Millennium Database Analysis
Urban Transportation Planning
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October 2010

Evaluating the Role of Urban Sprawl in the United States & Western Europe

Introduction

The *Millennium Cities Database for Sustainable Transport* contains transportation statistics from a variety of cities across the world from the year 1995. While the dataset is now somewhat outdated, the study provides a reliable snapshot of global transportation patterns at the turn of the 21st century. This analysis of the *Millennium Cities Database* focuses on the effects of urban density as a metric for comparison between the United States and Western Europe. The analysis was conducted from a regional standpoint instead of on a city-by-city basis because a critical mass of data points was required to establish any sort of meaningful significance. Furthermore, urban density was examined in relation to other data – such as modal split, total daily trips per capita, and private vehicle kilometers per capita – because urban density is one of the primary metrics of urban sprawl. This investigation of data from world cities seeks to quantify and numerically evaluate commonly held notions of urban transportation patterns in relation to perceived urban sprawl in these two regions of the world.

Intuition and Hypotheses

Even a cursory comparison of transportation patterns between Western Europe and the United States reveals that the two regions have inherently different transportation paradigms. The older cities of Europe are generally characterized by higher urban density and improved public transportation networks that can more efficiently move people around a compact area than the comparably vast and sprawling cities of America. Furthermore, the American government, in conjunction with automobile industries and lobbyists, has historically provided a number of

compelling incentives for private vehicle ownership since shortly after World War II. Combined with the expansive interstate highway system, relatively low gasoline and vehicle prices, and the stereotypical American values of private ownership, it is intuitively logical that America's cities are much more sprawling and less dense than those of Western Europe. The data from the *Millennium Database* corroborate this intuition. Indeed, all of the ten US cities included in the database had lower urban density (measured in persons/hectare) than every listed city from Western Europe (**Figure 1**).

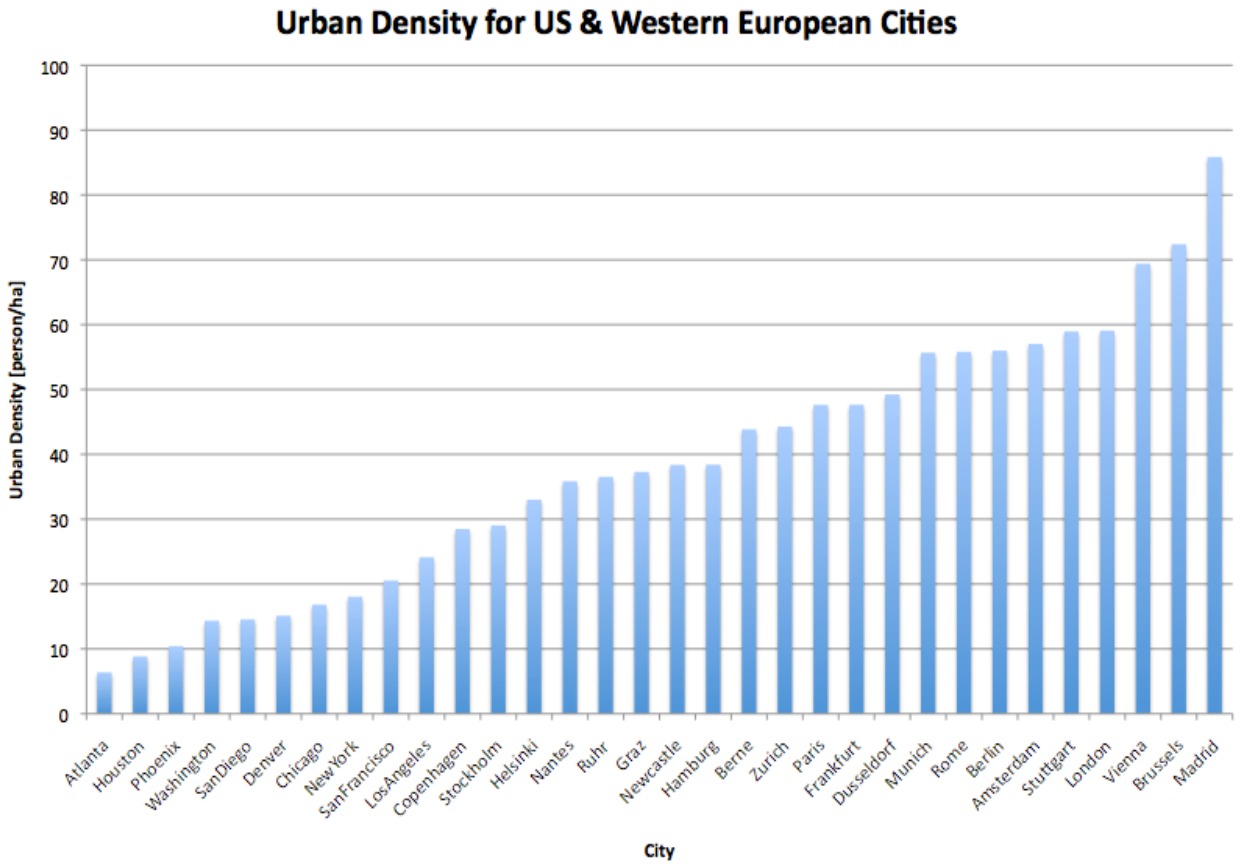

Figure 1: Urban Density for US & Western European Cities. Even the densest of US cities has lower density than the least dense of European cities.

While it is reassuring that numerical analysis of urban density reinforces our intuitive notions of sprawl patterns between the US and Western Europe, there are a number of interesting questions related to urban density that are not so obvious. For example, while low urban density

is often credited with causing long commutes and contributing to a modal split dominated by private automobiles, more complex relationships exist between urban density and these commuting metrics. If urban sprawl alone is the chief determinant of important metrics such as average daily trips, automobile mode split, and total private passenger vehicle kilometers, then the correlation between urban density and these metrics should be relatively independent of the region. In reality, there are likely other forces at work such as cultural norms, governmental policy, and wealth that factor into a city's transportation and commuting patterns. Thus this analysis seeks to test the hypothesis that urban sprawl is a primary factor in determining automobile dominance, number of daily trips, and commuting distances regardless of location. This hypothesis was tested with data from all ten US cities in the *Millenium Database* (Atlanta, Chicago, Denver, Houston, Los Angeles, New York, Phoenix, San Diego, San Francisco, & Washington DC) and 22 cities from Western Europe selected from the database based on availability of all metrics of interest (Amsterdam, Berlin, Berne, Brussels, Copenhagen, Dusseldorf, Frankfurt, Graz, Hamburg, Helsinki, London, Madrid, Munich, Nantes, Newcastle, Paris, Rome, Ruhr, Stockholm, Stuttgart, Vienna, & Zurich).

Automobile Mode Split

A sensible starting point for evaluating automobile dominance in relation to urban sprawl is an analysis of automobile mode split in the two regions of interest. As urban density increases, public transportation and non-motorized modes such as walking and bicycling generally become more accessible to people because they do not need to travel as far to access important urban amenities such as employment opportunities and commercial areas. The following figures show graphs of the percentage of motorized private modes vs. urban density for the ten United States cities and 22 Western European cities (**Figures 2 & 3**).

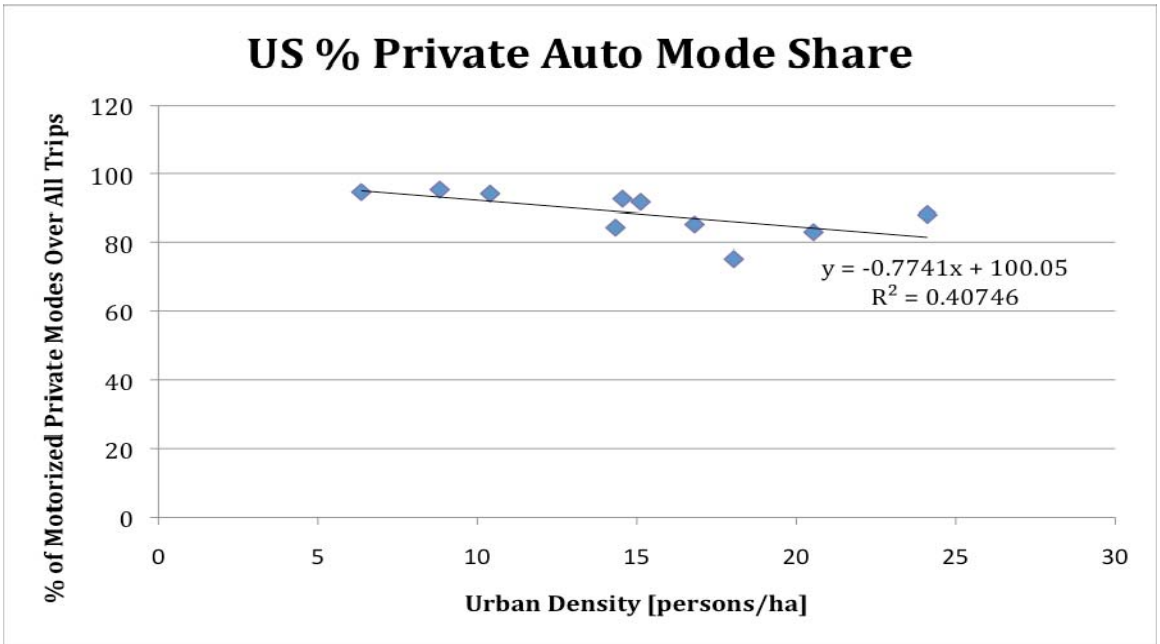

Figure 2: Percentage of Motorized Private Modes Over All Trips vs. Urban Density for US Cities

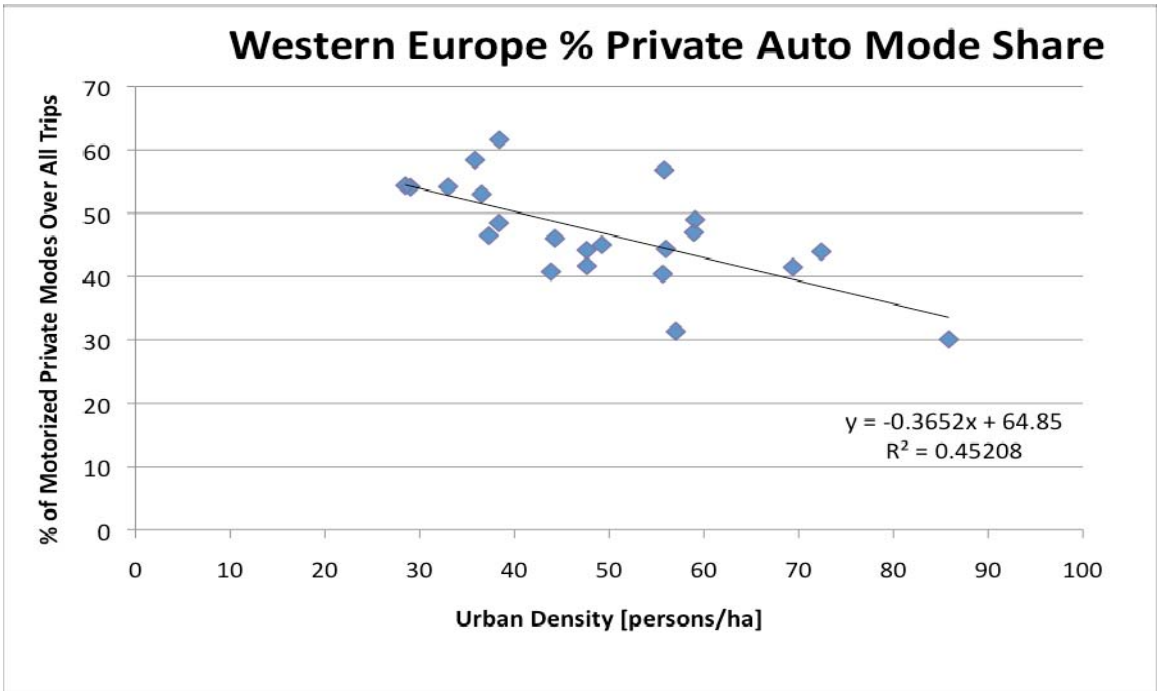

Figure 3: Percentage of Motorized Private Modes Over All Trips vs. Urban Density for Western Europe

As Figures 2 and 3 indicate, both regions exhibit a negative correlation between increasing urban density and percentage of motorized private modes. This is logical because as

the density increases, we expect that commuting via non-motorized modes and public transportation are more viable transportation options. It is critical to note that most US cities lie in the 80%-95% range for private automobile mode share while the European cities tend to range from 30%-60%. However, the fact that the two regions exhibit a similar trend is indicative of the role that urban density plays in private automobile mode share.

Private Passenger Vehicle Kilometers

An additional metric of interest in relation to urban density is the number of private passenger vehicle kilometers per capita. Intuitively, it would appear that cities with high urban density would have a lower number of passenger car kilometers per capita because higher density would allow for less driving due to increased access from transit and walking. To evaluate this relationship, the number of private passenger vehicle kilometers per capita was plotted against urban density and fit with a first-order linear regression to examine the correlation. **Figures 4 and 5** show these graphs for the two regions of interest. For the US, a somewhat noticeable negative correlation exists between passenger car kilometers and urban density. For the US cities, a midrange cluster for cities with density of about 15 persons/hectare corresponds to roughly between 10,000 and 15,000 passenger car kilometers. In Europe, while the kilometer counts are vastly lower, increasing urban density only corresponds very slightly with decreasing the passenger car kilometer ($r \approx -0.4$). In fact, the number of passenger car kilometers per capita is fairly constant between 4,000 and 6,000 kilometers for the 22 cities from Western Europe.

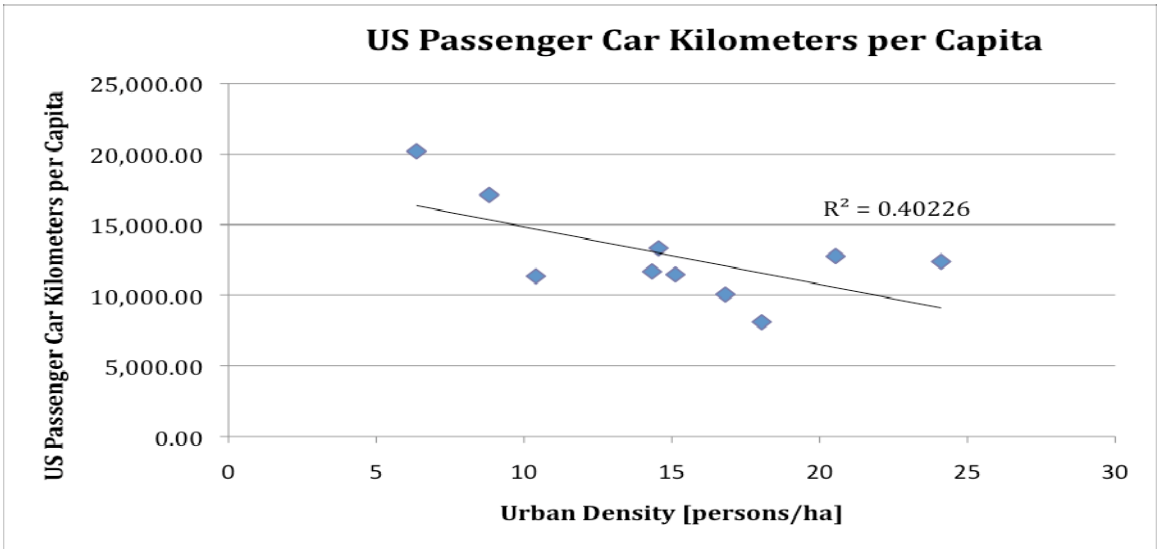

Figure 4: Passenger Car Kilometers per Capita vs. Urban Density for US Cities

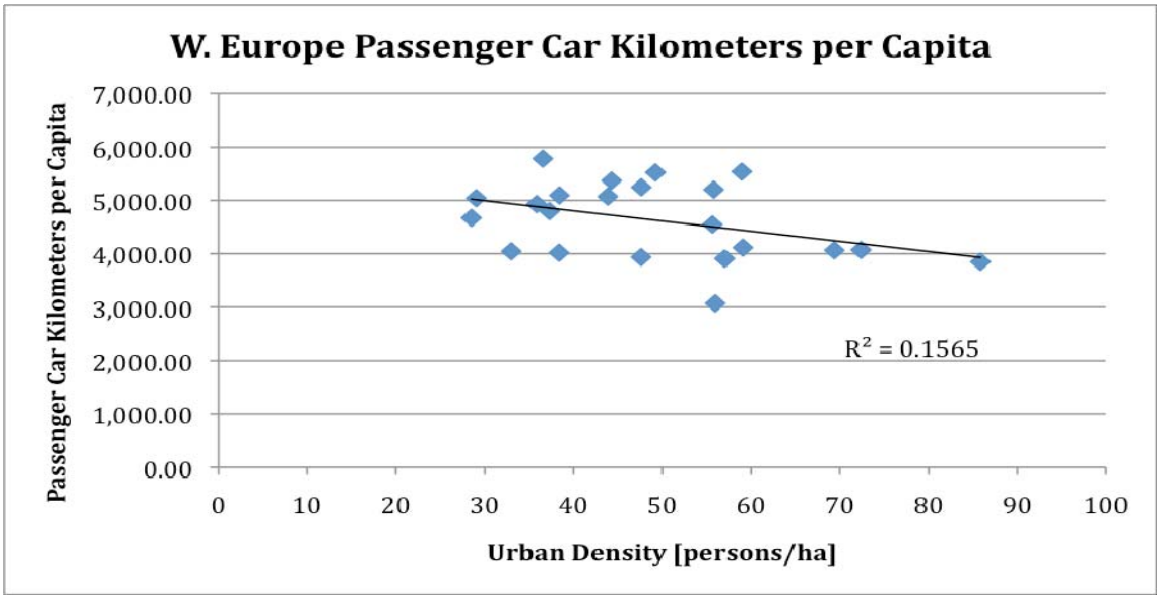

Figure 5: Passenger Car Kilometers per Capita vs. Urban Density for Western European Cities

Total Daily Trips per Capita

The number of daily trips per capita is a further important urban density indicator. A common assertion is that increased urban population density tends to decrease total daily trips per capita because usually higher density regions are associated with concentrated and mixed

land use developments (e.g., retail, offices, residential areas within close proximity), which reduce the total number of trips people make. **Figures 6 and 7** demonstrate this urban density to total daily trips relation in the US and in Europe.

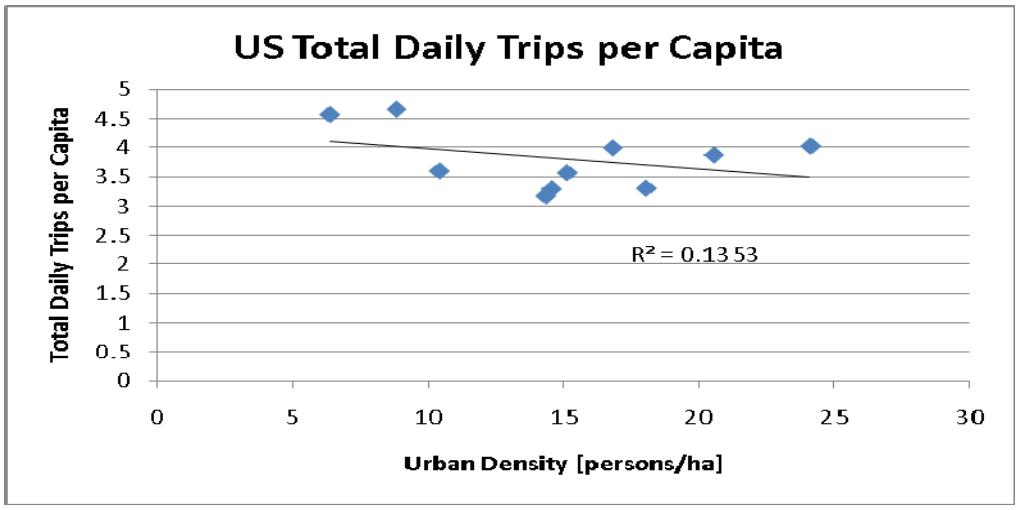

Figure 6: Total Daily Trips per Capita vs. Urban Density for US Cities

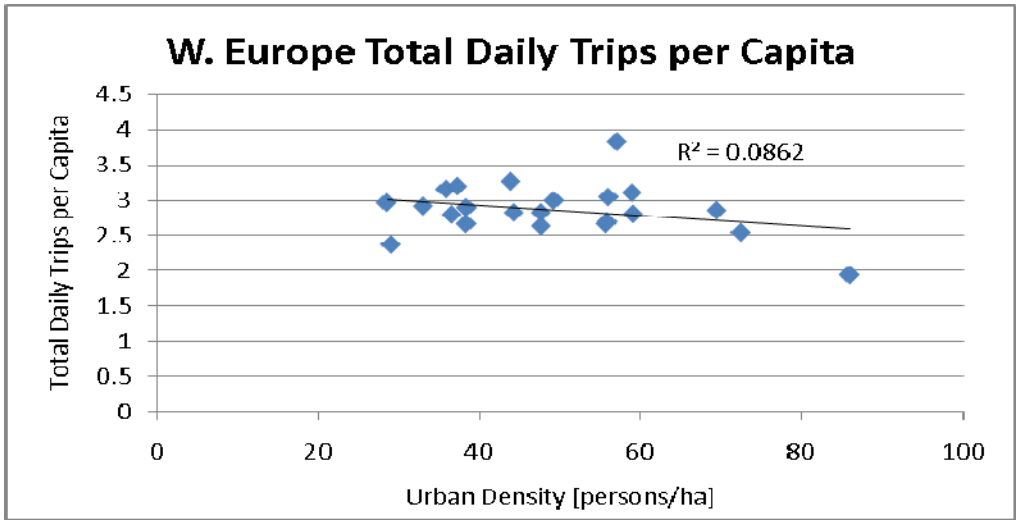

Figure 7: Total Daily Trips per Capita vs. Urban Density for Western European Cities

Figures 6 and 7 indicate that the relationship of total daily trips per capita with urban density is insignificant (R^2 is less than 15% in both cases). As opposed to the general belief that

urban sprawl increases total number of trips, the relation is not as strong as the relationships between automobile mode split, private passenger vehicle kilometers and urban density. This implies that high density does not necessarily bring about mixed land use development as a city might have high residential density but poor mix of land use. On the other hand, comparison of the US and Western European still indicates that less dense US cities on average experience more total daily trips (3.81 trips per capita) than European cities (2.87 trips per capita). If the data from the US and Western Europe are combined, the relationship between total daily trips and urban density becomes stronger, the percentage of variance explained being almost 50% (**Figure 8**, the US cities are separated from Western European cities with the vertical line).

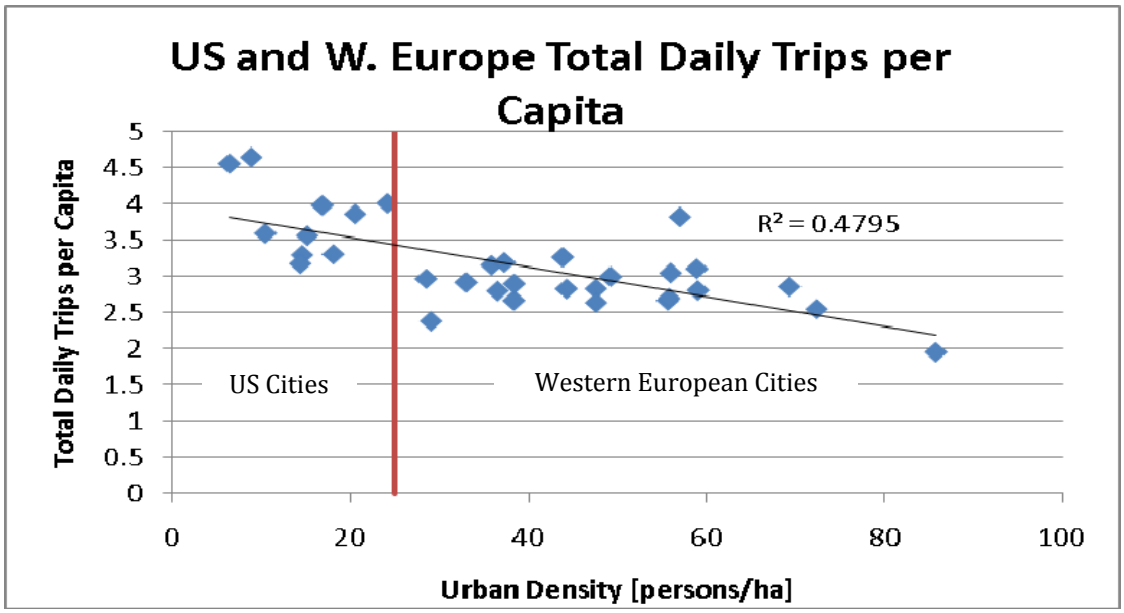

Figure 8: Total Daily Trips per Capita vs. Urban Density for Western European Cities and US Cities

Passenger Transport Cost as Percentage of Gross Domestic Product (GDP)

It is sometimes assumed that as urban density decreases, the overall proportion of a city's wealth spent on the operation of passenger transportation increases primarily due to huge

investments in highway systems and roadway infrastructure. Following figures show the relationship of passenger transport cost as percentage of GDP with urban density.

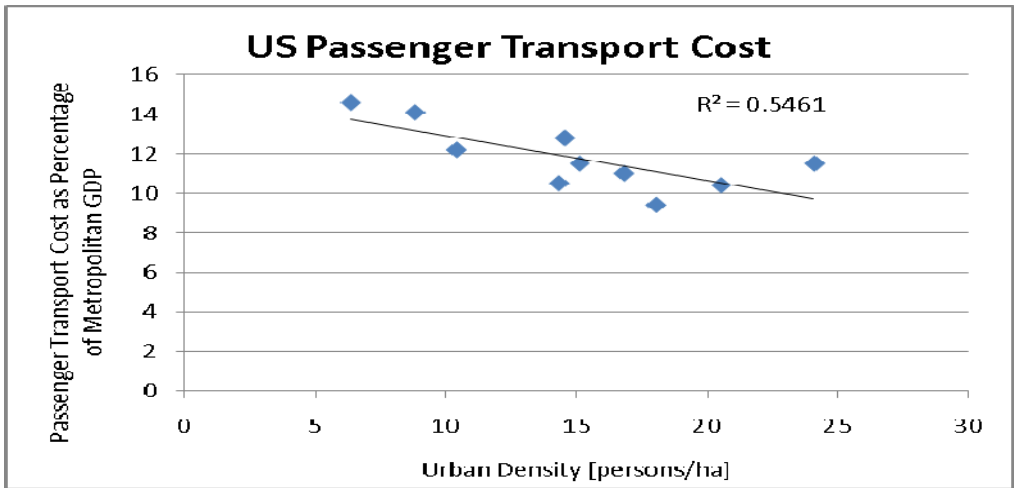

Figure 9: Passenger Transport Cost as Percentage of Metropolitan Gross Domestic Product (GDP) vs. Urban Density for US Cities

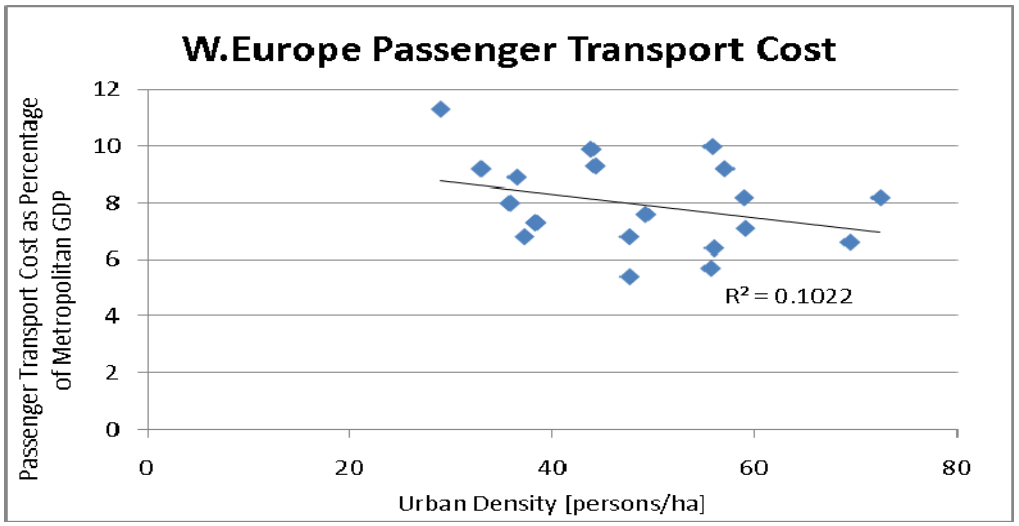

Figure 10: Passenger Transport Cost as Percentage of Metropolitan Gross Domestic Product (GDP) vs. Urban Density for Western European Cities

For the US cities, a strong negative correlation (r = -0.74) exists between passenger transport cost and urban density. For European cities, while the relationship is not very noticeable (only 10% of the variation can be explained), passenger transport cost still diminishes slightly as urban density increases.

Analysis of Findings and Policy Recommendations

The data in this study clearly demonstrate that both in the USA and in Europe, urban density substantially affects urban travel behavior and that cities with urban sprawl are more dependent on private automobile regardless of location. The analysis also suggests that while urban density is reasonably correlated with private motorized mode split, passenger vehicles kilometer per capita, and passenger transport cost, the correlation between urban density and average daily trips is insignificant. However, the level of suburbanization and automobile use remain different in the US as compared to Europe. In particular, car use and urban sprawl is much higher in the US than in Europe. Based on the observed results, policy recommendations to shape the urban system into a less auto-dependent form with the help of increased urban density are described as follows:

- Urban growth boundary programs should be developed to preserve farm lands and open spaces and to prevent further sprawl.
- Existing low density areas should be supported with mixed use, transit oriented development. Higher priority should be given to public transport investment rather than private modes (e.g., percentage of GDP spent on public transport in Europe was 0.49, while this number was only 0.17 in the US in 1995). Furthermore, accessibility and mobility of suburban rail should be improved to reduce automobile dependency in low density areas (e.g., in 1995, the US cities had only 59 suburban rail units per million people compared to 268 suburban rail units in Europe).
- Cost of private transportation should be increased by road pricing, higher parking fees, and gasoline taxes to discourage use of private automobiles.

Extensibility of Conclusions

It is worth noting that the extensibility of the findings in this analysis may be limited. Firstly, any correlation between data neither implies nor proves causation, and it is difficult to evaluate the role of an enormous number of externalities such as governmental and regulatory policies, cultural norms, and anomalies in individual commuting habits. Furthermore, since only two regions were evaluated, it is unlikely that this study is conclusive and applicable to the rest of the world. Other regions including Asia and Latin America were examined graphically and numerically but the data proved too erratic and inconsistent to draw any meaningful conclusions or patterns. This is perhaps related to the fact that many nations in these regions are still developing and thus have vastly different transportation patterns that are difficult to encapsulate with standard metrics such as best-fit linear regressions.

References

Millennium Cities Database for Sustainable Transport: Urban Transport, Land Use, Infrastructure, Economic and Environmental Indicators for 100 International Cities. UITP, 1995.