The Political Economy of Historic Districts: The Private, the Public, and the Collective

Yang Zhou *

West Virginia University

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Abstract

Historic heritage generates amenities for urban residents, and external designation of historic heritage may provide further amenities. Meanwhile, preservation regulations imposed on reconstruction and refurbishment require property owners to undertake undesired costs. The literature finds mixed but mostly positive effects of historic designation on property values. In this paper, I study two questions in the literature which have not been studied or not been addressed thoroughly: collective action cost of the political process of designation and the public good characteristic of historic districts. I develop a simple theory of the political economy of historic districts and provide corresponding empirical evidence. Theoretical predictions suggest that the cost of collective action impedes the realization of the socially-optimal equilibrium level of historic district designation, while achieving a historic designation ultimately leads to a political in-equilibrium where marginal benefit is higher than marginal cost. Empirical evidence from Denver is consistent with the implications from the theoretical model developed in this paper. Being in a historic district generates a 15-20% premium for house transactions after designation, while there is no premium before the designation. This paper also differentiates between types of historic designations and concludes that historic districts of private single-family homes do not have significant spillovers, while publicly accessible structures have a positive externality. Various robustness tests provide comparable results.

JEL Codes: D00, H40, R20, R30
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*John Chambers College of Business & Economics, Department of Economics, 1601 University Ave., PO Box 6025, Morgantown, WV 26506-6025, USA; Email: ygzhou@mix.wvu.edu

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1 Introduction

Historic heritage influences the utility of consumers in a city. Residents and politicians in a city often manage to officially preserve historic heritage by designating a historic district for a group of spatially and historically related historic buildings or designating an individual historic structure. However, often there are strict regulations on reconstruction and refurbishment of buildings in designated historic districts which aim to preserve the history. Facing both the marginal benefits of official certification and preservation and the marginal costs of regulation, it is difficult to predict the net effect on residents' utility and house price changes.

Do the costs of political processes also influence the economic outcomes? Both political and economic systems are the means people employ to exchange and allocate resources, and they are intertwined. The political process involves coordination and collective actions, which generate significant economic costs. Therefore, it should affect people's incentives and actions, and ultimately economic outcomes. The historic heritage designation process, especially that of the historic district, involves rounds of collective actions and bargaining within and between various parties, the costs of which influence the political equilibrium of designation and residents' utilities. Meanwhile, the designation process is endogenous rather than exogenous.

In the growing literature of historic designation policies and property values, most papers acknowledge but do not study the endogenous process of historic district designation. Instead, Noonan and Krupka (2011), Been et al. (2016), and Ahlfeldt et al. (2017) shed light on the endogenous characteristic of the historic district designation process, while all assuming that a social planner designates historic districts with zero cost of political process. In reality, a designation is never handled by one single social planner but rather by multiple parties with various rounds of collective actions involved. As established by Olson (1965), when there are collective actions, there are collective action problems and costs.

The literature has also explored the question of whether or not historic districts are public goods. Houses adjacent to official designations are found to enjoy a positive spillover in most research (Schaeffer and Millerick, 1991; Asabere and Huffman, 1994; Been et al., 2016; Ahlfeldt et al., 2017), while there is also research finding no spillovers or even negative spillovers (Clark and Herrin, 1997; Noonan and Krupka, 2011; Zahirovic-Herbert and Gibler, 2014). Ahlfeldt and

Holman (2018) investigate further and find that architectural amenities of historic heritage have positive spillovers. Public goods are traditionally defined as "non-rival" and "non-excludable." Many designated historic districts are of private residential houses, which are better classified as private goods, as they are "rival" and "excludable" for most parts except the outside view. This distinction between the public goods and private goods characteristic of historic districts has not been studied in the literature.

In this research, a theoretical model incorporating collective action cost and accessibility of historic district is constructed to investigate the property value change (resident utility change) within and outside historic districts after designation. Theoretical predictions suggest that the pre-designation political equilibrium will turn to be an in-equilibrium post designation since collective actions are no longer necessary once a district is officially designated.[1] It also predicts that only historic districts constituted of publicly accessible structures are public goods. Empirical evidence from Denver, Colorado provides consistent results as suggested by the theoretical predictions: collective actions matter in the endogenous designation process of historic districts and influence the post-designation political equilibrium and housing values. Meanwhile, whether a historic district has significant spillovers or not depends on whether it is a public good or not, i.e. publicly accessible structures versus private single-family homes.

This research contributes to the literature by addressing these two important questions that have not been asked or have not been addressed thoroughly in the literature. First, the political process with collective action involved does influence the political equilibrium of endogenous historic district designation. Second, whether historic districts are public goods depends on their specific characteristics. In addition to these two contributions, this research also adds to the literature by providing corresponding evidence from Denver, a representative Western and monocentric city in the United States, the evidence of which is missing in the current literature.

The rest of the paper proceeds as follows. Section 2 provides a simple theoretical model discussing the collective action problem and public goods question mentioned above. It also provides theoretical predictions of their effects on residents' utility thus housing prices. Section 3 details the institutional context in Denver, Colorado. Section 4 explains the data used for empirical analysis.

[1] By "in-equilibrium" it means that the marginal benefit turns to be higher than the marginal cost at the temporary "equilibrium", and there will be a call for more designation.

Section 5 discusses the empirical strategy employed. Section 6 provides and interprets the results. Section 7 concludes and provides policy implication.

2 Theory: Historic District Designation with Collective Actions

This section provides a simple theory for the political economy of historic district designation, which focuses on the collective actions involved and the public goods characteristics of historic districts.

Following the basic setups in Ahlfeldt et al. (2017), I assume that the spatial distribution of a city follows a linear dimension x on the interval [0, 1]. Ahlfeldt et al. (2017) assume a linear neighborhood, while in this paper it is relaxed to a general city, e.g. a monocentric one. The city itself is not linear, while for the sake of simplicity, the area or proportion of the city can be viewed and analyzed in this linear dimension setting. At each point along x, there exists a small district which can be designated as a historic district. Other than the officially designated historic district, internal historic heritages are also distributed in this city. The internal historic heritage at each point x is a decreasing function of the distance from the city center, $h(x) = \bar{h}g(x)$. $g(x) \geq 0$ is a heritage density function with a strictly negative first derivative $g_x < 0$, and $\bar{h} \geq 0$ is a scale parameter that reflects the overall city endowment of historic heritage (Ahlfeldt et al., 2017).

The city itself with its government can establish its own historic preservation system. Typically, a city is part of a broader jurisdiction, e.g. a nation, which might also have a broad historic preservation system covering this city. Therefore, with the same internal historic heritage endowment, two parallel but independent historic district systems can run at the same time, which are denoted as the "Local (l)" one and the "National (n)" one. As long as a district is designated by one of the two systems, it is viewed as being officially externalized.[2]

Suppose that at the current stage, the districts in the range of $[0,\ D^l]$ have been officially designated as local historic districts, and those in the range of $(D^l,\ 1]$ have a probability π^l $(0 \leq \pi^l < 1)$ of being designated as local historic districts in the future. Similarly, the districts in the range of $[0,\ D^n]$ have been officially designated as national historic districts, and those in the range of $(D^n,\ 1]$ have a probability π^n $(0 \leq \pi^n < 1)$ of being designated as national historic districts in

[2] Brueckner et al. (1999) also classify urban amenities into three categories: natural amenities (exogenous), historic amenities (exogenous), and modern amenities (endogenous). This provides a dichotomy separating the internal historic value and the external historic designation value.

the future. D denotes the general one representing both D^l and D^n.

The local external historic heritage H^l and national external historic heritage H^n can be denoted as the following:

$$H^l(D^l) = \int_0^{D^l} \mathrm{h}(x)\mathrm{d}x + \pi^l \int_{D^l}^1 \mathrm{h}(x)\mathrm{d}x \tag{1}$$

$$H^n(D^n) = \int_0^{D^n} \mathrm{h}(x)\mathrm{d}x + \pi^n \int_{D^n}^1 \mathrm{h}(x)\mathrm{d}x \tag{2}$$

The total local external heritage $H^l(D^l)$ increases with D^l but at a decreasing rate, which can be seen from the partial derivatives: $H^l_{D^l} = (1-\pi^l)h(D^l) > 0$ and $H^l_{D^l D^l} = (1-\pi^l)h_{D^l} < 0$. Similarly, the total national external heritage $H^n(D^n)$ increases with D^n but at a decreasing rate, which can be seen from the partial derivatives: $H^n_{D^n} = (1-\pi^n)h(D^n) > 0$ and $H^n_{D^n D^n} = (1-\pi^n)h_{D^n} < 0$. For the sake of generality: it uses $H(D)$ ($H_D > 0$, $H_{DD} < 0$) to denote external historic heritage in general. However, this does not indicate that the two systems can be simply pooled together, and it still distinguishes the two systems in the empirical analysis. Similarly, in the following parts of the theory section, it does not specify whether it is the local system or the national system, while any variable or parameter with a superscript l or n added denotes the corresponding local or national one.

For the building designated in historic districts, the cost from designation regulations on reconstruction and renovation is $C^D(x \leq D)$. Note that C^D can be zero, as long as there is no regulation ex post at all. Been et al. (2016) and Ahlfeldt et al. (2017) both assume a social planner designating historic districts or conservation zones, while this may not be true. In reality, it is often the case that residents and business owners in a district need to put together a set of application materials collectively in order to apply for a historic designation, which also incurs a cost along the political process of designation. The application is further reviewed by multiple committees on different levels, while the starting point of historic district designation is always a set of collective actions. Thus, there should also be a designation cost from the collective actions (Olson, 1965) incurred before the final designation, noted as $C^C(x = D, x)$. The size of the collective action cost is location specific and can be influenced by many factors at location x: the group size of property and business owners involved, the procedure of nomination, hearing, and approval process involved, the past cooperation experiences within this specific group, etc. Therefore, there is not any specific trend of the function $C^C(x = D, x)$ along x.

Time also plays a role here. If there is no endogeneity issue, residents' utility should not be influenced before the start of the designation process, which has not happened until some time point in the future. If the designation already occurred, the longer the time it has had, the more "historic" the historic district it will be. The tricky part is the time between the application and the designation. Another factor is cultural, as it takes time to build the reputation of a historic district before the designation has any significant effect on the utilities of residents city-wide. "Rome was not built in one day", neither is reputation. This research has no intention to delve too deep into the role of time, while it is important to consider the "Lucas Critique" (Lucas, 1976; Kydland and Prescott, 1977) that people's short-term preferences, expectations, and actions will adjust along the years-long application and designation process of historic districts. It would not be surprising if a smooth rather than sharp transition was observed. Therefore, one parameter ρ ($0 \leq \rho \leq 1$) is considered to be the discount rate of future costs to the current period. In the period before the designation, residents living in the candidate districts face the collective action cost C^C. They also face the time-discounted regulation cost in the near future ρC^D, which can be denoted as the cost of designation regulation residents facing in the "current" time period. In the post-designation time period, the residents also face the real regulation cost, C^D (for ρC^D while $\rho \equiv 1$). Note that the collective action cost C^C is now 0 in the post-designation period, because collective actions for the political process of designation are not needed anymore.

Formally, C^C only exists for residents within the historic districts to be designated before the designation ($x = D \,\&\, t \leq T^D$, T^D represents the time of official designation for the district at location x), therefore,

$$Collective\,Action\,Cost \begin{cases} > 0 & \text{if } x = D \,\&\, t \leq T^D \\ = 0 & \text{if } x = D \,\&\, t > T^D \\ = 0 & \text{if } x \neq D \end{cases}$$

Meanwhile, the "current" period regulation cost from the historic district designation is

$$Regulation\,Cost \begin{cases} = \rho C^D & \text{if } x = D \,\&\, t \leq T^D \\ = C^D & \text{if } x = D \,\&\, t > T^D \\ = C^D & \text{if } x < D \\ = 0 & \text{if } x > D \end{cases}$$

For residents living in houses right outside of the designated historic districts ($x > D$, $t > T^D$), they may also enjoy an externality at a reduced rate $\delta[x - D, b(D)]$ ($0 \leq \delta < 1$), which is decided by both the distance to closest historic district in both category $x - D$ and the accessibility to these structures in that historic district $b(D)$. The closer a non-designated district is to the closest designated historic district, the larger spillover residents in the former one enjoy: $\delta_{x-D} < 0$. Meanwhile, a larger degree of access to the structures in designated historic district also leads to a larger spillover: $\delta_b > 0$. Formally,

$$\delta[x - D, b(D)] \begin{cases} = 0 & \text{if } x \leq D \\ > 0 & \text{if } x > D \,\&\, b(D) > 0 \\ = 0 & \text{if } x > D \,\&\, b(D) = 0 \end{cases}$$

Moreover, residents' utility increases as local amenity $a(x)$ increases (Glaeser et al., 2001). The consumption of a composite numeraire good X and housing space S yields the local utility of residents at location x as:

$$U(x) = U\{h(x), H(D), C^C(x = D, x), C^D(x \leq D), \delta[x - D, b(D)], a(x), X, S\} \tag{3}$$

with $U_h > 0$, $U_H > 0$,$U_{C^C} < 0$, $U_{C^D} \leq 0$ ("=" holds when there is no regulation cost), $U_\delta > 0$, $U_a > 0$, $U_X \geq 0$, and $U_S \geq 0$. Meanwhile, $U_{DD} < 0$, $U_{C^C C^C} < 0$, $U_{C^D C^D} < 0$, $U_{XX} < 0$, and $U_{SS} < 0$.

2.1 Can Historic Districts' Designation Reach the Political Equilibrium?

In Ahlfeldt et al. (2017), Hypothesis 2 states that "In the political equilibrium D, designation of a zone leads to a zero capitalisation effect inside the zone but a positive effect in the rest of the neighbourhood" (Ahlfeldt et al., 2017). They also assume that the designation of conservation is made by a central planner representing the whole society.

When the designations are made by a central planner, the planner does not have all the knowledge for residents' preferences and utilities (Hayek, 1945, 1988). In reality, the designation process for historic districts of residential homes often starts with a collective application from residents and business owners within the district with historic heritage, and it will be further reviewed and evaluated by multiple committees. In general, collective actions by group members are less likely to be successful as that by one single central planner, as Olson (1965) indicates. Similar implications can also be found in Buchanan and Tullock (1962). More realistic details will be provided and discussed in the Institutional Context section.

That being said, since the historic district designation process is more decentralized and complicated than that by a single central planner, it is likely that the political equilibrium as in the Hypothesis 2 of Ahlfeldt et al. (2017) is more difficult to be reached for a city without such an omniscient central planner. If new historic districts have continued to become designated, it can be inferred that the marginal utility and capitalization effect inside the district are still greater than zero, i.e., the political equilibrium has not been reached. Otherwise, no more new historic districts should be designated.

Mathematically, when there is no cost for the designation process, e.g. by one single social planner as in Ahlfeldt et al. (2017) and Been et al. (2016), for residents in the districts right before the designation of historic districts (i.e. $x = D$), the marginal utility for residents is $U_D = \rho U_H H_D + \rho U_{C^D}$, since they need to undertake the extra, newly added regulation cost but also at a time discount rate. Ahlfeldt et al. (2017) provide the solution for the political equilibrium when the designation is by a social planner, $U_H H_D + U_{C^D} = 0$, where they assume no time factor. The historic district systems with a time factor $\rho U_H H_D + \rho U_{C^D} = 0$ give the same solutions.

However, when there is a designation cost from the political process with collective actions, the political equilibrium for residents within a historic district before the official designation and in the application and designation process should be $U_D = \rho U_H H_D + U_{C^C} + \rho U_{C^D}(=0)$.[3] It is the residents who live in the candidate district before the designation who go through the designation process and undertake the cost from the collective actions. In the decentralized situation, equilibrium $D^{*decentral,t\leq T^D}$ should always be smaller than the central planner equilibrium $D^{*central,t\leq T^D}$. However, once the designation passes, the collective action cost will be removed, thus $U_D = U_H H_D + U_{C^D} > 0$. The newly desired equilibrium post designation (by setting $U_D = U_H H_D + U_{C^D} = 0$), $D^{*decentral,t>T^D} = D^{*central,t>T^D}$, thus $D^{*decentral,t\leq T^D} < D^{*decentral,t>T^D}$ ($= D^{*central,t\leq T^D} = D^{*central,t>T^D}$). Intuitively, the marginal utility gain from the benefit of designation should be just the same as the marginal loss from the costs of designation, when $t \leq T^D$; when $t > T^D$, the marginal utility gain from benefits becomes greater than the marginal utility loss from costs. Thus, the decentralized pre-designation equilibrium is only temporary, and more applications for official designation should be observed.

Two implications can be concluded as the summary of this subsection. First, due to the cost from collective actions of multiple parties involved in the political process of designation, the expected political equilibrium via the decentralized process before the designation will always be a non-optimal political equilibrium in the post-designation period. Thus, after the designation, the real marginal utility of benefits for residents in the newly designated historic district is $U_H H_D$. The marginal utility of costs is U_{C^D}, the magnitude of which is smaller than the marginal utility of benefits.

HYPOTHESIS 1 (Political In-equilibrium Hypothesis). *The socially-optimal political equilibrium is unlikely to be reached, due to the collective action cost. Meanwhile, because the pre-designation collective action cost disappears after the designation, the marginal utility increase of residents from the benefits after the designation will be higher than the marginal utility loss of residents from the costs.*

Second, as the group size increases, the cost from the collective actions also increases (Olson, 1965). Because $C^C(x = D, x)$ is location specific at x, the value of U_{C^C} is therefore also location

[3] Solved by Chain Rule. No time discount for the positive effect of designation can also be assumed, which may be inconsistent with the assumption of time discount for the regulation cost from designation. Regardless, when there is no time discount for the positive effect of designation as specified in Ahlfeldt et al. (2017), $U_D = U_H H_D + U_{C^C} + \rho U_{C^D}$. As long as the designation cost is large enough or the time discount for future regulation cost is not too large, i.e., $|U_{C^C}| > |(1-\rho)U_{C^D}|$, the same implications for the rest of this paper can still be reached. In reality, one of the biggest resistances of residents to forming historic district is due to the concern of the regulation costs after designation.

specific at x. *Ceteris paribus*, the magnitude of U_{C^C} is larger if the group size is larger. Meanwhile, since $U_{C^C} < 0$ and $U_{C^C C^C} < 0$, a larger C^C leads to a large absolute value of the negative term U_{C^C}. Thus, a smaller group size leads to a smaller collective action cost, which will make the absolute value of marginal utility loss from costs before the designation $|U_{C^C} + \rho U_{C^D}|$ smaller, thus $\rho U_H H_D$ is smaller. Due to the concavity of $H(D)$, a larger D corresponds to a smaller H_D. In other words, dividing a large group into multiple smaller groups can generate a higher political equilibrium level D^* in the decentralized institutional setting.

HYPOTHESIS 2 (Collective Action Hypothesis). *The collective action cost of historic district designation increases as the group size increases. Therefore, dividing a large district into multiple smaller ones will lead to a higher decentralized political equilibrium level.*

2.2 Are Historic Districts Public Goods?

Are historic districts public goods? In the literature, little research really investigates the specific characteristics of historic districts when studying the public goods feature, and all historic districts receive the same pooled treatment without specifying the distinction (e.g. Schaeffer and Millerick (1991); Asabere and Huffman (1994); Noonan and Krupka (2011); Heintzelman and Altieri (2013); Been et al. (2016); Ahlfeldt et al. (2017)). Ahlfeldt and Holman (2018) delve further and find that architectural amenities of historic heritage have positive spillovers. Their work calls for a more general definition and thorough investigation of the public goods features of historic districts.

A traditional definition of public goods has two essential characteristics: non-rival and non-excludable. A publicly accessible structure, e.g. a public historic park, can be viewed as a public good. Therefore, residents living near those historic districts should have their utility positively influenced, while at a reduced rate since they do not live exactly in the historic districts. However, a historic district can also be constituted of private single-family homes, which are private goods: rival and excludable. Residents living next to a historic district of private single-family homes cannot have full access to them except the view from outside, thus it is likely that the historic district does not have much of an influence on the utility of their neighbors. Architectural amenity of a historic structure can be a local public good (Ahlfeldt and Holman, 2018), while the publicly accessible structures in historic districts, e.g. state capitol, are also likely to have more architectural amenities than private single-family homes. Accessibility should be the general measure to identify whether a historic district is public or private.

As defined earlier in this Theory section, the utility of residents next to a historic district is positively influenced by the accessibility of it: $U_b = U_\delta\, \delta_b$. For historic districts with public goods characteristics, $0 < \delta < 1$ for the residents next to them, and $U_b = U_\delta\, \delta_b > 0$. For historic districts with private goods characteristics, since $b \equiv 0$ and $\delta = 0$, thus $\delta_b = 0$, thus $U_b = U_\delta\, \delta_b = 0$.

HYPOTHESIS 3 (Public Goods Hypothesis). *The accessibility to the designated historic districts influences the spillovers to the utility of residents in the buffer zones. A historic district of publicly accessible structures has positive spillovers to the residents nearby, while that of private single-family homes which are not publicly accessible does not have any spillovers.*

2.3 How Are the Residents' Utilities Transmitted to Their Housing Prices?

Lastly, how are the residents' utilities transmitted to the housing prices of their homes? Ahlfeldt et al. (2017) include the budget constraint and use the comparative statics of the indirect utility function to illustrate this process. Following their setting, I provide the transmission mechanism of residents' utilities to their housing prices in this subsection.

Residents maximize their utility subject to the budget constraint $W = X + \theta(x)S$, where $\theta(x)$ is the bidding price (rent) for housing. Because the utility function is quasi-concave in both X and S and also assuming perfect competition, the indirect utility function is:

$$V(x) = V\{h(x), H(D), C^C(x = D, x), C^D(x \leq D), \delta[x - D, b(D)], a(x), X^d[W, \theta(x)], S^d[W, \theta(x)]\} \tag{4}$$

where $X^d[W, \theta(x)]$ and $S^d[W, \theta(x)]$ are the Marshallian demand functions. The Envelope Theorem gives that $V_W > 0$ and $V_\theta < 0$. When assuming perfect mobility, *ceteris paribus*, any effect on utility from the change of historic district designation should be compensated by the change of housing prices, to maintain the utility level of residents to be at the exogenous reservation level, i.e., $V_D\, \mathrm{d}D{=}{-}V_\theta\, \mathrm{d}\theta$.

Mathematically, since $U{=}V$, $U_D{=}V_D$ and $U_\theta{=}V_\theta$. Thus, $U_D\, \mathrm{d}D{=}{-}U_\theta\, \mathrm{d}\theta$. For a residential house right at D, before the official designation, $U_D = \rho U_H H_D + U_{C^C} + \rho U_{C^D} = 0$, thus $U_D \mathrm{d}D = (\rho U_H H_D + U_{C^C} + \rho U_{C^D})\mathrm{d}D = -U_\theta d\theta = 0$. Therefore, the housing price change before official designation is:

$$\mathrm{d}\theta(x = D, t \leq T^D) = -\frac{\rho U_H H_D + U_{C^C} + \rho U_{C^D}}{U_\theta}\mathrm{d}D \,(= 0) \tag{5}$$

However, right after the designation, residents do not need to undertake the collective action cost anymore. $U_D = U_H H_D + U_{C^D} > 0$, thus $U_D \mathrm{d}D = (U_H H_D + U_{C^D})\mathrm{d}D = -U_\theta d\theta > 0$. Therefore, the housing price change after the designation is:

$$\mathrm{d}\theta(x = D, t > T^D) = -\frac{U_H H_D + U_{C^D}}{U_\theta}\mathrm{d}D \,(> 0) \tag{6}$$

$U_D = \rho U_H H_D + U_{C^C} + \rho U_{C^D} = 0$ gives $U_H H_D + U_{C^D} = -\frac{1}{\rho} U_{C^C}$. Therefore, Equation (6) can be rewritten as:

$$\mathrm{d}\theta(x = D, t > T^D) = \frac{U_{C^C}}{\rho U_\theta}\mathrm{d}D \,(> 0) \tag{7}$$

For residents living in the buffer zones of the recent designated historic districts, based on the implication in Equations (6) and (7), their housing price change is also positive. But its size is not as much as that of the residents in the historic districts, due to the impact of the reduced rate $\delta[x - D, b(D)]$.

These solutions provide the transmission mechanism from residents' utilities to their housing prices. Intuitively, when residents' marginal utility is increased due to historic district designation, the housing price changes observed can be used to measure their unobservable utility changes. This provides motivation and guidance for the corresponding empirical analyses.

3 Institutional Context

3.1 History of Denver

Every city started from one geographical point once upon a time, and so did Denver, Colorado. A group of gold prospectors established the first settlement in Denver in 1858, during the Pike's Peak Gold Rush (Colorado Gold Rush). It was called "Montana City" where there is now the Grant-Frontier Park in Denver. Since then, starting from one tiny settlement, Denver has been witness to the rise and fall of explorers in the former wild and now gentle West in the last 160 years. Denver is now the 19th most populous city in the United States, with a city population estimated to be 678,467 in 2017 and 716,492 in 2018, and the 10-county Denver-Aurora-Lakewood CO Metropolitan Statistical Area population was 2,888,227 in 2017 (United States Census Bureau, 2019).

In the first decade after the first settlement, many houses which were made of wood were destroyed during various fires. This started the transition to the use of bricks to construct buildings in Denver, which has shaped Denver's construction culture as a "brick city" over time (Noel and Wharton, 2016). Just like many other cities in the United States, Denver has gone through all the historic periods since the middle 19th century. The silver boom in the 1860s and the first railroad in 1870 increased the population dramatically and made Denver a "modern" American western city. Of course, Denver has also experienced the effects of the Progressive Era, the Great Depression, and the World Wars.

During World War II, over four million soldiers came through Denver. Many of them chose Denver to settle as their home after the war. With the rapid growth of population, many old buildings were torn down to make way for the construction of new houses. New middle-class families were also looking for bigger houses with more space and with better schools, which made many people move to the suburbs. Denver's Urban Renewal Authority was created in 1959, but it did not start showing its muscle by demolishing various blocks until 1967 when the Skyline Urban Renewal Project was announced. In the 1960s, Denver was also experiencing the downtown boom and suburban growth. However, "urban renewal projects, speculation, and rapid and reckless growth spurts have eliminated many notable structures, especially in the Central Business District and Capital Hill" (Noel and Wharton, 2016).

3.2 History Preservation Systems in Denver

In response to the wholesale demolitions, the mayor and city council managed to establish the Denver Landmark Preservation Commission (DLPC) also in 1967, just one year after the passage of the National Historic Preservation Act. The DLPC has two types of landmark preservation systems: historic landmarks (individual structures) and historic landmark districts. According to the City and County of Denver Government (City and County of Denver, 2019c), "the designation is a five step process that takes approximately 120 days from the time an application is submitted to the Landmark Preservation Commission." The general process is: owner(s) applying, Landmark Preservation staff reviewing, Denver Landmark Preservation Commission deciding with public hearing, Denver City Council having meetings or readings and designating with public hearing, and then the mayor signing the final bill and second reading. For more details of the five step process, please see Appendix A.

As indicated in the first two steps, the starting point of the designation process is to submit the application (preliminary application in Step 1 and completed final application in Step 2). When it is for individual structures, the owner(s) of the individual structure must give their written consent, as required in the application form. However, for historic districts, at least three business owners or property owners have to give their written consent, as required in the application form. Meanwhile, for historic district applications, "public outreach" is also required. As shown in the Denver Landmark District Application Form Item 10 (City and County of Denver, 2019a):

> "Applicants must provide a written description of outreach efforts, describing all efforts including, but not limited to, property owner/resident meetings (including number and list of attendees, and information on neighborhood representation), newsletters, fliers, one-on-one meetings with property owners, etc. A signed petition of owners supporting the district is highly recommended. Any petitions or letters supporting or opposing the designation should also be included. A substantial effort to communicate with all property owners within a district prior to completing out an application is strongly encouraged."

In Step 4, "all owners of record are notified by mail of the date, time, and place of the hearing." Due to the collective action problem, the designation process for historic district is much more complicated than that for a single historic structure. Designations are made based on architectural, geographical, and historic significance. After the designation, the DLPC will review most exterior alterations that require a building or zoning permit. As discussed in the Theory section, the regulation cost is one of the major costs owners will be facing after designation. For more details about the designation regulation, please see Appendix B.

Note that there is a parallel nationwide system, National Park Service National Register of Historic Places (NRHP), which also has a list of National Register Historic District. According to the NRHP, the National Register nomination process usually starts with the State Historic

Preservation Office. The designation process is similar to the local one in general, while it "places no restrictions on what a non-federal owner may do with their property up to and including destruction, unless the property is involved in a project that receives Federal assistance, usually funding or licensing/permitting" (National Park Service, 2019b). Properties and districts may be nominated for the Colorado State Register by a citizen, the owner, local government, or an agency such as History Colorado, but they have to get the consent from property owners.

The Colorado State Historic Preservation Office is History Colorado, which is mainly an agency for the NRHP on the state level (History Colorado, 2019a). If one structure or district is listed by the national one, then it is automatically listed on the state's list. It also has its own listings of historic structures and districts, while there are no other state-level-only historic districts in Denver City and County.

The historic districts designated by the local level Denver Government face regulations, while the national (and state) ones do not undertake regulation costs. In addition, "A 1991 state statute provides state income tax credits up to $50,000 for authorized maintenance of designated residential landmarks and contributing structures in historic districts" (Noel and Wharton, 2016).[4] In 2014, the state of Colorado further increased the transfer credits cap up to $1 million for commercial projects. Because Denver local government is one of the "Certified Local Governments (CLGs)" jointly recognized by History Colorado and the National Park Service, the Colorado State Historic Preservation Tax Credits can be applied. It includes: (1) a 20% state tax credit for the rehabilitation of historic, owner-occupied residences; and (2) a 20%-30% state tax credit for the rehabilitation of historic buildings used for income-producing purposes (History Colorado, 2019b). Although a 20% federal tax credit for the rehabilitation of certified historic buildings used for income-producing purposes applies only to those listed on the NRHP, it is only for commercial properties but not residential ones (History Colorado, 2019b; Historic Denver, 2019).

History Colorado also provides a State Historical Fund (SHF) for historic preservation throughout the state (History Colorado, 2019c). Among all the 673 grants awarded in Denver since its inception in 1992 (state Fiscal Year 1993) through the end of Fiscal Year 2018, to the best of my knowledge, none of them was awarded to a single-family home. Therefore, this subsidy policy does

[4] According to History Colorado (History Colorado, 2019b), the original tax credit has been on the books since 1990, rather than 1991.

not directly influence the empirical analysis in this paper. In short, as summarized in Table 1, regardless of whether a residential property is listed by the local DLPC or the national NRHP, the financial incentives are the same. However, the local DLPC system has strict regulations on most exterior changes needing a building or zoning permit, while the NRHP system does not have any regulations in general.

3.3 Curtis Park Historic Districts: A Tale of Two Systems

One interesting case of historic district designation in Denver is the Curtis Park neighborhood, which has been designated in both the local Denver Landmark Preservation Commission system and the National Register of Historic Places system. However, because the two systems have different degrees of regulation on the properties in historic districts, they change residents' incentives differently, which further influences the designation levels.

Curtis Park neighborhood was first built in the 1870s and 1880s. Most of the buildings are made of brick and are in the Victorian style (West, 2012a). After nearing one century's development, with ups and downs, when it came to the late 1960s and 1970s, just like many other historic neighborhoods in American cities, Curtis Park neighborhood was in the middle of the battle between two contradictory ideas about American cities: urban renewal vs. historic preservation (West, 2012f).[5]

In order to stop the demolishment of houses in this neighborhood, protectionists and residents nominated Curtis Park for inclusion on the National Register of Historic Places as a historic district in 1974, and it was listed under the name "Curtis-Champa Streets District" as a district designation on the NRHP Register in recognition of its "significant contribution to the heritage of the State of Colorado" in 1975 (West, 2012f; National Park Service, 2019c). A further expansion occurred in September of 1983. However, because the NRHP system does not impose any regulation on the properties in the historic district, it barely had any effect on stopping the demolishment of houses within it. Instead, the local DLPC system requires design review for most exterior changes to all structures in Landmark Districts, and activists and residents turned to this system to achieve their ends. However, the other side of the local DLPC historic district designation is the regulation costs

[5]The serial articles by Bill West (West, 2012a,b,c,d,e,f) tell the complete story of Curtis Park' history from the beginning to present day.

faced by the residents, who may not want to undertake the external construction and renovation constraints on their houses.

The cost from regulations after designation lowers the equilibrium level. In order to prevent this, one mechanism is reducing the group size for the parties involved in the political process, which decreases the collective action cost. Indeed, the Curtis Park neighborhood was divided into eight groups for local DLPC historic district designation separately. The first one was "Curtis Park - B" designated on February 03, 1995, followed by "Curtis Park - A" designated on March 03, 1995, and the last one was "Curtis Park - H" designated on June 20, 2011. Curtis Park Neighbors states that "Curtis Park has been recognized by Denver City Council as having significant historic importance, and has been awarded Denver Landmark status for portions of the neighborhood on eight occasions" (Curtis Park Neighbors, Inc., 2019), and West (2012f) also states that it was based on the degree of demolishing urgency when each district was applied for and designated as a hisotric district. However, why was it easily designated as a NRHP historic district in 1975, with only one expansion afterwards, but it had to be divided into eight different occasions for the local DLPC historic district designation to cover a similar area?

As shown in Figure 1, the total size of all the eight local DLPC historic districts is slightly larger than that of the NRHP historic district, while they are comparable. As shown in Figure 2, the area south of the 30th Street was already included in the 1975 nomination and designation, which covers the area of the local Curtis Parks A, B, C, D, E, and most of F and H. Notably, the first two local DLPC historic districts designated in 1995, "Curtis Park - B" and "Curtis Park - A", are much smaller than that of the national historic district and even smaller than the first 1975 designation. It was not until 2008 and 2011 that Curtis Parks F and H were eventually designated as local DLPC historic districts.

I argue that the ultimate reason for this complication is the collective action problem. As predicted in the second half of Hypothesis 2 (Collective Action Hypothesis), "dividing a large district into multiple smaller ones will lead to a higher decentralized political equilibrium level." When facing the collective action problem, instead of having no local historic district getting designated when applying as a whole unit, separately applying step by step leads to a non-zero equilibrium level. There might be more opposition in local politics, while that can be incorporated into the cost of collective actions and thus can still be explained by the theoretical model in the

Theory section.

4 Data

Three data sets are used in this study for the empirical analysis. The first data set contains residential property transaction data, which are from the City and County of Denver Assessor's Office (City and County of Denver Assessor's Office, 2019).[6] Because Denver is a consolidated city-county, Denver County and the City of Denver are equivalent jurisdictions. The data set includes all the real estate transactions in Denver from January 01, 1990 to June 30, 2016. The data include information about property and sales: property type, transaction type, transaction price, address, above ground dwelling area, number of bedrooms, number of full bathrooms, number of half bathrooms, and other dwelling characteristics.[7] In this study, I use only single-family homes in order to exclude the unobservable building characteristics in multi-family dwelling transactions like condos and duplexes. I also drop a few thousand transactions whose total transaction price is under $5,000, since many of them are just inter-family transfers.[8]

The top panel of Table 2 shows the summary statistics of all the residential properties transacted. On average, the houses transacted were built in 1951, sold for $269,748, contain about 1,500 square feet living space, with 2.8 bedrooms, 2 full bathrooms, and 0.3 half bathrooms. Note that the minimum number of full bathrooms is 1 - houses with 0 full bathrooms were dropped from this sample.

The second data set comes from Denver Open Data Catalog, which includes all the historic districts in the City and County of Denver (City and County of Denver, 2019b). It is a GIS shape file containing all the Denver local historic districts (DLPC ones), with their name, id number, date of designation, and geographical location. As of April 2019, there are 55 local historic districts with

[6] Been et al. (2016) also study the impacts of historic districts designation on new construction activity. Denver Development Services of Denver Government (City and County of Denver Development Service, 2019) provides organized building permit records since 2015, but not those before 2015: "Permit records for 2000 - present can be found on our imaging system or hard copy", and "Permit records for 1970 - 1999 exist on microfiche." I have also contacted the government officer from Denver Development Services, and I was told that I can have access to individual building permit record before 2015 by providing the specific record number, while they are not coded together in organized files. Because construction is not the main focus of this study and comparing the marginal benefits and marginal costs, I decided to not include it in this study.

[7] Microsoft and Google provide programs to convert addresses into locations in terms of longitude and latitude. I use the Microsoft Bing Locations API to determine the latitude and longitude coordinates used in this paper (Microsoft, 2018).

[8] Results are robust when including these low-price transactions.

77 areas in total, since some of them include more than one area. 39 of the 55 were designated between January 01, 1990 and June 30, 2016, which means that most of the local DLPC historic districts were designated during the observation time period. The lot size for each area is calculated by using the "$area" function in QGIS. With the help of Google Maps Earth showing satellite images over time, I am able to identify the public goods characteristics for local historic districts: "private" represents that the historic district is of private residential houses, and "public" represents that it is of publicly accessible structures.

The third data set is of NRHP historic districts and is hand collected, based on various sources from the National Park Service and History Colorado. The National Park Service does provide an online GIS system for ArcGIS (National Park Service, 2019a) and also an online browser platform (National Park Service, 2014) for reference. However, it is read-only and cannot be edited for further empirical analysis. There is another serious problem with the NRHP historic districts shape files that the National Park Service provides: almost all of them are not accurately drawn. Because this study requires accurate geographical information for every historic district, I decided to create an accurate GIS shape file for NRHP historic districts myself. The two main reference sources are NPGallery Digital Asset Management System of the National Park Service, which has the scanned original Nomination Forms or Registration Forms (most of them include maps) for almost all the historic districts, and History Colorado, which also provides interactive maps for every historic district. I use the NPGallery application documents' original map as the default reference, and I use the History Colorado one as a supplement when a map is not provided in NPGallery. For example, Figure 3 displays the maps of two NRHP historic districts from the original National Register of Historic Places Inventory Nomination Form and the original National Register of Historic Places Inventory Registration Form collected in the NPGallery Digital Asset Management System. I also use Google Earth Pro[9] to check the inter-temporal land uses of all these historic districts in order to confirm that there are not any dramatic changes of these areas. The final shape file created also contains the name, id number, date of designation, and geographical information, based on the reference sources mentioned. There are 32 NRHP historic districts, and 7 of them were designated post January 01, 1990. The lot size for each NRHP historic district is

[9]Google Earth Pro currently provides the satellite images of Denver areas from June, 1993 to May, 2018, as in April 2019.

also calculated using the "$area" function in QGIS. Similarly, using Google Maps Earth, a dummy variable indicating the public goods characteristic for national historic districts is also created.

The middle panel of Table 2 displays the summary statistics of all the historic districts in the local DLPC system and the national NRHP system. On average, the local ones and the national ones both have half of them being of private residential houses. Meanwhile, the average lot size of national historic districts is slightly larger than that of the local ones. The mean lot size of national historic districts, 250,644 m^2, is a square about 500m $\times$ 500m, which is about several blocks long and several blocks wide in Denver. The mean lot size of local historic districts, 127,069 m^2, is a rectangle about 300m $\times$ 400m, which is also about several blocks long and several blocks wide in Denver.

Further, using GIS software ArcGIS and QGIS, I was able to calculate the geographical interactions between all the house transactions and historic districts: whether a house is in a historic district, whether a transaction occurs before or after the designation of the historic district it is in, whether a house is in the 100-meter buffer zone of a historic district, whether a house is in the 100-meter inner buffer zone of a historic district, etc. The bottom panel of Table 2 displays the historic district related geographical characteristics of all the house transactions. The variables without "Ever" indicate the house transactions in a district which has been designated, and those with "Ever" indicate the house transactions in a district which has been or will be designated as historic district. On average, house transactions have more interactions with local historic districts than national ones, and the numbers of houses with different types of interactions are all in thousands, which are sufficient for econometrics analysis.

The top panel of Figure 4 shows all the local DLPC historic districts and national NRHP historic districts, with Google Satellite map as the background. The bottom panel of Figure 4 also shows all the historic districts of both systems, while it also shows the census tracts and residential properties transacted in the sample.

Figure 5 shows the spatial diversity and complexity of homes, historic districts, and their interactions. Using central Denver as an example, the top panel only displays the historic districts and single-family homes. Some districts consist of private residential properties, while others are of publicly accessible structures. This is true for both local DLPC and national NRHP historic districts. The majority of private single-family homes are not included in either historic district, which provide a large sample as in the control group. The bottom panel further includes 100-meter buffer zones of historic districts, which further enriches the spatial characteristics of house transactions in the sample. In short, with the help of GIS software, various and accurate spatial characteristics of house transactions can be identified for further empirical analysis.

5 Empirical Strategy

This section illustrates the empirical strategies testing Hypothesis 1 (Political In-equilibrium Hypothesis), Hypothesis 2 (Collective Action Cost), and Hypothesis 3 (Public Goods Hypothesis). As indicated in the Theory section, $V_D\,\mathrm{d}D{=}{-}V_\theta\,\mathrm{d}\theta$: any effect on utility from the change of designation should be reflected in the change of housing rents. Therefore, I use the change of housing prices as the measure of utility change caused by historic district designation.

5.1 Hedonic Price Model

The baseline model is a hedonic price model. Hedonic price models are commonly used in the literature, and most research papers find a premium on property values from historic district designation (Ford, 1989; Asabere and Huffman, 1994; Clark and Herrin, 1997; Leichenko et al., 2001; Coulson and Leichenko, 2001; Coulson and Lahr, 2005; Mason, 2005; Noonan, 2007; Cebula, 2009; Gilderbloom et al., 2009; Been et al., 2016), while some others find null or negative results (Heintzelman and Altieri, 2013; Ahlfeldt et al., 2017).[10]

Specifically, for home i sold in census tract c at time t:

$$p_{ict} = \beta D_{it} + \phi x_{it} + \mu_c + \delta_t + \rho_a + u_{ict} \tag{8}$$

where p_{ict} is the log of the sale price. D_{it} is a dummy variable indicating whether a residential property i at time t is in an officially designated historic district or not. x_{it} includes home characteristics for each house: log of dwelling square footage, number of bedrooms, number of full and half bathrooms, and distance to the central business district (CBD).

[10] Although this research is focusing on historic district, the designation of which is more complicated and involves more collective actions, it is important to note that individual historic landmarks have also been studied in the literature. Many papers find that designated individual landmarks enjoy positive effects (Cebula, 2009; Franco and Macdonald, 2018), while null effects are also found (Ahlfeldt and Maennig, 2010). Meanwhile, individual historic structures are also found to have positive externalities to properties nearby (Turnbull et al., 2019).

The treatment identifications are both temporal and spatial. For example, for the homes never in any historic district designated area, D_{it} is always 0; for homes in a historic district designated before 1990, D_{it} is always 1; while for homes in a historic district designated after 1990, D_{it} turned from 0 to 1 at the designation time point. While it would be ideal to know the exact starting time of every historic district's application, it is not feasible. However, because the historic preservation systems started in the late 1960s and the observation period starts from 1990, it is reasonable to denote all the years between 1990 and the designation year of any specific historic district as the pre-designation preparation time period. In order to narrow the sample for comparison to the houses only near the boundary lines of historic districts (e.g. 100m in the baseline analysis), D_{it} is also used to identify whether houses are in that spatial range. Moreover, D_{it} also denotes other historic district related treatments and interactions, e.g. in a historic district but before its official designation or not, in a buffer zone of historic district or not, the interaction term of historic district designation and its size, etc.

Multiple fixed-effects are used in order to control for omitted variables and endogeneity issues (Greenstone and Gayer, 2009; Heintzelman and Altieri, 2013). μ_c is a census tract fixed-effect that captures unobservable neighborhood-level heterogeneity, δ_t is a year-sold fixed-effect that captures time-varying heterogeneity in sale prices across Denver in each year, and ρ_a is a year-built fixed-effect which captures structure age effects jointly with δ_t. u_{ict} is the unobservable error term and is clustered on the census tract and year-sold level, which captures other unobserved factors that affect transaction prices.

As indicated by Heintzelman and Altieri (2013), it is impossible to employ spatial analysis for a large sample size as in this research. However, by using fixed-effects and error-clustering at geographic level, it essentially employs a simplified spatial weighting model and can address potential concerns (LeSage and Pace, 2009; Heintzelman and Altieri, 2013).

One potential and important concern is the confounder issue. The historic district designation treatment not only influences residents' utility and thus house price (dependent variable) but also influences the numbers of bedrooms and bathrooms (independent variables). However, in this specific context, it should not be a major concern, because the regulation of DLPC system on houses is on most "exterior" changes.

As discussed in the Theory and Institutional Context sections, the designation process takes time, during which people's expectations keep adjusting (Lucas, 1976). Additionally, as indicated by Noonan and Krupka (2011), Been et al. (2016), and Ahlfeldt et al. (2017), the designation process is also endogenous rather than exogenous, thus the distribution of house transactions over time may have discontinuities. Also, because the treatment occurs before the official designation date, it may influence the pre-treatment covariates. Therefore, it does not meet the basic assumptions for a Regression Discontinuity Design (Imbens and Lemieux, 2008; Lee and Lemieux, 2010; Thoemmes et al., 2017). For more discussion of the RDD, please refer to Appendix C.

6 Results

This section displays and discusses the results from empirical analysis.

6.1 Premiums from Historic District Designation

The theoretical model predicts that there will be premiums of house values after historic district designation (Hypothesis 1, and as in Equation (6)).

Table 3 displays the results for house value premiums after historic district designation. The dependent variable is logged transaction price. As the five columns show, the larger a house is, the higher transaction price is. Meanwhile, conditional on the living area size, more bedrooms is generally linked with lower quality, or cheaper houses. On the contrary, more bathrooms, full or half, always lead to higher prices. Last but not least, as the distance to Denver Central Business District (CBD)[11] increases, the price decreases, which is reasonable given the monocentric city pattern of Denver. The patterns of these control variables are comparable and consistent across the results in all other tables, thus there will be no further redundant discussion on them in the rest of this paper.

As Column 1 in Table 3 shows, local historic district designation leads to a 15% premium on house value. Column 2 suggests a similar national historic district designation premium on house value of 18%. The magnitude is similar to that reported by Been et al. (2016) in New York City. Column 3 further includes both dummy variables in one regression model, and positive results are

[11] Downtown Denver's CBD is defined as an area, rather than a specific point. I use the intersection of Arapahoe Street and 16th Street (longitude-latitude 104.995651W, 39.747861N) as the center of Denver when calculating distance to the CBD.

found for both historic districts. It seems that the premium of national historic district is slightly higher than that of the local one, while a t-test of these two coefficients in Column 3 suggests that there is no statistically significant difference.[12] The prediction of Hypothesis 1 (Political In-equilibrium Hypothesis) is empirically verified.

There are also a couple of historic districts which are both national and local historic districts, and Columns 4 and 5 show that being in both historic districts leads to a slightly higher premium. Therefore, the theoretical model and empirical analysis in this paper distinguishing the two systems rather than simply pooling them together seems to be a reasonable approach.

6.2 Collective Action Cost

As the first half of Hypothesis 2 suggests, *ceteris paribus*, a larger district up for designation incurs a larger collective action cost. Equation (7) provides the collective action perspective for empirical analysis, which is on the essence of the theory in this paper:

$$\mathrm{d}\theta(x = D, t > T^D) = \frac{U_{C^C}}{\rho U_\theta}\mathrm{d}D\,(> 0)$$

I use the area size of each historic district to identify the magnitude of collective action cost, since a large district of single-family homes includes more houses and thus more residents in general.

Table 4 displays the corresponding results from the collective action cost perspective. Column 1 suggests that for a house in a larger local historic district, it will have a higher price premium after designation. If everything else is equal for all the local historic districts (though in reality it is probably not likely), then a larger local historic district's designation involves a higher collective action cost, which ultimately contributes to a higher price premium. The evidence found here is consistent with the theoretical implication. Column 2 focuses on the national historic districts, which also finds a significant result. Column 3 includes both local and national historic districts, and results are robust. The effects are also economically significant. For a local historic district of average size, it is related to a 1.6% premium, and the premium for the largest local historic district

[12] $t = \frac{\hat{\beta}_{local} - \hat{\beta}_{national}}{\sqrt{var(\hat{\beta}_{local}) + var(\hat{\beta}_{national}) - 2cov(\hat{\beta}_{local}, \hat{\beta}_{national})}}$. Another way is to simply rewrite the regression model from $p = \beta_0 + \beta_{local}D_{local} + \beta_{national}D_{national} + \epsilon$ to $p = \beta_0 + (\beta_{local} - \beta_{national})D_{local} + \beta_{national}(D_{local} + D_{national}) + \epsilon$, and the t-test of $(\beta_{local} - \beta_{national})$, i.e. the adjusted coefficient of D_{local} should give the same diagnostic statistic. Both methods show that the t-statistic is -0.439, and the corresponding p-value is 0.6610.

is 14.6%. Slightly larger effects are also found for national historic districts.

However, due to the scarcity of variation in historic district size, its distribution is not continuous nor balanced for the non-zero observations. Therefore, a log transformation of lot size is further conducted, "$log\, Size$" $= log(1 + Size)$, which leaves the zero observations still zero while making the non-zero observations more continuous and balanced. Columns 4 - 6 of Table 4 use the logged size as the identification of collective action cost, and results are robust.

6.3 Positive Spillovers

The theoretical model also predicts that there should be positive spillovers, which is summarized in the first half of Hypothesis 3 (Public Goods Hypothesis). Table 5 displays the results when a buffer zone treatment is added into the hedonic models. 100 meters is used in the main analysis, which is about the width of large blocks or the length of small blocks in Denver. Been et al. (2016) use 250 feet as the buffer zone distance in their study, which is about the length of a block in New York City. I follow their "rule of thumb" in the main analysis, and robustness tests of different buffer distances are also conducted and reported later. As Figure 5 shows, there are generally 2-4 houses along the line vertical to historic district boundary line in the 100m buffer zones, which provides the closest houses to those in the historic districts.

Column 1 of Table 5 suggests that designation of local historic districts generates a spillover to the neighboring houses, and the magnitude of premiums for neighboring houses is smaller than that for houses in historic districts (t-statistic = 3.6305, p-value=0.00028). Column 2 suggests the same phenomenon for national historic district designation. Column 3 includes both local and national historic districts and their buffer zone treatments, and the results are comparable to those in Columns 1 and 2. Last but not least, some parkways are listed as DLPC historic districts but as NRHP large structures. Therefore, Column 5 also includes the NRHP large structure buffer zone treatment, and the results are robust.

6.4 100-Meter Buffer Zone vs. Inner Buffer Zone

The buffer zone limits treatment to 100 meters for the results reported in Table 5, while the historic district treatment covers the whole historic district. It is possible that the houses in a historic district but far from the boundary lines are very different from the houses in the buffer zones.

Therefore, further specifying the historic district treatment to a narrower area can help provide more accurate comparisons. "Local District Buffer -100m" treatment captures the houses in historic districts but also within the 100-meter inner buffer zone from the boundary lines. Comparing those in "Local District Buffer 100m" and "Local District Buffer -100m" should provide more accurate results. It is essentially similar to matching models and spatial RDD. Additionally, being in a historic district but not in the 100m inner buffer zone treatment is still necessary in order to eliminate potential estimation bias.

Results are reported in Table 6. The first two columns report the results when only including the buffer zone and inner buffer zone treatments. Although the results suggest that the neighboring-historic-district houses do enjoy a smaller premium, for both local and national historic district designation, the t-test suggests that neither of them is statistically different at 5% significance level (t-statistic is -1.1287 for local and -1.8962 for national; however, the t-statistic for national historic district is significant at the 5% level for one-tail test). Column 3 reports the results for national historic districts while controlling for NRHP large structures, and comparable results are also found. As discussed in the former paragraph, failing to include the treatment of being in historic district but not in the 100m inner buffer zone leads to estimation bias. Column 4 and Column 5 include this treatment for local and national historic districts, respectively, and results suggest that the neighboring houses in buffer zones have a statistically significant smaller premium (t-statistic is -2.9719 for local and -3.2598 for national). Column 6 further controls for the large structures, and results are robust. The last three columns also show that the houses in the relatively central part of historic districts, rather than near boundary lines, have much higher premiums: about 21% for local historic districts and 22% for national ones.

6.5 Private Goods vs. Public Goods

Hypothesis 3 (Public Goods Hypothesis) suggests that when a historic district is of private residential homes, there should not be any positive spillovers to the neighboring homes; when a historic district is of publicly accessible structures, e.g. park or state capitol, it has the public goods characteristics and thus should generate positive spillovers to the neighboring homes.

Table 7 reports the results when separating historic districts into private ones of single-family homes and public ones of publicly accessible structures. As Column 1 indicates, only those public local historic districts have significant spillovers to the neighboring houses. Column 2 shows the same results for national historic districts. Column 3 includes both local and national historic districts, and results are similar. Column 4 further controls for large structures for national historic districts, and results are also robust.

Table 8 reports the results when further separating the historic district treatment into inner 100m buffer zone and the other part (relatively central part). Results are comparable to those in Table 7: private historic districts do not generate significant spillovers, while public ones do generate significant spillovers. Meanwhile, houses in the central part of historic districts have a higher premium than those near the boundary line.

6.6 Endogeneity

As explained in the Institutional Context section, historic district systems are created to stop historic structures from being demolished. Meanwhile, the designation process lasts months, years, or even decades (e.g. the Curtis Park Historic Districts). As the theoretical model suggests, the designation process is endogenous. However, according to the theoretical model, there should not be premiums nor discounts for houses in historic districts before the designation (Equation (5)), while there should be premiums after designation since there is a gap between marginal utility of benefits and marginal utility of costs when collective action cost is removed (Equations (6) and (7)).

Table 9 displays the related regression results. Column 1 includes the treatment of house transactions in historic districts but before the designation, i.e. a historic district but "future to be" treatment. A pre-designation discount is found for local historic districts but is statistically insignificant. This matches the institutional background of Denver, where the DLPC was established to preserve the demolishing of houses struggling in the urban renewal waves. However, combining the expected marginal benefit and marginal cost, a non-result suggests the temporary equilibrium before the historic district designation. Column 2 also reports an insignificant result for national historic districts, while the magnitude is positive. Column 3 includes both local and national ones, and results are comparable.

Columns 4-6 of Table 9 further control for the real historic district designation treatments. The estimated coefficient for local district as shown in Column 4 still suggests the political equilibrium before designation but in-equilibrium after designation. However, Column 5 now suggests a 5% significance level positive premium of national historic district even before the designation, which implies a weak in-equilibrium before the designation, but the magnitude and significance are both much smaller than that after designation. Further inspection of the data finds that there are only two national historic districts of residential homes designated post 1990. As shown in Appendix C, Cole Neighborhood Historic District (NRHP #95000264, designated in 1995) only had three transactions before the designation in the sample. The one that provides the most reasonable observations for empirical analysis is Park Hill Historic District (NRHP #04001348, designated in 2004).[13] Park Hill Historic District lies to the east of City Park Historic District (NRHP #86002190, designated in 1986) and City Park Golf Historic District (NRHP #86002198, designated in 1986), and thus the houses in Park Hill might have been enjoying the positive spillovers by being next to the two historic districts. As found by Humphreys and Zhou (2019), being next to a golf course yields a large premium. Humphreys and Zhou (2019) also suggest that being too close to a park generates discounts, while the Park Hill area is large enough to have most houses with a reasonable distance away from the City Park. Meanwhile, City Park is also classified as a "regional park" by Denver government, and this category yields the highest premium among the eight types of parks.

Overall, the empirical evidence is consistent with the theoretical predictions for both local and national historic district designations. It also shows that the pre-designation political equilibrium holds for local historic districts well; it also holds for national historic districts, while it is not perfectly held given the small number of related observations.

6.7 Time

Table 10 further reports the results for time since/before historic district designation. Only those house transactions in districts which have been designated as historic districts or will be designated as historic districts can have a reasonable time specification, while all the other transactions do not have any meaningful time value to be assigned. Therefore, I first run a pre-regression without any specification of treatment related to historic district designation or its time. I collect the residuals from the pre-regression as the dependent variable and use historic district designation and its time as the explanatory variables (this drops the number of observations to 7,194 for local historic district

[13] Dropping the treatment for Cole Neighborhood Historic District generates similar results.

and to 4,269 for national historic district). If historic district designation or its time really matters, then the unexplained residuals from the pre-regression should be explainable by historic district designation and its time.

Column 1 of Table 10 verifies the positive effect of local historic district designation as found in earlier analysis. Column 2 and Column 3 further suggest a positive linear time trend of premium after designation, almost 1% per year. The coefficient for local historic district itself is now negative due to the colinearity issue, a similar pattern of which is also found in Been et al. (2016).

Column 4 of Table 10 also yields a positive coefficient for national historic district designation. Column 5 also suggests a positive linear time trend for national historic district, while Column 6 indicates that a non-linear relationship might also exist.

When investigating only the sub-sample of positive time values (i.e. only the house transactions after historic district designation), similar patterns for house transactions in local and national historic districts are still found. Results are available upon request.

6.8 Repeat Sales Model

The residential homes sales data from Denver cover more than 26 years, during which many houses were sold more than once. As Greenstone and Gayer (2009), Heintzelman and Altieri (2013), and Been et al. (2016) suggest, hedonic models might overestimate the real effects of historic district designation due to the potential unobserved or missed characteristics of properties. Repeat sales models only include the homes sold before and after designation, which controls for any time-invariant characteristics of properties. With this benefit, repeat sales models also face the cost of having a limited sample of observations: not all houses have been transacted more than once in the observation time period. Among the 174,779 transactions, 102,388 transactions (58.6%) are identified as repeat sales. Therefore, repeat sales models can provide reasonable robustness tests.

The repeat sales model results are reported in Table 11. As Columns 1-7 show, the results for Local Historic District, National Historic District, Local Historic District Buffer Zone, and National Historic District Buffer Zone are all comparable to those found in the earlier models. The magnitudes of estimated coefficients for the two historic district systems are both comparable, while that for the buffer zones are slightly larger. The coefficient for NRHP Large Structure Buffer Zone is not significant anymore, while in the earlier models it was also only significant at the 5%

significance level. Overall, repeat sales models provide comparable results.

6.9 Different Distances

In the main analysis, 100 meters is chosen as the distance of buffer zones, which is following the "rule of thumb" as in Been et al. (2016). Therefore, it is necessary to conduct robustness tests of different distances in order to exclude the possibility that the significant results only hold for the specific 100-meter distance. Meanwhile, as indicated in the Theory section, $U_\delta > 0$ and $\delta[x - D, b(D)]_{x-D} < 0$, thus $U_{x-D} < 0$. Intuitively, as the distance to closest designated historic district increases, the utility of residents decreases. In other words, the positive spillovers from historic district designation as reflected in housing prices should be decreasing with distance.

50 meters is too narrow for the buffer zone distance, because it fails to include a sufficient number of houses due to the width of streets. 150 meters and 200 meters are used in the robustness tests, and 100-150m and 150-200m treatments are added into the original analyses as reported in Tables 5, 7, and 11. Overall, the results suggest that the positive spillovers are still significant for house transactions in the 100-150m and 150-200m buffer zones, while the magnitudes are smaller than that in the 0-100m buffer zones. For more details, please refer to Appendix D.

7 Conclusion

Historic heritage influences the urban amenities residents enjoy, while the sword of external historic designation has two edges. On the one hand, external designation helps historic preservation which increases residents' utility. On the other hand, the regulations restrict the "space" of redevelopment or refurbishment of designated buildings. Rather than purely exogenous, external historic designation is endogenous, which is related to the internal historic heritage.

This paper pushes the boundary of the current literature by addressing two important questions which have not been answered or not been addressed thoroughly. First, historic district designation always consists of rounds of collective actions, and costs from these collective actions influence the political equilibrium of historic district designation. Second, are all historic districts public goods, or does it depend on their specific characteristics? In order to answer these two questions, this paper constructs a simple theoretical model to study the collective action cost and public goods characteristics of historic district designation. The theoretical model suggests that there should be a premium for house prices in historic districts after designation, since the removal of collective action cost after designation creates a new "gap" between residents' marginal utilities of benefits and costs. Meanwhile, the collective action cost decreases the political equilibrium level of designation, but dividing a large group into multiple smaller ones reduces the collective action cost thus helps push the equilibrium level higher. The theoretical model also suggests that only historic districts with public goods characteristics have significant spillovers, while those of private homes do not.

The empirical results verify the theoretical predictions. Using all single-family home transactions in Denver, Colorado from January 01, 1990 to June 30, 2016 and employing various empirical models, the analysis finds a 15-20% premium of housing values from local and national historic district designations. The collective action cost, measured by the area size of historic district, is found to be related to the housing price change. Positive spillovers are found for the neighboring homes in the buffer zones, while only the historic districts composed of publicly accessible structures rather than of private family homes have significant spillovers. Accurate spatial treatments comparing homes near (inside and outside) the boundary lines of historic districts provide comparable results. Investigating house transactions in historic districts but before designation suggest that the pre-designation political equilibrium holds for local historic districts, and it also holds for national historic districts. Empirical analysis also finds that the premiums increase over time. Further robustness tests by repeat sales model analysis provide comparable results.

This research helps deepen the understanding of political economy issues in historic preservation and the broader urban economics studies. Both political and economic systems are the means people employ to exchange and allocate resources. However, the costs incurred from the political process are often not realized nor calculated when conducting policy analysis. Indeed, it is difficult to directly measure the real costs of the political process, while it can be indirectly reflected in the market process. It is important to note that the costs of the political process definitely shape the political equilibrium and thus economic outcomes. In the specific context of this study, the collective action cost along with the designation process deters applications for the designation and thus lowers the designation equilibrium level, while the removal of collective actions after designation creates a premium of house value. For policy makers and citizens involved, it is important to see the broader picture by realizing the existence of the opportunity costs of political process.

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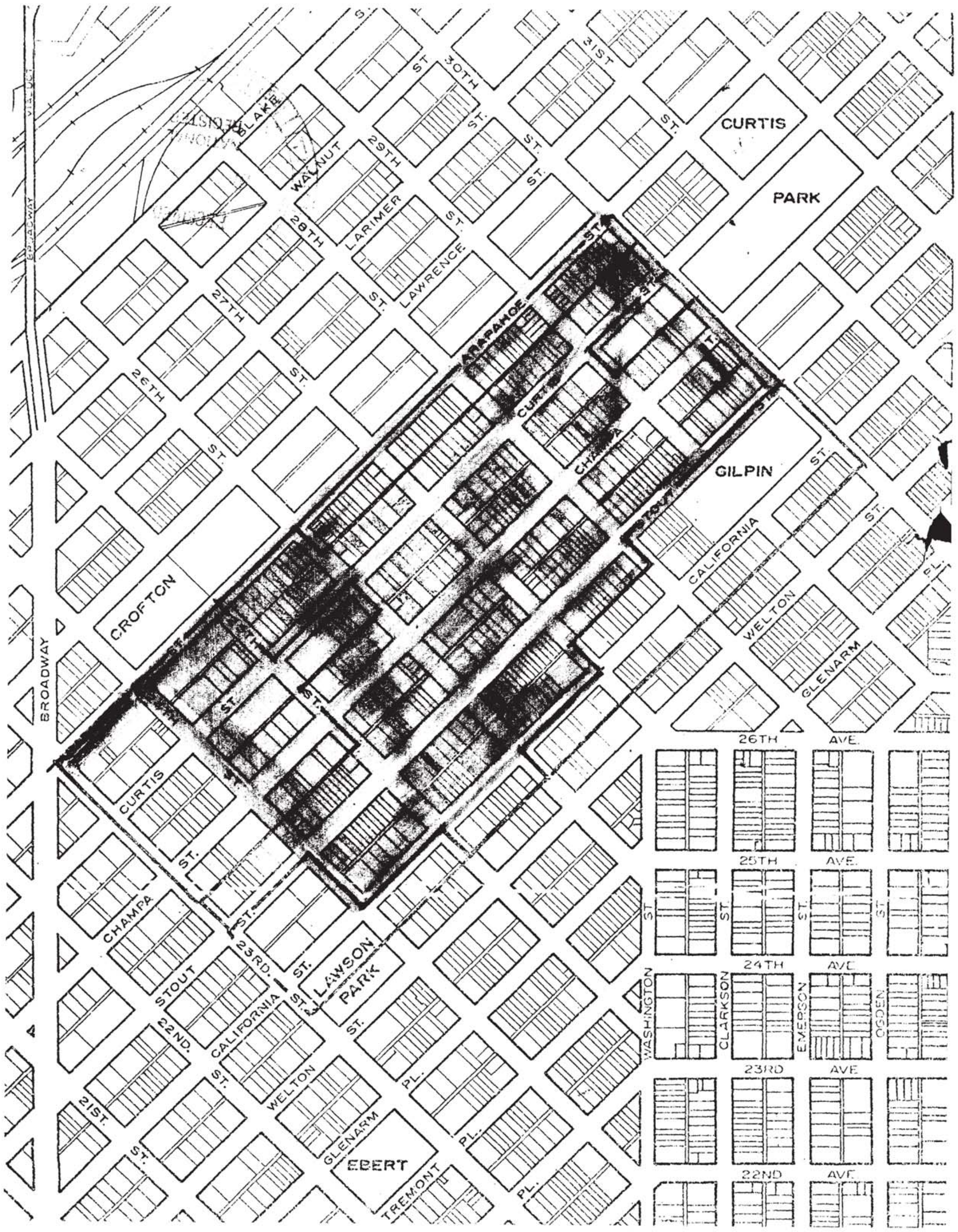
Figures and Tables

Figure 1: Curtis Park Historic Districts, National and Local

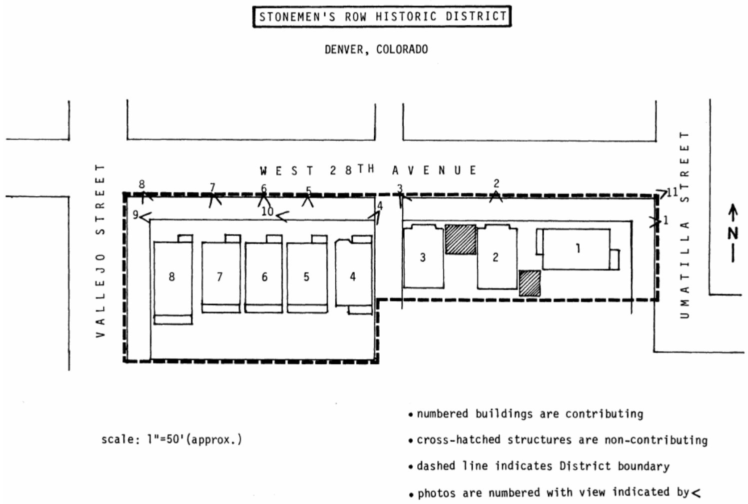
1. Figure 1 displays the national NRHP historic district and local DLPC historic districts of the Curtis Park Neighborhood. Left Panel: National Historic District; Right Panel: Local Historic Districts.
2. Designation date of national historic district: "Curtis-Champa Streets District", 04/01/1975; expansion in September 1983. Designation dates of local historic districts: Curtis Park - B, 2/3/1995; Curtis Park - A, 3/3/1995; Curtis Park - C, 4/22/1997; Curtis Park - D, 6/20/1997; Curtis Park - E, 11/13/2007; Curtis Park - F, 8/25/2008; Curtis Park - G, 1/4/2010; Curtis Park - H, 6/20/2011.
3. Maps Source: Curtis Park Neighbors, http://www.curtispark.org/historic-districts.

Figure 2: Curtis-Champa Streets District

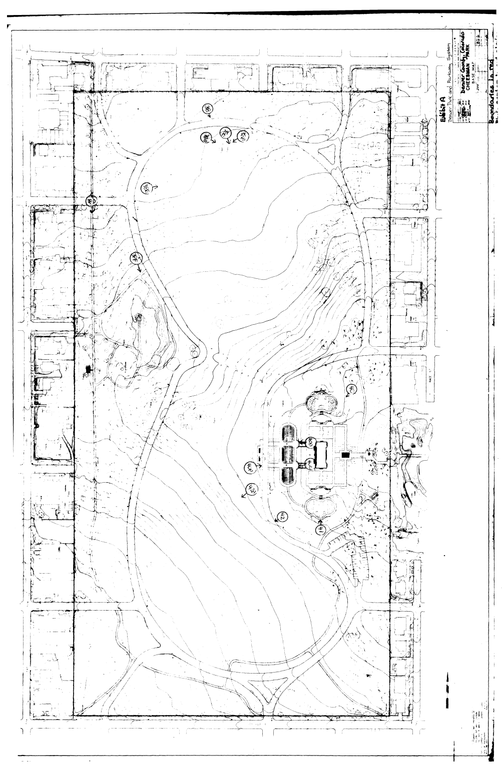


1. Figure 2 displays the area of blocks included in the first nomination and designation of the Curtis-Champa Streets District in the National Register of Historic Places (NRHP) system in 1975. As shown in Figure 2, the area is the part south of 30th Street and is about 70% of the final total area after the expansion in 1983.
2. Source: The original National Register of Historic Places Inventory - Nomination Form of "Curtis-Champa Streets District" from the NPGallery Digital Asset Management System, https://npgallery.nps.gov/AssetDetail/bd465401-007c-49bd-9cf8-8170cbd403e9.

Figure 3: NRHP Historic Districts - Stonemen's Row and Cheesman Park



This is the map of Stonemen's Row Historic District from the National Register of Historic Places Inventory Nomination Form in the NPGallery Digital Asset Management System of National Park Service. Link to the gallery page for this NRHP historic district, https://npgallery.nps.gov/AssetDetail/NRIS/84000824.



This is the map of Cheesman Park from the NPGallery Digital Asset Management System of National Park Service. Link to the gallery page for this NRHP historic district, https://npgallery.nps.gov/AssetDetail/NRIS/86002221.

Figure 4: Historic Districts and Residential Property Transactions in Denver, Colorado

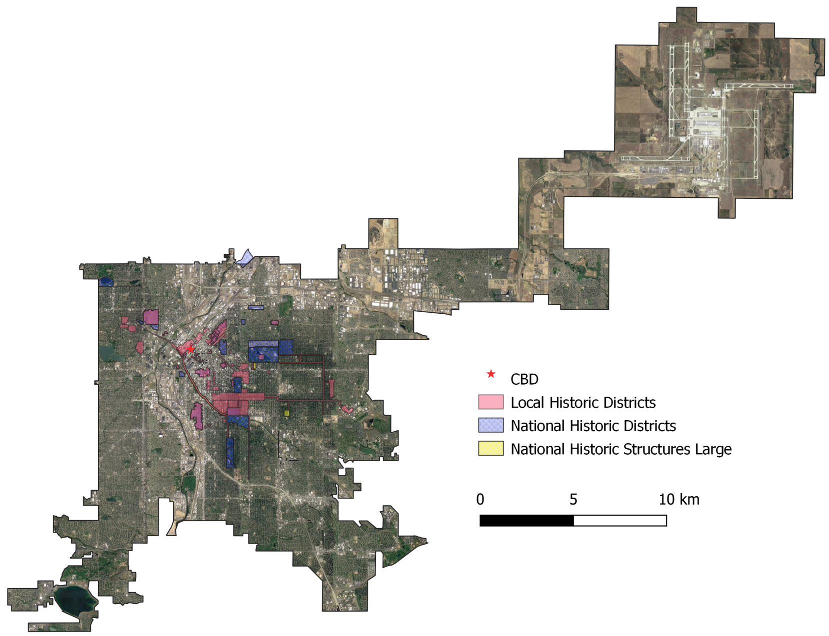


Figure 4 top panel shows all the current historical landmark districts and the Google satellite map in Denver.

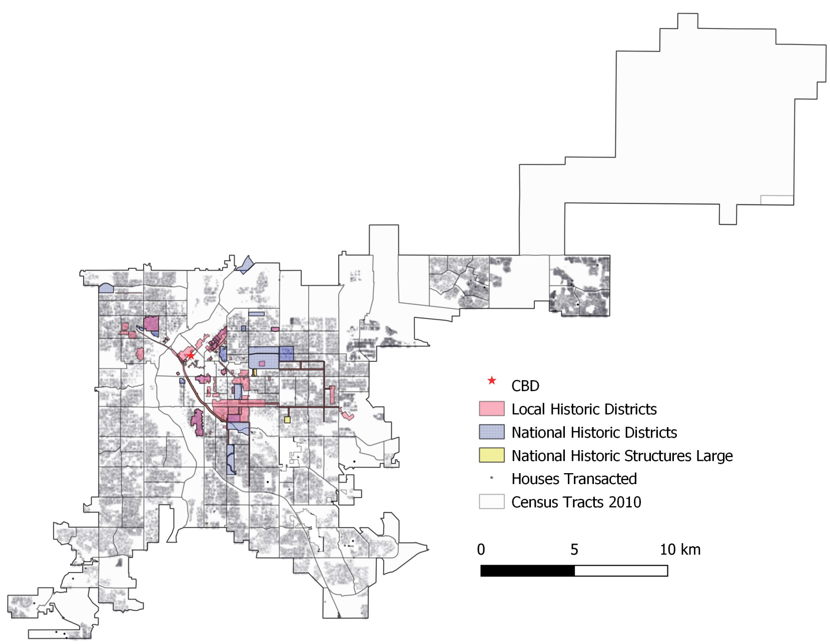


Figure 4 bottom panel shows all the current historical landmark districts and all the houses have been transacted for at least one time from 1990 onwards in Denver.

Figure 5: Housing Transactions in and out of Historic Districts and Buffer Zones in Denver

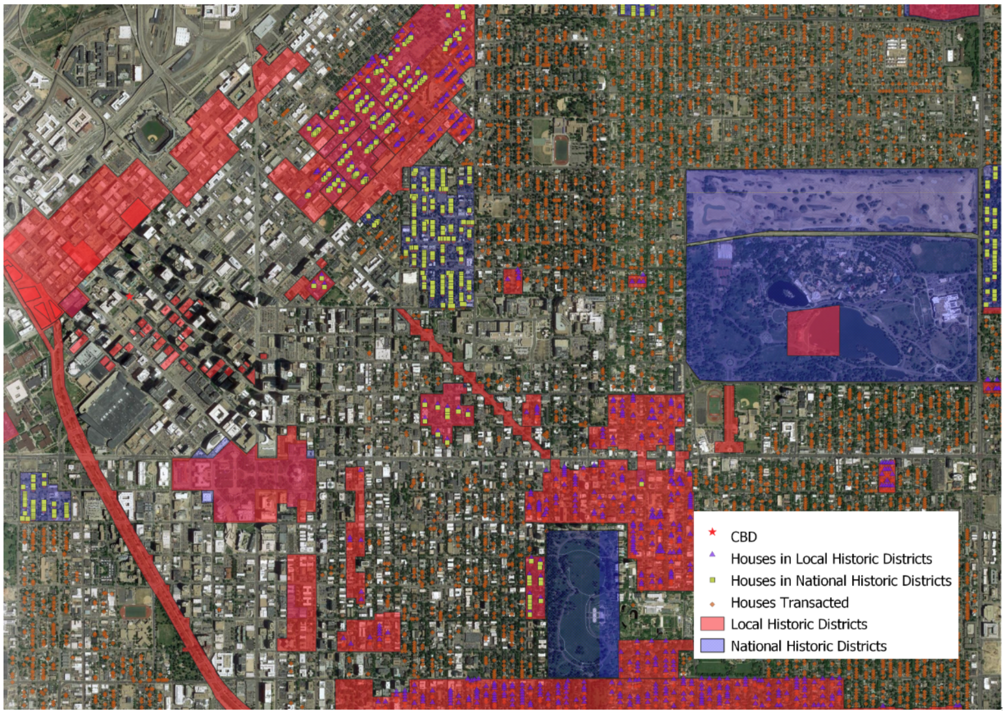


Figure 5 top panel shows one area of Denver, where there are house transactions in the local historic districts, in the national historic districts, and out of both types of historic districts.

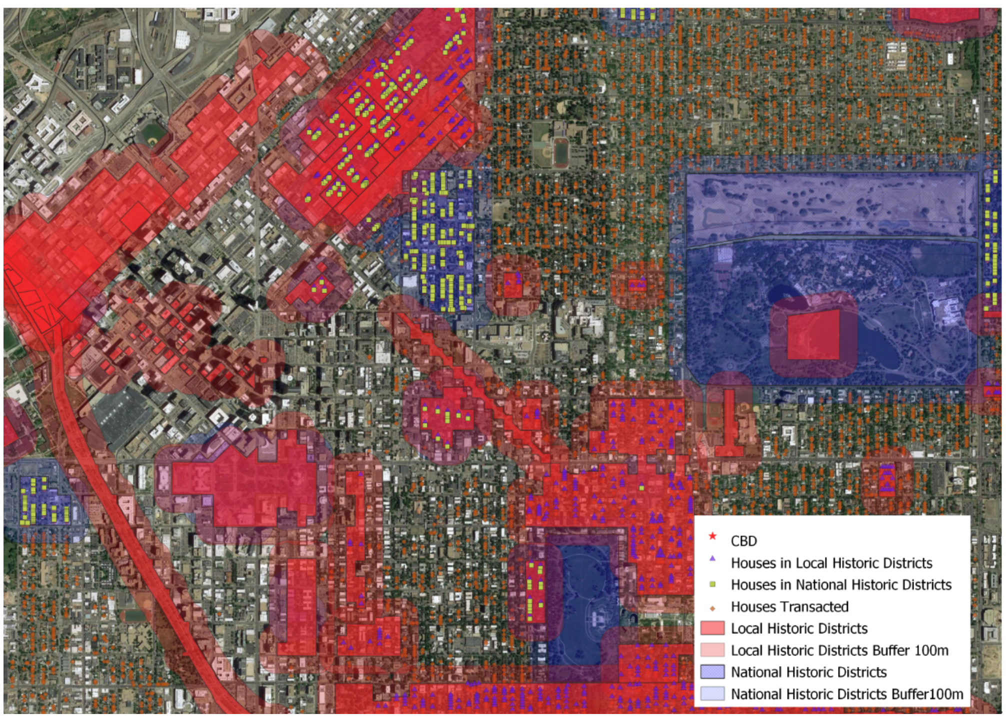


Figure 5 bottom panel shows one area of Denver, where there are house transactions in local historic districts, in national historic districts, and out of both types of historic districts. Meanwhile, the light red and the light blue zones are the 100 meter buffer zones for the local historic districts and the national historic districts, respectively.

Table 1: Historic District Designation: Benefits vs. Costs

System	Benefits	Costs
Local DLPC (CLGs)	1. 20% state tax credit for the rehabilitation of historic, owner-occupied residences; 2. 20% -30% state tax credit for the rehabilitation of historic buildings used for income-producing purposes	Regulation on most external changes needing a building permit (also see Appendix B)
National NRHP	1. 20% state tax credit for the rehabilitation of historic, owner-occupied residences; 2. 20% -30% state tax credit for the rehabilitation of historic buildings used for income-producing purposes; 3. 20% federal tax credit for the rehabilitation of certified historic buildings used for income-producing purposes	"Places no restrictions..., unless the property is involved in a project that receives Federal assistance..."

Sources: National Park Service; History Colorado; City and County of Denver Government.

Table 2: Summary Statistics - Full Sample

(a) All Transacted Houses

Statistic	Mean	St. Dev.	Min	Max
salePrice	269,748	248,328	50,000	5,700,000
saleYear	2004	6.622	1990	2016
aboveGroundSqft	1,500	781.462	226	12,433
bedrooms	2.778	0.812	1	9
fullBaths	1.993	0.882	1	7
halfBaths	0.321	0.503	0	4
yearBuilt	1951	34.330	1874	2015

N=174,779

(b) Local and National Historic Districts

Statistic	N	Mean	St. Dev.	Min	Max
Local Year	77	1997	10.319	1973	2018
Local Private	77	0.481	0.503	0	1
Local Size (km^2)	77	0.127	0.202	0.0013	1.157
National Year	32	1985	9.159	1973	2006
National Private	32	0.500	0.508	0	1
National Size (km^2)	32	0.251	0.305	0.0033	1.279

There are 55 local historic districts, while there are 77 different areas in total since some of them contain more than one area.

(c) House Transactions in Historic Districts

Statistic	Mean	St. Dev.	Min	Max
Local District	0.030	0.171	0	1
Local District Buffer 100m	0.035	0.184	0	1
Local District Buffer -100m	0.020	0.141	0	1
Local District Ever	0.041	0.199	0	1
Local District Ever Buffer 100m	0.044	0.206	0	1
Local District Ever Buffer -100m	0.029	0.167	0	1
Local District Ever Time (Year)	7.053	11.222	−26.667	40.583
National District	0.021	0.145	0	1
National District Buffer 100m	0.018	0.132	0	1
National District Buffer -100m	0.014	0.117	0	1
National District Ever	0.024	0.154	0	1
National District Ever Buffer 100m	0.019	0.137	0	1
National District Ever Buffer -100m	0.015	0.122	0	1
National District Ever Time (Year)	15.823	11.918	−14.000	41.167

N=174,779. For time (local), N=7,194; for time (national), N=4,269.

Table 3: Positive Effects from Historic District Designation

	logPrice	logPrice	logPrice	logPrice	logPrice
logSqft	0.4510***	0.4523***	0.4500***	0.4529***	0.4501***
	(0.0242)	(0.0241)	(0.0240)	(0.0241)	(0.0240)
bedrooms	−0.0178***	−0.0180***	−0.0179***	−0.0178***	−0.0179***
	(0.0038)	(0.0038)	(0.0038)	(0.0038)	(0.0038)
fullBaths	0.0738***	0.0739***	0.0737***	0.0740***	0.0737***
	(0.0069)	(0.0069)	(0.0069)	(0.0068)	(0.0069)
halfBaths	0.0535***	0.0534***	0.0532***	0.0534***	0.0532***
	(0.0091)	(0.0090)	(0.0090)	(0.0090)	(0.0090)
distanceCBD	−0.0253*	−0.0253*	−0.0258*	−0.0264*	−0.0259*
	(0.0107)	(0.0107)	(0.0107)	(0.0107)	(0.0107)
Local District	0.1484***		0.1130***		0.1103***
	(0.0292)		(0.0285)		(0.0272)
National District		0.1756***	0.1321**		0.1280***
		(0.0338)	(0.0402)		(0.0343)
Local&National District				0.1989***	0.0100
				(0.0545)	(0.0610)
Census Tract FE	Y	Y	Y	Y	Y
Year Sold FE	Y	Y	Y	Y	Y
Year Built FE	Y	Y	Y	Y	Y
Num. obs.	174779	174779	174779	174779	174779
R^2 (full model)	0.7810	0.7809	0.7813	0.7808	0.7813

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors cluster corrected at census tract-year level. $logSqft$ is the natural log of square feet living space, $bedrooms$ is the number of bedrooms, $fullBaths$ is the number of full bathrooms, $halfBaths$ is the number of half bathrooms, and $distanceCBD$ is the distance to CBD (km). *Local District* is an indicator for a house transaction being in designated local historic district. *National District* is an indicator for a house transaction being in designated national historic district. *Local&National District* is the interaction term of *Local District* and *National District*.

Table 4: Political Process with Collective Action Cost

	logPrice	logPrice	logPrice	logPrice	logPrice	logPrice
logSqft	0.4532***	0.4525***	0.4518***	0.4529***	0.4525***	0.4516***
	(0.0244)	(0.0242)	(0.0242)	(0.0244)	(0.0242)	(0.0242)
bedrooms	−0.0179***	−0.0178***	−0.0178***	−0.0179***	−0.0178***	−0.0178***
	(0.0038)	(0.0038)	(0.0038)	(0.0038)	(0.0038)	(0.0038)
fullBaths	0.0741***	0.0740***	0.0740***	0.0740***	0.0740***	0.0740***
	(0.0069)	(0.0069)	(0.0069)	(0.0069)	(0.0069)	(0.0069)
halfBaths	0.0537***	0.0537***	0.0535***	0.0537***	0.0537***	0.0535***
	(0.0091)	(0.0091)	(0.0091)	(0.0091)	(0.0091)	(0.0090)
distanceCBD	−0.0244*	−0.0256*	−0.0255*	−0.0247*	−0.0256*	−0.0256*
	(0.0108)	(0.0107)	(0.0107)	(0.0108)	(0.0107)	(0.0107)
Local District Size	0.1259**		0.0818*			
	(0.0400)		(0.0363)			
National District Size		0.3042***	0.2658**			
		(0.0725)	(0.0825)			
log Local District Size				0.2003***		0.1310*
				(0.0552)		(0.0530)
log National District Size					0.3895***	0.3279**
					(0.0920)	(0.1048)
Census Tract FE	Y	Y	Y	Y	Y	Y
Year Sold FE	Y	Y	Y	Y	Y	Y
Year Built FE	Y	Y	Y	Y	Y	Y
Num. obs.	174779	174779	174779	174779	174779	174779
R^2 (full model)	0.7805	0.7808	0.7809	0.7806	0.7808	0.7809

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors cluster corrected at census tract-year level. $logSqft$ is the natural log of square feet living space, *bedrooms* is the number of bedrooms, $fullBaths$ is the number of full bathrooms, $halfBaths$ is the number of half bathrooms, and *distanceCBD* is the distance to CBD (km). *Local District Size* is the size (km^2) of the local historic district designated a house transaction being in. $National\,District\,Size$ is the size (km^2) of the national historic district designated a house transaction being in. *log Local District Size* and $log\,National\,District\,Size$ are the corresponding natural log terms, respectively.

Table 5: Spillovers

	logPrice	logPrice	logPrice	logPrice
logSqft	0.4497***	0.4509***	0.4475***	0.4496***
	(0.0241)	(0.0241)	(0.0239)	(0.0240)
bedrooms	−0.0178***	−0.0178***	−0.0177***	−0.0178***
	(0.0038)	(0.0038)	(0.0038)	(0.0038)
fullBaths	0.0736***	0.0737***	0.0733***	0.0736***
	(0.0069)	(0.0069)	(0.0069)	(0.0069)
halfBaths	0.0533***	0.0534***	0.0530***	0.0532***
	(0.0091)	(0.0090)	(0.0090)	(0.0090)
distanceCBD	−0.0249*	−0.0252*	−0.0253*	−0.0251*
	(0.0107)	(0.0107)	(0.0107)	(0.0107)
Local District	0.1623***		0.1274***	
	(0.0304)		(0.0301)	
Local District Buffer 100m	0.0626**		0.0591**	
	(0.0216)		(0.0226)	
National District		0.1916***	0.1487***	0.1931***
		(0.0347)	(0.0410)	(0.0348)
National District Buffer 100m		0.0643**	0.0562*	0.0634**
		(0.0202)	(0.0221)	(0.0206)
National Large Structure Buffer 100m				0.0641*
				(0.0261)
Census Tract FE	Y	Y	Y	Y
Year Sold FE	Y	Y	Y	Y
Year Built FE	Y	Y	Y	Y
Num. obs.	174779	174779	174779	174779
R^2 (full model)	0.7812	0.7811	0.7817	0.7813

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors cluster corrected at census tract-year level. $logSqft$ is the natural log of square feet living space, *bedrooms* is the number of bedrooms, $fullBaths$ is the number of full bathrooms, $halfBaths$ is the number of half bathrooms, and $distanceCBD$ is the distance to CBD (km). *Local District* is an indicator for a house transaction being in designated local historic district. $National\,District$ is an indicator for a house transaction being in designated national historic district. $Local\,District\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a local historic district. $National\,District\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic district. $National\,Large\,Structure\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic large structure.

Table 6: Buffer Zones vs. Inner Buffer Zones Treatments

	logPrice	logPrice	logPrice	logPrice	logPrice	logPrice
logSqft	0.4524^{***}	0.4532^{***}	0.4519^{***}	0.4497^{***}	0.4509^{***}	0.4495^{***}
	(0.0245)	(0.0244)	(0.0243)	(0.0240)	(0.0240)	(0.0239)
bedrooms	-0.0179^{***}	-0.0179^{***}	-0.0179^{***}	-0.0177^{***}	-0.0178^{***}	-0.0177^{***}
	(0.0038)	(0.0038)	(0.0038)	(0.0038)	(0.0038)	(0.0038)
fullBaths	0.0738^{***}	0.0739^{***}	0.0738^{***}	0.0736^{***}	0.0737^{***}	0.0736^{***}
	(0.0069)	(0.0069)	(0.0069)	(0.0069)	(0.0069)	(0.0069)
halfBaths	0.0540^{***}	0.0540^{***}	0.0538^{***}	0.0531^{***}	0.0534^{***}	0.0531^{***}
	(0.0092)	(0.0091)	(0.0091)	(0.0090)	(0.0090)	(0.0090)
distanceCBD	-0.0242^{*}	-0.0245^{*}	-0.0244^{*}	-0.0249^{*}	-0.0252^{*}	-0.0251^{*}
	(0.0107)	(0.0107)	(0.0107)	(0.0107)	(0.0107)	(0.0107)
Local District Buffer 100m	0.0520^{*}			0.0627^{**}		
	(0.0217)			(0.0216)		
Local District Buffer -100m	0.0888^{*}			0.1445^{***}		
	(0.0352)			(0.0303)		
National District Buffer 100m		0.0467^{*}	0.0455^{*}		0.0637^{**}	0.0628^{**}
		(0.0221)	(0.0226)		(0.0202)	(0.0206)
National District Buffer -100m		0.1124^{**}	0.1117^{**}		0.1760^{***}	0.1763^{***}
		(0.0342)	(0.0341)		(0.0348)	(0.0347)
National Large Structure Buffer 100m			0.0614^{*}			0.0647^{*}
			(0.0263)			(0.0260)
Local District NonBuffer -100m				0.2109^{***}		
				(0.0486)		
National District NonBuffer -100m					0.2169^{***}	0.2206^{***}
					(0.0381)	(0.0389)
Census Tract FE	Y	Y	Y	Y	Y	Y
Year Sold FE	Y	Y	Y	Y	Y	Y
Year Built FE	Y	Y	Y	Y	Y	Y
Num. obs.	174779	174779	174779	174779	174779	174779
R^2 (full model)	0.7806	0.7805	0.7807	0.7813	0.7811	0.7813

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors cluster corrected at census tract-year level. $logSqft$ is the natural log of square feet living space, $bedrooms$ is the number of bedrooms, $fullBaths$ is the number of full bathrooms, $halfBaths$ is the number of half bathrooms, and $distanceCBD$ is the distance to CBD (km). $Local\, District\, Buffer\, 100m$ is an indicator for a house transaction being in the 100m buffer zone of a local historic district. $Local\, District\, Buffer - 100m$ is an indicator for a house transaction being in the 100m inner buffer zone of a local historic district. $National\, District\, Buffer\, 100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic district. $National\, District\, Buffer - 100m$ is an indicator for a house transaction being in the 100m inner buffer zone of a national historic district. $National\, Large\, Structure\, Buffer\, 100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic large structure. $Local\, District\, NonBuffer - 100m$ is an indicator for a house transaction being in a local historic district but not in the 100m inner buffer zone of it. $National\, District\, NonBuffer - 100m$ is an indicator for a house transaction being in a national historic district but not in the 100m inner buffer zone of it.

Table 7: Private Goods vs. Public Goods

	logPrice	logPrice	logPrice	logPrice
logSqft	0.4500***	0.4509***	0.4477***	0.4495***
	(0.0241)	(0.0241)	(0.0239)	(0.0240)
bedrooms	−0.0178***	−0.0178***	−0.0178***	−0.0178***
	(0.0038)	(0.0038)	(0.0038)	(0.0038)
fullBaths	0.0737***	0.0737***	0.0734***	0.0736***
	(0.0069)	(0.0069)	(0.0069)	(0.0069)
halfBaths	0.0534***	0.0535***	0.0531***	0.0532***
	(0.0091)	(0.0090)	(0.0090)	(0.0090)
distanceCBD	−0.0249*	−0.0253*	−0.0254*	−0.0252*
	(0.0107)	(0.0107)	(0.0107)	(0.0107)
Local District	0.1579***		0.1230***	
	(0.0313)		(0.0314)	
Private Local District Buffer 100m	0.0383		0.0347	
	(0.0262)		(0.0280)	
Public Local District Buffer 100m	0.0719**		0.0690**	
	(0.0254)		(0.0257)	
National District		0.1884***	0.1454***	0.1896***
		(0.0361)	(0.0428)	(0.0362)
Private National District Buffer 100m		0.0471	0.0432	0.0445
		(0.0286)	(0.0315)	(0.0284)
Public National District Buffer 100m		0.0814**	0.0751**	0.0823**
		(0.0261)	(0.0268)	(0.0265)
National Large Structure Buffer 100m				0.0645*
				(0.0258)
Census Tract FE	Y	Y	Y	Y
Year Sold FE	Y	Y	Y	Y
Year Built FE	Y	Y	Y	Y
Num. obs.	174779	174779	174779	174779
R^2 (full model)	0.7812	0.7811	0.7817	0.7813

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors cluster corrected at census tract-year level. *logSqft* is the natural log of square feet living space, *bedrooms* is the number of bedrooms, *fullBaths* is the number of full bathrooms, *halfBaths* is the number of half bathrooms, and *distanceCBD* is the distance to CBD (km). *Local District* is an indicator for a house transaction being in designated local historic district. *National District* is an indicator for a house transaction being in designated national historic district. *Private Local District Buffer 100m* is an indicator for a house transaction being in the 100m buffer zone of a local historic district constituted of private single-family homes. *Public Local District Buffer 100m* is an indicator for a house transaction being in the 100m buffer zone of a local historic district constituted of publicly accessible structures. *Private National District Buffer 100m* is an indicator for a house transaction being in the 100m buffer zone of a national historic district constituted of private single-family homes. *Public National, District Buffer 100m* is an indicator for a house transaction being in the 100m buffer zone of a national historic district constituted of publicly accessible structures. *National Large Structure Buffer 100m* is an indicator for a house transaction being in the 100m buffer zone of a national historic large structure.

Table 8: Private Goods vs. Public Goods Cont.

	logPrice	logPrice	logPrice	logPrice
logSqft	0.4499***	0.4508***	0.4476***	0.4495***
	(0.0240)	(0.0241)	(0.0238)	(0.0240)
bedrooms	−0.0178***	−0.0178***	−0.0177***	−0.0177***
	(0.0038)	(0.0038)	(0.0038)	(0.0038)
fullBaths	0.0737***	0.0737***	0.0734***	0.0736***
	(0.0069)	(0.0069)	(0.0069)	(0.0069)
halfBaths	0.0532***	0.0534***	0.0529***	0.0531***
	(0.0090)	(0.0090)	(0.0089)	(0.0090)
distanceCBD	−0.0249*	−0.0253*	−0.0255*	−0.0252*
	(0.0107)	(0.0107)	(0.0107)	(0.0107)
Local District Buffer -100m	0.1402***		0.1082***	
	(0.0312)		(0.0319)	
Local District NonBuffer -100m	0.2064***		0.1654**	
	(0.0495)		(0.0547)	
Private Local District Buffer 100m	0.0385		0.0345	
	(0.0262)		(0.0279)	
Public Local District Buffer 100m	0.0719**		0.0690**	
	(0.0254)		(0.0258)	
National District Buffer -100m		0.1725***	0.1381**	0.1724***
		(0.0360)	(0.0436)	(0.0358)
National District NonBuffer -100m		0.2140***	0.1519**	0.2174***
		(0.0394)	(0.0462)	(0.0403)
Private National District Buffer 100m		0.0462	0.0452	0.0435
		(0.0285)	(0.0330)	(0.0282)
Public National District Buffer 100m		0.0812**	0.0763**	0.0820**
		(0.0261)	(0.0264)	(0.0265)
National Large Structure Buffer 100m				0.0651*
				(0.0258)
Census Tract FE	Y	Y	Y	Y
Year Sold FE	Y	Y	Y	Y
Year Built FE	Y	Y	Y	Y
Num. obs.	174779	174779	174779	174779
R^2 (full model)	0.7813	0.7811	0.7818	0.7813

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors cluster corrected at census tract-year level. $logSqft$ is the natural log of square feet living space, $bedrooms$ is the number of bedrooms, $fullBaths$ is the number of full bathrooms, $halfBaths$ is the number of half bathrooms, and $distanceCBD$ is the distance to CBD (km). $Local\,District\,Buffer - 100m$ is an indicator for a house transaction being in the 100m inner buffer zone of a local historic district. $Local\,District\,NonBuffer - 100m$ is an indicator for a house transaction being in a local historic district but not in the 100m inner buffer zone of it. $Private\,Local\,District\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a local historic district constituted of private single-family homes. $Public\,Local\,District\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a local historic district constituted of publicly accessible structures. $National\,District\,Buffer - 100m$ is an indicator for a house transaction being in the 100m inner buffer zone of a national historic district. $National\,District\,NonBuffer - 100m$ is an indicator for a house transaction being in a national historic district but not in the 100m inner buffer zone of it. $Private\,National\,District\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic district constituted of private single-family homes. $Public\,National, District\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic district constituted of publicly accessible structures. $National\,Large\,Structure\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic large structure.

Table 9: Equilibrium Before Designation and In-equilibrium After Designation

	logPrice	logPrice	logPrice	logPrice	logPrice	logPrice
logSqft	0.4551***	0.4546***	0.4549***	0.4513***	0.4519***	0.4502***
	(0.0244)	(0.0244)	(0.0244)	(0.0242)	(0.0241)	(0.0241)
bedrooms	−0.0178***	−0.0179***	−0.0178***	−0.0178***	−0.0180***	−0.0179***
	(0.0038)	(0.0038)	(0.0038)	(0.0038)	(0.0038)	(0.0038)
fullBaths	0.0740***	0.0742***	0.0740***	0.0738***	0.0738***	0.0736***
	(0.0068)	(0.0069)	(0.0068)	(0.0069)	(0.0069)	(0.0069)
halfBaths	0.0539***	0.0539***	0.0539***	0.0535***	0.0534***	0.0531***
	(0.0090)	(0.0091)	(0.0090)	(0.0091)	(0.0090)	(0.0090)
distanceCBD	−0.0239*	−0.0240*	−0.0236*	−0.0252*	−0.0249*	−0.0252*
	(0.0108)	(0.0108)	(0.0108)	(0.0107)	(0.0107)	(0.0107)
Local District Future	−0.0914		−0.0912	−0.0224		−0.0566
	(0.0527)		(0.0527)	(0.0418)		(0.0537)
National District Future		0.0490	0.0479		0.0678*	0.0636*
		(0.0308)	(0.0311)		(0.0316)	(0.0318)
Local District				0.1422***		0.0939**
				(0.0328)		(0.0355)
National District					0.1776***	0.1448***
					(0.0345)	(0.0422)
Census Tract FE	Y	Y	Y	Y	Y	Y
Year Sold FE	Y	Y	Y	Y	Y	Y
Year Built FE	Y	Y	Y	Y	Y	Y
Num. obs.	174779	174779	174779	174779	174779	174779
R^2 (full model)	0.7804	0.7803	0.7804	0.7810	0.7810	0.7814

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors cluster corrected at census tract-year level. $logSqft$ is the natural log of square feet living space, *bedrooms* is the number of bedrooms, $fullBaths$ is the number of full bathrooms, $halfBaths$ is the number of half bathrooms, and *distanceCBD* is the distance to CBD (km). *Local District* is an indicator for a house transaction being in designated local historic district. $National\,District$ is an indicator for a house transaction being in designated national historic district. *Local District Future* is an indicator for a house transaction being in a district which will be designated as a local historic district later in the observation period. $National\,District\,Future$ is an indicator for a house transaction being in a district which will be designated as a national historic district later in the observation period.

Table 10: Time (Regression Adjusted Residuals)

	Residual	Residual	Residual	Residual	Residual	Residual
Local District	0.1358^{***}	-0.0391^{**}	-0.0247			
	(0.0090)	(0.0131)	(0.0151)			
Local District Time (Year)		0.0093^{***}	0.0082^{***}			
		(0.0005)	(0.0008)			
Local District Time^2 (Year)			0.0000			
			(0.0000)			
National District				0.0368^{*}	-0.1564^{***}	-0.0513
				(0.0146)	(0.0198)	(0.0298)
National District Time (Year)					0.0077^{***}	0.0005
					(0.0005)	(0.0016)
National District Time^2 (Year)						0.0002^{***}
						(0.0000)
Num. obs.	7194	7194	7194	4269	4269	4269
R^2 (full model)	0.0307	0.0725	0.0729	0.0015	0.0455	0.0504

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. The dependent variable is the residual collected from the pre-regression without time treatment. Then, only the observations in a historic district before or after designation are remained in the regression. *Local District* is an indicator for a house transaction being in designated local historic district. *National District* is an indicator for a house transaction being in designated national historic district. *Local District Time (Year)* is an indicator for the time (year) between the corresponding local historic district designation and a house transaction. *National District Time (Year)* is an indicator for the time (year) between the corresponding national historic district designation and a house transaction. *Local District Time^2 (Year)* is the square term of *Local District Time (Year)*, and *National District Time^2 (Year)* is the square term of *National District Time (Year)*.

Table 11: Repeat Sales Model

	logPrice	logPrice	logPrice	logPrice	logPrice	logPrice	logPrice
Local District	0.1691^{***}		0.1697^{***}	0.1709^{***}		0.1716^{***}	
	(0.0136)		(0.0136)	(0.0136)		(0.0136)	
National District		0.1707^{***}	0.1727^{***}		0.1711^{***}	0.1702^{***}	0.1711^{***}
		(0.0261)	(0.0261)		(0.0261)	(0.0261)	(0.0261)
Local District Buffer 100m				0.1147^{***}		0.1129^{***}	
				(0.0130)		(0.0130)	
National District Buffer 100m					0.1466^{***}	0.1438^{***}	0.1467^{***}
					(0.0375)	(0.0374)	(0.0375)
National Large Structure Buffer 100m							0.2480
							(0.1474)
Year Sold Factor	Y	Y	Y	Y	Y	Y	Y
Num. obs.	102388	102388	102388	102388	102388	102388	102388
R^2	0.5578	0.5573	0.5580	0.5581	0.5574	0.5583	0.5574

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. *Local District* is an indicator for a house transaction being in designated local historic district. *National District* is an indicator for a house transaction being in designated national historic district. *Local District Buffer 100m* is an indicator for a house transaction being in the 100m buffer zone of a local historic district. *National District Buffer 100m* is an indicator for a house transaction being in the 100m buffer zone of a national historic district. *National Large Structure Buffer 100m* is an indicator for a house transaction being in the 100m buffer zone of a national historic large structure.

A Appendix: Five Step Process of Landmark Designation

The Five Step Process of Historic Landmarks and Historic Landmark Districts Designation is (City and County of Denver, 2019c):

1. "Set a preliminary application review with Landmark Preservation staff. This meeting will be a review of the draft designation application to advise what additional research may be needed. Additional information will be provided regarding the designation process and guidance to improve and strengthen the application.

2. Submit the completed final application along with required fees to Landmark Preservation.

3. Landmark Preservation staff will review the application to determine whether the application is complete and Denver landmark designation criteria are met.

4. Once Landmark Preservation staff determines that an application is complete and the designation criteria met, a public hearing before the Landmark Preservation Commission is set. All owners of record are notified by mail of the date, time, and place of the hearing. The Commission will hear public testimony at the hearing and determine if the property meets landmark designation criteria. If the Commission determines that a property meets landmark designation criteria, the application is then forwarded to City Council.

5. Upon recommendation of the Commission the designation application is forwarded to City Council. A committee of City Council will review the designation application and determine whether the case is ready to move forward to the full City Council meeting. The Denver City Council designates a landmark by considering the designation bill at two meetings or readings of City Council. The second and final reading before City Council is a public hearing. City Council provides final historic designation approval for a structure or historic district at the second reading. The designation goes into effect once the mayor signs the bill and second reading."

B Appendix: Historic Designation Regulations

According to Historic Denver (Historic Denver, 2017), the following will not be influenced by historic designation and do not require design review:

1. Painting the exterior of your home the color of your choice,
2. Making interior changes to your home,
3. Most landscaping,
4. Installing an air conditioning unit,
5. Installing a lawn sprinkler system,
6. Installing a satellite dish,
7. Placing play ground equipment in the yard.

However, the following will require the design review process:

1. Sensitive additions to enlarge your home,
2. Adding or replacing a garage,
3. Replacing the front door.

C Appendix: Regression-Discontinuity Design (RDD)

McCrary (2008) suggests that the distribution discontinuity of assignment variable can be visually inspected and formally tested by a hypothesis test. Figure C.1 displays the histograms for local historic districts (the left column) and national historic districts (the right column). The sample includes the house transactions in a district which has been or will be designated as a historic district. In other words, it is the selected sample, in order to exclude the potential selection bias. The histograms in the top row indicate that many more transactions occur right after the designation. The middle row narrows the sample to only include house transactions within the 10-year window of designation: no more than 10 years before, and no more than 10 years after. Similar implications are found, too. The bottom row further limits the sample to houses in the historic districts designated no earlier than 1990. Similar discontinuity can be seen for the local historic districts histogram, while it is not evident for the national historic districts anymore. Further analysis shows that there are only two national historic districts of residential properties designated post-1990.

Kernel densities are plotted for both local and national historic districts, with the same three samples conducted for histograms, and they are provided in this Appendix C section. It also includes all the graphical RDD results, the general implication of which is that there is no significant difference by conducting RDD analysis. This is consistent with the theoretical implication discussed in the first paragraph of this subsection.

Figure C.2 shows the Kernel Density for transaction distribution of time in local and national historic districts, which echoes the implication from histograms in Figure C.1: RDD is not an appropriate method for empirical analysis in this context.

Figures C.3 and C.4 show the RDD results of different fitting methods for local and national historic districts which were designated no earlier than 1990, respectively. Panels in these figures show the fitted lines of different models and the 95% confidence intervals. Unsurprisingly, there is barely any significant difference before and after the designation.

Figures C.5 and C.6 further show the RDD results of different fitting methods for local and national historic districts which were designated no earlier than 1990, respectively, while the transactions are limited to those no more than 10 years earlier than the corresponding designation.

Panels in these figures show the fitted lines of different models and the 95% confidence intervals. It is difficult to pick the "correct" pre-designation time span, and 10 years is used here. However, as shown in the figures, the transactions a few years (about 5-6) before the designations barely have any significant difference from 0.

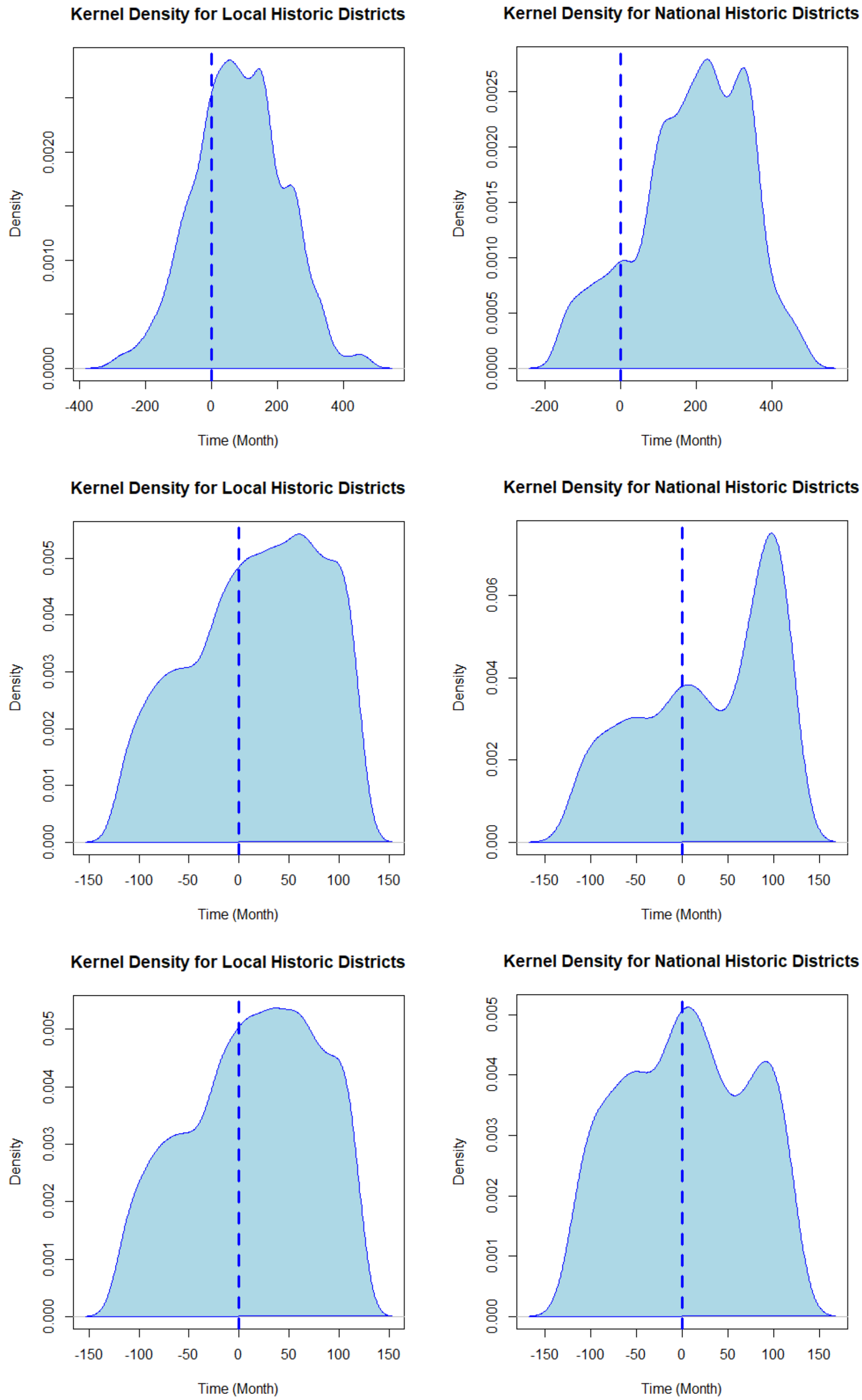
Because there are only two national historic districts of private residential properties designated post-1990, I further investigate them separately. Analysis of the relatively larger historic district with more transactions does not suggest any significant difference in general, as shown in Figure C.7. The smaller one only has three observations before the treatment, which barely provides any meaningful implications, as shown in Figure C.8.

Although the RDD analysis in general does not show any sharp "jump" of prices after designation, it can still help show the different trends of house prices before and after designation. As shown from the panels of these figures, transactions in local historic districts a few years before the designation do not seem to have a significant difference from zero, while national ones are slightly greater than zero. Note that there are only two national historic district designations of private residential homes in the time period of the sample.

Figure C.1: Histograms for Transactions in Local and National Historic Districts Over Time

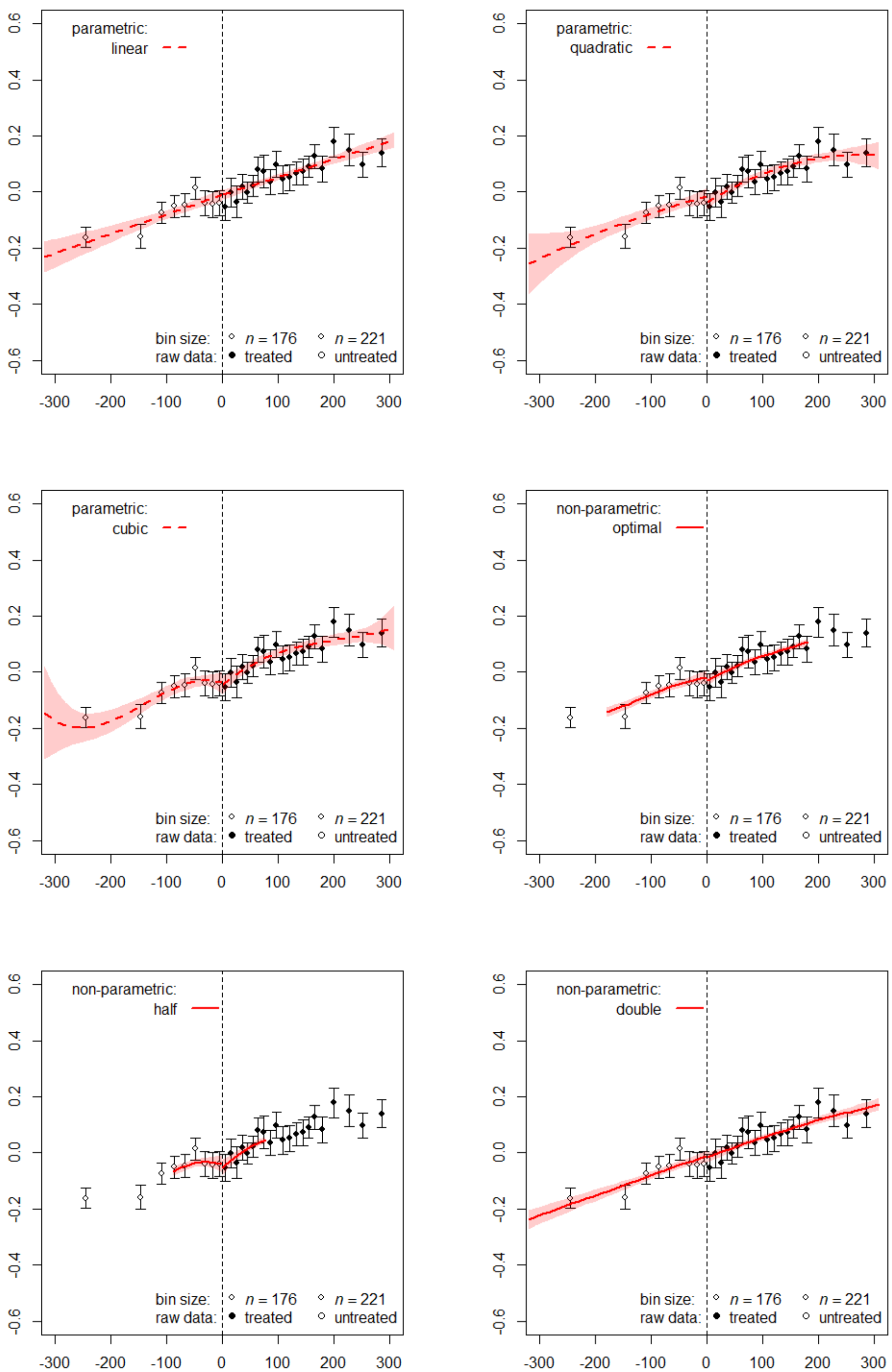
Top row: full sample; middle row: 10 years window; bottom row: selected sample only with districts designated after 1990.

Figure C.2: Kernel Density Plots for Transaction Distribution of Time in Local and National Historic Districts



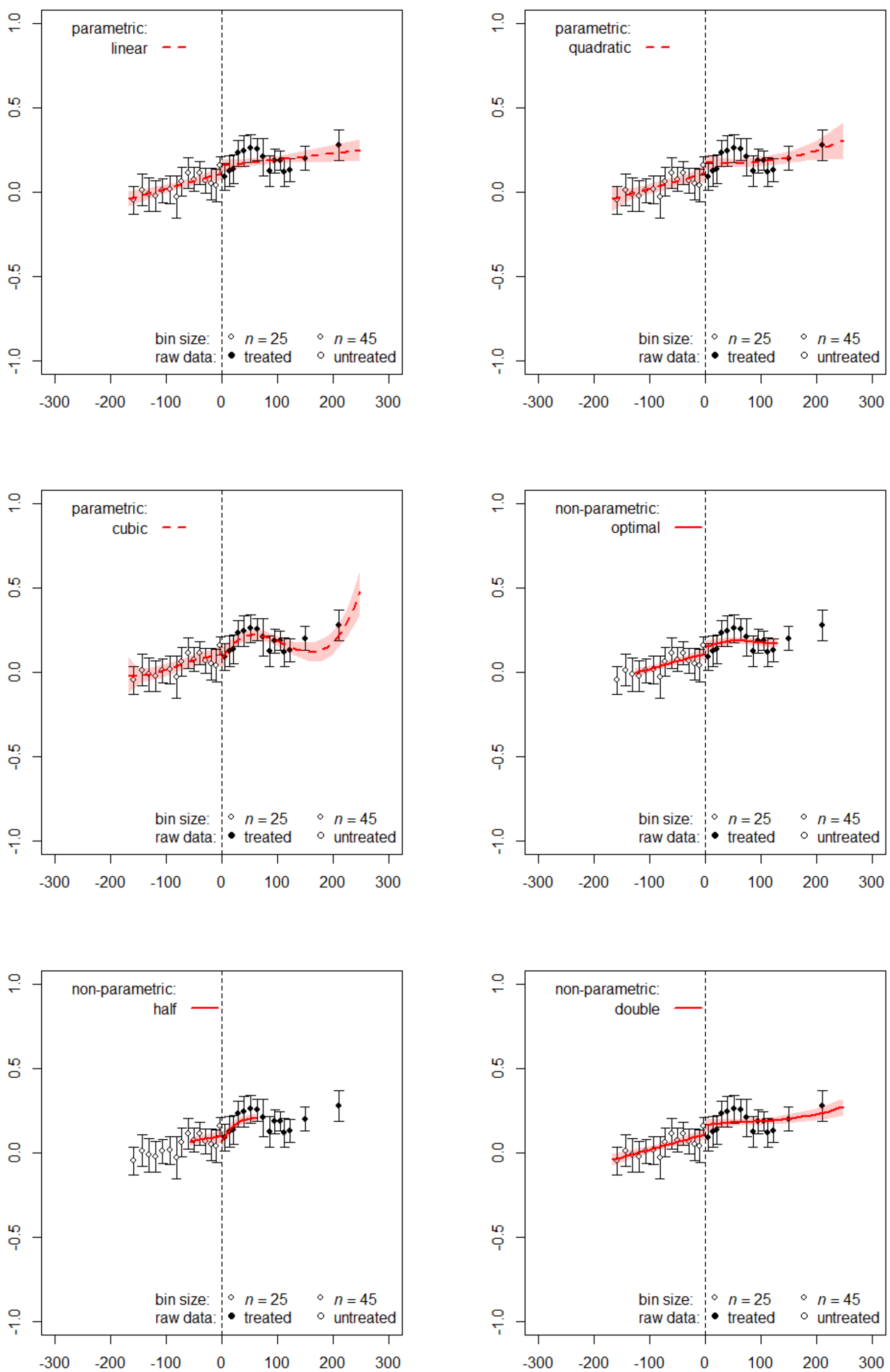
Top row: full sample; middle row: 10 years window; bottom row: selected sample only with districts designated after 1990.

Figure C.3: RDD for Local Historic Districts (Regression Adjusted, District Designated No Earlier than 1990)



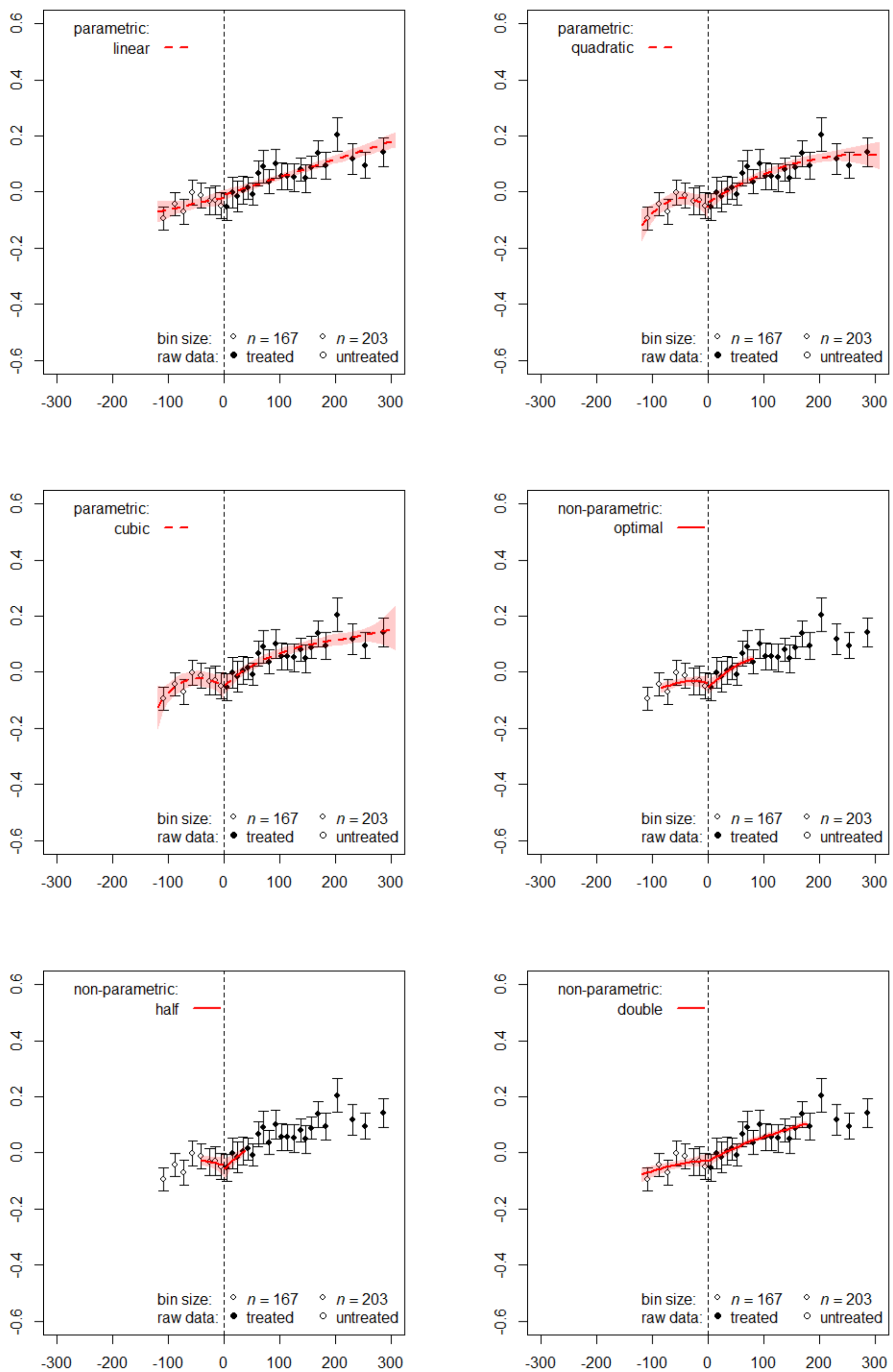
0 out of 6 methods indicate a statistically significant (5%) discontinuity. Linear: z=0.020 (p-value=0.9839); Quadratic: z=-0.945 (p-value=0.3445); Cubic: z=-0.330 (p-value=0.7413); Optimal: z=-0.510 (p-value=0.6102); Half-optimal: z=-0.457 (p-value=0.6476); Double-optimal: z=-0.293 (p-value=0.7697).

Figure C.4: RDD for National Historic Districts (Regression Adjusted, District Designated No Earlier than 1990)



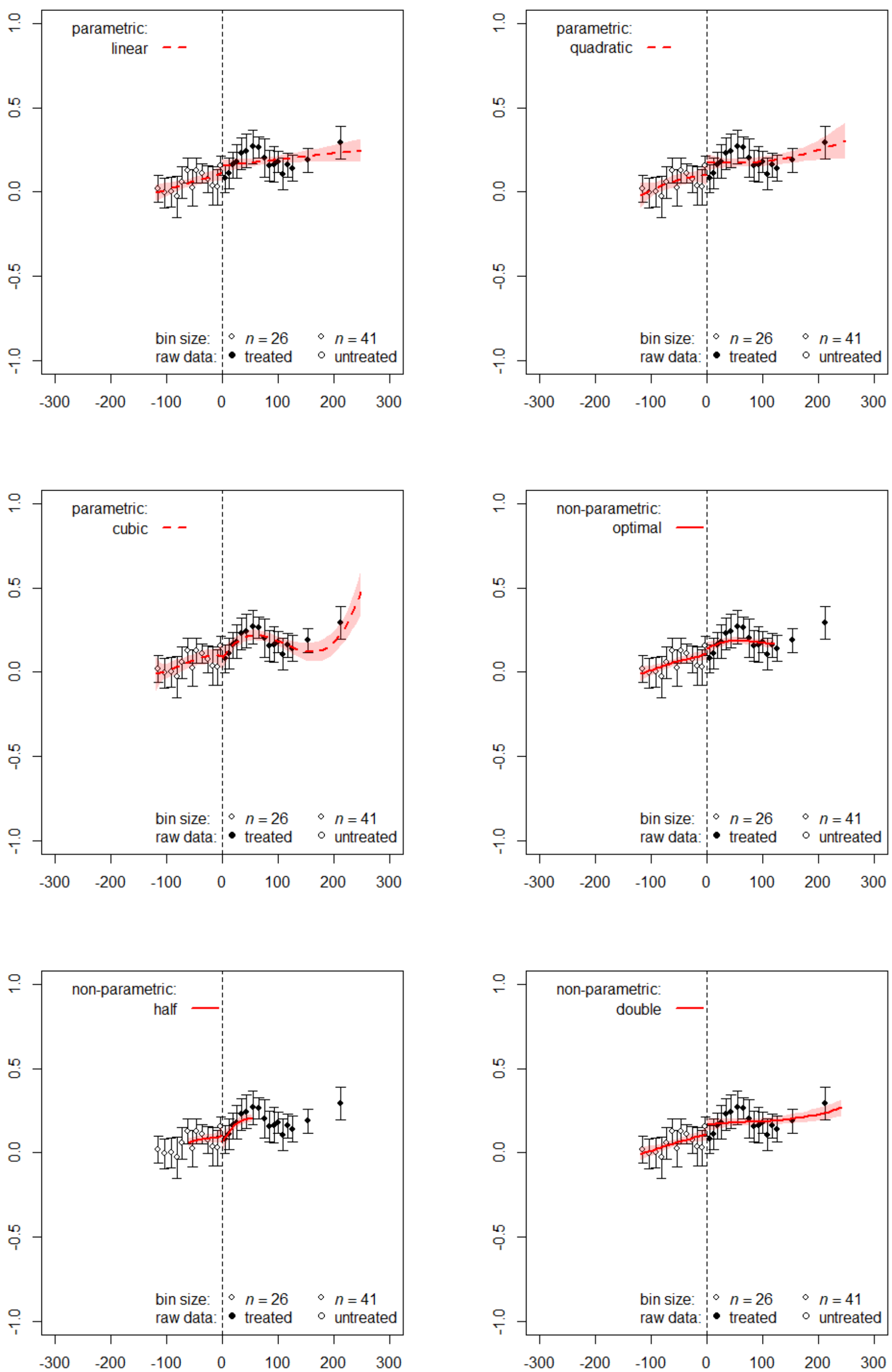
1 out of 6 methods indicate a statistically significant (5%) discontinuity. Linear: z=1.696 (p-value=0.0898); Quadratic: z=1.839 (p-value=0.0660); Cubic: z=-0.367 (p-value=0.7137); Optimal: z=1.180 (p-value=0.2380); Half-optimal: z=-0.825 (p-value=0.4093); Double-optimal: z=1.991 (p-value=0.0465).

Figure C.5: RDD for Local Historic Districts (Regression Adjusted, District Designated No Earlier than 1990, Transaction No Earlier than 10 Years)



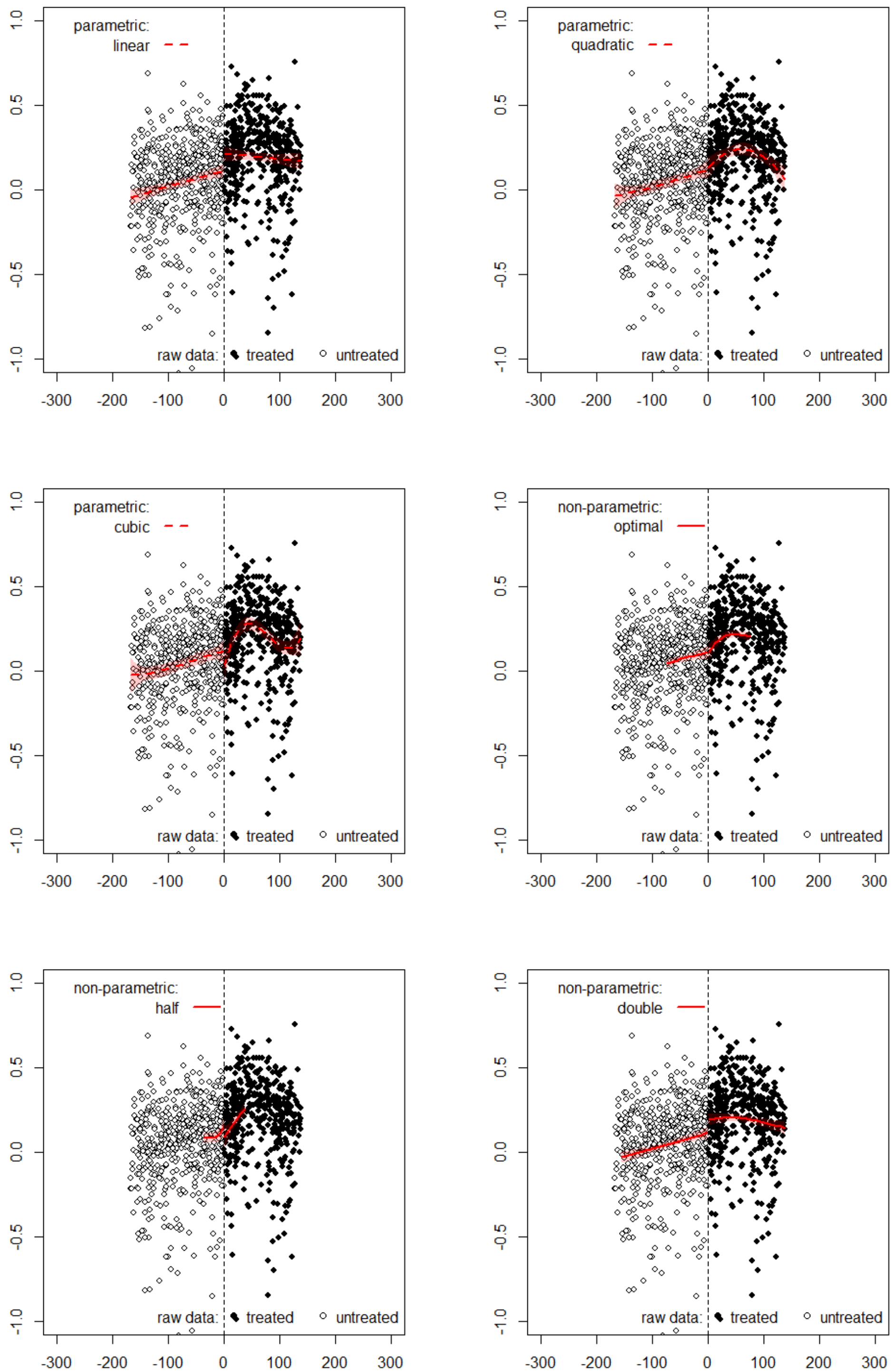
0 out of 6 methods indicate a statistically significant (5%) discontinuity. Linear: z=0.579 (p-value=0.5627); Quadratic: z=0.666 (p-value=0.5054); Cubic: z=0.062 (p-value=0.9503); Optimal: z=-0.452 (p-value=0.6510); Half-optimal: z=-0.407 (p-value=0.6840); Double-optimal: z=-0.130 (p-value=0.8966).

Figure C.6: RDD for National Historic Districts (Regression Adjusted, District Designated No Earlier than 1990, Transaction No Earlier than 10 Years)



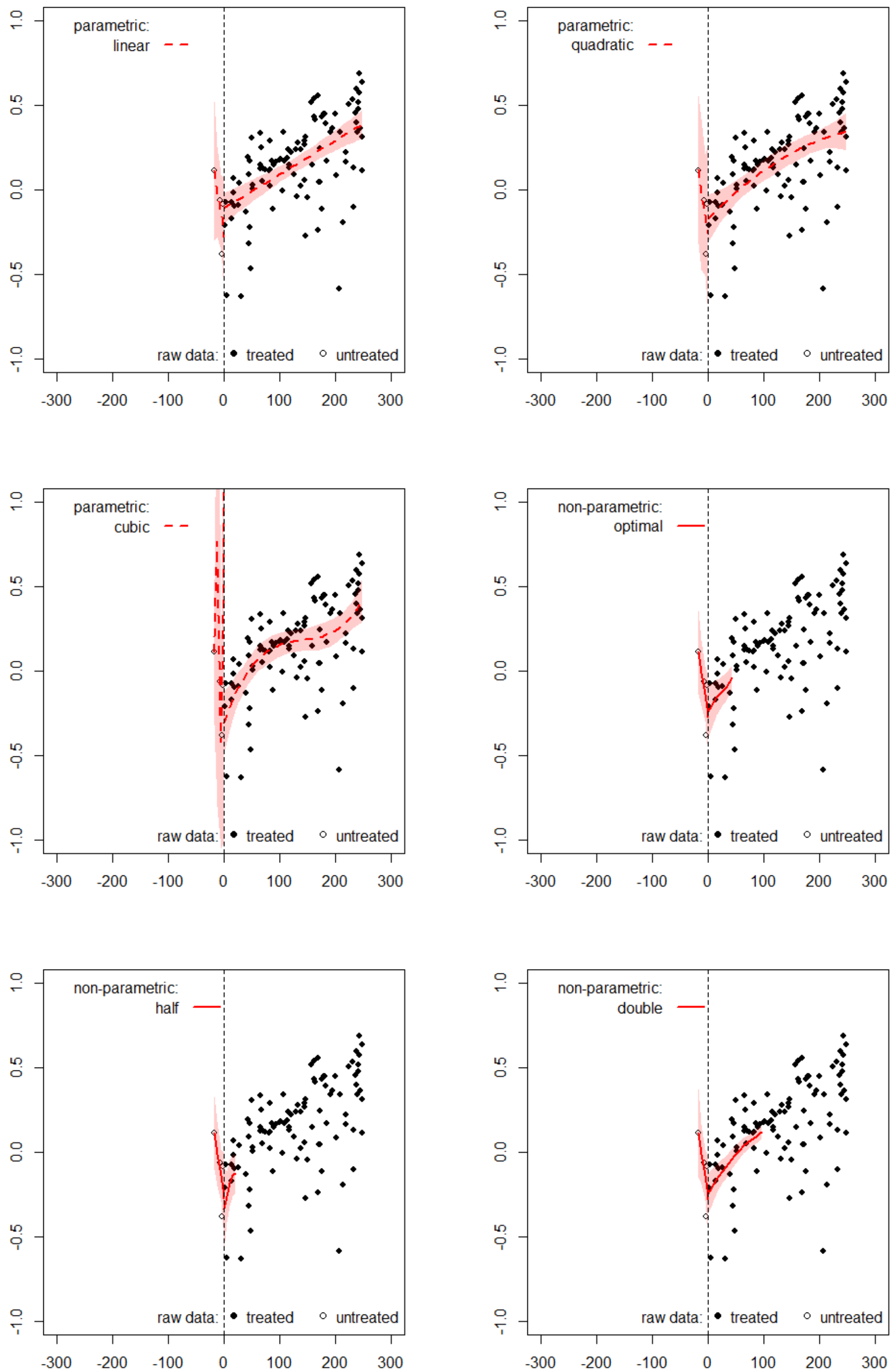
0 out of 6 methods indicate a statistically significant (5%) discontinuity. Linear: z= 1.469 (p-value=0.1419); Quadratic: z= 1.956 (p-value=0.0505); Cubic: z= -0.258 (p-value=0.7962); Optimal: z= 0.969 (p-value=0.3325); Half-optimal: z= -0.915 (p-value=0.3603); Double-optimal: z= 1.843 (p-value= 0.0654).

Figure C.7: RDD for National Historic District 04001348 (Regression Adjusted)



2 out of 6 methods indicate a statistically significant (5%) discontinuity. Linear: z= 3.423 (p-value=0.0006); Quadratic: z= 0.251 (p-value=0.8019); Cubic: z= -1.869 (p-value=0.0616); Optimal: z= -0.126 (p-value=0.9000); Half-optimal: z= -1.523 (p-value=0.1279); Double-optimal: z= 2.495 (p-value=0.0126).

Figure C.8: RDD for National Historic District 95000264(Regression Adjusted)



1 out of 6 methods indicate a statistically significant (5%) discontinuity. Linear: z= 1.333 (p-value 0.1824); Quadratic: z= 0.433 (p-value=0.6652); Cubic: z= -14.957 (p-value=0.0000); Optimal: z= 0.220 (p-value=0.8259); Half-optimal: z= -0.258 (p-value=0.7966); Double-optimal: z= 0.216 (p-value=0.8290).

D Appendix: Robustness Tests of Different Distances

50 meters is too narrow for the buffer zone distance, because it fails to include a sufficient number of houses due to the width of streets. 150 meters and 200 meters are used in the robustness tests, and 100-150m and 150-200m treatments are added into the original analyses as reported in Tables 5, 7, and 11. Overall, the results suggest that the positive spillovers are still significant for house transactions in the 100-150m and 150-200m buffer zones, while the magnitudes are smaller than that in the 0-100m buffer zones.

Table D.1 reports the results with more distance treatments added in the original analysis of positive spillovers to buffer zones as reported in Table 5. The spillover of local historic district designation is significant for the house transactions in the 100-150m range and 150-200m range, and the magnitude decreases as distance increases. Similar patterns are also found for national historic district designation and its 0-100m and 100-150m ranges, while the coefficient for the 150-200m distance is only significant in one out of three models and also only at a 5% significance level.

Table D.2 reports the results with more distance treatments added into the original analysis of public goods characteristics as reported in Table 7. For local historic district designation, only the public ones have significant effects, and the private ones have no significant effect. Meanwhile, the coefficient's magnitude decreases with distance. For national historic districts, the "magnitude decreasing with distance" pattern also holds. Meanwhile, the spillovers of national historic district designation with public goods characteristics are only significant for the 100m range; it is interesting that 100-150m private national historic district also has a significant effect now, while it is only at the 5% significance level.

Table D.3 reports the results with more distance treatments added into the original analysis of repeat sales model as reported in Table 11. Results are robust to different distance of buffer zone treatments and comparable to those reported in Table 11.

Table D.1: Spillovers - Different Distances

	logPrice	logPrice	logPrice	logPrice
Local District	0.1753***		0.1403***	
	(0.0310)		(0.0305)	
Local District Buffer 100m	0.0767**		0.0724**	
	(0.0256)		(0.0266)	
Local District Buffer 100-150m	0.0688**		0.0648**	
	(0.0228)		(0.0232)	
Local District Buffer 150-200m	0.0514**		0.0496**	
	(0.0179)		(0.0181)	
National District		0.2044***	0.1612***	0.2054***
		(0.0354)	(0.0420)	(0.0351)
National District Buffer 100m		0.0745**	0.0629*	0.0734**
		(0.0230)	(0.0249)	(0.0237)
National District Buffer 100-150m		0.0526**	0.0428*	0.0525**
		(0.0176)	(0.0180)	(0.0182)
National District Buffer 150-200m		0.0374*	0.0314	0.0375
		(0.0189)	(0.0197)	(0.0193)
National Large Structure Buffer 100m				0.0743*
				(0.0323)
National Large Structure Buffer 100-150m				0.0387
				(0.0276)
National Large Structure Buffer 150-200m				0.0317
				(0.0250)
House Characteristics Controls	Y	Y	Y	Y
Census Tract FE	Y	Y	Y	Y
Year Sold FE	Y	Y	Y	Y
Year Built FE	Y	Y	Y	Y
Num. obs.	174779	174779	174779	174779
R^2 (full model)	0.7815	0.7812	0.7821	0.7815

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors cluster corrected at census tract-year level. *Local District* is an indicator for a house transaction being in a designated local historic district. $Local\,District\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a local historic district. $Local\,District\,Buffer\,100-150m$ is an indicator for a house transaction being in the 100-150m buffer zone of a local historic district. $Local\,District\,Buffer\,150-200m$ is an indicator for a house transaction being in the 150-200m buffer zone of a local historic district. $National\,District$ is an indicator for a house transaction being in a designated national historic district. $National\,District\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic district. $National\,District\,Buffer\,100-150m$ is an indicator for a house transaction being in the 100-150m buffer zone of a national historic district. $National\,District\,Buffer\,150-200m$ is an indicator for a house transaction being in the 150-200m buffer zone of a national historic district. $National\,Large\,Structure\,Buffer\,100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic large structure. $National\,Large\,Structure\,Buffer\,100-150m$ is an indicator for a house transaction being in the 100-150m buffer zone of a national historic large structure. $National\,Large\,Structure\,Buffer\,150-200m$ is an indicator for a house transaction being in the 150-200m buffer zone of a national historic large structure.

Table D.2: Private Goods vs. Public Goods - Different Distances

	logPrice	logPrice	logPrice	logPrice
Local District	0.1669***		0.1326***	
	(0.0322)		(0.0323)	
Private Local District Buffer 100m	0.0488		0.0442	
	(0.0290)		(0.0310)	
Private Local District Buffer 100-150m	0.0415		0.0359	
	(0.0231)		(0.0238)	
Private Local District Buffer 150-200m	0.0269		0.0279	
	(0.0199)		(0.0228)	
Public Local District Buffer 100m	0.0864**		0.0822**	
	(0.0295)		(0.0298)	
Public Local District Buffer 100-150m	0.0820**		0.0773**	
	(0.0258)		(0.0259)	
Public Local District Buffer 150-200m	0.0633**		0.0585**	
	(0.0208)		(0.0203)	
National District		0.2020***	0.1585***	0.2024***
		(0.0372)	(0.0442)	(0.0370)
Private National District Buffer 100m		0.0587	0.0542	0.0552
		(0.0315)	(0.0347)	(0.0312)
Private National District Buffer 100-150m		0.0574*	0.0516*	0.0558*
		(0.0247)	(0.0259)	(0.0248)
Private National District Buffer 150-200m		0.0396	0.0349	0.0391
		(0.0297)	(0.0302)	(0.0299)
Public National District Buffer 100m		0.0904**	0.0773**	0.0914**
		(0.0289)	(0.0293)	(0.0301)
Public National District Buffer 100-150m		0.0477*	0.0396	0.0489*
		(0.0230)	(0.0212)	(0.0242)
Public National District Buffer 150-200m		0.0346	0.0306	0.0354
		(0.0237)	(0.0266)	(0.0254)
National Large Structure Buffer 100m				0.0747*
				(0.0321)
National Large Structure Buffer 100-150m				0.0388
				(0.0275)
National Large Structure Buffer 150-200m				0.0316
				(0.0249)
House Characteristics Controls	Y	Y	Y	Y
Census Tract FE	Y	Y	Y	Y
Year Sold FE	Y	Y	Y	Y
Year Built FE	Y	Y	Y	Y
Num. obs.	174779	174779	174779	174779
R^2 (full model)	0.7815	0.7812	0.7820	0.7815

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. Standard errors cluster corrected at census tract-year level. $Local\, District$ is an indicator for a house transaction being in a designated local historic district. $Private\, Local\, District\, Buffer\, Xm$ is an indicator for a house transaction being in the Xm buffer zone of a local historic district constituted of private single-family homes. $Public\, Local\, District\, Buffer\, Xm$ is an indicator for a house transaction being in the Xm buffer zone of a local historic district constituted of publicly accessible structures. $National\, District$ is an indicator for a house transaction being in a designated local historic district. $Private\, National\, District\, Buffer\, Xm$ is an indicator for a house transaction being in the Xm buffer zone of a local historic district constituted of private single-family homes. $Public\, National\, District\, Buffer\, Xm$ is an indicator for a house transaction being in the 100m buffer zone of a local historic district constituted of publicly accessible structures. $National\, Large\, Structure\, Buffer\, Xm$ is an indicator for a house transaction being in the 100m buffer zone of a national historic large structure.

Table D.3: Repeat Sales Model - Different Distances

	logPrice	logPrice	logPrice	logPrice
Local District	0.1744***		0.1754***	
	(0.0136)		(0.0136)	
Local District Buffer 100m	0.1160***		0.1141***	
	(0.0130)		(0.0130)	
Local District Buffer 100-150m	0.1135***		0.1114***	
	(0.0165)		(0.0165)	
Local District Buffer 150-200m	0.1188***		0.1171***	
	(0.0180)		(0.0180)	
National District		0.1695***	0.1666***	0.1695***
		(0.0261)	(0.0261)	(0.0261)
National District Buffer 100m		0.1564***	0.1525***	0.1564***
		(0.0374)	(0.0374)	(0.0374)
National District Buffer 100-150m		0.1583***	0.1506**	0.1583***
		(0.0478)	(0.0477)	(0.0478)
National District Buffer 150-200m		0.1998***	0.1993***	0.1998***
		(0.0428)	(0.0428)	(0.0428)
National Large Structure Buffer 100m				0.2490
				(0.1473)
National Large Structure Buffer 100-150m				0.2492
				(0.3607)
National Large Structure Buffer 150-200m				0.0772
				(0.1275)
Year Sold Factor	Y	Y	Y	Y
Num. obs.	102388	102388	102388	102388
R^2	0.5588	0.5578	0.5592	0.5578

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$. *Local District* is an indicator for a house transaction being in a designated local historic district. $Local\,District\,Buffer\;100m$ is an indicator for a house transaction being in the 100m buffer zone of a local historic district. $Local\,District\,Buffer\;100-150m$ is an indicator for a house transaction being in the 100-150m buffer zone of a local historic district. $Local\,District\,Buffer\;150-200m$ is an indicator for a house transaction being in the 150-200m buffer zone of a local historic district. $National\,District$ is an indicator for a house transaction being in a designated national historic district. $National\,District\,Buffer\;100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic district. $National\,District\,Buffer\;100-150m$ is an indicator for a house transaction being in the 100-150m buffer zone of a national historic district. $National\,District\,Buffer\;150-200m$ is an indicator for a house transaction being in the 150-200m buffer zone of a national historic district. $National\,Large\,Structure\,Buffer\;100m$ is an indicator for a house transaction being in the 100m buffer zone of a national historic large structure. $National\,Large\,Structure\,Buffer\;100-150m$ is an indicator for a house transaction being in the 100-150m buffer zone of a national historic large structure. $National\,Large\,Structure\,Buffer\;150-200m$ is an indicator for a house transaction being in the 150-200m buffer zone of a national historic large structure.