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HELSINKI GSE DISCUSSION PAPERS 48 · 2025

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Helsinki GSE Discussion Papers

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ISBN 978-952-7543-47-4 (PDF)
ISSN 2954-1492

Helsinki GSE Discussion Papers:
https://www.helsinkigse.fi/discussion-papers

Helsinki Graduate School of Economics
PO BOX 21210
FI-00076 AALTO
FINLAND

Helsinki, October 2025

Mobility, segregation and inequality: Who gains from urban transportation improvements?

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September 2025

Abstract

Urban transportation projects are massive public investments that can transform cities. This article reviews evidence on how these projects shape where people live, and how their benefits are shared across income groups. A simple model helps organize the findings. Three factors are especially important: who uses the new transportation mode, where it is built, and how easily people can relocate. Projects serving a narrow group in a specific area tend to increase segregation and inequality. These impacts can be severe if poorer households face barriers to relocation, as happened with the Interstate Highway System. Projects with broad spatial coverage and use by all income groups, like Bus Rapid Transit in developing countries, tend to have more modest segregation effects and broadly shared welfare gains.

Key words: urban transportation, segregation, welfare
JEL classification: R41, O18

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1. Introduction

Urban transportation investments are some of the largest and most consequential that governments make. They directly affect people by reducing travel times to reach venues, jobs, and friends. These investments also have large indirect effects: new transportation options can reshape cities as people relocate in response to better access, and house prices adjust.

This article studies who benefits from urban transportation improvements, and whether they affect the rich and poor differently. We first consider how these improvements affect where people choose to live, possibly leading to segregation or gentrification. We then consider the welfare effect of transportation projects, taking their impact on location choices into account. We start by reviewing the empirical literature, then present a simple model to interpret these patterns.

Understanding how transportation affects segregation and welfare inequality is important for several reasons. First, rising welfare inequality and the spatial concentration of poverty can have broader societal costs, for example by reducing social mobility (Chetty, Hendren, Kline, and Saez, 2014). Second, major transportation innovations transform cities and how people live. Heblich, Redding, and Sturm (2020) show that London's first train network in the 19th century enabled people to live farther from work, giving rise to the familiar pattern of dense urban cores surrounded by residential suburbs. Baum-Snow (2007) shows that postwar highway construction in the U.S. accelerated suburbanization. Finally, there are simple factors that can help policymakers anticipate the consequences of new projects. Three important factors are mode use by income group, the income of residents near planned improvements, and, though harder to measure, how easily people can relocate. For example, these factors help predict that a new bus line in a low-income area will raise the welfare of poor residents, who are more likely to take the bus, and attract more low-income households if relocation is easy.

In nearly every empirical study we review, transportation improvements increase income (and racial) segregation. This pattern holds across countries, time periods, and types of investment, from subways to highways. These investments allow households to sort based on preferences that often depend on income. For example, the construction of the Interstate Highway System in the United States made suburban areas more attractive to richer (typically White) households, who placed a higher value on time and were better able to afford cars. As a result, highways contributed to the suburbanization of the rich, rising poverty in inner cities, and greater racial segregation (Weiwu, 2024, Bagagli, 2024). In theory, however, it is possible for a transit improvement like a new bus line to reduce segregation. In our model, segregation only rises if that improvement targets neighborhoods where low-income households already reside, thereby concentrating poverty in those areas.[1] Projects that could reduce segregation in theory, such as building bus stops that draw low-income residents into wealthier neighborhoods, rarely occur in practice.[2]

Turning to welfare, the evidence is more nuanced. Recent work in quantitative spatial economics measures the full welfare effects of transportation improvements by income group, accounting for how households relocate within the city. This allows welfare and segregation to be studied jointly. Two main patterns emerge. First, studies of Bus Rapid Transit systems in developing countries - Tsivanidis (2023) in Bogotá, Warnes (2024) in Buenos Aires, and Balboni, Bryan, Morten, and Siddiqi (2020) in Dar es Salaam - find broadly shared gains across the income distribution. These results reflect that BRT is widely used by both rich and poor people and typically serves diverse areas of the city. Second, studies of the Interstate Highway System in the United States (Weiwu, 2024, Bagagli, 2024) find that highways benefited richer and white households while harming poorer and Black households. Highways were more valuable to car owners, reduced travel times in suburban areas where richer households lived, and created disamenities by cutting through poorer urban neighborhoods. Our model highlights the role of residential mobility in generating a trade-off between these welfare gains and segregation. When transportation modes are expanded in areas where their primary users are concentrated, as is often the case in practice, easier relocation increases income segregation, but also allows more households to move in to capture the benefits from improved access (or to move out if they rarely use that mode and want to avoid associated house price increases).

Finally, recent research also illustrate how the political process, through land-use restrictions, can amplify segregation and limit the benefits of transportation investments. These barriers work by preventing people from relocating to new opportunities or by blocking housing construction near improved transit. For instance, New York's 1916 zoning law reinforced segregation after subway expansion by reserving wealthy areas for single-family homes while allowing multi-family housing and industrial uses in poorer ones (Lee, 2022). Redlining in the 1960s prevented Black residents from leaving neighborhoods cut through by U.S. highways (Weiwu, 2024). Land use restrictions in Bogotá during the 2000s likely blocked new housing near Bus Rapid Transit stations (Tsivanidis, 2023).

Overall, both theory and evidence suggests that the impact of transportation investments on segregation and welfare inequality depends primarily on who uses them and where they are placed. Projects that serve a broad range of income groups and areas tend to

[1] Our model also implies that a sufficiently large improvement in travel times by any mode would increase segregation by concentrating richer households. In practice, however, this is not what we observe, as poverty levels often rise near transit stations.

[2] In our model transit is slower but cheaper per trip than driving a car. So poorer households rely more on transit, because they have a lower value of travel time and fewer resources to cover the fixed cost of owning a car.

have smaller effects on segregation and more balanced welfare gains. Investments that are disproportionally used by one group and target specific areas are more likely to increase both segregation and inequality.

2. Empirical evidence

This section reviews the existing empirical literature on how urban transportation investments affect the location choices and welfare of higher- and lower-income residents. We first discuss evidence on spatial segregation, i.e., on whether income groups concentrate in different areas of the city after a transportation improvement. We show that transportation improvement appear to always raise segregation.[3] Segregation matters not only in its own right but also because it shapes the welfare effects of transportation projects. As people adjust their residential choice in response, housing prices and other amenities also adjust, which alters the gains from the project. We review recent work that study segregation and welfare jointly, using quantitative spatial models that account for changes in location choices. We find that for projects serving a broad range of people across diverse areas, the benefits tend to be shared widely. Projects that target specific groups and locations tend to increase inequality.

2.1 Location choice of the rich and poor

Who benefits from a new transportation improvement, or relocates in response to it, depends in part on who is most likely to use it. For example, a new bus stop in the United States is unlikely to directly benefit richer households if they rarely use buses. Table 1 reports modal shares from household travel surveys in three metropolitan areas. For Atlanta and New York City, the data come from the 2017 National Household Travel Survey and compare people below and above median household income ($75,000). For Buenos Aires, the data come from a 2010 mobility survey reported in Warnes (2024) for high- and low-skill people, where low skill is defined as having no post-secondary education. Each row of the table reports the share of all trips taken by survey respondents during the survey period by one of five modes: car (includes motorcycles), bus, subway, train, walking & bicycling, and others. Appendix A describes this data in more detail.

[3]While our focus is on segregation, we also consider a related process, gentrification, defined here as higher-income households moving into lower-income neighborhoods. There is no agreed-upon definition of gentrification. Most often, it refers to richer households moving into poorer neighborhoods, which can reduce segregation locally, at least initially. A broader definition, such as rising house prices or rising share of college-educated residents in a neighborhood, may coincide with either rising or declining segregation. For instance, Couture and Handbury (2023) find that rising college shares in downtowns with initially low education levels led to more segregation, as college-educated residents clustered together.

Table 1: Mode Share by City and Income Group (%)

	Atlanta		New York		Buenos Aires	
Mode	Low income	High income	Low income	High income	Low skilled	High skilled
Car/Motorcycle	86.8	87.2	49.1	64.9	18.6	26.6
Bus	3.3	0.9	7.2	2.2	37.1	39.3
Subway	0.6	0.9	9.2	7.7	4.4	14.5
Walking/Bicycle	8.0	9.9	33.0	22.4	38.1	16.3
Other	1.3	1.2	1.6	2.8	1.8	3.2

Notes: Columns 1-4 use data from the National Household Travel Survey 2017 to report the shares of trips by different transportation modes in the Atlanta and the New York metropolitan area, for households with income above and below $75,000. Columns 5 and 6 instead use data from the 2010 "Encuesta de Movilidad Domiciliaria" for the Metropolitan region of Buenos Aires for people with and without a post-secondary education, as reported by Warnes (2024). All columns show shares for adults aged 18 and over.

In richer countries like the United States, bus use is higher among lower-income residents. In poorer countries like Argentina, where the poorest urban residents often walk or bike, bus ridership is more evenly distributed.[4] In all three cities in Table 1, subways have relatively more high income riders than buses. Given these patterns, Akbar (2024*a*) classifies transit into two categories: "slow transit," mainly buses with a poorer user base, and "fast transit," including subways, trains, and BRT, which tend to have more mixed ridership. The cities in Table 1 do not have BRTs, but Balboni *et al.* (2020) report that in Dar Es Salaam, Tanzania, 26% for low income people used BRT over the previous week, compared to 38% for high-income people (defined as having expenditures above the World Bank $US 5.50 per day poverty line.)

In all three cities in Table 1, car use is more prevalent among higher-income households, reflecting the costs of purchase and maintenance. In developing countries poorer residents may still rely on highways using low-cost motorcycles. There are also notable differences within a country. In a car-oriented city like Atlanta, car use accounts for more than 85 percent of trips for both high- and low-income people. By contrast, in New York City car use is lower overall, and the gap between income groups is larger, with higher-income households more likely to drive.

We do not emphasize walking and cycling in the paper, even though creating walking paths and bike lanes are increasingly common policy objectives. In Atlanta, the combined share of walkers and cyclists is similar across income groups, while in New York City and Buenos Aires it is higher among low-income residents. In the Appendix, Table A.2 presents additional evidence for the cities of Atlanta and New York (as opposed to their metropolitan

[4]The single-digit bus shares in both Atlanta and New York reflect not only the limited use of public transit in the United States, but how we split the data at the median rather than focus on the poorest households. The American Community Survery Briefs report that om 2017, median income in New York and Atlanta MSA were $75,368 and $65,381, `https://www.census.gov/content/dam/Census/library/publications/2018/acs/acsbr17-01.pdf`, retrieved on September 22^{nd} 2025. So using the 2017 NHTS brackets, "below median" most closely correspond to household incomes under $75,000.

areas), focusing on commute trips only, as well as alternative data on commute mode shares from the Census Transportation Planning Products (CTPP).[5] These alternative computations show that walking & bicycling shares are roughly the same in Atlanta and New York within city boundaries and when restricting to commute trips, making it less clear whether walking and cycling is really more common among poorer households in high-income countries. In low-income countries, however, walking and cycling is almost certainly more prevalent among poorer residents.

Highways Existing evidence on how highway construction affect the location choices of higher- and lower-income residents comes from the United States, in particular the construction of the Interstate Highway System (IHS). Car usage is now broad-based in the United States: in 2023, 70% of households in the lowest income quintile owned at least one car. This was less the case in the 1950s and 1960s when the Interstate Highway System (IHS) was built.[6] So the lessons from that era remain relevant for developing countries where major highway investments are currently being planned or implemented. Bagagli (2024) work on Chicago, along with studies by Weiwu (2024) and Mahajan (2024) on U.S. metropolitan areas, finds that the IHS increased Black–White segregation. This effect operated through three distinct mechanisms, the first two of which are specific to highways and the political context in which they were built. First, highways often acted as physical barriers between neighborhoods, reinforcing existing racial boundaries. Bagagli (2024) shows that highways in Chicago were deliberately routed along the boundaries between Black and White neighborhoods. Second, highways created disamenities in dense urban areas where they were less needed for transportation (Brinkman and Lin, 2024). Valenzuela-Casasempere (2025) documents how local government built urban highways disproportionately targeting Black neighborhoods, even though the 1947 federal plan did not have a racial bent after controlling for poverty. These routing decisions worsened living conditions in already disadvantaged areas, accelerating White flight to the suburbs. Black residents often lacked the means or legal ability to relocate (Weiwu, 2024), which further raised segregation and the concentration of poverty.

Finally, the IHS also contributed to segregation through a more general mechanism that applies across transportation modes: the placement of infrastructure and differences in mode usage. Cars were more commonly used by richer, often White, individuals. Highways disproportionately improved access to suburban areas, encouraging the affluent to move further out. So in the case of the IHS, the two main channels that shape location change in

[5] The city only vs whole metropolitan area comparison highlights variation in mode use within metropolitan areas (with transit and walking more prevalent in the city than in the suburbs). The comparison between two different surveys (NHTS and CTPP) highlight the difficulty of measuring mode shares consistently.

[6] Bureau of Transportation Statistics, `https://data.bts.gov/stories/s/Transportation-Cost-Burden-Transportation-Spending/v67s-yiqd/` retrieved on August 10th 2025.

response transportation, who uses the mode and where the infrastructure is placed, aligned in a way that increased segregation.

Transit Turning to how transit improvements affect location choices, Glaeser, Kahn, and Rappaport (2008) find that poverty rates increased within one mile of newly built rail stations in 16 large U.S. metropolitan areas, using data from 1980 to and 2000.[7] Pathak, Wyczalkowski, and Huang (2017) study Atlanta from 1970 to 2010 and also find that census tracts gaining bus stops between 1970 and 1990 became poorer in the long run. Heilmann (2018) study of a suburban light rail line in Dallas in the early 2000s finds that poorer neighborhoods receiving the line became poorer still, while richer neighborhoods that received a line became richer. One possible explanation is that poorer residents who previously needed to live in higher-income neighborhoods to access transit could relocate to poorer neighborhoods that gained access. These patterns of concentrated poverty and rising segregation following transit expansions fit the broader context of car-oriented cities like Atlanta and Dallas, where transit is used primarily by poorer residents.

Subways, in contrast, are typically faster than buses and attract a broader share of higher-income riders.[8] They are also more expensive to build. Lee (2022) shows that in early 20th-century New York, subway construction increased income segregation, and the city's 1916 zoning law exacerbated this segregation by assigning single family zoning to wealthy, white areas while permitting multi-family and industrial uses in lower-income, minority areas. As with the Interstate Highway System, this subway network gave local policymakers an opportunity to amplify segregation.

Recent studies of bus rapid transit (BRT) systems in developing countries also find that they increase segregation. A common rationale for investing in bus rapid transit (BRT) is that improved service quality can both enhance the bus system for its core low-income ridership and attract higher-income commuters who would otherwise drive. In Buenos Aires, Warnes (2024) finds that the BRT built in the 2010s led high-skilled residents to concentrate in already-affluent areas that gained better access, while their share in the poorest neighborhoods declined. Similarly, Tsivanidis (2023) finds that Bogotá's BRT, opened in 2000, drew high-skilled residents into neighborhoods with better market access, increasing residential segregation between low- and high-skilled residents.[9] As in the case of the IHS, higher-income people were more likely to relocate due to new BRT stations, either because of greater willingness or ability to move.

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[7] The one-mile radius makes these stations accessible on foot for poorer residents without cars. Kahn (2007) distinguishes between "Walk and Ride" stations in denser, more walkable neighborhoods and "Park and Ride" stations near parking facilities. He finds stronger signs of gentrification — rising house prices and college share — around Walk and Ride stations.

[8] For example, Akbar (2024*b*) finds that in cities with fast transit networks, higher-income commuters are the ones more likely to sort into the most transit-accessible residential locations.

[9] The segregation result appears in an earlier working paper version of this article.

Gentrification Gentrification is a type of relocation of particular interest. In the next section, our model illustrate theoretical cases in which transportation projects drive gentrification, which occurs when richer households move into poorer neighborhoods, which raises house prices and can hurt local residents. Gentrification can either reduce or increase segregation, depending on the share of rich people moving and that of poor people leaving. A key empirical issue in the gentrification literature is whether poorer residents are displaced, or simply replaced as they eventually move out. Gentrification with displacement is a special concern in the transportation context, because displaced poorer residents would bear moving costs without gaining from improved access. Considering first the broader gentrification literature - not necessarily due to transportation - it finds little evidence that poorer residents are displaced when richer residents move in.[10] Considering the impact of transportation projects in settings where gentrification might be more likely, such as developing countries where transit users often include richer residents, the evidence again points to limited effects. For example, Warnes (2024) in Buenos Aires and Balboni *et al.* (2020) in Dar es Salaam both track individual location through time following BRT installation, and neither find much evidence of displacement.[11]

Overall, the studies we reviewed consistently find that transportation improvements raise segregation. Evidence from different periods, modes, cities, and countries points to the same pattern. New infrastructure make some areas more or less desirable depending on preferences for access and ability to pay, which often vary by income. This leads to residential resorting. These effects are strongest when political decisions take advantage of sorting responses to deliberately reinforce segregation, as happened during the construction of the Interstate Highway System and the New York City subway. We do not interpret these results to mean that segregation is an inevitable outcome. The evidence is consistent with households responding to transportation improvements in ways that reflect their income and the location of the new infrastructure. So in principle, segregation could have declined if the Interstate Highway System had instead destroyed affluent neighborhoods and improved access primarily in poorer areas. Our model in the next section illustrates this possibility.[12]

[10] In the United States, gentrification tends to affect replacement more than displacement Ellen and O'Regan (2011). That is, low-income residents of gentrifying neighborhoods are generally no more likely to move than low-income residents of non-gentrifying neighborhoods. Beauregard (2024) also finds no evidence of displacement from gentrifying neighborhoods in Canada. A review of the urban planning literature on transit-oriented development and displacement of low-income residents Padeiro, Louro, and da Costa (2019) notes methodological challenges in establishing causal effects.

[11] In preliminary work, Balboni *et al.* (2020) find that higher-income individuals, defined as those above the World Bank poverty line, are more likely to have used the BRT in the last 7 days (38% vs. 26%). While rents rose near BRT stations, the share of higher-income residents did not, perhaps because rent increases were larger in the types of housing occupied by higher-income households.

[12] Theory suggests that for sufficiently large improvements in travel time, segregation will always rise as richer households concentrate in areas with better access. This could be the case for highway improvements, but empirical evidence from bus projects above shows that many transit improvements are not this special case.

2.2 *Welfare impact on the rich and poor*

Over the past decade, quantitative spatial models with detailed urban geography have become widely used. Building on Ahlfeldt, Redding, Sturm, and Wolf (2015) these models account for travel costs, amenities, and endogenous location choice. They are especially useful for measuring welfare gains from infrastructure investments (see Redding, 2025, for a review). Recent extensions with non-homothetic utility (Tsivanidis, 2023) allow researchers to study both how location choice and welfare vary across income groups. In the next section, we present a simplified two-neighborhood version of such a model.

Weiwu (2024) applies this class of model to study the impact of Interstate Highway System (IHS) on racial segregation and welfare. She finds that the IHS sharply raised welfare inequality. Highways were primarily used by richer, often While individuals, and improved access in areas where they lived, which raised welfare by almost 3% for White residents but reduced it by about 1% for Black residents. Features of the IHS that reinforced segregation also amplified its impact on inequality. Highways created disamenities by destroying parts of neighborhoods (often majority-Black) and leaving behind physical barriers and environmental degradation. Many Black residents could not move away from affected neighborhoods because of redlining, which accounts for much of their welfare losses.

In contrast, studies of Bus Rapid Transit (BRT) in developing countries find more equal welfare effects. Tsivanidis (2023) finds that both rich and poor residents of Bogotá benefited from the new BRT, with the rich gaining only slightly more. Low-skill individuals benefit mainly through increased BRT use, while high-skill individuals benefit through improved job access. Only 54% of total welfare gains come from travel-time savings; the rest arise from equilibrium effects through location changes. Tsivanidis (2023) also find that housing supply did not rise near transit station following highway construction, another example of zoning and the political process affecting location choice and welfare following a transportation improvement. Targeting more housing near BRT stations would have increased total welfare gains by 44% by allowing more people to relocate closer to stations. Indeed, if housing supply is not allowed to rise near stations, much of the gains from transit improvement might accrue to land owners through higher land values.

Warnes (2024), using a dynamic spatial model that tracks intra-city migration in Buenos Aires, finds that a new BRT system generated similar welfare gains of about 1% for high- and low-skilled incumbent residents living near the lines, and 0.6% over the entire city. This aggregate similarity hides substantial spatial variation: residents of the city's poorest neighborhoods—both high- and low-skill—saw net welfare gains more than twice as large as those in the richest areas. Once again, these spatial welfare patterns are tied to resorting. Specifically, the new BRT drove housing prices up in richer neighborhoods where the rich concentrated, which reduced the net gains for incumbents there.

Finally, Balboni *et al.* (2020) also find balanced overall welfare impacts, over the entire city, for low- and high-income residents of Dar es Salaam, Tanzania, following the construction of a BRT. The first line, connecting a wealthy area to downtown, favored higher-income residents; the second line favored lower-income residents. For residents living near these lines, the investment was actually overall pro-poor, with 3% welfare gains for the poor versus 2% for the rich. As in other cases, different station placement would have produced different welfare outcomes, but when stations are evenly distributed across rich and poor neighborhoods and use is broad-based, welfare gains tend to be broadly shared.

Overall, existing evidence on the welfare and inequality impacts of transportation improvements is mixed. Studies of BRT systems in developing countries suggest that when usage is relatively broad, investments are unlikely to affect welfare inequality much, provided stations do not overwhelmingly favor one group and people can move. The Interstate Highway System (IHS), by contrast, had special features that raised inequality: for instance highways were often routed through Black neighborhoods in inner cities where living near a highway is a disamenity. In all cases, mobility plays an important role in shaping outcomes. For the IHS, restrictions on Black residents' movement contributed to welfare losses; in the BRT cases, spatial mobility likely helped spread gains more evenly.[13] More generally, land-use barriers can limit the gains from transportation improvements not only by preventing people from moving to new opportunities, but simply by preventing new housing from being built near them.

3. Model

This section presents a model of travel mode and residential location choices, following the framework of Akbar (2024*a*). The model illustrates the types of underlying preferences that may drive the changes in location choice and welfare documented above. As in quantitative spatial models, households have idiosyncratic preferences for neighborhoods, but here we simplify by considering only two neighborhoods.

3.1 Setup

We model a closed city with two modes of travel, $m \in \{d, t\}$, two residential neighborhoods, $n \in \{1, 2\}$, and measure 1 of households of one of two types ($g \in \{L, H\}$): Λ households of type L and $(1 - \Lambda)$ households of type H. Household types differ in their incomes w_g and, consequently, in their value of travel time savings $\beta_g > 0$. Assume, without loss of generality, that $w_H > w_L$ and $\beta_H > \beta_L$. Additionally, households have idiosyncratic preferences ξ_{in} for

[13]Without spatial mobility, transportation improvements cannot affect segregation, and inequality impacts depend solely on placement and mode use. As shown in the next section, spatial mobility can mediate a trade-off between inequality and segregation by allowing more people to benefit. In practice, political factors can override this logic. In the IHS case, only Black residents faced mobility constraints, which contributed to raise both segregation and inequality.

residing in neighborhood n. Besides these idiosyncratic differences, neighborhoods also differ systematically in their (mode-specific) travel times to the city center τ_n^m and their housing prices p_n.

3.1.1 *Travel costs and travel mode choices*

Each household faces a continuum of trips, indexed by q, to the city center. For each trip, the household chooses to either drive ($m = d$) or ride transit ($m = t$) to minimize the following travel cost function:

$$\tilde{C}_{gn}(m) \equiv \beta_g \cdot \tau_n^m + \kappa^m - \gamma \cdot \mathbb{I}_{m=d} \tag{1}$$

which is the sum of the household's value of their time spent traveling, a mode-specific fixed cost κ^m, and a trip-specific preference γ for driving over transit. The γ reflects how one may find a trip sometimes more desirable on a private vehicle (such as when carrying enough bags to fill a car trunk) and at other times more desirable on mass transit (such as when parking is scarce). Assume the trip-specific preferences γ are drawn from independent and identical distributions with cumulative density function Ψ, and driving is faster than transit ($\tau_n^d < \tau_n^t$) but has a higher fixed cost ($\kappa^d > \kappa^t$). Then, minimizing the travel cost function in Equation 1 implies that the household chooses transit on trips where:

$$\gamma < \beta_g \cdot (\tau_n^d - \tau_n^t) + (\kappa^d - \kappa^t) \equiv \bar{\gamma}_{gn} \tag{2}$$

and the fraction of trips where the household chooses transit is $\Psi(\bar{\gamma}_{gn})$.

Equation 2 shows that transit ridership is high when driving travel times are high or transit travel times are low. Given that driving is faster than transit, transit ridership is higher among low-income households, who have a lower value of travel time (β_g). As the gap in travel times between driving and transit decreases, so does the difference in transit ridership between the household types. This distribution of driving and transit usage is consistent with the patterns documented in Table 1: high-income people use transit less than low-income people, and that difference is larger in cities like Atlanta where driving is much faster than transit.[14]

3.1.2 *Consumption and location choices*

Every household consumes a fixed unit of housing h and spends the rest of its income on consuming x units of some composite good at a (normalized) price of 1:

$$x = w_g - h \cdot p_n \tag{3}$$

[14] We do not see this pattern in Table 1 because transit use is very limited among both high- and low-income travelers in the Atlanta metropolitan area. In contexts where transit is more prevalent - for example, in the three New York vs Atlanta comparisons shown in Table A.2 of the Appendix (city only, commute only, and CTPP commute data) - the gap in bus use between low- and high-income travelers is wider in Atlanta than in New York City.

Subject to this spending constraint, each household i chooses consumption to maximize the following utility function:

$$U(x;\ \xi_{in}, \beta_g) = x - C_{gn}(\beta_g, \tau_n^d, \tau_n^t) + \xi_{in} \tag{4}$$

where C_{gn} denotes the aggregate travel cost (across all trips) from neighborhood n.

Plugging in the spending constraint (equation 3) into the utility function (equation 4) results in the following household indirect utility function:

$$V_{gn} + \xi_{in} \equiv w_g - h \cdot p_n - C_{gn} + \xi_{in} \tag{5}$$

Assuming idiosyncratic preferences for neighborhood 2 over 1, denoted by $\bar{\xi}_i \equiv (\xi_{i2} - \xi_{i1})$, are drawn independently from a distribution with c.d.f. F_g, a household of type g resides in neighborhood 1 if and only if

$$\bar{V}_g \equiv V_{g1} - V_{g2} \geq \bar{\xi}_i.$$

So, the fraction of households of type g residing in neighborhood 1 is $\bar{F}_g \equiv F_g\big(\bar{V}_g\big)$ and that in neighborhood 2 is given by $1 - \bar{F}_g$.

3.1.3 *Housing market equilibrium*

Without loss of generality, we define neighborhoods such that housing supply in each neighborhood is fixed at exactly half of the city's housing consumption.[15] For the housing markets to clear, aggregate housing demand must equal this housing supply in each neighborhood:[16]

$$h \cdot \big[\Lambda \cdot \bar{F}_L + (1 - \Lambda) \cdot \bar{F}_H\big] = \frac{1}{2} \tag{6}$$

and

$$h \cdot \big[\Lambda \cdot (1 - \bar{F}_L) + (1 - \Lambda) \cdot (1 - \bar{F}_H)\big] = \frac{1}{2} \tag{7}$$

3.2 *Segregation*

We now characterize how a transportation improvement affects the location choice of high- and low-income households across neighborhoods. We also define the conditions under which it raises residential segregation in the city.

[15] Making housing supply price elastic would not change how households sort across neighborhoods in response to a transportation improvement, unless the improvement also changes the price elasticity of housing supply, for instance due to changes in zoning regulations near new transit stops.

[16] Because total population in the city is constant (normalized to 1), the two housing market clearing conditions are equivalent. Any one of the market clearing equations 6 or 7 can be used to solve for $(p_2 - p_1)$, the housing price in neighborhood 2 relative to neighborhood 1.

3.2.1 *Residential neighborhood sorting*

Suppose we decrease τ_1^m, travel time by mode m to neighborhood 1. Then the fraction of type g households in neighborhood 1 shifts as follows:

$$\frac{d\bar{F}_g}{d\tau_1^m} = f_g \cdot \left(\frac{dp_1}{d\tau_1^m} - \frac{dC_{g1}}{d\tau_1^m} \right)$$

where f_g is the evaluation of the probability density function of the distribution of $\bar{\xi}_i$ at $\bar{V}_g$. Assuming the distribution is uniform, f_g is a constant. In the Appendix, we show that since housing prices rise when travel times drop ($dp_1/d\tau_1 < 0$) and households prefer lower travel times ($dC/d\tau > 0$), the effect on the share of type g households in neighborhood 1 depends on how the marginal utility of lower travel time compares to the marginal dis-utility from higher housing costs:

$$\frac{d\bar{F}_g}{d\tau_1^m} < 0 \Leftrightarrow \frac{dp_1}{d\tau_1^m} < \frac{dC_{g1}}{d\tau_1^m}. \tag{8}$$

So, the share of the household type that is most sensitive to travel times by mode m (i.e., with the largest $dC_{g1}/d\tau_1^m$) increases in neighborhood 1 while the share of the type that is least sensitive decreases.

So far these results are general to reduction in travel time by any mode m. We now review the impact of changes in either driving or transit time.

Proposition 1. When transit is slow enough relative to driving, marginal improvements in:

- driving time τ_n^d increases the neighborhood's share of high-income households.
- transit time τ_n^t increases the neighborhood's share of low-income households.

High-income households, with the highest value of travel time, are the most responsive to changes in driving time. Proposition 1 holds only if transit is slow enough, because once transit becomes faster, high-income households are also most responsive to transit improvements. It follows that:

Remark 1. Large enough improvements in either transit or driving travel times in a neighborhood necessarily increases the share of high-income households in that neighborhood.

3.2.2 *Residential segregation in the city*

We define segregation as $S \equiv \left|\bar{F}_H - \bar{F}_L\right|$, the difference in the share of high- and low-income households in neighobrhood 1.[17] Transportation improvements increase segregation when they attract more households of type g to the neighborhood that already has the highest share of type g households. So, it easily follows from Proposition 1 that:

Corollary 1. Suppose idiosyncratic preferences ξ of both high- and low-income households are drawn from the same distribution ($F = F_H = F_L$). When transit is slow enough relative to driving, marginal improvements in:

1. driving time to the high-income neighborhood or transit time to the low-income neighborhood increases income segregation.
2. driving time to the low-income neighborhood or transit time to the high-income neighborhood decreases income segregation.

As before, the result for transit improvements holds only if transit is slow enough that higher transit ridership among low-income households dominate higher value of travel time savings on the transit trips taken by high-income households. A large enough transit improvement, however, can transform the originally low-income neighborhood into the higher-income neighborhood, and even raise segregation beyond its original level.

Remark 2. Large enough improvements in either transit or driving travel times to any one neighborhood increases income segregation.

These theoretical results suggest two possible reasons why transportation improvements are generally observed to increase segregation. One is that projects reduce time saving by so much that they attract high-income households regardless of initial patterns (Remark 1). The other is that the kinds of projects that would reduce segregation, as in Corollary 1, rarely occur in practice. Given the evidence that poverty levels often rise near new bus or train stations in the U.S., it seems that transit projects typically do not lead to large enough time-saving to gentrify low-income neighborhoods. It is therefore more plausible that segregation-reducing projects are just uncommon. Transportation improvements tend to occur where households most likely to use that mode already live i.e., new highways are

[17]This definition of segregation is proportional to the commonly used dissimilarity index, which is the minimum fraction of the city's population that needs to relocate to achieve the same distribution of incomes in each neighborhood. In other words, the dissimilarity index measures how the fraction of households of each type in a neighborhood deviates from the fraction of all households residing in the neighborhood:

$$\text{Dissimilarity} \equiv \Lambda \cdot \left|\bar{F}_L - \frac{\eta_1}{h}\right| + (1-\Lambda) \cdot \left|\bar{F}_H - \frac{\eta_1}{h}\right| = 2\Lambda \cdot (1-\Lambda) \cdot \left|\bar{F}_H - \bar{F}_L\right| = 2\Lambda \cdot (1-\Lambda) \cdot S$$

where the second equality follows from substituting η_1/h from the housing market clearing condition.

built in suburbs where rich people live, and new bus stations in inner cities where poor people live. See Akbar (2024*a*) for a more complete characterization of the conditions under which transit improvements lead to higher income segregation.

Finally, the impact of transportation on segregation depends on the distribution of idiosyncratic neighborhood preferences $\bar{\xi}$. Stronger attachments to one's current neighborhood limit relocation in response to improved travel times or rising housing prices. This weakens the link between transportation improvements and segregation. If households of one type are less mobile than the other, such as poor households not being able to relocate away from new urban highways, then the segregation implications of driving improvement diverge from those of transit improvements.

3.3 Welfare

We now quantify how changes in travel time from $\tau \equiv \{\tau_1^d, \tau_1^t, \tau_2^d, \tau_2^t\}$ to $\tau' \equiv \{\tau_1'^d, \tau_1'^t, \tau_2'^d, \tau_2'^t\}$ affect welfare. We define welfare changes as the compensating variation in income, $CV_g(\bar{\xi}_i)$, needed for household of type g to maintain the same level of utility as before the travel time change. Let

$$\tilde{V}_{ig}(w_g; \tau) \equiv V_{gn^\star} + \xi_{in^\star}$$

denote the indirect utility of household i at their optimal neighborhood choice $n^\star$ given income w_g and vector of travel times τ. Then welfare change can be written as follows:

$$\begin{aligned} CV_g(\bar{\xi}_i; \tau, \tau') &= w_g - \tilde{V}_g^{-1}\big(\tilde{V}_g(w_g; \tau); \tau'\big) \\ &= -h \cdot (p'_{n'} - p_n) - \big(C_{gn'}(\tau') - C_{gn}(\tau)\big) + (\xi_{in'} - \xi_{in}) \end{aligned} \tag{9}$$

where p'_n is the price at which the housing market in neighborhood n is cleared at the new travel times τ'. Note that the original residential neighborhood $n \equiv n^\star(w_g; \tau)$ of the household may differ from their residential neighborhood $n' \equiv n^\star(w_g; \tau')$ after the travel time change. So, the change in welfare depends on changes in housing prices and travel times, but also on the household's latent neighborhood preferences ξ_{in} dictating where they reside initially and whether they relocate.

3.3.1 *Welfare gains depend on mode usage and residential location*

We first consider welfare changes for households who do not relocate ($n = n'$). Those households with larger reductions in aggregate travel costs C gain more. Because housing prices capitalize average gains, households with smaller reductions are worse off. Whether high- or low-income households benefit most again depends on whether transit times improve or driving times improve.

Proposition 2. Suppose transit is slow enough relative to driving. For households who remain in the same neighborhood, marginal improvements in:

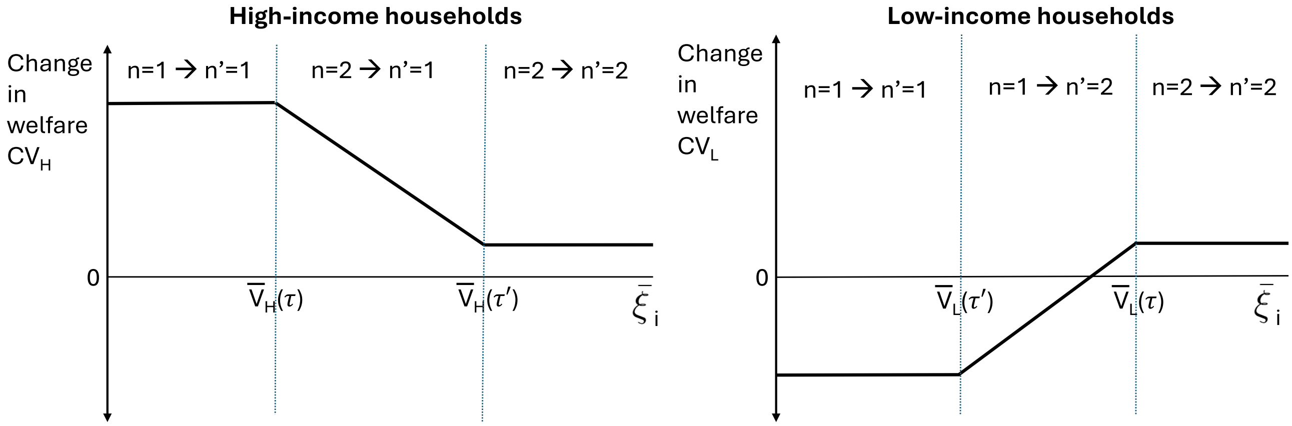

Figure 1: Change in welfare from improving driving travel time in neighborhood 1 as a function of $\bar{\xi}_i$, the household's idiosyncratic preference for neighborhood 2 over 1. Households with $\bar{\xi}_i \leq \bar{V}_g$ reside in neighborhood 1 and households with $\bar{\xi}_i > \bar{V}_g$ reside in neighborhood 2. Households with $\bar{\xi}$ between the dotted vertical lines relocate when the travel time improvement shifts $\bar{V}_g(\tau)$ to $\bar{V}_g(\tau')$.

1. their neighborhood's driving travel time:
   - increase their welfare it they are high-income, and
   - decrease their welfare if they are low-income.
2. their neighborhood's transit travel time:
   - increase their welfare if they are low-income, and
   - decrease their welfare if they are high-income.
3. travel time (by either mode) to the neighborhood they do not reside in:
   - increase the welfare of both high- and low-income households

The third statement of Proposition 2 follows from the fact that even if a neighborhood's own travel times do not improve, housing prices there fall as demand shifts toward the neighborhood that does benefit. Residents therefore gain in absolute welfare from lower housing costs, though their relative welfare may be lower than that of households who reside in the neighborhood with improved travel times.

3.3.2 Welfare gains depend on ease of relocating

We now consider welfare changes for households who relocate. Relocation allows households to benefit from travel time improvements in another neighborhood. Stronger idiosyncratic attachments raise relocation costs, so households with strong attachment to their original neighborhood benefit less from such improvements than households with lower relocation costs.

Figure 1 shows how welfare gains from improving driving times to neighborhood 1 vary with both income and relative idiosyncratic attachment to neighborhood 2 ($\bar{\xi}_i$). On the left of the figure ($\bar{\xi}_i = 0$), preference for neighborhood 1 is strongest. As $\bar{\xi}_i$ increases moving to the right, this preference weakens and gives way to preference for neighborhood 2. Recall that a household of type g resides in neighborhood 1 if and only if $\bar{\xi}_i \leq \bar{V}_g$. A reduction in driving times τ_1^d increases $\bar{V}_H$ and decreases $\bar{V}_L$, leading some high-income households to relocate to neighborhood 1 and some low-income households to relocate out of neighborhood 1.[18] The weaker a mover's attachment to their original neighborhood, the larger are their welfare gains (or the smaller their losses). Households with sufficiently strong attachment to their original neighborhood remain there and experience the welfare changes described earlier in Proposition 2. We show in the Appendix that movers benefit more (or lose less) than non-movers from either favorable transportation improvements in a different neighborhood or unfavorable transportation improvements in own neighborhood.[19]

3.3.3 Welfare gains depend on location of transportation improvements

Because relocation costs prevent some households from moving, they cannot take advantage of improvements in other neighborhoods. They also cannot avoid unfavorable effects in their own neighborhood, such as low-income people who rarely drive being hurt by rising house prices from lower driving times. The average distributional impact of a transport improvement therefore depends on where it is built.

Proposition 3. High-income households, on average, benefit more from driving and lose more from transit improvements in the high-income neighborhood. Low-income households, on average, benefit more from transit and lose more from driving improvements in the low-income neighborhood.

So as long as relocation is possible but costly, building transportation improvements where their primary users are concentrated increases segregation (see Corollary 1) but also raises the welfare of the targeted income group.

[18] While Figure 1 illustrates an improvement in driving times, an improvement in transit times in neighborhood 1 would instead produce welfare gains that increase in $\bar{\xi}_i$ for high-income households and decrease in $\bar{\xi}_i$ for low-income households. In other words, some low-income households would locate to neighborhood 1 while some high-income households would relocate out of neighborhood 1.

[19] Our model allows the distribution F_g of households' attachment to their original neighborhood (i.e., their relocation costs) to vary by type. So, for example, if low-income households typically have higher relocation costs than high-income households, they may lose more from driving improvements in the low-income neighborhood than high-income households would from transit improvements in the high-income neighborhood.

4. Conclusion

Our paper shows that simple factors help anticipate the impact of transportation improvements on location choices and welfare across income groups: who uses the mode, where the improvement is located, and how easily people can move. Projects that serve a specific group in a specific area, such as large parts of the Interstate Highway Systems and many new bus routes, tend to raise segregation and inequality. Projects with broader use and wider coverage, such as BRT in developing countries, likely generate more modest segregation effects and broader welfare gains.

People's ability to move in response to better travel access depends on other policies, including land use regulation. Allowing multi-family housing near new infrastructure, for example, increases the chances that poorer households share in the benefits. Since governments often use transportation projects to advance broader objectives, the political economy of project design, placement, and land use regulation remains an understudied research area (Glaeser and Ponzetto, 2018).

New data and methods also open other avenues for research on distributional impacts. Detailed geocoded panel data now allow researchers to track household location choices by income, and quantitative spatial models can measure welfare in general equilibrium. Extending these models to incorporate trip chaining, as in Miyauchi, Nakajima, and Redding (2021), could clarify whether differences in travel patterns between rich and poor have first-order welfare implications. These same tools can also inform current policy debates, for example by studying who gains when traffic lanes are removed to create walkable areas or bike lanes.

References

Ahlfeldt, Gabriel M., Stephen J. Redding, Daniel M. Sturm, and Nikolaus Wolf. 2015. The Economics of the Berlin Wall. *Econometrica* 83(6):2127–2189.

Akbar, Prottoy A. 2024*a*. Public transit access and income segregation. Forthcoming, *International Economic Review*.

Akbar, Prottoy A. 2024*b*. Who benefits from faster public transit? Helsinki GSE Discussion Papers 29.

Bagagli, Sara. 2024. The (express)way to segregation: Evidence from chicago. Working Paper.

Balboni, Clare, Gharad Bryan, Melanie Morten, and Bilal Siddiqi. 2020. Transportation, gentrification, and urban mobility: The inequality effects of place-based policies. Preliminary Version.

Baum-Snow, Nathaniel. 2007. Did highways cause suburbanization? *Quarterly Journal of Economics* 122(2):775–805.

Brinkman, Jeffrey and Jeffrey Lin. 2024. Freeway revolts! The quality of life effects of highways. *The Review of Economics and Statistics* 106(5):1268–1284.

Chetty, Raj, Nathaniel Hendren, Patrick Kline, and Emmanuel Saez. 2014. Where is the land of opportunity? The geography of intergenerational mobility in the united states. *Quarterly Journal of Economics* 129(4):1553–1623.

Couture, Victor and Jessie Handbury. 2023. Neighborhood Change, Gentrification, and the Urbanization of College Graduates. *Journal of Economic Perspectives* 37(2):29–52.

Ellen, Ingrid Gould and Katherine M. O'Regan. 2011. How Low-Income Neighborhoods Change: Entry, Exit, and Enhancement. *Regional Science and Urban Economics* 41(2):89–97.

Glaeser, Edward L., Matthew E. Kahn, and Jordan Rappaport. 2008. Why do the poor live in cities? The role of public transportation. *Journal of Urban Economics* 63(1):1–24.

Glaeser, Edward L and Giacomo AM Ponzetto. 2018. The political economy of transportation investment. *Economics of Transportation* 13:4–26.

Heblich, Stephan, Stephen J. Redding, and Daniel M. Sturm. 2020. The making of the modern metropolis: Evidence from London. *Quarterly Journal of Economics* 135(4):2059–2133.

Heilmann, Kilian. 2018. Transit access and neighborhood segregation: Evidence from the dallas light rail system. *Regional Science and Urban Economics* 73:237–250.

Kahn, Matthew E. 2007. Gentrification trends in new transit-oriented communities: Evidence from 14 cities that expanded and built rail transit systems. *Real Estate Economics* .

Lee, Sun K. 2022. Did the introduction of the subway promote racial segregation? Evidence from New York City. Job Market Paper.

Mahajan, Megha. 2024. Highways and segregation. *Journal of Urban Economics* 141.

Miyauchi, Yuhei, Kentaro Nakajima, and Stephen J. Redding. 2021. The economics of spatial mobility: Theory and evidence using smartphone data. Working Paper 28497, National Bureau of Economic Research. URL `https://www.nber.org/papers/w28497`. Revised July 2025.

Padeiro, Miguel, Ana Louro, and Nuno Marques da Costa. 2019. Transit-oriented development and gentrification: A systematic review. *Transport Reviews* 39(6):733–754.

Pathak, Rahul, Christopher K. Wyczalkowski, and Xi Huang. 2017. Public transit access and the changing spatial distribution of poverty. *Regional Science and Urban Economics* 66:198–212.

Redding, Stephen J. 2025. Evaluating Transport Improvements in Spatial Equilibrium. NBER Working Paper 33532, National Bureau of Economic Research.

Tsivanidis, Nick. 2023. Evaluating the impact of urban transit infrastructure: Evidence from Bogotá's transmilenio. Working Paper.

U.S. Department of Transportation, Federal Highway Administration. 2017 National Household Travel Survey. URL: http://nhts.ornl.gov.

Valenzuela-Casasempere, Pablo. 2025. Infrastructure provision and displacement: Evidence from the interstate highway system. Working Paper.

Warnes, Pablo Ernesto. 2024. Transport infrastructure improvements and spatial sorting: Evidence from Buenos Aires. Working paper.

Weiwu, Laura. 2024. Unequal access: Racial segregation and the distributional impacts of interstate highways in cities. Working Paper.

Appendix A. Data construction

1 Transportation modes of the rich and the poor

The analysis of modal shares by income group reported in Tables 1 and A.2 draws from three data sources: the 2017 National Household Travel Survey (NHTS; U.S. Department of Transportation), Warnes (2024), and the Census Transportation Planning Products (CTPP). Table A.1 show how we harmonize transportation modes into five categories (Car/Motorcycle, Bus, Subway, Walking/Bicycle, and Other).

National Household Travel Survey (NHTS 2017)

For the modal shares reported column 1 to 4 of Table 1, we create metropolitan statistical areas for New York–Newark–Jersey City, NY–NJ–PA (`https://data.census.gov/profile/New_York-Newark-Jersey_City,_NY-NJ_Metro_Area?g=310XX00US35620`, retrieved 23 September 2025) and Atlanta–Sandy Springs–Roswell (`https://censusreporter.org/profiles/31000US12060-atlanta-sandy-springs-roswell-ga-metro-area/`, retrieved 23 September 2025).[20] We assign each trip in the NHTS 2017 data to one of the five modal groups based on the TRPTRANS variable. Households with income below $75,000 are classified as low-income, while households with income above this threshold are classified as high-income. When compute aggregate modal shares within an income group by weighting each trip by individuals aged 18 or older using the "Final trip weight" provided in NHTS.

We also construct two additional trip samples reported in columns 1 to 8 of Table A.2. For the city-only results, we restrict to counties within the city proper (Bronx, Brooklyn, Manhattan, Queens, and Staten Island for New York City and Fulton and DeKalb counties

[20]This geographic matching requires the confidential geo-coded version of the NHTS. We thank Gilles Duranton, who has access to it, for producing these results.

for the city of Atlanta.) For the commute-only results, we use the WHYTO variable to select trip whose destination is "work".

Warnes (2024)

The modal shares reported in columns 5 and 6 of Table 1, from the metropolitan region of Buenos Aires, are those reported in Table I of Warnes (2024), based on the 2010 "Encuesta de Movilidad Domiciliaria" for people with and without a post-secondary education who are 18 or older.

Census Transportation Planning Products (CTPP)

As an alternative source of commute modal shares reported in columns 9 to 12 of table A.2, we use CTPP Table B103203 (Household Income in the Past 12 Months by Means of Transportation to Work) for cities of New York and Atlanta. Households with income below $75,000 are classified as low-income, while households with income above this threshold are classified as high-income. We compute modal shares as the share of commutes by each mode relative to the total number of commutes.

Table A.1: Harmonization of transportation modes across data sources

Harmonized Mode	**NHTS 2017**	**Warnes (2024)**	**CTPP**
Car / Motorcycle	Car, SUV, Van, Pickup truck; Motorcycle/Moped; RV (motor home, ATV, snowmobile); Taxi/limo (incl. Uber/Lyft); Rental car (incl. Zipcar/Car2Go)	Car/Motorcycle; Taxi	Car, truck, or van (drove alone, 2-person carpool, 3+ person carpool); Taxicab, motorcycle, or other means
Bus	School bus; Public or commuter bus; Private / Charter / Tour / Shuttle bus	Bus	Bus
Subway	Subway / elevated / light rail / streetcar	Subway	Subway or elevated rail; Light rail; Streetcar or trolley
Walking / Bicycle	Walk; Bicycle	Walk; Bicycle	Bicycle; Walked
Other	Golf cart/ Segway; Paratransit/Dial-a-ride; Amtrak / Commuter rail; Airplane; Boat / ferry / water taxi; Something else	Train; Other	Long-distance train; Commuter rail; Ferryboat

Table A.2: Mode Share by City and Income Group - City Only (%)

	NHTS City Only				NHTS City Only, Commute Only				CTPP City Only, Commute Only			
	Atlanta		New York		Atlanta		New York		Atlanta		New York	
Mode	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Car/Motorcycle	77.3	81.6	26.0	33.7	76.7	83.3	25.8	22.0	77.6	88.3	27.8	34.6
Bus	7.2	0.6	10.8	4.1	9.3	0.8	14.2	4.6	10.4	2.6	14.3	9.1
Subway	1.6	1.4	16.3	18.6	4.3	2.8	34.5	38.4	5.5	4.0	43.1	43.2
Walking/Bicycle	12.5	15.4	45.1	41.8	8.1	11.7	23.7	32.9	6.1	5.0	13.4	11.3
Other	1.3	1.1	1.8	1.8	1.5	1.4	1.8	2.1	0.4	0.1	1.5	1.8

Notes: Columns 1-8 use data from the National Household Travel Survey 2017 to report the shares of trips by different transportation modes in the Atlanta and the New York city proper, for households with income above and below $\$75,000$. Columns 1-4 sample all trips in the city proper of both cities. Columns 5-8 only use data for trips with their destination purposes as "work" in NHTS 2017. Columns 9-12 use data from the Census Transportation Planning Program 2017-2021 to report the shares of trips by different transportation modes in Atlanta and New York, for households with income above and below $\$75,000$. The sample of trips from the Census Transportation Planning Program is restricted to trips to work and within the city proper of two cities. Columns 1-8 show the shares for adults aged 18 and over. Columns 9-12 show the shares for adults aged 16 and over.

Appendix B. Model derivations

1 Travel costs

Households face the following aggregate travel cost across all trips from their neighborhood:

$$\begin{aligned} C_{gn} &\equiv \int_{\gamma_q} \tilde{C}_{gnq}(m^\star) \cdot d\Psi(\gamma_q) \\ &= \Psi(\bar{\gamma}_{gn}) \cdot (\beta_g \cdot \tau_n^t + \kappa^t) + [1 - \Psi(\bar{\gamma}_{gn})] \cdot (\beta_g \cdot \tau_n^d + \kappa^d) - \int_{\bar{\gamma}_{gn}}^{+\infty} \gamma_q \cdot d\Psi(\gamma_q) \end{aligned}$$

Let $\psi(\gamma)$ denote the probability density of γ. Then the marginal cost of higher transit travel times is:

$$\begin{aligned} \frac{dC_{gn}}{d\tau_n^t} &= \frac{d\Psi(\bar{\gamma}_{gn})}{d\tau_n^t} \cdot \Big[(\beta_g \cdot \tau_n^t + \kappa^t) - (\beta_g \cdot \tau_n^d + \kappa^d)\Big] + \beta_g \cdot \Psi(\bar{\gamma}_{gn}) - \beta_g \cdot \bar{\gamma} \cdot \psi(\bar{\gamma}_{gn}) \\ &= \beta_g \cdot \bar{\gamma}_{gn} \cdot \psi(\bar{\gamma}_{gn}) + \beta_g \cdot \Psi(\bar{\gamma}_{gn}) - \beta_g \cdot \bar{\gamma} \cdot \psi(\bar{\gamma}_{gn}) \\ &= \beta_g \cdot \Psi(\bar{\gamma}_{gn}) \end{aligned} \tag{B1}$$

Similarly, the marginal cost of higher driving travel times is:

$$\frac{dC_{gn}}{d\tau_n^d} = \beta_g \cdot [1 - \Psi(\bar{\gamma}_{gn})] \tag{B2}$$

2 Residential location sorting

2.1 Housing price effects of changes in travel times

Using the implicit function theorem on the housing market clearing condition in equation 6:

$$\frac{d\Delta p}{d\tau_n^m} = -\left[\Lambda \cdot \frac{\partial \bar{F}_L}{\partial \tau_n^m} + (1-\Lambda) \cdot \frac{\partial \bar{F}_H}{\partial \tau_n^m}\right] \cdot \left[\Lambda \cdot \frac{\partial \bar{F}_L}{\partial \Delta p} + (1-\Lambda) \cdot \frac{\partial \bar{F}_H}{\partial \Delta p}\right]^{-1}$$

We know from Equation 5 that

$$\frac{\partial \bar{F}_g}{\partial \tau_n^m} = \frac{\partial F(V_{g1} - V_{g2})}{\partial \tau_n^m} = (1 - 2\mathbb{I}_{n=2}) \cdot f \cdot \frac{\partial V_{gn}}{\partial \tau_n^m} = -f \cdot (1 - 2\mathbb{I}_{n=2}) \cdot \frac{dC_{gn}}{d\tau_n^m}$$

and $\frac{\partial \bar{F}_g}{\partial \Delta p} = f$. If we plug these into the expression for $\frac{d\Delta p}{d\tau_n^m}$ above, we get:

$$\begin{aligned} \frac{d\Delta p}{d\tau_n^m} &= (1 - 2\mathbb{I}_{n=2}) \cdot \left[\Lambda \cdot \frac{dC_{Ln}}{d\tau_n^m} + (1-\Lambda) \cdot \frac{dC_{Hn}}{d\tau_n^m}\right] \cdot \Big[\Lambda + (1-\Lambda)\Big]^{-1} \\ &= (1 - 2\mathbb{I}_{n=2}) \cdot \left[\Lambda \cdot \frac{dC_{Ln}}{d\tau_n^m} + (1-\Lambda) \cdot \frac{dC_{Hn}}{d\tau_n^m}\right] \end{aligned} \tag{B3}$$

Note that

$$\frac{d\Delta p}{d\tau_n^m} = \frac{d\Delta p}{dp_1} \cdot \frac{dp_1}{d\tau_n^m} = \frac{d\Delta p}{dp_2} \cdot \frac{dp_2}{d\tau_n^m}$$

So

$$\frac{dp_1}{d\tau_n^m} = -\frac{1}{h} \cdot \frac{d\Delta p}{d\tau_n^m} \text{ and } \frac{dp_2}{d\tau_n^m} = \frac{1}{h} \cdot \frac{d\Delta p}{d\tau_n^m} \tag{B4}$$

2.2 *Neighborhood sorting effects of changes in travel times*

Lemma 1. Decreasing travel time to a neighborhood n increases its share of type g households if and only if

$$\frac{dC_{gn}}{d\tau_n^m} > \frac{dC_{g'n}}{d\tau_n^m} \text{ for } g' \neq g$$

Proof We know from Equation 8 that decreasing travel time to a neighborhood increases its share of type g households if and only if

$$\begin{aligned} \frac{d\bar{F}_g}{d\tau_n^m} < 0 \Leftrightarrow & \frac{dC_{gn}}{d\tau_n^m} > -h \cdot \frac{dp_n}{d\tau_n^m} \\ \Leftrightarrow & \frac{dC_{gn}}{d\tau_n^m} > \Lambda \cdot \frac{dC_{Ln}}{d\tau_n^m} + (1-\Lambda) \cdot \frac{dC_{Hn}}{d\tau_n^m} \end{aligned}$$

where the inequality in the second line follows from Equations B3 and B4. So

$$\begin{aligned} \frac{d\bar{F}_L}{d\tau_n^m} < 0 \Leftrightarrow \frac{dC_{Ln}}{d\tau_n^m} > \frac{dC_{Hn}}{d\tau_n^m} \\ \text{and } \frac{d\bar{F}_H}{d\tau_n^m} < 0 \Leftrightarrow \frac{dC_{Hn}}{d\tau_n^m} > \frac{dC_{Ln}}{d\tau_n^m} \end{aligned} \tag{B5}$$

□

2.3 *Proof of Proposition 1*

Proof First, consider changes in driving travel times. We know from Lemma 1 and Equation B2 that

$$\frac{d\bar{F}_L}{d\tau_n^d} > 0 \text{ and } \frac{d\bar{F}_H}{d\tau_n^d} < 0 \Leftrightarrow \beta_L \cdot [1 - \Psi(\bar{\gamma}_{Ln})] < \beta_H \cdot [1 - \Psi(\bar{\gamma}_{Hn})]$$

Since β is larger and $\bar{\gamma}$ is smaller for high-income households, improving driving travel times increases the share of high-income households (and decreases the share of low-income households) in the neighborhood.

Similarly, for transit travel time changes, we know from Equation B1 that

$$\frac{d\bar{F}_L}{d\tau_n^t} < 0 \text{ and } \frac{d\bar{F}_H}{d\tau_n^t} > 0 \Leftrightarrow \beta_L \cdot \Psi(\bar{\gamma}_{Ln}) > \beta_H \cdot \Psi(\bar{\gamma}_{Hn})$$

In this case, improving transit travel times increases the share of low-income households in the neighborhood as long as transit is slow enough (and the transit ridership $\Psi(\bar{\gamma}_{Hn})$ of high-income households small enough) that

$$\frac{\beta_H}{\beta_L} < \frac{\Psi(\bar{\gamma}_{Ln})}{\Psi(\bar{\gamma}_{Hn})}$$

Otherwise, transit time improvements would also increase the neighborhood share of high-income households (like driving time improvements).

□

3 Segregation

Since the idiosyncratic preferences over neighborhoods are drawn from a uniform distribution with probability density f_g over its support, our measure of segregation can be rewritten as:

$$\begin{aligned} S &= \left| f_H \cdot (V_{H1} - V_{H2}) - f_L \cdot (V_{L1} - V_{L2}) \right| \\ &= \left| f_H \cdot (C_{H2} - C_{H1}) - f_L \cdot (C_{L2} - C_{L1}) \right| \end{aligned}$$

Note that segregation is proportional to the difference in relative travel costs.

3.1 Proof of Corollary 1

Proof Consider the derivative of S with respect to travel time:

$$\frac{dS}{d\tau_n^m} = (1 - 2\mathbb{I}[\bar{F}_H < \bar{F}_L]) \cdot (1 - 2\mathbb{I}[n = 1]) \cdot \left(f_H \cdot \frac{dC_{Hn}}{d\tau_n^m} - f_L \cdot \frac{dC_{Ln}}{d\tau_n^m} \right)$$

where

$$\left(f_H \cdot \frac{dC_{Hn}}{d\tau_n^m} - f_L \cdot \frac{dC_{Ln}}{d\tau_n^m} \right) = \begin{cases} f_H \cdot \beta_H \cdot [1 - \Psi(\bar{\gamma}_{Hn})] - f_L \cdot \beta_L \cdot [1 - \Psi(\bar{\gamma}_{Ln})] & \text{for } m = d \\ f_H \cdot \beta_H \cdot \Psi(\bar{\gamma}_{Hn}) - f_L \cdot \beta_L \cdot \Psi(\bar{\gamma}_{Ln}) & \text{for } m = t \end{cases}$$

First, consider changes in driving travel times. Since we assumed idiosyncratic preferences for high- and low-income households are drawn from the same distribution ($f_H = f_L$), we know that $f_H \cdot \beta_H \cdot [1 - \Psi(\bar{\gamma}_{Hn})] > f_L \cdot \beta_L \cdot [1 - \Psi(\bar{\gamma}_{Ln})]$. So, driving time improvements increase segregation ($dS/d\tau_n^d < 0$) if and only if either:

- $n = 1$ and $\bar{F}_L < \bar{F}_H$ (neighborhood 1 has more high-income households), OR
- $n = 2$ and $\bar{F}_L > \bar{F}_H$ (neighborhood 2 has more high-income households)

In other words, marginal improvements in driving time to the high-income neighborhood increases segregation. Equivalently, marginal improvements in driving time to the low-income neighborhood decreases segregation.

On the other hand, transit travel time improvements increase segregation if and only if one of the following holds true:

1. transit improvement in low-income neighborhood ($n = 1$, $\bar{F}_L > \bar{F}_H$ OR $n = 2$, $\bar{F}_L < \bar{F}_H$) and transit is sufficiently slow ($f_H \cdot \beta_H \cdot \Psi(\bar{\gamma}_{Hn}) < f_L \cdot \beta_L \cdot \Psi(\bar{\gamma}_{Ln})$)
2. transit improvement in high-income neighborhood ($n = 1$, $\bar{F}_L < \bar{F}_H$ OR $n = 2$, $\bar{F}_L > \bar{F}_H$) and transit is sufficiently fast ($f_H \cdot \beta_H \cdot \Psi(\bar{\gamma}_{Hn}) > f_L \cdot \beta_L \cdot \Psi(\bar{\gamma}_{Ln})$)

$\square$

4 Welfare

4.1 Welfare gains for neighborhood stayers (Proof of Proposition 2)

Proof Based on Equation 9, for households who do not move neighborhoods ($n = n'$), the change in welfare is:

$$CV_g(\bar{\xi}_i, \tau, \tau') = -h \cdot (p'_n - p_n) - \big(C_{gn}(\tau') - C_{gn}(\tau)\big)$$

Following a marginal travel time improvement on mode m,

$$\begin{aligned} CV_g > 0 \Leftrightarrow & \frac{dC_{gn}}{d\tau_n^m} > -h \cdot \frac{dp_n}{d\tau_n^m} \\ \Leftrightarrow & \frac{dC_{gn}}{d\tau_n^m} > \Lambda \cdot \frac{dC_{Ln}}{d\tau_n^m} + (1-\Lambda) \cdot \frac{dC_{Hn}}{d\tau_n^m} \end{aligned}$$

where the inequality in the second line follows from Equations B3 and B4 (just as in Section 2.2). So

$$\begin{aligned} CV_L > 0 \Leftrightarrow & \frac{dC_{Ln}}{d\tau_n^m} > \frac{dC_{Hn}}{d\tau_n^m} \\ \text{and } CV_H > 0 \Leftrightarrow & \frac{dC_{Hn}}{d\tau_n^m} > \frac{dC_{Ln}}{d\tau_n^m} \end{aligned} \tag{B6}$$

Note the resemblance between equations B5 and B6. The travel time improvements that benefit the type g stayers in a neighborhood are also the ones that increase the share of type g households in the neighborhood. So we can re-apply the logic of the proof of Proposition 1

First, consider improvements in driving travel times ($\tau_n'^d < \tau_n^d, \tau_n'^t = \tau_n^t$). We know from Equations B6 and B2 that

$$CV_H > 0 \text{ and } CV_L < 0 \Leftrightarrow \beta_L \cdot [1 - \Psi(\bar{\gamma}_{Ln})] < \beta_H \cdot [1 - \Psi(\bar{\gamma}_{Hn})]$$

Since β is larger and $\bar{\gamma}$ is smaller for high-income households, improving driving travel times always increases the welfare of high-income stayers (and decreases the welfare of low-income stayers) in the neighborhood.

Similarly, for transit travel time improvements ($\tau_n'^d = \tau_n^d, \tau_n'^t < \tau_n^t$), we know from Equation B1 that

$$CV_H < 0 \text{ and } CV_L > 0 \Leftrightarrow \beta_L \cdot \Psi(\bar{\gamma}_{Ln}) > \beta_H \cdot \Psi(\bar{\gamma}_{Hn})$$

In this case, improving transit travel times benefits low-income stayers in the neighborhood as long as transit is slow enough (and the transit ridership $\Psi(\bar{\gamma}_{Hn})$ of high-income households small enough) that

$$\frac{\beta_H}{\beta_L} < \frac{\Psi(\bar{\gamma}_{Ln})}{\Psi(\bar{\gamma}_{Hn})}$$

Finally, for travel time improvements in neighborhoods where the households do not reside (and will not relocate to), there are no changes in travel costs but lower housing prices (see Section 2.1). This leads to higher absolute welfare for both high- and low-income stayers in the neighborhood. □

4.2 *Welfare gains for neighborhood movers*

Lemma 2. Suppose transit is sufficiently slow relative to driving. The change in welfare CV_g from improving:

1. transit time in neighborhood 1 or driving time in neighborhood 2 is
   - (weakly) decreasing in $\bar{\xi}_i$ for low-income households
   - (weakly) increasing in $\bar{\xi}_i$ for high-income households
2. driving time in neighborhood 1 or transit time in neighborhood 2 is
   - (weakly) increasing in $\bar{\xi}_i$ for low-income households
   - (weakly) decreasing in $\bar{\xi}_i$ for high-income households

Proof First, for households who do not move neighborhoods ($n = n'$), their welfare change CV_g does not depend on their idiosyncratic neighborhood preferences $\bar{\xi}_i$. So, $\frac{\partial CV_g}{\partial \bar{\xi}_i} = 0$ for them.

For households who do move neighborhoods ($n \neq n'$) when travel time τ_1^m decreases in neighborhood 1, their change in welfare depends on costs that are invariant across households of a given type and idiosyncratic neighborhood preferences:

$$(\xi_{in'} - \xi_{in}) = \begin{cases} -\bar{\xi}_i & \text{if } n = 2 \text{ and } n' = 1 \\ +\bar{\xi}_i & \text{if } n = 1 \text{ and } n' = 2 \end{cases}$$

We know from Proposition 1 that when either τ_1^d or τ_2^t decreases, high-income movers move to neighborhood 1 ($n' = 1, n = 2$) and low-income movers move to neighborhood 2 ($n' = 2, n = 1$). So, welfare change is decreasing in $\bar{\xi}_i$ for high-income households and increasing in $\bar{\xi}_i$ for low-income households.

Similarly, when either τ_1^t or τ_2^d decreases, low-income movers move to neighborhood 1 ($n' = 1, n = 2$) and high-income movers move to neighborhood 2 ($n' = 2, n = 1$). So, welfare change is decreasing in $\bar{\xi}_i$ for low-income households and increasing in $\bar{\xi}_i$ for high-income households. □

4.3 Expected welfare gains by location of transportation improvement (Proof of Proposition 3)

Proof Without loss of generality, suppose neighborhood 1 has a larger share of high-income households and neighborhood 2 has a larger share of low-income households. Recall that a household of type g resides in neighborhood 1 if and only if $\bar{\xi}_i \leq \bar{V}_g$. So, when CV_g is increasing in $\bar{\xi}$, stayers in neighborhood 2 benefit more than movers to neighborhood 2, who benefit more than stayers in neighborhood 1. On the other hand, when CV_g is decreasing in $\bar{\xi}$, stayers in neighborhood 1 benefit more than movers to neighborhood 1, who benefit more than stayers in neighborhood 2.

So, Lemma 2 implies that improving driving travel time in neighborhood 1 benefits high-income stayers in neighborhood 1 more than high-income movers to neighborhood 1. Whereas, the exact opposite is true for improving driving time in neighborhood 2: high-income movers to neighborhood 2 benefit more than high-income stayers in neighborhood 1. Given neighborhood 1 already has a larger share of high-income households, on aggregate, high-income households benefit more from driving time improvements in neighborhood 1 than in neighborhood 2.

Lemma 2 also implies that improving driving travel time in neighborhood 1 benefits low-income stayers in neighborhood 2 more than low-income movers to neighborhood 2. Whereas, the exact opposite is true for improving driving time in neighborhood 2: low-income movers to neighborhood 1 benefit more than low-income stayers in neighborhood 2 (who experience a decrease in welfare). Given neighborhood 2 has a larger share of low-income households to begin with, low-income households lose more on aggregate from driving time improvements in neighborhood 2 than in neighborhood 1.

Analogous arguments hold for transit time improvements. $\square$