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Does Location Matter? Performance Analysis of the Affordable Housing Programs with Respect to Transportation Affordability in Dallas Fort Worth (DFW) Metropolis

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Abstract

Transportation costs are the second largest expenditure for a family, thus have a substantial influence on housing affordability. In an auto-oriented region like DFW, the situation is exacerbated for low-income families due to limited transportation options. This study seeks to evaluate the efficiency of major affordable housing programs for low-income people in terms of transportation affordability. This study uses a rigorous methodology that involves a solid transportation cost modeling with disaggregated data available at property level for housing assistance programs in DFW. Our findings show that about 69% of the assisted units in DFW are unaffordable in terms of transportation costs. The majority of them are spending about 17% to 20% of their income on transportation. The most affordable program is Low-Income Housing Tax Credit with 58% affordability rate and the least affordable program is the Continuum of Care with 9% affordability rate when accounting for transportation costs. We also found that almost all affordable units (regarding the transportation costs) are located in main economic hubs of the region such as Dallas and Fort Worth which have better access to jobs and public transit. In contrary, almost all housing properties in the areas between Dallas and Fort Worth are unaffordable. These are areas adjacent to the University of Texas at Arlington with a high number of transit dependent population and in Arlington, the biggest midsize city with no public transit. Our findings urge HUD to consider modifying these programs by incorporating the location-efficiency factors to ensure true affordability.

According to National Association of Home Builders, Dallas is the least affordable city in Texas and housing affordability has been declining in DFW since 2013 (*1*). As a result, the issue of housing affordability in DFW is receiving enormous attention in recent years. Such critical housing affordability issues are not confined at the local level but also nationwide. The federal government annually spends about 50 billion dollars to provide housing assistance specifically for low-income families (*2*). But housing costs burden still found to be critical for low-income households (*3*). This raises the question about effectiveness of housing assistance programs and the answer depends on how the definition of affordability is conceptualized.

Historically, the measure of housing affordability has been viewed as ratio of housing price and income (*4*). Since the United States National Housing Act of 1937, the income- housing costs ratio threshold was evolved and by 1981, the standard was raised to 30 percent of household income, which is still considered affordable for most housing assistance programs (*4*, *5*).

Transportation costs, on the other hand, are the second largest expenditure for an American family (*6*). Due to limited choices to transportation modes and in search of affordability, the vulnerable low-income families make critical trade-offs between housing and transportation costs. Previous literature explored that households may be willing to spend more for housing and less for commuting or may choose more affordable dwelling farther from jobs with higher transportation costs (*7*). This often leads low-income worker groups to suffer from spatial mismatch. The mismatch between individual needs and

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the location of daily services has been researched on the pertinent basis of transportation equity (*8–10*).

In an auto-oriented region like DFW, the situation might be exacerbated for low-income families with lack of private vehicles. It is not only the provision of affordable housing that matters, but also the access to daily needs and availability of a supportive system to enhance the well-being and livability of people and communities. This study seeks to identify these gaps by evaluating location efficiency for major affordable housing programs in DFW.

To address the gaps, this study uses an innovative and robust methodology with disaggregated data at property level and measures built environmental variables around each property. Then, compared to the methodology of Housing + Transportation Affordability Index and Location Affordability Index (LAI) that measure location affordability for typical households (*11*), this study estimates transportation costs specifically for low-income households to whom HUD is intended to provide housing support. Inclusion of address level disaggregated data for all available housing assistance programs in DFW and use of solid transportation costs modeling tailored for low income make this study unique than previous studies on affordable housing programs in DFW (*12*).

Transportation equity and location efficiency are growing concerns in DFW Metro area, so this study can provide an insight for current as well as long term performances of rental assisted properties. This study is conducted in an effort that can guide further federal initiatives to consider the combined effect of housing and transportation. It will tell HUD and other organizations whether the rental housing they subsidize is truly affordable and how, in the future, it can be made more so by directing subsidies to better (more compact, walkable, and transit-served) locations. For this, it is fundamental to understand the mechanism of major affordable housing programs of HUD which has been discussed as program overview in next section.

Literature Review

Overview of Affordable Housing Programs

HUD is responsible for the majority of the federal housing programs to support distressed economic group of people. In their recent report, HUD (*13*) have listed an overall 100 active and authorized housing assistance programs. Schwartz (*14*) in his book provides an overview of major national housing assistance programs under different categories. The major HUD programs primarily focus on availability of affordable housing units for the low and very low-income people as well as ensuring to protect people from housing discrimination. Table 1 presents a summary of major affordable programs covered in this study.

These programs have different funding mechanisms. The LIHTC program, for instance, allows investors to deduct their federal income taxes by $1 for every dollar of tax credit to cover the project costs. The rent of LIHTC assisted properties cannot exceed 30 percent of income limit for particular sized households and the property can be occupied for at least 15 years (*14*). Similarly, Housing Trust Funds with a minimum affordability period of 30 years, provides funding for construction and preservation of rental housings as well as support for homeownership to the households living below the poverty line (*13*, *19*). On the other hand, the residents relocated due to HOPE VI receive vouchers to rent housing units in private market with the intention to allow them move into better neighborhoods (*15*).

Some of these assistance programs are designed for elderly people and persons with special needs like, Section 202 and Section 811. Under the Section 202 program, rental assistance is provided to the landlords to cover the difference between the renters' share toward rent and the HUD permitted expenses for senior citizens (*13*). The CoC is also aimed to provide housing facilities to immediately rehabilitate homeless people and provide them with long-term housing stability (*13*).

Another category of housing assistance initiatives are voucher programs like HOV, HCV and PBV programs. Among all the voucher programs, HCV is the largest federal rental subsidy program (*20*) which provides low-income families with vouchers to find their preferred housing unit (*13*). PBV, on the other hand, is location based and 25% of units in a project can be supported by the program to accommodate eligible low-income people. In this program, property owners initially can have 15 years of contract to receive financial security from the Public Housing Agencies (PHA) (*13, 21*).

In other assistance programs such as CDBG and HOME, HUD provides grants to the state and local governments to implement local housing strategies intended to increase homeownership for low-income people (*16*, *22*).

Transportation Costs and Affordability Studies

Previous studies have criticized HUD's simple percentage (or ratio) of income-to-housing costs measure to define housing affordability. They indicated that the ratio fails to include other 'costs of living', like transportation and other living expenditures (*23*). In most cases, housing affordability studies disregarded the spatial dimensions of transportation costs despite the influence of travel distance on land price, housing value and household transportation costs (*24*).

Table 1. Summary of the Major Housing Assistance Programs Covered in This Study

Category	Housing programs	Established by	Eligibility	Location preference	Mechanism	Type
Public Housing	Housing Trust Fund	Article XVIII of the Private Housing Finance Law (PHFL)	Households $\leq$ 30 % Area Median Income (AMI) and $\leq$ 50 % AMI	Areas with distressed economic condition (*13*)	Fund through contributions from Fannie Mae and Freddie Mac	Rent and ownership
	HOPE VI	The United States Housing Act of 1937	Residents of severely distressed public housing	Neighborhoods with closer proximity to economic opportunities (*15*).	Capital cost to PHA for major reconstruction of housing. Vouchers to the recipients to rent housing in private market	Rent
	Section 32 Public Housing Homeownership Program	The United States Housing Act of 1937	Households $\leq$ 80 % AMI	–	Down payment assistance or subordinate mortgages, and/or below market financing to purchase home	Ownership
Nonprofit Sector and community development	HOME Investment Partnerships	The Cranston-Gonzalez National Affordable Housing Act	Households $\leq$ 60 % AMI and $\leq$ 80 % AMI	–	Fund to the state and local agencies to support rehabilitation and construction of rental housing.	Rent and ownership
	Community Development Block Grants (CDBG)	The Housing and Community Development Act of 1974	Households $\leq$ 50 % AMI; and $\leq$ 80 % AMI	Residential areas where at least 51 percent of residents are low and moderate income people (*16*)	Fund to state and local government to support acquisition, disposition or retention of property; rehabilitation of residential or non-residential buildings; social and economic development	Support community development
Multifamily or privately owned project-based	Section 8 Project-Based Rental Assistance Renewal Program	–	Households $\leq$ 30 %AMI and $\leq$ 50 %AMI; Or, $\leq$ 80 %AMI (depending on availability of unit)	–	Renewal of expiring contracts on units already receiving project-based Section 8 rental assistance.	Rent
	Rental Assistance Demonstration (RAD)	Consolidated and Further Continuing Appropriations Act, 2012	Owners of other any HUD assisted properties	–	Allow owners of other type HUD assisted properties convert units to project based Section 8 programs	Rent
	Section 236 or Below Market Interest Rate (BMIR)	National Housing Act, 1968	Households $\leq$ 80 %	–	Combined mortgage insurance and reduced interest rate for the mortgagee to develop low rental housings	Rent

(continued)

Table 1. (continued)

Category	Housing programs	Established by	Eligibility	Location preference	Mechanism	Type
Housing for people with special needs	Section 811 Project Rental Assistance (PRA) Program (PRAC811)	The National Affordable Housing Act of 1990	Households $\leq$ 30 % AMI or $\leq$ 50 % AMI and also have at least one adult member with a disability	–	Interest free capital advances to sponsors	Rent
	Section 202 Supportive Housing for the Elderly Program (202/PRAC)	The Housing Act of 1959	Households $\leq$ 30 % AMI and have at least one person 62 years of age or older	–	Capital grants and project rental assistance to developers	Rent
	Continuum of Care Program (CoC)	The Homeless Emergency Assistance and Rapid Transition to Housing Act of 2009 (HEARTH Act)	Homeless individuals or families	–	Fund to developers to provide housing facilities to accommodate homeless	Rent and ownership
Voucher programs	Housing Choice Vouchers (HCV)	The United States Housing Act of 1937	Households $\leq$ 30 % AMI	Participants' preference. Most of the voucher holders live in MSA neighborhoods (*17*)	Monthly rental subsidy to the recipients	Rent
Taxes and housing	Low-Income Housing Tax Credit (LIHTC)	The Tax Reform Act of 1986	AMI and $\leq$ 50 % AMI; Or, $\leq$ 60 %	Census tracts in which 50 percent or more of the households have incomes below 60% AMI (*18*)	Allocation of tax credits (an amount of money that can be offset against a tax liability) to developers to	Rent

Transportation, however, is the second largest spending sector of a household budget (*6*, *25*). In recent years, transportation costs and affordability has become a growing concern and is suggested to be factored in while measuring affordability for low-income families (*11*, *24*, *26*). Mattingly and Morrissey (*24*), for instance, found that there is a decrease in affordability in the peripheral areas of Auckland-Netherland if transportation costs are included in the measure. In some urban fringes, income spent for housing and transportation found to be more than 70%. Results of these studies suggest that when transportation costs are incorporated into the concept of affordability, they provide a more comprehensive picture of affordability than traditional measures of housing affordability.

The reason is simple: The residents living in location-efficient neighborhoods require less travel time and, in turn, lower transportation costs to access their daily necessities (*27*). Lipman (*28*) found that location is a major factor influencing the costs of housing and transportation, especially the distance between residential neighborhoods and work. A recent study by Center for Neighborhood Technology (CNT) (*29*) also found that lower income households pay more attention to the surrounding sites in search of transportation options to reduce VMT. Developing affordable housing for low-income families in location-efficient areas can reduce VMT at higher rates than for higher income households (*29*). Litman (*30*) thus considered "location efficient" or "Affordable-Accessible Developments" as those lower-priced residences in which households can reduce transportation costs due to higher accessibility, multimodal transportation choices, and affordable access to activities and services.

The big challenge in studying transportation affordability is how to measure transportation costs and how to incorporate that into the concept of affordability. In 2006, the CNT attempted to address this challenge by developing the Housing + Transportation Affordability Index. The H + T Index took into account not only the costs of housing but also the intrinsic value of location as quantified through transportation costs. According to CNT, housing is affordable if the combined costs of housing and transportation do not exceed 45 percent of a household's income. Later in 2013, in a joint project by the departments of Transportation and Housing Development, the index was upgraded to become the Location Affordability Index (LAI). The LAI is based on the same methodology as the H + T Affordability Index but uses the most recent and better quality data with more coverage (*11*). In the LAI Index, total housing costs are estimated based on the current housing sales prices and rents from the American Community Survey, and household transportation costs are estimated at the census block group level as three cost components: costs of auto ownership, auto use, and transit use. Auto use is modeled based on household VMT data from Chicago and St. Louis. Auto ownership is modeled based on vehicle ownership data from the American Community Survey. Transit use and associated costs are based on Google Transit Feeds. The LAI, however, has significant limitations in two of its three component models. The VMT model is based on data from two metropolitan areas which can hardly represent the national variation. Also the model used block group level aggregate data which may have problem of aggregation bias (11).

Most recently, Hamidi et al. (*11*), using disaggregate household travel data from 15 diverse regions in the U.S., estimated and summed automobile capital costs, automobile operating costs and transit fare costs for households at 8,857 HUD multifamily Section 8 rental assistance properties. Their models account for all of the so-called D variables found to affect travel and vehicle ownership in the peer-reviewed literature. Their analysis is based on disaggregate (household) travel and vehicle ownership data for tens of thousands of households in many diverse metropolitan regions of the U.S. All surveys provide XY coordinates for households and their trips. This allows travel to be modeled in terms of the precise built environment in which households reside and travel occurs. For travelers, individual age, employment status, driver's licensure and other variables are available from the survey data set. For households, household size, household income, vehicle ownership and other variables are available from the survey dataset. This allowed the authors to control for socio-demographic influences on travel at the household level. They found that the mean percentage of income spent on transportation is 15 percent for households at the eligible income scale. However, in highly sprawling metropolitan areas and in suburban areas of more compact metropolitan areas, a higher percentage of household budget is spent on transportation, which exceeds the 15 percent threshold.

This study is built on the work of Hamidi et al.'s (*11*) findings and modeling efforts. Our study, however, focuses on all major affordable housing programs in DFW. Focusing on various programs provides an opportunity to make comparison on the efficiency of these programs with respect to providing true affordability.

Methods

To calculate the housing and transportation affordability, this paper follows the work of Hamidi et al. (*11*). Inclusion of address level disaggregated data and use of transportation costs model designed to consider low-income people provides higher validity compared to the LAI methodology.

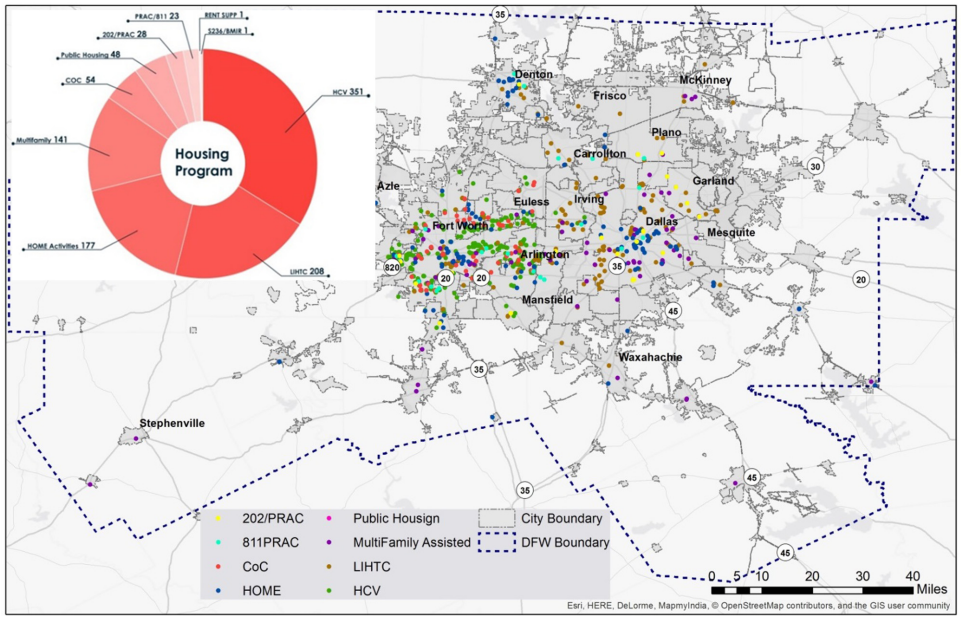

Figure 1. Location of assisted housing project in DFW.

Sample

We gathered address level data for properties in major affordable housing assistance programs in DFW through an extensive data collection process. We used three major data sources in our data collection process:

1) *"Picture of Subsidized Households" website:* This particular website of HUD contains the data of Public Housing, Housing Choice Vouchers (HCV), Moderate Rehabilitation, Section 8 Project Based Rental Assistance, Rent Supplement, Below market interest rate - section 236 (S236/BMIR), Section 202 Supportive Housing for the Elderly Program (S202 PRAC) and Section 811 Supportive Housing for Persons with Disabilities (S811 PRAC), HOME Investment Partnership Program and of Low-Income Housing Tax Credit (LIHTC).
2) *HUD eGIS Storefront:* This site provides HUD's geospatial datasets with web-based mapping tools. For our study, we extracted location data for Multifamily Assisted properties, Public Housing properties and HOME Investments Partnerships (HOME).
3) *Local Housing Agencies in DFW:* Contacted the local agencies in DFW, we acquired the data for Housing Choice Vouchers (HCV) and Continuum of Care (COC) for Tarrant County.

We successfully geocoded all 1,032 affordable housing assistance properties found in the sample. Figure 1 shows the number and spatial distribution of these properties in DFW.

In order to estimate transportation outcomes, we created network buffers of 0.25 mile, 0.50 mile and 1 mile around these locations using Business Analyst and measured D variables in these buffers. The D's that extensively are related to travel by literature are population and job *density* (actden), *diversity* measured in term of jobs–population balance and land-use entropy (entropy), *design* measured in terms of intersection density (intden) and street connectivity (int4way), *destination accessibility* measured in terms of jobs reachable within a given travel time by auto (emp10), and *distance to transit* measured as the frequency of transit service in the neighborhood (tfreq). Variables extracted from these datasets and used in subsequent transportation costs calculations are shown in Table 2. The table makes reference only to ½-mile buffers, but data for ¼-mile and 1-mile buffers are also available. This gave us a total of 21 built environment variables around each housing assistance property.

Transportation Models

In this study, we use the same methodology as CNT, LAI and Hamidi et al. (*11*) and estimate household transportation costs as the sum of three terms - auto ownership, auto use and public transit:

Table 2. Built Environmental Variables Used in the Household Transportation Costs Calculations

Symbol	Definition	Level
actden	Activity density within a half mile (sum of population and employment divided by gross land area in square miles)	Household
entropy	Land use mix within a half mile of a household (entropy index based on net acreage in different land use categories that ranges from 0, where all developed land is in one use, to 1, where developed land is evenly divided among uses)	Household
intden	Intersection density within a half mile (number of intersections divided by gross land area in square miles)	Household
int4way	Proportion of 4-way intersections with a half mile (4-or-more-way intersections divided by total intersections)	Household
emp10	Proportion of regional employment accessible within a 10-minute travel time via automobile	Household
sf	Single-family housing unit (dummy variable; yes = 1, no = 0)	
tfreq	Aggregate frequency of transit service within a quarter mile of block group boundary per hour during evening peak period	Block group

$$\text{Household T Costs} = [\text{C\_AO}*\text{F\_AO(X)}] + [\text{C\_AU}*\text{F\_AU(X)}] + [\text{C\_TU}*\text{F\_TU(X)}]$$

where,
C = cost factor (i.e. dollars per mile)
F = function of the independent variables (F_AO is auto ownership, F_AU is auto use, and F_TU is transit use)

For computing the F's, instead of developing transportation models, we borrow equations from Hamidi et al.'s (*11*) study since their models have all of the specifications we need for this study.

(1) **Household vmt** = oddsanyvmt*vmtpred
   a) oddsanyvmt = exp [1.7 + (0.2*hsize) + (0.3*emp) + (0.03*inc) + (0.9*sf)–(0.02*emp10)–(0.7*entropy)–(0.003*intden)–(0.01*pct4wy)–(0.0009*tfreq)]
   b) vmtpred = exp [2.6 + (0.2*hsize) + (0.2*emp) + (0.007*inc)–(0.008*emp10)–(0.005*actden/1000)–(0.3*entropy) –(0.002*intden)–(0.003*pct4wy)–(0.00009*tfreq)]

(2) **Household vehicle ownership** = exp [–0.1 + (0.1*hsize) + (0.1*emp) + (0.009*inc) + (0.3*sf)–(0.002*emp10)–(0.006*actden/1000)–(0.1*entropy)–(0.0009*intden)–(0.001*pct4wy)–(0.003*tfreq)]

(3) **Number of household transit trips** = oddsanytransit*transittrip
   a) oddsanytransit = exp [–2.8 + (0.2*hsize) + (0.3*emp)–(0.02*inc)–(0.8*sf) + (0.5*enthropy) + (0.003*intden) + (0.01*pct4wy) + (0.0009*tfreq)]
   b) transittrip = exp [0.9 + (0.1*hsize)–(0.006*inc) + (0.2*entropy)]

Finally, we used sociodemographic characteristics of a typical low-income household in all transportation equations since the focus of this paper is to evaluate affordability for a low-income household. As a result, in all five equations, sociodemographic characteristics (household size, household income and number of workers in the household) were kept constant so the variation in predicted transportation outcomes results from the built environmental variability and not sociodemographic characteristics. To obtain sociodemographic characteristics of a typical low-income household, we used the National Household Travel Survey (NHTS) database and extracted a subsample of households who qualify for HUD rental assistance, i.e. those with annual incomes of less than 80 percent of AMGI.

Transportation Costs Calculation

Transportation costs consist of vehicle costs (a household's expenses to own and use private vehicles) and public transit costs (transit fares). Vehicle costs are divided into fixed and variable costs. Fixed or ownership costs are not generally affected by the amount a vehicle is driven. Depreciation, insurance and registration fees are considered fixed. Variable costs are the incremental costs that increase with vehicle mileage. Fuel is a variable vehicle cost proportional to mileage (*31*).

We computed vehicles' fixed costs based on our household vehicle ownership model and the average cost of car ownership specific. Our average car ownership costs are based on a car ownership costs calculator called the True Cost to Own® pricing (TCO®) system developed by Edmunds Inc. The components of TCO® are depreciation, interest on financing, taxes and fees, insurance premiums, fuel, maintenance, repairs and any federal tax credit that may be available. In this paper, we used all categories except fuel because we treat fuel as a variable vehicle cost.

TCO® values are specific to each state as well as the vehicle's make, model and year. We were interested in costs for the most popular vehicles' model and make for low-income households. Therefore, we created a sample of low-income households from the NHTS database based on the HUD low-income standard and identified the 15 most popular vehicles owned by households in this sample. These vehicles account for more than 34 percent of vehicles owned by low-income households in the NHTS database. We acquired, for each state, the five-year average costs of car ownership for these 15 vehicles for the earliest year (2009) reported by the TCO® because, according to the NHTS database, low-income households tend to buy and own older cars. We then weighted the five-year average costs by the popularity of each make and model for low-income households in the NHTS database to obtain the average vehicle ownership costs for low-income households. We multiplied this by the predicted number of cars owned by a household to obtain the household's ownership or fixed vehicle costs.

Second, we computed auto operating costs based on our household VMT model. We acquired metropolitan-level average gasoline prices for 2010 from the Oil Price Information Service (OPIS), inflated them to 2014 dollars and then multiplied the fuel costs per mile by the predicated VMT to obtain the household's operating or variable vehicle costs.

Third, we computed transit costs based on our household transit trip model. Transit fare data comes from the National Transit Database. We computed average transit fare for each transit agency in the region by dividing the total transit revenue by the total number of unlinked passenger trips for the region. We multiplied the fare per transit trip by the predicted number of transit trips to obtain the household's public transit costs.

To estimate the overall household's transportation costs for each property in our sample, we added the three transportation cost components. Finally, we calculated the percentage of the household's income spent on transportation for a household with a size of three who qualifies for renting HUD assistance programs (average household size for a typical low-income household is 2.39).

Results and Discussion

Transportation is considered affordable if a household spends no more than 15% of its budget on transportation costs (*6*, *11*). Figure 2 shows the histogram distribution of transportation affordability for the 1032 properties in our sample. Interestingly, the distribution is not normal and is skewed toward less affordability. About 69% (718 properties out of 1032 properties) of the housing projects in DFW are spending more than 15% of their income for

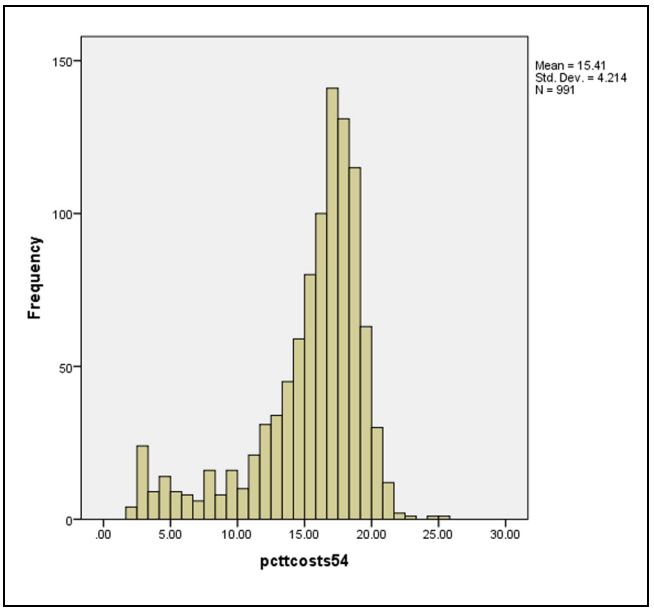

Figure 2. Frequency distribution of predicted transportation affordability (percentage of income spent for transportation costs).

transportation and thus unaffordable. The majority of them are spending about 17% to 20% of their income on transportation. The lowest expenditure found to be 2.14 % for a HOME property located in downtown Dallas. In contrast, a property supported by LIHTC program located in a suburban area, thirty five miles north from downtown Dallas, is spending the highest (25.76%) portion of their budget on transportation.

Figure 3 presents an overall picture of transportation affordability's spatial distribution for all housing assistance programs in our sample. The majority of the affordable units are concentrated in the main economic hubs of the region such as the City of Dallas and the City of Fort Worth. In addition to the sprawling northern and southern part of DFW, almost all housing properties in the areas between Dallas and Fort Worth are unaffordable. These are areas adjacent to the University of Texas at Arlington with a high number of transit dependent population and in Arlington, the biggest mid-size city with no public transit.

Regarding the performance analysis of individual programs, as evident from Figure 4, the LIHTC program is providing the highest number (121 samples) of affordable housing units among all programs in DFW and 58% of their supported housing is affordable in terms of transportation costs. As this study includes various programs, it would be interesting to make statistical comparison across the programs.

Table 3 provides descriptive statistics on the transportation affordability of various programs in DFW. The lowest average value is for the LIHTC program which is

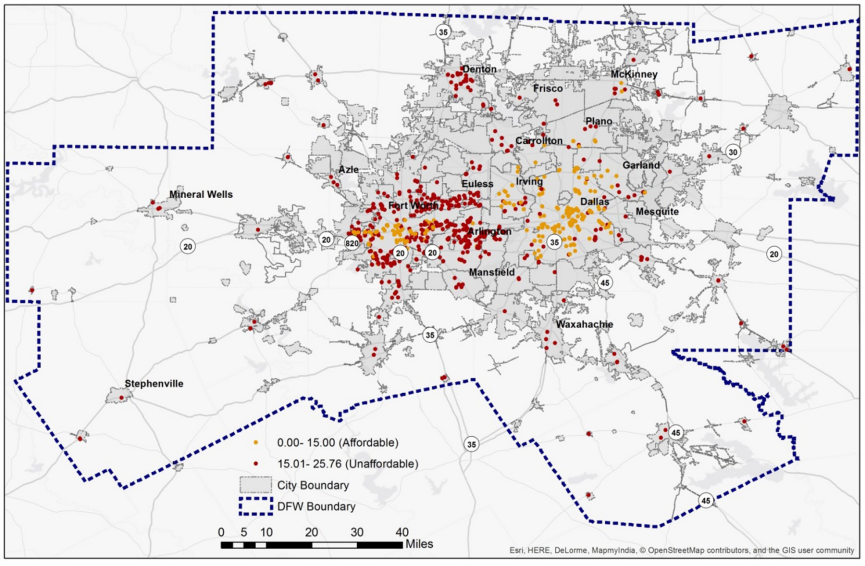

Figure 3. Transportation affordability of all the assisted housing properties in DFW.

Table 3. Percentage of Income Spent for Transportation under Different Programs

Housing program	Mean	Minimum	Maximum
202/PRAC	15.49	7.71	20.31
HOME	15.69	2.14	22.55
Multifamily assisted	16.17	4.14	21.61
PRAC811	17.00	12.14	20.02
Public housing	15.20	4.70	20.09
CoC	17.03	9.35	20.88
HCV	16.82	3.88	24.41
LIHTC	11.74	2.42	25.76

also found to provide maximum number of affordable units. On the other hand, the properties under CoC are spending the highest average percentage of transportation costs with only 9.26% affordable units which makes it the least affordable program in DFW. A follow up ANOVA analysis reveals that there is a statistically significant difference (with significance value of <0.001) in percentage of income spent on transportation across programs.

Figure 5 compares the spatial distribution of the most affordable (LIHTC) and the least affordable (CoC) programs. All the 121 affordable LIHTC housing units are found in six cities: Carrolton, Dallas, Fort Worth, Garland, Irving and Plano. These cities have public transit services provided by Dallas Area Rapid Transit (DART) and Trinity Rail Express (TRE) (*32*, *33*) and hence are less car dependent. Those affordable units found to be located in areas close to the Medical District in Fort Worth, Ridgmar Mall, Downtown Dallas, and Downtown Fort Worth. Those areas are designed with a grid street pattern which provides increased accessibility, street connectivity, a vibrant mixture of land uses, and access to amenities and transit service.

On the contrary, only five housing units of the CoC program are located in areas of such characteristics. Most of the CoC (91%) units are found in areas with irregular street patterns that reduce the accessibility and street connectivity. Their units are located in sites which are distant from the central urban areas. Also, daily necessities and transit services are unavailable within a reachable distance. Previous studies explored that, development of housing for accommodating homeless individuals (or households) faces "not in my backyard" (NIMBY) syndrome of existing higher income residents which influences the placement of such programs (*18*, *34*). Therefore, such properties tend to locate farther from the dense urban areas, which push residents to commute longer distance (*18*, *24*). These factors lead to more auto dependency which results in higher

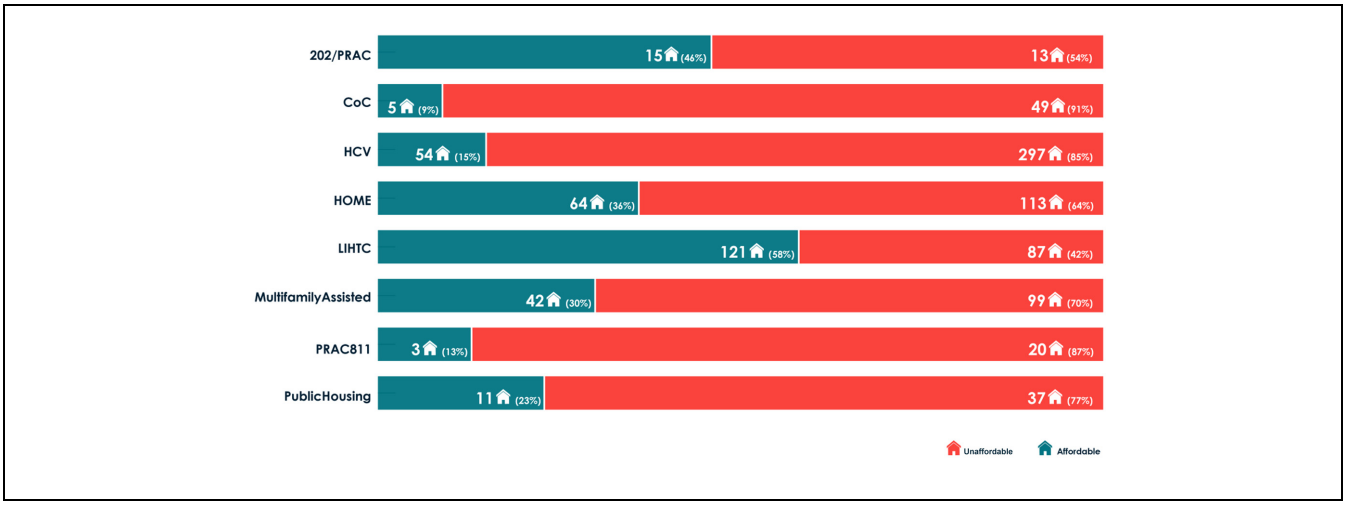

Figure 4. Number and percentage of affordable and unaffordable assisted housing properties in terms of transportation costs.

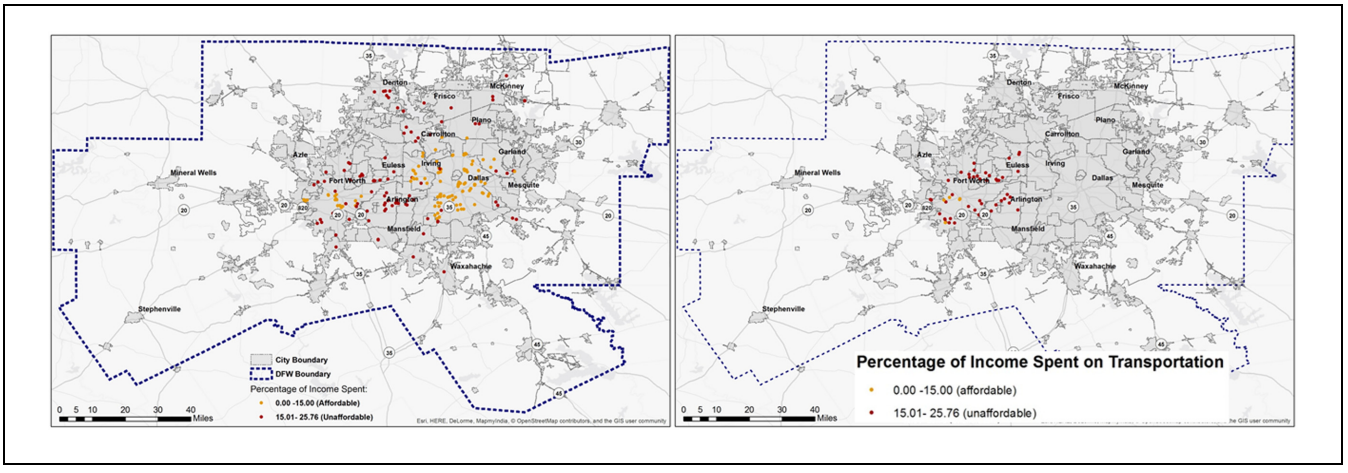

Figure 5. Transportation affordability for LIHTC (left) and CoC (right) assisted properties in DFW area.

transportation costs, making the HUD-designated properties less affordable in terms of transportation.

Even though the recipients of a rental assistance program like HCV have more flexibility to choose the location of their housing unit (*35*), most of the unaffordable HCV properties (84.62%) are interestingly found to be located in suburban neighborhoods which are designed with irregular street patterns (Figure 6). Literature suggests that HCV recipients tend to suburbanize themselves due to their preference for living in more spacious suburb neighborhoods (*36*).

For all cases, location and distance from daily destinations, availability of transit services, accessibility, street connectivity, and mixed use development are found to be influential for property's affordability in terms of transportation costs. It is clear from our findings that the "Location Matters" for assisted housing properties to be truly affordable in terms of both housing and transportation costs. The HUD and local housing authorities work with the mission of providing affordable housing units for low-income families. However according to our findings, living in inaccessible areas would cancel out the benefits of low housing costs.

Our findings urge HUD to consider modifying these programs by incorporating the location-efficiency factors to ensure true affordability. Government and city officials can control urban land market to incentivize low cost housing development in high accessible areas. Simultaneously, the existing unaffordable properties can be connected to the major destinations through improvement of transit services.

Our study has limitations. Data on transportation services like Uber and Lyft was not available for the assisted housing units and hence was not considered in the transportation costs calculation. This study is the first attempt to evaluate performance of assisted

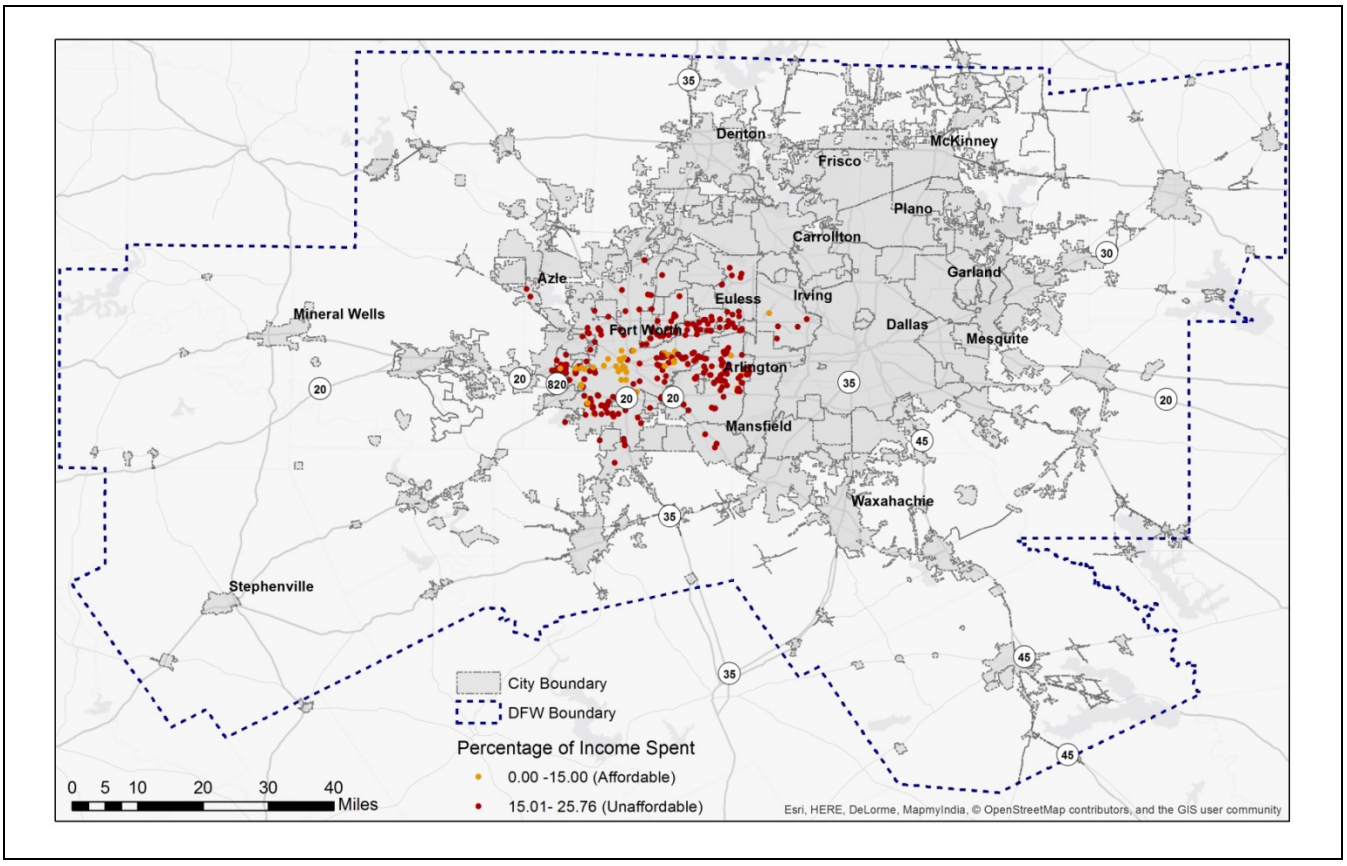

Figure 6. Transportation affordability for HCV assisted properties.

housing units in DFW area by incorporating the typical travel modes and related expenditure of low-income households.

Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: Shima Hamidi; data collection: Somayeh Moazzeni, Jinat Jahan; analysis and interpretation of results: Shima Hamidi, Jinat Jahan; draft manuscript preparation: Shima Hamidi, Jinat Jahan. All authors reviewed the results and approved the final version of the manuscript.

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