# Difficult Development Areas and the Supply of Subsidized Housing

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December 4, 2016

***Abstract***

The Low-Income Housing Tax Credit (LIHTC) provides a subsidy to developers who construct housing with maximum tenant incomes and contributions towards rent. The designation of a metropolitan area as a Difficult Development Area (DDA) by the U.S. Government increases the generosity of the subsidy that private developers receive under the program, but does not increase the aggregate total of tax credits available to be allocated. Regression discontinuity methods are used to compare how DDA designation affects the quantity, composition, and location of LIHTC units based on the restriction that no more than 20% of metropolitan areas can receive the designation annually. Results indicate a significant reduction in LIHTC subsidized construction occurs at the 20% population limit, although increases the share of subsidized units located in higher-income neighborhoods.

*Keywords*: Housing Policy; Tax Credits; LIHTC; Regression Discontinuity
*JEL Classification*: H23, H42, R31, R38

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# I. INTRODUCTION

The United States government spends over $50 billion per year subsidizing the rent of low-income households (US OMB, 2015). These expenditures represent a combination of subsidies targeted to individual households (i.e., tenant-based) and suppliers of housing (i.e., place-based). Research has generally shown that tenant-based subsidies are more cost-effective in providing housing services to low-income households in most housing markets (Olsen, 2003; Olsen and Zabel; 2015). However, recent research also suggests tenant-based subsidies may at least temporarily increase the housing rent of unsubsidized households in inelastically supplied housing markets (Susin, 2002; Eriksen and Ross, 2015). Place-based housing subsidies may therefore be complementary to tenant-based subsidies in some markets. This paper explains how the nation's largest place-based housing subsidy, the Low-Income Housing Tax Credit (LIHTC), affects the incentives of private developers in where to locate subsidized housing.

The LIHTC is the nation's largest place-based subsidized rental housing program, and has subsidized the construction of at least 40,502 housing projects and 2.6 million units since the program's inception in 1987 (HUD, 2015). The program is governed by Section 42 of the United States' Tax Code and permits state agencies to allocate federal income tax credits to private developers who construct or rehabilitate rental housing units with maximum tenant incomes and rents for at least 30 years. The U.S. Joint Committee on Taxation (2014) estimated the program resulted in $7.6 billion in lost tax revenue in 2015, and that this amount will increase to $8.6 billion by 2018. Private developers can receive a subsidy of up to 91% of non-land development costs through the LIHTC program and often bundle additional federal and state subsidies to finance projects (Eriksen, 2009). In recent years additional subsidies used by developers to finance LIHTC projects have been reduced, making some policymakers concerned if the LIHTC subsidy alone is sufficiently generous to produce affordable housing units (Lawrence, 2011). Others have argued the LIHTC subsidy is too generous and are concerned about potential rent-seeking behavior by developers associated with the allocation process (Case, 1991; Stegman, 1991; Olsen, 2003).

A key feature of the LIHTC program is that private developers must apply for and then be allocated a subsidy by their respective state government. Each state is constrained in the total amount of subsidy they can allocate to developers annually based on its population. Earlier research on the LIHTC program has primarily analyzed how the program affects the incentives of developers in where to locate rental housing within metro areas (Baum-Snow and Marion, 2009; Freedman and Owens, 2011; Lang, 2012). Relatively little is known about how the program alters financial incentives of developers in where to locate subsidized units between metro areas. It is important to better understand these incentives because of significant heterogeneity in affordability and underlying economic justifications of place-based subsidized housing. In addition, Eriksen and Rosenthal (2010) showed a relatively high degree of crowd out of unsubsidized rental housing should be expected in some markets.

The primary focus of the research is on two features of the LIHTC program. First, each state agency is limited in the number of tax credits they can allocate to developers based on its respective state population. This means a state, such as California, where LIHTC housing is perhaps most justified due to inelastically supplied housing receives the same per capita subsidy to allocate to developers as Iowa. Second, the program systematically increases the generosity of the subsidy received by developers by 30% if they locate a project in a metro area in the top 20% nationally of housing rent divided by median household income. The specific metro areas in the top 20% where developers receive the increase subsidy are called "Difficult Development Areas (DDA)" and are designated annually by the U.S. Department of Housing and Urban Development (HUD).

The primarily contribution of the research is to show each of the above features, especially in tandem, results in arguably a poorly targeted subsidy. Potential economic arguments in how to target place-based housing at the metro-level are discussed, and then compared to specific institutional features of the LIHTC Program. It is shown that despite significant variation among in the 100 largest metro areas in housing affordability, LIHTC construction is virtually uncorrelated with underlying need and existing estimates of supply elasticity. A regression discontinuity (RD) empirical strategy is then adopted using HUD administrative records from 1993 until 2013 to test how proximity to the 20% annual population threshold in the number of metro areas designated a DDA affects the per capita number LIHTC subsidized units placed-into-service the following year.

It is theoretically unclear how DDA status would affect the per capita number of subsidized units because the DDA designation does not increase the number of tax credits available to be allocated to developers in those targeted areas.[2] From a mechanical perspective, a 30% increase in the generosity of the subsidy while not increasing the aggregate number of tax credits available to be allocated would result in a 23% reduction in subsidized units. Reasons why more or less than a 23% actual reduction in subsidized construction occurs are discussed, including a substitution between metro areas, increases in development costs, or substitutions among subsidy alternatives. A combination of conventional parametric and bias-corrected non-parametric RD estimators with data-driven optimal bandwidths as suggested by Calonico, Cattaneo, and Titiunik (2014) are used to estimate the reduction in LIHTC construction at the 20% population threshold.

[2] State governments may, however, decide to shift available tax credits either directly or indirectly to developers in DDAs, although this would result in a reduction in construction elsewhere in the state. This possibility is discussed later in the paper.

These results suggest the designation of a metro area as a DDA between 1993 and 2013 was found to decrease the per capita number of LIHTC units by between 33.3% and 42.8%. It is also shown that DDA designation results in reduction in the share of units located in the lowest-income neighborhoods.

In summary, place-based housing subsidies may be economically justified in some housing markets. The LIHTC program, however, is currently structured in a manner that decreases the supply of subsidized units in metro areas where economic justifications are the strongest. The manuscript concludes with policy implications of the research, including a brief discussion of the US governments proposal to redefine how DDAs are designated starting in 2016.

## II. Background and Prior Research

The U.S. federal government first subsidized rental housing in 1935 by directly constructing and operating units that low-income households would occupy and pay a fixed proportion of their income as rent. These projects came to be known as public housing and have since constructed 1.3 million units, although virtually no new projects have been constructed since the early (Quigley, 2000). One of the reasons public housing was phased out was the recognition that tenant-based subsidies (e.g., housing vouchers) were more cost effective to provide an equivalent subsidy than constructing new units strictly for that purpose, especially in areas with a large supply of vacant housing (Olsen, 2003). Another reason was that public housing was predominantly located in the lowest-income neighborhoods, and the hope was that voucher recipients would voluntarily move to better areas (Quigley, 2000). In 2015, the federal government spent $19.3 billion on housing vouchers as compared to $6.6 billion to maintain and operate the remaining public housing units (US OMB, 2015).

An original concern of the shift to tenant-based subsidies was the uncertain supply response of private market landlords. These landlords would supply units to voucher recipients who would pay a fixed proportion of their income towards the landlord, with the government paying the difference between that contribution and a market standard rent. The primary concern was that without a sufficient supply response, the increased demand of voucher recipients would increase housing rents for unsubsidized households. It was also unclear whether landlords in higher-income areas would be willing to accept voucher recipients.

This concern was initially assuaged based on evidence that rents did not increase in 4 cities when vouchers were first allocated in the 1970's, although Susin (2002) provides evidence housing rents in the early 1990's were higher in cities with more vouchers. Eriksen and Ross (2015) provide evidence that a large increase in housing vouchers starting in 2000 did not result in an overall increase in rents, but did result in at least a temporary increase in rents in metropolitan areas shown in earlier research to be more supply inelastic. Devine et al (2013) showed voucher-eligible units were often available in higher-income areas, but voucher recipients were still predominantly located in lower-income neighborhoods. Evidence from the Moving to Opportunity field experiment showed a relatively high percentage of households (52%) awarded a voucher and required to find a voucher eligible unit in a low-poverty area failed to find a suitable unit within 90 days and forfeited the subsidy (Katz, Kling, and Liebman, 2001).

In summary, research generally supports the shift to tenant-based housing subsidies in most housing markets. Place-based housing subsidies, however, may be important in housing markets that are inelastically supplied or vacancy rates are low. There may also be a role for place-based subsidies if there is a policy desire to increase the number of units with specific characteristics (e.g., located in a low poverty neighborhood) able to be rented by low-income households with or without a subsidy.

*The Low-Income Housing Tax Credit*

The LIHTC was created by the Tax Reform Act of 1986 and administered by the U.S. Internal Revenue Service under Section 42 of the tax code. The basic premise of the program is to award federal income tax credits to developers who construct or rehabilitate rental housing with maximum income and rent limits for at least 30 years.[3] The maximum household-size adjusted tenant income of an LIHTC subsidized unit is 60% of the area median income as determined annually by HUD, and the maximum rent is 18% of the area median income.[4]

The tax credits are allocated to developers by state-designated housing finance agencies, and there are two variants of the program to which developers can apply. The first program variant awards a 10-year stream of tax credits equal in present value to 70% of a project's non-land development costs of either newly supplied units, or the substantial rehabilitation of existing units (Keightley and Stupak, 2013).[5] State allocating agencies are constrained by their population in the total dollar amount of tax credits they can allocate to developers under the competitive variant of the LIHTC program.[6] The competition by developers to receive these tax credits is high in most

[3] The Omnibus Reconciliation Act of 1990 statutorily changed the minimum number of years of rental restrictions to 30 years for LIHTC projects, although in practice this has remained 15 years unless state agencies meet certain guidelines (Wallace, 1995).

[4] LIHTC developers are eligible to charge rents up to 18% of AMI if at least 40% of their units are subsidized through the LIHTC program, but only 15% of AMI if between 20 and 39% of their units are subsidized under the program. In practice, virtually all LIHTC developers elect to receive a subsidy for 95% or more of their units, so the higher 18% cap is most common (Eriksen, 2009).

[5] The 70% variant of the LIHTC program is also know at the 9% credit, since the present value calculation based on prevailing discount rates used by the IRS at the program's inception resulted in developers receiving a 10-year stream of annual credits equal to approximately 9% of the project's eligible basis. Likewise, the 30% variant of the program resulted in developers receiving a 10-year stream of tax credits equal to 4%.

[6] The maximum amount of federal income tax credits state agencies can allocate to LIHTC developers is determined annually by their population. As of 2014, each state agency was able to allocate $2.30 per state resident to LIHTC

states, with some estimates as high as $3 requested for every $1 available to be allocated (Olsen, 2003). State agencies are required to create a Qualified Allocation Plan for how they determine which developers receive a tax credit allocation, and often results in developers making several concessions to appear more attractive in the allocation process (Gustafson and Walker, 2002; Ellen et al, 2015). For example, developers can increase the probability of being awarded an allocation of tax credits by their state agency by voluntarily lowering maximum rents, incomes, or where the project is located (Ellen et al, 2015).

Developers also have the option to apply for a non-competitive variant of the LIHTC program that awards tax credits equal in present value to 30% of non-land development costs. Despite the lower base subsidy level, this variant of the program is available to developers conducting less substantial rehabilitations, and also enables them to utilize additional subsidy sources, including the use of federal income tax exempt bonds to finance the project. The aggregate number of tax credits allocated to LIHTC developers under the 30% variant are also not capped, and therefore does not require developers to make voluntary concessions in order to receive an allocation from the state agency.

In summary, LIHTC developers have the option to either apply for a non-competitive subsidy equal to 30% of non-land development expenses, or apply for a competitive version of the program to receive a base subsidy equal to 70%.[7] Developers may receive a 30% increase in the generosity of the subsidy, so a total subsidy equal in present value to either 91% or 39% of non-land development costs, depending on where their project is located. First, they may receive the subsidy increase if they locate their project in a Qualified Census Tract (QCT). Neighborhoods are

developers applying for the competitive version of the program awarding a base subsidy equal to 70% of the present-value of non-land development costs.

[7] The variants of the LIHTC program where developers receive a base subsidy equal to 70% and 30% of their non-land developments costs will be referred to as the competitive and non-competitive variants, respectively.

designated a QCT by HUD, and determined by whether an individual census tract, which is approximately 1,600 households, is within the lowest 20% of incomes within the metro area.[8] The effect of QCT designations on neighborhood-specific outcomes was first studied by Baum-Snow and Marion (2009). They found QCT designation at the margin resulted in an increased number of LIHTC units, increased homeowner turnover, and raised property values in declining areas. Freedman and Owens (2012) also used the QCT discontinuity to find LIHTC units were associated with a reduction in violent, but not property, crime.

Developers may also receive a 30% increase for locating their LIHTC project in a metro area designated as a Difficult Development Area (DDA). A metro area is designated by HUD as a DDA based on the ratio of metro area's rent divided by income, subject to a 20% population constraint nationally. For annual ranking purposes, HUD defines a metro area's rent as equal to its estimated 40$^{th}$ percentile of rent for a 2 bedroom unit, and income as 18% of the area median income for a 4-person family.[9] It is important to note that LIHTC developers can only receive one 30% increase in subsidy from locating their project in either a DDA or QCT.

There are a number of potential reasons to provide a higher subsidy for some LIHTC developers, especially in areas with relatively high rents relative to incomes. First, such metro areas are where rental housing is arguably least affordable as a percentage of income, and suggestive of possible supply constraints. Second, housing developers in cities with the highest rents may also have the greatest opportunity cost in producing rent-restricted units. The gap

[8] See Freedman and Owens (2011) for a history of QCT designations. Prior to 2002, QCT status was solely determined by if 50% of census tract population had an estimated income less than the LIHTC maximum of 60% of the area median gross income, with no more than 20% of the metro area's population in a tract deemed as such. Starting in 2002, this was expanded to include census tracts where at least 25% of its respective population lived in poverty, subject to the same 20% constraint.

[9] HUD is required to publish annually in the Federal Register the criteria to how DDAs are designated. For example, see Federal Register (2015).

between a metro area's market rent and maximum LIHTC rent represents the developer's lost rent for participating in the program and agreeing to the restrictions. If the gap between the market and LIHTC maximum rent is sufficiently generous, profit-driven developers may choose not to apply to receive a subsidy under the program without the additional 30% increase in subsidy.[10]

A third potential justification for the increase in the generosity of the subsidy is to compensate developers for higher non-subsidized costs in high-rent metro areas. In particular, land costs are not subsidized through the program and earlier research has shown LIHTC developers are more likely to construct more capitally intensive housing units holding land constant (Lang, 2015). The cost of land to construct units could therefore be higher in DDA designated metropolitan areas, and the additional subsidy may offset the differences in these unsubsidized expenses.

## III. CONCEPTUAL MODEL

Private housing developers have several decisions to make when deciding to apply to their state housing authority to receive an LIHTC subsidy. First, a developer needs to decide where to locate housing units. Next, they need to decide how market rents compare to LIHTC rent-restricted units for a given quality of housing services provided, and whether to apply for either the competitive or non-competitive versions of the LIHTC program. Developers deciding to apply for the higher subsidy-level associated with the competitive version of the LIHTC program, must also then decide which concessions to make in their application to win an allocation from their state agency. The exact sequence of these decisions, and how DDA-designation affects each of them, is unclear.

[10] The LIHTC program only caps a tenant's contribution towards rent, not the total rent inclusive of additional government subsidies. For example, a LIHTC project would receive the tenant's 30% contribution towards rent plus gap between contribution and FMR if they were a housing choice voucher recipient. In other words, there is a strong incentive for LIHTC developers to attract voucher recipients in these relatively higher rent-to-income areas.

A simple conceptual model is constructed below to better understand the effects of the LIHTC program on developer behavior. First, consider a potential developer of a known parcel of land ($l$) with fixed acquisition cost of $LC$ and non-land development costs $DC$, which is a function of quality of capital ($k$) installed on the land. This hypothetical developer is deciding between the supply of a single housing unit, but is unsure of quality of housing to supply and whether to apply to receive a competitive subsidy from the LIHTC program. Without the LIHTC program and land costs as given, the developer will maximize their profit function ($\pi$) by charging net market rents ($R$), or

$$\max \pi = \int_{t=0}^{\infty} R_t(l,k) - DC(k) - LC(l)\,. \tag{1}$$

A potential motivation for the LIHTC program is due to increasing returns to quality $k$ for developers at the region perceived affordable for some socially-important (e.g., low-income) households. The intent of the LIHTC program is to instead offer the alternative for developers to charge restricted rent $\overline{R}$ in exchange for a subsidy equal to

$$Subsidy = \gamma\theta DC(k)\,, \tag{2}$$

where $\theta$ represents the subsidy level (e.g., 70%) and $\gamma$ represents the probability of being awarded a subsidy. If it is assumed that developers install the same level of quality $k$ regardless of applying for the program, developers will apply for the program if

$$\gamma\theta DC(k) \geq \int_{t=0}^{30} (R_t(l,k) - \overline{R_t^*})\,, \tag{3}$$

when the program's rental restrictions last 30 years and the developer selects rental restrictions $\overline{R_t^*}$ in order to maximize $\gamma$. Three things are interesting to note with regards to the LIHTC program. First, the rental restriction $\overline{R}$ is not a function of land and capital of the development as it is a fixed percentage of the metro-wide area median income. Second, the decision of how much capital to install enters the participation decision in a strictly positive fashion by increasing the subsidy an amount θ. This result is consistent with Eriksen (2009) who illustrated that LIHTC construction costs in California are 22% higher than average-quality unsubsidized construction, but arguably inconsistent with motivating the program through a need to reduce quality of housing provided by private developers.

Last, developers must be compensated with additional subsidy if uncertainty exists in their ability to select the package of concessions ($\overline{R_t^*}$) due to the state allocation process, resulting in $\gamma < 1$. It is costly for developers to submit an application as they are usually required to submit design plans, market studies, and purchase land options to apply. Since in some states 2 out of every 3 competitive LIHTC applications are rejected, it is common practice to employ consultants aware of the individual state allocation process to increase the probability an application is selected. Although what happens to developments associated with failed LIHTC application is an open area of research, it is thought developers either construct market rate units, submit an application for the non-competitive LIHTC variant, or wait to submit a revised LIHTC application. To the extent that uncertainty surrounding the LIHTC application process delays otherwise viable market-rate construction is a previously unrecognized, and perhaps important, cost of the program.

*Theoretical Effect of DDA Designation*

The effect of a metro area designated as a DDA compounds these decisions by developers. At the margin, an increase in the generosity of the subsidy by 30% in some metro areas would lead to increased demand by developers to receive an allocation. It is theoretically unclear how the increased demand affects the actual number of LIHTC subsidized units, especially at the metro level, considering the aggregate supply of tax credits available to be allocated is capped at the state-level. From a mechanical perspective, a 30% increase in generosity for the capped subsidy for all developers would result in a 23% reduction in subsidized units if developers were unaware of the designation until after applications were submitted.[11] In reality, DDA designations are made approximately a year in advance of when applications are due to state agencies, which suggests most developers have sufficient time to alter their applications in response. Depending on economic conditions, these behavioral responses range from either no reduction in subsidized construction at the metro level to a significantly greater than the mechanical 23% reduction.

The most basic response is if a developer was previously infra-marginal in their decision to supply any additional subsidized or unsubsidized housing units, and the state would have otherwise received fewer applications to subsidize than their allocation limit (ie, the allocation constraint was not binding). In such situations, DDA designation would result in a net increase in the total number of housing units, subsidized or not, in the designated metro area. If the subsidy was sufficiently generous and the allocation constraint was not binding, some developers who may have found it previously profitable to supply unsubsidized housing units, may now decide to impose rent and tenant income restrictions on otherwise identical units. This would result in additional LIHTC units, but no net increase in the total number of housing units (ie, crowd out).

A second potential response by developers is to increase the amount of capital installed per unit. The subsidy is equal in present value to a fixed percentage of non-land development costs, which increases from 70 to 91% in DDAs. At the margin, developers would only directly pay for $0.09 for every $1 of additional capital installed, and could benefit from the additional capital through lower tenant vacancy rates, reduced future maintenance expenditures, and substitution

[11] The mechanical decrease in number of units associated with a 30% increase in generosity holding everything else constant is proportional to 1 / (1 + 0.3), or 23.08%. For example, if a subsidized unit cost $100,000 to construct, the state would need to allocate $7,000,000 in tax credits to construct 100 units under the competitive variant of the program. If the area was a DDA, only 76.9 units could be subsidized holding total allocations constant.

away from unsubsidized land expenditures. The increase in development costs associated with LIHTC projects located in DDAs would result in a greater than the otherwise mechanical 23% reduction in subsidized units. DDA designation increases the generosity of the subsidy from 70 to 91% of non-land development for the competitive variant, and from 30 to 39% for the non-competitive variant. The increase is relatively larger in magnitude for the competitive subsidy, but may increase competition and potentially the required concessions by developers to receive the constrained subsidy. The non-competitive variant could therefore become relatively more attractive under some circumstances, may the net effect unclear.

A third potential response DDA designation increases the generosity of the subsidy from 70 to 91% of non-land development for the competitive variant, and from 30 to 39% for the non-competitive variant. The increase is relatively larger in magnitude for the competitive subsidy, but may increase competition and potentially the required concessions by developers to receive the constrained subsidy. The non-competitive variant could therefore become relatively more attractive under some circumstances depending on competition, making the net effect on the number of subsidized units unclear.

A fourth and final response is for developers to shift the location of their proposed projects to DDA designated metro areas within allocation constrained states. This increase in demand would be capitalized into land values, especially in metro areas where developable land in inelastically supplied. Developers would also no longer receive an additional subsidy for locating in a Qualified Census Tract, so fewer projects would be located in those areas. Since land is unsubsidized, this response would not necessarily alter the total number of subsidized units within the state, but would increase the number of subsidized units in the DDA designated metro at the cost of an equivalent reduction elsewhere in the state. The associated increase price of land could result in reduced unsubsidized development in the designated metro area though.

## IV. LOCATION OF LIHTC SUBSIDIZED UNITS

The main source of data available on LIHTC projects is compiled by HUD. The database is available at the project-level for 40,502 projects containing 2.6 million housing units constructed, or placed-into-service, between 1987 and 2013. The main interest of the analysis is estimating how designation of a metro area as an DDA effects the number of LIHTC subsidized units constructed, or placed into service the following year. DDA designations are determined annual by HUD and indicated in the Federal Register. Administrative data on annual rent, income, and metro population actually used to make the designations from 1993 and 2013 were obtained from HUD. There were 1.5 million LIHTC units constructed in 250 metro areas during this time period.[12] Of those metro areas, 66 metro areas were at least once designated a DDA, and only 4 metro areas received it continuously.

Before measuring how DDAs impact the location of LIHTC housing, it is important to understand where housing is "less affordable" based on LIHTC definitions. The LIHTC program defines a household as "low-income" and eligible to live in a subsidized unit if the household earns less than 60% of their metropolitan area's median income (AMI), adjusted for household size, and contribute 30% of that maximum household income towards rent.[13] The maximum statutory rent under the program for LIHTC subsidized tenants is therefore 18% of the AMI, unless developers

[12] DDA designations are made at the metropolitan area level, but geographic boundaries defining each metropolitan area may periodically change. Geographically consistent metropolitan areas based on 2004 HUD definitions are used throughout the analysis.

[13] There is also a 50% income eligibility requirement of tenants if between 20-40% of units are subsidized, although this is rare as developers choose to receive a subsidy for virtually all (i.e. greater than 90%) of units (HUD, 2015).

make voluntary reductions to the state agency during the allocation process. As suggested by Green (2011), one way to compare housing affordability between regions is to measure the "housing affordability gap" between the 40$^{th}$ percentile of rent as estimated by HUD and 18% of the AMI.[14] The 40$^{th}$ percentile of housing rent is meaningful as this determines the maximum rent for housing voucher recipients in the majority of metro areas. A positive dollar value means the 40$^{th}$ percentile of rent exceeds 18% of the AMI, and is the effective subsidy the federal government would pay a landlord of a housing voucher recipient earning exactly 60% of the AMI. A negative dollar value is indicative that 18% of the AMI exceeds the 40$^{th}$ percentile of housing rent, and the LIHTC maximum rent is not binding based on this standard.

Figure 1 illustrates the distribution of the housing affordability gap for the 100 largest metro areas. There is a 1.5 persons to bedroom rule that governs the maximum tenant income and rent, so the gap represented in the figure, and throughout the paper, is associated with a 3-person household renting a 2-bedroom housing unit in each metro area.[15] Panel A of Figure 1 is the distribution of the affordability gap in 2013, and shows the gap was positive for 34 of the 100 largest metro areas. Table 1 lists the top 5 and the bottom 5 metro areas for the 100 largest metro areas. The largest positive gap was $4,373 in San Francisco, CA and the most negative was -3,728 in Huntsville, AL. The middle row indicates the population-weighted average of the gap for the 100 largest metro areas was $355. The second and third column of Table 1 reports the 40$^{th}$ percentile of housing rents and 18% of the area's median income. It is interesting to note that

[14] This dollar amount is also meaningful as it represents the amount HUD would compensate landlords of housing voucher recipients to reside in LIHTC subsidized units.

[15] The 4-person household median income associated with the Section 8 program is publicly available at the metro level from HUD. A 3-person household is assumed to live in a 2-bedroom LIHTC subsidized unit based on programmatic rules, which is assumed to equal to 90% of the 4-person household standard.

Minneapolis, MN and Madison, WI are in the bottom 5 of the most affordable despite having top 40 housing rents given their relatively high median incomes.

Panel B of Figure 1 illustrates the distribution of the housing affordability gap measured in 1992 for same 100 metro areas. Exactly half of the 100 largest metro areas had a positive housing affordability gap in 1992. The population-weighted average gap was $497, indicating that the gap had decreased by $142 between 1992 and 2013. The fourth column of Table 1 indicates the change in the affordability gap over this period for the selected metro areas. The 5 least affordable metro areas in 2013 became less affordable between 1992 and 2013, whereas the bottom 5 each became more affordable. Figure 2 is a scatterplot of the housing affordability gap measured in 1992 as the x-axis and the 2013 affordability gap measured as the y-axis for the 100 largest metro areas. The dashed lined represents a population-weighted regression of the relationship. The slope coefficient would be equal to 1 if the housing affordability gap in 1992 perfectly predicted the gap in 2013. The population-weighted slope coefficient was equal to 0.900 and the R-squared of the relationship was 0.703. Altogether, 37 of the 100 metro areas became less affordable over this time period.

The underlying determinants of housing affordability is beyond the scope of the paper, although recent research has suggested the importance of both natural and artificial supply constraints (Quigley and Raphael, 2004; Saiz, 2010; Paciorek, 2013). An example of a natural supply constraint is the share of developable land due to the presence of water or elevation changes. An example of an artificial supply constraint are citizen imposed land-use regulations. Saiz (2010) provided supply elasticity estimates for 76 of the 100 largest metro areas taking both accounts factors into account. The relationship between the natural log of those elasticity estimates and the 2013 housing affordability gap is displayed in Figure 3. The dashed line again represents a population-weighted linear-log regression and the slope coefficient represent semi-elasticity of the supply elasticity. The relationship was highly statistically significant and indicated a doubling of the supply elasticity would reduce the affordability gap by $2,315.

The above results indicate that significant heterogeneity exists in housing affordability among the 100 largest metro areas in the United States. The exact determinants of the heterogeneity is unclear, but there appears to be significant persistence over time and affordability is at least partially correlated with housing supply elasticity. It is important to emphasize that each state government is given the same dollar value of tax credits per resident to reallocate to private developers under the LIHTC regardless of those underlying economic factors.

The number of LIHTC units constructed per 1,000 metro residents between 1993 and 2013 is reported in the last column of Table 1. On average, there were a population-weighted 7.0 LIHTC units constructed per 1,000 metro residents over this time period. Of the top 5 and bottom 5 metro areas ranking by housing affordability, it is interesting to note that Des Moines, IA had the most LIHTC construction with 11.9 units constructed and Honolulu, HI had the least with 5.1 units. This anecdotal relationship is not entirely fair given the affordability of housing in 2013 may at least be partially affected by previous LIHTC construction. Panel A of Figure 4 displays the relationship between the 1992 housing affordability gap for the 100 largest metro areas and resulting per capita LIHTC construction between 1993 and 2013. The greatest per capita number of LIHTC units were constructed over this time period was in Orlando, FL (16.4) and the least were constructed in Springfield, MA (0.5).[16] The dashed line represents a population-weighted regression of the relationship and had an r-squared of 0.016 and slope coefficient of -0.0002. This

[16] It is interesting to note that several of the outliers with seemingly more LIHTC construction per capita that other metro areas (e.g., Richmond, Raleigh, Des Moines, and Little Rock) also serve as state capitols.

implies that areas with a higher affordability gap actually had slightly less LIHTC construction, bt the relationship is virtually random.

Panel B of Figure 4 plots per capita LIHTC construction as a function of Saiz (2010) estimated housing supply elasticities. A similar flat and almost random relationship exists with a regression R-squared less than 0.001 and a doubling of the supply elasticity resulting in 0.07 fewer LIHTC units per 1,000 metro residents.

## V. Effect of Difficult Development Areas.

There are at least 2 empirical strategies to recover a causal effect of DDA status on the number and composition of LIHTC subsidized units, albeit with different identification assumptions. The most basic is to use linear regression where the variable *Y* is the aggregate or per capita number of LIHTC units constructed during year *t* in metropolitan areas *i, or*

$$Y_{it} = \alpha + \beta\left(DDA_{it}\right) + u_{it} \,, \tag{4}$$

where α and β are estimated parameters, and *u* is an idiosyncratic error term. An estimated β statistically different from 0 would be indicative of DDA affecting the number of units, although a number of empirical factors could potentially bias that estimate. For example, future projected housing rent or household income could either linearly or non-linearly affect the decision for developers to apply for a subsidy under the LIHTC program based. If linear in relation and observed, these factors could be directly specified in the equation (4), although would still be reliant on relatively strong assumptions about no further omitted variables and possible trends, especially given the nonlinearity of ratio used in the designation. For example, developers will locate units based not only on current and observable market attributes, but also unobserved conditions anticipated in the future. A combination of metro- and time-specific fixed effects could also be adopted in the model, but would eliminate a great deal of the sample and underlying variation to identify estimates.

Fortunately for identification purposes, federal law dictates a seemingly arbitrary cutoff that no more than 20% of the US population can live in a DDA. In making the designation, HUD first nationally ranks metro areas based on the 40th percentile of 2-bedroom housing rents divided by the 4-person median housing income. HUD designates the metro area with the highest annual rent-to-income ratio as a DDA, and then proceeds down the ranking of the ratio until no more than 20% of the population in a metro areas lives in a DDA. Depending on the underlying population of the top ranked metro areas, between 19 and 45 metro areas received the DDA designation each year between 1993 and 2013.

The rigid, yet arbitrary, nature of the DDA designation process based on the 20% population threshold enables several identification assumptions associated with traditional linear regression discussed above to be relaxed. Regression discontinuity (RD) empirical methods were first popularized by Hahn, Todd, and van der Klaaw (2001), although applications of RD within Urban Economics have been relatively limited (Baum-Snow and Ferreira, 2015). The key intuition of a regression discontinuity empirical approach is that the probability of receiving "treatment" through being designated a DDA is uncorrelated with any omitted variables or other confounders, and thus an unbiased estimate of the designation exactly at the discontinuity can be recovered using parametric or non-parametric estimators.

The exact conditions under which an RD is valid, and the "best" or "optimal" methods to recover an unbiased estimate has be much discussed in the recent empirical literature (see Imbens and Lemeiux (2008) or Lee and Lemeiux (2010) for reviews). Arguably the most important choice of the researcher is the correct specification of the "running" or "forcing" variable ($Z$), where the probability of treatment increases discretely from 0 to 1 at $z_0$. In the current context, the forcing variable (Z) is defined as the annual difference for each metro area nationally ranked by its rent-to-income ratio to the 20% population threshold. By definition, z0 is defined at 0 and all metro areas receiving DDA designation status have a value greater than 0 and 0.2. Metro areas not designated as a DDA have a value of the forcing variable less than 0 and -0.8.

A polynomial interacted with DDA status is perhaps most intuitive in describing the RD estimation process. In the simplest case of a linear polynomial,

$$Y_{it} = \alpha + \beta\left(DDA_{it}\right) + \delta(Z_{it}) + \lambda(Z_{it} \times DDA_{it}) + u_{it} \tag{5}$$

where β represents an unbiased estimate of the effect of DDA designation exactly at the 20% population threshold.

For simplicity and robustness, the main results of the paper will be presented using a combination of three RD estimators suggested in the past literature. The first will be a conventional parametric RD estimator similar to above using a quadratic polynomial interacted with DDA status. The second will be a conventional non-parametric RD estimator using a local quadratic regressions around the discontinuity using a triangular kernel similar to as suggested by Imbens and Lemieux (2008). The third will be the more recently proposed bias-corrected non-parametric estimator of Calonico, Cattaneo, and Titiunik (2014) using a triangular kernel, quadratic local regressions, and a cubic bias correction. Results with and without additional specified control variables (e.g., rent, income, and population) will be presented, and the optimal bandwidth will be allowed to vary independently on each side of the discontinuity and selected to minimize the coverage error as implemented by Calonico, Cataneo and Farrell (2016).

*Main Results*

Table 2 presents descriptive statistics of the constructed sample. The first column present the mean for the pooled 5,076 annual observations for the 250 metro areas in the sample. The second and third column present stratified means based on whether the metro area was designated a DDA that year. There were 492 unique metro-year observations of 66 different metro areas that were designated a DDA. On average, 23.4 metro areas received the designation each year and 4 metro areas received it continuously.

The first evidence of a difference in LIHTC activity based on DDA designation is from comparing the average number of units completed in Table 2. While DDAs had more LIHTC construction, they were also more than twice as large in population as non-DDA metro areas. The second row of Table 2 presents on average, 0.327 LIHTC units are constructed per 1,000 metro residents in DDAs as compared to 0.335 per 1,000 metro areas in non-DDAs.[17] An OLS regression suggests this difference in averages is not statistically meaningful at the 10% level.[18]

Table 3 presents the main RD estimates of the paper. The outcome variable is defined as the number of LIHTC constructed per 1,000 metro residents, and standard errors of the RD estimates clustered at the metro level are presented in parentheses below each estimate. The estimates in each column vary by whether the additional control variables of metro rent, income, and population are additionally included in the estimation model.

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[17] In practice, not all housing units in a LIHTC subsidized project need to be subsidized, although in practice most developers choose to receive a subsidy for all units (Eriksen, 2009). Only the number income-restricted, and thus subsidized, units within projects is used in the analysis, although similar estimates were obtained if the total number of units within LIHTC-subsidized were alternatively used.

[18] A regression model controlling for time-invariant differences at the metro level (i.e., metro fixed effects) implies DDA designation resulted in -0.092 fewer LIHTC units per 1,000. This estimate is statistically different than 0 at the 5% level of significance with metro-clustered standard errors, but relies on arguably stronger identification assumptions. This conventional result is similar with further introduction of year fixed effects and controlling for metro, rent, income, and population.

The main goal of RD empirical strategies is to estimate the difference of the effect exactly at the discontinuity, and therefore wish to include only observations sufficiently close to that threshold. The data-driven bandwidth selection procedure of Calonico, Cattaneo, and Farrell (2016) that minimizes the restricted error coverage rate suggests the optimal bandwidth left of the threshold was 0.192, and right of the threshold was 0.062. This includes 1,024 observations in 129 unique metro areas.

The discontinuity without additionally specified controls was estimated to be between -0.188 and -0.247 fewer LIHTC units constructed as a result of DDA designation. The parametric estimate with a quadratic polynomial was the smallest and statistically different from 0 at the 5% level of significance with clustered standard errors, while the bias-corrected non-parametric estimate was the largest and statistically significant at the 1% level.

Panel A of Figure 6 presents visual evidence of the discontinuity based on the parametric estimates, and a better understanding of the economic significance of the difference. The horizontal axis of the figure is the value of the forcing variable for the selected bandwidth, where DDA designation occurs at 0 and above. From a visual perspective, a sharp discontinuity seemingly occurs at 0. To the immediate left of the discontinuity, there were on average 0.442 LIHTC units constructed per 1,000 metro residents as compared to 0.254 LIHTC constructed units to the immediate right. The difference (0.188) is equivalent to the estimate reported in the first row of the column 1 in Table 3, and represents as 42.4% decrease in LIHTC construction associated with DDA designation.

Given a valid RD strategy, the specification of additional control variable in the estimation may include precision of the estimates through reduction in variance, but threaten identification if mis-specified. It is still common in earlier research using RD empirical strategies to still present estimates with such covariates to confirm robustness (Imbens and Lemeiux, 2008). Reassuringly, similar estimates were obtained for all three RD estimators with metro rent, income, and population were additional included in the model. While the estimates in the discontinuity were still statistically significant at least at the 5% level, relatively few gains in precision were observed. Panel B of Figure 6 visually presents the parametric estimates, with a similar discontinuity observed associated with an estimated 33.3% reduction in subsidized units as a result of the designation.

A series of alternative specification and falsification tests further support the robustness of the estimates. In particular, selection of higher order polynomials produced similar estimates, although generally required larger bandwidths. A combination of alternative kernels (i.e., rectangular and Epanechinov), and the use of metro and year identifiers as control variables also did not affect the underlying results. Bandwidths alternatively selected based on the mean-squared error procedure as suggested Imbens and Kalyanaraman (2009) also produced similar results, although both the restricted-error rate method used in the paper and alternative mean-squared error procedures support relaxing the requirement the bandwidths to be the same on each side of the discontinuity.

Falsification tests for a similar discontinuity occurring for rent, income, and population are presented in Table 4. Significant differences of observable covariates at the discontinuity may imply an improper RD design (Imbens and Lemieux, 2008). In addition, to being much larger in population, Table 2 also suggests that DDAs had higher rents than non-DDAs ($13,386 as compared to $9,103 at the 40$^{th}$ percentile), although incomes were slightly higher (18% of the 4-person household median family income was $12,525 as compared to 11,652). Reassuringly, the estimates reported in Table 4 suggests no significant differences for these attributes were present at the DDA 20% population threshold using a similar bandwidth selection procedure as above.

It is important to emphasize the generalization of RD results only extends to differences at the DDA 20% population threshold, and therefore should be interpreted as a local average treatment effect. Figure 7 compares the distribution of metro rent, income, and population for observations inside and outside the optimal bandwidth used. For the 250 possible metro areas, there were 1,024 observations within this bandwidth and 4,047 observations outside of this bandwidth. These figures suggests that while minor distributional differences occur, the 132 metro areas in closest proximity to the DDA 20% population were remarkably similar to non-marginal metro areas based on these three attributes.

The next two subsections explore possible sources of heterogeneity in the results based on allocation mechanism and location of subsidized units.

*Competitive v. Non-Competitive Allocation*

Developers have two versions of the LIHTC program they could apply, and the 30% increase in generosity associated with DDA status has an ambiguous effect on the relative attractive ness of each program. Estimates in the first column of Table 5 directly test the effect of DDA designation on the number of competitive LIHTC Units at the DDA 20% population threshold. Depending on RD estimator, there was between a -0.050 and -0.086 reduction in the number of competitive LIHTC units per 1,000 metro residents. The parametric estimate (0.050) was not statistically distinguishable from 0 at the 10% level, although the bias-corrected non-parametric estimate (-0.086) was at the 10% level. In economic terms, there were an estimated 0.209 competitive per capita LIHTC units in non-DDAs at the threshold. This estimate implies there were between a

24.1% and 41.1% decrease of LIHTC units receiving a competitive allocation in DDAs. Figure 8 represents these effects graphically.

The theoretical effect of DDA designation on LIHTC units receiving a non-competitive allocation is even less clear, especially in equilibrium. While DDA status may unambiguously increase the generosity of the non-competitive program in isolation, some previous developers who would have applied for the program may instead decide to either apply for the even more generous competitive subsidy, or now become infra-marginal in their development decision due to the increased price of developable land. The second column of Table 5 illustrates DDA status results in a significant decrease in non-competitive LIHTC units constructed at the 20% threshold. This estimated decrease ranges from 0.117 to 0.134 fewer units per 1,000 metro residents and is always at least statistically distinguishable from 0 at the 5% level of significance. Given there were an estimated 0.276 non-competitive LIHTC units constructed in non-DDAs at the 20% population threshold, these estimates imply between a 42.3% to 48.5% decrease as a result of the designation.

*Qualified Census Tracts*

QCTs are designations, similar to DDAs, made by HUD based largely on the share of the population in a census tract earning less than 60% of the area median income. LIHTC developers would receive an additional 30% increase in subsidy for locating a project in a QCT if the metro area was not already designated as a DDA. In other words, these are relatively low-income areas that LIHTC developers would have received a financial incentive to locate projects without the DDA designation.

Estimates reported in Table 6 illustrate statistically significant reductions in the per capita number of LIHTC units occur in both QCT and Non-QCTs following DDA designation at the metro level. Figure 9 represents these effects graphically. To comprehend the economic magnitudes of the results it is important to understand that the majority of LIHTC construction does not occur in QCTs, especially at the 20% DDA population cap. At the 20% DDA population cap in non-DDAs, an estimated 0.164 LIHTC units per 1,000 metro residents are constructed in QCTs as compared to 0.355 units in non-QCTs. The estimates reported in Table 6 are therefore interpreted as DDA status results in between a 46.3% to 50.6% reduction in QCTs and a 35.5% to 39.7% reduction in non-QCTs.

Table 7 presents how DDA status affects the share LIHTC units based on the version of the program and location of the units simultaneously. The estimates reported in the table are the bias-corrected non-parametric RD estimates where the outcome variable is the percentage share of LIHTC units in the metro area for each of the 4 possible iterations of the program. For example, the estimate reported in the top left is interpreted as the effect of DDA status on the share of LIHTC units allocated a non-competitive subsidy and located in a QCT.

The main interpretation of the results presented in Table 7 is that DDA designation appeared to significantly increase the share of LIHTC units allocated a competitive subsidy and were not located in a QCT by 16.6 percentage points. While useful to understand how DDA status affects developer's incentives conditional upon participation, it potentially introduces a new source of selection bias as metro areas with no LIHTC units constructed are systematically excluded as the share is unobserved.

## VI. CONCLUSIONS AND POLICY IMPLICATIONS.

This paper argued that place-based housing subsidies could be justified in some markets to increase the supply of housing affordable to lower-income households, especially in supply inelastic areas. The current LIHTC subsidy structure, however, is poorly targeted to increase the supply of subsidized units in those markets. This result was illustrated in two ways. First, the allocation mechanism was discussed in how state governments were given the same dollar amount of tax credits to reallocate to developers under the program under the most generous variant of the program. This resulted in virtually no correlation in the number of LIHTC units constructed per capita between 1993 and 2013, and underlying housing affordability or housing supply elasticity measures. This part of the paper also illustrated that in 66 of the 100 largest metro areas in 2013 the maximum rents developers agreed to charged tenants in order to receive an LIHTC subsidy exceeded the 40$^{th}$ percentile of metro housing rents. Developers could still agree to voluntarily charge tenants rents below the maximum, but suggests LIHTC rents are not binding in some markets.

The second part of the paper used regression discontinuity methods to show the potentially harmful effect of increasing the generosity of the LIHTC subsidy for developers in Difficult Development Areas. While there are potentially valid reasons to increase the subsidy generosity in high rent metro areas, the current subsidy structure increases the generosity in the top 20% of metro areas based on ranking rent by income without increasing the aggregate number of tax credits available to be allocated in those areas. Using a variety of alternative RD estimators and specifications, this results in between a 33.3% and 42.4% reduction in the per capita number of LIHTC units constructed at the 20% threshold. It is also shown that DDA designation results in a similar reduction in developers receiving a less generous, unconstrained non-competitive LIHTC allocation, or locating in the lowest-income census tracts.

A number of caveats are important to disclose. First, the sample was restricted LIHTC completed units between 1993 and 2013 in metropolitan areas. The effects of DDA designations on LIHTC units in non-metropolitan areas are left to future research. The extent that developers previously allocated a subsidy may have temporarily delayed construction as a result of an area losing DDA designation. Second, the regression discontinuity estimates are identified based on the proximity of metro areas to the current 20% population cap, although Figure 7 illustrates marginal metro areas in close proximity to the 20% threshold are similar to non-marginal areas. It is unclear how results would generalize if the cap was expanded or contracted. Third, the analysis focused on how DDA designation affects the quantity and location of units in metropolitan areas. A potential area for future research is how DDA designation affects the attributes of developers' applications to receive an allocation.

The policy implications of the research are that the practice of increasing the per-unit generosity of the LIHTC subsidy by 30% for some developers should be re-examined. There are at least 3 policy alternatives that could help mitigate the reduction in LIHTC units following DDA designation. The first is to completely abolish the practice of designating DDAs and the 30% increase in generosity for developers. This would increase the total number of units subsidized under the program annually without an associated increase tax expenditures.

There are arguably good reasons for increasing the generosity of the subsidy for LIHTC developers in some metro areas though. For example, developers in high-rent metro areas face higher unsubsidized land and opportunity costs in supplying units under the program, and may not participate in some markets if the gap grows sufficiently large. A policy alternative is to systematically increase the aggregate number of tax credits available to be allocated to developers under the LIHTC program in relatively high-rent metropolitan areas to reflect these costs. In effort to remain revenue neutral, the dollar number of tax credits available to be allocated within a state could be indexed to the underlying affordability of housing.

A third policy alternative would be to index the per-unit generosity of the subsidy directly to land costs. Arguably, areas with higher costs of land are where developers are the least likely to supply affordable housing units, and potential crowd out concerns are minimized. This policy is similar to that recently proposed by HUD, where DDAs would no longer be defined for entire metropolitan areas, but rather targeted to the 20% highest Zip codes in each metro area (Federal Register, 2015). Although it is unclear to what extent it may still displace LIHTC construction elsewhere in the city without increasing the aggregate subsidy amount, it has significant potential to expand the supply of affordable housing in those higher income neighborhoods.

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TABLE 1. HOUSING AFFORDABILITY GAP OF THE 100 LARGEST METRO AREAS

| Rank | Metro Area | Affordability Gap in 2013 | 40th Percentile of Housing Rent | 18% of Median Income | Change in Affordability Gap Between 2013 and 1992 | Per Capita Number of LIHTC Units Constructed |
|---|---|---|---|---|---|---|
| 1 | San Francisco, CA | 4,373 | 21,196 | 16,823 | 405 | 8.46 |
| 2 | Honolulu, HI | 3,837 | 19,449 | 15,612 | 327 | 5.11 |
| 3 | New York, NY | 3,707 | 17,406 | 13,699 | 1,683 | 11.77 |
| 4 | Los Angeles, CA | 3,580 | 16,780 | 13,199 | 284 | 5.19 |
| 5 | San Diego, CA | 3,471 | 16,319 | 12,849 | 528 | 6.44 |
| Population-Weighted Average | | 355 | 12,161 | 11,806 | -142 | 7.00 |
| 95 | Cincinnati, OH | -2,219 | 8,738 | 10,957 | -781 | 5.14 |
| 96 | Fort Wayne, IN | -2,245 | 7,628 | 9,873 | -157 | 9.32 |
| 97 | Minneapolis, MN | -2,261 | 10,864 | 13,125 | -917 | 6.74 |
| 98 | Madison, WI | -2,404 | 10,498 | 12,902 | -648 | 5.67 |
| 99 | Des Moines, IA | -2,770 | 8,856 | 11,627 | -1,372 | 11.86 |
| 100 | Huntsville, AL | -3,728 | 7,675 | 11,403 | -1,321 | 5.54 |

*Notes:* The housing affordability gap is defined as the 40th percentile of housing rent for a 2-bedroom unit minus 18% of the median income for a 3-person household. The sample is restricted to the 100 largest metro areas in 2013. The 1992 housing affordability gap is measured in year 2013 constant dollars adjusted using the consumer price index.

TABLE 2. DESCRIPTIVE STATISTICS.

| | All | DDA | Non-DDA |
|---|---|---|---|
| Number of LIHTC Units | 276.265 | 587.933 | 242.814 |
| Per Capita Number of LIHTC Units | 0.334 | 0.327 | 0.335 |
| Population (1,000s) | 724.166 | 1,468.905 | 644.234 |
| Rent (1,000s) | 9.518 | 13.386 | 9.103 |
| Income (1,000s) | 11.737 | 12.525 | 11.652 |
| Ratio of Rent/Income | 0.811 | 1.065 | 0.783 |
| Observations | 5,076 | 492 | 4,584 |
| Number of Metro Areas | 250 | 66 | 246 |

*Notes*: Sample means obtained from LIHTC units constructed, or placed-into-service, between 1993 and 2013 in metropolitan areas according to HUD (2015). The population and per capita number of LIHTC units are in 1,000s. The rent is the 40th percentile of annual rents in the metro area as reported by HUD. Income is the maximum annual rent of LIHTC units, which is equal to 36% percent of HUD's very-low-income limit for the metro area as described in the text. Rent and income are in constant 2013 $1,000s adjusted by the CPI.

TABLE 3. REGRESSION DISCONTINUITY ESTIMATES OF THE EFFECT OF DDA DESIGNATION STATUS ON THE ANNUAL NUMBER OF LIHTC UNITS CONSTRUCTED PER 1,000 METRO RESIDENTS.

| RD Estimator | (1) No Control Variables | (2) With Control Variables |
|---|---|---|
| Parametric | -0.188** | -0.165** |
| | (0.081) | (0.082) |
| Non-Parametric: Conventional | -0.237*** | -0.205** |
| | (0.087) | (0.086) |
| Non-Parametric: Bias-Corrected | -0.247*** | -0.215** |
| | (0.091) | (0.089) |
| Observations | 1,024 | 1,029 |
| Bandwidth – Left of Cutoff | 0.192 | 0.188 |
| Bandwidth – Right of Cutoff | 0.062 | 0.070 |
| Number of MSA Clusters | 129 | 128 |
| Control Variables | No | Yes |

*Notes*: The dependent variable is the annual number of LIHTC units constructed per 1,000 metro area residents between 1993 and 2013. Each row and column combination represents separate RD estimates, where estimates in the second column include control variables for rent, income, and metropolitan area income. The first row represent parametric RD estimates based on a quadratic polynomial. The second row represent conventional non-parametric estimates, whereas the third row represent bias-corrected non-parametric estimates. The optimal bandwidth was selected based on the coverage-area ratio method of (*Calonico et al*., 2016) and allowed to vary on each side of the threshold. Standard errors clustered at the metro level are in parentheses. Asterisks indicate significance at the following levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

TABLE 4. FALSIFICATION TESTS OF THE EFFECT OF DDA DESIGNATION STATUS ON METRO RENT, INCOME AND POPULATION

| RD Estimator | (1) Rent | (2) Income | (3) Population |
|---|---|---|---|
| Parametric | -0.370 | -0.062 | 167.01 |
| | (0.678) | (0.672) | (177.74) |
| Non-Parametric: Conventional | 0.434 | 0.294 | 225.37 |
| | (0.919) | (0.992) | (220.25) |
| Non-Parametric: Bias-Corrected | 0.472 | 0.307 | 225.66 |
| | (0.929) | (0.940) | (221.83) |
| Observations | 1,504 | 1,454 | 1,006 |
| Bandwidth – Left of Cutoff | 0.285 | 0.268 | 0.194 |
| Bandwidth – Right of Cutoff | 0.075 | 0.093 | 0.052 |
| Number of MSA Clusters | 156 | 152 | 129 |
| Control Variables | No | No | No |

*Notes*: The dependent variable is the annual number of LIHTC units constructed per 1,000 metro area residents between 1993 and 2013. Each row and column combination represents separate RD estimates, where estimates in the second column include control variables for rent, income, and metropolitan area income. The first row represent parametric RD estimates based on a quadratic polynomial. The second row represent conventional non-parametric estimates, whereas the third row represent bias-corrected non-parametric estimates. The optimal bandwidth was selected based on the coverage-area ratio method of (*Calonico et al*., 2016) and allowed to vary on each side of the threshold. Standard errors clustered at the metro level are in parentheses. Asterisks indicate significance at the following levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

TABLE 5. REGRESSION DISCONTINUITY ESTIMATES OF THE EFFECT OF DDA DESIGNATION STATUS ON THE ANNUAL NUMBER OF LIHTC UNITS CONSTRUCTED PER 1,000 METRO RESIDENTS RECEIVING A COMPETITIVE ALLOCATION.

| | (1) | (2) |
|---|---|---|
| RD Estimator | Competitive | Non-Competitive |
| Parametric | -0.050 | -0.134*** |
| | (0.049) | (0.056) |
| Non-Parametric: Conventional | -0.084* | -0.117** |
| | (0.044) | (0.056) |
| Non-Parametric: Bias-Corrected | -0.086* | -0.122** |
| | (0.045) | (0.059) |
| Observations | 1,175 | 1,098 |
| Bandwidth – Left of Cutoff | 0.218 | 0.209 |
| Bandwidth – Right of Cutoff | 0.072 | 0.056 |
| Number of MSA Clusters | 135 | 132 |
| Control Variables | Yes | Yes |

*Notes*: The dependent variable is the annual number of LIHTC units constructed per 1,000 metro area residents between 1993 and 2013. Each row and column combination represents separate RD estimates, where estimates in the second column include control variables for rent, income, and metropolitan area income. The first row represent parametric RD estimates based on a quadratic polynomial. The second row represent conventional non-parametric estimates, whereas the third row represent bias-corrected non-parametric estimates. The optimal bandwidth was selected based on the coverage-area ratio method of (*Calonico et al*., 2016) and allowed to vary on each side of the threshold. Standard errors clustered at the metro level are in parentheses. Asterisks indicate significance at the following levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

TABLE 6. REGRESSION DISCONTINUITY ESTIMATES OF THE EFFECT OF DDA DESIGNATION STATUS ON THE ANNUAL NUMBER OF LIHTC UNITS CONSTRUCTED PER 1,000 METRO RESIDENTS LOCATED IN A QUALIFIED CENSUS TRACT (QCT).

| | (1) | (2) |
|---|---|---|
| RD Estimator | QCT | Non-QCT |
| Parametric | -0.076** | -0.126* |
| | (0.033) | (0.071) |
| Non-Parametric: Conventional | -0.080** | -0.133* |
| | (0.036) | (0.075) |
| Non-Parametric: Bias-Corrected | -0.083** | -0.141* |
| | (0.038) | (0.077) |
| Observations | 1,295 | 1,107 |
| Bandwidth – Left of Cutoff | 0.243 | 0.203 |
| Bandwidth – Right of Cutoff | 0.063 | 0.071 |
| Number of MSA Clusters | 145 | 131 |
| Control Variables | Yes | Yes |

*Notes*: The dependent variable is the annual number of LIHTC units constructed per 1,000 metro area residents between 1993 and 2013. Each row and column combination represents separate RD estimates, where estimates in the second column include control variables for rent, income, and metropolitan area income. The first row represent parametric RD estimates based on a quadratic polynomial. The second row represent conventional non-parametric estimates, whereas the third row represent bias-corrected non-parametric estimates. The optimal bandwidth was selected based on the coverage-area ratio method of (Calonico *et al*., 2016) and allowed to vary on each side of the threshold. Standard errors clustered at the metro level are in parentheses. Asterisks indicate significance at the following levels: *** p < 0.01, ** p < 0.05, * p < 0.10.

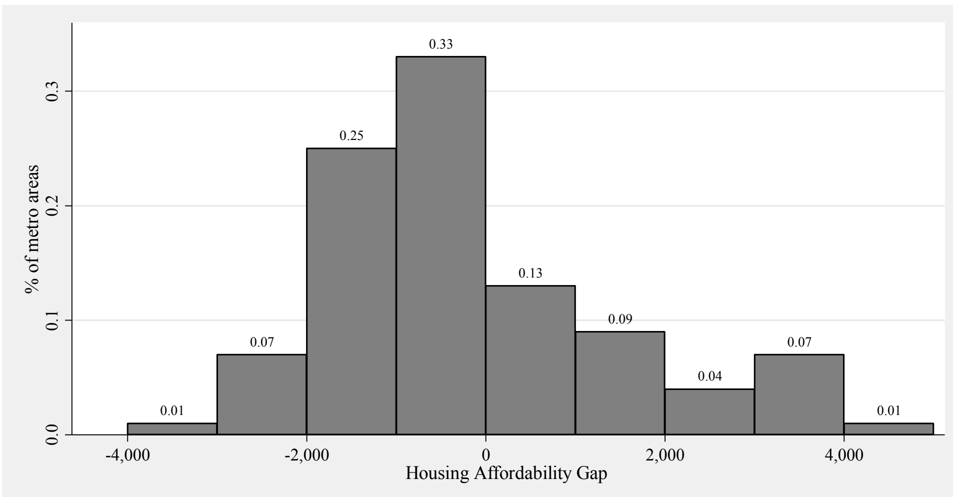
TABLE 7. COMPARISON OF REGRESSION DISCONTINUITY ESTIMATES OF THE DDA DESIGNATION ON THE SHARE OF SUBSIDY LEVEL AND QCT STATUS.

| Subsidy Level | Qualified Census Tract | |
|---|---|---|
| | Yes | No |
| Non-Competitive | 0.001 | -0.046 |
| | (0.048) | (0.074) |
| Competitive | -0.040 | 0.166** |
| | (0.063) | (0.085) |

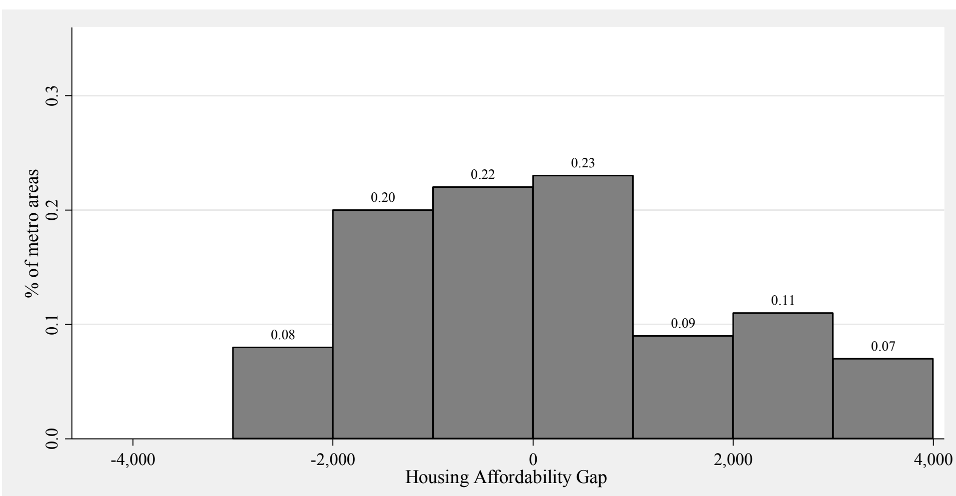
*Notes*: Each estimate represents a separate bias corrected non-parametric regression discontinuity estimate of DDA designation on the share of each category of LIHTC Construction in the metro area. Each estimate was obtained with a triangular kernel and optimal bandwidth selected according to Calonico *et al*. (2016). Standard errors clustered at the metro level are in parentheses. Asterisks indicate significance at the following levels: *** p < 0.01, ** p < 0.05, * p < 0.10.

FIGURE 1. DISTRIBUTION OF THE DIFFERENCE IN THE 40TH PERCENTILE OF HOUSING RENT AND 18% OF THE MEDIAN HOUSEHOLD INCOME (HOUSING AFFORDABILITY GAP) FOR 100 LARGEST METRO AREAS IN THE UNITED STATES

Panel A. Affordability Gap in 2013

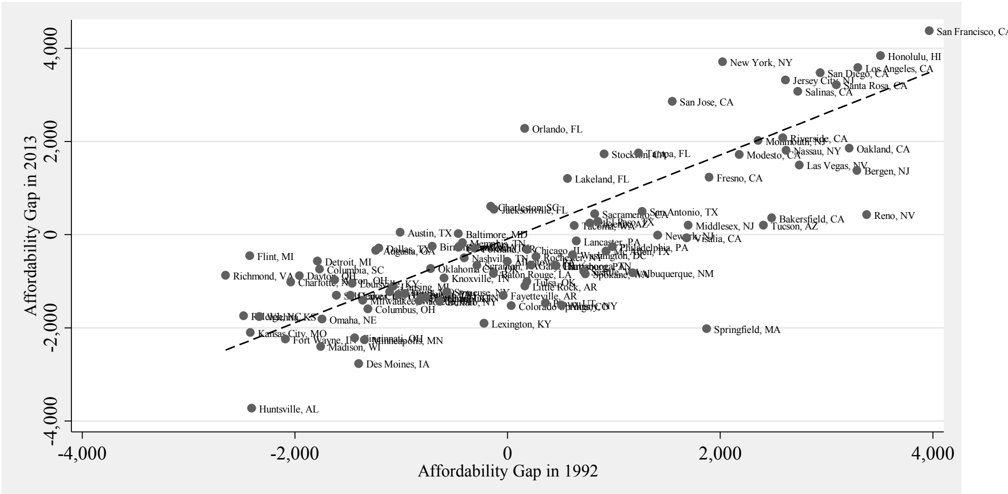



Panel B. Affordability Gap in 1992



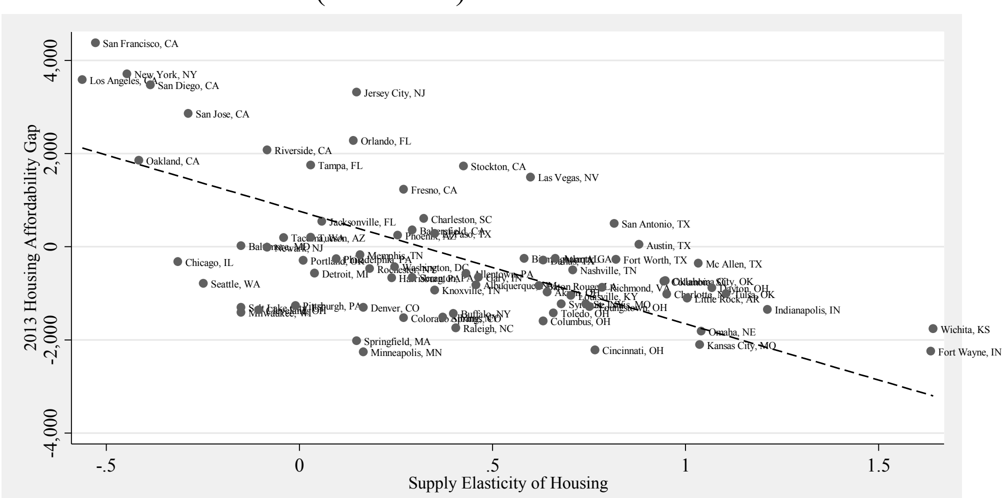

*Notes:* Housing affordability gap defined as the difference between the 40th percentile of housing rents for a 2 bedroom unit and 18% of the metro area's median income for a 3-person family. The gap is measured in constant 2013 dollars.

FIGURE 2. COMPARISON OF 2013 HOUSING AFFORDABILITY GAP TO 1992 AFFORDABILITY GAP FOR 100 LARGEST METRO AREAS IN THE UNITED STATES.



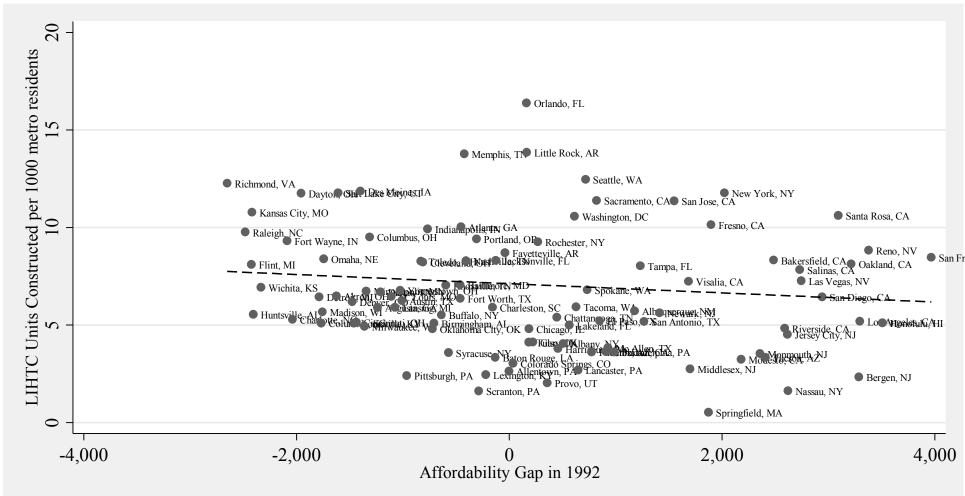

*Notes:* The affordability gap is defined as the annual difference in the 40th percentile of housing rent for a 2 bedroom apartment as compared to 18% of the area median income for a 3 person household. All dollar values are in constant 2013 dollars. The dashed line represents a population weighted linear regression (based on 2013 population) for the 100 largest metro areas. The regression slope coefficient was 0.900 and the R-squared was 0.703.

FIGURE 3. COMPARISON OF 2013 HOUSING AFFORDABILITY GAP TO THE SUPPLY ELASTICITY OF HOUSING (SAIZ 2010)



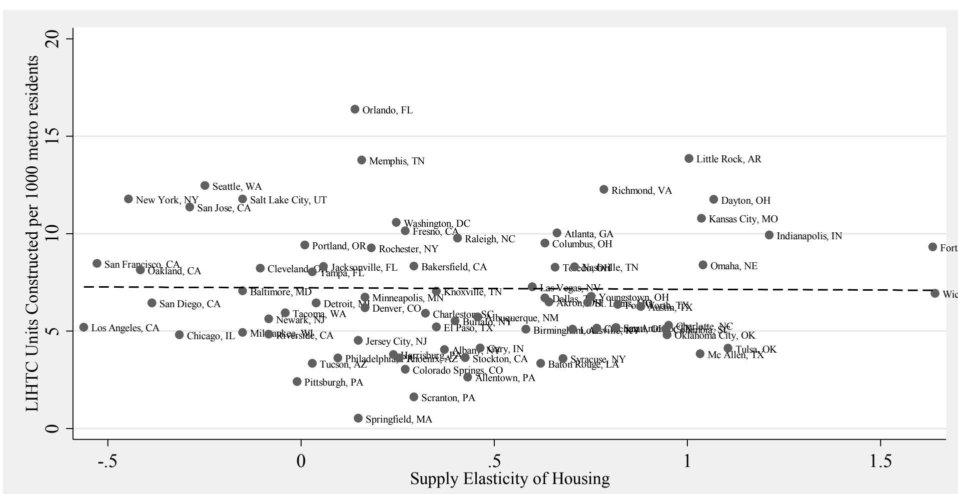

*Notes:* The y-axis is the 2013 housing affordability gap defined as the difference in the 40th percentile of housing rent for a 2-bedroom unit to 18% of the median income for a 3-person household. The x-axis is the natural log of the supply elasticity of housing as estimated by Saiz (2010). The sample is restricted to the 76 of 100 largest metro areas with a specified supply elasticity. The dashed line represents a population-weighted linear regression of the relationship. The regression slope coefficient was -2,414.975 and the R-squared was 0.432.

FIGURE 4. TOTAL LIHTC CONSTRUCTION BETWEEN 1993 AND 2013 AS A FUNCTION OF 1992 AFFORDABILITY GAP FOR 100 LARGEST METRO AREAS




*Notes*: The y-axis is the number of LIHTC units constructed per 1,000 metro residents between 1993 and 2013. The x-axis is the 1992 affordability gap defined as the difference between the 40th percentile of housing rents for a 2-bedroom unit and 18% of the median area income for a 3-person household. The affordability gap is in 2013 constant dollars. The dashed lined is a population weighted linear regression of the relationship. The regression slope coefficient was -0.0002 and the R-squared was 0.016.

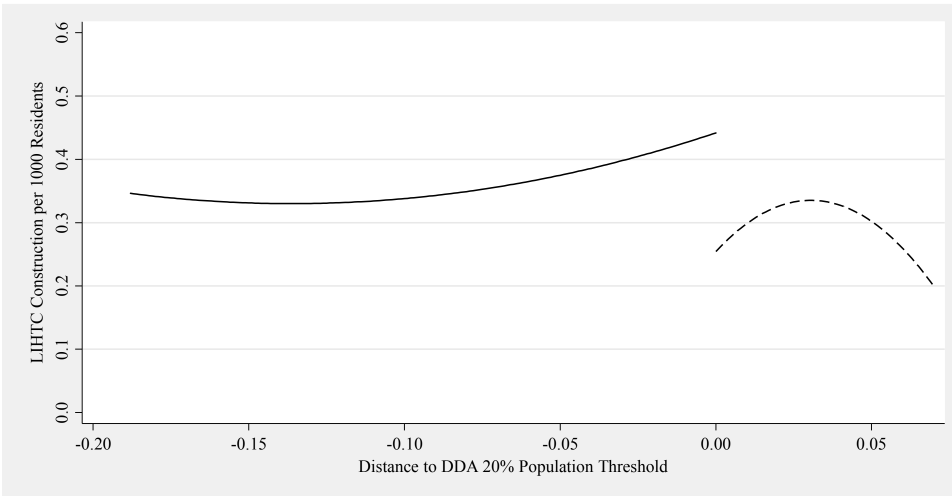
FIGURE 5. TOTAL LIHTC CONSTRUCTION BETWEEN 1993 AND 2013 AS A FUNCTION OF SUPPLY ELASTICITY FOR 100 LARGEST METRO AREAS



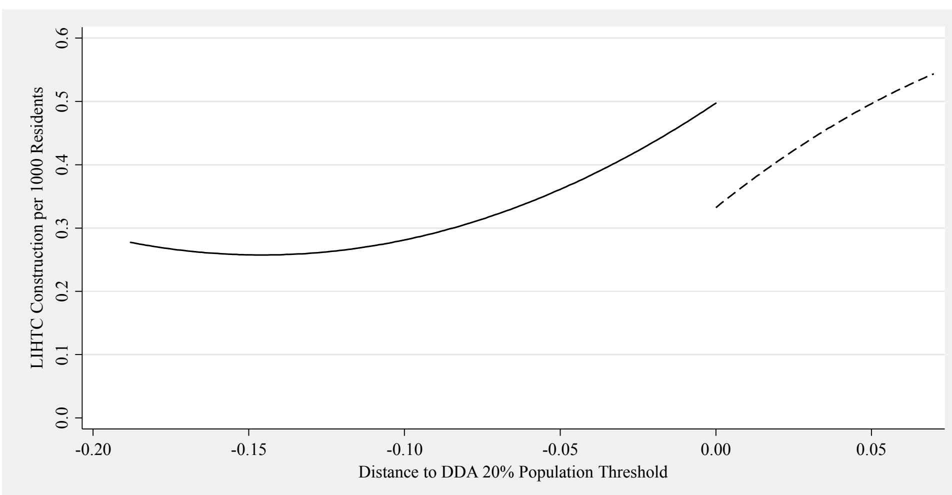

*Notes*: The y-axis is the number of LIHTC units constructed per 1,000 metro residents between 1993 and 2013. The x-axis is the natural log of the supply elasticity of housing as estimated by Saiz (2010). The dashed lined is a population weighted linear regression of the relationship. The regression slop coefficient was -0.078 and the R-squared was less than 0.001.

FIGURE 6. ANNUAL NUMBER OF LIHTC UNITS CONSTRUCTED PER 1,000 METRO RESIDENTS RELATIVE TO THE DDA 20% POPULATION THRESHOLD.

PANEL A. WITHOUT CONTROL VARIABLES



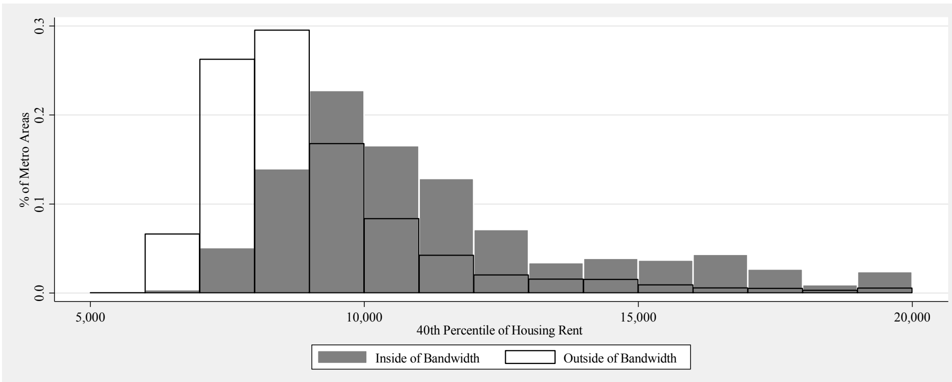

PANEL B. WITH CONTROL VARIABLES



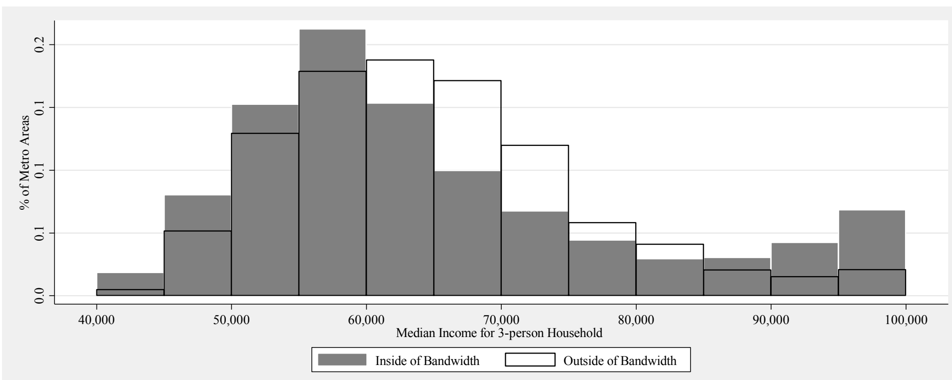

*Notes:* Each panel represents regression discontinuity estimates of the annual number of LIHTC units completed per 1,000 metro residents as a function of distance to the DDA 20% population threshold defined as 0. The estimates were estimated parametrically using a quadratic polynomial of distance to the threshold interacted with DDA status. The bandwidth was selected based on the coverage-area ratio method as suggested by (Calonico *et al.*, 2016). The control variables in Panel B are metro rent, income and population.

FIGURE 7. DISTRIBUTION OF METRO RENT, INCOME, AND POPULATION BASED ON PROXIMITY TO DDA 20% POPULATION THRESHOLD

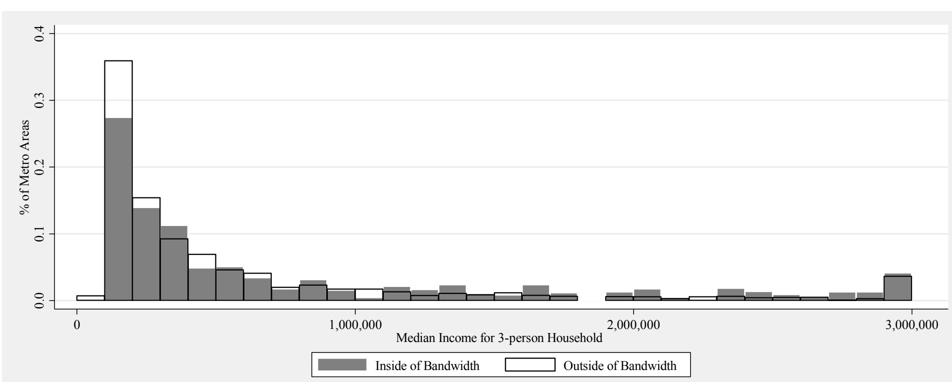
PANEL A. 40TH PERCENTILE OF HOUSING RENT




PANEL B. MEDIAN INCOME FOR A 3-PERSON HOUSEHOLD

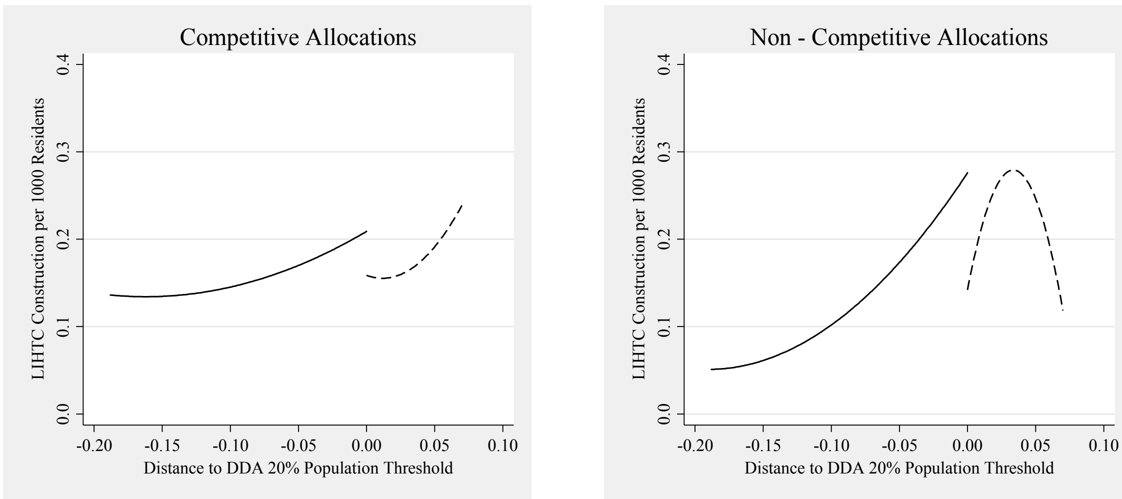



PANEL C. POPULATION



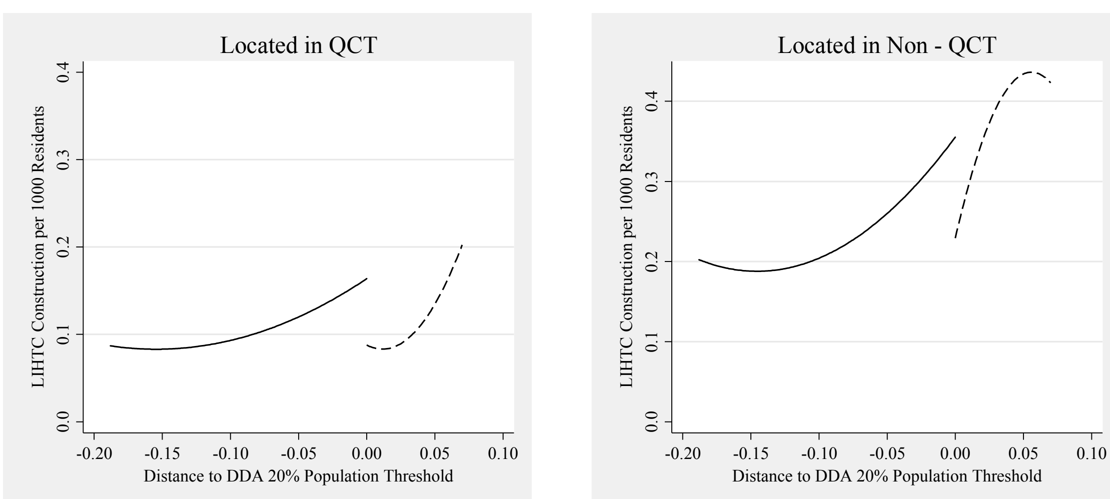

*Notes:* The above figures compare the distribution of annual metro rent, income, and population for the 1,029 observations inside the determined optimal bandwidth of DDA 20% population threshold, and the 4,047 observations outside of the optimal bandwidth. The optimal bandwidth was determined based on the coverage-area rate method of (Calonico *et al.*, 2016) as was 0.188 left of the threshold and 0.07 right of the threshold. The rent measure is the 40th percentile of housing rent for a 2 bedroom unit. The income measure is the median income for a 3-person household.

FIGURE 8. COMPARISON OF ANNUAL COMPETITIVE AND NON-COMPETITIVE LIHTC CONSTRUCTION PER 1,000 METRO RESIDENTS RELATIVE TO DDA 20% POPULATION THRESHOLD




*Notes*: The above figures compare the number of annual competitive and non-competitive LIHTC subsidized units per 1,000 metro residents relative to the DDA 20% population threshold. The estimates were estimated parametrically using a quadratic polynomial of distance to the threshold interacted with DDA status. The bandwidth was selected based on the coverage-area ratio method as suggested by (Calonico *et al.*, 2016). The estimates control metro rent, income and population.

FIGURE 9. COMPARISON OF ANNUAL LIHTC CONSTRUCTION PER 1,000 METRO RESIDENTS LOCATED IN A QUALIFIED CENSUS TRACT RELATIVE TO DDA 20% POPULATION THRESHOLD




*Notes*: The above figures compare the number of LIHTC subsidized units per 1,000 metro residents relative to the DDA 20% population threshold located in a Qualified Census Tract (QCT). The estimates were estimated parametrically using a quadratic polynomial of distance to the threshold interacted with DDA status. The bandwidth was selected based on the coverage-area ratio method as suggested by (Calonico *et al.*, 2016). The estimates control metro rent, income and population.