ERASMUS UNIVERSITY ROTTERDAM - Erasmus School of Economics

Bachelor Thesis Urban, Port, and Transport Economics

The Role of Transportation in Urban Sprawl: An Exploration into the Impacts on Poverty and Income Inequality in the United States

Name student: de Rijk, Ruari

Student ID number: 597941

Supervisor: Mingardo, Giuliano

Second assessor: Nefs, Merten

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Abstract

This paper studies the effect of transportation factors within urban sprawl on poverty and income inequality in metropolitan statistical areas in the United States. Urban sprawl is separated into the key aspects of distance traveled to work, the proportion of individuals who take public transportation to work, and the proportion of trips conducted by active transport. The dataset of a representative origin-destination national travel survey is combined with census data for the year 2022 to perform regression analyses. The results show a negative correlation between the distance traveled to work and the poverty rate, and no significant effect of distance on income inequality. They also showed that the proportion of individuals who take public transport to work is significantly positively correlated to the poverty rate and income inequality. Furthermore, the proportion of trips conducted by active transport is significantly negatively associated with the poverty rate and income inequality. The findings of this paper could be helpful in the development of city-level policy in the United States.

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Introduction

In recent years, much discourse in the United States has been surrounding the “15-minute city”. The concept, popularized as a vision for Paris has garnered much attention from American city planners and conspiracy theorists alike (Marcelo, 2023). The 15-minute city is a concept that envisions a city where all residents can meet most of their daily needs within a 15-minute walk or bike ride from their homes. This model of urban design prioritizes accessibility, mixed-use developments, and vibrant, localized economies, which foster more sustainable and resilient urban environments (Moreno et al., 2021). The 15-minute city concept exists to solve many of the problems plaguing modern cities, such as low walkability, a large climate footprint, traffic congestion, social inequalities, and isolation.

In stark contrast with the ideals of the 15-minute city concept is the pervasive issue of urban sprawl. Urban sprawl can be defined as “the rapid expansion of the geographic extent of cities and towns, often characterized by low-density residential housing, single-use zoning, and increased reliance on the private automobile for transportation.” (Rafferty, 2024). This phenomenon is fundamentally opposite to the ideals of the compact, integrated design principles of the 15-minute city because of the lack of mixed-use environments, walkability, and mid to high-density housing. Understanding the dynamics between these two urban models is crucial, especially in exploring how urban sprawl might exacerbate poverty and inequality.

A significant proportion of Americans lack basic public transportation infrastructure and walkable environments in the areas where they live. According to the American Public Transportation Association (APTA), approximately 45% of Americans have no access to public transportation (2023). Furthermore, even in metropolitan areas with public transit access, it often remains inadequate and inefficient. The overly spread-out nature of urban sprawl facilitates car dependency due to the increased distances between destinations being beyond walking distance. The need for a car makes it challenging for low-income individuals and families to access essential services, employment opportunities, and education (Sanchez et al., 2003) This car dependency can further entrench economic disparities because the costs associated with vehicle ownership impose a substantial financial burden.

Furthermore, the lack of public transportation and walkable neighborhoods in sprawling urban areas contributes to the cycle of poverty in several ways. Crucially, the spatial mismatch between affordable housing and job locations means that many low-income residents face increasingly long commutes to employment centers. Not only does it consume valuable time that could be spent on other productive activities but also incurs significant transportation costs. Kneebone and Holmes (2015) highlight that the urban poor often live far from job-rich areas and keep moving into suburbs further away. This exacerbates unemployment and underemployment rates among poorer populations.

Urban sprawl also impacts social mobility and education. As a result of the economic segregation brought about by urban sprawl, wealthier individuals tend to live in sprawling suburbs and poorer individuals reside in separate “pockets of poverty” (Nechyba & Walsh, 2004). Due to the funding of public schools in the United States being through property taxes, a significant disparity arises between the wealthier and poorer school districts. This disparity means that wealthier neighborhoods can afford better educational facilities and services. Despite state government efforts to close this gap, it is often insufficient (Leachman et al., 2017). Consequently, children from low-income families in pockets of poverty face inequities that hinder their long-term prospects, perpetuating the cycle of poverty across generations.

Another critical negative externality of urban sprawl is environmental degradation which disproportionately affects low-income communities. Sprawling developments often encroach upon natural habitats, increasing the risk of flooding and other environmental hazards, such as in Houston, Texas, where the building of suburban developments upon floodplains has reduced the city’s ability to absorb floodwaters and exacerbated the damages caused by hurricanes (Muñoz et al., 2018). Low-income residents are more likely to live in areas vulnerable to such risks, lacking the financial resources to relocate or protect their homes. Additionally, sprawled areas tend to have higher levels of air pollution due to increased vehicular emissions (Nechyba & Walsh, 2004), which can lead to respiratory illnesses and other health problems, further increasing poverty.

In contrast, the principles underlying the 15-minute city offer potential solutions to mitigate these issues. By promoting higher-density, mixed-use developments, cities can reduce the need for long commutes and car dependency, enhancing accessibility to jobs, education, and essential services. Improved public transportation networks and pedestrian-friendly infrastructure can lower transportation costs and improve health outcomes, contributing to a higher quality of life for all residents, especially those from low-income backgrounds. It is for these reasons this paper will seek to investigate and quantify the link between aspects of urban sprawl and poverty and inequality.

Research Question

How do transportation factors within urban sprawl contribute to poverty and income inequality in the United States?

Literature Review

Urban Sprawl and the Shape of Sprawl

A sizeable literature surrounds urban sprawl and its well-documented social and economic effects. Nechyba and Walsh (2004) define urban sprawl as “the tendency toward lower city densities as city footprints expand”. Their article examines the economic forces and trends behind urban sprawl, as well as analyses its consequences. Nechyba and Walsh state that urban sprawl arises due to market failures such as unpriced road developments and infrastructure costs to support suburban development. Furthermore, the authors state that another main driver of urban sprawl in the United States is due to rising incomes. Following the Monocentric city model (Alonso, 1964; Muth, 1969; Mills, 1967) where land rent is greatest in the central business district (CBD), as incomes rise demand for larger houses and more land increases, which leads consumers to move towards suburban development due to lower land prices than equivalent plots closer to the (CBD). Other key reasons for large amounts of urban sprawl are rapidly declining transportation costs, which come about through the relative affordability of automobiles compared to previous generations. As transportation costs decrease, the incentive to live near to the CBD decreases. Furthermore, as people can afford faster and more comfortable means of transportation, their tolerance to commuting increases. These factors combine to create urban sprawl. This, according to Nechyba and Walsh, creates significant negative externalities. These externalities include unproductive congestion on roads and high levels of metropolitan car pollution due to a large number of car commuters from the suburbs. Furthermore, urban sprawl facilitates “the loss of open space amenities, and unequal provision of public goods and services across sprawling metropolitan suburbs that give rise to residential segregation and pockets of poverty.” (2004).

However, not all economists believe that it is appropriate to study cities with the monocentric model of Alonso, Muth, and Mills. Newer economists, such as Angel and Blei (2016) postulate that the monocentric model of cities is no longer the best method of looking at cities. This arises because, in the United States, the share of metropolitan employment in CBDs has significantly declined. The majority of workplaces are no longer concentrated in traditional downtown areas; on average 3 out of 4 workplaces are outside employment centers. Their findings suggest a need to adapt to the new reality of urban living. The authors analyzed five different models to determine which is most appropriate for modern American cities, they found the constrained dispersal model to be the best fit for how Americans live and work. The constrained dispersal model is, in essence, a hybrid model of the monocentric, polycentric city model, the mosaic of live work communities model, & the maximum dispersal model. The model accounts for the weakening centripetal forces that historically concentrated jobs in CBDs and the inability of employment sub-centers to attract jobs that have left the CBD (2016). This model falls in line with the phenomenon discovered by Gordon and Richardson (1996), which incorporates the fact that the majority of jobs now disperse beyond both CBDs and sub-centers. However, unlike the Maximum Disorder model, which assumes complete job dispersal, the Constrained Dispersal model acknowledges that weak centripetal forces still exist, attracting jobs to shared infrastructure and amenities, thus constraining total dispersal. In this single metropolitan labor market, workers choose residential locations within a tolerable commuting distance of the best available jobs, balancing commute considerations with other residential preferences. Aguilera et al. (2009) further supports this by noticing a large increase in reverse commuting from the city center to work in more suburban regions. Furthermore, workplaces are dispersed across the metropolitan area to reduce land and building costs while remaining accessible to the labor force. While CBDs and sub-centers still attract a minority of workplaces, the vast majority are spread throughout the metropolitan area, necessitating urban planning that focuses on improving overall connectivity and accommodating dispersed patterns of employment and residences (Angel & Blei, 2016). This paper operates under the assumption that this model is valid.

The link between Urban Sprawl and Poverty

There is a sizeable literature that explores the connection between urban sprawl and negative socioeconomic outcomes. Olvera et al. (2003) analyze how urban sprawl and transport deregulation in Dar es Salaam, Tanzania deepen existing socioeconomic inequalities. The authors found that the city's growth with insufficient transportation availability particularly impacted the poor by forcing them into the neighborhoods with the worst urban facilities and are effectively unable to participate in the rest of the city's economy, furthering inequality in Tanzania's largest city.

Trukba et al. (2010) demonstrate that the current model of suburban expansion is inefficient and that substantial costs could be saved in infrastructure and transport if urban redevelopment became the focus. The authors also determine that American cities can receive minor healthcare savings-related benefits from active transport. Active transport is any transportation performed by physical activity such as walking or cycling. It is induced by denser and more connected urban environments. Moreover, if walkable developments were pursued in cities, those cities would see an estimated benefit to employment productivity of $34 million per 1000 dwellings (Trukba et al., 2010).

Thus, there is a clear body of work that examines the links between sprawl and its negative consequences, however, there is a sizeable gap in the literature measuring the direct link between urban sprawl and poverty and inequality and another gap in identifying how the different elements of sprawl relate to these negative socioeconomic outcomes.

Data and Methodology

To determine the effect of urban sprawl on poverty and inequality in the United States data must first be collected to determine the level of sprawl by metropolitan area. According to the constrained dispersal model, this would best be measured by the average distance taken to get to work (Angel & Blei, 2016). A Metropolitan Statistical Area (MSA) is defined by the United States Census Bureau as "a core area containing a substantial population nucleus, together with adjacent communities having a high degree of economic and social integration with that core" and that "Each metropolitan statistical area must have at least one urban area of 50,000 or more inhabitants." (2023). Therefore, MSA-level data is the most appropriate aggregation for regional economies because cities and towns right next to each other do not function independently (Angel & Blei, 2016) and should therefore be counted as one area.

To find the average distance traveled to work per MSA in the United States, data was retrieved from the 2022 National Household Travel Survey (NHTS), conducted by the U.S. Department of Transportation Federal Highway Administration. The survey contains origin-destination (OD) Data of "daily non-commercial travel by all modes, including characteristics of the people traveling, their household, and their vehicles." (Federal Highway Administration, n.d.). The dataset contains OD data for every MSA in the country and utilizes a representative sample to accurately depict trends across the country. Firstly, to study each MSA in isolation. Trips conducted between MSAs were dropped, so only trips where both the origin and destination MSA matched were kept. Secondly, trip totals from different states, but the same MSA were summed to measure the MSA as a whole not the specific portions in neighboring states.

The dataset contains the number of trips conducted for each mode, for work and non-work, and for each distance. The distance parameters are from 0-10 miles, 10 -25 miles, 25-50 miles, 50-75 miles, 75-100 miles, 150-300 miles, and 300+ miles. A weighted average distance per trip was created by multiplying the midpoint of each distance parameter by the trip count of the respective parameter, and then each of these multiples were summed before dividing the sum by the total number of trips. The 300+ mile range was not included in this calculation. This process was performed for both work and non-work trips. The equation is given below where i represents each distance category and n is the total number of distance categories.

$$Average\ Distance\ Traveled\ to\ Work = \frac{\sum_{i=1}^{n}(Midpoint\ Distance_i * Trip\ Count_i)}{Total\ number\ of\ Trips}$$

Following this process, data was retrieved from the United States Census Bureau for the year 2022. The dataset downloaded contains per MSA: the total population, the population under 100% of the poverty level, the population between 100% and 149% of the poverty level, and the population at or above 150% of the poverty level. The dataset also contains the means of transport to work for both the total and each stated poverty level band. The proportions of people in each income band were derived by dividing the number in each band for each MSA, by the total population of the respective MSA.

It must be noted that the specific means of transport are grouped differently among the Census dataset and the NHTS data; specifically, the NHTS data concerns four modes of transport. The four modes of transport measured by the NHTS are air travel, which measures the distance between airports by airplane. Rail travel, which includes the total distance of all legs of a journey, which the main segment of the trip was by rail. Vehicle travel, which does not distinguish between private car, bus, motorcycle, or vehicle passenger, also includes the distance of all legs of the journey if the main segment of the trip was by vehicle. For both vehicle and rail trips the distance is determined by “The sum of all road segment lengths along a reconstructed trip path based on the map-matching and routing algorithms” (Federal Highway Administration, 2023). Active transport/ ferry is the length of the journey performed by any other means than the other categories, predominantly walking or cycling.

On the other hand, the Census data contains a different methodology, where the specific distance of trips is not measured, but the mode of transport is captured in more detail. This proves useful in determining modal splits for trips going to work. The specific modes of transport measured are, car/van/truck (drove alone), car/van/truck (carpooled), public transportation, walked, taxicab/motorcycle/bicycle/other, and worked from home. (Census, 2022). From this dataset, the proportions of people who took each mode to work were calculated for each MSA.

Another data set containing the Gini Index scores for each MSA was taken from the US Census Bureau. Gini Index scores measure the income distribution of a place on a scale from 0 to 1 where 0 represents perfect equality and 1 represents perfect inequality where one person has all the income. This score can be used to calculate the effect of urban sprawl on income inequality.

Using these datasets the effects of urban sprawl on both inequality and the poverty rate will be measured. Four key variables that capture a transport-related element of urban sprawl were chosen to analyze the association between each element and poverty & income inequality. Firstly, the average distance traveled to work is the key independent variable of study. The distance traveled to work (in miles) should be the key variable measuring the level of urban sprawl according to the constrained dispersal model of Angel and Blei (2016). Secondly, the effect of a city's population on poverty rates and inequality will be controlled. This is because there may be stark contrasts between the large metropolis of the New York-Newark-Jersey City MSA and the lesser-populated MSA of Flagstaff, Arizona. This is due to existing agglomeration effects which can best be proxied by population (Glaeser & Gottlieb, 2009). Thirdly, the proportion of people who use public transport to get to work will be controlled, because this gives insight into the availability and use of public transportation of each MSA, because this shows the effect of cities with more comprehensive or more popular public transportation networks. Lastly, the proportion of trips conducted by active transportation, which is mostly cycling and walking, is used as an independent variable. This is because the proportion of trips done on foot or by bike is indicative of an environment where people are not far from their workplace and feel safe enough to walk or cycle there.

Data Analysis and Results

It is crucial to control for multicollinearity in a regression analysis. This is done using the Variance Inflation Factor (VIF). High VIF values are indicative of a substantial degree of collinearity among the predictors. This may result in unstable and unreliable coefficient estimates, inflated standard errors, and diminished statistical significance of the predictors. Such multicollinearity complicates the interpretation of the regression model, rendering it difficult to isolate and determine the individual effects of each predictor on the dependent variable. By checking for the absence of multicollinearity present through VIF, it can be ensured that the regression model produces results that are both accurate and interpretable. This methodological rigor is essential for maintaining the validity and reliability of the statistical inferences drawn from the analysis. A VIF score of less than 10 is considered sufficient (Kutner, 2005).

Table 1

Variance Inflation Factor Test for Key Variables

	VIF	1/VIF
Population	2.995	.334
Proportion Public Transport	2.562	.39
Average Distance Traveled to Work	1.76	.568
Proportion Trips ATF	1.448	.691
Mean VIF	2.191	.

Table 1 above shows the VIF values for the predicting variables of the regression analysis. There is universally low multicollinearity, which means that the variables can be interpreted independently of each other and accurately.

Descriptive Statistics

After ensuring sufficiently low multicollinearity, examining the variables used to study helps understand the environment being researched.

Table 2

Descriptive Statistics for Sample Data

Variable	Obs	Mean	Std. Dev.	Min	Max
Gini Index	379	.461	.026	.392	.543
Proportion Below Poverty Line	323	.065	.024	.019	.169
Population	323	422276.92	896760.12	36505	9700467
Average Distance Traveled to Work	379	7.78	.989	5.095	10.998
Proportion Public Transport	323	.01	.017	0	.24
Proportion Trips ATF	379	.125	.036	.067	.265

Table 2 above shows the descriptive statistics of the chosen independent and dependent variables. What can be considered particularly striking is the level of public transport use in the United States, with a mean of 1% of trips to work being conducted by public transport. Another striking figure is the distance traveled to work on average, being 7.78 miles. This is a significantly large distance that is far out of walking range or cycling range for most people.

Regression Formulae

To determine the effect of Urban Sprawl on poverty and inequality, six linear regression models were created. The first three study the correlation between the chosen independent variables that measure different aspects of urban sprawl and the percentage of the population under 100% of the poverty level. The next three investigate the link between the same independent variables and the level of income inequality as measured by the Gini coefficient. It is important to note that the regression functions shown are not causal but still indicative of the relationship between variables.

The first linear regression model only demonstrates the correlation between the proportion of individuals under 100% of the poverty line and the average distance traveled to work.

$$Proportion\ Below\ Poverty\ Line = \beta 0 + \beta 1 * Average\ Distance\ Traveled\ to\ Work + \varepsilon$$

The second regression model includes the population of the MSA to control for the effect larger population sizes may have on the poverty level.

$$Proportion\ Below\ Poverty\ Line = \beta 0 + \beta 1 * Average\ Distance\ Traveled\ to\ Work + \beta 2 * Population + \varepsilon$$

The third model adds the transport modes used as explanatory variables, the proportion of trips made via active transport, and the proportion of people that take public transportation to work are added to the linear regression model. These variables capture the effects of modal choice and availability and their impact on poverty.

$$Proportion\ Below\ Poverty\ Line = \beta 0 + \beta 1 * Average\ Distance\ Traveled\ to\ Work + \beta 2 * Population + \beta 3\ Proportion\ Trips\ ATF + \beta 4\ Proportion\ Public\ Transport + \varepsilon$$

Following the construction of these linear regression models, these same models are repeated, but instead focused on a new dependent variable. The new dependent variable is the income inequality of the MSA as measured by the Gini coefficient. Hence, the regression models are as follows.

$$GINI\ Index = \beta 0 + \beta 1 * Average\ Distance\ Traveled\ to\ Work + \varepsilon$$

$$GINI\ Index = \beta 0 + \beta 1 * Average\ Distance\ Traveled\ to\ Work + \beta 2 * Population + \varepsilon$$

$$GINI\ Index = \beta 0 + \beta 1 * Average\ Distance\ Traveled\ to\ Work + \beta 2 * Population + \beta 3\ Proportion\ Trips\ ATF + \beta 4\ Proportion\ Public\ Transport + \varepsilon$$

Regression Models

Table 3

Regression Analysis on the Effect of Urban Sprawl on the Poverty Rate

VARIABLES	(1) Model 1 Proportion Below Poverty Line	(2) Model 2 Proportion Below Poverty Line	(3) Model 3 Proportion Below Poverty Line
Average Distance Traveled to Work	-0.00527***	-0.00328**	-0.00613***
	(0.00124)	(0.00155)	(0.00172)
Population		-4.18e-09***	-5.67e-09**
		(1.56e-09)	(2.49e-09)
Proportion Trips ATF			-0.242***
			(0.0417)
Proportion Public Transport			0.333***
			(0.111)
Constant	0.106***	0.0925***	0.143***
	(0.0104)	(0.0123)	(0.0162)
Observations	323	323	323
R-squared	0.047	0.065	0.162

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Regression analysis was performed on two dimensions of poverty. The poverty rate and the level of income inequality as measured by Gini index. Table 3 shows the results of regression analysis on the poverty rate as measured by the fraction of the population below 100% of the poverty line. The table shows the results of three separate regressions, firstly only the distance to work is used. Secondly, the distance to work and population of the MSA are used in the regression model. Lastly, the proportion of individuals who take public transportation to work and the proportion of trips that were made via active transportation were factored into the equation. Table 3 shows that as the average distance traveled to work increases, the percentage of people below the poverty level decreases, model three estimates that as the average distance traveled to work increases by a mile, the poverty rate for the MSA is approximately 0.6% lower. This is a very impactful finding that goes contrary to the findings of Kneebone & Holmes (2015) where it was expected that increased work distances would increase poverty. Furthermore, the population of the MSA is found to have a negative impact on the fraction living under the poverty line, with models 2 & 3 showing significantly that as the population increases, the percentage of individuals living under the poverty line decreases. Lastly, model 3 shows that the modes of transport also play a role in the level of poverty. Model 3 demonstrates that in an MSA the more people who use public transport to get to work, the higher the fraction of the population under the poverty line. Conversely, the number of trips made by active transport in an MSA is associated with a lower fraction of people below the poverty line.

Table 4

Regression Analysis on the Effect of Urban Sprawl on Income Inequality

VARIABLES	(1) Model 1 Gini Index	(2) Model 2 Gini Index	(3) Model 3 Gini Index
Average Distance Traveled to Work	0.00519***	0.00180	0.00198
	(0.00112)	(0.00140)	(0.00175)
Population		4.76e-09***	-0
		(1.14e-09)	(2.66e-09)
Proportion Trips ATF			-0.0964**
			(0.0478)
Proportion Public Transport			0.388***
			(0.132)
Constant	0.420***	0.446***	0.455***
	(0.00919)	(0.0112)	(0.0169)
Observations	379	323	323
R-squared	0.039	0.044	0.074

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 uses the same independent variables as Table 3 but studies their effect on the Gini index score of the MSAs. When population and transport modes are taken into account, there is no significant association found of the average distance for a work trip on the level of income inequality of an MSA in the United States. Similarly, Model 3 shows that the population also has no significant correlation with income inequality of an MSA. Transportation modes, however, are shown to significantly affect income inequality. The proportion of trips conducted via active transport is significantly linked to a lower level of income inequality, with a higher proportion of trips being walked or biked, being associated with lower levels of income inequality. On the other hand, the proportion of people who take public transportation to work is significantly positively related to income inequality. Meaning that the more people who take public transportation to work, the higher the level of income inequality as measured by Gini index in the MSA.

Discussion

Distance Traveled to Work

The results of the linear regression models provide interesting insights into how the different aspects of urban sprawl impact poverty. Some results are surprising whereas others are more consistent with the literature. Firstly, and most surprisingly, the distance traveled to work is significantly negatively correlated with the poverty rate. According to Model 3 of Table, an MSA that has an average of an extra mile traveled to work would have a 0.6% lower poverty rate than another MSA with other characteristics being identical. This goes directly against much of the previously discussed scientific literature that relates urban sprawl to negative externalities, such as Kneebone and Holmes (2015) who find that the urban poor live and are continuously moving away from job-rich areas, towards suburbs further away.

Scientific literature like that of Kneebone and Holmes (2015) would suggest that lower travel distances to work would be correlated with lower levels of poverty. However, this does not mean the results are unexplainable. According to the constrained dispersal model of Angel & Blei (2016), urban sprawl is best measured by travel distances to work. Following from this Engelfriet & Koomen find that “large cities without clear clusters of businesses and other facilities have longer average commuting times and distances” (2018). Their findings support the model of Angel and Blei by following the definition of their constrained dispersal model. Considering that cities in the United States are best described as having no clear CBD and business clusters (Angel & Blei, 2016). It is appropriate to apply the findings of Engelfriet & Koomen to American cities as well. Engelfriet & Koomen find that increased prosperity in a city facilitates “longer and lengthier commutes” (2018). This serves as a potential explanation for how cities with larger commutes have less poverty.

Table 4, Model 3 suggests that the distance traveled for work has no significant effect on inequality. The MSA level data that was used to study the effects perhaps was not sufficiently low level to measure the "pockets of poverty" described by Nechyba & Walsh, (2004) that arise with increased urban sprawl. Furthermore, it is possible that urban sprawl, measured by distance traveled to work, does not create more inequality, but rather increases segregation among those of different income groups.

Population

Table 3, Models 2 and 3 indicate that the population of an MSA is significantly negatively correlated with the poverty rate. However, the total effect of population on a city's poverty rate is quite small. Table 3, Model 3 estimates that an MSA with an increase in population of 1 resident would only cause a 5.67e-09% decrease in the poverty level. This means that an MSA with an additional million residents would receive a 0.567% reduction in the poverty rate. Only 92 of the 379 studied MSAs in the United States contain more than a million residents. Considering this it can be reasoned that while the agglomeration effects described by Glaeser & Gottlieb (2009) are in effect, they do not seem to play a large role in the prediction of the poverty level.

Furthermore, Table 4, Model 3 implies that the population of an MSA has no effect whatsoever on the level of income inequality. This may seem counterintuitive. If larger cities with diversified and specialized economies benefit from agglomeration effects, then it may be expected that population size would play a role in determining the level of income inequality among MSAs. However, Ganong & Shoag conclude that the rate of income convergence among states has declined in the previous thirty years due to a "disproportionate increase in housing prices in high-income places, a divergence in the skill-specific returns to moving to high-income places, and a redirection of low-skill migration away from high-income places" (2017). This house price increase in high-income areas, in combination with high-skilled labor receiving higher wages, and low-skilled labor moving towards cheaper areas, creates wage homogenization among areas. Meaning that the population of an MSA is not useful in determining the level of inequality of the MSA but would be better in determining the income of the area.

Active Transport

Active transportation is shown to be significantly negatively correlated with both the poverty rate and income inequality. Where the higher the proportion of trips that were conducted on foot, by bicycle, or by ferry, the lower the percentage of people below the poverty line and the lower the level of income inequality in the Metropolitan Statistical Area. Table 2, Model 3 shows that an MSA where every trip is conducted by active transport will have 24.2% fewer people under the poverty line compared to an otherwise identical MSA where no trips are conducted by active transport. This falls perfectly in line with the expectations set by the literature of Moreno et al. (2021) with their description of the 15-minute city and its effect on the local economy. The MSAs in the United States with greater levels of walkability and cyclability are shown to have a significant correlation with the reduction of both poverty and inequality. Furthermore, this finding supports the findings of Trukba et al. (2010) where they found large benefits to employment productivity as a result of walkable developments.

However, another reason for the reduction of poverty and inequality in more walkable MSAs could come through another mechanism. Walkable developments increase the property values of the areas where they are located and increase the amenity value of the area (Gilderbloom et al., 2015). This increase in the price of housing could drive out poorer residents, who would migrate to other, cheaper areas. This would still reduce the poverty rate and income inequality of the MSA, but through a different mechanism where those below 100% of the poverty line move elsewhere, and as a result income inequality is also reduced in the MSA where the poor migrated away from because those in poverty no longer factor into the calculation of the Gini coefficient of the MSA.

Public Transport

The proportion of people who take public transportation to work is shown by Table, 3 Model 3, and Table 4, Model 3 to be significantly positively associated with both the poverty rate and income inequality. Where the higher the percentage of individuals in an MSA who take public transportation to work, the higher the percentage of people below the poverty line, and the higher the level of income inequality in the MSA. Taken at face value, this seems surprising, a higher percentage of people taking public transportation should be an indicator of a well-functioning public transportation system that should lower transportation costs and facilitate easier access to employment. However, as previously mentioned, many metropolitan areas lack adequate and efficient public transportation access (APTA, 2023). This fundamentally changes public transportation from a desired mode of transportation that allows users to easily and cheaply get from place to place, to a transport mode of last resort for those who do not own a car. Globally, higher incomes are associated with higher rates of car ownership (Dargay et al. 2007). Because the transportation systems of many MSAs are inadequate, the users would only be the ones who cannot afford the better alternative in a car. This supports the observations of Olvera et al. (2003), that a city with insufficient transportation availability impacts the poor leaving them effectively unable to participate in the rest of the city's economy, which furthers both poverty and inequality. Therefore, in many MSAs the use of public transportation to get to work does not increase poverty, it is a result of it.

Alternatively, another potential mechanism whereby the proportion of people who use public transportation may increase inequality in an MSA is through property values. Within cities, homes within closer proximity to public transportation lines have greater property values than other homes further away (Li et al., 2019; Zhang et al., 2021). This means that wealthier individuals are able to take residence in homes with the easiest access to jobs and other places, while poorer individuals cannot as easily reach the same areas. In the instance that the number of people who take public transportation to work is indicative of an efficient network, it would increase the level of income inequality in the MSA because the poorer individuals have worse access to jobs compared to the wealthier individuals who can afford the easy access to the network. However, this would not be universally applicable, this would be applicable to cities where the public transport frequency and efficiency is good, but the range of the network is lacking. Therefore wealthy individuals can access reliable transport to key areas of the city, but poorer residents outside the network's range are left without access.

Conclusion

The findings of this paper have shown significant associations between the transport factors within urban sprawl and poverty and income inequality. This paper has identified how the different aspects of urban sprawl are correlated with poverty and income inequality and explored the causal pathways through which these effects may happen. Firstly, it was found that the distance traveled to work has no significant effect on income inequality. More importantly, it was found that a longer average commute to work is associated with a higher level of income. As people being farther from work reducing poverty is contrary to the academic literature (Kneebone & Holmes, 2015) it is probable that the association is not caused by longer commute times reducing poverty, but rather the residents of wealthier MSAs driving greater distances (Engelfriet & Koomen, 2018).

Furthermore, this paper has found that the use of public transportation to get to work is significantly positively associated with the poverty rate and income inequality. This is likely due to the underfunding and ineffectiveness of these systems across the country (APTA, 2023), that they become a mode of transport for only the poorer residents. Meaning that the number of people taking public transportation doesn't increase poverty in the MSA, but rather, the more people under the poverty line in the MSA, the higher the percentage that takes public transportation to work. Moreover, because the public transportation is of poor quality it further isolates the poor who must take it, leaving them excluded from the local economy, increasing poverty and inequality (Olvera et al.,2003)

The last key finding is that the number of trips conducted via active transport is significantly positively correlated with lower levels of poverty and inequality. Where the more trips conducted by walking or cycling, the lower the level of poverty and income inequality. This can be attributed to the economic benefits of more walkability outlined by the principles of the 15-minute city (Moreno et al., 2021) and the employment productivity benefits incurred by pursuing more walkable developments (Trukba et al., 2010).

Policy Recommendation

The research from the literature and the data identifies one clear policy recommendation for American city and state governments to take into consideration. Crucially, further investment into the walkability and cyclability of neighborhoods and cities would be beneficial to local economic health and is likely to reduce poverty and income inequality in the areas where these investments are pursued. This conclusion is reached based off of both the empirical research in this paper as well as the literature findings such as that of Trukba et al. (2010).

Suggestions for Future Research

Due to the nature of the data required to analyze how people move within cities, it is difficult to find causal links that overcome omitted variable bias. There were many aspects of sprawl that are still to be studied. There were also limitations to this paper, naturally omitted variable bias was present, however, more explanatory variables were not included to avoid overfitting the data. Furthermore, the weighted average estimations of distance traveled for work studied were not representative of the true distances traveled by individuals in each MSA but were useful to rank MSAs by sprawl level. It is probable that the distance traveled to work significantly overestimates the average distance traveled for most MSAs because the arbitrary assignment of the midpoint of each distance band is likely higher than the real distribution, especially for the higher distance bands, such as the 25-50 miles, 50-75 miles, 75-100 miles, and 150-300 miles bands. This would be because the distances traveled would not be uniformly distributed. And especially at the higher bands the frequency of observation at every mile marker would probably decrease the entire range. To fix this it would be useful to use data that gave the accurate distance of every individual in an MSA to observe the effect of distance on individuals or to use the actual average distances to compare MSAs.

Local and state governments should research whether public transportation requires more funding and better oversight to increase the efficacy and access of the public transportation networks. This could create greater access for the poor to jobs, potentially reducing poverty (Olvera et al., 2003). Furthermore, by bettering the public transportation networks, they may become more than the last choice of the desperate and will have knock-on benefits in reducing congestion allowing younger people with fewer resources freedom of movement within the cities.

It would be useful to replicate this study for cities in a European country or an East Asian country where the data is able to be acquired, and where a greater difference can be found in the modal distributions of transportation among the different cities on the continents. In Europe and East Asia, there is significantly less car use, more public transportation use, and more active transport use compared to the US and Canada (Prieto-Curiel & Ospina, 2024). The greater variability in modal splits would serve as a richer data pool because there are more significant differences to study.

Another area for future research would be to see how time series or panel data would affect the results of the study. The NHTS NextGen National Passenger OD Data survey, from which this paper studied, has data for 2020, 2021, and 2022. The reason time series data was not done for this paper was because of the small timeframe and how the COVID-19 pandemic may have disrupted the data. However, it may be interesting to use panel data measuring the mode and distances of trips over time of the different MSAs to see their effect on poverty throughout 10 to 20 years.

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