International Transport Forum

# Housing plus Transportation Affordability Indices: Uses, Opportunities, and Challenges

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**Erick Guerra and Mariel Kirschen**
City and Regional Planning,
University of Pennsylvania,
United States

OECD

International Transport Forum

# Housing plus transportation affordability indices: uses, opportunities, and challenges

## Technical paper on the Center for Neighborhood Technology's H+T affordability index for OECD roundtable on income inequality, social inclusion, and mobility

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**Erick Guerra**
Assistant Professor of City and Regional Planning, University of Pennsylvania, United States

**Mariel Kirschen**
Master's Student in City and Regional Planning, University of Pennsylvania, United States

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International Transport Forum
2 rue André Pascal
F-75775 Paris Cedex 16
contact@itf-oecd.org
www.itf-oecd.org

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# Abstract

This technical paper provides an overview of the Center for Neighborhood Technology's (CNT) H+T affordability index and its potential application outside of the United States (US), where it has played a prominent role in documenting the relationship between housing and transportation and in influencing local and national housing policies. After describing the index and its policy use, we detail some of the challenges and opportunities of applying the index in Mexico, apply a modified H+T index to the Mexico City metropolitan area, and examine the effect of accounting for transportation costs on maps and measures of housing affordability.

Finally, we conclude with a discussion of some of the opportunities and challenges of applying the H+T index in other OECD nations. The objective is to develop a better understanding of how an H+T index or similar tool could lead to improved public policy throughout the OECD.

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# Introduction and overview

This technical paper provides an overview of the Center for Neighborhood Technology's (CNT) H+T affordability index and its potential application outside of the United States (US). The H+T index incorporates transportation costs into measures of neighbourhood affordability and maps these relationships across US metropolitan areas. The central motivation for the index is to encourage more centralized housing development and discourage urban sprawl. According the index's supporters, the failure to account for the higher transportation costs in remote neighbourhoods has led to policies, plans, and regulations that exacerbate sprawl and locate households far from civic, social, and economic amenities and opportunities. It also may harm families: After housing, transportation costs absorb the largest share of American households' income.

The relationship between transportation and housing costs is well-known and central to theories and models of urban form, suburbanization, and housing markets (Alonso 1960, 1964, Muth 1969, Mills 1972, Brueckner 1987). It also features in popular explanations of American real estate markets: households drive far enough out from an urban centre until they can qualify for a home mortgage. Transit plays a particularly prominent role in where transit-using households choose to live (Cervero 2007) and may help explain part of why poor American households tend to concentrate in cities (Glaeser et al. 2008). Put simply, households often make trade-offs between how much they spend on housing and how much they spend on transportation.

This well-established relationship has led researchers, advocates, and policy makers to argue that measures of neighbourhood affordability ought to incorporate the costs of transportation as well as the costs of housing (Bogdon and Can 1997, Belsky et al. 2005, Jewkes and Delgadillo 2010). It has also resulted in a number of policies to try to encourage more generous mortgages and the construction of more affordable housing construction in areas with good transit access and lower average transportation costs. The CNT's H+T index has played a prominent role in documenting the relationship between housing and transportation and in influencing local and national housing policies.

Throughout the remainder of this paper, we describe the H+T index, its policy uses, and its critiques in greater detail. We then describe some of the challenges and opportunities of applying the index in Mexico, apply a modified H+T index to the Mexico City metropolitan area, and examine the effect of accounting for transportation costs on maps and measures of housing affordability. Finally, we conclude with a discussion of some of the opportunities and challenges of applying the H+T index in other OECD nations. The objective is to develop a better understanding of how an H+T index or similar tool could lead to improved public policy throughout the OECD.

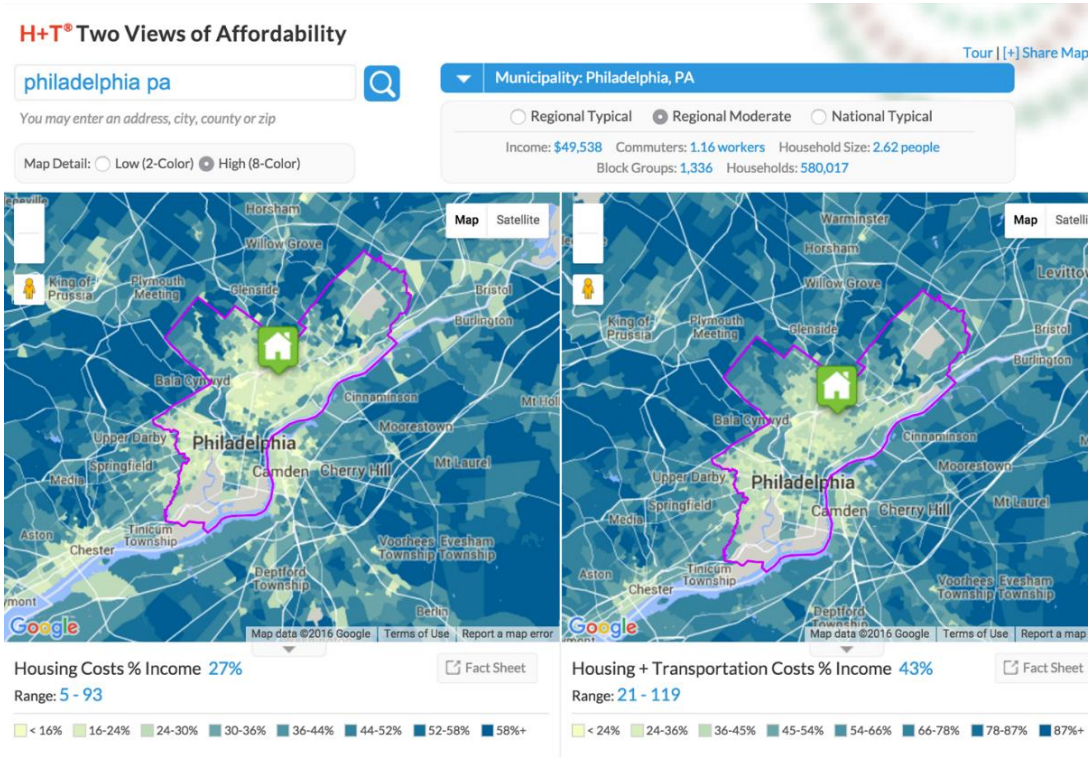
# The housing plus transportation index

The H+T index provides an estimate of the typical cost of housing and transportation in different neighbourhoods and compares this estimate to a household or typical household's income. The CNT deems a neighbourhood affordable if a given household would spend 45% or less of its income on housing and transportation costs. This number accounts for an existing rule of thumb that households should spend 30% or less of their income on housing and adds another 15% for transportation costs. (According to the national consumer expenditure survey, American households spend an average of 18% of their income on transportation.)

$$H + T\ Index = \frac{Housing\ Costs + Transportation\ Costs}{Income}$$

On its website, the CNT provides an interface to map neighbourhood affordability for a typical household earning the metropolitan median income in 917 US metropolitan and micropolitan areas. Figure 1 shows the results of the online map for the Philadelphia region. Areas shaded in dark blues are increasingly less affordable, while lighter greens are increasingly more affordable. Accounting for transportation costs (the map on the right) instead of just housing costs (the map on the left), suburban neighbourhoods become relatively less affordable to a median-income household. However, the overall geography of affordability does not change much. Other regions, such as St. Louis, experience notable changes in the geography of affordability when accounting for transportation costs. Specifically, suburban neighbourhoods become substantially less affordable.

Figure 1. **CNT's default online affordability maps for Philadelphia and surrounding counties**




Source: Center for Neighborhood Technology's Affordability Comparison Maps (http://htaindex.cnt.org/compare-affordability/)

## Estimating transportation costs

The primary contribution of the CNT's affordability index is the estimation of typical transportation costs in different neighbourhoods. Building on earlier work from a 1994 Natural Resources Defense Council study (Holtzclaw et al. 2002), the CNT estimates models of car ownership, vehicle miles travelled (VMT), and transit expenditures using multivariate ordinary least squares regression. Table 1 lists the three independent variables and the predictor variables to estimate each one. Appendix A provides additional details on the 13 publicly available data sources CNT uses to estimate travel expenses for the H+T affordability index. The national Census and American Community Survey provide the data on median household income and median housing prices and rents by Block Group (600 to 3 000 people) and Census Tract (1 200 to 8 000 people).

The tool then applies the results of the model to estimate typical car ownership, car use, and transit use within and across neighbourhoods and regions using publicly available data. The predictive model uses regional rather than local socioeconomic data to estimate local VMT, car ownership, and transit use to estimate at the likely expenses for a typical regional household rather than a typical local household. Finally, the CNT multiplies these predicted figures by the expected costs of car ownership, car use, and transit use to arrive at the final estimate of transportation costs:

$$Household\ T\ Costs = [C_{AO} * F_{AO}(X)] + [C_{AU} * F_{AU}(X)] + [C_{TU} * F_{TU}(X)]$$

where:

*C* is the cost factor (i.e. dollars per mile)

*F* is a function of the independent variables $F_{AO}$ is auto ownership, $F_{AU}$ is auto use, $F_{TU}$ is transit use).

Table 1. **Data and sources used to predict car ownership, car use, and transit use**

| Prediction | Source | Predictors |
|---|---|---|
| **Auto Ownership** | 2013 ACS | Fraction of single family detached housing |
| | | Commuters per household |
| | | Transit connectivity index |
| | | Median household income |
| | | Gross household density |
| | | Employment Mix |
| | | Household Size |
| | | Regional Household Intensity |
| | | Block Density |
| | | Employment Gravity |
| **Auto Use (VMT)** | Odometer readings in IL from 2010-2012 | Fraction of Single family detached housing |
| | | Average Available Transit Trips per Week |
| | | Commuters/Household |
| | | Gross Household Density |
| | | Regional Household Intensity |
| | | Transit connectivity index |

| | | |
|---|---|---|
| | | Median household income |
| | | Average Household Size |
| | | Employment Access Index |
| | | Transit Access Shed |
| **Transit Use** | 2013 ACS | Regional Household Intensity |
| | (% public transportation commuters) | Transit Connectivity |
| | | Employment Access Index |
| | | Employment Mix Index |
| | | Fraction of single family detached housing |
| | | Transit Access Shed |
| | | Transit Access Shed Jobs |
| | | Median Household Income |
| | | Average Available Transit Trips per Week |
| | | Average Household Size |

Source: Center for Neighborhood Technology's 2015 H+T Methodology Document (accessed 1/25/2016)

***Car ownership and vehicle travel costs***

The CNT estimates the cost of car ownership and VMT using 2013 inflation-adjusted data from the 2005 – 2010 Consumer Expenditure Survey. Because wealthier households tend to own more expensive cars with different operating costs than poorer households, the CNT takes the average costs per vehicle for five income groups (those earning USD 0-20 000, 20 000-40 000, USD 40 0000-60 000, 60 000 – 100 000, and 100 000 and above). For the affordability index, it applies the costs of vehicle ownership to one of the five groups, depending on the regional median income. For example, households in greater Philadelphia had a 2013 median income of USD 49 538, so the index applies the average cost per vehicle of households earning between USD 40 000 and 60 000 from the Consumer Expenditure Survey. To estimate costs per vehicle mile of travel, the CNT matches total transportation expenditures by the five income groups to estimates of vehicle travel for those groups. Unlike the model of car ownership and transit use, which use nationally available date, the model of vehicle travel relies on odometer readings from Illinois drivers in the Chicago and St. Louis metropolitan areas from 2010 to 2012.

***Transit costs***

To estimate transit costs, the CNT matches metropolitan areas to data from the 2013 National Transit Database (NTD), which includes estimates of total miles of passenger travel (PMT), unlinked passenger trips (UPT), and total fare revenues. Because the geographies of the two datasets do not match, the CNT also estimates the proportion of fare revenues that come from each county within a transit agencies jurisdiction, based on the proportion of total transit stations that fall within a county from publicly available General Transit Feed Specification (GTFS) feeds. County-level fare revenues are then applied to block groups based on the proportion of total county commute trips (taken from the ACS) that originated from each block group. In counties that do not have GTFS feeds, the CNT uses national averages. Finally, the CNT estimates average transit expenditures as the total amount of fare revenues assigned to a block group divided by the number of households in that block group.

## H+T and public policy

Since its inception, the H+T index's emphasis has been to encourage more housing development in areas that have higher land prices but lower transportation costs. Box 1 summarizes some of the ongoing uses of the H+T that the CNT describes on its website. These range from policies designed to increase the availability of public housing around transit to tools to help analyse where to invest in new transit. Of particular note, the national Department of Housing and Urban Development and Department of Transportation worked with the CNT to create an online location affordability index and transportation cost calculator as part of a larger national Sustainable Communities Initiative (US Department of Housing and Urban Development 2016). These tools are designed to help policy makers and individual households make informed decisions about where to encourage development, where to live, and how much transportation is likely to cost in a given neighbourhood or home. The Sustainable Communities Initiative also provides grants to cities and regions in order to encourage transit-oriented development, affordable housing construction, and sustainable development.

**Box 1. Sample of users of the CNT's H+T affordability index (CNT 2015)**

*Planners*

- Chicago - Metropolitan Panning Council (MPC) used H+T index data in a "corridor selection analysis" to determine potential BRT locations
- Chicago Metropolitan Agency for Planning (CMAP) used suggested H+T index standard as their livability measure in their GO TO 2040 comprehensive regional plan.
- Ohio –Living Cities sponsored the CNT and the Ohio Governor's office to utilize the tool for suggestions for state urban revitalization strategies to reduce cost of living in Cincinnati, Cleveland, and Columbus.
- Washington, DC – Office of Planning worked with CNT on a custom H+T index that integrated market-rate housing costs and local land-use and transit network data.

*Housing professionals:*

- Minneapolis-St.Paul; Washington, DC; Boston; San Francisco Bay Area – Partnered with the Urban Land Institute (ULI), CNT developed customized calculators that could both compare neighbourhood costs and direct transportation choices.
- Santa Fe, NM – Local housing non-profit uses a tailored Index platform to inform prospective homeowners about location efficiency and how to manage transportation costs in order to save for homeownership.
- San Francisco, CA – The Metropolitan Transportation Commission (MTC) gave credit to the Index for the establishment of the Bay Area Transit Oriented Affordable Housing Fund.
- Center for Housing Policy – Research with CNT concerning struggles of moderate-income households to tackle hidden factors that threaten affordability of housing and transportation.

*Policy makers*

- Department of Housing and Urban Development (HUD) - Sustainable Communities Initiative grants to support sustainable development projects.
- State of Illinois – The 45% affordability measure adopted into law with bipartisan support to be used by

five government agencies for both financing and siting decisions.

- El Paso, TX – City Council adopted 50% H+T affordability standard for City funding and policy decisions.

### *Affordability rankings*

The H+T index can also help paint a substantially different picture of which parts of the country are most affordable or expensive. These types of lists feature frequently in news stories and public policy dialogues, but rarely feature transportation costs. Table 2 provides a list of cities by how affordable they are to a typical household in that region when ignoring and considering transportation costs. Washington D.C. is the most affordable city to its typical residents when accounting for transportation as well as housing costs, but only the 8th most affordable when ignoring transportation costs. Other cities like Cincinnati and Detroit are decidedly less affordable when considering transportation costs.

Table 2. **Affordability rankings for major US cities and metropolitan areas**

| *Moderate-Income Housing and Transportation Burden* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **MUNICIPALITY** | **% Housing Rank** | **% Housing + Transportation Rank** | **Change in Rank After Adding Transportation** | | **CMSA** | **% Housing Rank** | **% Housing + Transportation Rank** | **Change in Rank After Adding Transportation** |
| Washington | 8 | 1 | -7 | | Washington | 4 | 1 | -3 |
| Baltimore | 1 | 2 | 1 | | Minneapolis | 1 | 2 | 1 |
| Philadelphia | 6 | 3 | -3 | | Baltimore | 9 | 3 | -6 |
| Boston | 12 | 4 | -8 | | Boston | 16 | 4 | -12 |
| Minneapolis | 7 | 5 | -2 | | Denver | 6 | 5 | -1 |
| NYC | 17 | 6 | -11 | | Seattle | 13 | 6 | -7 |
| St. Louis | 3 | 7 | 4 | | Philadelphia | 15 | 7 | -8 |
| Cincinnati | 2 | 8 | 6 | | San Francisco | 18 | 8 | -10 |
| Pittsburgh | 5 | 9 | 4 | | Cincinnati | 2 | 9 | 7 |
| Detroit | 4 | 10 | 6 | | Pittsburgh | 3 | 10 | 7 |
| Denver | 10 | 11 | 1 | | St. Louis | 5 | 11 | 6 |
| San Francisco | 20 | 12 | -8 | | Dallas | 7 | 12 | 5 |
| Chicago | 15 | 13 | -2 | | Detroit | 12 | 13 | 1 |
| Dallas | 11 | 14 | 3 | | NYC | 22 | 14 | -8 |
| Seattle | 16 | 15 | -1 | | Houston | 8 | 15 | 7 |
| Houston | 9 | 16 | 7 | | Chicago | 17 | 16 | -1 |
| Sacramento | 13 | 17 | 4 | | Portland | 14 | 17 | 3 |
| Portland | 18 | 18 | 0 | | Atlanta | 10 | 18 | 8 |
| Atlanta | 19 | 19 | 0 | | Phoenix | 11 | 19 | 8 |
| Phoenix | 14 | 20 | 6 | | Sacramento | 19 | 20 | 1 |
| Miami | 21 | 21 | 0 | | San Diego | 23 | 21 | -2 |
| Los Angeles | 24 | 22 | -2 | | Los Angeles | 24 | 22 | -2 |
| San Diego | 25 | 23 | -2 | | Tampa | 20 | 23 | 3 |
| Riverside | 22 | 24 | 2 | | Riverside | 21 | 24 | 3 |
| Tampa | 23 | 25 | 2 | | Miami | 25 | 25 | 0 |

Source: Table generated by authors using data from the Center for Neighborhood Technology's website

### *Affordable housing and mortgage policies*

Lastly, the H+T index has influenced public policies about where to site of subsidized housing developments and how much to lend households to buy a home. Perhaps its largest influence has been through the Low-Income Housing Tax Credit, the largest source of funding for constructing and maintaining subsidized housing in the US. This program requires that states develop and manage a competitive allocation process to determine which sites and developers receive federal funds. A number

of states—notably California, Massachusetts, Colorado, Minnesota, New Jersey, Illinois, Louisiana, Nevada, New Mexico, and Virginia—give priority to projects that are suited near transit or have good accessibility to job centres and other amenities (Governors' Institute n.d., Texas Department of Housing and Community Affairs 2010, Smart Growth America 2016). Other state and local programs, such as California's Transit Oriented Development (TOD) Housing Program and the Bay Area's Transportation for Livable Communities initiative provides subsidies to build or purchase housing units near transit (Renne 2008, California Department of Housing and Community Development 2015).

Beginning in the late 1990s, the Federal National Mortgage Association (Fannie Mae) developed and promoted the location-efficient and smart commute mortgage programs. The intention was to allow homeowners to access larger loans in areas with lower commuting costs and thereby reduce auto use, support transit use, increase the supply of housing near transit, and increase homeownership among low- and moderate-income households. Despite initial interest, lenders only used the program to make around 300 loans and the program closed in 2008 due to a lack of lender interest (Chatman and Voorhoeve 2010). This lack of interest stemmed at least partially from some of the theoretical and technical challenges of applying an H+T index to inform housing policy.

# Challenges and critiques of the H+T index

For all its benefits and policy uses, several challenges limit the use and applicability of the H+T in the US and its transferability to other countries.

## Affordability

One of the biggest challenges of the H+T index is that the concept of affordability is somewhat arbitrary. Early measures and popular expressions of affordability considered housing affordable if it absorbed roughly 25% of income, which came from a popular expression: a week's wages for a month's rent (Feins and Lane 1981). In 1969, Congress gave legal weight to this affordability concept through the Brooke Amendment. The amendment capped the amount that any family would spend on housing at 25% of household income with some variation based on other household characteristics. In 1983, the Housing and Urban-Rural Recovery Act increased and simplified the affordability standard to 30% for all households (Pelletiere 2008). HUD publishes affordability guidelines that vary by region and household size that are used to determine eligibility for subsidized housing and the public merit of affordable housing developments (US Department of Housing and Urban Development 2016).

Although easy to calculate and compare across regions (Bogdon and Can 1997), researchers and advocates have criticized the measure for more than just its exclusion of transportation costs. These criticisms extend to the H+T index:

1. Affordability thresholds qualify something that is inherently quantitative in nature. A household hold that spends 31% of its income on housing is not substantially more burdened than one that spends 29% on housing. Yet the notion of affordability treats these two households similarly to households than spend 50% and 15% of their respective income on housing.

2. Affordability indices do not consider household size, age, or composition (Bogdon and Can 1997, Belsky et al. 2005, Jewkes and Delgadillo 2010). A family with only working-age member and several school children will likely find it more burdensome to spend 30% of income on housing, yet likely needs a larger house than a single-person household with an income.

3. In addition to housing and transportation costs, other important expenditures like schools and food vary substantially within and across regions (Tegeler and Chouest 2010). In practice this may tend to offset some of the effects of the H+T index. For example, a household in the suburbs may spend money to drive to a large grocery store with lower priced goods. Schooling costs almost certainly play a large role in household expenditures as well. For example, a household may prefer to send their kids to free public schools in a suburban school district, but would choose to send them to an expensive private school if the public school is in a poorly performing urban district.

4. Indices ignore household preferences. Some households are willing to pay more for a larger or high-quality house, while others might prefer to conserve housing expenditures in order to spend more on other items like food, transportation, or entertainment.

5. By focusing on income, the indices ignore life-stage considerations, accumulated wealth, and debt. For example a young household may elect to spend a significantly higher portion of income on housing in the expectation of future earnings. Many university students and recent graduates experience high rent burdens but are financially and socially quite privileged. At the other end of the spectrum, an elderly household spending 30% of income on housing might be extremely burdened, since houses are the largest source of wealth for most households and elderly households often rely on this accumulated wealth in retirement.

## Aggregation bias

At its heart, affordability affects individuals not census block groups, cities, or metropolitan areas. A homogenous neighbourhood where all housing costs the median price is likely much less affordable than a diverse neighbourhood with the same median housing cost but substantial variation in housing costs. The same holds true for cities and regions. In fact, households may prefer to live in neighbourhoods with higher median housing costs, provided that they can find a single affordable house or apartment. What matters is not the median income or housing price, but the distribution of income and housing prices along with ability to match houses and apartments to those that can afford them. By lumping all incomes and housing costs into a single median measure, the index fails to account for this important component of affordability. This type of aggregation bias is common when indices fail to analyse the correct unit of analysis, but instead aggregate up to a larger geographic area.

The aggregation of transportation expenses is perhaps even more problematic since there is so much variation and potential variation in how much a household spends on transportation. For example, a household where every member drives to all destinations would spend substantially more than an otherwise identical household that carpooled or used transit. Some neighbourhoods may be affordable for transit users, but not for car owners with the same income.

Even across individuals, there is a temporal component to housing and transportation affordability. For example, transportation costs almost certainly vary with job location as well as housing location. Changing jobs could substantially influence how much a household spends on transportation and thus how much it can afford to spend on housing. This temporal uncertainty helped contribute to lenders' lack

of interest in Fannie Mae's location-efficient and smart commute mortgage programs (Chatman and Voorhoeve 2010).

## VMT estimate

The CNT uses odometer readings and built environment data from a single region to estimate car use for the rest of the country in its H+T estimates. There is, however, significant variation in built environments, travel behavior, and probably also the empirical relationship between the two throughout the country. The CNT argues that this is not a problem because the Illinois data include a variety of built environments from rural areas and large cities. Although there are substantial commonalities across many studies examining the relationship between the built environment and vehicle travel (Ewing and Cervero 2010), whether the model estimates are applicable to other regions remains an open question. The existing model is not suitable for other OECD nations, where car ownership and use tend to be more expensive than in the US.

## The high cost of new construction

Constructing new housing in transit-friendly areas is one of the CNT's recommendations based on the H+T Index. However, new construction by its nature is expensive and, unless highly subsidized, unaffordable to most households. Furthermore, land prices and housing values frequently increase with proximity to transit (Knapp 2001, Cervero and Duncan 2002, Rodríguez and Targa 2004, Debrezion et al. 2007, Hess and Almeida 2007, Kahn 2007, Cervero and Kang 2009). Since wealthy households are more likely to opt for a combination of new construction and car ownership, building market rate housing around transit is unlikely to reduce H+T expenditures for vulnerable households.

## Fair housing critique

One argument against the use of H+T measures to help determine where to locate affordable housing is that it may encourage concentration of poverty (Tegeler and Chouest 2010). This argument is particularly poignant in the US, where a history of racist housing discrimination has contributed to concentrations of poor and non-white households in specific neighbourhoods, often in central neighbourhoods with good transit access. This fair housing critique against place-based affordable housing development recently came to a head with a ruling by the Supreme Court in the case of Texas Department of Housing & Community Affairs v. Inclusive Communities Project, Inc. (for an overview of the ruling, see (Epstein et al. 2015)). The Supreme Court ruled 5-to-4 that the Texas Department of Housing & Community Affairs was in violation of the Fair Housing Act (Title VIII of the Civil Rights Act of 1968) based on arguments that affordable housing allocations perpetuated and strengthened existing patterns of racial and socioeconomic segregation. Unless carefully implemented, policies to increase the development of affordable housing or extend credit to low income households around transit will tend to increase socioeconomic and racial segregation and in some cases may even be in violation of federal law.

# Housing plus transportation index in Mexico City metropolitan area

How readily could a housing and transportation affordability index be applied to Mexico and Mexico City? While household expenditure data are readily available from the annual consumer expenditure survey (INEGI 2016), the decennial census does not provide information on household income or vehicle ownership (since 2000, the census asks where a household owns one or more vehicle, but not how many). Furthermore, spatially refined data on vehicle travel are sparse, though estimable for Mexico City (Guerra 2014a) using a 2007 household travel survey (INEGI 2007). With four times the population of the next largest urban agglomeration and the most robust public transportation network, however, Mexico City's residents' travel behavior likely vary substantially from residents of other regions.

This section applies the housing plus transportation affordability index to the Mexico City metropolitan area (Zona Metropolitana del Valle de México, henceforth referred to as "Mexico city"). Given that most households rely on public transportation and driving accounts for under a third of trips, we limit the analysis to non-driving households from the 2007 household travel survey. This excludes wealthier households, who are the most likely to drive, but emphasizes poorer households who are most constrained by a lack of affordable housing or transportation options. Note that we aggregate the results to the metropolitan area's 76 boroughs and municipalities rather than census tracts (Agebs). This produces clearer maps and avoids the problem of insufficient samples in many of the region's 5 000 census tracts. Box 2 summarises a similar exercise conducted in Qom, Iran.

**Box 2. Applying an H+T Index in Qom, Iran**

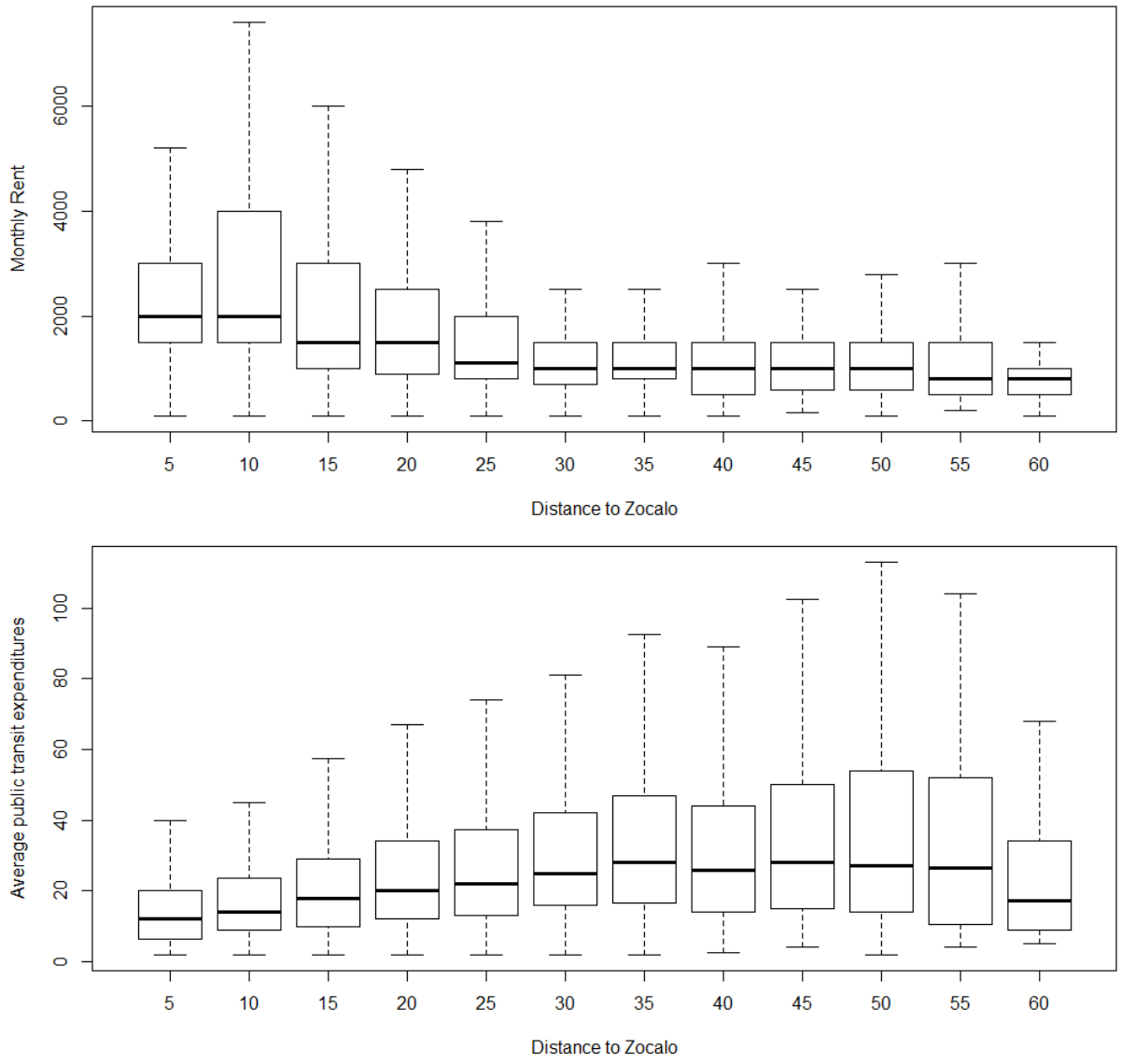
Unaffordable housing is a growing concern in many developing-world cities, where rapid population growth, insufficient infrastructure, and shrinking household sizes have led to substantial increases in housing and transportation prices. Isalou et al (2014) conducted a study in Qom, Iran, to evaluate the usefulness and findings of the H+T index in a developing-world context. Unlike in the US, the authors relied on a survey to collect data about household characteristics, travel behavior, transportation expenditures, and housing costs. In Qom, a typical suburban household spends 57% of their monthly income on housing and transportation, compared to 45% for a centrally located household. As in the US and Mexico City, accounting for travel expenditures increases the affordability of urban neighbourhoods relative to suburban ones.

## Rents and transit expenditures in Mexico City

The average non-driving household spends an estimated 33% of income on rent and 15% of income on transit expenditures in Mexico City (authors' estimates using (INEGI 2007)). This suggests that the Center for Neighborhood Technology's measures of rent and transportation burden are at least somewhat transferable to this metropolitan area. Across the metropolis, monthly rents decrease with distance from the urban centre (measured here as the network distance to the central Zocalo) while transit expenditures increase. Figure 2 plots households' transit expenditures and monthly rents by 5 kilometre increment from the Zocalo. Although median household transit expenditures increase with distance into the most remote neighbourhoods, the rent gradient flattens at around 20 kilometres from the centre. Beyond this point increase in travel costs do not appear to correlate with reductions in transit expenditures. Finally, it

is important to note that incorporating car ownership and use into travel expenditures would tend to increase central households' transportation expenditures more than peripheral households' expenditures. In Mexico City, as in much of the world, wealthier households tend to choose both central housing locations and cars (Guerra 2015a). Peripheral neighbourhoods are generally poorer and more transit reliant.

Figure 2. **Boxplots of monthly rent and public expenditures by 5-kilometre increment from the central Zocalo.**

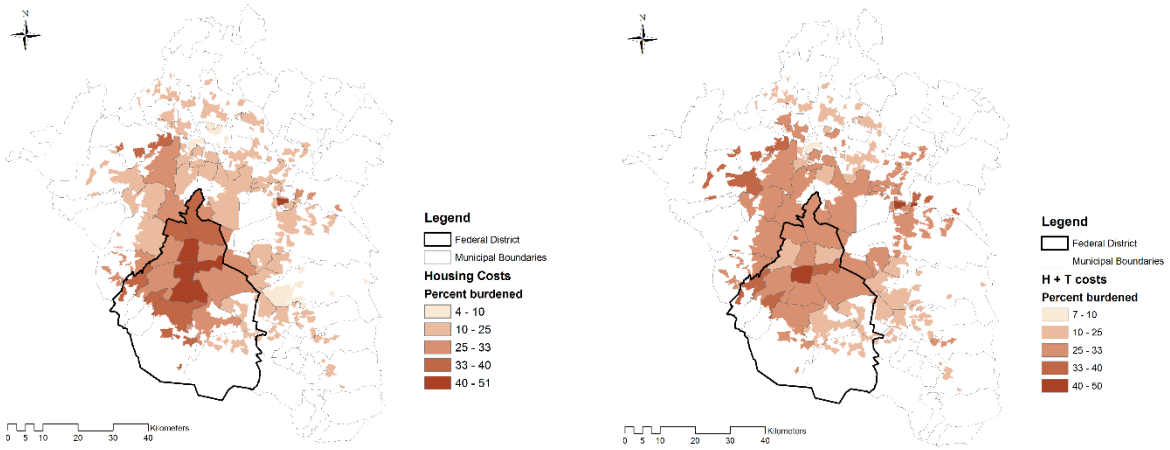



*Source:* Compiled and calculated by author from Census Tract boundary files from the Instituto Nacional de Estadística y Geografía (INEGI, 2013), OpenStreetMap (2015), and the 2007 household travel survey (INEGI 2007). Default boxplot settings are used with upper and lower arms representing 1.5 times the inter quartile range and outliers excluded.

## Measuring affordability in Mexico City

According to data from the 2007 household travel survey, 34% of non-driving households spend more than 30% of their income on rent and qualify as rent-burdened. This number goes about by one percentage point to 35% when accounting for housing and transportation costs. Figure 3 maps the percentage of burdened households across municipalities when accounting for rents along and accounting for housing and transportation costs. Across municipalities (boroughs within the dark black outline Mexico City proper), a maximum of half of households are rent-burdened. Accounting for transportation costs changes the geography of affordability, in particular by making the centrally located boroughs more affordable. These areas have the best access to the 200-kilometer metro system, which charges flat fares and is faster and less expensive than road-based forms of transit (Guerra 2014b). Similarly, the far periphery becomes less affordable to its residents when accounting for transit costs. That said many peripheral neighbourhoods have relatively small percentages of H+T-burdened households.

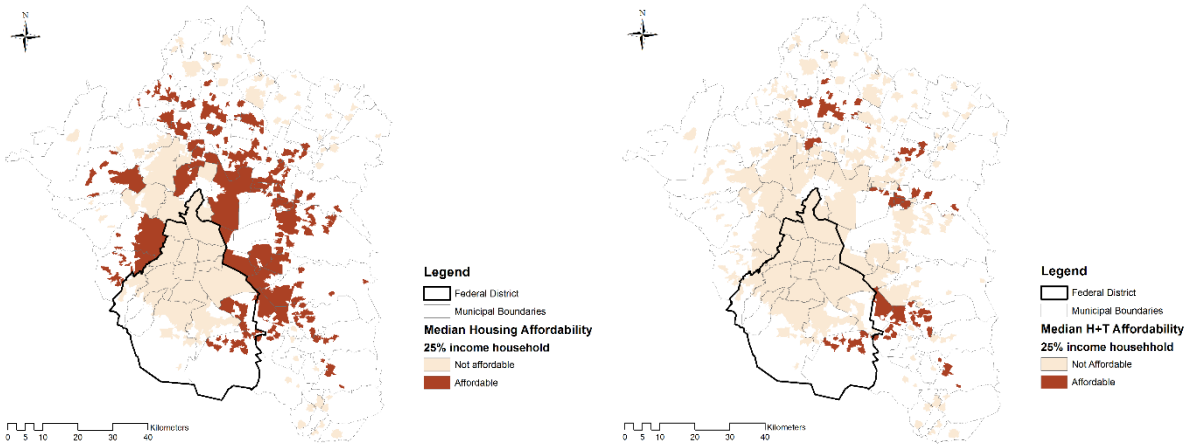
Figure 3. **Percent of rent and H+T burdened households by municipality**




*Source:* Compiled by authors from state, municipal, and locality boundary files from the Instituto Nacional de Estadística y Geografía (INEGI, 2013) and calculations from the 2007 household travel survey (INEGI 2007).

When looking at which municipalities tend to be affordable to a household earning a 25$^{th}$ percentile income, a different spatial pattern emerges (Figure 4). The median rent in each central borough is unaffordable to a poor household, while most of the northern and eastern municipalities of the State of Mexico remain affordable. When accounting for transportation costs, however, only a few of the poorer, more remote municipalities remain affordable. Again, there is a pattern that incorporating transportation costs lowers the relative affordability of the periphery and increases the relative affordability of the centre. Nevertheless, median expenditures in most municipalities would burden a household earning the 25$^{th}$ percentile of regional income for non-driving households.

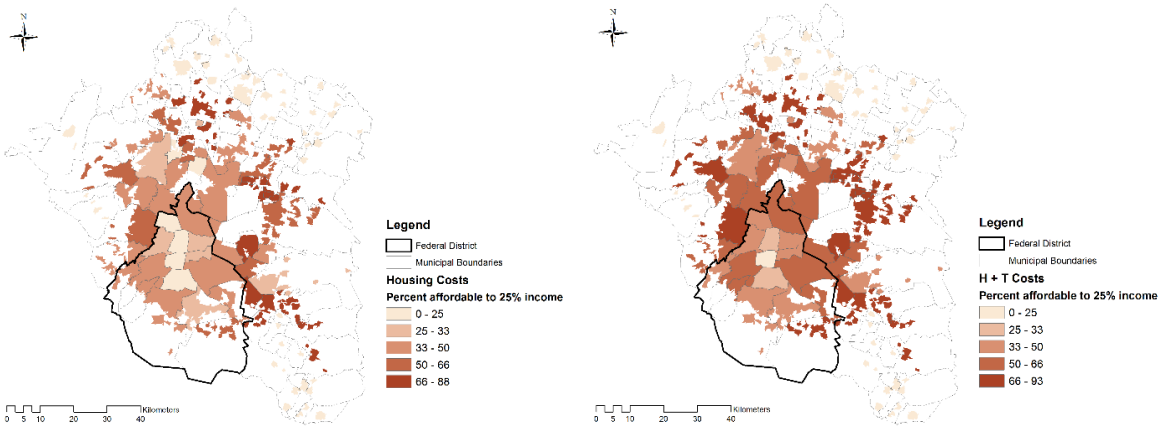
Figure 4. **Municipal affordability indices for household earning the 25th percentile income**




*Source:* Compiled by authors from state, municipal, and locality boundary files from the Instituto Nacional de Estadística y Geografía (INEGI, 2013) and calculations from the 2007 household travel survey (INEGI 2007).

Households, however, probably do not care that much about median prices in an area—one of the fundamental problems of affordability indices and aggregation bias. Instead households care about whether they are able to match to a home that is affordable and meets other needs and priorities, including affordable transportation. Figure 5 tries to circumvent this aggregation problem by mapping the percentage of households' housing and transportation expenditures that would be affordable to a 25th percentile income household by municipality. This gives a sense of the relative ease with which a poor household might be able to find suitable accommodations in different parts of the metropolis. Again, adding transportation costs makes central regions relatively more affordable. However, it also tends to increase the affordability of many suburban neighbourhoods. These are the places where many of Mexico City's poor residents live and by necessity or desire are able to reduce transportation and housing expenditures. It is also interesting to note that even some of the wealthier parts of the city sometimes have 25% to 33% of their housing affordable to a poor household when accounting for transportation costs.

Figure 5. **Percent of housing options affordable to a household earning the 25th percentile income**




*Source:* Compiled by authors from state, municipal, and locality boundary files from the Instituto Nacional de Estadística y Geografía (INEGI, 2013) and calculations from the 2007 household travel survey (INEGI 2007).

## Policy implications

Taken together, these analyses demonstrate that it is possible to apply an H+T index in a place like Mexico City with relative ease and that the findings are somewhat similar to findings from a US context, at least when excluding car expenses. In general, more transit-friendly central locations appear relatively more affordable when accounting for travel costs as well as housing costs. Since Mexico is the poorest of the OECD countries and the US is one of the wealthiest, these findings likely extend to the rest of the OECD. Unfortunately, a shortage of the necessary data would make it difficult to extend this analysis beyond Mexico City to the rest of the country. Furthermore, the data from the household travel survey are now nearly ten years old. Nevertheless, there are two broad takeaways for public policy in Mexico City and perhaps beyond.

### *1. Affordable housing policy*

First, the principal form of housing production has encouraged substantial new housing development in remote areas with high transportation costs. Over the past two decades, Mexico City's principal form of new housing production has shifted from an informal process, where households built their own properties generally in informal settlements on the periphery, to a formal process where private developers acquire large peripheral lots, build new housing speculatively, and sell completed homes in massive developments to households that qualify for publicly subsidized mortgages (Pardo and Velasco Sánchez 2006, Monkkonen 2011a, 2011b). The public sector is highly involved in this process. Between 1995 and 2005, public agencies funded 75% of all housing loans by value—and even more by volume—in Mexico. Infonavit accounted for 81% of these publicly-financed loans (Monkkonen 2011b).

In addition to remote locations, these commercial housing developments have more parking, wider streets, less-connected street-grids, and less accessible transit stops than nearby informally developed neighbourhoods. These features encourage car ownership and use, which cost even more than transit and reinforce high peripheral transportation costs. Accounting for regional housing location, household income, age, and composition, a household in a commercial development is 62% more likely to own a car and drives nearly four times as much as a household in a traditional neighbourhood (Guerra 2015b).

A consideration of H+T costs instead of just housing costs would encourage a shift in subsidies to favour more central development. This may already be happening in the wake of the Great Recession. Numerous homebuilders have gone bankrupt or failed to report earnings, after foreclosures of tens of thousands of homes, particularly the most peripheral ones (Juarez 2013). President Peña Nieto's administration has made it a public priority reorient government loans to support vertical construction in more central locations (La Crónica de Hoy 2013). However, until home building increases again, it remains to be seen what the effects of the policy will be and whether increases in housing costs can be offset by decreases in transportation costs.

### *2. Transit investment policy*

In 2007, just 11 of Mexico City's 192 metro stations were outside of the Federal District. Nevertheless suburban residents of the states of Mexico and Hidalgo rely on transit for a higher share of trips (65%) than urban residents (60%) and even use the centrally located metro for a similar share (18% vs. 19%) (INEGI 2007). These suburban residents are also poorer and more numerous than centrally located ones. Nevertheless the most notable transit policy of the last decade has been the construction of a new bus rapid transit network, which like the metro is a centralized system that provides only limited service into the populous, dense, and transit-reliant suburbs. Increasing high-capacity transit investments into the suburbs, although expensive, will likely increase housing density around suburban stations and

reduce travel times and transportation expenditures for low income households as occurred around the suburban Line B metro extension.

## Conclusion and transferability to other OECD nations

Throughout this paper, we documented the development, technical details, policy uses, and challenges of CNT's H+T affordability index. We then applied a modified version to Mexico City to explore some of the opportunities and challenges of applying the index to another country. Despite some of previously described challenges and critiques of the H+T index, applying an H+T index to OECD countries and cities has the potential to:

- Strengthen the public and policy makers' understanding of which countries, cities, and regions are most affordable;
- Encourage bank lending and the construction of affordable housing in neighbourhoods with higher land costs but lower transportation costs; and
- Focus transit investments in a way that could help to reduce the amount that poorer households spend on transportation.

Transferring the index will likely present two additional challenges:

- **Data availability.** The CNT developed the H+T index specifically to be estimable using publicly available data. Much of this data is not available or comes in a different form in different countries. As a result, no single methodology can or should be applied to all OECD countries and regions. There is insufficient publicly available data to estimate an H+T index in Mexico and applying a model built from the Mexico City region's 2007 household travel survey to census data for other regions would likely create substantial and systematic bias. To estimate an H+T index in Qom, researchers had to conduct their own survey, an expensive and time-consuming endeavour that does not lend itself to the publicly available nature of the H+T index. Estimating the costs of vehicle travel, in particular, is likely to be problematic. Even in the US, it remains unclear how well the model built from Illinois data predicts travel behavior or costs outside of Illinois.
- **Context.** As seen in Mexico City, some preconceived notions about the relationship between transportation costs and housing location do not hold outside of the US. For example, wealthy households in Mexico City generally opt to live in transit accessible areas but own and use cars. This would tend to make central locations look less affordable to poor and moderate-income households than they actually are. Urban economists have found similar differences when comparing American and European cities—a difference that they attribute to the relative desirability of central locations (Brueckner et al. 1999). The US's local control and financing of public school districts almost certainly also leads to substantial differences in housing markets when compared to other countries. Many households move to the suburbs because they cannot afford private schools but view public schools in urban locations as undesirable.

Based on these findings, we stress that no single methodology, model, or dataset can or should be applied throughout OECD countries or regions. If there is interest in extending the index to cover additional OECD nations, we therefore recommend that researchers identify low-hanging fruit, where data are readily available, and test and adopt the index to different contexts. Examples from Mexico City and Qom show that this is possible but that additional data collection and model construction will be necessary and may in fact be specific to each OECD nation.

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International Transport Forum

**International Transport Forum**
2 rue André Pascal
F-75775 Paris Cedex 16
contact@itf-oecd.org
www.itf-oecd.org