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THE IMPACT OF URBAN SPRAWL ON JOURNEY TO WORK TIMES FOR MASS TRANSIT AND ALL OTHER COMMUTERS IN THE UNITED STATES: A RESEARCH NOTE

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ABSTRACT

As government budgets get tighter, there has been considerable public outcry about the continued investment in public mass transit systems and their financial viability. Amid this outcry, a number of studies have been conducted to determine which factors influence the use and efficiency of publicly-funded mass transit systems. These factors include population density and less sprawl (or greater urban compactness). However, their impact on mass transit usage is somewhat contradictory in that the heavy concentration of populations in the urban area and greater compactness is believed to increase mass transit usage due to a bigger number of potential passengers. In fact, greater compactness and greater transit ridership have played a role in lengthening the journey to work for most commuters and thus discouraged the use of mass transit systems. Thus, some questioned the wisdom of mass transit subsidies and "smart growth" policies. To attempt to answer this question and avoid any further confusion, this paper examines how urban sprawl affects the journey to work commute time of mass transit riders and other commuters throughout the United States after controlling for variables such as the volume of ridership, local per capita income, the presence of a local rail transit system, and local weather. The findings for this research note defy some conventional wisdom and point to several public policy recommendations on how to improve public mass transit at the local level. For instance, we find that greater urban compactness can be turned into a mass transit advantage if mass transit riders can use a commuter rail option.

INTRODUCTION

Public transportation (hereafter, mass transit)[1] has been a popular subject of scientific inquiry for the past few decades due to its role in enriching some people's lives by increasing their mobility and access to employment, shopping, medical care, educational resources, and recreational activities. Though being considered important public goods, undisciplined investment in mass transit has been criticized and is under constant scrutiny. Thus, considerable efforts have been made to understand what makes mass transit more useful and to determine which factors influence the efficient utilization of mass transit. These efforts will help policy makers develop ways to better allocate their limited financial resources to the improvement of mass transit services. Those efforts that were published in the scholarly literature reveal the following:

1. Greater housing and population density (less "sprawl") usually lead to greater mass transit ridership (e.g., Ewing et al 2003, Lin and Yang 2009, O'Sullivan 2012).
2. Greater ridership, in turn, has the benefit of reducing traffic congestion for lower occupancy vehicles such as automobiles, and helps reduce other negative externalities such as air pollution and traffic noise/accidents if less cars travel the

roadways due to greater mass transit usage (Ewing et al 2003, O'Sullivan 2012[22] The analysis by Winston and Langer (2006) argues that most of the road construction undertaken to reduce traffic congestion yields fewer benefits than costs.

3. On the other hand, beyond a certain point, it is possible that greater population and housing density can cause greater traffic congestion, and thereby increase, not decrease commute times for both mass transit riders and private vehicle users. Therefore, it is often difficult to predict the effect of greater density (or less sprawl) on commute times in general (Levinson and Kumar 1997, Prud'homme and Lee 1999, O'Sullivan 2012, Droes and Rietvald 2013), although Ewing and Hamidi (2010) show that less sprawl is associated with shorter drive times for commuters on average.

4. The reduction in externalities and the fact that mass transit serves a disproportionate number of low income commuters and disabled travelers are often used as justifications for subsidies to mass transit as many mass transit agencies fail to operate at a surplus or break even (Parry and Small 2009, O'Sullivan 2012), although those with greater ridership usually operate with greater financial and operating efficiency (Nolan, Ritchie, and Rowcraft 2001, O'Sullivan 2012, Min and Lambert 2015). Some, however, contend that federal subsidies generate inefficiencies with regard to operating expenses (Nolan, Ritchie, and Rowcraft 2001), and O'Sullivan (2012) notes that transit subsidies could be better targeted with more appropriate investment and clearer performance goals in mind.

5. Because greater ridership is associated with denser development, policies favorable toward mass transit often have also gone hand in hand with those favoring "smart growth" urban policies—policies that promote denser residential and commercial development along with mixed use and mixed income zoning and land usage (Ewing et al 2003, Handy 2005). Su and DeSalvo (2008) found that taxes and subsidies were likely targeted for mass transit systems in high density urban areas, whereas those areas that encouraged private auto use to one extent or another had greater degrees of urban sprawl.

In the meantime, mass transit subsidies and smart growth policies have been criticized as being as inefficient as the externalities they are supposed to address. The basic arguments against transit subsidies and smart growth policies are that they defy market principles (i.e., market forces should mostly determine transportation modes and urban development while subsidies encourage inefficiencies) and that the negative externalities that transit and planned development are supposed to address are not as great or as overwhelming as estimated (Nolan, Ritchie, and Rowcraft 2001, O'Toole 2000, 2001, 2006, 2010, Cox 2013). Moreover, the non-scholarly literature (O'Toole 2001, 2006, 2010, Cox 2013) contends that smart growth policies can only result in greater traffic congestion and longer commute times for all travel journeys despite companion policies that promote greater mass transit usage and service delivery. Cox (2013) argues that any reductions in harmful emissions in metro areas have come about mainly because more fuel efficient and environment-friendly automobiles (e.g., bio-fuel, hybrid) have been put on the road over the last few decades rather than due to mass transit, and that most of the benefits of the subsidies of mass transit accrue to a mere six urban areas in the United States out of over 300 metropolitan areas. That is to say, Cox (2013) argues that there have been some doubts about the role of mass transit in alleviating any traffic congestion and air pollution.

To ease these doubts, this research note examines the past premises that greater urban compactness (or less sprawl) causes longer commutes (using journey to work times as a proxy) and that some form of rail (light or heavy) transit is effective in alleviating congestion by shortening journey to work times for mass transit riders.

This note proceeds as follows. The next section details the research methods employed for the analysis of transit data obtained from the United States. After that, a section discusses the key findings of the statistical data analysis, which in turn is followed by a concluding section which outlines the important implications of this paper's findings, summarizes the limitations of the current research, and makes suggestions for future research, while recommending plausible policy guidelines.

RESEARCH METHODOLOGY

To answer research questions raised in the prior section, we gathered secondary data mostly from public sources such as 2012, five-year estimates, American Community Survey (http://www.census.gov/acs/www/), the US Bureau of Transportation Statistics (BTS), and a compactness index developed by Ewing and Hamidi (2010). These data were analyzed using least squares regression analysis. In the proposed three regression models, the following variables were used as dependent variables to measure average commute times for 845 metro area counties in the U.S.[3]

1. The natural log[4] of the average journey to work time in minutes for all commuters in the county[5] (Ln Overall Average hereafter).

2. The natural log of the average journey to work time in minutes for public transit riders in the county[6] (Ln Public Transit Average hereafter).

3. The natural log of the ratio of the average journey to work time in minutes for public transit riders in the county to the average journey to work time in minutes for all commuters in the county (Ln Ratio hereafter).[7]

To predict the three dependent variables described earlier, we used the following dimensions as independent variables.

1. Climate (Weather). This is a dummy variable where states in the northeastern, midwestern, and northwestern parts of the US (coded as 1s) are classified as states having a greater chance of heavier snow precipitation than other states (coded as 0s).

2. Rail transit. Using data from the US BTS, counties were noted as having some type of mass transit service featuring light and/or heavy rail (US Bureau of Transportation Statistics, 2010). For the purposes of this paper it was important to highlight the effects of rail transportation since it receives higher subsidies, which is part of the criticism of smart growth and transit subsidy policies.

3. Natural log of the percentage of the work force not working at home and using public transit for the journey to work (Ln Public Tran Ridership). This is used as a way to see if greater ridership leads to longer journeys to work on average due to more frequent stops to collect and release a greater number of passengers than would otherwise be the case (O'Sullivan 2012).

4. Natural log of a compactness index (Ln Compactness Index). This is the natural log of a sprawl or compactness index developed by Ewing et al (2010), and is an improvement over one developed by Ewing and others earlier (Ewing et al 2003). The compactness index uses principal components analysis at the census tract level of urban population density, housing density, job density, road connectivity, and the degree of mixed land usage. It draws upon data from various sources and gives a score to counties, metro areas and urbanized areas according to their degree of compactness

(or lack of sprawl). The greater the score, the greater the compactness (or less sprawl).[8]

The compactness index and the percentage of the workforce using mass transit are strongly correlated. The mass transit and urban economics literature note that historically greater urban density leads to the formation and expansion of mass transit services and greater ridership, especially in the densest parts of urban areas (O'Sullivan 2012). As long as a certain population density is maintained along transit routes, the services for a certain level of ridership will continue to be offered in spite of the development of possible operating losses and competition from other forms of transportation (O'Sullivan 2012). As time goes by, since some commuters prefer mass transit to other forms of transportation, or can only afford mass transit, many choose to locate their residencies as closely as possible to transit lines since proximity to those lines reduce walking and waiting times (Mohring costs) of using mass transit (O'Sullivan 2012). This in turn leads to greater ridership. Hence, greater density leads to greater mass transit services, which in turn could lead to more commuters' willingness to locate close to the transit stops and lines, and then this in turn could lead to even greater density. Therefore, although originally greater urban density leads to mass transit services and a certain level of ridership, it is later difficult to distinguish whether ridership is a function of density, or if density is a function of ridership. For this reason, both were used as separate independent variables since the variance inflation factors for these variables were not greater than 5.0, a value which indicates no signs of multicollinearity (Studenmund 2005).[9]

It was found in models employing path analysis that density or compactness was often used as a predictor of ridership (Golob 2003). For this paper, since it is often hard to determine how the two interact, they were used as separate independent variables in the least squares models.

5. Natural log of county's per capita income, 2010 (Ln Per Capita Income). This is used to see if average journey to work times are higher or lower according to levels of per capita income in a county. The hypothesis is that if mass transit is an inferior good (O'Sullivan 2012), then higher per capita income should be associated with less mass transit usage, which would cause greater congestion, and therefore average journey to work times should be longer, all else held constant.

RESULTS AND DISCUSSIONS

Table 1 shows the descriptive statistics for the variables used in the three models developed. Around 60% of the counties were in states that were in the northern top half of the US, only around 7% had some form of rail transit. Overall public transit ridership as a percentage of all of those who commute to work was fairly low at only a little over 2%, and average mass transit commute times were almost twice those of overall commute times.

Robust standard errors were used for all three models because Breusch-Pagan test results showed some evidence of heteroscedasticity for the first model (Koenker 1981). In Table 2, all independent variables show statistical significance (p-values < 0.05), and the Ln Compactness Index is a negative predictor of overall commute times whereas greater ridership is associated with longer average commute times. The presence of rail transit and higher per capita income cause longer commute times, on average. Perhaps higher income may be indicative of greater preferences for private automobile use among those who commute to work, which could lead to greater traffic congestion, and the presence of rail transit does not appear to offset this. For the climate variable, the northern counties tend to have shorter commute times on average, so a higher

TABLE 1
DESCRIPTIVE STATISTICS

Variable	Mean	Standard Deviation
Climate	0.61	0.49
Rail	0.07	0.33
Compactness Index	102.62	25.81
Overall Avg. Journey to Work Time in Minutes	24.39	4.95
Public Trans Avg. Journey to Work Time in Minutes	41.99	17.74
Ratio Public to Overall Average	1.72	0.60
Per Capita Income	$27,142.00	$6283.00
Public Trans Ridership Pct.	2.31	5.55

TABLE 2
LEAST SQUARES REGRESSION, LN OVERALL AVERAGE JOURNEY TO WORK TIME FOR ALL COMMUTERS

Dependent Variable: Ln Overall Average Journey to Work Time for All Commuters				
Linear regression	Number of observations = 845			
F(5, 839) = 22.36				
Prob > F = 0.0000				
R-squared = 0.1245				
Root MSE = 4.6387				
	b	**Robust SE**	**t-score**	**p-value**
Climate	-1.06	0.33	-3.24	0.00
Rail	2.90	0.83	3.48	0.00
Ln Public Tran Ridership	0.54	0.20	2.70	0.01
Ln Compactness Index	-6.19	2.15	-2.89	0.00
Ln Per Capita Income	6.66	0.96	6.91	0.00
Constant	-14.44	9.73	-1.48	0.14

probability of encountering snow and ice is not a factor in impeding commute times to work, which could be due to such parts of the country being better prepared for inclement weather.

In Table 3, neither the presence of rail transit nor compactness has any impact on mass transit average commute times, although higher income causes longer commute times. Greater mass transit ridership is associated with longer commute times on average, since it leads to more frequent and longer stops on average. The northern counties also tend to have shorter mass transit commute times on average. This finding is the same as that of the previous model.

In comparing mass transit to overall commute times by using a ratio of the two (Table 4), climate and per capita income are not good predictors of the ratio. The compactness index also does not work, yet the presence of rail transit is associated with lower ratios (i.e., the mass transit times make only a smaller portion

TABLE 3
LEAST SQUARES REGRESSION, LN PUBLIC TRANSIT AVERAGE JOURNEY TO WORK TIME

Dependent Variable: Ln of Public Transit Average Journey to Work Time				
Linear regression	Number of observations = 845			
F(5, 839) = 21.21				
Prob > F = 0.0000				
R-squared = 0.1217				
Root MSE = .40056				
	b	**Robust SE**	**t-score**	**p-value**
Climate	-0.07	0.03	-2.49	0.01
Rail	-0.05	0.03	-1.38	0.17
Ln Public Tran Ridership	0.10	0.02	5.25	0.00
Ln Compactness Index	-0.12	0.12	-1.00	0.32
Ln Per Capita Income	0.39	0.07	5.63	0.00
Constant	0.30	0.90	0.33	0.74

TABLE 4
LEAST SQUARES REGRESSION, LN RATIO OF PUBLIC TRANSIT AVERAGE JOURNEY TO WORK TIME TO THE AVERAGE JOURNEY TO WORK TIME FOR ALL COMMUTERS

Dependent Variable: Ratio of Public Transit Average Journey to Work Time to Overall Average Journey to Work Time for All Commuters				
Linear regression	Number of observations = 845			
F(5, 839) = 11.64				
Prob. > F = 0.0000				
R-squared = 0.0857				
Root MSE = .36777				
Dependent Variable: Ratio of Public Transit Average Journey to Work Time to Overall Average Journey to Work Time for All Commuters				
	b	**Robust SE**	**t-score**	**p-value**
Climate	-0.02	0.03	-0.85	0.40
Rail	-0.17	0.04	-4.34	0.00
Ln Public Tran Ridership	0.08	0.02	4.68	0.00
Ln Compactness Index	0.14	0.12	1.17	0.24
Ln Per Capita Income	0.11	0.06	1.62	0.11
Constant	-1.23	0.87	-1.41	0.16

of overall commute times) on average. However, the high volume of ridership tends to increase mass transit commute times.

CONCLUDING REMARKS AND POLICY IMPLICATIONS

Recently the Obama Administration signed into law a broad $41.6 billion program of tax breaks that would retroactively raise the monthly mass-transit subsidy to $250 per month per rider for 2014 (Heckman, 2014). Although this law intends to increase mass transit ridership, ease traffic congestion, and conserve energy; there is no funding in place to honor this subsidy. Since its funding is often tied to government tax policy, the mass transit subsidy has become controversial legislation. To ease controversy over this legislation, this research note tested the validity of arguments against mass transit subsidies or "smart growth" policies and then discovered that such arguments had no empirical evidence to support them. To elaborate, in the first regression model, compactness is actually associated with lower average journey to work times, and has neither positive nor negative impacts on mass transit commute times or the ratio of mass transit to overall average commute times. The critics mentioned above indicate that greater compactness usually leads to more congestion and subsequently longer commute times on average, but this conjecture is not verified by our test results. Greater transit ridership is associated with longer journey to work times, on average, which is probably related to traffic congestion, but in the last model, the presence of rail transit actually closes the gap between mass transit commute times and overall commute times. However, in the first model, rail transit is associated with longer average overall commute times, so the ultimate impact of rail transit is indeterminate.

In all three models, greater per capita income is associated with longer commute times, on average, hinting that due to mass transit being an inferior good, residents in higher income areas tend to drive their own vehicles more and thereby cause more traffic congestion which, in turn, leads to longer commute times. In other models developed for this study, the percentage of families living in poverty in the counties was used as an independent variable, and was a good predictor of the three independent variables and had a negative coefficient. The ridership percentage was also usually a good predictor and had a positive coefficient. Hence, the poorer the community, the shorter the average commute times for community residents regardless of their greater use of mass transit services.

It is also apparent that the northern counties have lower overall and public transit journey to work times on average than the southern counties. These counties also typically had the greatest compactness index numbers on average as well. Areas which have lower average journey to work times, thanks to their lower level of sprawl, tend to be more productive probably because commuters in those areas have more time to work in that they experience less tardiness in arriving to work and subsequently enjoy less wasted time for their work. This finding is congruent with that of the study conducted by Prud'homme and Lee (1999) who observed that the northern counties tended to be more productive than southern counties.

Despite some refreshing findings that were summarized above, this note is confined by several limitations. For instance, since the adjusted r-squared values for the models are low, much of the variation in the dependent variables remains unexplained. This paper's conjecture that greater income in an area is associated with greater auto ownership and usage needs to be verified further using alternative statistical models with mediating variables (e.g., parking cost/time and limit, auto accident/theft risk). Also, given that the economic theory (e.g., O'Sullivan 2012) confirming that mass transit is considered an inferior good is pretty strong, a more direct variable needs to be developed and employed within the models other than just per capita income.

Although some prior studies conducted by Parry and Small (2009) and Ewing and Hamidi (2010) presented evidence in favor of mass transit subsidies and the benefits of compact urban environments, some critics still argue against mass transit subsidies and more compact urban planning for their perceived lack of freedom of choice over commute options. Also, those critics overlook the negative consequences of automobile transportation externalities and the urban sprawl externalities. In fact, they suggest that mass transit and more compact urban development can cause longer commute times due to more traffic congestion. However, the results of this note do not support those assertions.

(Endnotes)

[1] Most mass transit entities in the U.S. are public or non-profit organizations (O'Sullivan 2012).

[2] The analysis by Winston and Langer (2006) argues that most of the road construction undertaken to reduce traffic congestion yields fewer benefits than costs.

[3] When using metro area level data, the composite index had no connection to any of the commute times. The Pearson correlation coefficients were all below 0.08. This may be because on a regional level, for example, some counties may have heavy rail, light rail, and bus mass public transit services whereas others may have only bus service. For this reason, the public, mass transit commute time for a metro area may not reflect a typical commute time for most commuters. For example, the public transit average journey to work time for the New York metro region is 51 minutes whereas for Manhattan (New York County) it is around 35 minutes. Because of such great dispersion possible among several counties in coming up with a metro level average, county average commute times are used/

[4] Log models, especially double log models of interval data, tend to offer the best fit for models predicting dependent variables denoting time (Lambert and Meyer 2006 and 2008, Lambert, Min and Srinivasan 2009, Lambert, Srinivasan and Katirai 2012).

[5] Does not include those who work from home.

[6] Does not include usage of any type of taxis or private sector transit services.

[7] The ACS does not separately calculate an average time for all those traveling to work except for those using public transit. There is only an overall trip time and then different trip times for different modes of transportation.

[8] This exploratory paper only looks at county level data. A follow up paper using metro and urbanized area data is planned, which would permit the employment of the Ewing and Hamidi metro area sprawl index as well as a traffic congestion index developed by the Texas A&M Transportation Institute (http://mobility.tamu.edu/ums/). Unlike the findings of other research, a quadratic form of this variable did not work well in the models developed, which does not indicate some type of peak in density or compactness with relation to commute times. That is, there was no evidence of a decreasing commute times and then increasing times as density became greater.

[0] It was found in models employing path analysis that density or compactness was often used as a predictor of ridership (Golob 2003). For this paper, since it is often hard to determine how the two interact, they were used as separate independent variables in the least squares models.

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