on Historic Preservation of the United States Conference of Mayors in 1966 would set the agenda, prompting both federal and local governments to advance policies to protect historically or aesthetically significant buildings.[10] The political efforts of preservationists eventually were rewarded by government intervention, much to the ire of developers and other real estate interests. The movement has since evolved from solely protecting buildings to preserving the cultural heritage of communities for the benefit of

[9] Early achievements include the nation's first historic district in Charleston, South Carolina, designated in 1931.

[10] The National Historic Preservation Act of 1966 was passed within months following the release of *With Heritage So Rich.*

subsequent generations.

Historic Preservation in New York City

Historic preservation in New York City has a rich history dating back to the late 19th century when Andrew Harwell Green founded The American Scenic and Historic Preservation Society in 1895 (Wood, 2008, p. 17). The creation of the Landmarks Preservation Commission (LPC) in 1962 gave civic activists [11] an initial vehicle to protect the city's architectural heritage from demolition (Wood, 2008, chap. 11). However, the lack of legal authority for the LPC meant that in reality, any efforts at preservation were nonexistent. The outcome was a failure to prevent the loss of several iconic structures. This ultimately prompted legislative action intended to promulgate effective legal authority for preservation.

The demolition of the original Pennsylvania Station marked a significant moment in the advancement of preservation for New York City (Wood, 2008, chap. 1). Far from the Beaux-Arts paragon at its height of popularity as a center of transportation, the demolition of the prominent structure in 1963 was not enough for the city to act for another two years (Wood, 2008, p. 333). The razing of the Brokaw mansion in 1965, despite its designation two years earlier (Wood, 2008, p. 333), prompted Mayor Robert F. Wagner to sign the Landmarks Preservation Law [12] that same year (Wood, 2008, p. 361). The law established the LPC as a municipal agency with the authority to protect the city's cultural and historical assets.[13] Within the same year, the city designated its first historic district in Brooklyn. The city's Landmarks Law became a notable legislative accomplishment to advance historic preservation following the Supreme Court decision to uphold the statute in 1978 entirely on aesthetic considerations.[14]

Although the LPC does not regulate height [15] , the impact of preservation through regulation has adversely affected development and investment within designated districts (Glaeser, 2010; Been, Ellen, Gedal, Glaeser, & McCabe, 2016). In an article in *City Journal*, Glaeser (2010) details his concern that historic preservation is stifling development in New York City. His principal thesis is that cities must be diverse in order to thrive and that the persistence of unaffordable housing will imperil that prospect (Byrne, 2012). For dynamic real estate markets with limited housing for low-income residents, predominantly urban markets like New York City, soaring housing prices present a genuine threat of societal homogenization where the bulk of the inhabitants are both elite and wealthy. The ubiquitousness of historic districts was adduced by Glaeser as contributing to the rising cost of housing by restricting development of new housing to meet demand, and, therefore, exacerbating the affordability crisis.

Over one hundred districts containing over 30,000 properties have been designated throughout the city in all five boroughs since the first designation of a historic district

[11] A luminary figure during that period was Jane Jacobs, who had risen to prominence following the release of *The Death and Life of Great American Cities* in 1961.

[12] New York City Administrative Code §25-301.

[13] N.Y.C. Admin. Code §25-302.

[14] *Penn Central Transportation Co. v. City of New York* 438 U.S. 104 (1978).

[15] N.Y.C. Admin. Code §25-304.

occurred in 1965.[16] Interestingly, there have been many district extensions since 1981.[17] The presence of historic district extensions, or expansions, begs the question of why these properties were overlooked in the initial designation process. Listokin et al. (1998) offer the following explanation: "the process by which one neighborhood is designated as a historic district, encouraging rehabilitation in an adjacent neighborhood that may ultimately itself be designated, in turn catalyzing rehabilitation in yet another area." This suggests that historic preservation, by virtue of designation, serves as a catalyst to increase renovation activity in adjacent undesignated areas because property owners are seeking designation status for their neighborhood. As a result, historic designation should incentivize property owners to invest in their homes. The spillover effect, therefore, should be a function of propinquity since nearby properties are more likely to capture these benefits than would those farther away.

3 Literature Review

Historic preservation is an interdisciplinary subject among jurisprudence, philosophy, and economics. The subject touches upon several economic concepts and theories apart from being a sub-discipline in its own right. In contrast to other areas of economic research, studies examining the spillover effects of historic designation on renovation activity are meager. This is not a sign of disinterest, rather it is more a case of the richness and complexity of the subject making comprehensive studies hard to achieve. This study draws on the historic preservation and renovation literature to examine the relationship between historic district designation and the renovation decisions of owners of single-family homes. Each topic will be separately discussed in the following literature review.

3.1 Renovations

Research into the mechanics of the housing supply has produced an exiguous level of literature. The few empirical studies conducted in this area have thus far provided equivocal findings pertaining to neighborhood and housing attributes. Analysis of the housing supply has largely been encumbered by the complexities of the market as well as the attributes of the commodity itself (Quigley, 1979, cited in Fallis, 1985; DiPasquale, 1999). This is especially true for household renovation decisions. Limited or otherwise unavailable data has also been cited as a reason for the dearth of research on renovation decisions (Mendelsohn, 1977; Fallis, 1985; Boehm & Ihlanfeldt, 1986; Montgomery, 1992; DiPasquale, 1999). In recent years, the literature has sharpened to include more sophisticated analyses that model homeowners' decisions. This review is predominantly concerned with the impact of neighborhood quality with a primary emphasis on more recent work that has accounted for this measure in non-linear regression analysis.

Theoretical analysis dominated early research and was primarily concerned with modeling factors of maintenance. Sweeney (1974a; 1974b; 1974c) produced papers that

[16] NEW YORK CITY LANDMARKS PRESERVATION COMMISSION, About LPC, `https://www1.nyc.gov/site//about/about-lpc.page` (last visited June 12, 2017).

[17] The first designated extension occurred in the neighborhood of Chelsea, NYC. The report can be found at the following link `http://s-media.nyc.gov/agencies/lpc/lp/1088.pdf` (last visited June 1, 2017).

concentrated on various aspects of housing markets, two of which focus on the stock of housing (1974b; 1974c). Sweeney (1974b) develops a conceptual framework to model the determinants of maintenance using optimal control theory. However, he neither offered an explanation on how changes in local amenities affect the optimal level of maintenance nor employed his model empirically. The author's seminal work was noteworthy for its theoretical contributions to the subject and for producing a set of hypotheses that would spur future research in the field.

Early empirical work has mainly analyzed improvement expenditures. Mendelsohn (1977) authored the first empirical study on the subject of improvement. He found that household characteristics and age are important determinants of improvement. Although he omitted a control for neighborhood quality, Mendelsohn (1977) discussed the importance of the measure in determining renovation expenditures. Years later, Mayer (1981) focused on rehabilitation decisions of landlords in Berkeley, California. This study is notable for drawing on data for a particular housing market. He found that neighborhood characteristics have a significant effect on investment. These prior works suffered from numerous limitations, mostly due to the lack of data present at the time (Mendelsohn, 1977, p. 460; Mayer, 1981, p. 77).

The research following Mendelsohn (1977) and Mayer (1981) examined the renovation activities of homeowners using various data, but mostly found conflicting results regarding the effect of neighborhood quality (Shear, 1983; Boehm & Ihlanfeldt, 1986; Montgomery, 1992). Shear (1983) uses the American Housing Survey (AHS) in his analysis, but finds only age and structural soundness as significant determinants. The effects of neighborhood quality are insignificant in his logit analysis, and he attributes this finding to measurement error in the AHS dataset. Boehm and Ihlanfeldt (1986) expanded on the work of Mendelsohn (1977) to include a control for neighborhood quality. The authors found significant impacts of neighborhood quality that concern safety and the condition of buildings in the area. Montgomery (1992) utilizes the AHS for 1985. She includes a 10-point scale measure in her analysis based on the homeowner's assessment of neighborhood quality. Her mildly significant findings indicated that property owners are less likely to improve in better quality neighborhoods.

Much of the early empirical work has consistently found age to be a significant predictor on the likelihood of renovation. Apart from Mayer (1981), these studies have used either the U.S. Census or AHS. While these authors have acknowledged a relationship between improved conditions and the likelihood to improve, none have been able to decisively conclude the exact nature of the relationship. Helms (2003) challenged the findings of previous research that neighborhood quality and local amenities are insignificant determinants of residential renovation. He aggregated five years of renovation expenditures, in Chicago over the years 1995 to 2000, for 31,744 out of a sample of 403,760 buildings. He finds that neighborhood amenities, such as distance to city parks, encourages renovations, whereas increases in distance from public transportation decrease the likelihood of renovation.

Recent work continues to produce mixed findings regarding the true impact of neighborhood quality on household renovations. Culp (2011) builds an index using micro data on homes located in Lehigh County, Pennsylvania. He includes attributes such as views, distance to parks, and other environmental factors in his construction. His results support the position that environmental factors have a positive impact on the decision by homeowners to renovate. Helms (2012) expanded on his earlier work in Chicago to investigate the effect of endogenous feedbacks between renovation and neighborhood quality. In contrast to his (2003) previous findings, many of the explanatory variables lose their explanatory power once a control for endogenous effects is added to the model. His findings demonstrate that controls for exogenous neighborhood quality, such as amenities, essentially serve as proxies in the absence of a control for endogenous spatial effects. He concludes that most of these contextual variables are not true determinants of renovation. Munneke and Womack (2015) produced the most recent study on the subject in which they examined the decision to renovate or tear down. The authors estimate a multinomial logit where they also found no significant effects for many of their controls for neighborhood quality.

3.2 Historic Preservation

For several decades, historic preservation has been an active topic of research in housing and urban economics (Leichenko et al., 2001; Zahirovic-Herbert & Gibler, 2014). Empirical work has considered a number of real estate markets, but the literature has mostly focused on the amenity values that are capitalized into property, land, and appraised values (Zahirovic-Herbert & Gibler, 2014, p. 113). Research on price effects typically estimates hedonic price models (See Rosen, 1974, cited in Heintzelman & Altieri, 2013) using either sales or appraisal data. Longitudinal studies have employed various statistical techniques, such as difference-in-difference (Noonan, 2007; Heintzelman & Altieri, 2013; Been et al., 2016) [18], 2SLS (Noonan & Krupka, 2011), and 3SLS (Zahirovic-Herbert & Gibler, 2014).

Many studies have yielded conflicting results (Leichenko et al., 2001; Heintzelman & Altieri, 2013) but typically find positive effects of historic district designation on property values (Ford, 1989; Clark & Herrin, 1997; Coulson & Leichenko, 2001; Leichenko et al., 2001; Coulson & Lahr, 2005; Noonan, 2007; Zahirovic-Herbert & Chatterjee, 2012). [19] Ford (1989) found significant positive price premiums for single-family homes in Baltimore, Maryland. Schaeffer and Millerick (1991) found that preservation policies yielded a price discount for property owners in Chicago, Illinois, noting that the effect on property values may depend on whether a property is federally or locally designated. Several papers concentrating on the impact of preservation policies were written by Asabere and Huffman (1991; 1994a; 1994b) that were mostly critical of historic district designation in Philadelphia, Pennsylvania. Their work focused on the effects of both federal and local designation. The authors found a premium associated with federal preservation policies on land (1991) and residential market values (1994b), but found that historic facade easements, i.e., the restrictions that are associated with local preservation laws, negatively impact value (1994a). In the same city, Asabere et al. (1994) separated between federal and local preservation policies in a study examining the impact of preservation on small apartment buildings. They found a 24% discount associated with local designation while the results for federal designation was insignificant. Asabere et al. (1994) concluded that the difference was explained by the austere restrictions of local historic designation as practiced in Philadelphia and limited incentives

[18] The study refers to more recent difference-in-difference studies that employ hedonic price models to assess the implicit price of attributes belonging to a property. See Leichenko et al. (2001).

[19] Leichenko et al. (2001) wrote a comprehensive review of the literature that concludes that homes within the confines of historic districts typically sell at a premium.

that were offered to property owners. Heudorfer (1975, cited in Rickman, 2009) is credited with the earliest study analyzing the economic impact of historic preservation on property values in New York City. The author found a neutral effect using a difference-in-difference that was based on comparing averages of the growth rate of property prices in historic districts with those that were undesignated (Leichenko et al., 2001). While novel for its time, the study omits several factors independent of designation that explain changes in property values [20] (Leichenko et al., 2001, p. 1975). The studies mentioned above have a number of limitations, but each has overlooked the external impacts of preservation on nearby undesignated properties.

The internal and external effects of historic designation on property values also have produced conflicting results. Clark and Herrin (1997) used sales price data from Sacramento, California, and found a 17.3% positive effect of designation on property values for structures within districts. For undesignated buildings, they found a 20% discount for buildings located across the street from the boundary and no significant premiums for properties a block away. In contrast, Coulson and Leichenko (2001) use appraisal data to estimate several models to account for differences between national and local designation, the impact of local tax breaks, and external effects in Albilene, Texas. They find positive economic benefits for both designated properties and nearby homes of 15-17.6% and 0.14%, respectively. Coulson and Lahr (2005) analyzed appreciation rates for several neighborhoods in Memphis, Tennessee, and found that designation increased property values 14-23% higher than in comparable neighborhoods. Additionally, they found that older properties within historic districts benefit as much or less than newer buildings. Leichenko et al. (2001) carried out an extensive study analyzing price premiums for nine cities in Texas. They find price premiums between 5-20% in seven cities and larger premiums in districts that were less restrictive.

Endogeneity plagues historic preservation studies due to the omission of factors that are correlated with the structure attaining designation status as well as the designation process itself. Neighborhoods experiencing increased renovation activity can attract property owners and activists that support historic preservation (Noonan, 2007; Been et al., 2016). Noonan (2007) performed a repeat sales fixed effects hedonic analysis to control for unobserved attributes of housing using property transactional data in Chicago from 1990-1999. He found a positive premium ranging from 3-11% on attached homes. Heintzelman and Altieri (2013) adopted the same approach in a study examining the impact of preservation on home prices in Boston. However, they found significant negative internal impacts of designation and no significant external effects. In another study, Noonan and Krupka (2011) used an instrumental variable (IV) approach to control for potential endogeneity of the designation process. They found negative price impacts in designated districts and small negative external effects. Zahirovic-Herbert and Chatterjee (2012) addressed the issue of heterogeneity in property value impacts by estimating a quantile regression. They found that preservation has significant price premiums for designated homes in Baton Rouge, Louisiana. Likewise, they found positive significant spillover effects for nearby residential properties.

The majority of empirical research on the subject of preservation has explored the impact of designation on property values. There are noteworthy papers that have addressed the effects of preservation on neighborhood transition (Coulson & Leichenko,

[20] These factors include attributes belonging to the property.

2004; McCabe & Ellen, 2016), the external effects of designation on the selling duration of nearby homes (Zahirovic-Herbert & Gibler, 2014) and new construction activity (Been et al., 2016). Coulson and Leichenko (2004) found no evidence that preservation had any effect on neighborhood composition in Fort Worth, Texas. The results of that study found little effect on vacancy rates or rates of owner occupancy and no significant effect on neighborhood composition. The authors concluded that historic designation neither leads to gentrification nor has any considerable effect on economic development. The findings illustrate that historic preservation may not be an effective policy instrument. McCabe & Ellen (2016) uncovered different results in a study based in New York City. The authors found that residents in historic districts experience an increase in socioeconomic status post-designation in comparison to other neighborhoods. However, they admit that the results cannot be explained by preservation alone and offer several explanations (See pp. 143-144). The authors suggest that increases in homeownership rates post-designation might be the result of conversions. Zahirovic-Herbert and Gibler (2014) examine an entirely different external effect of historic preservation that had not been previously considered. They found significant evidence that selling duration captures a portion of the capitalization of preservation. The authors found that single-family homes that were nearby historic districts sold faster on average than those farther away. Also, they found no such evidence of shorter selling duration for designated properties and no significant evidence of price premiums for nearby properties. A more recent study by Been et al. (2016) examined the impact of preservation on new construction activity and property values in New York City using micro data between the years 1974 to 2009. The authors found that designation had a significant negative effect on new construction post-designation by as much as 14% per year. However, they do not conclude that designation reduced supply overall in the city based on the results of the study. With respect to price premiums, they found significant effects of historic designation on property values both within designated districts and just outside the boundary. The strength of the premium is especially high in areas where the value of the option to redevelop is low. Not a great deal is known about the effect of preservation on renovation activity as there are only two empirical studies (Laska, Seaman, & McSeveney, 1982; Lockard & Hinds, 1983) that have investigated the topic.

Laska et al. (1982) analyzed renovation activity for 68 census tracts in New Orleans, Louisiana, from 1970 to 1978. Their analysis consisted of estimating three stepwise regressions for the existence, extent, and timing of renovation activity. The authors found that proximity to a historic district was a modest predictor of the extent of a renovation but a weak predictor of its timing. Lockard and Hinds (1983) examined restoration rates of homes within and outside the confines of the Old and Historic District of Charleston, South Carolina. They performed an analysis using sixteen years of building permit information from 1960 to 1975 properties, where properties were segmented into three groups based on their architectural quality. The authors found that restoration rates were significantly higher for homes within historic districts, but that the rates decreased with architectural quality. Additionally, restoration rates for homes located within districts that had high architectural quality were 22.9% and 18.3% for those located outside districts over the sixteen-year period. However, the results for the difference were inconclusive.

This study extends the previous research on historic preservation by considering a separate external effect. Furthermore, neither of the studies mentioned has accounted for the influence of neighbors as it relates to property investment. If historic designation serves as a catalyst for renovation in nearby communities, then a building's propinquity to a historic district should increase the likelihood that a renovation will occur. In order to gain insight into the impact of historic district designation on renovation activity, an analysis of how preservation influences the renovation decisions of homeowners must be performed. This paper will bridge the gap between the literature on historic preservation and renovation by evaluating how historic district designation affects the renovation decisions of property owners. In addition to making a theoretical contribution, I use new data to estimate the determinants of renovation decisions for New York City.

4 Theory

Housing, as a durable and heterogeneous good, introduces a notion of quality that challenges theoretical analyses of housing markets (Sweeney, 1974a; 1974b; 1974c). The supply of housing is sourced by either new development or the existing stock. Producers range from firms to individuals. Thus, suppliers of housing are a diverse set of agents whose production decisions are separated by their underlying motives.

Owner-occupiers can assume the role of both supplier and consumer. Homeowners may decide to consume some portion of housing services as their residence and supply the remaining portion on the market (DiPasquale, 1999). In this situation, objectives can be modeled either as a joint consumption-investment decision in an inter-temporal framework or static utility optimization problem (Fallis, 1985, pp. 62-63). Consequently, theoretical contributions often rely on strict assumptions. This study is no different in that regard and will rely on similar assumptions to model the determinants of residential renovation decisions.

Sable and Kling (2001) define historic built resources as a " tangible construction embodying value that is both historically and socially determined." For this reason, historic preservation is often characterized as a public good [21] because of the prestige or nostalgia it imparts on owners and consumers. [22] In their presentation of the "double public good" model, Sable and Kling (2001) highlight that market intervention is necessary in order to attain social efficiency. Therefore, government plays a prominent role in enforcing preservation policies and maintenance obligations which has implications on the renovation decisions of property owners, both within and outside of historic districts.

Lockard and Hinds (1983) describes the "investor's dilemma" by making an analogy to a classic case in game theory: "The Prisoner's Dilemma". [23] In the "investor's dilemma", an owner's decision to improve their property takes into account the improvement decisions of all their neighbors. Similar to the outcome in "The Prisoner's Dilemma", the optimal decision for homeowners is to make no improvements to their property because they benefit

[21] Sable and Kling (2001) model historic assets as a pure public good.

[22] Consumers in this context refer to any individual that attains satisfaction from viewing a preserved structure, living in a historic district, etc. Readers are referred to Sable and Kling (2001) and Heintzelman and Altieri (2013) for an insightful discussion on the characterization of historic preservation as a public good.

[23] Davis and Whinston (1961, cited in Lockard & Hinds, 1983) were the first to reference "The Prisoner's Dilemma" to explain why urban blight can develop and persist.

from the investments made by their neighbors (Lockard & Hinds, 1983). If all neighbors decide to employ this strategy, then everyone is worse off than if they had all agreed to invest. Historic districts are attributed with stabilizing or revitalizing neighborhoods because of the maintenance obligations that are imposed on owners of designated properties. (Ford, 1989; Schaeffer & Millerick, 1991). Owners of designated properties internalize the spillover of maintenance (Lockard & Hinds, 1983). By reducing investment risk, the regulatory approach to preservation policies solves the investor's dilemma. The notion that historic preservation serves as a catalyst for the rehabilitation of nearby areas is a consequence of solving for the interdependencies of investment decisions among property owners in designated areas. But this outcome may not apply to nearby homeowners located in undesignated districts. Theory suggests that these owners have no incentive to improve their buildings as they already benefit by being near a designated district. Hence, a model to understand the spillover effects of historic preservation on investment decisions must explicitly account for this interdependency.

Brueckner (2003) proposed the "spillover model" to model strategic interaction among governments while expanding on earlier work by Case, Rosen, and Hines (1993, cited in Brueckner, 2003). The household renovation model presented by Helms (2003), which is based on the capital-stock adjustment model used earlier by Mayer (1981), describes the behavior of adjusting the holdings of housing stock by improvement of the existing dwelling. The theoretical framework of Bruecker's (2003) "spillover model" allowed Helms (2012) to include the interdependencies of investment decisions of neighbors in his earlier model. Munneke and Womack (2015) recently proposed the general redevelopment model which allows for the outcome of redevelopment to occur either by renovations or tear downs. The authors expanded on the work of Helms (2003) by extending the model to allow for an additional outcome.[24]

This study relies heavily on the housing renovation model that was extended by Helms (2012) and follows the general derivation and all notations. I modify Helms's (2012) model by combining elements of the "double public good" (Sable & Kling, 2001) model in order to account for the spillover effect of designation on the renovation decisions of homeowners that are not subjected to the restrictions of the preservation ordinance. For tractability, the model assumes perfect capital markets, perfect foresight, and that housing is a homogeneous good[25]. The following presentation is a static utility optimization framework in which the agents are homeowners that consume all the housing services that are produced by their property. Some of the more restrictive assumptions are later relaxed.

Theoretical Model

Following Helms (2003, 2012), consider a utility maximizing household that chooses between housing services h, neighborhood quality n, and all other consumption goods z. Let k_0 denote the building's initial level of investment made during renovation so that the post-investment capital level is $k_0 + R$. Assume that the post-renovation condition of the building is given by the function $c(b, k_0 + R)$, where b is a vector of structural attributes

[24] The authors model the outcome of negative investment as a "teardown".

[25] This assumption allows for the treatment of housing services as an explicit argument in the households objective function. See Fallis (1985, pp. 27-28).

inherent to the building. A building's structural characteristics include area, age, number of stories, and other attributes that would be unaffected by a renovation. The inclusion of b in the building's condition function c allows for the marginal return to housing investment to depend on building type. For any building that undergoes a renovation, the change in the building's condition c is assumed to be positive, i.e., $\partial c \,/\, \partial R > 0$.

The total housing services $h(q,\, c(b,\, k_0 + R))$ provided by a building can be expressed as a function of its size q and condition c.[26] Increases in size and improved conditions is associated with positive changes to the housing services provided, i.e. $\partial h \,/\, \partial R > 0$ and $\partial h \,/\, \partial q > 0$. The vector n is an explicit argument in the utility function allowing for households to have different preferences for amenities and other neighborhood characteristics.[27] The utility function for households can be expressed as

$$u(\, h(\, q,\, c(\, b,\, k_0 + R\,)\,),\, n,\, z), \tag{1}$$

where z denotes a numeraire composite good. Let $s = (q,\, b)$ denote the vector of structural characteristics, then household preference can be rewritten as an indirect utility function

$$v(s,\, R,\, n,\, z). \tag{2}$$

Renovation activity affects neighborhood quality (Helms, 2012, p. 303). In his analysis of neighborhood endogenous effects, Helms (2012) highlights that n must capture spillovers from nearby renovation activity. He separates the effects of neighborhood quality and expresses neighborhood characteristics as the function

$$n_i \;=\; n(a_i,\, R_{-i}), \tag{3}$$

where exogenous effects are denoted by a and R_{-i} denotes the level of investment of neighbors, i.e., $R_{-i} \;\equiv\; \{R_j \;|\; j \;\neq\; i\}$. I take a similar approach in order to include the influence of historic district designation as an explicit argument.

Sable and Kling (2001) describes the "heritage experience" as the outcome that follows from consuming historic assets. The "double public good" model is a general equilibrium model developed by Sable and Kling (2001) in order to capture the range of values[28] of preserved historic resources. This paper draws on certain aspects of the "double public good" model in the modification of equation (3) to incorporate the spillover effects of historic districts as a neighborhood characteristic.

As discussed above, historic districts are regarded as an amenity. Designation status is often highly esteemed and considered to improve not only the area within the confines of the district but also nearby surroundings. Let hd_i indicate the designation status of household i. Then, the influence of historic districts can be explicitly incorporated in (3) as

$$n_i \;=\; n(a_i,\, hd_i,\, hd_{-i},\, R_{-i}), \tag{4}$$

[26] The study uses either direct or proxy variables for structural attributes, size, and other building or location characteristics.

[27] The marginal utility of housing services, U_h, is likely to depend on n.

[28] These values include environmental, social, and private market values of historic preservation.

where hd_{-i} is defined as the designation status of neighbors. The propinquity [29] to a historic district can be expressed as a function of hd_{-i}

$$H = f(hd_{-i}) = \sum_{j \neq i} hd_j, \tag{5}$$

where H is the sum of all neighbors that own designated homes. Then (4) for household i becomes

$$n_i = n(a_i,\, hd_i,\, H,\, R_{-i}), \tag{6}$$

Substituting (6) for n in (2) gives the objective function:

$$v_i = v(s_i,\, n(a_i,\, hd_i,\, H,\, R_{-i})) \tag{7}$$

for household i, which includes both the interdependence of housing investment and designation status of neighbors.

The budget constraint for household i is given as $y_i = z_i + p^k R_i$, where income is denoted by y, and the price of capital by p^k. Households that maximize the utility function given in (7) over z and r yield the necessary conditions:

$$\frac{\partial u}{\partial h} \frac{\partial h}{\partial c} \frac{\partial c}{\partial R} = 0,$$

or equivalently,

$$\frac{\partial v}{\partial R_i} = 0. \tag{8}$$

Equation (8) shows that the marginal rate of substitution between home improvements and consumption must equal the cost of capital. Moreover, equation (8) implicitly defines the optimal housing capital investment:

$$R^* = R(s,\, n,\, p^k). \tag{9}$$

The solution for (9) implicitly expresses a spatial reaction function (Brueckner, 2003) for household i. Contemporaneous feedbacks by neighbors is captured in the determination of household i's level of investment. Thus, (9) is expressed as the equilibrium solution for R^*:

$$R_i^* = R(s_i,\, n(a_i,\, hd_i,\, H,\, R_{-i}),\, p^k). \tag{10}$$

Total differentiation (10) and application of the chain rule is used to yield two expressions of interest to the study:

$$\frac{\partial R_i}{\partial R_{-i}} = -\frac{\frac{\partial^2 v}{\partial R_i\, \partial R_{-i}}}{\frac{\partial^2 v}{\partial R_i^2}} = -\frac{\frac{\partial^2 v}{\partial R_i\, \partial n}\, \frac{\partial n}{\partial R_{-i}}}{\frac{\partial^2 v}{\partial R_i^2}}, \tag{11a}$$

[29] Although proximity is often defined as distance, this paper relies on the broader definition of nearness in space.

and

$$\frac{\partial R_i}{\partial H} = -\frac{\frac{\partial^2 v}{\partial R_i\,\partial H}}{\frac{\partial^2 v}{\partial R_i^2}} = -\frac{\frac{\partial^2 v}{\partial R_i\,\partial n}\,\frac{\partial n}{\partial H}}{\frac{\partial^2 v}{\partial R_i^2}}. \tag{11b}$$

Satisfaction of the second order condition implies that $\frac{\partial^2 v}{\partial R_i^2} < 0$ in expressions (11a) and (11b). The partial derivatives $\partial n/\partial R_{-i} > 0$, and $\partial n/\partial H > 0$, since increases in renovation activity improves neighborhood quality and historic districts is assumed to confer positive externalities on nearby surroundings. Thus, the sign for equations (11a) and (11b) is determined by the sign of the derivative $\frac{\partial^2 v}{\partial R_i\,\partial n}$ which indicates the change in the marginal benefit of renovation from an increase in neighborhood quality.

The strength of the level of investment R^* in equation (10) determines whether a household will perform renovations. Naturally, R^* can be considered as the household's propensity to renovate, since the level of investment is observed indirectly after the realization of an improvement. Despite the consumer choice problem allowing for R to be negative, only non negative values will be observed.[30] However, the scope and scale of a renovation project that is performed by households is unknown for $R^* > 0$.[31] Intuitively, households will not undertake a renovation in the case of $R < 0$. Let r be an indicator for the presence or absence of a renovation such that:

$$r = \begin{cases} 1 & \text{if } R^* > 0, \\ 0 & \text{if } R^* \leq 0. \end{cases} \tag{12}$$

Equation (12) will be used to motivate the empirical model for the study.

While the inclusion of a term to capture the spillover of preservation controls some endogeneity of historic district designation, the model will not account for policy endogeneity. Also, the static optimization framework ignores any temporal factors which may influence the likelihood of renovation. Household renovation decisions are intrinsically dynamic processes (Helms, 2003). Nevertheless, the benefit of this framework is that it allows for the explicit treatment of the spatial spillovers of historic preservation and interdependence of renovation activity among neighbors.[32]

5 Methods

5.1 The SAR Probit Model

Along with heterogeneity and durability, housing is distinguished by spatial fixity (see Fallis, 1985, pp. 5-11). Helms's (2012) study on renovation decisions is notable for its use of spatial econometrics to estimate endogenous neighborhood effects. Anselin (1988, p. 11) wrote in his influential text on spatial econometrics that spatial dependence is "the

[30] Presumably, negative values for level of investment R are considered to be "disinvestment" in the building that can take the form of demolition, or deterioration. Montgomery (1992) defines "moving down" to describe disinvestment by homeowners deciding to move in order to reduce their holdings of housing stock.

[31] A large level investment does not necessarily imply a large project.

[32] Further specification issues will be discussed in the next section.

existence of a functional relationship between what happens at one point in space and what happens elsewhere." In other words, observations are either independent of one another or there is a spatial process underlying the correlation between observations. Standard econometric methods, e.g., regression models for cross-sectional data, do not account for spatial dependence in the covariates which can result in loss of efficiency and potential bias. For researchers, spatial econometrics expands the toolbox of methods to include models that explicitly account for interdependence among observations.

The "spatial autoregressive model" (SAR) is one approach to solve the problem of spatial dependence.[33] The SAR model takes the structural form

$$\mathbf{Y}^{*} = \rho \mathbf{W} \mathbf{Y}^{*} + \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}, \tag{13}$$

where $\mathbf{Y}^{*}$ is an $N \times 1$ vector of observations on the dependent variable, $\mathbf{X}$ is an $N \times K$ matrix of explanatory variables, and $\boldsymbol{\beta}$ is a $K \times 1$ vector of regression coefficients. The term $\boldsymbol{\varepsilon}$ is an $N \times 1$ vector that follows a multivariate normal distribution, i.e., $\boldsymbol{\varepsilon} \sim \mathcal{MVN}(0,\, \sigma^2 \mathbf{I_N})$. The spatial weights matrix, $\mathbf{W}$, is an $N \times N$ spatial weights matrix that captures the dependence structure, and ρ is the dependence parameter such that $\rho \in \mathscr{R}$. The "spatial lag" of the dependent variable, $\mathbf{W}\mathbf{Y}^{*}$, is the $N \times 1$ vector that extends the standard regression model to control for endogenous interaction in the outcome between observations.

The reduced form of the model is

$$\mathbf{Y}^{*} = (\mathbf{I} - \rho \mathbf{W})^{-1} (\mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}) = (\mathbf{I} - \rho \mathbf{W})^{-1} \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\xi}, \tag{14}$$

where $\boldsymbol{\xi} = (\mathbf{I} - \rho \mathbf{W})^{-1} \boldsymbol{\varepsilon}$. The disturbance $\boldsymbol{\xi}$ is both spatially correlated and heteroskedastic, and, therefore, follows an N-dimensional multivariate normal distribution

$$\boldsymbol{\xi} \sim \mathcal{MVN}\{(\mathbf{I} - \rho \mathbf{W})^{-1} \boldsymbol{\varepsilon},\, [\,(\mathbf{I} - \rho \mathbf{W})^{\intercal} (\mathbf{I} - \rho \mathbf{W})\,]^{-1} \sigma_{\varepsilon}^{2} \mathbf{I_N}\}\,. \tag{15}$$

The term σ_{ε}^{2} is normalized to 1 to avoid the identification problem of separating β and σ^2 (See LeSage & Pace, 2009, chap. 10). Then the mean and variance of $\boldsymbol{\xi}$ is given by

$$\mathbb{E}[\,\boldsymbol{\xi}\,] = 0 \tag{16}$$

and

$$V[\,\boldsymbol{\xi}] = \Sigma = [(\mathbf{I} - \rho \mathbf{W})^{\intercal} (\mathbf{I} - \rho \mathbf{W})]^{-1}\,, \tag{17}$$

where Σ denotes the variance-covariance matrix.

The spatial weights $\mathbf{W}$ is the formal expression of spatial dependence (Anselin, 1988). There are several types of spatial weights matrices that can be used to summarize the relations between spatial units. This study will utilize a k-nearest neighbor weights matrix where for each i the distance, $d_{i,j}$, between all spatial units $j \neq i$[34] is sorted in increasing order up to some positive integer m. For each spatial unit i, let $N_m(i)$ denote

[33] Another popular model is the "spatial error model" which controls for spatial dependence in the unobservables.

[34] A spatial unit i cannot be its own neighbor.

the neighborhood set that contains the first m neighbors.[35] Then each element $w_{i,j} \in \mathbf{W}$ is defined as:

$$w_{i,j} = \begin{cases} 1/k & \text{if } d_{i,j} \in N_m(i), \\ 0 & else \end{cases}, \tag{18}$$

where each row is standardized so that the elements sum to unity (See Anselin, 1988).

Row standardization of the weights matrix W is common practice in applied research for interpretive reasons and tractability. In this case, the matrix product $\mathbf{WY}^*$ in equation (13) is interpreted as a weighted average of the values observed at neighboring locations. The critique of this specification is that $\mathbf{WY}^*$ imposes equal weights on each neighboring value rather than placing more weight on nearby observations (See McMillen, 2012). The advantage of specifying a row standardized $\mathbf{W}$ is that the inverse of $(\mathbf{I} - \rho\mathbf{W})$ is guaranteed to exist for all ρ such that $\mid \rho \mid < 1$ (See LeSage & Pace, 2009, chap. 4).[36]

The equation that links the unobserved latent variable $\mathbf{Y}^*$ to the observed binary outcome $\mathbf{Y}$ is

$$y_i = \begin{cases} 1 & \text{if } y_i^* > 0, \\ 0 & else \end{cases}, \tag{19}$$

for each spatial unit i. In the standard probit model, where $\mathbf{Y}^* = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\mu}$, the probability that $\mathbf{Y} = 1$ for the ith observation is

$$\begin{aligned} \mathbb{P}\{y_i = 1 \mid \mathbf{X}\} &= \mathbb{P}\{y_i^* \leq 0 \mid \mathbf{X}\} \\ &= \mathbb{P}\{\mu_i < x_i^{\intercal}\boldsymbol{\beta}\} \\ &= \boldsymbol{\Phi}\{x_i^{\intercal}\boldsymbol{\beta}\}\,, \end{aligned} \tag{20}$$

where $\boldsymbol{\Phi}$ is the cumulative normal distribution (Cameron & Trivedi, 2005). For the SAR probit, equation (20) for the ith observation is expressed as

$$\begin{aligned} \mathbb{P}\{y_i = 1 \mid \mathbf{X}\} &= \mathbb{P}\{y_i^* \leq 0 \mid \mathbf{X}\} \\ &= \mathbb{P}\{\xi_i < (\mathbf{I} - \rho\mathbf{W})^{-1}\, x_i^{\intercal}\boldsymbol{\beta}\} \\ &= \boldsymbol{\Phi}\{(\mathbf{I} - \rho\mathbf{W})^{-1}\, x_i^{\intercal}\boldsymbol{\beta}\}\,. \end{aligned} \tag{21}$$

The likelihood function, L, for (21) is an N-dimension integral

$$L = \mathbb{P}\left\{\bigcap_{i=1}^{N} Y_i\right\} = \int_{\mathbf{Y}^*} \cdots \int \phi(\boldsymbol{\xi})\, d\boldsymbol{\xi}\,, \tag{22}$$

$$\phi(\boldsymbol{\xi}) = (2\pi)^{\frac{N}{2}} \;\mid \Sigma \mid^{-1}\; exp\left\{-\frac{1}{2}\,(\varepsilon^{\intercal}\,\Sigma^{-1}\,\varepsilon)\right\}\,,$$

where ϕ is the normal density function and $\{Y_i\}_{i=1}^{N} = \{y_i \in \boldsymbol{Y} \mid Y_i = y_i\}$. The disturbance term $\boldsymbol{\xi}$ captures the spatial interdependence of $\boldsymbol{\varepsilon}$, and, therefore, the marginal distribution of $\boldsymbol{\xi}$ for each observation i is not independent. This requires that all $N-1$ other dimensions be integrated out of the full multivariate normal distribution which is a substantial computational challenge. The following section will briefly discuss some of the methodologies that have been proposed to address the multidimensional integration problem.

[35] Ties are ignored for simplicity.

[36] This attribute also reduces the computational burden of finding the inverse of $(\mathbf{I} - \rho\mathbf{W})$, especially when dealing with a high dimensional spatial weights matrix.

5.2 Estimation

Probit variants of the SAR model and their estimation methods have been considered for over two decades. [37] McMillen (1992) was the first to address the integration problem in (22) using maximum likelihood estimation (MLE). He proposed an expectation-maximization (EM) algorithm to produce consistent estimates for the model. Albert and Chib (1993) provided a Bayesian solution to estimate non-spatial probit models by treating the latent variable y^* as a parameter to estimate. This provided the foundation for LeSage (2000, cited in LeSage & Pace, 2009) to develop the Bayesian Markov chain Monte Carlo (MCMC) estimation procedure for the SAR probit model. This study will estimate the SAR probit model under the Bayesian paradigm. The following section will specify the distributions of the parameters of the model and discuss the estimation methods of the procedure.

Albert and Chib (1993) concluded that the joint conditional posterior distribution for a set of parameters on both y^* and y is equivalent to the posterior distribution involving a continuous dependent variable. This is because if y^* were known then the outcome, y, would be known as well. Thus, $p(\beta, \rho \mid y^*, y) = p(\beta, \rho \mid y^*)$. LeSage (2000, cited in LeSage & Pace, 2009) builds on the MCMC sampling scheme developed by Albert and Chib (1993) to estimate the SAR probit model

$$p(y^*, \beta, \rho \mid \mathbf{y}) \propto p(\mathbf{y} \mid y^*, \beta, \rho)\, p(y^* \mid \beta, \rho)\, p(\beta, \rho)\,, \tag{23}$$

and,

$$p(y^* \mid \beta, \rho) \propto p(\beta, \rho \mid y^*)\, p(y^*). \tag{24}$$

LeSage and Pace (2009) outline the procedure to sample from the posterior distribution. The procedure is performed by sequentially sampling from the following three conditional densities $p(y^* \mid \beta, \rho)$, $p(\beta \mid y^*, \rho)$, and $p(\rho \mid y^*, \beta)$ in an MCMC and Gibbs sampling scheme (LeSage & Pace, 2009, p. 254). The presentation of the Bayesian procedure mirrors that presented in LeSage and Pace (2009) and uses much of the same notation.

Dependence across observations is intrinsic to spatial models, and, therefore, the conditional posterior distributions must allow for the case where the dependent variable follows a spatial dependence process. In order to sample the latent y^* parameters, the procedure requires sampling from a multivariate truncated normal (TMVN) distribution,

$$y \sim \mathcal{TMVN}\{\mu, \Sigma\}\,, \tag{25}$$

where $\sigma^2 = 1$ for identification, and $\mu = (\mathbf{I} - \rho\mathbf{W})^{-1}\mathbf{X}\beta$ (LeSage & Pace, p. 283). LeSage and Pace (2009) adopt the approach developed by Geweke (1991, cited in LeSage & Pace, 2009, p. 285) to sample from $p(y^* \mid \beta, \rho)$ by drawing from the $TMVN$ distribution expressed in equation (25) using Gibbs sampling.

The procedure assumes independent prior distributions for β and ρ. The parameter β is assigned a normal conjugate prior $\beta \sim \mathcal{N}(c, T)$ [38], and a beta prior for the parameter $\rho \sim \mathcal{B}(\alpha, \alpha)$. The parameter β is sampled from the conditional density

$$p(\beta \mid y^*, \rho) \propto \mathcal{N}(c^*, T^*) \tag{26}$$

[37] Readers are referred to Elhorst, Heunen, Samarina, and Jacobs (2017) for a review of estimation methods for the spatial probit model.

[38] LeSage and Pace (2009) found that the prior distribution for β is uninformative (diffuse) when $c = 0$ and T is set to a large magnitude, e.g., $T = 10^9 \cdot I_N$.

$$S = (\mathbf{I} - \rho\mathbf{W})$$
$$T^* = (X^\intercal X + T^{-1})^{-1}$$
$$c^* = T^*(X^\intercal S y^* + T^{-1}c).$$

Next, the parameter ρ is sampled from the conditional density

$$p(\rho \mid y^*, \beta) \propto \mid S \mid exp\left\{-\frac{1}{2}\,[S\,y^* - \mathbf{X}\beta]^\intercal[S\,y^* - \mathbf{X}\beta]\right\}. \tag{27}$$

The conditional density for the parameter ρ is non-standard, and requires an alternative sampling scheme, often Metropolis-Hastings. LeSage and Pace (2009, chap. 5) present and discuss the Metropolis-Hastings procedure for sampling the parameter ρ.[39]

Non-linear models differ from linear regression models by the interpretation of the marginal effects. The marginal effect of a point estimate β_j is constant, whereas in non-linear models the marginal effect is dependent on all the covariates. For a continuous regressor x_j, the instantaneous rate of change of x_j on the response y conditional on $\mathbf{x}$ in the standard probit model (20) is

$$\frac{\partial\mathbb{P}(y_i = 1 \mid \mathbf{x})}{\partial x_j} \equiv \frac{\partial\mathbb{E}(y_i = 1 \mid \mathbf{x})}{\partial x_j} = \phi(\mathbf{x}\boldsymbol{\beta})\beta_j\,, \tag{28}$$

where the marginal effect of β_j varies with values of $\mathbf{x}$ in the normal density function ϕ (Cameron & Trivedi, 2005, p. 467). A common approach is to use the average of the regressors in $\mathbf{x}$, denoted by $\bar{\mathbf{x}}$, then equation (28) is interpreted as a change in the probability of the response for the typical or average observation.[40]

The marginal effects for the SAR probit model must account for spatial dependence because changes in the covariates of observation i can potentially impact the expectation of the response in all $N-1$ observations (LeSage et al., 2011; Elhorst el al., 2017). LeSage and Pace (2009, p. 294) give an expression for the marginal effects for the jth regressor x_j as

$$\frac{\partial\mathbb{E}(y_i = 1 \mid x_j)}{\partial x_j^\intercal} = \phi(S^{-1}\mathbf{I}_N\bar{x}_j\beta_j) \odot S^{-1}\mathbf{I}^N\beta_j\,, \tag{29}$$

where $\bar{x}_j$ is the mean of the jth explanatory variable, $x_j^\intercal$ is a $1\times N$ vector representing the jth regressor for all observations, S^1 is the inverse of S as defined in (26), $\mathbf{I}_N$ is an $N\times N$ identity matrix, and the operator $\odot$ represents the Hadamard product.[41] The evaluation in (29) is interpreted as a MEM because the expression is conditional on all other covariates held fixed at their respective means. The result of equation (29) is an $N \times N$ matrix where the average of the main diagonal elements represents the average direct impact of the marginal effect of x_j. Similarly, the average of the row or column is the average total impact. The difference of the two produces the average indirect impact of the marginal effect of x_j.

[39] The full "Metropolis within Gibbs" sampling procedure is described in LeSage and Pace (2009, chap. 10).

[40] This approach for computing the marginal effects of the point estimates $\boldsymbol{\beta}$ is known as Marginal Effects at the Means (MEM). This approach can be problematic if the "average" is not representative of the sample.

[41] The Hadamard (or Schur) product is a binary operator between two matrices, $\mathbf{A}$ and $\mathbf{B}$, of the same dimension, and returns the matrix $\mathbf{C}$ where each element $c_{i,j} = a_{i,j}\,b_{i,j}$.

5.3 Empirical Model

This section will introduce the empirical model that the study will estimate using the procedure discussed above. Equation (10) is used to derive the latent spatial autoregressive (SAR) index function for the propensity to invest:

$$\mathbf{R}^* = \rho\mathbf{W}\mathbf{R}^* + \mathbf{X}\boldsymbol{\beta} + \mathbf{NC}\boldsymbol{\omega} + \mathbf{HD}\boldsymbol{\theta} + \mathbf{Undesignated}\boldsymbol{\phi} + \mathbf{SD}\boldsymbol{\tau} + \boldsymbol{\epsilon}, \tag{30}$$

where **X** is a vector of structural characteristics, such as age and size. The vector **NC** describes neighborhood characteristics namely zoning. The term **HD** is a vector of historic preservation variables designed to capture spillover effects of historic districts on undesignated homes. Finally, **Undesignated** is a binary variable that takes on the value of 1 for buildings that are just on the opposite side of a historic district boundary;the boundary of a historic district, and **SD** is a vector socio-demographic attributes measured at the zip code level. Finally, the spatial weights matrix **W** is specified as a row standardized matrix containing the 6 nearest neighbors for each home in the sample.[42]

In this analysis, spatial interactions are assumed to occur simultaneously.[43] The spatial lag term $\mathbf{WR}^*$ is correlated with $\boldsymbol{\epsilon}$, and is considered to be endogenous. The common approach to remedy the endogeneity problem is to use the spatially lagged explanatory variables **WX** [44] as instruments for $\mathbf{WR}^*$. Recently, Gibbons and Overman (2012) have criticized this technique by highlighting the several identification issues which arise from relying solely on **WX** as an instrument. Without a suitable remedy, the estimate on ρ is vulnerable to Manski's (1993, cited in Helms, 2012) "reflection problem", in which both "endogenous" and "correlated" effects are captured by the parameter ρ. This study will not address the identification issue.

Manski's (1993, cited in Helms, 2012) "reflection problem" states that only the overall effect of neighbors' characteristics is identified. According to Gibbons and Overman (2012), in the absence of "correlated" effects or spatial autocorrelation in the unobservables, the mean neighborhood, or "endogenous", effect is indistinguishable from the mean group effect, or "contextual" on expected individual outcomes. Their work does not affect this analysis because the model proposed in equation (30) does not contain any spatially lagged explanatory variables. Therefore, the "contextual" effects, **Undesignated** and the terms of **HD**, are identified (See Gibbons & Overman, 2012, p. 178).

In the renovation literature, authors often distinguish between maintenance and improvement activities (Shear, 1983; Montgomery, 1992). Maintenance is an activity that should keep the building in a sound operating condition. As opposed to improvements, maintenance work should not substantially prolong the use of the property or significantly alter the existing structure. In line with the renovation literature, this paper considers improvements to be a separate activity from maintenance.

Neither the theoretical nor the empirical model accounts for depreciation. Thus, the results of this study may be impacted by measurement error if the level of investment, R^*, is not sufficient to offset depreciation. The impact of this error depends on local building regulations and the type of alteration that requires a permit. The City of New York requires

[42] See section 5.1 .

[43] See section 4 .

[44] The term **X** denotes the matrix of explanatory variables as defined in equations (13) and (14) .

all building owners to file for a permit [45] from the Department of Buildings prior to starting any "major" alteration activity. [46] According to the City of New York, no permit is required for "minor alterations" and "ordinary repairs". [47] Nonetheless, this study acknowledges the potential for upward bias in the coefficients due to this error.

6 Data

Figure 1 shows annual totals of designated districts and affected boroughs since 1965. Historic preservation had a real impact in New York City in 2009. During that year, designation occurred in 4 out 5 boroughs for a total of 8 designated historic districts. Hence, this study uses public micro-level data single-family homes that were privately owned in 2009.

As previously mentioned, all property owners are required to obtain a permit from the Department of Buildings (DOB) before beginning any major alteration project. First, the applicant submits plans and drawings along with the application to the DOB for review. Then, the DOB reviews the submission to determine the job type and cost of the proposed project. [48] If the plan is approved, then the final step for the applicant is to file for a permit.

The DOB offers three types of alteration permits. These are Alteration-Type 1, 2, and 3. An Alteration-Type 3 (ALT3) permit is required for projects that involve only one work type. [49] Alteration projects that involve several work types require an Alteration-Type 2 (ALT2) permit. Neither ALT3 nor ALT2 affects the use, egress, or occupancy of the building. Such cases would require an Alteration-Type 1 (ALT1) permit. ALT1 permits typically cover conversions such as converting a 3-family home into a 1-family home, or commercial building into a residential building. [50]

The data for this analysis come from several administrative sources. The variables were created using three separate datasets. I use the Historical DOB Permit Issuance dataset to construct the dependent variable. [51] For the explanatory variables, I rely on the Primary Land Use Tax Lot Output (PLUTO) dataset maintained by the Department of City Planning (DCP). [52] The fields that I used from PLUTO and the Historical DOB permit issuance

[45] N.Y.C. Admin. Code §28-101.5 and §28-105.4.

[46] N.Y.C. Admin. Code §27-332 and §28-101.5.

[47] N.Y.C. Admin. Code §28-105.4.2 and §28-105.4.2.1. For single-family homes, see https://www1.nyc.gov/assets/buildings/rules/1_RCNY_101-14.pdf for examples of jobs types that require permits.

[48] NYC Buildings, Permits, https://www1.nyc.gov/site/buildings/homeowner/permits.page (last visited May 5, 2017). The typical applicants is a licensed professional (Professional Engineer or Registered Architect).

[49] For example, plumbing, electrical, boiler, etc.

[50] Provided that local zoning laws allow for such conversions in the first place.

[51] This dataset is publicly available at NYC OpenData, and can be accessed here: https://data.cityofnewyork.us/Housing-Development/Historical-DOB-Permit-Issuance/bty7-2jhb (last visited May 5, 2017).

[52] This dataset can be accessed directly via the following links: https://www1.nyc.gov/assets/planning/download/zip/data-maps/open-data/nyc_pluto_07c.zip, https://www1.nyc.gov/assets/planning/download/zip/data-maps/open-data/nyc_pluto_09v1.zip and https://www1.nyc.gov/assets/planning/download/zip/data-maps/open-data/nyc_pluto_09v2.zip (last visited May 5, 2017).

datasets are presented in table 1 . Lastly, the 2000 Decennial Census was used to create socio-demographic measurements at the zip code level.

The Historical DOB Permit Issuance dataset contains information for 1,110,544 permits that were issued between 1989 and 2013. Permits that were renewals or issued for anything other than an alteration, such as new construction or demolition, were dropped from the dataset. Also, I discarded permits that were missing the filing date. While this dataset contains some structural attributes, it lacks information on important building characteristics such as age, area, and designation status. For that information, I rely on the PLUTO dataset.

The PLUTO dataset is a collection of administrative data that describes geographic, political, and structural attributes for hundreds of thousands of parcels or tax lots. Other city agencies in addition to the DCP, such as the Landmarks Preservation Commission (LPC) and Department of Finance (DOF), contribute to the collection. At the time of this study, there are twenty-one datasets covering the years between 2002 and 2016. This study uses the 2009 release to construct several of the explanatory variables. [53] Table 2 contains definitions for the variables that were used in the analysis.

The initial goal in processing the PLUTO data was to create a sample of privately owned single-family homes. This was accomplished using two fields: Building Class and Type of Ownership. [54] Every building is assigned a building class code by the DOF to describe the building's use. [55] The type of ownership includes private, public, and mixed. Any parcel that did not satisfy the criteria was dropped from the final dataset.

Next, I construct the following explanatory variables: *Age*, *BldgAreaK*, *LotAreaK*, *Detached*, *Semi-Attached*, *Attached*, *Irregular*, and *Easements*. [56] *BldgAreaK* and *LotAreaK* measure the size of the parcel and lot, respectively. Both variables were rescaled to units of 1000 square feet. The dichotomous variables *Detached*, *Semi-Attached*, *Attached* describe the physical relationship of buildings to their neighbors. Additional dichotomous measures are *Irregular* and *Easements*, which describe whether the parcel is located on an irregular lot and has an easement, respectively. Finally, *Age* is calculated as the difference between 2009 and the year the building was constructed.

It is important to note that the *YearBuilt* field has been found to be highly inaccurate (Lewis, 2014). A study by Lewis (2014, p. 43) found that some entries are off by as much as 73 years. Because Lewis (2014) used all building types, the extent to which this inaccuracy affects single-family homes is not clear. Hence, I use the field to create the variable *Age*. Nevertheless, this study acknowledges the bias that may result from the measurement error.

In line with previous research (Coulson & Leichenko, 2001), a variable was designed to capture a building's propinquity to a historic district for each observation in the sample. The first measure *Undesig* is an indicator variable that takes on the value 1 if a parcel is not historically designated. [57] The second variable *NumHist* is designed to capture a building's nearness to a historic district as described in equation (5). [58] *NumHist* is an aggregate of

[53] Building characteristics for 2,218 homes were obtained from the late 2008 release (version 7c).

[54] These fields are *BldgClass* and OwnershipType, respectively.

[55] The DOF assigns the code 'A' to single-family homes.

[56] I use the following fields *YearBuilt*, *LotArea*, *BldgArea*, *ProxCode*, *IrrLotCode*, and *Easements*, respectively.

[57] I use the field *HistDist* to build the variable.

[58] Coulson and Leichenko (2001) construct a similar measure, except at the census tract level.

neighboring designated properties. However, it can be argued that for dynamic urban real estate markets, such as New York City, the specification in equation (5) fails to account for the heterogeneity of historic districts as well as neighborhood density (See Coulson & Leichenko, 2001). For example, a household can be near several districts where each district differs in the number of designated properties it contains. This study does not specify a measure to account for heterogeneity of historic districts as it relates to density.

The hypothesis that historic designation has a positive impact on neighborhood quality is shown in equation (11b). *Undesig* and *NumHist* are key measures in equation (30). But, historic districts in New York City are heterogeneous in both size and age. The age of a home, as a structural characteristic, has an impact on renovation decisions. Similarly, the age of the amenity is a neighborhood characteristic and should affect renovation decisions indirectly.[59] For undesignated properties outside of historic districts, the variable *TimePost* measures the number of years post-designation. The GIS methods that I employ to construct *NumHist* and *TimePost* are subsequently discussed.

The geographic location of the sample units is necessary in order to construct *NumHist* and *TimePost*. I rely on two fields to accomplish this: the X and Y coordinates. The coordinates are expressed in the New York-Long Island State Plane coordinate system.[60] These fields combined describe the approximate location of parcels. Parcels that are missing either coordinate were discarded. The 2009 release of PLUTO provides the name of the historic district for each designated parcel. However, the dataset does not provide the date of designation. For that information, I use data obtained from the LPC [61] to match historic district names with their date of designation. Next, I split the PLUTO data according to *Undesig* to calculate the number of designated buildings within *750*ft[62] in two steps. First, the data was split into two groups: undesignated single-homes and designated properties. Then, for each undesignated home, I calculate the Euclidean distance between each property in the designated group counting only those properties that had a distance of at most *750*ft. For each undesignated property, I sort the set of neighboring designated buildings according to distance and select the first two nearest neighbors. Then, these two properties were joined with their corresponding district and date of designation information. Finally, the earliest date of designation between the two nearest neighbors was chosen to calculate *TimePost*. Afterward, I repeat this process for designated single-family homes and all other designated buildings. Lastly, I interact each continuous measure with the binary variable *Undesig* to create *NumHistxUndesig* and *TimePostxUndesig*. The first interaction will capture the impact of propinquity for undesignated homes with increases in *NumHist*. Similarly, *TimePostxUndesig* captures the impact of designation status on renovation decisions for undesignated homes.

Parcels in New York City are assigned two identification codes. The first is a 10 character code known as the "Borough-Block-Lot" (BBL), which is a concatenation of the borough, tax block, and tax lot. The second identification number called the "Building

[59] I assume designation is exogenously determined. See section 4 .

[60] PLUTO Data Dictionary. (9v2) New York City Department of City Planning 2009. Page 37.

[61] Historic district names and date of designation was retrieved from `http://www1.nyc.gov/site/lpc/designations/designation-reports.page` (last visited June 10, 2017).

[62] The distance was chosen arbitrarily. *750*ft is approximately the length of three city blocks or one avenue. See Been et al. (2016).

Identification Number" (BIDN). Normally, there is no one-to-one correspondence between the two because many buildings can be constructed on a single lot.[63] This is not an issue on the presumption that each lot contains only one building since the sample is restricted to single-family homes. The dependent variable *Alter* is a dichotomous variable that takes the value 1, if there was a record of a permit issued in 2009. To create *Alter*, I merged the Historical DOB permit issuance dataset together with the Pluto dataset. Later, missing entries were replaced with 0. Unfortunately, there was no information to denote the length of ownership or mode of tenure. I included one characteristic of ownership that describes the last recorded occurrence of an alteration. The variable *YearsLastAlt* subtracts the latest year between fields *YearAlter1* or *YearAlter2* from 2009.

Two measures of zoning regulations were included in the final analysis. The first is *BuiltMaxFAR*, which is calculated as the built residential Floor-to-Area ratio (FAR) divided by the maximum allowable residential FAR. The second is an indicator for a special purpose or limited height zoning regulation given by *SpecialZoning*. Finally, I use subsets of the 2000 Decennial Census to create the remaining explanatory variables measuring socio-demographic measures at the zip code level. The variables *Black*, *Asian*, *OtherMin* are percentage measures of the racial and ethnic composition of the zip code for each home in the sample. For each zip code, the variable *MeanEarningsK* is the average of earning reported by households rescaled to units of a thousand dollars. The last two variables *ForeignMaj* and *CollegeMaj* are dichotomous. *ForeignMaj* takes the value 1 if most households in a zip code reported another country as their place of birth, and *CollegeMaj* measures whether or not the majority of households in a zip code report holding at least a college degree. These columns were joined by zip code to create the final sample.

The final sample contains 315,627 observations. Only 3,064 homes, or approximately one percent of the sample, performed an alteration in 2009. As expected, most of the alterations were performed by undesignated homes. Only 141 designated homes performed an alteration in 2009. Basic summary statistics for all variables included in the analysis are given for all observations in table 3. Summary statistics for undesignated and designated homes are given in tables 4 and 5 , respectively.

7 Results

This paper includes a non-interactive probit model as a benchmark for comparison with the SAR probit model. The Bayesian MCMC sampling procedure [64], as described in section 5.2 , was used to estimate the parameters in equation (30) . The spatial probit model was estimated using a random sample of 124,248 observations from the full sample of 315,627. The entire sample was used to estimate the standard non-spatial probit.

The results for the standard probit is reported in table 6 along with cluster-adjusted standard errors and marginal effects calculated at means. The pseudo-$\mathbf{R}^2$ statistic is low, but low predictive power is common in previous studies on renovation. Table 7 shows the

[63] Depends on local zoning regulations.

[64] The estimation procedure has been performed using the `spatialprobit` library in `R`. The `logLik.sarprobit` function was modified in order to accommodate high dimensional spatial weights matrices.

estimates of the SAR probit model. The “direct”, “indirect”, and “total” marginal effects for the spatial probit are presented in tables 8 , 9 , and 10 , respectively.

The coefficients in the spatial lag model in table 7 show the variables' influence on renovation decisions independent of spatial neighborhood effects. The size and direction for most of the coefficients are strikingly similar between the two models. However, some of the estimates, especially those of interest to study, lost some or all significance for the SAR probit model. The estimates that lost significance in the spatial model also had insignificant marginal effects. The loss in the significance is not surprising and it is in accordance with the previous empirical work on spatial neighborhood effects.

Table 7 suggests that the interdependence among neighbors should not be ignored. In particular, the result for ρ is positive and statistically significant. However, the effect of the spatial dependence parameter ρ can include spatial autocorrelation in the unobservables. In the absence of such autocorrelation, the coefficient is interpreted as the strength of the “first order” spatial feedbacks. The result finds that spatial neighborhood effects have a positive influence on renovation decisions, but whether or not the effects work only through endogenous neighborhood effects cannot be determined.

The estimate for *Age* does not vary between both models. The results in both estimations consistently show *Age* to be a significant predictor of renovation. While significant, the “total” marginal effects of *Age* in table 10 is much less than in the standard probit, and effectively zero. This finding could be the result of measurement error which may have produced a downward bias given the direction of the coefficient. Despite the potential for downward bias due to measurement error [65] the estimates and marginal effects for *Age* are very close in magnitude to the findings of other empirical studies.

In the non-spatial model, the coefficients for *BldgAreaK* and *LotAreaK* were positive and significant at the 1% level. Unlike *LotAreaK*, the significance of *BldgAreaK* is reduced once the standard errors are clustered by zip code. The findings suggest that both variables have a positive impact on the propensity to renovate. The marginal effect for both variables was statistically significant, but the impact on the probability to renovate was different. The marginal effect for *LotAreaK* is effectively zero, whereas the marginal effect for *BldgAreaK* is positive. All else equal, a change in the area of the home increases the probability of renovating by 0.015%. In the SAR probit model, the estimates of both variables were statistically significant but the magnitude slightly increased for *LotAreaK* and decreased for *BldgAreaK*. There is no change in the marginal effects of *LotAreaK*, and the variable continues to have no practical effect suggesting that lot size has a trivial impact on the probability of performing a renovation. However, the “direct” effect of a change in *BldgAreaK* increases the probability of performing a renovation by 0.014%. Like *LotAreaK*, the “indirect” effect of a change in *BldgAreaK* is effectively zero suggesting that a change average building size of neighboring properties have little to no effect on the probability that a homeowner will renovate. The combined effects or “total” effect for *BldgAreaK* shows that a change in building size increases the probability to renovate by 0.0176%.

With regard to the dichotomous measures describing the physical relationship of buildings, the direction and significance of these variables were consistent in every estimation. Both *Attached* and *SemiAttached* had a significantly lower impact on the probability to

[65] See section 6 .

renovate when compared to the baseline of *Detached* homes. The marginal effects for *Attached* and *SemiAttached* in the non-spatial probit were slightly larger than in the spatial counterpart, i.e., "total" marginal effects.

Likewise, the findings for the dummy variable indicating whether the home was built on an irregular shaped lot was consistent in both estimations. The direction of the coefficient on *Irregular* shows that homes built on irregular shaped lots are more likely to renovate then those built are standard lots. The marginal effects of *Irregular* is slightly stronger in the spatial model. This finding demonstrates how taking into account spatial dependencies can help better explain regional phenomena. The direct marginal effect of *Irregular* increases the probability of renovating by 0.016%, which is slightly larger than the marginal effect in the standard probit model. The indirect effect of *Irregular* is interpreted as a positive spillover effect on the probability to renovate. Although the impact is not strong, the indirect effect of *Irregular* increases the probability of renovating by 0.00423%, whereas, the effect is zero in the non-spatial probit because spatial interdependencies are ignored. The combined effects, total, of *Irregular* increases the probability of renovating by 0.02%.

In contrast, the significance on the coefficients for *Easements* and *YrsLastAlt* changed across estimates. The direction and magnitude was the same for *YrsLastAlt*, but was only significant at the 10% level in the SAR probit model. Once a control for spatial neighborhood effects was introduced, the coefficient on *Easements* lost all significance. The marginal effects for the standard probit show that the effect of *Easements* negatively impacts the probability of renovating by 0.074%, while the effect for *YrsLastAlt* had a positive impact on the probability to renovate of 0.002%. The marginal effect for both *Easements* and *YrsLastAlt* was insignificant in the spatial model.

The coefficients on *SpecialZoning* and *BuiltMaxFAR* were positive and negative, respectively. However, the result for *SpecialZoning* was insignificant in every estimation. The interpretation of the coefficient of *BuiltMaxFAR* is that increases in the built FAR of a home relative to the maximum allowable FAR decreases the probability of performing an alteration on the home. The marginal effect of *BuiltMaxFAR* is similar for both models, but somewhat weaker in the non-spatial model. This difference in marginal effects is another example why the underlying spatial process in renovation decisions should not be omitted.The "direct" effect of *BuiltMaxFAR* is -0.0048, while "indirect" effect of *BuiltMaxFAR* is at -0.00131. The interpretation of the direct effect is that a change in the built FAR relative to the maximum allowable FAR decreases the probability of renovation by 0.048%. The indirect effect is interpreted as a change in the average of the built FAR relative to the maximum allowable FAR for homeowner's first six neighborhoods decreases the probability to renovate by 0.0131%. The total effect of *BuiltMaxFAR* decreases the probability of renovating for the average single-home by -0.061%.

The results for the explanatory variables controlling for various aspects of historic preservation were surprising. Except for *TimePostxUndesig*, the magnitude, and direction for *Undesig*, *NumHist*, *NumHistxUndesig*, and *TimePost* were similar in both models. Although the direction of *Undesig* indicates that undesignated homes have a higher propensity to renovate, the lack of significance suggests that designation status has no real influence on renovation decisions for single-family homeowners. The coefficient and marginal effect of *NumHist* was significant at the 10% level in the standard probit estimate. Ceteris paribus, a change in nearness to a historic district, as measured by the number of neighboring historic district properties, has no real impact on the probability to renovate. In the SAR model, the direction on *NumHist* does not change; however, the estimate and the marginal effect is no longer significant. The insignificance on the interaction term *NumHistxUndesig* does not support the hypothesis that nearness to a historic district has any effect on renovation decisions of single-family homeowners in undesignated neighborhoods. The direction of the coefficient on *NumHistxUndesig* suggests that nearness to a historic district decreases the propensity to renovate for owners of undesignated single-family homes. The findings above does not mean that these homeowners take no action as a result of the propinquity to a historic district. The impact of historic preservation on nearby areas could incentivize these homeowners to take other courses of action such as selling their property.

The variables *TimePost* and *TimePostxUndesig* are, in effect, temporal measures of historic preservation as measured by the age of the amenity. The result for *TimePost* was consistently significant at the 5% level in the non-spatial model, although the significance changed to 10% in the SAR model. The result for *TimePost* suggests that the number of years post-designation has a positive impact on renovation decisions. As the age of the amenity increases by one year, the probability of renovation increases by 0.0016%, all else equal. However, the marginal effect of *TimePost* was no longer significant in the spatial model. While the designation of historic districts appears to have a temporal effect, the findings for *TimePostxUndesig* does not support the hypothesis that historic preservation has such an effect on the renovation activity of undesignated single family-homes. These findings suggest that much of the increases in renovation activity could be occurring within designated districts. Then, the results would be consistent with the conclusion that enforcement of the local preservation laws solves the investor's dilemma.[66]

The remaining variables measure socio-demographics were mixed as well. The strongest result in both models was the effect of *CollegeMaj*. The "total" marginal effect of *CollegeMaj* was 0.144% in the standard probit, and 0.0809% in the SAR model. Additionally, *CollegeMaj* had large and significant "direct" and "indirect" marginal effects of 0.065% and 0.0159%, respectively. The effect of the racial and ethnic composition of neighborhoods largely conforms to previous findings with respect to the impact of *Black* and *OtherMin*. The impact on renovation decisions of residing in a zip code that is mostly inhabited by homeowners of Asian descent is strongly positive and statistically significant in both estimations. The analysis did not find a significant effect for *ForeignMaj*.

The results of both models do not support the hypothesis that historic preservation has any real or meaningful impact on renovation decisions for single-family homeowners. At the same time, the results do not support the claim that historic preservation negatively impacts renovation decisions either. As suggested by earlier research, many of the explanatory variables, such as the controls for historic districts, are proxies for endogenous spatial neighborhood effects and are not themselves determinants of renovation decisions. However, the results of this study can only apply to owners of single-family homes. The question whether historic preservation generates or impedes renovation activity in general remains open.

[66] See section 4 .

8 Conclusion

The preservation movement arose out of the need to protect resources of historical distinction before they were truly lost to history. Historic districting has manifested as an efficacious means to advance preservation. Its prevalence in many cities, nationally and internationally, evinces the widening consensus among policy makers, community leaders, and proponents on the necessity and mode of preserving historic assets. Yet, the mainstream approach through regulation has considerable implications on property rights.

This study was concerned with the external effects of historic preservation on adjacent neighborhoods as it relates to renovation decisions. The restrictions on property rights serve as a point of contention in the debate over historic preservation in general, and historic districts in particular. Despite these concerns, this study found no evidence to support the claim that historic preservation inhibits renovation activity among single-family homeowners. At the same time, the results of this study challenge the effectiveness of historic preservation as a policy instrument to spur investment in New York City residential housing markets.

This analysis provides some insight into the impact of historic preservation on renovation activity by single-family homeowners. However, this study is limited in scope and has considerable shortcomings leaving the door open for more empirical work on the subject. Future research can expand on the theory presented in this paper to include maintenance, a range of property types, and temporal effects in an inter-temporal framework. The findings of this paper hope to spur more research into historic preservation and its role in the adjustment mechanism of the housing supply.

9 References

[1] Ahlfeldt, G. M., & Maennig, W. (2010). Substitutability and complementarity of urban amenities: External effects of built heritage in Berlin. *Real Estate Economics*, 38(2), 285-323.

[2] Albert, J. H., & Chib, S. (1993). Bayesian analysis of binary and polychotomous response data. *Journal of the American statistical Association*, 88(422), 669-679.

[3] Anselin, L. (1988). *Spatial Econometrics: Methods and Models*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

[4] Asabere, P. K., & Huffman, F. E. (1991). Historic Districts and Land Values. *The Journal of Real Estate Research*, 6, 1-7.

[5] Asabere, P. K., & Huffman, F. E. (1994a). The Value Discounts Associated with Historic Facade Easements. *The Appraisal Journal*, 62(2), 270-277.

[6] Asabere, P. K., & Huffman, F. E. (1994b). Historic Designation and Residential Market Values. *The Appraisal Journal*, 62(3), 396-401.

[7] Asabere, P. K., Hachey, G., & Grubaugh, S. (1989) Architecture, Historic Zoning, and the Value of Homes. *Journal of Real Estate Finance and Economics*, 2, 181-195.

[8] Asabere, P. K., Huffman, F. E., & Mehdian, S. (1994). The Adverse Impacts of Local Historic Designation: The Case of Small Apartment Buildings in Philadelphia. *Journal of Real Estate Finance and Economics*, 8, 225-234.

[9] Been, V., Ellen, I. G., Gedal, M., Glaeser, E., & McCabe, B. J. (2016). Preserving history or restricting development? The heterogeneous effects of historic districts on local housing markets in New York City. *Journal of Urban Economics*, 92, 16-30.

[10] Bell, J. S. (2013). The politics of preservation: privileging one heritage over another. *International Journal of Cultural Property*, 20(4), 431-450.

[11] Boehm, T. P., & Ihlanfeldt, K. R. (1986). The improvement expenditures of urban homeowners: An empirical analysis. *Real Estate Economics*, 14(1), 48-60.

[12] Boge, G., & Boge, M. (1993). Early Preservation Efforts In *Paving Over the Past: A History And Guide To Civil War Battlefield Preservation*(2). Retrieved from `https://books.google.com/books?id=Q92C7xwkxHgC&printsec=frontcover&source=gbs_atb#v=onepage&q&f=false`.

[13] Brueckner, J. K. (2003). Strategic Interaction Among Governments: An Overview of Empirical Studies. *International Regional Science Review*, 26(2), 175-188.

[14] Byrne, J. P. (2012). Historic preservation and its cultured despisers: Reflections on the contemporary role of preservation law in urban development. *George Mason Law Review* 19(3), 665-688.

[15] Cameron, A. C., & Trivedi, P. K. (2005). *Microeconometrics: methods and applications.* Cambridge University Press.

[16] Clark, D. E., & Herrin, W. E. (1997). Historical preservation districts and home sale prices: Evidence from the Sacramento housing market. *Review of Regional Studies*, 27(1), 29-48.

[17] Coulson, N. E., & Lahr, M. L. (2005). Gracing the Land of Elvis and Beale Street: Historic Designation and Property Values in Memphis. *Real Estate Economics*, 33(3), 487-507.

[18] Coulson, N. E., & Leichenko, R. M. (2001). The Internal and External Impact of Historical Designation on Property Values. *Journal of Real Estate Finance and Economics*, 23(1), 113-124.

[19] Coulson, N. E., & Leichenko, R. M. (2004). Historic Preservation and Neighbourhood Change. *Urban Studies*, 41(8), 1587-1600.

[20] Culp, R. (2011). Relocate then renovate: An empirical analysis of the role of environmental attributes in the home improvement decision. *Journal of Housing Research*, 20(1), 53-66.

[21] DiPasquale, D. (1999). Why Don't We Know More about Housing Supply?. *Journal of Real Estate Finance and Economics*, 18(1), 9-23.

[22] Elhorst, J. P., Heijnen, P., Samarina, A., & Jacobs, J. P. (2017). Transitions at different moments in time: A spatial probit approach. *Journal of Applied Econometrics*, 32(2), 422-439.

[23] Fallis, G. (1985). *Housing Economics.* Toronto, Canada: Butterworths-Heinemann.

[24] Ford, D. A. (1989). The effect of historic district designation on single-family home prices. *Real Estate Economics*, 17(3), 353-362.

[25] Gibbons, S. & Overman, H. G. (2012). Mostly Pointless Spatial Econometrics? *Journal of Regional Science*, 52(2), 172-191.

[26] Glaeser, E. (2010). Preservation Follies. *City Journal*, 20(2).

[27] Heintzelmann, M. D., & Altieri, J. A. (2013). Historic Preservation: Preserving Value?. *Journal of Real Estate Finance and Economics* 46(3), 543-563.

[28] Helms, A. C. (2003). Understanding Gentrification: An Empirical Analysis of the Determinants of Urban Housing Renovation. *Journal of Urban Economics*, 54(3), 479-498.

[29] Helms, A. C. (2012). Keeping Up with the Joneses: Neighborhood Effects in Housing Renovation. *Regional Science and Urban Economics*, 42, 303-313.

[30] Joint Center for Housing Studies of Harvard University. (2017). *Demographic Change and the Remodeling Outlook*. Retrieved from Joint Center for Housing Studies of Harvard University: http://www.jchs.harvard.edu/sites/default/files/harvard_jchs_2017_remodeling_report_0.pdf.

[31] Laska, S. B., Seaman, J. M., & McSeveney, D. R. (1982). Inner-City Reinvestment: Neighborhood Characteristics and Spatial Patterns Over Time. *Urban Studies*, 19, 155-165.

[32] Leichenko, R. M., Coulson, N. E., & Listokin, D. (2001). Historic Preservation and Residential Property Values: An Analysis of Texas Cities. *Urban Studies*, 38(11), 1973-1987.

[33] LeSage, J., & Pace, R. K. (2009). *Introduction to Spatial Econometrics*. Chapman and Hall/CRC.

[34] LeSage, J. P., Kelley Pace, R., Lam, N., Campanella, R., & Liu, X. (2011). New Orleans business recovery in the aftermath of Hurricane Katrina. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 174(4), 1007-1027.

[35] Lewis, J. B. (2014). Measuring the Impact of Historic District Designation on Real Estate in New York City. (Master's Thesis). Retrieved from https://doi.org/10.7916/D8K072S3.

[36] Lindsay, P. (2012). Can we own the past? Cultural artifacts as public goods. *Critical Review of International Social and Political Philosophy*, 15(1), 1-17.

[37] Listokin, D., Listokin, B., & Lahr, M. (1998). The Contributions of Historic Preservation to Housing and Economic Development. *Housing Policy Debate*, 9(3), 431-478.

[38] Lockard, W. E., & Hinds, D. S. (1983). Historic Zoning Considerations in Neighborhood and District Analysis. *The Appraisal Journal*, 51(4), 485-497.

[39] Loflin, J. J., Rankin. J. L., Marcus, N., & Goldstone, H. H. (1971). Historic Preservation in the American City: A New York Case Study. *Law and Contemporary Problems*, 36(3), 362-385.

[40] Matthes, E. H. (2016). The Ethics of Historic Preservation. *Philosophy Compass*, 11(12), 786-794.

[41] Mayer, N. S. (1981). Rehabilitation Decisions in Rental Housing: An Empirical Analysis. *Journal of Urban Economics*, 10(1), 76-94.

[42] McCabe, B. J., & Ellen, I. G. (2016). Does Preservation Accelerate Neighborhood Change? Examining the Impact of Historic Preservation in New York City. *Journal of the American Planning Association*, 82(2), 134-146.

[43] McMillen, D. P. (1992). Probit with spatial autocorrelation. *Journal of Regional Science*, 32(3), 335-348.

[44] McMillen, D. P. (2012). Perspectives on spatial econometrics: Linear smoothing with structured models. *Journal of Regional Science*, 52(2), 192-209.

[45] Mendelsohn, R. (1977). Empirical Evidence on Home Improvements. *Journal of Urban Economics*, 4, 459-468.

[46] Montgomery, C. (1992). Explaining Home Improvement in the Context of Household Investment in Residential Housing. *Journal of Urban Economics*, 32, 326-350.

[47] Munneke, H. J., & Womack, K. S. (2015). Neighborhood Renewal: The Decision to Renovate or Tear Down. *Regional Science and Urban Economics*, 54, 99-115.

[48] Newsom, M. D. (1971). Blacks and Historic Preservation. *Law & Contemporary Problems*, 36(3), 423-431.

[49] Noonan, D. S. (2007). Finding an Impact of Preservation Policies: Price Effects of Historic Landmarks on Attached Homes in Chicago, 1990-1999. *Economic Development Quarterly*, 21(1), 17-33.

[50] Noonan, D. S., & Krupka, D. J. (2011). Making-or picking-winners: Evidence of internal and external price effects in historic preservation policies. *Real Estate Economics*, 39(2), 379-407.

[51] Rickman, D. S. (2009). Neighborhood historic preservation status and housing values in Oklahoma County, Oklahoma. *Journal of Regional Analysis and Policy*, 39(2), 99-108.

[52] Robinson, N. A. (1981). Historic preservation law: The metes (and) bounds of new field. *Pace Law Review*, 1(3), 511-566.

[53] Rose, C. M. (1981). Preservation and community: New directions in the law of historic preservation. *Stanford Law Review*, 473-534.

[54] Rypkema, D. D. (2000). The So-Called Property Rights Movement. *Bulletin of Science, Technology & Society*, 20(4), 321-325.

[55] Schaeffer, P. V., & Millerick, C. A. (1991). The impact of historic district designation on property values: An empirical study. *Economic Development Quarterly*, 5(4), 301-312.

[56] Schneider, T. (2001). From Monuments to Urban Renewal: How Different Philosophies of Historic Preservation Impact the Poor. *Georgetown Journal on Poverty Law & Policy*, 8, 257-281.

[57] Shear, W. B. (1983). Urban housing rehabilitation and move decisions. *Southern Economic Journal*, 1030-1052.

[58] Sweeney, J. L. (1974a). Quality, commodity hierarchies, and housing markets. *Econometrica: Journal of the Econometric Society*, 147-167.

[59] Sweeney, J. L. (1974b). Housing unit maintenance and the mode of tenure. *Journal of Economic Theory*, 8(2), 111-138.

[60] Sweeney, J. L. (1974c). A commodity hierarchy model of the rental housing market. *Journal of Urban Economics*, 1(3), 288-323.

[61] Uzdavinis, B. (2007). To Save or Note to Save: Historic Preservation in New Jersey-Justifications, Hindrances, Future. *Rutgers Journal of Law & Public Policy*, 4(4), 649.

[62] Warren, K. J. (1999). A philosophical perspective on the ethics and resolution of cultural property issues. In P. M. Messenger (Ed.), *The Ethics of Collecting Cultural Property*, p. 1-26. USA: University of New Mexico Press.

[63] Wetzstein, S. (2017). The global urban housing affordability crisis. *Urban Studies*, 54(14), 3159-3177.

[64] Wojno, C. T. (1991). Historic preservation and economic development. *Journal of Planning Literature*, 5(3), 296-306.

[65] Wood, A. (2008). *Preserving New York: Winning the right to protect a city's landmarks.* New York City: Routledge.

[66] Zahirovic-Herbert, V., & Chatterjee, S. (2012). Historic preservation and residential property values: Evidence from quantile regression. *Urban Studies*, 49(2), 369-382.

[67] Zahirovic-Herbert, V., & Gibler, K. M. (2014). The effect of new residential construction on housing prices. *Journal of Housing Economics*, 26(C), 1-18.

10 Tables

Table 1: Description of Data Fields

Source	Field	Description
Pluto	BBL	A concatenation of the borough code, tax block, and tax lot.
	ZipCode	The zip code where the building is located.
	BldgClass	A code describing the major use of buildings on the tax lot.
	SPDist	The special purpose or limited height district assigned to the tax lot.
	Easements	Number of easements on the tax lot.
	OwnerType	A code describing the type of ownership for the tax lot.
	LotArea	The total area of the tax lot rounded to the nearest integer, expressed in units of square feet.
	BldgArea	The total gross area of the building, expressed in units of square feet.
	ProxCode	The physical relationship of the building to neighboring buildings.
	IrrLotCode	A code indicating whether the tax lot is irregularly shaped.
	YearBuilt	The year when the construction of the buildings was completed.
	YearAlter	The year of the building's most recent alteration.
	XCoord	The X coordinate of the XY coordinate[a] pair.
	YCoord	The Y coordinate of the XY coordinate[a] pair.
	HistDist	The name of the historic district as designated by the Landmarks Preservation Commission.
	DateofDesignation [b]	The date of the historic district as designated by the Landmarks Preservation Commission.
	BuiltFAR	The built Floor Area Ratio is the total building floor area divided by the area of the tax lot.
	MaxAllwFAR	The maximum allowable residential Floor Area Ratio.
Historical DOB Permit Issuance	Bin Num.	Building identification number.
	Borough	The borough where the building is located.
	Block	The number of the tax block where the building is located.
	Lot	The number of the tax lot where the building is located.
	Job Doc. Num.	The number assigned to jobs that were approved by the Department of Buildings.
	Job Type	A code describing the permit that was approved.
	Work Type	A code describing the type of work that the job entails.
	Filing Date	The date of when the permit was filed.
	Filing Status	A code indicating whether the permit is a renewal.

[a] The coordinates are expressed in the New York-Long Island State Plane coordinate system.
[b] *DateofDesignation* is not included in the PLUTO dataset. This field was constructed using *HistDist* and an data retrieved from the LPC.

Table 2: Definition of Variables

Variable	Definition
Alter	A dummy variable indicating whether the building performed an alteration.
Age	The age of the structure as of 2009.
BldgAreaK	The total gross area of the home, expressed in 1000 square feet.
LotAreaK	The total area of the lot, expressed in 1000 square feet.
Attached	A dummy variable indicating whether the building is attached to neighboring buildings.
SemiAttached	A dummy variable indicating whether the building is partially attached to neighboring buildings.
Irregular	A dummy variable indicting whether the shape of the tax lot is irregular.
Easements	A dummy variable indicting whether a building has an easement.
YrsLastAlt	The number of years since the building's last alteration as of 2009.
BuiltMaxFAR	The ratio between the *BuiltFAR* over the *MaxAllwFAR*.[a]
SpecialZoning	A dummy variable indicting whether a special zoning rule is assigned to the building.
Undesig	A dummy variable indicating whether a building is not located within a historic district.
NumHist	The number of historically designated properties within a radius of 750 feet.
NumHistxUndesig	An interaction term between *NumHist* and *Undesig*.
TimePost	The number of years that have passed since the nearest historic districts was designated.
TimePostxUndesig	An interaction term between *TimePost* and *Undesig*.
Black	A percentage of residents in a zip code that identify as black or having African ancestry.
Asian	A percentage of residents in a zip code that identify as having Asian ancestry.
OtherMin	A percentage of non-white residents in a zip code that identify as having an ancestry other than African or Asian.
MeanEarningsK	The mean of reported earnings of residents by zip code, expressed in unit of $1000 dollars.
ForeignMaj	A dummy variable indicating whether the majority of residents in a zip code reported another country as their birth place.
CollegeMaj	A dummy variable indicating whether the majority of residents in a zip code reported having a college degree.

[a] See table 1 .

Table 3: Statistical Summary for Single-Family Homes

	Mean	St. Dev.	Min	Max
Age	65.858	24.926	0	280
BldgAreaK	1.678	0.840	0.000	72.520
LotAreaK	3.490	23.530	0.000	12,253.430
Attached	0.186	0.389	0	1
SemiAttached	0.218	0.413	0	1
Irregular	0.109	0.312	0	1
Easements	0.004	0.061	0	1
YrsLastAlt	0.286	1.810	0	109
BuiltMaxFAR	0.838	0.484	0.000	22.800
SpecialZoning	0.135	0.341	0	1
Undesig	0.986	0.117	0	1
NumHist	1.891	18.814	0	428
NumHistxUndesig	0.405	6.190	0	365
TimePost	0.485	3.751	0	44
TimePostxUndesig	0.187	2.275	0	43
Black	25.487	31.285	0.100	93.500
Asian	10.356	10.287	0.300	53.900
OtherMin	11.072	9.438	0.400	57.600
MeanEarningsK	61.833	10.747	28.661	166.873
ForeignMaj	0.091	0.288	0	1
CollegeMaj	0.008	0.088	0	1

Table 4: Statistical Summary for Undesignated Single-Family Homes

	Mean	St. Dev.	Min	Max
Age	65.459	24.768	0	280
BldgAreaK	1.657	0.802	0.000	72.520
LotAreaK	3.480	23.689	0.000	12,253.430
Attached	0.182	0.386	0	1
SemiAttached	0.220	0.414	0	1
Irregular	0.109	0.311	0	1
Easements	0.004	0.062	0	1
YrsLastAlt	0.275	1.764	0	109
BuiltMaxFAR	0.836	0.480	0.000	22.800
SpecialZoning	0.133	0.339	0	1
Undesig	1.000	0.000	1	1
NumHist	0.411	6.233	0	365
NumHistxUndesig	0.411	6.233	0	365
TimePost	0.190	2.291	0	43
TimePostxUndesig	0.190	2.291	0	43
Black	25.462	31.263	0.100	93.500
Asian	10.373	10.311	0.300	53.900
OtherMin	11.068	9.443	0.400	57.600
MeanEarningsK	61.689	10.203	28.661	166.873
ForeignMaj	0.090	0.287	0	1
CollegeMaj	0.004	0.063	0	1

Table 5: Statistical Summary for Designated Single-Family Homes

	Mean	St. Dev.	Min	Max
Age	94.245	19.105	1	185
BldgAreaK	3.129	1.744	0.000	21.700
LotAreaK	4.215	4.465	0.000	64.277
Attached	0.505	0.500	0	1
SemiAttached	0.120	0.325	0	1
Irregular	0.148	0.355	0	1
Easements	0.001	0.030	0	1
YrsLastAlt	1.007	3.793	0	48
BuiltMaxFAR	0.962	0.692	0.000	4.240
SpecialZoning	0.254	0.435	0	1
Undesig	0.000	0.000	0	0
NumHist	107.293	107.424	0	428
NumHistxUndesig	0.000	0.000	0	0
TimePost	21.479	13.992	0	44
TimePostxUndesig	0.000	0.000	0	0
Black	27.303	32.750	0.400	89.200
Asian	9.188	8.284	0.400	45.900
OtherMin	11.369	9.089	2.700	55.400
MeanEarningsK	72.106	28.650	32.417	139.896
ForeignMaj	0.171	0.377	0	1
CollegeMaj	0.278	0.448	0	1

Table 6: Estimation Results of Standard Probit Model and Marginal Effects

Dependent variable:			
ALTER			
	Probit Model	Robust Error	Marginal Effects
Constant	-2.49273^{***}	-2.49273^{***}	
	(0.12501)	(0.17793)	
Age	0.00241^{***}	0.00241^{***}	0.00005^{***}
	(0.00035)	(0.00055)	(0.00001)
BldgAreaK	0.06506^{***}	0.06506^{**}	0.00147^{***}
	(0.00658)	(0.03028)	(0.00015)
LotAreaK	0.00142^{***}	0.00142^{***}	0.00003^{***}
	(0.00049)	(0.00040)	(0.00001)
Attached	-0.12066^{***}	-0.12066^{***}	-0.00273^{***}
	(0.02219)	(0.03383)	(0.00050)
SemiAttached	-0.14197^{***}	-0.14197^{***}	-0.00321^{***}
	(0.02023)	(0.03948)	(0.00045)
Irregular	0.06807^{***}	0.06807^{***}	0.00154^{***}
	(0.02140)	(0.02373)	(0.00048)
Easements	-0.32824^{*}	-0.32824^{**}	-0.00743^{*}
	(0.17095)	(0.15019)	(0.00386)
YrsLastAlt	0.00767^{***}	0.00767^{**}	0.00017^{***}
	(0.00295)	(0.00356)	(0.00007)
BuiltMaxFAR	-0.19383^{***}	-0.19383^{***}	-0.00439^{***}
	(0.02137)	(0.04019)	(0.00048)
SpecialZoning	0.00229	0.00229	0.00005
	(0.02295)	(0.03544)	(0.00052)
Undesig	0.06199	0.06199	0.00140
	(0.08584)	(0.11675)	(0.00194)
NumHist	0.00073^{*}	0.00073^{*}	0.00002^{*}
	(0.00042)	(0.00043)	(0.00001)
NumHistxUndesig	−0.00035	−0.00035	−0.00001
	(0.00109)	(0.00077)	(0.00002)

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Table 6: Estimation Results of Standard Probit Model and Marginal Effects (Cont.)

Dependent variable:			
ALTER			
	Probit Model	Robust Error	Marginal Effects
TimePost	0.00718**	0.00718**	0.00016**
	(0.00365)	(0.00358)	(0.00008)
TimePostxUndesig	−0.00024	−0.00024	−0.00001
	(0.00456)	(0.00422)	(0.00010)
Black	−0.00278***	−0.00278***	−0.00006***
	(0.00032)	(0.00051)	(0.00001)
Asian	0.00634***	0.00634***	0.00014***
	(0.00083)	(0.00110)	(0.00002)
OtherMin	−0.00066	−0.00066	−0.00001
	(0.00093)	(0.00137)	(0.00002)
MeanEarningsK	−0.00039	−0.00039	−0.00001
	(0.00094)	(0.00128)	(0.00002)
ForeignMaj	−0.00810	−0.00810	−0.00018
	(0.02695)	(0.04024)	(0.00061)
CollegeMaj	0.40504***	0.40504***	0.00917***
	(0.07648)	(0.10406)	(0.00173)
McFadden's Psuedo-R^2	0.0356		
Observations	315,627		

Note:

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

The robust standard errors are cluster-robust by zip code for a total of 168 zip codes.

Marginal effects calculated at the mean (MEM).

Table 7: Estimation Results of Spatial Probit Model

Dependent variable:	
Alter	
	SAR Probit
Constant	-2.00694^{***}
	(0.23525)
Age	0.00228^{***}
	(0.00050)
BldgAreaK	0.05977^{***}
	(0.00783)
LotAreaK	0.00200^{***}
	(0.00066)
Attached	-0.07618^{***}
	(0.02739)
SemiAttached	-0.12854^{***}
	(0.03096)
Irregular	0.06897^{***}
	(0.02625)
Easements	-0.26910
	(0.19699)
YrsLastAlt	0.00755^{*}
	(0.00400)
BuiltMaxFAR	-0.21077^{***}
	(0.03794)
SpecialZoning	0.01357
	(0.02432)
Undesig	0.06371
	(0.09140)
NumHist	0.00036
	(0.00048)
NumHistxUndesig	-0.00026
	(0.00121)

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Table 7: Estimation Results of Spatial Probit Model (Cont.)

Dependent variable:	
ALTER	
	SAR Probit
TimePost	0.00751*
	(0.00405)
TimePostxUndesig	−0.00002
	(0.00502)
Black	−0.00240***
	(0.00052)
Asian	0.00510***
	(0.00109)
OtherMin	−0.00085
	(0.00098)
MeanEarningsK	−0.00013
	(0.00101)
ForeignMaj	−0.01714
	(0.02893)
CollegeMaj	0.27292***
	(0.09226)
rho	0.21437**
	(0.09376)
Observations	124,248

Note:

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 8: SAR Probit Model *Direct* Effects Estimate

	Lower 2.5%	Marginal Effect	Upper 97.5%	Significance
Age	0.000029451	0.000051662	0.000073483	†
BldgAreaK	0.000779789	0.001390989	0.001908739	†
LotAreaK	0.000016547	0.000047504	0.000093669	†
Attached	-0.003031413	-0.001731819	-0.000582413	†
SemiAttached	-0.004274472	-0.002949052	-0.001610091	†
Irregular	0.000353445	0.001572242	0.002869914	†
Easements	-0.016220837	-0.006169405	0.001700551	
YrsLastAlt	-0.000018964	0.000169130	0.000353670	
BuiltMaxFAR	-0.006568870	-0.004796104	-0.003055647	†
SpecialZoning	-0.000817056	0.000313908	0.001488568	
Undesig	-0.002658032	0.001467757	0.006221997	
NumHist	-0.000014771	0.000008205	0.000032762	
NumHistxUndesig	-0.000068032	-0.000005856	0.000050320	
TimePost	-0.000001718	0.000177232	0.000393011	
TimePostxUndesig	-0.000251324	-0.000004244	0.000231393	
Black	-0.000076253	-0.000054813	-0.000031901	†
Asian	0.000055753	0.000116950	0.000174605	†
OtherMin	-0.000064637	-0.000017357	0.000028947	
MeanEarningsK	-0.000047119	-0.000001353	0.000049677	
ForeignMaj	-0.001781971	-0.000367144	0.001056281	
CollegeMaj	0.001579034	0.006500266	0.011960738	†

Note: † indicates significance at the 95% level.

Table 9: SAR Probit Model *Indirect* Effects Estimate

	Lower 2.5%	Marginal Effect	Upper 97.5%	Significance
Age	0.000004487	0.000013959	0.000031438	†
BldgAreaK	0.000143526	0.000365123	0.000738685	†
LotAreaK	0.000003540	0.000012479	0.000031289	†
Attached	-0.001047329	-0.000457501	-0.000110736	†
SemiAttached	-0.001714677	-0.000792618	-0.000246564	†
Irregular	0.000074890	0.000423280	0.001085449	†
Easements	-0.005256784	-0.001683805	0.000339032	
YrsLastAlt	-0.000003815	0.000046263	0.000135868	
BuiltMaxFAR	-0.002980886	-0.001308056	-0.000425188	†
SpecialZoning	-0.000220023	0.000073994	0.000376581	
NumHist	-0.000003852	0.000002037	0.000008837	
Undesig	-0.000631449	0.000402156	0.001837770	
NumHistxUndesig	-0.000017479	-0.000001211	0.000014258	
TimePost	-0.000000416	0.000045517	0.000117322	
TimePostxUndesig	-0.000074480	-0.000002440	0.000059222	
Black	-0.000030219	-0.000014533	-0.000005218	†
Asian	0.000011705	0.000029943	0.000056543	†
OtherMin	-0.000020983	-0.000004894	0.000006423	
MeanEarningsK	-0.000014470	-0.000000834	0.000011543	
ForeignMaj	-0.000537422	-0.000107345	0.000235626	
CollegeMaj	0.000473978	0.001585061	0.003149157	†

Note: † indicates significance at the 95% level.

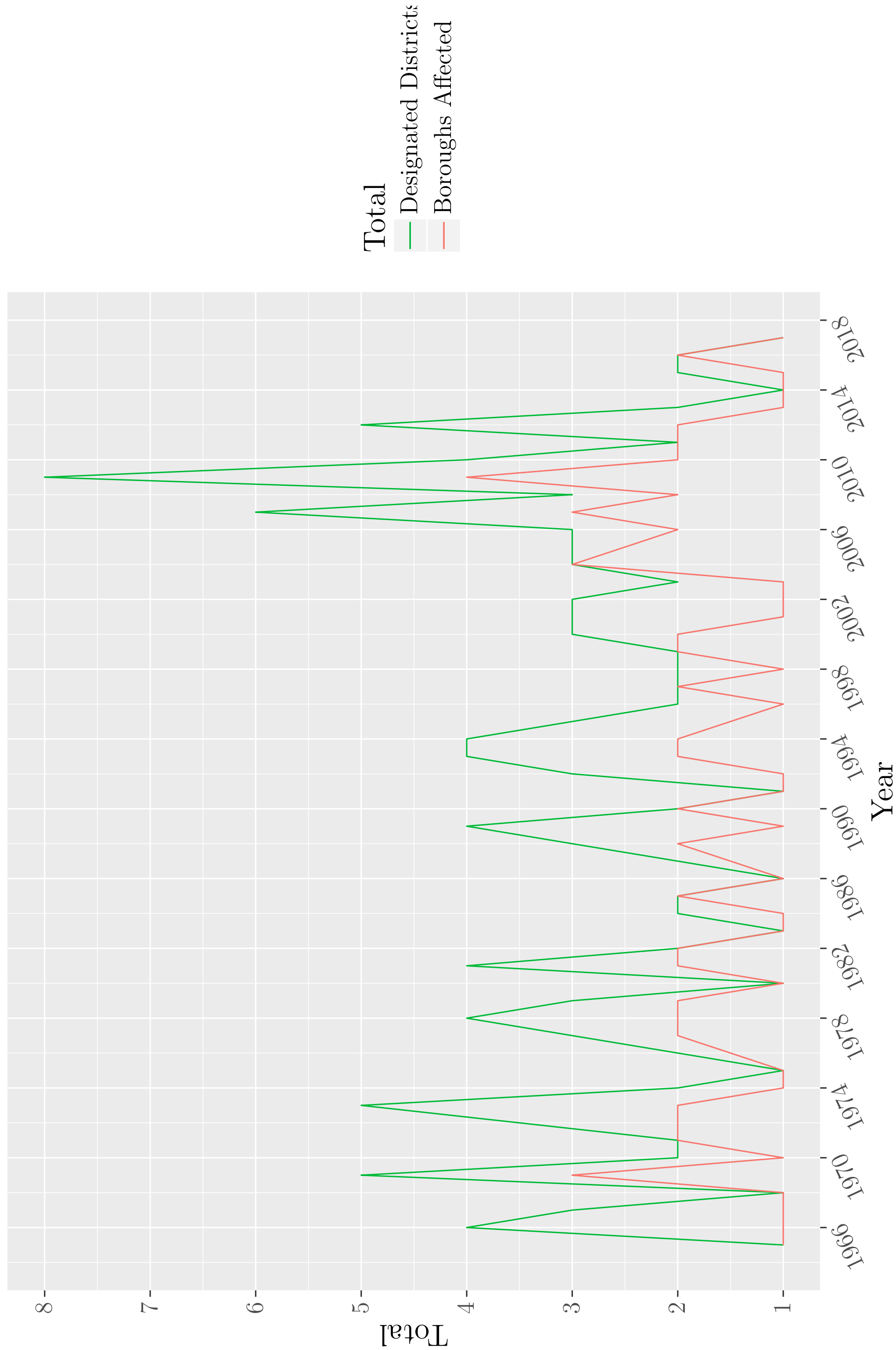
Table 10: SAR Probit Model *Total* Effects Estimate

	Lower 2.5%	Marginal Effect	Upper 97.5%	Significance
Age	0.000039828	0.000065621	0.000093612	†
BldgAreaK	0.001224794	0.001756111	0.002357280	†
LotAreaK	0.000023050	0.000059983	0.000117418	†
Attached	-0.003700311	-0.002189320	-0.000789187	†
SemiAttached	-0.005307408	-0.003741670	-0.002158751	†
Irregular	0.000489309	0.001995522	0.003563551	†
Easements	-0.020265505	-0.007853210	0.002090899	
YrsLastAlt	-0.000023176	0.000215392	0.000447426	
BuiltMaxFAR	-0.008599580	-0.006104159	-0.004172808	†
SpecialZoning	-0.001018202	0.000387902	0.001793653	
Undesig	-0.003225254	0.001869913	0.007628427	
NumHist	-0.000018475	0.000010243	0.000039907	
NumHistxUndesig	-0.000083016	-0.000007067	0.000062901	
TimePost	-0.000002262	0.000222749	0.000482114	
TimePostxUndesig	-0.000315753	-0.000006684	0.000282631	
Black	-0.000092707	-0.000069345	-0.000046386	†
Asian	0.000087287	0.000146893	0.000207958	†
OtherMin	-0.000081583	-0.000022251	0.000035195	
MeanEarningsK	-0.000058900	-0.000002187	0.000060402	
ForeignMaj	-0.002216278	-0.000474489	0.001279126	
CollegeMaj	0.002454685	0.008085327	0.014079201	†

Note: † indicates significance at the 95% level.

11 Figures

Figure 1: Yearly Aggregate of Designated Historic Districts and Boroughs Affected, 1965-2017



Source: Landmarks Preservation Commission.