REDUCING VEHICLE-MILES TRAVELED:
AN ARGUMENT FOR LAND USE AS A POLICY LEVER

A Dissertation
Presented to
The Academic Faculty

By

Eric William Sundquist

In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Philosophy in City and Regional Planning
In the School of City of Regional Planning

Georgia Institute of Technology

December 2012

REDUCING VEHICLE-MILES TRAVELED:
AN ARGUMENT FOR LAND USE AS A POLICY LEVER

Approved by:

Dr. Catherine Ross, Adviser
School of City and Regional Planning
Georgia Institute of Technology

Dr. Michael Elliott
School of City and Regional Planning
Georgia Institute of Technology

Dr. Randall Guensler
School of Civil and Environmental Engineering
Georgia Institute of Technology

Dr. Joel Rogers
Law School, LaFollette School of Public Affairs, Department of Public Policy, Department of Sociology
University of Wisconsin-Madison

Dr. Nisha D. Botchwey
School of City and Regional Planning
Georgia Institute of Technology

Date approved:
November 7, 2012

ACKNOWLEDGEMENTS

The author owes a debt of gratitude to Dr. Catherine Ross, chair of the dissertation committee, for her patient mentorship on this research and on other important work undertaken by the Center on Quality Growth and Development and the Georgia Tech School of City and Regional Planning. The author is also indebted to Dr. Joel Rogers, both for serving on the committee, and also for the opportunities he has provided for exciting work through the Center on Wisconsin Strategy. As well, the author owes thanks to Dr. Michael Elliott and Dr. Randall Guensler, not only for their service on the dissertation committee, but for their thoughtful guidance throughout the course of the author's doctoral studies, and to Dr. Nisha D. Botchwey, for her service on the committee.

Finally, the author thanks his wife, Dorothy Sundquist; daughter, Madelyn Sundquist; and mother, Madelyn Sundquist, for their patience, forbearance and support over the nine years of his doctoral studies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

CBD. Central business district.

CARB. California Air Resources Board.

CO2e. Carbon dioxide equivalent, in terms of greenhouse effect.

Criteria pollutants. Substances regulated under the U.S. Clean Air Act: ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxides, and lead.

DelDOT. Delaware Department of Transportation.

ESD. Washington Employment Security Department.

GIS. Geographic Information System.

GMA. (Washington) Growth Management Act.

GHG. Greenhouse gases.

LUTSAM. Land Use and Transportation Scenario Analysis and Microsimulation

MPO. Metropolitan planning organization.

PSRC. Puget Sound Regional Commission.

PSTP. Puget Sound Transportation Panel.

QCEW. U.S. Bureau of Labor Statistics Quarterly Census of Employment and Wages.

SOV. Single-occupancy (motor) vehicle.

TDM. Transportation demand management.

TIGER. Topologically Integrated Geographic Encoding and Referencing system.

VMT. Vehicle-miles traveled.

SUMMARY

Reducing vehicle-miles traveled (VMT) has become an important goal for improving environmental outcomes and reducing the costs of travel and infrastructure. One way to accomplish such reductions could be to enact policies that foster more compact development. However, while it is accepted that compact development is associated with lower VMT, there remain disagreements about the efficacy of this policy lever. One issue casting doubt on the power of compact development relates to travelers' exposure to density. A conventional view holds that many travelers' neighborhoods are "locked in place" because change in established neighborhoods is slow. Additionally, conventional explanations of the effect of denser development focus on travelers' own neighborhoods, or on the metro area as a whole, failing to isolate the effect of densifying nodes near, but outside of, the travelers' neighborhoods. This study employs housing and travel data from the Seattle-Tacoma, Wash., where policies aimed at encouraging compact development have been in place since the mid-1990s. Findings suggest that 1) in established neighborhood, incremental change often results in exposure to substantially higher density, and 2) that even where localized density is constant, increases in density at intentional nodes or other areas near, but outside of, a traveler's own neighborhood, has a strong effect on VMT. The findings tend to undermine some of the key doubts about using land use as a policy lever for VMT reduction.

CHAPTER 1: INTRODUCTION

Understanding the factors that influence how people travel is one of the central concerns of planning research. Interest in the subject is motivated not only by the need for more robust planning theory, but also by immediate concerns of planning practice. Planners and decision-makers would like to know, for example, how various pricing schemes might affect travelers' decisions about travel at peak hours. They would like to know how much the provision of non-auto facilities will shift modes, and they would like to know how changes in land use affect the need for travel.

The current study provides some new insight into the emerging answers to this last question. Where many previous studies have looked at the effect of land use in the immediate neighborhood where a traveler lives, here we 1) dispute the conventional wisdom that land use patterns in travelers' neighborhoods are largely locked in place, and 2) consider the effect of land use changes not just in travelers' neighborhoods but in nearby neighborhoods as well. The effects we find are considerable, adding weight to the argument that land use is an important policy lever in efforts to manage travel demand. This suggests continued, more detailed explorations may yield even more insight on how changes in land use affect the need for travel – a difficult subject that has defied scholarly consensus despite decades of study.

1.1 Purpose of the Study

For most of the automobile era, U.S. vehicle-miles traveled (VMT) have grown at a much faster rate than the population (Figure 1). This growth has raised a host of policy concerns, and efforts to rein in the trend or reverse it. Climate policy, for example, seeks to reduce greenhouse gas emissions by increasing vehicle fuel efficiency, reducing the carbon content of fuel, and reducing VMT.[1] Lowered VMT would also improve air quality in terms of ozone and other criteria pollutants. It would reduce the perceived need for costly, land-consuming new highway capacity; reduce wear and tear on existing facilities; and ease congestion. Reduced VMT would benefit travelers as well, assuming they could meet needs with less driving, because both time and dollar costs would decrease, as would exposure to highway safety hazards. In addition, lower VMT would increase community livability by reducing noise and hazards to non-SOV travelers.

[1] Many cities and states are formulating climate policies aimed at reducing VMT. The most striking is Washington State, which actually gives its agencies a goal of reducing per capita personal VMT by 50 percent by 2059 (*H.B. 2815*, 2008).

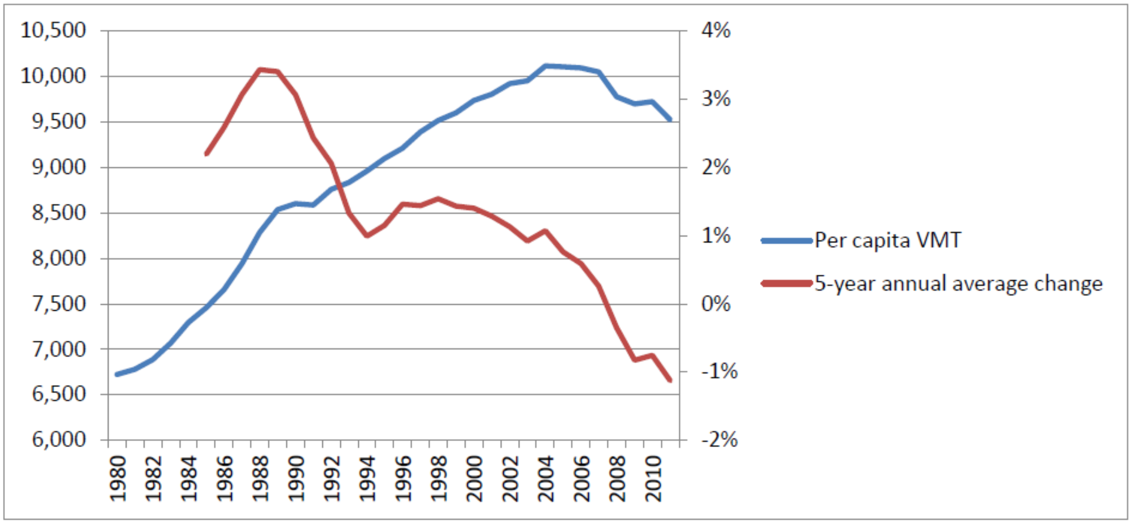

Figure 1. Per capita VMT in the U.S. (U.S. Census Bureau, n.d.; U.S. Federal Highway Administration, n.d.).

Many policies have been proposed to effect a VMT reduction. These include employing price signals, perhaps through a carbon-fuel tax or new highway fees; providing new transit and other non-auto transportation facilities; enacting employer-based transportation-demand management (TDM); performing public outreach and education; and changing the way land use is regulated and incentivized.

Research into the drivers of VMT helps inform all of these policy initiatives. A variety of factors have been cited for what is still, despite recent moderation, a sharp long-term increase in VMT, including income gains, which allowed more households to acquire a car or cars; the late 20th century shift toward women working outside of the home; the provision of highways, parking facilities and other infrastructure devoted to the auto; and changing land uses. Polzin (2006) assessed these VMT drivers and concluded that "There is evidence that the United States has reached a critical juncture in terms of national mobility trends and socio-demographic conditions that will result in more moderate rates of annual vehicle miles of travel (VMT) growth in the future” (Polzin, 2006, p. 1). Polzin predicted per capita VMT growth from 2001 to 2025 at 51 percent to 60 percent. Those numbers were much lower than those for the preceding 24 years, but now it appears the actual numbers will be far lower still. In the first 10 years of the period, per capita VMT actually declined by nearly 3 percent.

One reason for the apparent underestimation might be that while Polzin looked at such factors as the aging of the population and the saturation of the automobile market, he acknowledged that the VMT effects from land use changes were difficult to assess. Yet a comparison of U.S. urban area density and VMT (Figure 2) suggests that land use might in fact be critically important. For decades U.S. urbanized area densities declined as per capita VMT rose, but more recently density has stabilized, and simultaneously per capita VMT has leveled off and begun to decline. In fact there is general consensus that higher densities (which generally also imply a mixture of land uses), are associated with lower single-occupancy vehicle (SOV) travel.

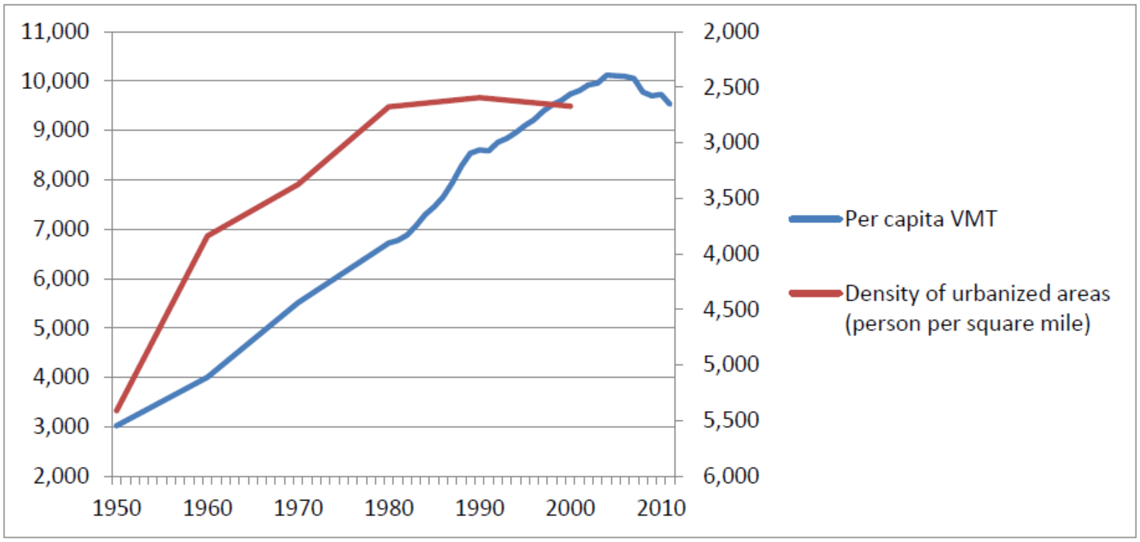

Figure 2. U.S. per capita VMT and urbanized-area density (U.S. Census Bureau, n.d.; U.S. Federal Highway Administration, n.d.). (Note that the density scale is reversed to highlight the similarity of the trends.)

But beyond this association, existing research has yet to gel around a consensus theory of causation. Many studies have been concerned about self-selection, for example, worrying that people who want to travel less choose dense neighborhoods in which to live.[2] Others have looked at the built environment in various ways in order to identify the best ways to operationalize variables of concern – density, mixture of uses, accessibility at various scales, jobs-housing balances, and others.

In 2009 a Transportation Research Board committee produced *Special Report 298, Driving and the Built Environment*, which provides a convenient reference point on the state of knowledge, and conventional wisdom, in this area. The report distills thinking on how the built environment affects VMT, and then produces a series of scenarios to get a

[2] Note that self-selection is not a serious practical concern in the effort to lower VMT if many people would like to self-select into dense neighborhoods but cannot. The "walkability premium" seen in many markets suggests this is the case. See, e.g. Leinberger and Alphonso (2012).

sense of how effective changes to the built environment might be over the coming decades in reducing VMT and emissions.

Driving and the Built Environment cites a number of reasons for low expectations, including the long-term nature of the built environment:

> The durability of the housing stock makes it difficult to change development patterns, at least in the short and medium terms. In contrast to passenger vehicles, whose median age in 2007 was 9.2 years,16 housing typically lasts 50 years or longer (Brown et al. 2005). The longevity of existing housing is often coupled with the negative receptivity of existing homeowners to change, particularly to increasing density levels in their communities, which is frequently perceived as threatening the value of their homes. More generally, most U.S. metropolitan areas have mature land use patterns and transportation systems that make change difficult, except at the margin. [Emphasis added.] The maturity and durability of metropolitan development patterns help explain why policies to change land use have incremental effects that only cumulate over a long time frame (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009, p. 122).

With that in mind, when *Special Report 298's* scenarios assume that people living in existing housing units will not change their behavior, because the densities they are exposed to at the local neighborhood level will not change. "All three scenarios assume that the driving patterns of those who live in existing housing will remain unchanged at 21,187 miles per household per year, the figure reported in the 2001 NHTS" (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009, p. 150). This study argues that that assumption is far too conservative.

More interesting, the conventional view often operationalizes a travelers' exposure to the built environment at the level of the neighborhood in which she lives. *Special Report 298's* modeling is based on changes in Census tracts and their effect on residents of those same tracts (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009). Again this framing suggests that land use changes will be slow to prompt VMT reductions; if a travelers' neighborhood is built out or in some other way prevented from change, there will be no lever to cause a reduction in driving. Other research considers metro-wide measures that implicate density at the metro-wide level, often in tandem with metro-wide transportation systems – "destination accessibility."[3]

Considering land use exposure at the immediate neighborhood or the metro-wide levels leaves out another possibility – namely that changes in the built environment away from a person's home neighborhood, but short of those necessary to materially change the overall metro density or land-use mix, might also have an effect on travel behavior.

The research into "destination accessibility" suggests that this not-quite-local scale could matter a great deal. Unlike authors who focus on conventional local-neighborhood density, Ewing and Cervero (2010) find destination accessibility to be more important than local density in reducing travel. Destination accessibility is sometimes operationalized as the ease by which residents can access the central business district (CBD) or, more broadly, the ease by which they can reach jobs and other destinations

[3] See Ewing and Cervero (2010).

metro-wide. As an accessibility measure, destination accessibility implicates both the transportation system and land use. Holding the former constant, improving destination accessibility may imply sweeping land use changes across a metro area, a daunting prospect, and by some measures dooms residential areas far from the CBD to ever-poor scores. The present study, with its focus of new development near travelers' neighborhoods, shares the interest in destination accessibility. Distributed compact nodes may be seen as mini-CBDs, and when such a node develops near a residential area, it improves that area's destination accessibility.

At least one relevant policy document discusses this intuition, albeit without much substantiation. "Wisconsin's Strategy for Reducing Global Warming," produced by a gubernatorial task force in 2008, suggests that new, compact development could directly reduce VMT for people living in the newly built housing units, but that such development would also reduce VMT for those in nearby existing neighborhoods as well (Wisconsisn Governor's Task Force on Global Warming, Wisconsin Dept. of Natural Resources, & Public Service Commission of Wisconsin, 2008, p. 150).[4] The intuition was that people frequently travel outside of their neighborhoods, and if newly dense areas were created that were reasonably accessible, nearby residents might meet their needs for shopping, school, work and other activities with fewer and shorter car trips.

In short, if built neighborhoods are tending toward more density, and if behavior can be affected by non-local, non-metro-level changes also, then the upside possibility of VMT

[4] The author of the present study served as a member of the working group that expressed this intuition and attempted to roughly quantify it.

reduction through built environment changes could be much greater than conventionally assumed, and land use strategies might be more attractive than assumed as tools to address climate change and other negative outcomes from current levels of VMT.

1.2 Statement of the Problem

This research investigates a subset of the more general question of land use and transportation interactions:

1) the extent to which the density in built-up neighborhoods are truly locked in place, and
2) whether changes in land use intensity near a traveler's neighborhood can influence the traveler's behavior – specifically, reduce VMT – even after controlling for changes in the traveler's own neighborhood.

In both cases, neighborhoods are operationalized as Census tracts. This practice matches that of the landmark TRB committee study mentioned above (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009) and other work, so comparisons are facilitated. Practically, using Census tracts has the obvious advantage that associated Census data – and in the case of the Puget Sound area, locally collected data on the same geographies – exist. In addition, the Census Bureau draws tract boundaries at highways, streams, railroad tracks and other physical barriers – barriers that tend to bound neighborhoods as well.

To fully describe land use, we could potentially consider a host of attributes, including density and/or mix of population, structures, economic activity and other variables (Alberti, 1999; Cao, Mokhtarian, & Handy, 2009; Crane, 2000; R. Ewing & Cervero, 2001, 2010; S. Handy, 2005a). Here we look specifically at housing-unit density. Of all the land use measures, this one is most relevant to the concept of "compact development" – indeed it is often treated as synonymous. Housing-unit density is the key unit of analysis in *Special Report 298* as well as other studies (Boer, Zheng, Overton, Ridgeway, & Cohen, 2007; Zegras, 2010), and this measure is a close cousin to household density, which is used in many other studies (Chatman, 2003; Holtzclaw, Clear, Dittmar, Goldstein, & Haas, 2002). With perfect information we might also consider the land use mix, which with density is also considered to be a determinant of travel behavior. Such measures remain subject to various types of specification, and are difficult to compute when crossing municipal boundaries, with varying land use classifications (or sometimes none at all), and all but impossible to calculate historically in a longitudinal analysis. Here, we employ a regionwide set of housing data that is robust over time and across localities in a way that land use mix data would not be.

Finally, with the policy considerations listed above, the travel behavior of interest and dependent variable is household VMT. This is a commonly used metric in the literature on travel and the density or other aspects of the built environment (See, e.g., R. Ewing, DeAnna, & Li, 1996; Frank & Engelke, 2005; Holtzclaw et al., 2002; Zhou & Kockelman, 2008). Using typical transportation survey data, as this research does, makes this practically a necessity, as households are the unit of analysis in the surveys. Many surveys list trip data by members of households, and it would be tempting to use this information to analyze travel at the person level. But doing so would violate random selection, as selection of one household member is linked to selection of others. To address differences in size of households across time and space, household size is employed as a control in models.

1.3 Theoretical Framework

While the intent of the study is call into question some elements of conventional wisdom, the theoretical basis of the assertions is quite conventional.

In the case of Question 1, whether developed parts of metro areas are being affected by infill, theory is not an issue. The question is empirical. The data will tell us how locked in place neighborhoods are.

In the case of Question 2, whether densification has spillover effects on travel behavior in areas that are more static, the core relevant theory is that travel can be treated as a cost to individuals, households and businesses. Sometimes the need for travel is called a "derived demand," to signify its utility not as an end but as a means to some other end – reaching a destination in the case of a traveler, or delivering a good in the case of a shipper. This cost has two components, economic – dollars spent for vehicles, fuel, insurance and the like – and time. If travelers can meet their needs while lowering their dollar and time costs, theory suggests they will do so. Figure 2 above, tracking per capita VMT along with metro U.S. population density, suggests that as destinations became more dispersed – as density decreased – motor vehicle travel increased. Transportation demand theory suggests the reverse would also be true; the questions here relate to exposure to density in travelers' neighborhoods and in nearby neighborhoods. Considering density at just the neighborhood level ignores the fact that most people routinely travel to jobs, shopping, school and other destinations that are outside of their neighborhoods. A denser area near a traveler's neighborhood may provide the ability to meet many needs in a compact area, reducing distances and/or numbers of trips, just as density in the originating neighborhood would. Some researchers' focus on destination accessibility, as discussed above, reflects this notion. The development of denser nodes, corridors or neighborhoods in proximity to a travelers' home may have the effect of "moving" the home closer to a CBD. Findings here suggest that density exposure at a moderate distance does, in fact, have this effect.

The details of transportation demand theory are not all settled. Despite the predominant view of transportation as a derived demand, some people may positively value the time spent traveling, at least sometimes (Susan Handy, Weston, & Mokhtarian, 2005). Some workers may travel by SOV because they require a car at work. Households are influenced by age, income, presence of children and other "lifecycle" factors (Kostyniuk & Kitamura, 1986), but not uniformly. Even the weather can affect travel decisions (Chung, Ohtani, Warita, Kuwahara, & Morita, 2005). We will not soon see a regression equation with the power to explain all of these. Yet we know that with all of these factors, the built environment does have an effect on VMT, and if we can tease out the density-exposure question, we will have a better idea of how it does, and whether the pessimistic conventional view of land use and VMT is warranted.

1.4 Hypotheses

We test two hypotheses, one through straightforward examination of full-popultion descriptive data and the second through formal hypothesis testing of sample data:

1) Contrary to conventional views that built-up neighborhoods are substantially locked in place, incremental intensification is raising the exposure to density in travelers' own neighborhoods.
2) Increasing density near to but outside of travelers' neighborhoods has a significant and negative effect on travelers' VMT.

1.5 Scope and Limitations of the Study

Many localities in recent years have pursued policies designed to advantage infill development generally, and to create dense nodes within the metro area specifically. Famously, since 1999 the Atlanta-area metropolitan planning organization has devoted some $200 million in planning and transportation funding to develop denser nodes, as part of its Livable Centers Initiative (Atlanta Regional Commission, n.d.). In the Puget Sound region, driven in part by the Washington Growth Management Act, the MPO – the Puget Sound Regional Commission (PSRC) – and local governments have likewise encouraged growth in existing nodes and corridors. Whether these policies or some other factor, such as market demand for walkable housing, are responsible, there has been significant compact development activity in these areas. The present study concentrates on the Puget Sound area, because it presents a range of densifying areas and neighborhoods that have not changed since they were originally built (Figures 3-8), and because the PSRC has done numerous travel demand surveys in these areas. This study utilizes the most recent survey, from 2006, as well as a survey from 1990, which corresponds with the collection of Census housing and population data, and which predates an effort launched in the mid-1990s effort to promote denser nodes.

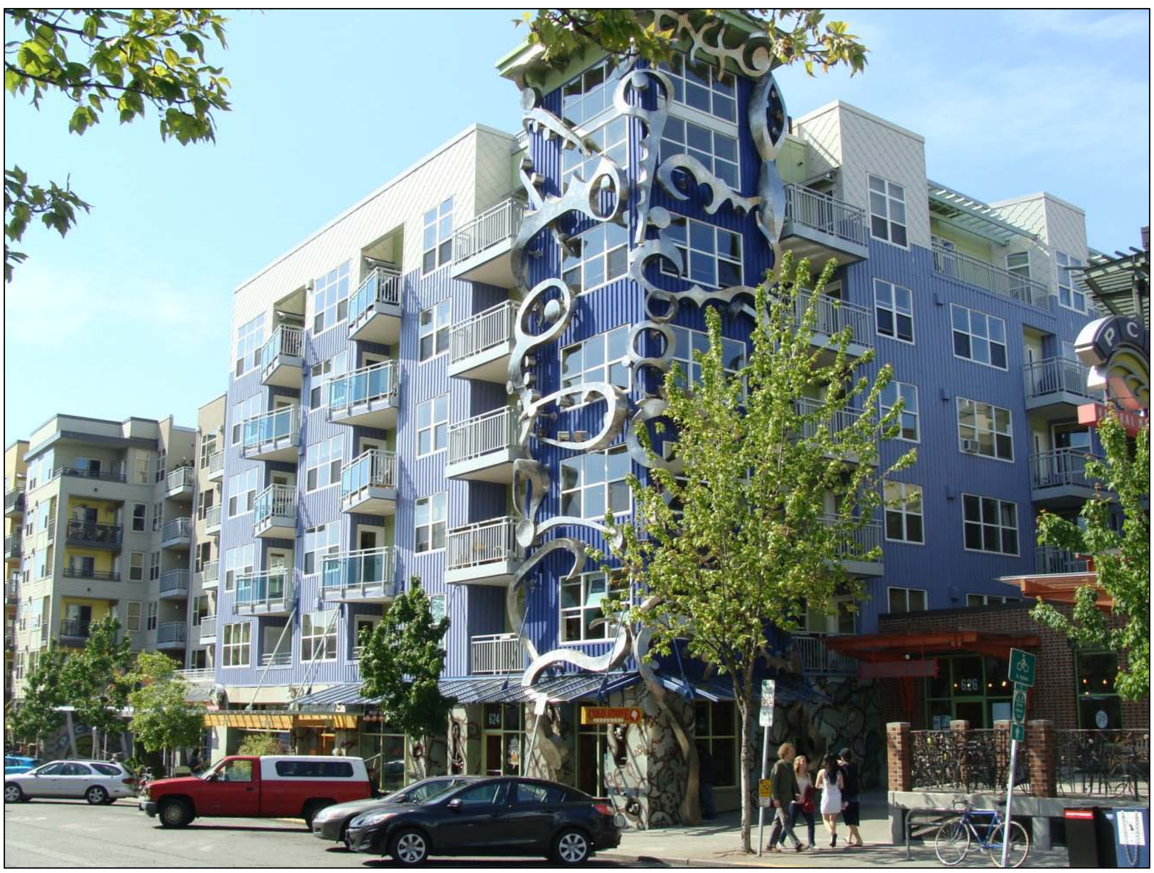

Figure 3. New housing and retail development at NW 34th St. and Fremont Avenue, at center of Seattle's Fremont neighborhood (photo by the author).

Figure 4. Residential and commercial infill along a Seattle corridor, the 3900 block of Stone Way North (photo by the author).

Figure 5. Infill mixed with early 20th century housing on a residential street in Seattle, the 3600 block of Evanston Avenue North (photo by the author).

Figure 6. A Seattle residential street, Jones Avenue at NW 83rd Street, in a neighborhood with little new infill (photo by the author).

Figure 7. Infill development rising above an older strip mall in suburban Bellevue, at NE 8th Street and 106th Avenue NE (photo by the author).

Figure 8. Little neighborhood infill in evidence at SE 4th Street and 11th Avenue SE, about a mile from the scene in Figure 7 (photo by the author).

The travel and housing data employed allow for an assessment across the four-county PSRC region: King, Kitsap, Pierce and Snohomish counties. This area comprises very dense neighborhoods, such as those in central Seattle and Tacoma, and places with very few residents, such as sections of the Cascade Mountains.

While the data employed in the study cover a full metro area over a period of 16 years, they nevertheless are from only one of hundreds of metro areas in the nation and thousands in the world. City- or region-specific studies are common in planning, but they always raise the possibility that the single area under consideration is different in an important way from all or many others.

As noted above, the current study treats the question of compact development literally, operationalizing it as housing unit density. As research into specifications for non-residential uses and residential/non-residential land use mixes improves, and databases showing land uses become more robust, it would be possible to investigate not only the effects of residential density in travelers' neighborhoods and in nearby nodes, but also non-residential activity, and the mix of the two.

CHAPTER 2: REVIEW OF THE LITERATURE

2.1 VMT Trends

For decades, U.S. VMT grew steadily, at a rate substantially exceeding population growth. From 1970 to 2000, for example, VMT grew by 145 percent, at a period when the national population grew by 38 percent. In per capita terms, VMT grew from 5,508 miles annually to 9,761 miles annually. However, that long-running trend appears to have ended. From 2000 to 2011, U.S. population grew by 10 percent, while the nation's VMT grew by just 6.7 percent. In per capita terms, U.S. VMT peaked at 10,141 miles annually in 2004, then fell to 9,474 miles annually by 2011 (U.S. Census Bureau, n.d.; U.S. Federal Highway Administration, n.d.). (See Figures 9 and 10.)

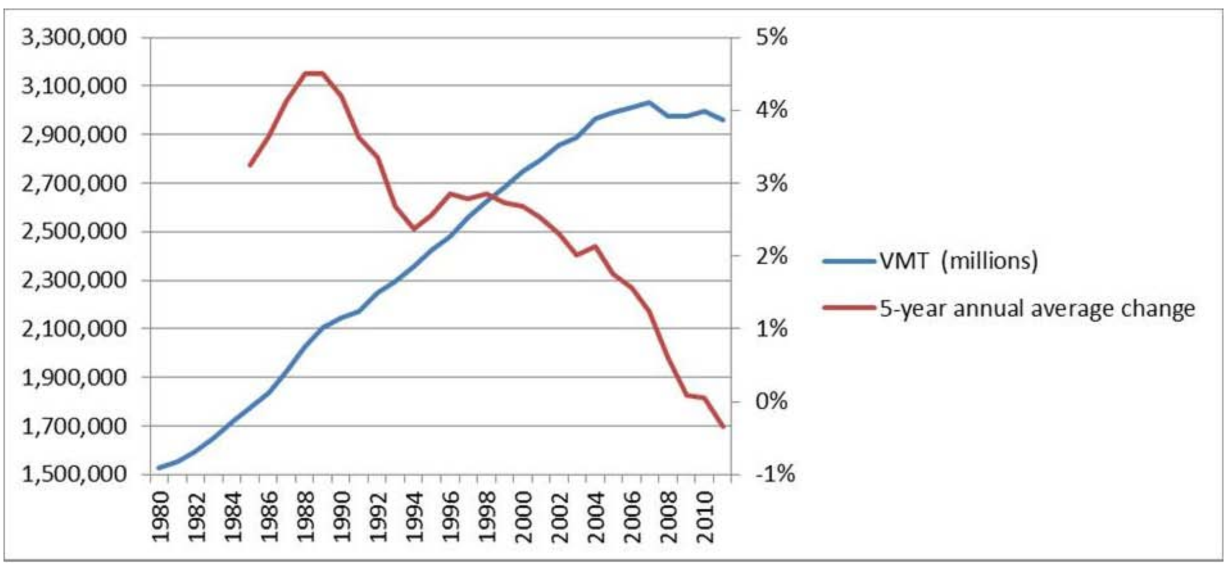

Figure 9. U.S. total VMT 1980-2011 (U.S. Federal Highway Administration, n.d.).

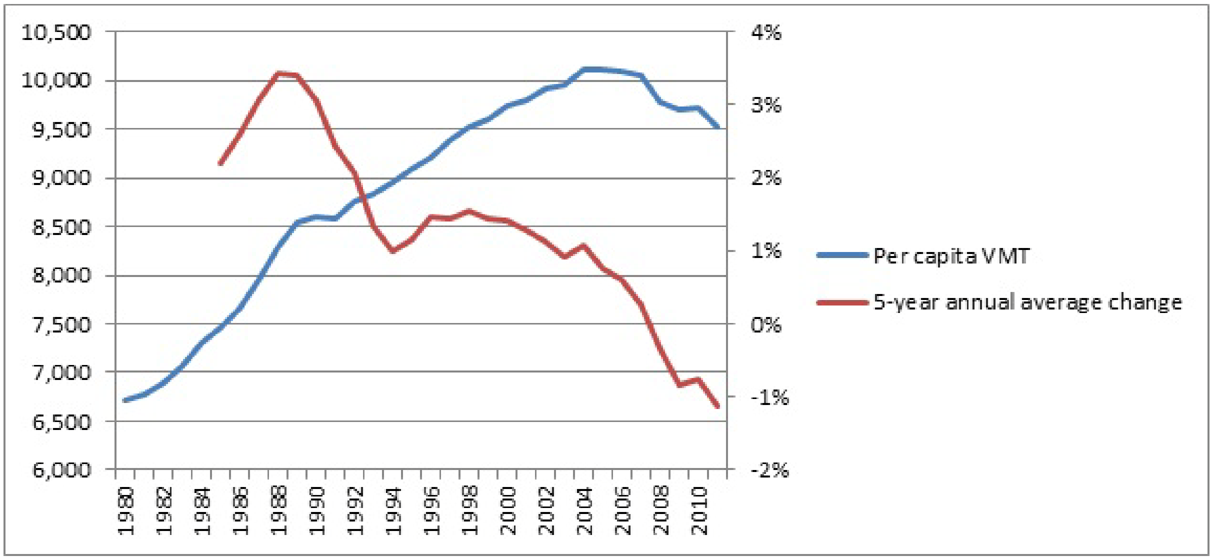

Figure 10. U.S. per capita VMT 1980-2011 (U.S. Census Bureau, n.d.; U.S. Federal Highway Administration, n.d.).

Polzin, writing before the per capita VMT peak had been documented, predicted that the United States was at a "critical juncture" in VMT (2006, p. 1). Based on a conceptual model of VMT causation inspired by the four-step travel demand model (see Figure 9), Polzin explores a variety of causal variables drivers to estimate future U.S. VMT. He suggests that:

- Trip rates will grow more slowly due to saturation of the participation of women in the labor force, declining growth in household income, slower change in household size, and a changing national age profile.
- Trip length will grow more slowly, because of increasing highway congestion.[5]
- The mode choice change toward SOV travel will slow, because the non-auto mode shares have already substantially eroded.

[5] Congestion may also reduce the speed of travel, a factor Polzin considers in one of his two estimation formulas.

- Time spent traveling will grow more slowly as travelers are unwilling to give up ever-more time for transportation.

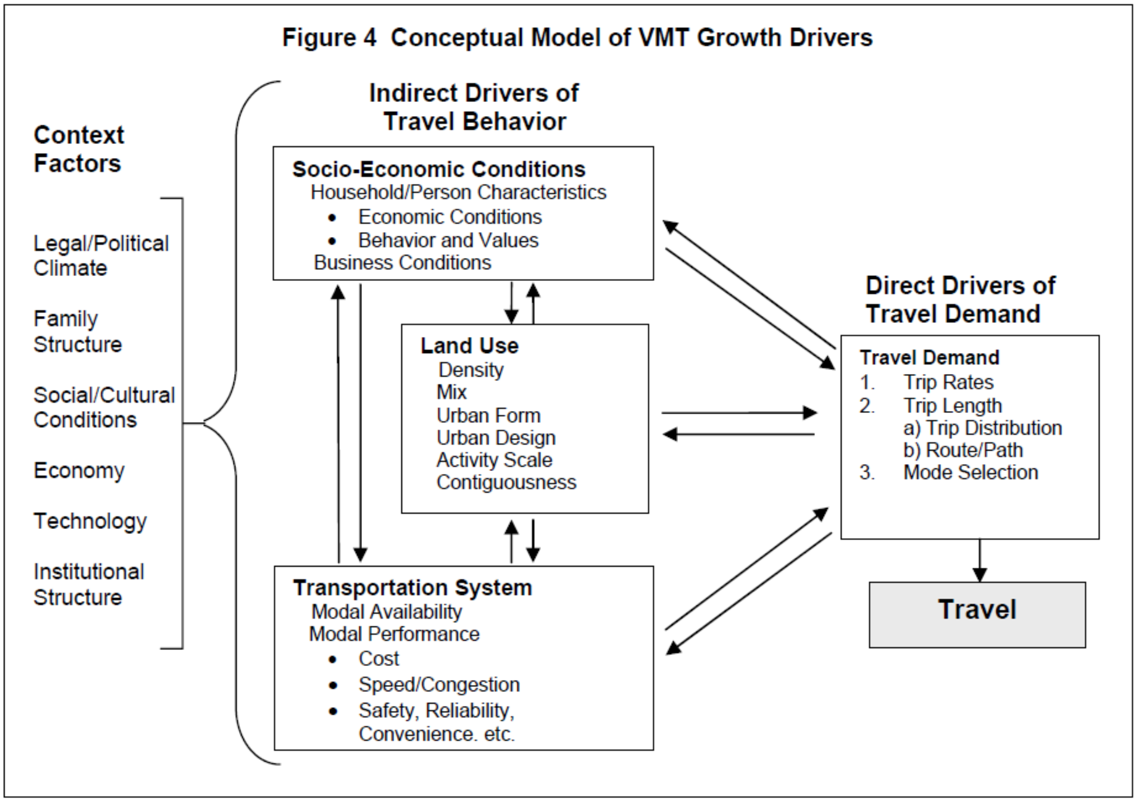

Figure 11. Polzin's (2006) conceptual model of VMT causation.

Using these factors, Polzin produces estimates for per capita VMT for 2001-2025. One method suggests 60 percent growth, and the second projects 51 percent growth – both of these substantial increases, but far lower than the 151 percent over the previous 24 years (2006, p. 32).

Though Polzin's conceptual model includes development density, mix, urban form, urban design, activity scale, and contiguousness, his estimations do not employ consider these.

> In time, the presence of powerful Geographic Information System (GIS) analysis tools and greater precision in defining land use characteristics are likely to produce a refined understanding of the empirical relationship between land use and travel and enable researchers to monitor the relationship over time. At present, such longitudinal data with sufficient precision are unavailable and researchers are less able to discern the relative impacts of land use from the other impacts such as changes in socio-economic conditions as noted earlier (Polzin, 2006, p. 20).

Following Polzin's paper, VMT data as described above began to suggest the "critical juncture" had indeed been reached, and that Polzin may have been too conservative in his estimates of the change. Rather than moderate to a third the rate of the previous quarter century, per capita VMT actually decreased.

Puentes and Tomer (2008) documented the slowing increase in VMT by geography, highway type and other categories. The major insight: "Americans have simply been driving less, when considering both historic growth rates and the most recent annualized measures of vehicle miles traveled." (Puentes & Tomer, 2008, p. 2). Puentes and Tomer do not explore the reasons for this change, aside from a footnote referring to overtaxed travel-time budgets (2008, p. 38).

Millard-Ball and Schipper find a similar VMT trend across eight developed countries: Australia, Canada, France, Germany, Great Britain, Japan, Sweden, and the United States. "There are signs of a levelling out or saturation of total passenger travel since the early years of the twenty-first century," they write. But they are unable to isolate the cause. "To some extent, this saturation is related to higher fuel prices since 2002, but this levelling out predated the rapid rise in oil prices from 2007" (Millard-Ball & Schipper, 2011, p. 363).

Newman and Kenworthy, reviewing travel data from major world cities, note the trend toward moderating VMT as well. They discuss causation, but only in terms of "possible" factors: maxed-out travel time budgets, growth in public transit use, aging populations, fuel prices, and – significantly for the current study – reduction in sprawl and greater demand for urban living. They cite data from 18 world cities that show a general trend toward higher density (Peter Newman & Kenworthy, 2011).

To conclude this section, the data and literature show strong evidence for a "critical juncture," in Polzin's words, in terms of VMT. The literature provides an incomplete theory of causation, resting strongly on travel-time budgets and demographics – variable for which national and subnational data exist. There is much literature on land use and travel interactions, and this will be explored below, but little in the way of using land use changes to explain current VMT trends. Rather, the general focus in this body of work is prospective: If X policy is implemented, Y change in VMT will result. A number of issues make land use more difficult to track over time along with VMT. For example, a nation's borders are set (generally), so any increase in population will increase density at the national level. But the American post-World War II experience shows that such an increase could come at a time when metro areas, where most people live and work, are moving toward lower density. In a nod to the importance of metro areas as the relevant unit for land use, *Special Report 298*, the metastudy mentioned in the introduction, does include historical data for U.S. metro-area density (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009, p. 39). Yet its data raises questions, in that it extends to 1940, before the Census Bureau standardized metropolitan statistical areas (US Census Bureau, n.d.), and it is sourced to a paper that extends metro-area density to 1890 without explanation (Kim, 2007). Moreover, *Special Report 298* does not attempt to compare this historical data with the historical VMT record.

It is beyond the scope of the current paper to fill this gap. However, the trend lines in Figure 2 above arguably comprise the state of the art in this area. Rather than calculating density in metropolitan areas, which beginning in 1950 were based on county boundaries, here we employ urban areas – units of Census geography defined down to the block level (US Census Bureau Geography Division, n.d.). As stated above, there is no corresponding VMT record, but the large majority of U.S. residents live in urban areas – 81 percent in 2010 (US Census Bureau Geography Division, n.d.) – so it is reasonable to expect that density in urban areas will affect VMT nationally. This appears to be the case; the correlation is .9. No strong claims are made here, as this relationship is not controlled for any other variable, and the density data has an N of just 7, at each decennial census. For the present purposes, this finding begins to fill the gap in the recent VMT trend and, more important supports the notion that exploring land use change and VMT will yield interesting and useful results.

2.2 VMT Policy Response

While U.S. VMT may have leveled off or even begun to decline on a per capita basis, it remains a major policy concern. Litman provides a concise list of reasons for setting goals to reduce VMT:

- To help solve various problems and provide various benefits, including congestion reduction, facility cost savings, consumer savings, accident reductions, improved mobility for non-drivers, energy conservation, emissions reductions, and improved public health.
- To support implementation of policy and planning reforms, such as more efficient pricing and investment practices, that increase efficiency and equity.
- To provide strategic guidance for individual policy and planning decisions by different jurisdictions and agencies. VMT reduction targets encourage transport agencies to choose solutions to traffic and parking problems that also help achieve other planning objectives, such as improved mobility for non-drivers, energy conservation and emission reductions.
- To help create a more efficient and diverse transport system that better prepares for future travel demands (Litman, 2010, p. 1).

Of these issues, the most commonly cited is emissions, and the most commonly cited emission of concern is carbon dioxide (CO2) and other greenhouse gases (GHG). As shown in Figure 10, in 2006 the U.S. transportation sector accounted for 29 percent of the nation's GHG, measured in terms of CO2 equivalence (CO2e) (US Department of Transportation, 2010, p. 2/6). Because of the United States' disproportionate use of fossil fuels, its transportation sector also accounted for a third of the world's CO2e from transportation, fully 7 percent of global CO2e (US Department of Transportation, 2010, pp. 2/6–7). Of particular concern to the current study, the majority of these transportation emissions were from on-road sources, largely cars and light trucks. (See Figure 11.)

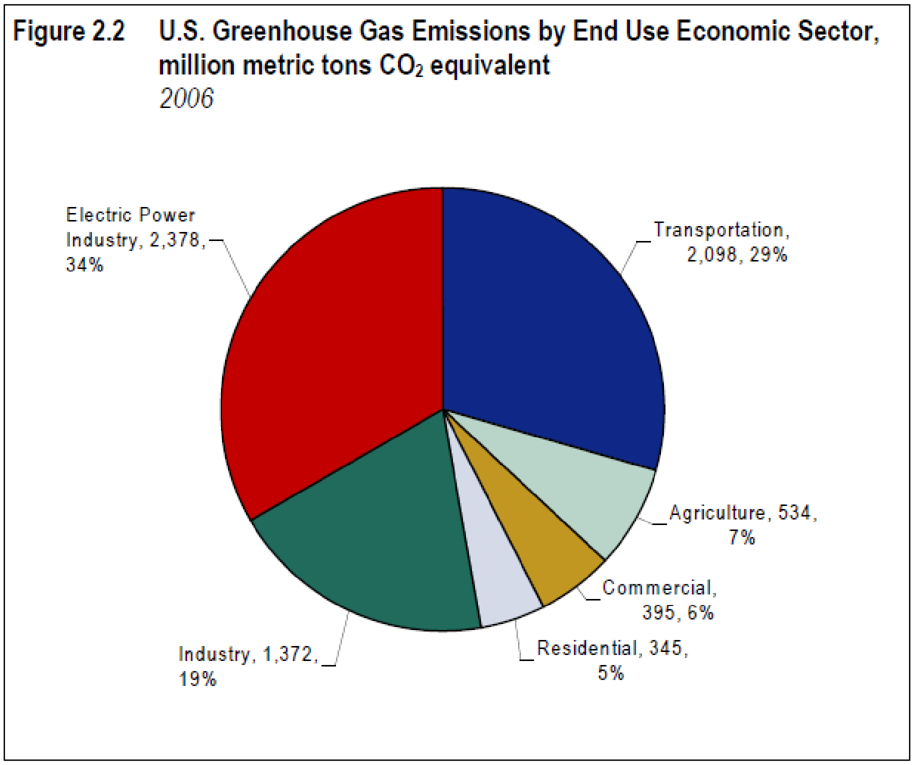

Figure 12. U.S. GHG emissions by sector, 2006 (US Department of Transportation, 2010).

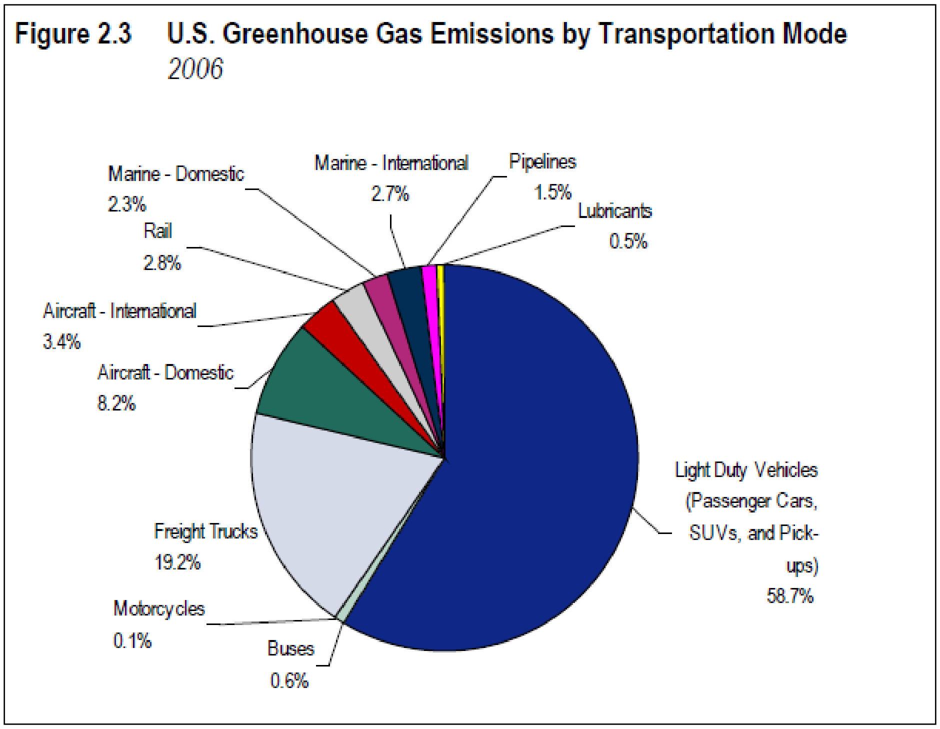

Figure 13. U.S. GHG by mode, 2006 (US Department of Transportation, 2010).

GHG emissions in transportation suggest many policy changes for vehicles – e.g., moves to more fuel-efficient vehicles – for fuels – e.g. regulations on the "well-to-wheels" GHG content of gasoline and Diesel – and for VMT. Reduction of the latter would also address concerns described above by Litman, including community livability and highway congestion relief. VMT reduction might be accomplished in various ways, including:

- Raising the price of SOV travel – e.g., via fuel or VMT taxes, or tolls.
- Establishment of activity-center-based transportation demand management (TDM) programs.
- Provision of non-SOV transportation choices.
- Greater density, mixture of use and connectivity of land uses.

Such efforts, described as some real-world examples below, are not universally embraced in a transportation community that sometimes sees growing highway infrastructure and its use as a boon to the economy, not to mention as a revenue source. The 2004 Iowa DOT strategic plan, for example, measures customer satisfaction through the magnitude of automobile and truck VMT (Iowa Department of Transportation, 2004). Pisarski (2009) argues that “VMT equals trips with economic and social transactions of value to society,” (Pisarski, 2009, p. 32) and complains that “transportation appears to be the only sector in which output—passenger miles and ton miles—is targeted for reduction, rather than their emissions or fuel consumption. No one has proposed parallel cuts in agricultural or industrial, and outputs proportionate to their emissions, or reductions in the amount of housing or commercial activity” (Pisarski, 2009, p. 39).

Such arguments, particularly Pisarski’s, imply that driving is the only form of travel, and also run counter to the notion that transportation is a derived demand – a cost – and that reduction in driving might be a benefit. Indeed, the conventional view is that VMT reduction will not hurt the economy. Puentes and Tomer argue, “Causation is from national output to VMT and not the reverse. VMT is a proxy for driving, which is an indicator of mobility. Mobility is a requirement of economic activity because individuals must be able to reach certain locations where their economic activities take place. If an individual’s same level of mobility is achieved through other means, less driving does not have a negative effect on their economic actions. Thus, aggregated up, declining VMT for a large geographic area will not be an indication of declining economic activity. This is especially true in modern times with other substitutes for mobility, such as telecommuting and online retail" (2008, p. 38). McMullen and Eckstein, reviewing U.S. economic and travel data over time, conclude that "In most circumstances the causal relationship is found to be from economic activity to VMT, confirming conventional wisdom and suggesting that exogenous shocks to VMT would not negatively impact national GDP" (McMullen & Eckstein, 2011, p. 1).

The debate over the economic effects of VMT reduction is not fully settled, but many policy-makers have already begun to act. The important question for them is how best to achieve the reductions, a subject the current research addresses.

Several states have established formal policy to reduce VMT, including:

- California. SB 375 directs the California Air Resources Board (CARB) to set GHG emission limits for cars and light trucks for the 18 MPO regions in the state (*S.B. 375*, 2008). MPOs in turn, must develop land-use and transportation plans that meet the targets. In 2011, CARB issued targets ranging from 1 percent increase to 8 percent decrease in per capita GHG emissions by 2020 and 1 percent increase to 16 percent decrease in per capita GHG emissions by 2035 ("Executive Order No. G-11-024 Attachment 4," 2011).
- New York. Gov. David Patterson's Executive Order 2 in 2008 called for reduced VMT. His Renewable Energy Task Force in 2008 called for a 10 percent reduction in VMT over 10 years (Center for Climate and Energy Solutions, n.d.).

- Oregon. Similar to California's SB 375, Oregon SB 1059 directed state agencies to set GHG reduction targets for the state's six MPOs (*S.B. 1059*, 2010). Released in 2011, the targets all call for per capita reductions ranging from 17 percent to 21 percent by 2035 ("Oregon Sustainable Transportation Initiative (OSTI)," n.d.). State agencies, in consultation with local governments and MPOs, are required to report to the Legislature in 2013 on costs and strategies for implementation.
- Washington. HB 2815 sets per capita VMT reduction targets, relative to 1990 levels, of 18 percent by 2020, 30 percent by 2035, and 50 percent by 2050 (*H.B. 2815*, 2008).

In addition, like New York, 36 states had adopted climate action plans or were developing them as of January 2011 (Center for Climate and Energy Solutions, 2011). Many of them, like the Wisconsin plan mentioned in the introduction, rely on VMT reductions to achieve GHG goals. In addition, many other state and local plans call for compact development, transit expansion, and many other measures that reduce VMT, often citing the gains that come from reduced VMT without setting specific targets. One of these is the Seattle comprehensive plan, which includes this goal (emphasis added): "Coordinate with other city, county, regional, state, and federal agencies to pursue opportunities for air and water quality improvement, street and stormwater runoff prevention, reduction in vehicle miles traveled, [emphasis added] and noise reduction"(City of Seattle, 2012, p. 3.15). Seattle and surrounding localities have pursued land use strategies in part to address transportation challenges for nearly two decades. That history is described in the next section.

2.3 Efforts at Densification and Traffic Reduction in Seattle

In the 1980s, citizens in the Puget Sound region and around the state voiced strong complaints about problems from rapid, uncontrolled growth – traffic congestion, land consumption, environmental degradation, and property tax increases (Hinshaw, 1999). Citizen groups such as the League of Women Voters and the 1000 Friends of Washington (now known as Futurewise), along with many local planning directors and some developers who sought uniformity in local land-use regulation, supported a wide range of growth control (Lawrence, 2005). In 1990, the legislature passed a Growth Management Act (GMA), and then strengthened it in 1991 (*ReSHB 1025*, 1991, *SHB 2929*, 1990). The law has four major policy goals:

- New growth must be concentrated in Urban Growth Areas that are contiguous to existing urban areas.
- New development may not occur unless transportation and other public facilities are provided "concurrently."
- Local governments must include affordable housing.
- Natural resource lands and environmental critical areas must be protected (Calthorpe & Fulton, 2001).

Three hearings boards were established to adjudicate disputes under the law in three regions of the state, but implementation was left to local governments.

In the Seattle area, the regional planning agency – the Puget Sound Council of Governments, since renamed the Puget Sound Regional Council – had led a group of local officials and growth-management activists in a planning effort that began in 1987 and three years later produced *Vision 2020.* The plan was wide-ranging, and it provided both inspiration for policy-makers involved with the GMA and a basis for how Seattle and other localities would jointly and individually respond to the mandates of the act. It envisioned containing new development in "urban growth areas," and a series of densifying urban and town centers within these areas (Calthorpe & Fulton, 2001; Puget Sound Regional Council, 2009). "One of the most remarkable results of this collective planning was the designation of a dozen 'urban centers' throughout the region into which *more and denser* development would be channeled, in return for no longer expanding outward"(Hinshaw, 1999). The GMA essentially mandated this approach, which the PSRC has continued to pursue, providing regional funding for implementation ("Regional Growth Centers," n.d.). For example, the region's transportation project selection process advantages projects that are within the centers, or which provide access to them (Puget Sound Regional Council, 2012).

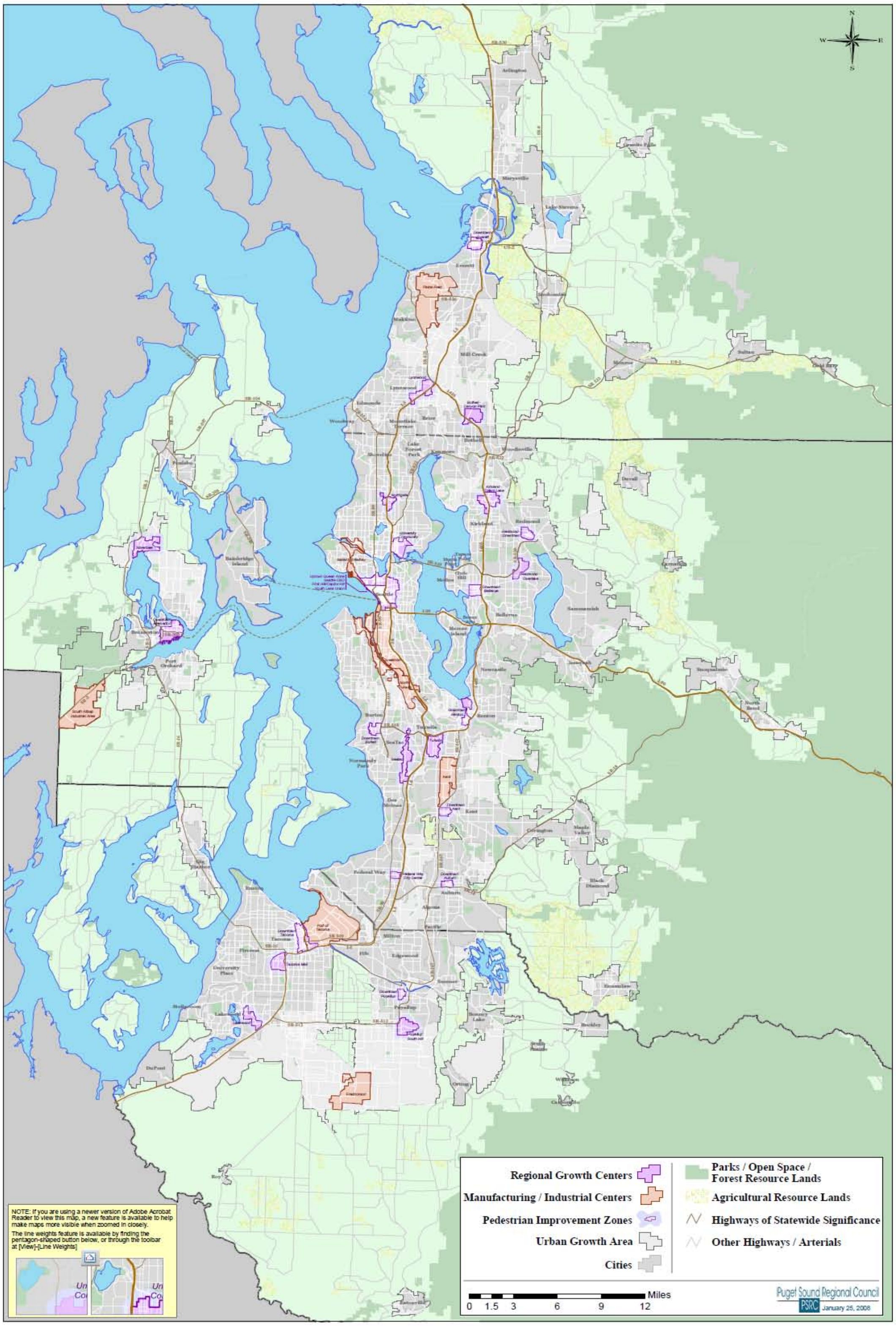

Figure 14. PSRC regional growth and manufacturing/industrial centers, 2008 ("Regional Growth Centers," n.d.).

The regional plan set the framework for growth management, but the details were left to local governments. After the GMA was enacted, the largest of these, Seattle, was faced with developing a comprehensive plan – and a planning department. Previously, planning functions had been dispersed through various departments, as City Council had seen a planning department under the executive as reducing its power vis-à-vis the mayor (Lawrence, 2005). The planners' job was daunting: to accommodate 70,000 new residents and 150,000 jobs in 20 years, without increasing density in single-family-zoned areas, and with maximal public participation. They produced what became known as "the Mayor's urban villages strategy" – technically, the comprehensive plan called "Toward a Sustainable Seattle" – which was adopted by City Council in 1994. The plan called for increased residential density in neighborhood-scale villages, with mixed use in the retail cores and rings of multi-family, townhouse and single-family detached housing radiating outward, as well as downzoning outside of the villages. Developers seeking to build multi-family and commercial projects in the villages were required to meet with local, five-member review boards early in the permitting process; the boards include both citizen representatives and design professionals. The boards, whose jurisdictions generally encompassed more than one urban village, were developed in the early 1990s but independently of the mayors' plan, after some neighborhoods, alarmed at the sort of growth they saw, sought authority to enact their own design guidelines. "People are pretty empowered here," said John Skelton, Land Use Policy Manager in the Department of Planning and Development (Skelton, 2007). The boards had authority to grant "departures" from land use codes developers found "onerous" (Bicknell, 2007), with the goal of provoking developers to not simply "build to code," or erect low-design structures that simply use the maximum allowed development potential (Skelton, 2007). The boards did not help sell the mayor's plan with the public, as they were untested at the time, but they have helped with the implementation – "no question," according to Skelton. As adopted, the comprehensive plan launched a five-year neighborhood planning effort, supporting residents' efforts to develop their own plans for the urban villages where they lived. Afterward, the city continued to make some neighborhood planning support available – $571,736 in 2004 – as well as matching funds for neighborhood projects – $2,247,493 in 2004 (Lawrence, 2005).

The public face of the plan was Mayor Norman Rice. Rice was not a planner by trade, having worked as an editor at a television station, as associate director of the local Urban League chapter, and as a bank's corporate communications manager, and having run for mayor because of a school issue. He had been exposed to planning issues, however, as a City Council member during the debates over downtown urban design in the 1980s, and during a stint as assistant director of government services for the Puget Sound Council of Governments. When a major downtown planning issue arose during his terms as mayor, Rice sided with downtown retailing power Nordstrom against neighborhood residents when the store insisted on traffic being permitted on a street that had been devoted to a civic plaza (Keene & Nelson, 1997).

To develop the comprehensive plan, Rice hired as planning director Gary Lawrence. "It's fair to say it was the mayor's plan. … He called it a moral struggle…, a referendum on what we should become," Lawrence says. "The mayor decided planning was about people's lives, justice and opportunity (Lawrence, 2005)." Despite a warm reception from the Chamber of Commerce, "the grassroots hated it" (Lawrence, 2005) – at least some very vocal elements did. One City Council Member, Charlie Cong led an effort for the West Seattle neighborhood to secede from the city; other neighborhood activists formed the Civic Foundation, which fought "the urban village concept as a way of shoving development down the throats of neighborhoods," says City Council Member Nick Licata, who was allied with the group (Licata, 2005). The negative reaction showed the need for more public participation than planners had anticipated. Before signing off on the plan, City Council advocated for more public engagement, and the mayor agreed. The result was the five-year neighborhood planning program discussed above. Said Karma Ruder, who directed the Neighborhood Planning Office, "The mayor was very courageous in this willingness to open up the process to an extraordinary level of public involvement, because he saw that was going to be needed" to implement the urban villages plan (Ruder, 2006).

Over time, residents' anger dissipated. Though it placed Licata on the City Council, the Civic Foundation gradually ran out of steam and finally went out of business. Charlie Cong ran for mayor and failed, while other council members who voted for the comprehensive plan generally did well in re-election voting. Design Review Board decisions for projects in urban villages were initially appealed often, by both residents and developers, but now no longer are, as all sides learned to use the process in the first few years (Hinshaw, 1999; Skelton, 2007). In 1999, five years after the plan passed, a Seattle Times columnist signaled the growing acceptance: "The urban villages plan, massaged by years of citizen participation, has now come back with a veneer of acceptability and a new urgency from all the traffic congestion" (Brewster, 1999). Even Licata says "concern has lessened perceptibly. There's a greater recognition that the city needs to accommodate more growth" (Licata, 2005).

The passage of time also permits an assessment of urban design and environmental outcomes. Mark Hinshaw, an architect and architectural critic for the Seattle Times, is enthusiastic about the city and regional effort at planning. "Downtowns throughout the region are thriving, bustling with shops, theaters, and – yes – dense urban housing. All sorts of new housing forms are now being built and people cannot get enough of them" (Hinshaw, 1999). This impression is supported in a 2003 assessment by the city, which found greater population increases in the urban villages during the 1990s than in the rest of the city, despite the relatively small land area of the former. (See Table 1.) "Urban villages are fulfilling their role defined in the Comprehensive Plan as the primary locations for growth in Seattle…. This growth within urban villages appears to be strengthening their communities and their business districts. It is also serving the Comprehensive Plan's purpose by focusing residential growth in areas where services and transit are readily available." The report cites some specific successes of neighborhood planning under the comprehensive plan, including streetscape and park improvements. Such planning "created a remarkable legacy of citizen participation. People in every urban village we studied said (usually before asked) that involvement and activism are still high today because of the neighborhood planning process…." In four of five urban villages studied – there are a total of 37 urban villages in the city, classified as villages within “Urban Centers,” plus “Residential Urban Villages” and “Hub Urban Villiages – pedestrian activity was up, but the report warned that increasing walking in some villages with auto-dependent development would be more challenging (Seattle Department of Design, Construction, and Land Use, 2003).

Table 1. Seattle population (Seattle Department of Design, Construction, and Land Use, 2003).

		Population		
	Acres	1990	2000	Change
Urban villages	9,350	146,960	175,240	19 percent
Outside of villages	44,410	369,300	388,130	5 percent

2.4 The Land Use Policy Lever

2.4.1 Establishing the land use-VMT relationship

The relationship between development patterns and human behavior is central to planning. Yet guidance has been slow in coming. In 1999, Alberti reviewed the research and found it wanting: “Urban policymakers are, more than ever, challenged by the task of redirecting urban change into a more sustainable course. To do so, they expect urban analysts to answer one fundamental question: What is an environmentally appropriate urban form? However, as this review shows, the study of urban morphology in relation to environmental processes is still too fragmentary and lacks a theoretical framework to answer such a complex question (Alberti, 1999, pp. 159–160).” Specifically regarding travel demand, Crane’s 2000 review of the literature concludes that “Little if any hard evidence indicates how the built environment can reliably manipulate travel behavior” (Crane, 2000, p. 18).

Yet planners and policymakers must act, even if prescriptions are imprecise. According to a leading textbook in transportation planning:

> Of greatest interest to transportation planners over the next several decades will be the question of whether a proactive land-use policy (i.e., where government takes a lead role in influencing land-use decisions) can be combined with transportation investment decisions to provide a more 'desirable' urban form…. Some of the policies and planning tools include [Deakin, 1991; Ewing, 1997]
> 1. Urban limit lines and urban development reserves designed to produce compact development in areas where urban services are already available or are scheduled.
> 2. Mandatory consistency between local land-use plans and local and regional transportation plans.
> 3. Requirements for the provision of adequate public facilities concurrent with development, or attainment of minimum level-of-service standards.
> 4. Mandatory balancing of job growth with housing development, priced and located to match the needs and incomes of the work force.
> 5. Minimum as well as maximum densities and floor area ratios to ensure adequate development for transit to work.
> 6. Incentives and bonuses for desired land uses and for developments that provide desired transportation and land-use amenities.
> 7. Site design planning emphasizing pedestrian access and transit serviceability (Meyer & Miller, 2001).

That density of the built environment, whether measured by population, housing, or jobs, is associated with travel demand at an aggregated, metro level is not in dispute. Newman and Kenworthy, for example, found that among large global cities, urban density was highly correlated with transportation energy use (Peter Newman & Kenworthy, 1999). Similar, more sophisticated analyses that controlled for income and other variables confirm this relationship (Van De Coevering & Schwanen, 2006). For policy, however, we would like to know the effect of built environment variables on household and individual behavior, which requires an analysis of disaggregated data (R. Ewing & Cervero, 2010), and we would like more evidence of causation. These issues are far less straightforward than correlations at the metro level.

One difficulty in judging the effects of density, mixture of uses, and other aspects of the built environment on household or individual travel demand is the methodological problem of self-selection – the notion that the reason compact neighborhoods are associated with lower VMT might be that they attract people who dislike driving. This theme in the literature dates to the mid-1990s, when Kitamura, Mokhtarian and Laidet examined travel behavior in five San Francisco-area neighborhoods. Density, mixed land use and presence of transit all showed the expected negative relationship with VMT. But when travelers' attitudes about travel and other issues were added to the models, these factors accounted for more of the variation in VMT than did the land use variables. "The finding that attitudes are more strongly associated with travel than are land use characteristics suggests that land use policies promoting higher densities and mixtures may not alter travel demand materially unless residents' attitudes are also changed" (Kitamura, Mokhtarian, & Laidet, 1997). Handy, another California-based researcher, followed this line of research, raising a strong warning about the role of self-selection, concluding that existing studies have shown only that "it is safe to conclude that land use and design strategies such as those proposed by the new urbanists may reduce automobile use a small amount, at least to the degree that these strategies help to address an unmet need for neighborhoods conducive to driving less (S. Handy, 2005b, p. 162). She cautions researchers that demonstrating the link between the built environment and travel behavior requires association, time precedence, nonspuriousness, and a plausible causal mechanism, including travel time and cost (S. Handy, 2005b).

Many studies had been able to show association and to posit a causal mechanism, such as time and dollar costs. Time precedence and spuriousness remained a concern, however – do people walk more because they live in a dense neighborhood, or do they choose the dense neighborhood because they want to walk more? (Cao et al., 2009). One problem is that most studies used cross-sectional data, making time precedence and nonspuriousness difficult to claim. However, instrumental variables can be employed, and some research has relied on longitudinal data, with its greater claim to temporal precedence. In 2003 Krizek used the PSRC's panel data on travel behavior to show that travelers who moved from one part of the area to another demonstrated altered travel demand – those exposed to higher density and other measures of neighborhood accessibility had lower VMT (Krizek, 2003). Soon after, a longitudinal approach using data from eight California communities found significant built environment effects even after accounting for attitudes (S. Handy, Cao, & Mokhtarian, 2005). By the end of the decade, dozens of studies had addressed the self-selection question, showing "resounding" evidence of environmental effect (Cao et al., 2009). Some studies estimated the relative contribution of attitudes and environment. For example, Bhatt and Eluru, using data from the San Francisco area, compared traditional urban and car-oriented suburban neighborhoods. They estimated that 87 percent of the difference in VMT was due to environmental factors, not self-selection (Bhat & Eluru, 2009). Finally, in terms of policy interest, self-selection may not be a critical factor if there is an undersupply of compact environments, relative to the number of households who would self-select into them if they could. Several studies suggest this is, in fact, the case (Levine & Frank, 2007; Levine, Inam, & Torng, 2005; Tu & Eppli, 1999).

As researchers have addressed self-selection, they have also developed important explanatory built-environment variables and the understanding of the variables' interrelationship. As described above, socioeconomic variables have long been understood to affect VMT. Age, marital status and presence of children in a household have been so thoroughly studied that combining these factors into "lifecycle" categories has become standard practice in travel behavior research (Kostyniuk & Kitamura, 1986). Sorting out the built environment variables along with socioeconomic factors has been more contentious. In one frequently cited study from the 1990s, Kockelman considered the effects of socioeconomics as well as built environment variables on travel behavior. She found that VMT increased with household size, income and auto ownership. While some built environment variables were significant, density was not (Kockelman, 1997).

However, intuition would suggest that built environment characteristics might prompt households to own more or fewer cars. If so, then models like Kockelman's that include auto ownership as controls will underestimate the effect of the built environment. In fact Kockelman did find that built environment variables affected auto ownership. Kuzmyak et al., in a study using Baltimore travel data, also found density and other land use characteristics affected auto ownership (J. R. Kuzmyak, Baber, & Savory, 2006), and Holtzclaw et al. reported similar findings based on data from Chicago, Los Angeles and San Francisco (Holtzclaw et al., 2002).

In addition to addressing socioeconomic and auto ownership variables, research has improved our understanding of important elements of the built environment. In the 2000s it became common to examine the "3Ds" of local land use – density, diversity and design, as coined by Cervero and Kockelman (1997). Ewing and Cervero synthesized 14 studies involving these variables to estimate elasticities for trips and VMT (R. Ewing & Cervero, 2001), and their work was employed by the U.S. Environmental Protection Agency (EPA) for modeling emissions credit for land use activities (J. R. Kuzmyak, Pratt, Douglas, & Spielberg, 2003). The model "measures density as residents plus jobs per square mile; diversity as the ratio of jobs to residents divided by the regional average of that ratio; and design as street network density, sidewalk coverage, and route directness (road distance divided by direct distance)" (R. Ewing & Cervero, 2010, p. 268). An updated meta-analysis by the same authors almost a decade later (R. Ewing & Cervero, 2010) expanded the list of Ds to include destination accessibility and distance to transit. Their definitions:

> *Density* is always measured as the variable of interest per unit of area. The area can be gross or net, and the variable of interest can be population, dwelling units, employment, building floor area, or something else. Population and employment are sometimes summed to compute an overall activity density per areal unit.
>
> *Diversity* measures pertain to the number of different land uses in a given area and the degree to which they are represented in land area, floor area, or employment. Entropy measures of diversity, wherein low values indicate single-use environments and higher values more varied land uses, are widely used in travel studies. Jobs-to- housing or jobs-to-population ratios are less frequently used.
>
> *Design* includes street network characteristics within an area. Street networks vary from dense urban grids of highly interconnected, straight streets to sparse suburban networks of curving streets forming loops and lollipops. Measures include average block size, proportion of fourway intersections, and number of intersections per square mile. Design is also occasionally measured as sidewalk coverage (share of block faces with sidewalks); average building setbacks; average street widths; or numbers of pedestrian crossings, street trees, or other

physical variables that differentiate pedestrian-oriented environments from auto-oriented ones.

Destination accessibility measures ease of access to trip attractions. It may be regional or local (S. Handy, 1993). In some studies, regional accessibility is simply distance to the central business district. In others, it is the number of jobs or other attractions reachable within a given travel time, which tends to be highest at central locations and lowest at peripheral ones. The gravity model of trip attraction measures destination accessibility. Local accessibility is different, defined by Handy (1993) as distance from home to the closest store.

Distance to transit is usually measured as an average of the shortest street routes from the residences or workplaces in an area to the nearest rail station or bus stop. Alternatively, it may be measured as transit route density, distance between transit stops, or the number of stations per unit area.

Weighted average elastiticies of VMT related to these variables range from 0 to -0.22. Population and job density, in particular, showed little effect. “Conventional wisdom holds that population density is a primary determinant of vehicular travel, and that density at the work end of trips is as important as density at the home end in moderating VMT. This does not appear to be the case once other variables are controlled” (R. Ewing & Cervero, 2010, p. 275). The authors suggest that planners and decision-makers employ their findings to inform policy via scenario planning or to refine estimates of travel activity produced by four-step travel demand models. “If planners are willing to make assumptions about the increases in density and other D variables that can be achieved with policy changes, they can use elasticity values from this article to estimate VMT reductions in urbanized areas and to translate these in turn into effects on CO2” (R. Ewing & Cervero, 2010, pp. 276–277). The Delaware Department of Transportation (DelDOT) takes such an approach with its Land Use and Transportation Scenario Analysis and Microsimulation (LUTSAM) process, which combines GIS and microsimulation software with a four-step model to run various build-out scenarios in developing areas, allowing zoning authorities to understand impacts on VMT, congestion and other outcomes (State Smart Transportation Initiative, n.d.).

Yet, while models employing variables operationalizing numerous separate elements of the built environment are likely to "explain" more variation than those with fewer, they have significant drawbacks in other ways, both in their utility to planners and policy-makers and as models of reality. In the day-to-day world of land use development, planners primary method of governance is via density and use, but in the five D's above density outside of a traveler's neighborhood is conflated with the transportation system. Moreover, even when all the Ds can be considered – and the data exist to do so – these variables interact; e.g. density is a needed precondition for all of the other Ds to make headway in lowering VMT or even, in the case of transit and mixed use, to exist. At the policy-making level, to provide guidance on the magnitude of land use policy levers on GHG emissions, a single, rolled-up variable such as density may be superior. According to Cervero and Murakami (2010), "In the recent works of Ewing et al (2008), Ewing and Nelson (2008), and Marshall (2008), density serves as a stand-in for smart growth, soaking up the influences of three other 'D's': diversity (of land uses), designs (which are pedestrian friendly), and destination accessibility. At the extreme, very dense neighborhoods in Manhattan are also land-use diverse, highly walkable (eg short block faces), and very accessible to other destinations (courtesy of public transit, which itself can only be sustained by density)." *Special Report 298* (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009) and *Growing Cooler* (Reid Ewing, Bartholomew, Winkelman, Walters, & Chen, 2008), the two major recent scenario-based national-level assessments of the potential for built environment policy to reduce GHG, both use density in this way.

2.4.2 Two scenarios employing VMT and land use elasticities

Any relationship between the built environment and VMT, of course, means little if the built environment is unchanging, or changing slowly in comparison to fleet mix, carbon content of fuels and other potential GHG policy levers. Pisarski expresses optimism about operations, including eco-driving, truck fleet optimization, and better route planning to make inroads on GHG. Not so land use. "Just as strong as the operations case is, the almost opposite applies to prospective land-use solutions. There is little in the way of pay-offs in the immediate near term. Most land use pay-off potentials are in the long-term future, and studies to date place the potential pay-offs there as limited" (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009, p. 39).

Special Report 298 also expresses pessimism on the chances for significant and relatively quick land use changes.

> The durability of the housing stock makes it difficult to change development patterns, at least in the short and medium terms. In contrast to passenger vehicles, whose median age in 2007 was 9.2 years, housing typically lasts 50 years or longer (Brown et al. 2005). The longevity of existing housing is often coupled with the negative receptivity of existing homeowners to change, particularly to increasing density levels in their communities, which is frequently perceived as threatening the value of their homes. More generally, most U.S. metropolitan areas have mature land use patterns and transportation systems that make change difficult, except at the margin. The maturity and durability of metropolitan

> development patterns help explain why policies to change land use have incremental effects that only cumulate over a long time frame (p. 122).

To quantify the pace of change, both *Special Report 298* and *Growing Cooler* cite well-known studies by Nelson (2004, 2006). The latter extends his projections from 2030 to 2050. *Special Report 298* reports these estimates, along with those from Pitkin & Meyers (2008). (See Table 2.) In contrast to *Special Report 298's* rather gloomy qualitative assessment above, *Growing Cooler* sees these projections as a validating the notion that land use can be important. “If Nelson’s forecasts are correct, two-thirds of the development on the ground in 2050 will be built between 2007 and then. Pursuing smart growth is a low-cost climate change strategy, because it involves shifting investments that have to be made anyway” (Reid Ewing et al., 2008, p. 8).

Table 2. Estimates of new U.S. housing units (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009).

TABLE 4-4 Comparison of Estimates of New Housing Units, 2030–2050 (in millions)

	Pitkin and Myers	Nelson and Ewing et al.
2030		
New units for population growth	37.6–48.0	38.8
Net replacement units	8.2–8.7[a]	20.1[b]
Total new and replacement units	45.8–56.7	58.9
Percent of 2000 dwelling units	43.5–53.9[c]	50.8[c]
2050		
New units for population growth	47.6–86.8	52.0
Net replacement units	14.8–18.6[a]	37.0[b]
Total new and replacement units	62.4–105.4	89.0
Percent of 2000 dwelling units	59.3–100.2[c]	71.8[d]

[a] Pitkin and Myers assume a net replacement rate of 0.2 percent per year.

[b] Nelson assumes a net replacement rate of 0.58 percent per year. Ewing et al. extrapolate this rate to 2050.

[c] Pitkin and Myers' 2000 base is all occupied housing units (105.2 million), while Nelson's 2000 base is all housing units (115.9 million).

[d] The base year of Ewing et al. is 2005 (124 million housing units from the American Housing Survey). Using census population estimates for the same year, they derive a ratio of units per capita, which they then apply to census population estimates for 2050, assuming household size will not change substantially.

Sources: Pitkin and Myers 2008; Nelson 2004; Ewing et al. 2007.

Armed with land use elasticities related to VMT and projections of the magnitude of new development, *Special Report 298* and *Growing Cooler* must make a judgment about what the new development will look like. The former runs two scenarios, one assuming that a quarter of new housing development will be built at double the baseline density, and the second assuming that three quarters of new housing development will be compact (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009). *Growing Cooler* assumes that with smart growth policies overall new development will be 75 percent more compact than the baseline. With the assumption that 66 percent of existing growth will be new by mid-century, *Growing Cooler's* scenario has the gross density of U.S. urbanized areas rising by 50 percent by 2050 (Reid Ewing et al., 2008).

Growing Cooler estimates that land use policy changes, shown in its model as increased population density, would reduce annual VMT growth by 7.7 percent compared to the baseline. Combined with policies to rein in new highway lane miles, increase transit revenue miles and impose new price signals on motor fuel, the reduction grows to 38.1 percent annual (Reid Ewing et al., 2008). In contrast, *Special Report 298* finds a total 1.3 percent to 1.7 percent VMT reduction through 2050 under its first scenario, and an 8.4 to 11.0 percent reduction under the second scenario (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009). *Special Report 298* occasioned a rejoinder from the authors of *Growing Cooler*, who charged that "The NRC report reflects a conservative bias that is common in much academic work" and proceeded to attack some of the report's assumptions, including the *Special Report 298's* assumption about the VMT elasticities related to density and other Ds. "The NRC report reflects a conservative bias that is common in much academic work. It assumes that the distant future, even out to 2050, will not be very different from the world today" (R. Ewing, Nelson, Bartholomew, Emmi, & Appleyard, 2011, p. 1).

2.4.3 The role of land use in travel demand reduction

Settling that dispute over *Special Report 298* is not within the scope of the present work. Rather, here we explore one element of conventional wisdom, present in both studies, that may significantly underestimate the effect of land use on VMT: a multiplier effect of infill development. In addition, we consider another built environment variable that might, along with the other Ds, suggest a larger role for land use as well: the spillover effects of densification.

In considering effect of new growth, both *Special Report 298* and *Growing Cooler* fail to take into account the multiplier effect of infill. If new housing takes is built near existing housing, not only is the density of the new housing important – and both studies recognize this – but it also raises the density of the existing housing around it – something neither acknowledges.

Special Report 298 assumes lower VMT, compared to the baseline, for residents living in new compact housing. But for those in existing homes, nothing will change. The scenarios "assume that the driving patterns of those who live in existing housing will remain unchanged at 21,187 miles per household per year, the figure reported in the 2001 NHTS (Hu and Reuscher 2004)" (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009, p. 150).

Growing Cooler is less explicit about the assumption, but it assumes 66 percent of the built environment will be new in 2050 and that 60 to 90 percent of that will be compact, leaving "more than 40 percent of development as it is today, largely sprawling and auto oriented" (Reid Ewing et al., 2008, p. 33). In their rejoinder to *Special Report 298*, they repeat their view that "we are talking about the increment of new development on top of a base that is mostly sprawl" (R. Ewing et al., 2011).

Both scenarios, then, essentially expect new development, whether compact or not, to occur outside of "locked-in" developed areas. This is true despite both studies' acknowledgement that much new development will not add to the current stock but will replace existing buildings. In addressing housing, *Special Report 298* says, "Where replacement units are involved, either the new unit could be built more compactly than the one it replaces (e.g., a single unit could be split into two) if zoning permits, or the homeowner could sell the replacement unit and move to a unit in a more compactly developed area" (Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council, 2009, p. 149). In the former case, such redevelopment would also expose the neighbors to greater density, yet as discussed, the authors chose to assume the status quo for VMT for people living in existing housing.

The Seattle area, as described above, in the 1990s launched an effort to facilitate infill. It therefore offers a good test case for these assumptions. If there is evidence that infill is substantially increasing the density exposure to residents in existing housing, then we need to recalibrate our expectations for the power of land use to reduce VMT and GHG. That we can attach any such findings to the specific policies enacted in Seattle will provide planners with the kind of real-world example they so often need to make policy headway; hence the rather long description in the earlier part of this chapter.

That infill can expose existing housing – and, less discussed, other land uses – to higher density is an uncontestable assertion. The analysis will show the extent to which this is true.

More subtle is another issue related to the question of where development occurs. Studies abound with analyses at the aggregate, metropolitan level (P. Newman & Kenworthy, 2006; Van De Coevering & Schwanen, 2006) and at the disaggregate neighborhood or Census tract level.[6] At the disaggregate level, the relationship between neighborhoods is typically addressed, as noted above, as "destination accessibility." Such a variable has been shown to have considerable power, with elasticities to VMT that are far greater than that of neighborhood-level residential or job-center density when these variables are considered together (R. Ewing & Cervero, 2010). Yet this construct has some problems in terms of explanation and as a guide for planners and policy-makers. Destination accessibility, as any kind of accessibility, implicates land use and transportation systems; accessibility is measured in time or dollar costs to reach a destination, so it improves with both proximity and speed of travel. As discussed above, density is a measure of proximity, so a model including both variables has one soaking up the effect of the other. Moreover, as with the approval of individual development projects, the question of land

[6] Ewing and Cervero (2010), in estimating VMT elasticities with regard to built environment variables cite 62 such studies.

use is often considered in different forums and on different time horizons from changes in the transportation system. In 2010 study of U.S. urbanized areas, Cervero and Murakami (2010) provide perhaps the most compelling reason to consider disaggregating proximity/density from transportation. At the urbanized area level, they found a population density to VMT density of -0.604 – far higher than that estimates used in *Growing Cooler* or *Special Report 298.* They suggest, however, that density prompts transportation projects – often highways – which in turn induce travel. Netting the direct effect of density with this induced infrastructure and travel yields a elasticity of -0.381, which is fairly close to *Growing Cooler's* -0.3. The authors describe the link between density and induced infrastructure and travel:

> The positive association of population density and road density, and the countervailing influence this has on VMT, could be called the `Los Angeles effect'. The city of Los Angeles averages the highest overall population density in the USA, matched by a thicket of criss-crossing freeways and major arteries that form a dense road network (Eiden, 2005). The city also averages the highest level of vehicular travel per capita, and the worst traffic congestion in the USA, according to the Texas Transportation Institute (Schrank and Lomax, 2007). Eiden (2005, pages 7-8) calls this dysfunctional combination of high population and road densities the ``worst of all worlds'' and concludes that ``because traffic congestion increases exponentially with car density and city size, so do the externalities associated with car travel''. In Los Angeles, population densities are generally too high for a car-dependent city, yet they are not organized along linear corridors, such as is found in transit-friendly cities like Stockholm and Curitiba (Cervero, 1998), to draw sufficient travelers to public transit. Such population densities are too high for cars, and too poorly organized for transit – they are, by and large, dysfunctional densities (p. 416).

Of course, some cities aspire to achieve greater density without inducing new highway development or automobile travel. Vancouver, B.C., for example, adopted a 1997 plan that called for accommodating new residents and businesses, while not adding automobile infrastructure. By 2005, the city grew by 50,000 residents, while many measures of auto traffic actually declined, e.g. per capita VMT by Vancouver drivers declined 29 percent. Some travel shifted to transit, abetted by the city's growing investment in its SkyTrain system, but bicycling and walking travel grew even faster (Vancouver Engineering Services/Strategic Transportation Planning, n.d.). In other words, by planning for density without new auto infrastructure, Vancouver displayed a VMT to density elasticity of -2.98,[7] an order of magnitude higher than the Growing Cooler elasticity. (Annual VMT data do not exist for Seattle, but for King County, Wash., the VMT to density elasticity over the period 1999 to 2009 was -0.66,[8] double the *Growing Cooler* figure. This is not directly comparable to Vancouver, because King County is a much larger geographic area including more suburban and rural neighborhoods, and because the King County figure is based on VMT in on roads in the county, while Vancouver's is based on VMT of Vancouver residents.)

Drawing firm conclusions from the Vancouver experience would be hazardous. There are no controls for demographics, nor comparisons with similar groups not affected by the density increase. Yet as a city story, it stands in stark contrast to the Los Angeles experience described above, suggesting that increased density under the right conditions may have very beneficial effects on VMT. In a very different setting, the Phoenix area, Kuzmyak investigated density and traffic, though on a more localized scale, and also reported encouraging findings: "Fears about compact, mixed-use development leading to intolerable traffic congestion do not appear to be substantiated by what is seen in practice" (J. Richard Kuzmyak, 2012, p. 214).

[7] Population density change based on 1996 base of 514,008 ("2001 Community Profiles," n.d.).
[8] Population estimates from PSRC ("Population and Housing Estimates," n.d.), VMT estimates from King County Office of Performance, Strategy and Budget ("VMT per capita in King County," n.d.).

The Seattle area, like Vancouver, in the 1990s embarked on a strategy of densifying already-developed areas, particularly in selected neighborhoods and corridors. The resulting development offers an opportunity to look again at land use and VMT. As discussed, the relationship between neighborhood-level density and VMT has been much studied. However, as skeptics of land use policy levers point out – perhaps in exaggerated terms – much of the built environment does not change rapidly. The Seattle area's policy, by focusing on urban villages, accepts this reality, channeling growth into selected portions of the city while "protecting" other neighborhoods from densificaton. Does this mean that residents in static areas will not be affected by the densification one or two neighborhoods away? The concept of destination accessibility suggests they might, but such a measure conflates land use and transportation variables, as discussed above. Seattle, like Vancouver, has begun to invest rail transit, albeit on a far smaller scale. The major project is the Central Link light rail line, running from the airport to downtown Seattle, which opened in 2009 (Sound Transit, 2009). The first part of a planned streetcar system opened in 2007 (Seattle Streetcar, n.d.). The study period intentionally predates these. The area did experience other transportation system changes, mainly new commuter rail service 2000 and regional express buses in 1999, as well as a 1.6-mile light rail line in downtown Tacoma (Office of Corporate Communications Operations, Projects & Corporate Services, 2007). Because of their scale and location, as well as their small mode share relative to the region,[9] these have little or no effect on access between nearby neighborhoods, the question here. Some parts of the area also worked to improve bicycle

[9] Combined average daily boardings in 2006 for commuter rail, express buses and the Tacoma light rail line were 33,110 (Office of Corporate Communications Operations, Projects & Corporate Services, 2007). That year the region's population was more than 3.5 million ("Population and Housing Estimates," n.d.).

and pedestrian amenities, but these were generally improvements to existing routes, so it would be difficult to assign a value of accessibility improvement. So the Seattle-area experience, at the period studied, is a relatively pure look at the effect of land use change on VMT at the near-neighborhood level – “relatively pure” meaning that at the time of the study the area was beginning to attend to improvements in non-auto modes, an important caveat for the findings regarding the second research question.

CHAPTER 3: AN ANALYSIS OF DENSITY AND TRAVEL DEMAND

This study employs data on the Seattle area across two time periods to explore the magnitude and role of infill development, as well as effects of new density in one neighborhood as felt by residents of nearby neighborhoods in terms of travel demand.

The question of magnitude and location of infill development is one that can be answered without sample data and inferential statistics, because annual estimates of housing units exist. These data are presented in the succeeding chapter.

The question of travel demand effect of densification on surrounding, more static areas is more challenging. Again, complete data exist for housing units, but the same is not true for travel data. Here we employ survey data collected for the PSRC in 1990, as policies to spur densification were taking shape, and in 2006.

The research employs multiple regression modeling to explore the question in several ways, using VMT as the dependent variable:

- To compare the effect of housing density in travelers' home tracts with housing density in tracts within a 5-mile radius.
- To compare the housing and job density in travelers' home tracts with housing and job density in tracts within a 5-mile radius.
- To compare the effect of housing density in travelers' home tracts in 1990 and 2006.

- To compare the effect of housing density outside of areas that densified between 1990 and 2006.
- To test for self-selection effects in areas outside of areas that densified between 1990 and 2006.

3.1 Data

Housing data are from the U.S. Census Bureau, with geographic normalization across Census periods by Geolytics Inc., and from PSRC. Travel data for this study was collected by the PSRC in 1990 and 2006. Employment data, from 2006, are from the PSRC as well. Transportation network data, as well as GIS software, are from ESRI.

3.1.1 Housing and jobs in the Puget Sound region

Housing data – housing units per Census tract – are taken from the 1990 U.S. Census (“Census Bureau Homepage,” n.d.) and a 2006 PSRC intercensal estimate (“Population and Housing Estimates,” n.d.). See Table 3 for a summary; see the appendix for tract-level data.

Table 3. Puget Sound area housing summary (“Census Bureau Homepage,” n.d., “Population and Housing Estimates,” n.d.).

	Housing units	
County	1990	2006
King	647,343	803,268
Kitsap	74,038	100,636
Pierce	228,842	312,521
Snohomish	183,942	267,676
Region total	*1,134,165*	*1,484,101*

One problem is that the 1990 data uses 1990-era Census geographies, and the 2006 data is based on 2000-era Census geographies. It is thus necessary to normalize the 1990 data to 2000 geographies. Geolytics Inc.'s "1990 Long Form in 2000 Boundaries" does this by starting at the Census block level. Nationally, 85 percent of 1990 Census blocks employed the same boundaries in the 2000 Census, but the other 15 percent of 1990 blocks were split into two or more 2000 blocks. Geolytics assigned population and housing to these new, smaller blocks based on the presence of street-miles in the new blocks, circa 1990. Block data then can be rolled up into larger geographies, including tracts ("1990 data to 2000 areas weighting methodology," n.d.).

PSRC describes its process for estimating housing at the Census tract level between Censuses:

> The estimates are developed using the "housing unit method" of population estimation. The methodology begins with housing unit counts from the most recent federal decennial census as its base. Residential building permit data for authorized housing unit construction and demolition activity are then used to approximate postcensal change in local housing stocks and to update the base year census housing unit counts. Estimates of local occupancy rates are applied to the updated housing unit counts to develop current estimates of households (Puget Sound Regional Council, 2007).

PSRC has also collects employment data by Census tract annually. The analysis employs 2006 data, summarized in Table 4.

Table 4. Puget Sound area employment summary (Puget Sound Regional Council, n.d.-a).

County	Jobs 2006
King	1,125,197
Kitsap	83,427
Pierce	261,792
Snohomish	228,518
Region total	*1,698,934*

PSRC describes its process for estimating jobs at the Census tract level:

> [E]mployment estimates are based on the Washington State Employment Security Department's (ESD) Quarterly Census of Employment and Wages (QCEW) series (formerly known as ES-202). This series consists of employment for those firms, organizations and individuals whose employees are covered by the Washington Unemployment Insurance Act. Covered employment excludes self-employed workers, proprietors, CEOs, etc., and other non-insured workers. Typically, covered employment has represented 85-90% of total employment. Note that this includes part-time and temporary employment, and if a worker holds more than one job, each job would appear in the database (Puget Sound Regional Council, n.d.-a).

PSRC withholds data in cases where there are few employers in a category in a tract. The analysis here uses total employment in tracts; in six of 715 tracts these totals are withheld (Puget Sound Regional Council, n.d.-a).

3.1.2 Household transportation in the Puget Sound region

The Puget Sound region has been exceptionally diligent about collecting travel data from residents. Between 1989 and 2002, the PSRC conducted the Puget Sound Transportation Panel (PSTP), collecting travel data from a panel of residents, in 10 waves (Puget Sound Regional Council, n.d.-b). Because the 1990 wave coincided with a decennial Census and with the region’s initial efforts to direct growth to urban villages, it is employed in this analysis. In addition to collecting the panel data, the PSRC conducted stand-alone household travel surveys in 1999 and 2006 (Puget Sound Regional Council, n.d.-b). We employ the 2006 survey. Both of these employ two-day travel diaries and are targeted to weekday travel. (See appendix for diary format.) Out-of-area travel is not included in the 2006 data; out-of-area travel is included in the 1990 survey data, but these trips have been removed for this research.

The original PSTP participants were recruited in 1989. Through random phoning, 5,419 households were contacted and interviewed. Of those, 2,944 agreed to fill out two-day household travel surveys. Ultimately 91 percent, or 1,553, of the returned surveys came from this group. The additional surveys 9 percent, or 160, were collected from respondents to previous surveys or from solicitation on bus routes, in order to include enough households with at least one transit riders and with a member who car-pooled to work in the sample to analyze those groups. There were 581 members of the two groups, which became co-mingled, with car-pool households that also included a bus rider being included in the bus-rider category (Gilmore Research Group, 1990). The oversampling equals 27.5 percent of these groups. For subsequent waves, households that moved or otherwise dropped out of the sample were replaced through calling random phone numbers, with an additional 80 added in order to have the “appropriate number” of newcomers (Puget Sound Regional Council, n.d.-c). To reduce any bias introduced by oversampling in the 1990 wave, we remove the last 160 households recruited in 1989 as carpoolers and transit riders. Not all of them participated in the 1990 survey, so this data-cleaning removes 130 households from that survey data. Recruited newcomers for 1990 remain in the analysis dataset, because the available documentation indicates the PSRC consultants were making up for a shortage of newcomers in the random phone sample, and because newcomers do not add an obvious bias to the VMT analysis.

The 2006 survey was much larger, with 4,746 households. Of these, 3,937 were recruited with random telephone dials, 699 were recruited specifically from relatively dense areas in order to study households with transit access, and 110 were recruited at transit intercepts (Cambridge Systematics, 2007). In the current study we exclude the non-random participants.

Variables of interest in both surveys include:

1) Miles traveled by trip and by mode. For auto trips, the number of passengers is also relevant, allowing for calculation of VMT to be adjusted for vehicle occupancy. If a member of a survey household travels two miles in a car with a non-survey household passenger, we assess one mile traveled to the survey household. If two survey household members were traveling, we would assess two miles to the household. Trip mileage can then be totaled for the full two-day diary period. No long-distance, out-of-the region trips are included.
2) Lifecycle of the households. As described in the previous chapter, controlling for lifecycle has become a common practice. In both surveys, lifecycle is recorded in eight categories:
    a. Pre-school Age Kids (under 6 years old)
    b. School Age Kids (6-17 years)

c. One Adult Under 35, No Kids

d. One Adult 35 to 64, No Kids

e. One Adult 65+, No Kids

f. Two + Adults Under 35, No Kids

g. Two + Adults 35 to 64, No Kids

h. Two + Adults 65+, No Kids (Puget Sound Regional Council, n.d.-d)

3) Household size.

4) Length of time in residence. Reported in bins, this variable is employed in one model to test for self-selection effects.

5) Income of the households. The 1990 survey let respondents report their actual income or select one of eight bins, e.g. less than $10,000, $10,000-$15,000, etc. Sixty percent of households reported an income figure, while another 28 percent reported an income bin. In 2006, income is reported only in a series of 16 bins.[10] For cross-sectional analysis of the 2006 survey, these bins are used. For longitudinal analysis, the following procedure is used: To account for inflation, 1990 respondent incomes are multiplied by 1.79, based on the increase in Seattle MSA median family income as reported by the U.S. Department of Housing and Urban Development (U.S. Department of Housing and Urban Development, n.d.). These inflated incomes are assigned to 2006 bins. For those who reported income in bins only, the midpoint of the bin is multiplied by 1.79 and assigned to a 2006 bin. Respondents reporting income of $75,000+ in 1990, the highest bin that year, are assigned to the highest bin in 2006, $150,000+. Finally, because the 1990

[10] In both surveys, respondents who were reluctant to report their income in specific bins were given much broader categories, e.g. above or below $35,000 in 1990. These responses cannot be reliably translated into the narrower bins most respondents used, and so they are treated as missing values.

survey had fewer bins, resulting in artificially bunching those responses in 2006 bins, we collapse the 16 2006 bins to eight: $0-$20,000, $20,001-$40,000, $40,001-$60,000, $60,001-$80,000, $80,001-$100.000, $100,001-$120,000, $120,001-$140,000, and $140,000 and above. While actual incomes would be preferable, in the current study income serves as a control, not a variable of particular interest. Because auto travel rises sharply with income at lower incomes – in part because very low-income households cannot afford vehicles – but is generally flat across middle and upper-income households, binned income variables serve as adequate controls.

6) Job density. These values are calculated for 2006 by dividing the PSRC-reported job totals for each tract by the land acreage. We create eight bins to explore non-linearity. Cutpoints are chosen to assign an equal number of tracts to each bin, resulting in the following (names indicate coding in model results):

   Job density1, 0-.1240 jobs per acre.

   Job density2, .1241-.3310 jobs per acre

   Job density3, .3311-.6030 jobs per acre

   Job density4, .6031-1.1270 jobs per acre

   Job density5, 1.1271-1.6880 jobs per acre

   Job density6, 1.6881-2.5710 jobs per acre

   Job density7, 2.5711-5.7440 jobs per acre

   Job density8, 5.27441 and more jobs per acre

7) Location. X-Y coordinate data useful for locating households' residences in a GIS are provided.

Summary descriptives from the two surveys are shown in Table 5.

Table 5. Transportation survey variables (coding in models show in parentheses).

		1990	2006
Households		1,764	3,937
2-day total VMT	Mean	102.2	71.9
	Median	85.7	57.4
	Minimum	0	0
	Maximum	702.6	737.7
Household size	Mean	2.57	2.22
	Median	2	2
	Minimum	1	1
	Maximum	8	8
2-day household per capita VMT	Mean	39.8	32.4
	Median	33.3	25.9
	Minimum	0.0	0.0
	Maximum	273.4	332.3
Lifecycle	Any child < 6 (Lifecycle1)	16.0%	13.0%
	All children 6-17 (Lifecycle2)	18.6%	18.2%
	1 adult < 35 (Lifecycle3)	3.6%	2.6%
	1 adult 35-64 (Lifecycle4)	9.5%	23.9%
	1 adult 65+ (Lifecycle5)	4.5%	11.5%
	2+ adults < 35 (Lifecycle6)	6.1%	2.6%
	2+ adults 35-64 (Lifecycle7)	25.0%	28.8%
	2+ adults 65+ (Lifecycle8)	12.1%	16.3%
	Missing value	4.6%	0.7%
Time at residence	0-20 years		78.7%
	20+ years		21.2%
	Missing value		0.1%
Household income (2006 dollars)	$0-20,000 (Income1)	1.8%	7.0%
	$20,001-$40,000 (Income2)	18.2%	14.5%
	$40,001-$60,000 (Income3)	7.4%	19.7%
	$60,001-$80,000 (Income4)	10.1%	16.6%
	$80,001-$100,000 (Income5)	23.2%	11.6%
	$100,001-$120,000 (Income6)	17.7%	7.2%
	$120,001-$140,000 (Income7)	0.0%	4.0%
	$140,000+ (Income8)	10.1%	7.4%
	Missing value	11.5%	11.9%

3.1.3 Other data sources

GIS shapefiles for 2000-era Census tracts are from PSRC (Puget Sound Regional Council, n.d.-e). GIS streets, used to estimate surface-transportation distances, are from ESRI's Detailed Streets layer of ESRI Data & Maps 2006. ESRI Detailed Streets, in turn, are based on U.S. Census Bureau's Topologically Integrated Geographic Encoding and Referencing (TIGER) system line files. Water and other layers used in the analysis and display are also from ESRI Data & Maps 2006 (ESRI, 2007).

3.2 Methodology

3.2.1 Calculation of density and distance

Calculations are made with ArcGIS 10, a standard GIS program by ESRI (ESRI, n.d.).

Land area of Census tracts is calculated by subtracting water area from total area of the tracts, using the "erase" tool in ArcGIS 10. These areas are used in the denominator to determine housing and employment densities.

One question addressed in the current study is to assess travel behavior related to density of resident's nearby neighborhoods. For this purpose, to assess "nearby," one might simply use straight-line distances. However, in the Puget Sound area, barriers to movement posed by water and topography must be considered. To better approximate the distances faced by residents, we use the 2006 street network described above, with distances calculated with the network analyst tool in ArcGIS 10. All links are included in the network except ferries, which have a much higher time cost than other modes; the issue is not critical, as most ferry links are longer than 5 miles, which is the longest definition of “nearby” employed in the study, so these links would be irrelevant. These distances are not intended to indicate travel time or other accessibility indicators, as we assume travelers will use various modes with various travel times. Distance here is simply distance.

3.2.2 Assessing the effect of infill on existing housing

Armed with the number of housing units by 2000-era Census tract in 1990 and 2006, and the densities of the same tracts, it is a straightforward exercise to describe the pattern of infill and the effect on existing housing. This assessment is described in the succeeding chapter.

3.2.3 Assessing the effect of densification in nearby neighborhoods

Models are estimated using PASW Statistics 18, a standard statistical program by IBM known in earlier and later releases as SPSS (IBM, n.d.).

For cross-sectional analysis of 2006 survey data, all of the households’ home locations are located in ArcGIS. An origin-destination cost analysis, using the ArcGIS network analyst, is performed. Home locations are origins, and Census tract centroids are destinations, with a 5-mile limit. The program produces a matrix showing all of the tract centroids that are 5 miles or less from each household along the street network. The Puget Sound region extends into the mountains, and in the most-sparsely populated exurbs, some households can only reach their own tract centroid, or in the case of 70 of the 2006 survey households, in very rural sections of the region, none at all. The average household can reach more than 20 centroids. For each household, total land area of the tracts within 5 miles is summed, as are the housing units and jobs, allowing density to be calculated.

With this data and the demographic and travel data described above, it is possible to estimate models aimed at assessing the effect on VMT of density of neighborhoods outside of travelers own, but nearby.

Model 1. Controlling for the density in respondents' home tract, as well as household size, income and lifecycle, we isolate the effect of the neighboring tracts' housing density. Because lifecycle and income are categorical variables, they appear as a series of dummies.

Effect of nearby neighborhood housing densities on household VMT

VMT = ßconstant + ßlifecycle dummies + ßincome dummies + ßhousehold size + ßhome tract housing density + ßaverage housing density of tracts within 5 miles

Model 2. Same as Model 1, but here we add job density as a variable, again both in the home tract and the neighboring ones, to assess relative contribution to VMT. We use dummy variables to represent the density of jobs in the home tract and in surrounding tracts, because we don't expect the relationship with VMT to be linear; we expect VMT to decline as job density increases, but only to a point. Very job-dense tracts would tend to be regional employment draws and may not have as much local effect.

Effect of nearby neighborhood housing and employment densities on household VMT

VMT = ßconstant + ßlifecycle dummies + ßincome dummies + ßhousehold size + ßhome tract housing density + ßaverage housing density of tracts within 5 miles + ßhome tract job density + ßaverage job density of tracts within 5 miles

Models 3 and 4. Starting in the early 1990s and proceeding to the present, the Seattle region has pursued a dense-node strategy. To identify areas that have seen the greatest densification, we rank tracts by the amount of housing growth from 1990 to 2006. Plotting these yields a scree plot-style pattern (Figure 15), with an inflection point at 1.5 units per acre. For this analysis we identify tracts with 1.5 units per acre in housing unit density growth as the area in the region demonstrating high densification. This area comprises 6.2 percent of the region’s tracts, 6.3 percent of the region’s population and 8.2 percent of the region’s housing units. The tracts’ spatial distribution is shown in Figure 16.

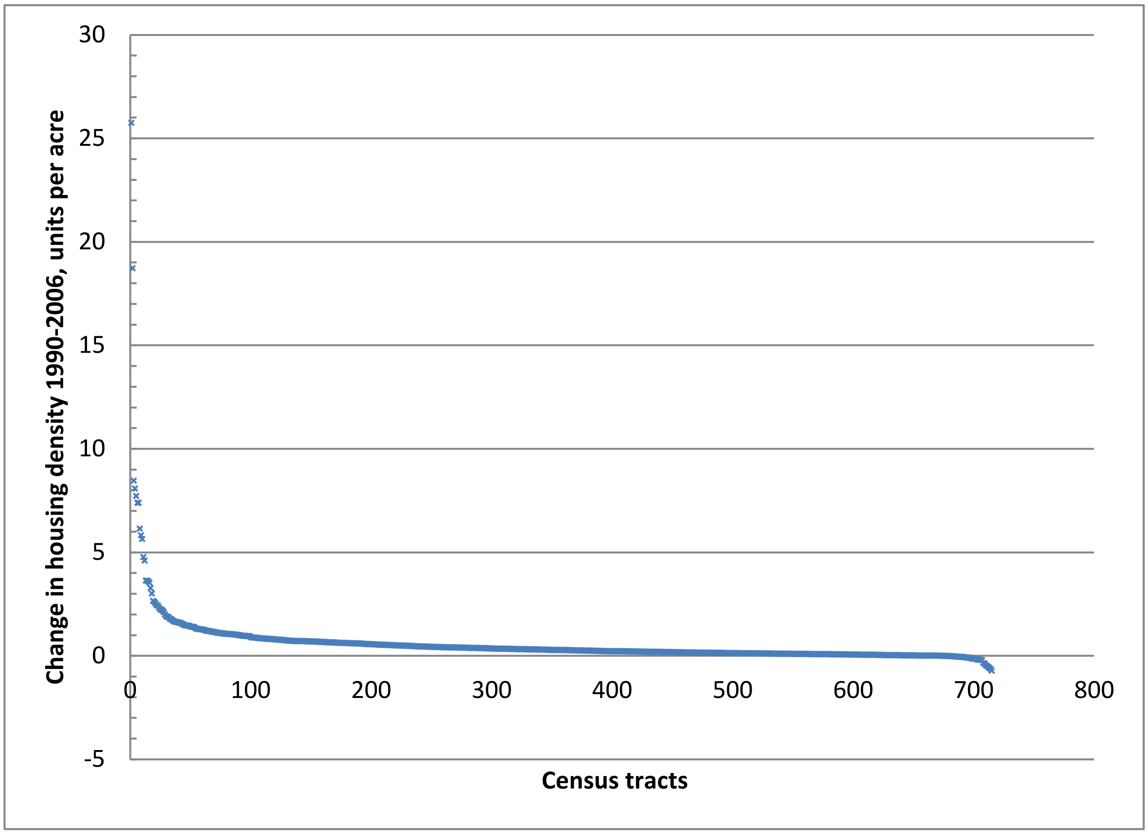

Figure 15. Distribution of 2006 Census tracts by growth in housing unit density (Puget Sound Regional Council, 2007; GeoLytics Inc., n.d.).

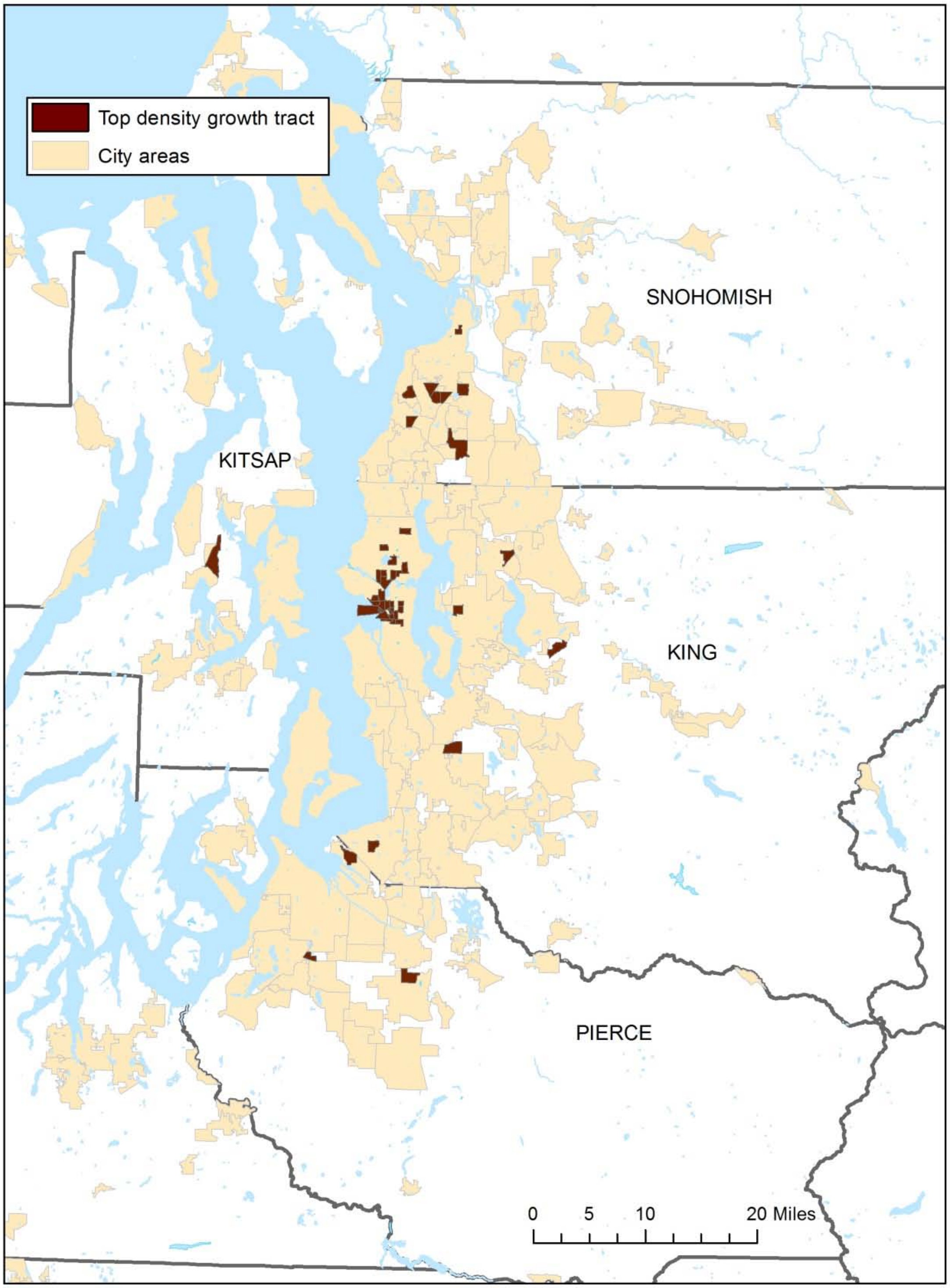

Figure 16. Tracts with highest housing density growth, 1990-2006.

Here we are interested in the “spillover” effects of these densifying nodes. First, we examine the relative effect of home-tract density over time; if densification in some built-up areas is having a spillover effect on other neighborhoods, we would expect the home-tract effect to decline over time. Second, we examine the effect of a household’s location outside of the high-densification areas, where we would expect to see spillover effects if they exist. Two difference-in-differences models using pooled cross sections are similar to an oft-cited textbook case, investigating the effect over time of the construction of an incinerator on prices for houses (Wooldridge, 2002).

Effect of home tract density on household VMT over time

VMT = ßconstant + ßyear 2006 dummy + ßlifecycle dummies + ßincome dummies + ßhousehold size + ßhome tract density + ßyear 2006 home tract density

Effect of household location outside of densifying areas on household VMT over time

VMT = ßconstant + ßyear 2006 dummy+ ßlifecycle dummies + ßincome dummies + ßhousehold size+ ßhome tract density + ßlow density growth area + ßyear 2006 low density growth area

Model 5. Finally, much of the literature is fixated on the issue of self-selection. Perhaps people who live in dense neighborhoods drive less than average because they chose to live in those neighborhoods in order to drive less. Unfortunately the bins on the length-of-residence variable for the 2006 survey don’t match 1990 exactly; instead we compare households from the 2006 survey who have lived in the area at least 20 years to those who moved in more recently. Following on results from Models 3 and 4, we explore the effect of length of residence on VMT for households outside of the rapidly densifying areas.

Effect of household time-in-residence on household VMT

VMT = ßconstant + ßlifecycle dummies + ßincome dummies + ßhousehold size+ ßhome tract density ßbuffer zone 2006 short-term + ßbuffer zone 2006 long-term

CHAPTER 4: FINDINGS

4.1 The Effect of Infill on Existing Housing

The Puget Sound region, with its emphasis on fostering infill development, is a good place to test the assumption, common to the two most prominent scenario-based predictions regarding density and VMT, that development will essentially leave built-up areas untouched. This cannot be literally true, at least as measured by Census tracts, as every tract in the region has at least a few residents, so any additional housing would increase the tract-level housing unit density. But if development took place in exclusively very low-density areas, the assumption could be true enough to guide policy. If, on the other hand, growth was taking place in already built-up areas, implications for the effects on travel demand, and hence policy, would be significant.

To explore the question here we employ the definition of "compact" development used in *Special Report 298.* The report considers development at twice the 2000 density to be compact. Measured as gross housing unit density by Census tract, the standard would be 2.2 units per acre, double the 2000 figure of 1.1 units per acre based on national averages.

In the Puget Sound region between 1990 and 2006, the growth in tracts at 2.2 housing units or more per acre in 2006 equaled 61 percent of regional housing growth. This growth occurred both in the area that was already compact in 1990, and in a net of 56 additional Census tracts pushed over the 2.2. level by new housing development.[11]

In this area, about 130,000 housing units, or 37 percent of the regional total, represented net new construction in this area – housing units in 2006 minus those in 1990. The remainder of the increase came from expansion of the number of "compact" tracts, as infill increased densities to encompass existing housing.

These newly compact tracts accounted for 203,818 residents and 84,101 housing units in 1990. All of these were exposed to compact level of density, as defined by *Special Report 298*, simply by being proximate to infill development. In addition, the tracts already at the compact level in 1990 saw a density increase from infill as well, from 3.8 to 4.3 units per acre overall, a 13 percent increase.

Tables 6-8 summarize the findings discussed above.

Table 6. "Compact" Puget Sound region Census tracts 1990-2006.

	1990	2006	Change 1990-2006
Number of tracts	304	360	56
Population	1,325,011	1,772,947	310,222
Percent of regional population	48.2	50.3	
Percent of regional population growth			57.8
Housing units	596,943	811,405	214,462
Percent of regional housing units	52.6	54.7	
Percent of regional housing unit growth			61.3

[11] In 1990 there were 304 tracts at 2.2 housing units or greater. Between 1990 and 2006, 59 new tracts attained this density, while three experienced slight declines and dropped off the list.

Table 7. Puget Sound region Census tracts that were "compact" in 1990.

	1990	2006	Change 1990-2006
Number of tracts	304	304	0
Population	1,325,011	1,462,725	137,714
Overall population density (persons/acre)	8.4	9.3	0.9
Percent of regional population growth			17.8
Housing units	596,943	676,763	79,820
Overall housing unit density (housing units/acre)	3.8	4.3	0.5
Median tract housing unit density (housing units/acre)	3.6	4.0	0.4
Percent of regional housing unit growth			22.8

Table 8. Puget Sound region Census tracts that were "compact" in 2006.

	1990	2006	Change 1990-2006
Number of tracts	360	360	0
Population	1,528,829	1,772,947	244,118
Overall population density (person/acre)	7.4	8.6	0.8
Percent of regional population growth			31.5
Housing units	681,044	811,405	130,361
Overall housing unit density (housing units/acre)	3.3	3.9	0.6
Median tract housing unit density (housing units/acre)	3.2	3.7	0.6
Percent of regional housing unit growth			37.3

Assessing tracts that reach a density threshold is useful in comparing the Seattle area data to a particular assumption, but this masks a more sweeping trend toward densification through infill. Starting with all the tracts that in 1990 were at 1.1 housing units per acre or higher – the *Special Report 298* baseline – and considering new development in these tracts to be infill, infill would account for 46 percent of housing units and 39 percent of population increase in the region. Additionally, infill development raised median tract housing density in this area from 3.6 to 4.3 units per acre, a 20 percent increase.

Assuming a .3 elasticity of VMT with respect to density (Reid Ewing, Bartholomew, Winkelman, Walters, & Chen, 2008), this 20 percent increase in density equates to a 6 percent decrease in VMT for the 1.9 million people living in 847,463 housing units that existed in 1990 and were exposed to the greater density through infill. Table 9 summarizes data from tracts that were at 1.1 housing units per acre or greater in 1990.

Table 9. Puget Sound region tracts that held 1.1 housing units per acre or more in 1990.

	1990	2006	Change 1990-2006
Tracts	466	466	0
Population	1,970,187	2,274,816	304,629
Percent of population growth			39.4
Housing units	847,463	1,009,304	161,841
Percent of housing unit growth			46.3
Median tract housing density (housing units/acre)	3.6	4.3	0.7

4.2 The Effect of Densification in Nearby Neighborhoods

We employ a series of cross-sectional and difference-in-differences models to assess the hypothesis that neighborhood density has a spillover effect. Model results are shown in this section, while residuals plots -- which indicate near-normal distributions -- are presented in the appendix. Not shown, due to the large number and resulting size of tables, are correlation matrices, used to inspect for multicollinearity.[12] No model is shown demonstrating the effect of density in travelers' home neighborhoods alone, as this effect is well-accepted; the research here does not dispute that understanding, but rather seeks to augment it by looking in addition at the effect of density in neighboring areas.

[12] There are no highly correlated variables in the models. A few moderate correlations approach r = 0.6, well below a reasonable level of concern -- r = 0.8.

Table 10. Summary of variables employed in models.

Variable code	Value	Remarks
Lifecycle1	1 = yes, 0 = no	Any child < 6
Lifecycle2	1 = yes, 0 = no	All children 6-17
Lifecycle3	1 = yes, 0 = no	1 adult < 35
Lifecycle4	1 = yes, 0 = no	1 adult 35-64
Lifecycle5	1 = yes, 0 = no	1 adult 65+
Lifecycle6	1 = yes, 0 = no	2+ adults < 35
Lifecycle7	1 = yes, 0 = no	2+ adults 35-64
Lifecycle8	1 = yes, 0 = no	2+ adults 65+
Income1	1 = yes, 0 = no	$0-$20,000, 2006 dollars
Income2	1 = yes, 0 = no	$20,001-$40,000, 2006 dollars
Income3	1 = yes, 0 = no	$40,001-$60,000, 2006 dollars
Income4	1 = yes, 0 = no	$60,001-$80,000, 2006 dollars
Income5	1 = yes, 0 = no	$80,001-$100,000, 2006 dollars
Income6	1 = yes, 0 = no	$100,001-$120,000, 2006 dollars
Income7	1 = yes, 0 = no	$120,001-$140,000, 2006 dollars
Income8	1 = yes, 0 = no	$140,000+ , 2006 dollars
Household size	Persons per household	
Home tract housing density	Housing units per land acre	For Census tract where traveler lives
Neighbor tracts housing density	Housing units per land acre	For Census tract traveler can reach within 5 network miles
Home tract job density	Jobs per land acre	For Census tract where traveler lives
Neighbor tracts job density	Jobs per land acre	For Census tract traveler can reach within 5 network miles
Lower density growth area	1 = yes, 0 = no	For Census tracts that grew by less than 1.5 housing units per acre 1990-2006
Long-term resident	1 = yes, 0 = no	For residents who lived in their current homes for at least 20 years

4.2.1 Effect of nearby neighborhood housing densities on household VMT

With controls for lifecycle, income and household size, this model compares the VMT effect of housing unit density in the travelers' home tracts with that of the tracts they can reach over the network in 5 miles or less. As shown in Table 10, both coefficients are significant at the 95 percent level, but the tracts in a five-mile radius appear to be much more important. The dependent variable is household VMT over two days, so the unstandardized coefficients imply that an increase in one housing unit per acre in the home tract would decrease VMT by less than a half-mile, while a similar increase in housing density in neighboring tracts would cause a decrease of nearly 7 miles.

Table 11. Multivariate model predicting household VMT over two days in 2006.

	Unstandardized		Standardized		
Variable	B	SE	Beta	t	p
Constant	18.606	7.521		2.474	0.013
Lifecycle2	14.665	3.484	0.086	4.209	0.000
Lifecycle3	8.816	8.169	0.020	1.079	0.281
Lifecycle4	7.811	5.780	0.049	1.352	0.177
Lifecycle5	-1.533	6.276	-0.007	-0.244	0.807
Lifecycle6	24.265	7.485	0.054	3.242	0.001
Lifecycle7	27.146	4.285	0.182	6.335	0.000
Lifecycle8	-2.176	4.726	-0.011	-0.460	0.645
Income2	11.369	3.931	0.065	2.892	0.004
Income3	21.429	3.809	0.139	5.625	0.000
Income4	29.898	4.001	0.181	7.473	0.000
Income5	40.836	4.281	0.214	9.539	0.000
Income6	36.063	4.740	0.153	7.608	0.000
Income7	45.041	5.537	0.145	8.135	0.000
Income8	43.581	4.735	0.188	9.204	0.000
Household size	15.799	1.587	0.303	9.954	0.000
Home tract housing density	-0.445	0.226	-0.035	-1.967	0.049
Five-mile radius tracts housing density	-6.953	0.547	-0.227	-12.712	0.000
Model statistics					
N	3,397				
Adjusted R^2	0.316				
Significance	P<0.000				

4.2.2 Effect of nearby neighborhood housing and employment densities on household VMT

While housing density may be considered a proxy for compact growth in general, it would be interesting to separate the effects of housing and job densities. The addition of job-density variables – themselves markers not just for employment but also proxies for commercial and institutional activity – reduces the power of housing density variables, as would be expected, validating the notion that housing density serves as a reasonable proxy. Housing density in the five-mile radius tracts remains more important than that in the home tract. The same goes for jobs, with neighboring tract coefficients exhibiting much greater power than those in home tracts.

Table 12.Multivariate model with job densities predicting household VMT over two days in 2006.

	Unstandardized		Standardized		
Variable	B	SE	Beta	t	p
Constant	49.396	7.823		6.314	0.000
Lifecycle2	14.379	3.414	0.084	4.212	0.000
Lifecycle3	9.543	7.994	0.022	1.194	0.233
Lifecycle4	10.483	5.67	0.066	1.849	0.065
Lifecycle5	1.460	6.153	0.006	0.237	0.813
Lifecycle6	28.409	7.326	0.063	3.878	0.000
Lifecycle7	27.228	4.196	0.182	6.489	0.000
Lifecycle8	-2.946	4.637	-0.015	-0.635	0.525
Income2	9.395	3.86	0.054	2.434	0.015
Income3	19.025	3.742	0.123	5.085	0.000
Income4	27.143	3.932	0.165	6.903	0.000
Income5	37.243	4.212	0.196	8.843	0.000
Income6	32.708	4.67	0.139	7.003	0.000
Income7	40.658	5.437	0.131	7.478	0.000
Income8	38.932	4.679	0.167	8.321	0.000
Household size	16.656	1.553	0.320	10.722	0.000
Home tract housing density	-0.492	0.237	-0.039	-2.080	0.038
Neighbor tracts housing density	-2.641	0.860	-0.086	-3.070	0.002
Home tract job density2	-4.482	4.401	-0.023	-1.019	0.309
Home tract job density3	-11.288	4.693	-0.057	-2.405	0.016
Home tract job density4	-9.785	4.998	-0.047	-1.958	0.050
Home tract job density5	-12.822	5.019	-0.063	-2.555	0.011
Home tract job density6	-18.229	4.825	-0.098	-3.778	0.000
Home tract job density7	-13.579	4.991	-0.074	-2.721	0.007
Home tract job density8	-14.400	5.721	-0.069	-2.517	0.012
Five-mile radius tract job density2	-18.219	5.453	-0.061	-3.341	0.001
Five-mile radius tract job density3	-31.321	5.122	-0.147	-6.115	0.000
Five-mile radius tract job density4	-25.320	5.454	-0.119	-4.643	0.000
Five-mile radius tract job density5	-34.112	5.969	-0.145	-5.715	0.000
Five-mile radius tract job density6	-35.323	5.671	-0.212	-6.228	0.000
Five-mile radius tract job density7	-39.285	5.984	-0.259	-6.566	0.000
Five-mile radius tract job density8	-37.225	7.214	-0.212	-5.16	0.000

Model statistics

N 3,937

Adjusted R^2 .350

Significance P<0.000

4.2.3 Effect of home tract density and effect of household location outside of densifying areas on household VMT over time

Longitudinal models often provide stronger evidence of causation than do cross-sectional models. Here, we use two difference-in-differences models to explore the effect in change in housing density over time.

First, if many existing neighborhoods have experienced growing density – as shown above is the case in the Seattle region – we would expect spillover effects from on neighborhood to another to cause the relative importance of density in the home tract to decline. A model comparing home tract density in 1990 and 2006 shows just this. The coefficient for "home tract housing density," -4.6, can be interpreted as the 1990 value; the 2006 value is the sum of that coefficient and "home housing density 2006," or -1.9. By this estimate, home tract housing density had more than double the effect on VMT in 1990 compared with 2006. Yet the 2006 year dummy coefficient predicts an important across-the-board drop in VMT in 2006 – results consistent with the notion that there is a spillover effect from the widespread densification that occurred between 1990 and 2006. The next model explores this idea further.

Table 13. Multivariate difference-in-differences model examining home tract density effects, 1990-2006.

	Unstandardized		Standardized		
Variable	B	SE	Beta	t	p
Constant	28.474	6.730		4.231	0.000
2006 dummy	-25.960	2.235	-0.165	-11.617	0.000
Lifecycle2	16.391	2.931	0.088	5.592	0.000
Lifecycle3	13.183	6.555	0.031	2.011	0.044
Lifecycle4	9.406	4.904	0.052	1.918	0.055
Lifecycle5	-0.317	5.360	-0.001	-0.059	0.953
Lifecycle6	33.610	5.339	0.089	6.295	0.000
Lifecycle7	31.263	3.598	0.193	8.688	0.000
Lifecycle8	3.428	3.984	0.016	0.861	0.390
Income2	9.160	3.651	0.050	2.509	0.012
Income3	19.116	3.655	0.106	5.231	0.000
Income4	27.141	3.796	0.144	7.151	0.000
Income5	37.368	3.872	0.199	9.650	0.000
Income6	38.606	4.142	0.175	9.321	0.000
Income7	40.107	5.508	0.101	7.281	0.000
Income8	40.744	4.254	0.170	9.577	0.000
Household size	16.175	1.339	0.285	12.078	0.000
Home tract housing density	-4.576	0.432	-0.333	-10.582	0.000
Home tract housing density 2006	2.643	0.461	0.189	5.733	0.000

Model statistics	
N	5,701
Adjusted R^2	0.295
Significance	P<0.000

Second, if density has spillover effects, we would expect to see reduced VMT in neighborhoods outside of rapidly densifying nodes scattered around the region (Figure 16 above), even after controlling for home tract housing density. In this model we compare the households outside of the densifying areas in 1990 to those in 2006. In 1990 the expected VMT in the outside-of-densification is small and is not significantly different from zero. In 2006, the coefficient is -19.3 and is significant at the 90 percent level. The inclusion of the outside-of-densifying areas variables renders the 2006 year dummy insignificant. This result again is consistent with the notion that densifying nodes exert spillover effects on areas around them. The mean two-day VMT for all cases is 81.3, meaning that the -19.3 figure equates to a 24 percent drop.

Table 14. Multivariate difference-in-differences model examining densification spillover effects, 1990-2006.

	Unstandardized		Standardized		
Variable	B	SE	Beta	t	p
Constant	23.996	13.081		1.834	0.067
2006 dummy	1.788	11.366	0.012	0.157	0.875
Lifecycle2	16.507	3.154	0.088	5.233	0.000
Lifecycle3	8.892	7.177	0.020	1.239	0.215
Lifecycle4	7.685	5.326	0.041	1.443	0.149
Lifecycle5	-1.749	5.880	-0.006	-0.298	0.766
Lifecycle6	33.819	5.860	0.087	5.771	0.000
Lifecycle7	32.168	3.902	0.194	8.244	0.000
Lifecycle8	2.808	4.333	0.013	0.648	0.517
Income2	10.062	4.072	0.054	2.471	0.014
Income3	20.336	4.079	0.109	4.985	0.000
Income4	28.187	4.216	0.146	6.685	0.000
Income5	39.850	4.289	0.209	9.291	0.000
Income6	40.159	4.571	0.181	8.786	0.000
Income7	44.361	6.148	0.107	7.216	0.000
Income8	45.533	4.723	0.184	9.641	0.000
Household size	15.684	1.429	0.273	10.974	0.000
Home tract housing density	-2.918	0.225	-0.190	-12.988	0.000
Lower density growth area	0.021	11.024	0.000	0.002	0.998
Lower density growth area 2006	-19.323	11.507	-0.128	-1.679	0.093

Model statistics	
N	5,701
Adjusted R^2	0.285
Significance	P<0.000

4.2.4 Effect of household time-in-residence on household VMT

If we accept that densification appears to have a spillover effect, the issue of self-selection remains. Perhaps households move to regions where densifying nodes are developing in hopes of minimizing driving; if so the real effect of the greater density on other households might be less. In this model we examine areas outside of the densifying nodes and compare VMT of long-term residents – those living in their homes for 20 years or more – to relative newcomers. Indications are that the long-term residents actually drive less, all other variables held constant, but this effect is not significant, so we cannot confidently say length of residence has any effect.

Table 15. Multivariate model examining self-selection effects, 2006.

	Unstandardized		Standardized		
Variable	B	SE	Beta	t	p
Constant	11.478	7.902		1.453	0.146
Lifecycle2	15.301	3.655	0.090	4.186	0.000
Lifecycle3	11.555	8.837	0.025	1.308	0.191
Lifecycle4	7.826	6.097	0.048	1.284	0.199
Lifecycle5	-1.563	6.675	-0.007	-0.234	0.815
Lifecycle6	23.474	7.875	0.052	2.981	0.003
Lifecycle7	28.631	4.536	0.192	6.312	0.000
Lifecycle8	0.340	5.092	0.002	0.067	0.947
Income2	12.095	4.244	0.068	2.850	0.004
Income3	22.883	4.088	0.148	5.598	0.000
Income4	31.033	4.276	0.189	7.257	0.000
Income5	41.015	4.558	0.216	8.999	0.000
Income6	34.566	5.033	0.147	6.868	0.000
Income7	44.315	5.856	0.143	7.567	0.000
Income8	41.055	5.027	0.177	8.168	0.000
Household size	15.908	1.658	0.305	9.593	0.000
Home tract housing density	-4.481	0.329	-0.205	-13.603	0.000
Long-term resident	-2.185	2.514	-0.014	-0.869	0.385

Model statistics

N	3,734
Adjusted R^2	0.290
Significance	P<0.000

CHAPTER 5: CONCLUSION AND FUTURE RESEARCH

Research suggests that a compact built environment would necessitate less travel, particularly by motor vehicle. Yet years of theory building in this area has produced what we argue are too-conservative estimates of this effect, as well as less-than-clear policy guidance. The present research provides evidence of the conservative nature of previous estimates and, it is hoped, improved clarity for practitioners, policy-makers and the public. In short it appears the kind of targeted densification through planning and upzoning that occurred in the Seattle region can have greater dampening effects on travel demand than conventionally assumed.

5.1 Conclusion

Previous attempts at estimating VMT effects from the built environment, as exemplified by *Special Report 298* as well as *Growing Cooler,* have insufficiently addressed the likely location and effect of new development in the United States. In the former case, the study actively asserts that such development will take place on the urban fringe, and its efforts at sensitivity analysis do not address alternate cases. Such assumptions are based on assertions of the difficulty of developing infill, with barriers including public sentiment against density and existing zoning law, as well as figures showing that homes and other buildings generally last for decades before they are replaced. Yet the question need not be settled on theory, and the Seattle region provides a good test case of whether given some policy support, infill can occur in significant quantity.

The answer is yes. Between 1990 and 2006, the number of housing units exposed to "compact" levels of density, as defined by *Special Report 298*, grew by 36 percent. New development in neighborhoods already developed to the *Special Report 298* baseline in 1990 accounted for 46 percent of new housing units in the region – a far cry from zero. Such infill has the effect both of exposing the new housing units to relatively high densities, and to push up the density of the tracts in which the infill takes place. Using a conventional elasticity for VMT with respect to housing density, this effect could account for a 6 percent decrease in VMT in infilling areas – an effect felt by people and housing units that were pre-existing and did nothing other than experience growth around them.

But this effect does not account for the reduction in VMT seen in the Seattle region over a decade and a half, after accounting for household demographic variables. Cross-sectional and longitudinal models suggest that density changes in a traveler's home tract are important, but not as important as the density changes nearby – spillover effects. This is good news for areas like Puget Sound, which are pursuing a dense-node strategy. Distributed densification appears to have a strong negative effect on VMT even where travelers' home tracts do not densify.

This finding is consistent with, but stands apart from, previous research on destination accessibility. The latter, based on a combination of transportation and land use, may achieve a higher R-squared in explaining the effect of the built environment, but suffers as a guide to practice, where land use and transportation often are considered apart, or where funding may not exist to make transportation improvements[13] implied in an accessibility measure. Here, in the Puget Sound region in a period before major transit improvements went on line, we see strong evidence that simple compact development – fueled by infill – has a strong effect on VMT. This effect is across neighborhood boundaries, which means we do not have to raise density everywhere to significantly reduce VMT and its negative effects.

5.2 Limitations of the Current Study and Suggestions for Future Research

As with any study focusing on one city or metro area, there are dangers in generalizing results to other areas. Seattle is a growing area, for example, and it is unlikely that a more stable metro would experience the level of infill and densification that the Puget Sound has. Washington's Growth Management Act and the Puget Sound area's efforts to foster compact, infill development are atypical for the United States, and these political decisions may indicate more interest among households in reducing travel than in peer households elsewhere. Moreover, the Puget Sound region's natural geography may serve to limit low-density development in contrast to, say, a Midwestern city that can sprawl across the plains. So exploring the role of infill, densification and density spillover effects in other settings, or across regions – or even with national data – would be of value.

So too would other research approaches. While it is hoped the general exploration of infill descriptives, coupled with multiple inferential models here serve at least to demonstrate the plausibility of the arguments made, clearly the field concerning land use

[13] Improvements which, if they lower the time cost of highway travel, might induce more VMT rather than cut it.

and travel behavior continues to evolve and grow, with better statistical and spatial tools, as well as more useful data, on the horizon. For example, assuming that infill multiplier and spillover effects can be confirmed in other metro areas, perhaps with differing data and methodologies, it would be useful to extend the insight by exploring how reduced VMT is achieved: through fewer SOV trips, shorter SOV trips, more car-pooling or mode shifting. In the case of the latter, of course, it would be useful to understand the particular modes that absorb some of the forgone SOV demand. In addition, it would be useful to compare density effects in various parts of a region, exploring whether densification in a suburban or exurban area has more or less effect than densification in a more urban setting. Such work could also look at synergistic effects of multiple densifying nodes in proximity. Additionally, research could go further in breaking down densification by various land uses, looking at the value of proximity to residences, schools, shopping and other destinations.

Better data that is now being collected via global positioning systems (GPS) could create much more robust motor-vehicle travel information, spanning many more days than do two-day diaries and providing much better accuracy.[14] Another source for data to confirm or extend results here could be odometer records from vehicle-emissions inspections in areas where those are conducted.

In addition, research into the economic effects of reduced VMT through compact development would provide important extensions. These could explore not only the effect

[14] As a indication of the improvements in accuracy to be expected, when PSRC's consultant compared travel diary data employed here with GPS-collected data, they found many short trips had gone unreported. Here we use diary data from 1990 and 2006, so that whatever underrporting occured should be consistent.

of low-VMT development on property values, but also on residents' budgets. Does lower VMT translate into meaningful savings, and if so what do households do with these newfound funds, and how does that spending affect the local economy? And finally, it is unclear how modern infill and densification policies affect low-income residents. It may be that by creating desirable, low-VMT infill, cities push lower-income residents to more car-dependent neighborhoods, burdening them with greater costs to access jobs and other destinations.

5.3 Implications for policy

Skeptics of the power of land use to affect VMT often point to the durability of the built environment, suggesting that instead of concentrating on the built environment, policy makers should look at vehicle-mileage standards, fuel mixes, big transit infrastructure provision and other policy areas. Many buildings do last for decades or even centuries, but consider the time horizon of the present study – 16 years. In that time the Seattle region experience significant infill, nodal densification and VMT reduction. That period compares fairly well, for example, with the time it takes for the vehicle fleet to turn over, so that newly efficient vehicles or those using more benign fuels can enter service. In 2011, the average age of a U.S. auto reached 11.1 years and was rising (R. L. Polk & Co., 2012).

Moreover, it appears that the reduction came in large part via land use regulations that, while controversial at first, came to be accepted within a few years. These regulations cost much less than creating or expanding urban transit systems (though the land use effects may very well be multiplied by such investments), and they rely less on top-down decision-making: Once rules are in place, residents, developers and the market can interact to create new built environments that incrementally reduces travel demand over time.

This finding has immediate practical applications for planners and others considering strategies that seek sustainability by reducing the need for driving. The under-appreciated double effect of targeted densification -- exposing existing housing to greater density and providing a spillover effect into more static areas -- appears to succeed, with requiring a major transformation of the transportation system. While planning and zoning for higher density is not cost-free -- more intense development may require localized transportation improvements to create better connectivity and mitigate congestion, for example -- it can produce offsetting local revenues via property assessment, and pales in comparison to the billions of dollars required for construction, operation and maintenance of major highway and transit facilities.

APPENDICES

A1 PSRC travel diaries

A1.1 1990 diary

Puget Sound Transportation Panel

1990 Travel Diary

Address or Nearest Intersection to Where You Started This Day:

IF YOU DID NOT GO ANYWHERE ON THIS DAY PLEASE CHECK HERE: ☐

THINGS TO REMEMBER

- Fill out the diaries for the days indicated on the labels
- Use a separate line for each stop.
- Record each return trip to home or work.
- The last entry should by your home, or where you were at 1 am.
- When household members travel together, each should record a trip.

THEN WHERE? (Address or Intersection)	WHY? (Work/school/work/ dinner/visit/etc.)	HOW? (Car/truck/van/ walk/bus/taxi/etc.)	Driver or Rider ?	TIME STARTED	TIME ARRIVED	How Many Total in your group	WHO? (Relationship of people with you)	How Many family under 15?
1.			D R	AM PM	AM PM			
2.			D R	AM PM	AM PM			
3.			D R	AM PM	AM PM			
4.			D R	AM PM	AM PM			
5.			D R	AM PM	AM PM			
6.			D R	AM PM	AM PM			
7.			D R	AM PM	AM PM			
8.			D R	AM PM	AM PM			
9.			D R	AM PM	AM PM			
10.			D R	AM PM	AM PM			
11.			D R	AM PM	AM PM			
12.			D R	AM PM	AM PM			

Use the back for additional trips.

A1.2 2006 diary

Place # 1 | **START HERE**

WHAT is Place #1? ☐ My Home
☐ My Regular School Location ☐ My Primary Workplace
☐ Another Place *(Complete the information below.)*

WHAT kind of place is this? (bank, grocery, park, etc.) ______

Name of Place ______

Street Address ______

City ______ State ______ Zip ______

______ & ______
Nearby Cross Streets

Diary start time at place #1: 3:00 am

WHAT did you do at Place #1?

Main Activity (Check only one)		Other Activities (Check all that apply)
☐	Home – Paid Work	☐
☐	Home – Other	☐
☐	Work	☐
☐	Attend Childcare	☐
☐	Attend School	☐
☐	Attend College	☐
☐	Eat Out	☐
☐	Personal Business	☐
☐	Everyday Shopping	☐
☐	Major Shopping	☐
☐	Religious/Community	☐
☐	Social	☐
☐	Recreation – Participate	☐
☐	Recreation – Watch	☐
☐	Accompany Another Person	☐
☐	Pick-Up/Drop-Off Passenger	☐
☐	Turn Around	☐

For this diary, your day begins at 3:00 a.m. Many people are home asleep at 3:00 a.m. If this is the case, then under "START HERE" check "My Home" and check the "Home" activities you did before leaving home. Then record the exact time you left home below and continue with the diary.

At what time did you leave Place #1 to go to Place #2: ___ : ___ am/pm

Next Place #2

Place #
2

WHAT is Place #2? ☐ Day 1 ☐ Day 2

☐ My Home
☐ My Primary Workplace
☐ My Regular School Location
☐ Another Place *(Complete the information below.)*

WHAT kind of place is this? (bank, grocery, park, etc.) ______

Name of Place ______

Street Address ______

City ______ State ______ Zip ______

______ & ______
Nearby Cross Streets

At WHAT TIME did you ARRIVE at Place #2? ___ : ___ am/pm

WHAT did you do at Place #2?

Main Activity (Check only one)		Other Activities (Check all that apply)
☐	Home – Paid Work	☐
☐	Home – Other	☐
☐	Work	☐
☐	Attend Childcare	☐
☐	Attend School	☐
☐	Attend College	☐
☐	Eat Out	☐
☐	Personal Business	☐
☐	Everyday Shopping	☐
☐	Major Shopping	☐
☐	Religious/Community	☐
☐	Social	☐
☐	Recreation – Participate	☐
☐	Recreation – Watch	☐
☐	Accompany Another Person	☐
☐	Pick-Up/Drop-Off Passenger	☐
☐	Turn Around	☐

HOW did you get here from Place #1? Show all the methods of travel you used to make this trip and related travel details

		1st →	2nd →	3rd →	4th →	5th →
	Travel method (See "List of Travel Methods" below)					
If an auto method (1 or 2)	Vehicle used					
	Driver or passenger					
	Total # of persons in vehicle					
	Parking cost paid	$	$	$	$	$
If a transit method (6 thru 11)	How long did you wait?					
	Payment method (cash, pass or ticket)					
	If cash or ticket, how much did you pay?	$	$	$	$	$
	If walk or bicycle - Time (minutes)					
While Traveling	Which activities did you do for more than 15 minutes? (See "List of Activities" below)					
	Name(s) of household member(s) with you for each segment of the trip					

List of Travel Methods

1 Car, van, truck
2 Motorcycle/ Moped
3 Bicycle
4 Walk
5 School Bus
6 Taxi/Shuttle
7 Dial-A-Ride/ ACESS
8 Ferry
9 Train (Operator) ______
10 Public Bus (Operators) ______ Rtes ______
11 Other (Specify)

List of Activities

1 Work (reading, laptop computer, cell phone, etc.)
2 Maintenance (eating, sleeping, personal grooming, etc.)
3 Recreation (games, visiting, cell phone, DVD, etc.)
4 None

At what time did you leave Place #2 to go to Place #3 ___ : ___ am/pm

Next Place #3

A2 Model residuals plots

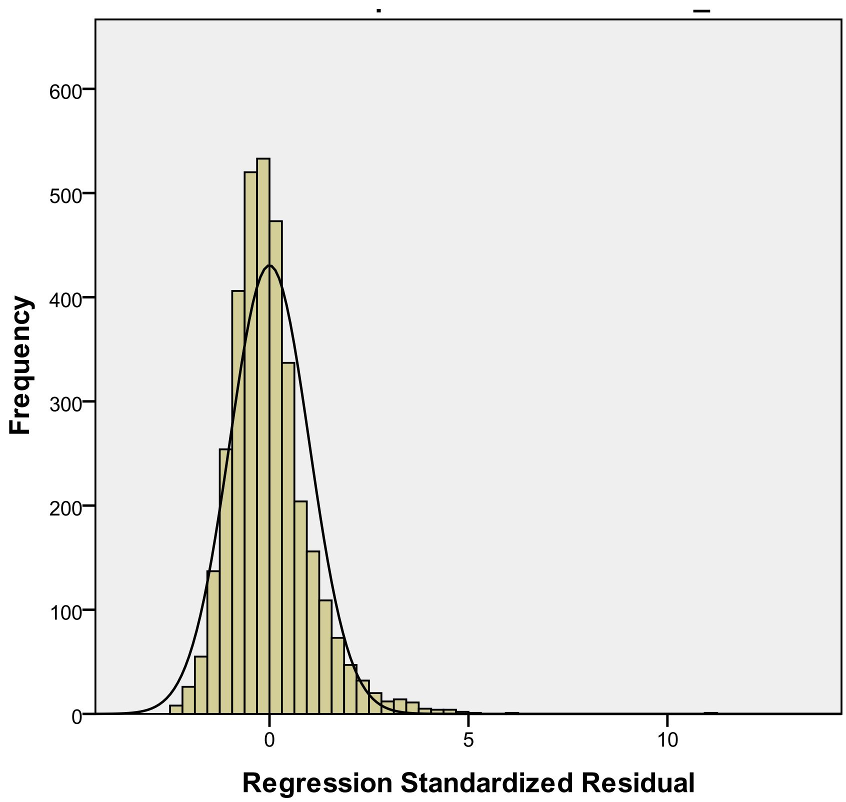

Figure 17. Model 1.

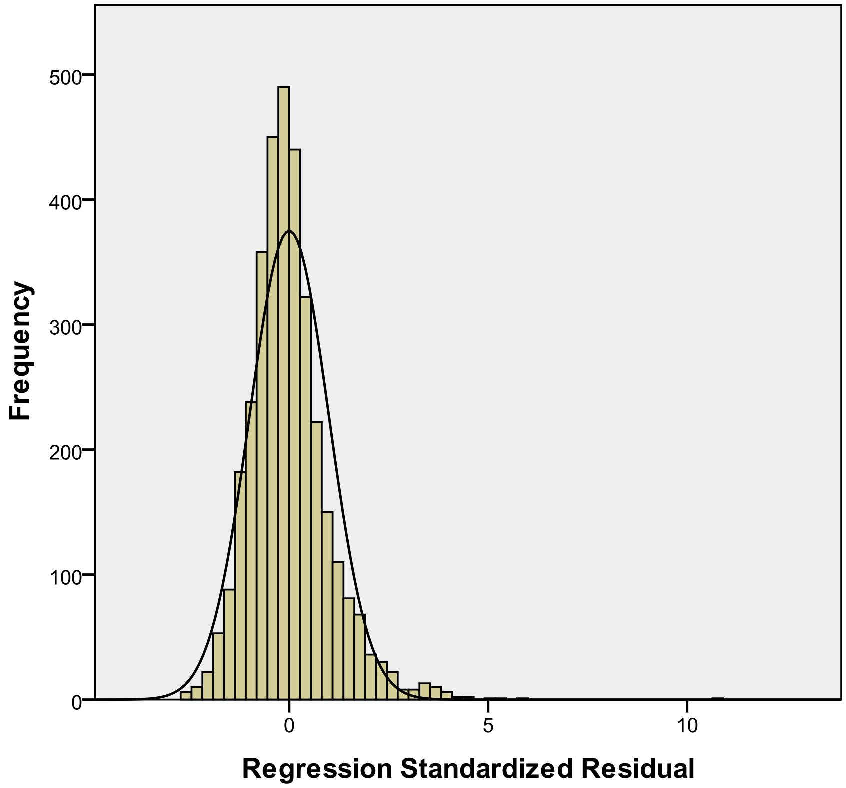

Figure 18. Model 2.

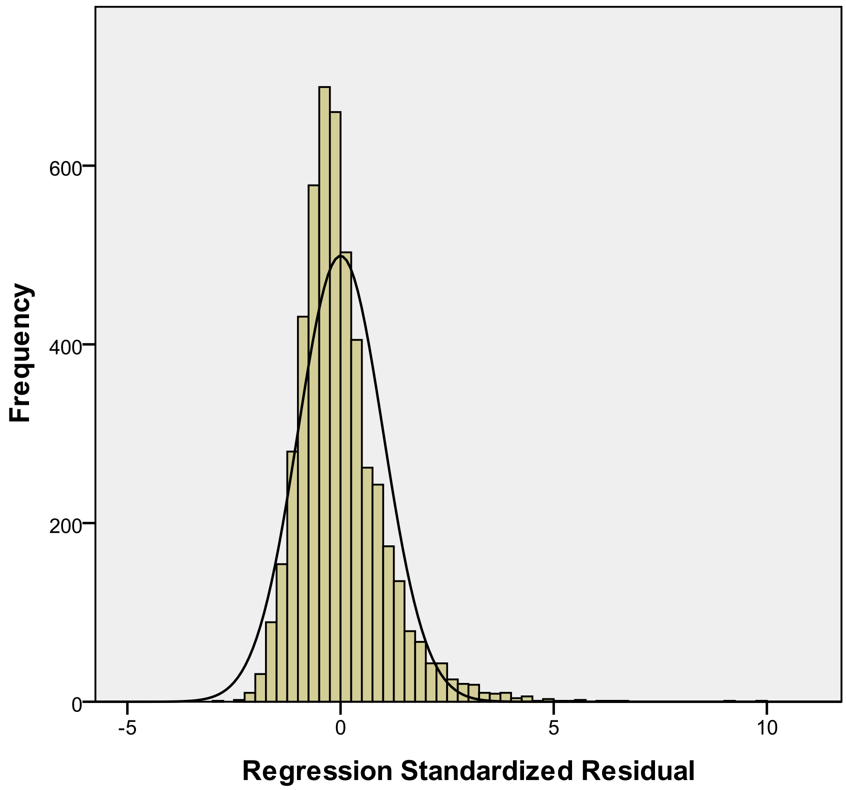

Figure 19. Model 3.

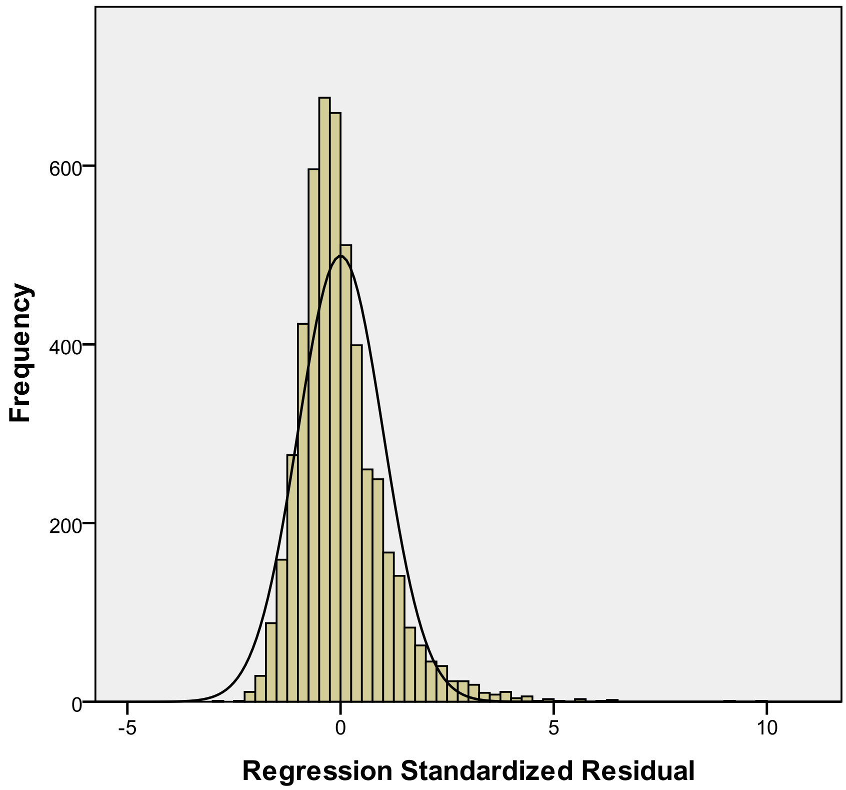

Figure 20. Model 4.

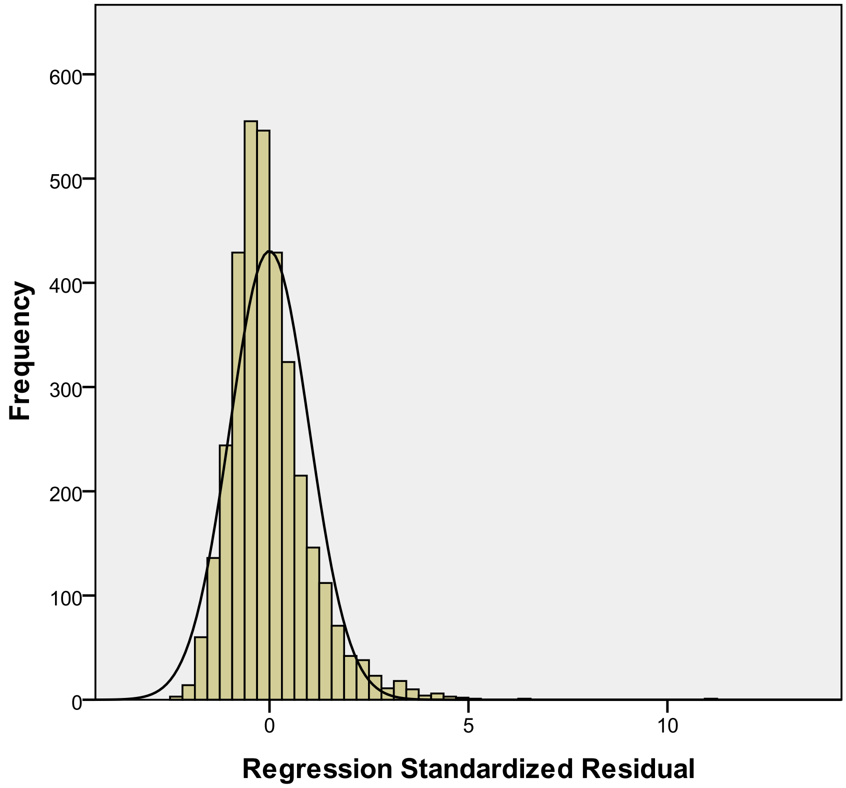

Figure 21. Model 5.

A3 Puget Sound area Census tract data

Table 16. 2000-era Census tract data, Puget Sound region.

`	Land acres	Population density change 1990-2006	Housing units 1990	Housing units 2006	Housing unit density 1990	Housing unit density 2006	Housing density change 1990-2006	Jobs 2006	Job density 2006
1	461.1	2.48	2,488	3,091	5.4	6.7	1.31	1,491	3.23
2	796.9	0.44	3,359	3,637	4.22	4.56	0.35	902	1.13
3	300.0	0.13	1,054	1,116	3.51	3.72	0.21	505	1.68
4.01	320.4	2.91	2,370	2,801	7.4	8.74	1.35	1,610	5.02
4.02	433.5	1.14	1,978	2,241	4.56	5.17	0.61	1,434	3.31
5	695.3	0.22	1,309	1,397	1.88	2.01	0.13	313	0.45
6	938.0	0.99	3,051	3,358	3.25	3.58	0.33	4,630	4.94
7	319.5	3.16	1,801	2,335	5.64	7.31	1.67	1,233	3.86
8	283.9	0.43	1,010	1,071	3.56	3.77	0.21	113	0.4
9	236.2	0.43	880	903	3.72	3.82	0.1	74	0.31
10	235.5	1.21	598	789	2.54	3.35	0.81	785	3.33
11	263.1	0.65	904	1,104	3.44	4.2	0.76	540	2.05
12	464.3	1.38	3,161	3,462	6.81	7.46	0.65	5,483	11.81
13	294.8	1.26	1,946	2,187	6.6	7.42	0.82	2,745	9.31
14	531.0	0.67	1,994	2,270	3.75	4.27	0.52	665	1.25
15	288.0	0	1,038	1,113	3.6	3.86	0.26	158	0.55
16	488.1	0.32	1,772	1,821	3.63	3.73	0.1	940	1.93
17	539.1	1.98	3,173	3,856	5.89	7.15	1.27	1,761	3.27
18	234.0	3.05	1,695	2,140	7.24	9.15	1.9	327	1.4
19	418.1	0.5	1,473	1,661	3.52	3.97	0.45	4,193	10.03
20	274.6	1.02	1,357	1,566	4.94	5.7	0.76	657	2.39
21	334.6	0.74	1,618	1,750	4.84	5.23	0.39	589	1.76
22	685.0	0.57	2,092	2,220	3.05	3.24	0.19	257	0.38
24	243.9	0.25	1,246	1,299	5.11	5.33	0.22	289	1.18
25	245.3	0.53	1,190	1,315	4.85	5.36	0.51	501	2.04
26	307.9	0.88	1,878	2,001	6.1	6.5	0.4	956	3.1
27	395.3	0.25	2,206	2,307	5.58	5.84	0.26	867	2.19
28	242.3	0.81	2,043	2,200	8.43	9.08	0.65	711	2.93
29	245.6	-0.05	1,881	1,896	7.66	7.72	0.06	584	2.38
30	373.1	0.21	2,397	2,477	6.42	6.64	0.21	640	1.72
31	540.4	0.41	2,646	2,704	4.9	5	0.11	343	0.63
32	521.5	0.43	3,812	4,047	7.31	7.76	0.45	1,828	3.51
33	324.4	0.48	2,929	3,115	9.03	9.6	0.57	1,018	3.14
34	195.7	-0.34	1,521	1,523	7.77	7.78	0.01	330	1.69

Table 16 continued

35	307.2	-0.34	1,704	1,826	5.55	5.94	0.4	2,180	7.1
36	297.4	2.63	2,584	3,110	8.69	10.46	1.77	1,992	6.7
38	157.3	1.01	753	841	4.79	5.35	0.56	679	4.32
39	242.1	-0.35	1,141	1,180	4.71	4.87	0.16	353	1.46
40	606.9	-0.81	1,274	998	2.1	1.64	-0.45	1,373	2.26
41	783.7	-0.15	3,097	3,146	3.95	4.01	0.06	4,927	6.29
42	611.3	0.42	3,164	3,297	5.18	5.39	0.22	1,325	2.17
43	309.0	1.27	2,457	2,962	7.95	9.59	1.63	2,873	9.3
44	237.5	0.21	2,423	2,655	10.2	11.18	0.98	1,581	6.66
45	166.8	0.13	935	1,009	5.61	6.05	0.44	258	1.55
46	391.8	0.22	1,447	1,451	3.69	3.7	0.01	298	0.76
47	499.8	1.8	2,636	3,334	5.27	6.67	1.4	9,305	18.62
48	328.2	0.48	2,116	2,236	6.45	6.81	0.37	1,736	5.29
49	269.4	1.77	3,172	3,737	11.78	13.87	2.1	4,930	18.3
50	185.0	3.38	1,450	1,862	7.84	10.06	2.23	2,315	12.51
51	212.2	-0.17	1,605	1,657	7.56	7.81	0.25	785	3.7
52	242.4	3.53	2,367	2,999	9.77	12.37	2.61	1,700	7.01
53.01	127.4	3.15	2,171	2,554	17.03	20.04	3.01	4,602	36.11
53.02	630.5	0.6	463	228	0.73	0.36	-0.37		
54	335.6	1.99	2,091	2,718	6.23	8.1	1.87	3,584	10.68
56	770.7	-0.08	2,723	2,788	3.53	3.62	0.08	1,096	1.42
57	1,289.9	0.23	2,693	2,900	2.09	2.25	0.16	1,170	0.91
58.01	465.8	0.77	2,484	2,708	5.33	5.81	0.48	3,382	7.26
58.02	780.7	0.87	2,357	2,656	3.02	3.4	0.38	3,606	4.62
59	451.1	1.98	2,517	2,722	5.58	6.03	0.45	3,577	7.93
60	342.8	0.64	2,436	2,659	7.11	7.76	0.65	2,188	6.38
61	306.4	0.48	2,622	2,823	8.56	9.21	0.66	4,021	13.12
62	656.1	-0.25	1,594	1,591	2.43	2.43	0	650	0.99
63	594.4	-0.48	2,788	2,853	4.69	4.8	0.11	1,810	3.05
64	222.5	-0.58	1,266	1,300	5.69	5.84	0.15	369	1.66
65	278.9	-0.28	2,365	2,448	8.48	8.78	0.3	446	1.6
66	295.9	0.62	1,771	1,981	5.99	6.7	0.71	7,825	26.45
67	325.9	3.87	2,830	3,653	8.68	11.21	2.53	6,845	21
68	176.1	0.53	1,150	1,271	6.53	7.22	0.69	1,782	10.12
69	223.8	0.61	2,158	2,244	9.64	10.03	0.38	310	1.39
70	195.4	0.93	4,800	5,274	24.56	26.99	2.43	1,671	8.55
71	208.5	4.23	1,159	2,118	5.56	10.16	4.6	11,986	57.49
72	247.9	7.75	1,624	3,145	6.55	12.69	6.14	18,517	74.71
73	225.3	11.73	559	2,225	2.48	9.88	7.39	19,154	85.02
74	129.6	9.09	6,009	6,763	46.38	52.2	5.82	1,462	11.28

Table 16 continued

75	199.4	1.02	3,742	3,949	18.77	19.8	1.04	3,902	19.57
76	140.1	1.79	1,740	1,990	12.42	14.21	1.78	2,463	17.58
77	253.0	1.27	1,800	2,150	7.12	8.5	1.38	751	2.97
78	532.1	-0.36	2,133	2,277	4.01	4.28	0.27	1,093	2.05
79	171.5	5.17	2,321	2,944	13.53	17.17	3.63	1,735	10.12
80.01	129.5	29.8	1,107	4,443	8.55	34.3	25.75	8,804	67.96
80.02	55.1	25.09	1,409	2,441	25.56	44.28	18.72	6,751	122.46
81	212.5	9.19	1,084	2,881	5.1	13.56	8.46	58,586	275.68
82	91.2	2.06	2,156	2,178	23.65	23.89	0.24	23,926	262.42
83	59.4	4.95	1,770	2,105	29.81	35.45	5.64	6,719	113.15
84	93.5	15.09	2,320	3,075	24.82	32.89	8.08	6,585	70.44
85	116.1	17.25	1,443	1,703	12.43	14.67	2.24	19,994	172.23
86	178.3	9.13	1,164	1,747	6.53	9.8	3.27	4,782	26.81
87	183.3	3.28	1,498	1,735	8.17	9.47	1.29	1,588	8.66
88	225.7	0.48	1,446	1,542	6.41	6.83	0.43	306	1.36
89	309.4	2.88	1,823	2,207	5.89	7.13	1.24	1,578	5.1
90	205.7	5.49	881	1,330	4.28	6.47	2.18	3,747	18.22
91	104.7	9.03	533	1,342	5.09	12.81	7.72	3,714	35.46
92	80.0	3.51	1,057	1,439	13.21	17.99	4.77	4,127	51.59
93	2,362.2	0.04	845	1,052	0.36	0.45	0.09	39,855	16.87
94	425.4	1.02	2,002	2,347	4.71	5.52	0.81	6,055	14.24
95	631.2	0.31	2,193	2,437	3.47	3.86	0.39	2,018	3.2
96	463.9	0.8	2,475	2,967	5.34	6.4	1.06	1,011	2.18
97.01	470.3	0.04	2,885	3,034	6.13	6.45	0.32	559	1.19
97.02	549.8	-0.29	2,187	2,301	3.98	4.19	0.21	593	1.08
98	483.1	0.23	2,735	2,926	5.66	6.06	0.4	1,374	2.84
99	1,618.1	0.55	1,767	2,510	1.09	1.55	0.46	6,940	4.29
100	793.4	1.72	2,941	3,493	3.71	4.4	0.7	4,244	5.35
101	615.2	1.16	2,261	2,699	3.68	4.39	0.71	1,536	2.5
102	698.8	0.34	1,862	2,000	2.66	2.86	0.2	370	0.53
103	405.8	2.07	2,291	2,398	5.64	5.91	0.26	2,396	5.9
104	832.6	1.81	2,709	3,051	3.25	3.66	0.41	589	0.71
105	432.5	1.26	2,570	3,196	5.94	7.39	1.45	3,313	7.66
106	650.7	0.28	3,488	3,718	5.36	5.71	0.35	740	1.14
107	550.7	2.38	2,080	2,566	3.78	4.66	0.88	516	0.94
108	1,006.4	0.81	1,241	1,579	1.23	1.57	0.34	1,833	1.82
109	1,179.7	-0.05	689	678	0.58	0.57	-0.01	16,360	13.87
110	681.4	2.51	2,172	2,758	3.19	4.05	0.86	1,121	1.65
111.01	283.5	2.39	1,383	1,480	4.88	5.22	0.34	232	0.82
111.02	339.5	0.39	1,467	1,501	4.32	4.42	0.1	650	1.91

Table 16 continued

112	703.2	1.32	1,250	1,379	1.78	1.96	0.18	5,856	8.33
113	773.4	0.74	2,130	2,332	2.75	3.02	0.26	1,780	2.3
114	596.8	2.05	2,872	3,545	4.81	5.94	1.13	1,514	2.54
115	379.3	-0.44	1,960	1,992	5.17	5.25	0.08	226	0.6
116	799.8	0.08	2,822	2,966	3.53	3.71	0.18	703	0.88
117	877.4	1.31	1,531	1,732	1.74	1.97	0.23	2,159	2.46
118	587.5	1.53	2,849	2,817	4.85	4.79	-0.05	1,340	2.28
119	787.1	0.74	2,451	2,618	3.11	3.33	0.21	161	0.2
120	360.6	-0.36	1,452	1,489	4.03	4.13	0.1	100	0.28
121	440.8	-0.14	1,200	1,239	2.72	2.81	0.09	56	0.13
201	439.8	0.29	1,205	1,302	2.74	2.96	0.22	416	0.95
202	635.6	0.47	2,092	2,257	3.29	3.55	0.26	1,421	2.24
203	635.1	0.88	2,557	2,707	4.03	4.26	0.24	1,905	3
204.01	572.0	0.38	1,272	1,444	2.22	2.52	0.3	950	1.66
204.02	684.8	0.33	2,059	2,266	3.01	3.31	0.3	607	0.89
205	673.0	0.75	2,496	2,711	3.71	4.03	0.32	1,358	2.02
206	484.8	0.52	1,297	1,385	2.68	2.86	0.18	330	0.68
207	425.4	0.2	1,483	1,523	3.49	3.58	0.09	2,467	5.8
208	771.5	0	1,757	1,824	2.28	2.36	0.09	375	0.49
209	1,177.8	0.02	1,358	1,418	1.15	1.2	0.05	3,375	2.87
210	650.9	0.62	2,076	2,210	3.19	3.4	0.21	1,466	2.25
211	644.4	-0.27	1,575	1,656	2.44	2.57	0.13	1,596	2.48
213	436.8	0.35	1,649	1,744	3.78	3.99	0.22	650	1.49
214	767.5	0.32	1,364	1,467	1.78	1.91	0.13	902	1.18
215	865.3	-0.22	1,622	1,687	1.87	1.95	0.08	291	0.34
216	718.2	0.21	1,709	1,849	2.38	2.57	0.19	1,070	1.49
217	1,399.0	1.98	1,925	3,399	1.38	2.43	1.05	1,732	1.24
218.02	1,164.8	1.61	1,216	2,040	1.04	1.75	0.71	7,684	6.6
218.03	809.3	0.71	1,590	1,899	1.96	2.35	0.38	2,034	2.51
218.04	787.8	0.44	1,529	1,750	1.94	2.22	0.28	1,291	1.64
219.03	749.1	-0.06	2,282	2,640	3.05	3.52	0.48	7,421	9.91
219.04	855.1	0.38	1,552	1,767	1.81	2.07	0.25	1,856	2.17
219.05	648.6	2.17	1,215	2,121	1.87	3.27	1.4	812	1.25
219.06	953.9	1.09	1,160	1,656	1.22	1.74	0.52	3,747	3.93
220.01	1,111.7	1.49	1,101	2,173	0.99	1.95	0.96	427	0.38
220.03	566.7	-0.38	1,926	1,994	3.4	3.52	0.12	962	1.7
220.05	608.6	1.37	1,734	2,245	2.85	3.69	0.84	3,299	5.42
220.06	348.8	-0.21	1,615	1,720	4.63	4.93	0.3	731	2.1
221.01	893.0	1.74	1,269	1,881	1.42	2.11	0.69	987	1.11
221.02	1,166.2	1.65	1,355	2,168	1.16	1.86	0.7	458	0.39

Table 16 continued

222.01	552.3	-0.18	1,605	1,727	2.91	3.13	0.22	490	0.89
222.02	640.1	0.1	2,689	3,221	4.2	5.03	0.83	832	1.3
222.03	759.0	0.91	1,441	1,845	1.9	2.43	0.53	592	0.78
223	1,273.6	-0.89	1,320	1,069	1.04	0.84	-0.2	228	0.18
224	1,146.0	0.49	2,988	3,863	2.61	3.37	0.76	2,612	2.28
225	938.7	0.68	2,803	3,649	2.99	3.89	0.9	6,349	6.76
226.03	715.3	1.83	1,525	2,382	2.13	3.33	1.2	1,612	2.25
226.04	723.2	0.49	1,386	1,678	1.92	2.32	0.4	2,451	3.39
226.05	1,164.5	1.27	1,783	2,440	1.53	2.1	0.56	6,051	5.2
226.06	677.7	-0.22	2,364	2,427	3.49	3.58	0.09	583	0.86
227.01	404.1	0.9	1,276	1,681	3.16	4.16	1	4,904	12.14
227.02	607.3	-0.12	1,337	1,424	2.2	2.34	0.14	890	1.47
227.03	1,044.4	0.26	695	877	0.67	0.84	0.17	1,257	1.2
228.01	1,205.2	0.58	3,734	3,941	3.1	3.27	0.17	2,443	2.03
228.02	627.9	0.36	1,792	1,988	2.85	3.17	0.31	256	0.41
228.03	1,157.9	1.49	1,406	2,682	1.21	2.32	1.1	47,416	40.95
229.01	365.1	0.62	956	1,054	2.62	2.89	0.27	499	1.37
229.02	892.2	0.22	2,450	2,709	2.75	3.04	0.29	408	0.46
230	812.5	-0.19	1,897	1,921	2.33	2.36	0.03	2,119	2.61
231	626.3	-0.15	1,469	1,481	2.35	2.36	0.02	149	0.24
232.01	397.0	1.48	2,408	2,607	6.07	6.57	0.5	1,152	2.9
232.02	368.6	1.05	1,779	1,892	4.83	5.13	0.31	2,260	6.13
233	892.0	-0.08	2,213	2,253	2.48	2.53	0.04	886	0.99
234.01	882.5	0.45	1,249	1,554	1.42	1.76	0.35	9,618	10.9
234.02	1,248.6	-0.2	2,700	2,855	2.16	2.29	0.12	5,574	4.46
235	548.1	0.66	1,378	1,563	2.51	2.85	0.34	711	1.3
236.01	1,122.6	0.47	1,398	1,903	1.25	1.7	0.45	7,834	6.98
236.03	496.2	1.28	2,527	2,554	5.09	5.15	0.05	2,576	5.19
236.04	738.1	0.95	2,192	2,655	2.97	3.6	0.63	1,009	1.37
237	1,841.7	-0.1	1,719	1,820	0.93	0.99	0.05	23,811	12.93
238.01	935.2	0.24	1,102	1,300	1.18	1.39	0.21	7,755	8.29
238.02	445.0	10.38	684	3,973	1.54	8.93	7.39	32,968	74.08
239	1,213.2	0.11	2,800	2,990	2.31	2.46	0.16	828	0.68
240	1,153.0	-0.01	3,491	3,603	3.03	3.12	0.1	4,540	3.94
241	1,112.8	-0.17	1,668	1,672	1.5	1.5	0	797	0.72
242	910.6	-0.11	1,172	1,170	1.29	1.28	0	283	0.31
243	1,033.0	0.76	2,788	3,318	2.7	3.21	0.51	4,076	3.95
244	427.6	1.19	1,051	1,339	2.46	3.13	0.67	921	2.15
245	937.3	-0.24	1,841	1,810	1.96	1.93	-0.03	672	0.72
246.01	978.4	0.37	1,502	1,650	1.54	1.69	0.15	557	0.57

Table 16 continued

246.02	691.1	0	1,139	1,289	1.65	1.87	0.22	584	0.85
247.01	678.2	0.35	1,372	1,558	2.02	2.3	0.27	383	0.56
247.02	1,572.8	1.14	1,913	2,789	1.22	1.77	0.56	623	0.4
248	974.6	0.61	2,218	2,432	2.28	2.5	0.22	9,869	10.13
249.01	773.3	-0.21	1,783	1,835	2.31	2.37	0.07	578	0.75
249.02	489.6	-0.05	1,252	1,387	2.56	2.83	0.28	162	0.33
249.03	1,246.0	1.33	1,724	2,358	1.38	1.89	0.51	255	0.2
250.01	889.0	0.81	1,463	1,851	1.65	2.08	0.44	715	0.8
250.03	1,562.5	3.34	657	2,658	0.42	1.7	1.28	722	0.46
250.04	7,410.4	0.73	808	3,003	0.11	0.41	0.3	1,089	0.15
251.01	726.1	2.26	1,509	2,118	2.08	2.92	0.84	876	1.21
251.02	1,535.3	1.98	1,124	2,323	0.73	1.51	0.78	843	0.55
252	1,147.7	2.11	1,939	3,097	1.69	2.7	1.01	749	0.65
253	1,910.4	1.11	3,325	4,815	1.74	2.52	0.78	19,509	10.21
254	567.0	1.67	2,669	3,036	4.71	5.35	0.65	2,579	4.55
255	377.0	2.44	1,730	2,127	4.59	5.64	1.05	294	0.78
256	2,003.0	1.06	2,459	3,616	1.23	1.81	0.58	1,627	0.81
257.01	988.7	0.88	2,695	3,061	2.73	3.1	0.37	465	0.47
257.02	688.7	0.39	952	1,178	1.38	1.71	0.33	133	0.19
258.01	1,336.2	1.38	2,760	3,837	2.07	2.87	0.81	4,125	3.09
258.03	317.6	-0.8	1,695	1,675	5.34	5.27	-0.06	569	1.79
258.04	608.3	-0.75	1,375	1,318	2.26	2.17	-0.09	460	0.76
260.01	684.6	-0.15	1,931	2,015	2.82	2.94	0.12	546	0.8
260.02	685.5	1.05	2,126	2,548	3.1	3.72	0.62	854	1.25
261	1,070.4	0.47	2,341	2,539	2.19	2.37	0.18	732	0.68
262	3,863.8	0.16	2,466	2,708	0.64	0.7	0.06	40,842	10.57
263	1,205.6	0.35	491	637	0.41	0.53	0.12	11,270	9.35
264	1,204.8	0.36	2,367	2,486	1.96	2.06	0.1	3,508	2.91
265	317.5	0.2	827	870	2.61	2.74	0.14	573	1.8
266	287.2	0.16	807	832	2.81	2.9	0.09	717	2.5
267	729.4	0.27	2,116	2,170	2.9	2.98	0.07	391	0.54
268.01	381.1	2.23	1,948	2,055	5.11	5.39	0.28	847	2.22
268.02	499.0	1.64	1,666	1,835	3.34	3.68	0.34	543	1.09
269	174.4	0.54	524	574	3	3.29	0.29	111	0.64
270	481.3	0.41	1,107	1,174	2.3	2.44	0.14	151	0.31
271	378.1	1.1	1,161	1,336	3.07	3.53	0.46	840	2.22
272	821.7	0.36	904	1,064	1.1	1.29	0.19	5,787	7.04
273	877.3	1.05	1,910	2,050	2.18	2.34	0.16	960	1.09
274	820.6	0.75	1,786	1,900	2.18	2.32	0.14	1,372	1.67
275	547.9	0.16	1,771	1,875	3.23	3.42	0.19	1,252	2.29

Table 16 continued

276	664.4	0.96	1,623	1,759	2.44	2.65	0.2	565	0.85
277.01	11,065.0	0.04	2,378	2,463	0.21	0.22	0.01	2,032	0.18
277.02	12,865.2	0.09	2,139	2,560	0.17	0.2	0.03	343	0.03
278	631.3	-0.06	1,410	1,506	2.23	2.39	0.15	137	0.22
279	826.2	0.22	2,977	3,142	3.6	3.8	0.2	6,101	7.38
280	516.0	-0.92	1,937	1,683	3.75	3.26	-0.49	1,466	2.84
281	415.7	0.93	914	851	2.2	2.05	-0.15	960	2.31
282	660.4	1.4	1,854	1,934	2.81	2.93	0.12	930	1.41
283	2,069.3	0.26	1,135	1,322	0.55	0.64	0.09	5,523	2.67
284.02	2,034.6	0.47	1,684	1,844	0.83	0.91	0.08	18,107	8.9
284.03	511.3	1.15	2,348	2,436	4.59	4.76	0.17	3,136	6.13
285	874.9	-0.03	1,615	1,753	1.85	2	0.16	1,433	1.64
286	1,578.9	0.13	2,401	2,752	1.52	1.74	0.22	821	0.52
287	660.6	-0.04	1,937	1,956	2.93	2.96	0.03	408	0.62
288.01	1,279.4	0.38	1,214	1,088	0.95	0.85	-0.1	3,154	2.47
288.02	589.2	0.77	2,483	2,507	4.21	4.25	0.04	1,784	3.03
289.01	577.0	0.87	1,506	1,614	2.61	2.8	0.19	1,340	2.32
289.02	515.3	0.93	2,593	2,646	5.03	5.13	0.1	1,366	2.65
290.01	638.7	0.41	1,760	1,860	2.76	2.91	0.16	673	1.05
290.03	639.1	1.82	1,888	2,395	2.95	3.75	0.79	1,147	1.79
290.04	452.5	0.17	1,393	1,407	3.08	3.11	0.03	1,215	2.69
291	1,506.1	1.22	1,839	2,739	1.22	1.82	0.6	423	0.28
292.01	4,706.2	0.91	2,515	4,525	0.53	0.96	0.43	39,280	8.35
292.03	528.6	1.51	871	1,289	1.65	2.44	0.79	3,448	6.52
292.04	1,070.7	1.85	1,822	2,557	1.7	2.39	0.69	1,351	1.26
293.03	922.0	3.59	1,408	2,882	1.53	3.13	1.6	1,472	1.6
293.04	1,036.9	0.76	1,225	1,743	1.18	1.68	0.5	216	0.21
293.05	739.9	0.99	1,068	1,313	1.44	1.77	0.33	331	0.45
293.06	594.3	2.38	662	1,354	1.11	2.28	1.16	629	1.06
293.07	960.2	0.48	1,145	1,324	1.19	1.38	0.19	463	0.48
294.03	575.7	3.34	1,302	1,994	2.26	3.46	1.2	321	0.56
294.05	589.0	2.03	1,392	1,801	2.36	3.06	0.69	217	0.37
294.06	688.2	2	933	1,432	1.36	2.08	0.73	255	0.37
294.07	347.2	1.69	1,526	1,695	4.4	4.88	0.49	807	2.32
294.08	312.8	1.65	1,409	1,620	4.5	5.18	0.67	165	0.53
295.02	1,070.1	2.1	1,293	2,042	1.21	1.91	0.7	821	0.77
295.03	586.2	4.01	2,681	3,339	4.57	5.7	1.12	2,750	4.69
295.04	471.7	2.48	1,801	2,319	3.82	4.92	1.1	940	1.99
296.01	984.7	2.95	1,474	2,334	1.5	2.37	0.87	819	0.83
296.02	1,686.6	1.13	695	1,356	0.41	0.8	0.39	289	0.17

Table 16 continued

297	2,781.7	0.2	2,542	2,845	0.91	1.02	0.11	6,659	2.39
298.01	1,948.1	0.73	2,397	3,144	1.23	1.61	0.38	994	0.51
298.02	1,708.7	0.83	2,078	2,595	1.22	1.52	0.3	748	0.44
299.01	954.4	0.83	1,333	1,559	1.4	1.63	0.24	362	0.38
299.02	1,553.8	0.67	1,103	1,525	0.71	0.98	0.27	3,430	2.21
300.02	1,021.5	1.44	2,897	3,549	2.84	3.47	0.64	3,836	3.76
300.03	1,128.7	1.02	1,860	2,413	1.65	2.14	0.49	1,058	0.94
300.04	508.3	3.6	2,964	3,182	5.83	6.26	0.43	246	0.48
301	1,515.0	-0.37	3,060	2,966	2.02	1.96	-0.06	669	0.44
302.01	678.1	0.51	1,872	2,018	2.76	2.98	0.22	524	0.77
302.02	789.1	0.45	2,311	2,439	2.93	3.09	0.16	2,029	2.57
303.03	1,638.4	1.06	3,155	3,793	1.93	2.32	0.39	11,656	7.11
303.04	1,830.1	0.4	645	954	0.35	0.52	0.17	2,389	1.31
303.05	1,023.2	0.11	1,777	2,034	1.74	1.99	0.25	387	0.38
303.06	986.8	0.06	1,864	1,978	1.89	2	0.12	434	0.44
303.08	503.5	5.35	1,529	2,367	3.04	4.7	1.66	361	0.72
303.09	518.0	2.96	2,010	2,526	3.88	4.88	1	1,294	2.5
303.1	802.5	4.02	913	1,860	1.14	2.32	1.18	1,160	1.45
303.11	472.5	-0.11	1,656	1,725	3.5	3.65	0.15	357	0.76
303.12	453.5	1.72	1,613	1,848	3.56	4.07	0.52	506	1.12
304.01	2,914.7	0.41	1,957	2,464	0.67	0.85	0.17	4,557	1.56
304.03	892.7	2.67	676	1,625	0.76	1.82	1.06	105	0.12
304.04	1,506.2	0.49	1,143	1,454	0.76	0.97	0.21	301	0.2
305.01	2,839.2	0.12	763	1,117	0.27	0.39	0.12	14,467	5.1
305.03	844.0	-0.36	1,879	1,701	2.23	2.02	-0.21	1,637	1.94
305.04	379.8	0.77	1,774	2,048	4.67	5.39	0.72	739	1.95
306	848.9	0.11	2,070	2,188	2.44	2.58	0.14	1,811	2.13
307	381.4	0.98	1,526	1,743	4	4.57	0.57	1,594	4.18
308.01	1,719.3	0.33	2,283	2,388	1.33	1.39	0.06	9,875	5.74
308.02	337.7	1.22	1,208	1,468	3.58	4.35	0.77	395	1.17
309.01	801.0	1.57	744	1,174	0.93	1.47	0.54	1,803	2.25
309.02	979.4	1.58	1,383	1,972	1.41	2.01	0.6	1,523	1.55
310	3,115.9	0.8	325	1,212	0.1	0.39	0.28	600	0.19
311	1,832.1	0.61	2,226	2,734	1.22	1.49	0.28	2,877	1.57
312.02	16,721.6	0.06	1,744	2,139	0.1	0.13	0.02	1,189	0.07
312.04	9,090.7	0.03	1,893	2,138	0.21	0.24	0.03	563	0.06
312.05	1,496.1	2.12	649	1,856	0.43	1.24	0.81	685	0.46
312.06	915.1	1.45	1,181	1,621	1.29	1.77	0.48		
313.01	8,279.8	0.04	837	980	0.1	0.12	0.02	291	0.04
313.02	2,706.3	0.91	990	1,797	0.37	0.66	0.3	819	0.3

Table 16 continued

314	1,569.4	0.79	1,955	2,584	1.25	1.65	0.4	3,322	2.12
315.01	40,172.8	0.02	1,009	1,307	0.03	0.03	0.01	284	0.01
315.02	25,453.1	0.04	1,219	1,602	0.05	0.06	0.02	819	0.03
316.01	3,606.1	0.26	1,222	1,544	0.34	0.43	0.09	474	0.13
316.02	4,870.5	1.02	1,222	2,752	0.25	0.57	0.31	791	0.16
316.03	14,095.8	0.16	922	1,682	0.07	0.12	0.05	1,059	0.08
317.02	2,250.3	2.13	1,653	3,270	0.73	1.45	0.72	2,759	1.23
317.03	1,819.8	0.87	2,063	2,758	1.13	1.52	0.38	400	0.22
317.04	1,450.2	1.88	935	1,809	0.64	1.25	0.6	613	0.42
318	6,222.8	0.12	1,196	1,575	0.19	0.25	0.06	653	0.1
319.03	2,911.4	0.04	2,093	2,265	0.72	0.78	0.06	823	0.28
319.04	4,648.2	0.02	1,131	1,256	0.24	0.27	0.03	651	0.14
319.06	2,636.2	0.41	738	1,116	0.28	0.42	0.14	326	0.12
319.07	1,344.4	1.44	1,554	2,532	1.16	1.88	0.73	236	0.18
319.08	442.4	0.66	1,753	1,991	3.96	4.5	0.54	828	1.87
319.09	494.2	0.73	894	1,104	1.81	2.23	0.42	375	0.76
320.02	6,826.2	0.04	952	1,118	0.14	0.16	0.02	397	0.06
320.03	30,108.7	0.03	1,458	1,752	0.05	0.06	0.01	1,335	0.04
320.05	1,562.3	0.78	1,931	2,324	1.24	1.49	0.25	421	0.27
320.06	1,884.1	0.59	989	1,485	0.52	0.79	0.26	289	0.15
320.07	2,873.2	0.49	728	1,282	0.25	0.45	0.19	725	0.25
320.08	569.8	1.85	1,086	1,470	1.91	2.58	0.67	130	0.23
320.09	2,016.3	3.48	567	2,972	0.28	1.47	1.19	1,299	0.64
321.02	19,692.3	0.02	1,654	1,817	0.08	0.09	0.01	603	0.03
321.03	1,036.2	1.24	1,540	2,170	1.49	2.09	0.61	7,343	7.09
321.04	5,552.1	0.17	1,948	2,599	0.35	0.47	0.12	1,182	0.21
322.03	2,490.0	0.78	1,392	2,303	0.56	0.92	0.37	620	0.25
322.07	1,146.4	0.76	899	1,068	0.78	0.93	0.15	377	0.33
322.08	2,722.3	1.21	1,074	3,117	0.39	1.15	0.75	9,184	3.37
322.09	6,667.7	1.26	1,075	3,908	0.16	0.59	0.42	2,009	0.3
322.1	10,297.6	0.23	678	2,077	0.07	0.2	0.14	2,745	0.27
322.11	753.7	-0.81	2,123	1,726	2.82	2.29	-0.53	756	1
322.12	772.3	10.17	45	2,831	0.06	3.67	3.61	597	0.77
323.07	2,904.5	-0.03	2,068	2,210	0.71	0.76	0.05	737	0.25
323.09	1,475.9	1.57	588	2,024	0.4	1.37	0.97	16,167	10.95
323.11	5,822.1	0.37	1,317	2,029	0.23	0.35	0.12	479	0.08
323.12	6,543.7	0.6	1,048	2,296	0.16	0.35	0.19	1,029	0.16
323.13	3,289.0	1.12	1,026	2,626	0.31	0.8	0.49	9,842	2.99
323.14	4,488.7	1.12	1,118	2,525	0.25	0.56	0.31	1,319	0.29
323.15	11,320.6	0.21	1,044	1,865	0.09	0.16	0.07	356	0.03

Table 16 continued

323.16	1,469.9	0.97	1,149	1,733	0.78	1.18	0.4	306	0.21
323.17	1,156.8	0.76	1,704	2,180	1.47	1.88	0.41	409	0.35
323.18	1,754.6	1.24	1,069	1,717	0.61	0.98	0.37	715	0.41
323.19	1,722.0	0.88	1,735	2,286	1.01	1.33	0.32	9,647	5.6
323.2	2,364.9	0.22	1,188	1,456	0.5	0.62	0.11	786	0.33
323.21	3,112.3	0.41	873	1,419	0.28	0.46	0.18	904	0.29
323.22	1,160.9	0.07	1,138	1,173	0.98	1.01	0.03	146	0.13
323.23	817.6	2.73	991	2,025	1.21	2.48	1.26	688	0.84
323.24	498.7	0.3	1,992	2,200	3.99	4.41	0.42	452	0.91
323.25	546.0	3.69	1,550	2,497	2.84	4.57	1.73	313	0.57
324.01	13,952.9	0.17	1,208	1,993	0.09	0.14	0.06	1,372	0.1
324.02	6,260.1	0.35	1,261	2,058	0.2	0.33	0.13	554	0.09
325	53,415.9	0.03	1,391	1,919	0.03	0.04	0.01	1,167	0.02
326.01	15,552.5	0.01	966	1,098	0.06	0.07	0.01	634	0.04
326.02	7,412.7	0.73	622	2,677	0.08	0.36	0.28	1,817	0.25
327.02	127,318.5	0.02	1,897	2,740	0.01	0.02	0.01	397	0
327.03	2,600.9	-0.01	808	773	0.31	0.3	-0.01	896	0.34
327.04	4,388.6	0.39	1,863	2,436	0.42	0.56	0.13	2,787	0.64
328	34,515.5	0.02	1,295	1,427	0.04	0.04	0	304	0.01
401	1,282.7	1.1	1,841	1,802	1.44	1.4	-0.03	6,517	5.08
402	669.5	2.33	1,971	2,532	2.94	3.78	0.84	1,130	1.69
403	260.4	-0.35	1,404	1,406	5.39	5.4	0.01	363	1.39
404	381.9	-0.08	1,872	2,032	4.9	5.32	0.42	1,621	4.24
405	460.2	-0.09	945	1,031	2.05	2.24	0.19	517	1.12
406	465.5	0.2	435	353	0.93	0.76	-0.18	3,096	6.65
407	226.0	1.26	1,348	1,708	5.96	7.56	1.59	4,637	20.51
408	360.3	0.55	1,082	1,251	3	3.47	0.47	6,093	16.91
409	815.6	0.52	994	1,286	1.22	1.58	0.36	198	0.24
410	751.4	0.31	2,179	2,547	2.9	3.39	0.49	3,626	4.83
411	672.0	1.97	1,338	1,926	1.99	2.87	0.88	1,885	2.81
412.01	363.9	2.89	839	1,225	2.31	3.37	1.06	58	0.16
412.02	675.8	1.04	2,046	2,277	3.03	3.37	0.34	1,979	2.93
413.01	1,123.5	0.57	1,760	2,174	1.57	1.94	0.37	1,482	1.32
413.02	3,452.5	1.02	1,287	2,688	0.37	0.78	0.41	27,301	7.91
414	839.8	-0.22	2,176	2,132	2.59	2.54	-0.05	1,034	1.23
415	1,334.4	0.1	525	577	0.39	0.43	0.04	254	0.19
416.01	1,151.6	0.62	1,338	1,815	1.16	1.58	0.41	435	0.38
416.05	612.2	3.38	1,050	1,986	1.72	3.24	1.53	714	1.17
416.06	633.9	2.21	1,227	1,766	1.94	2.79	0.85	503	0.79
416.07	704.0	2.03	554	1,123	0.79	1.6	0.81	71	0.1

Table 16 continued

416.08	953.0	1.3	1,328	1,802	1.39	1.89	0.5	318	0.33
417.01	691.0	2.11	1,066	1,953	1.54	2.83	1.28	1,681	2.43
417.02	1,893.2	2.08	1,824	3,933	0.96	2.08	1.11	2,959	1.56
418.04	1,311.4	2.56	2,371	4,225	1.81	3.22	1.41	2,472	1.88
418.05	810.3	1.89	1,567	2,404	1.93	2.97	1.03	4,945	6.1
418.06	711.0	3.61	2,111	3,148	2.97	4.43	1.46	1,139	1.6
418.07	482.3	8.76	3,086	4,787	6.4	9.93	3.53	935	1.94
418.08	432.7	2.87	1,089	1,793	2.52	4.14	1.63	941	2.17
419.01	2,189.6	0.43	1,048	1,386	0.48	0.63	0.15	5,564	2.54
419.03	825.4	2.84	2,002	3,076	2.43	3.73	1.3	2,674	3.24
419.04	349.4	4.95	1,667	2,179	4.77	6.24	1.47	1,167	3.34
419.05	550.3	4.45	1,200	2,237	2.18	4.06	1.88	896	1.63
420.01	1,257.1	0.8	1,861	2,355	1.48	1.87	0.39	642	0.51
420.03	671.9	0.43	934	1,184	1.39	1.76	0.37	100	0.15
420.04	588.0	1.44	1,117	1,489	1.9	2.53	0.63	564	0.96
420.05	1,632.8	1.59	953	1,822	0.58	1.12	0.53	1,952	1.2
420.06	550.1	7.42	105	2,104	0.19	3.83	3.63	3,378	6.14
501.01	621.5	0.41	803	937	1.29	1.51	0.22	116	0.19
501.02	455.9	5.11	802	2,008	1.76	4.4	2.65	466	1.02
502	1,112.6	0.17	1,400	1,613	1.26	1.45	0.19	309	0.28
503	920.1	-0.07	2,058	2,166	2.24	2.35	0.12	257	0.28
504.01	815.9	0.36	2,747	3,239	3.37	3.97	0.6	912	1.12
504.02	720.3	-0.17	2,216	2,418	3.08	3.36	0.28	2,771	3.85
505	869.3	0.56	3,121	3,637	3.59	4.18	0.59	3,435	3.95
506	802.1	0.34	310	429	0.39	0.53	0.15	80	0.1
507	763.8	0.15	2,470	2,707	3.23	3.54	0.31	1,067	1.4
508	786.5	-0.13	2,471	2,607	3.14	3.31	0.17	718	0.91
509	376.4	0.28	1,462	1,545	3.88	4.1	0.22	1,482	3.94
510	808.6	-0.06	1,814	1,861	2.24	2.3	0.06	4,537	5.61
511	509.8	0.3	1,570	1,559	3.08	3.06	-0.02	662	1.3
512	521.1	0.28	1,724	1,845	3.31	3.54	0.23	367	0.7
513	752.1	1.67	2,550	3,051	3.39	4.06	0.67	522	0.69
514	978.8	0.98	3,051	3,367	3.12	3.44	0.32	6,450	6.59
515	803.7	1.24	1,811	2,298	2.25	2.86	0.61	3,568	4.44
516.01	597.6	1.56	1,314	1,740	2.2	2.91	0.71	971	1.62
516.02	509.5	0.33	1,533	1,644	3.01	3.23	0.22	563	1.1
517.01	607.0	0.43	2,473	2,558	4.07	4.21	0.14	2,375	3.91
517.02	534.6	2.29	1,344	1,819	2.51	3.4	0.89	3,594	6.72
518.01	991.2	3.3	2,552	4,023	2.57	4.06	1.48	789	0.8
518.02	1,255.7	1.55	973	1,790	0.77	1.43	0.65	6,245	4.97

Table 16 continued

519.05	1,336.6	0.41	2,753	2,932	2.06	2.19	0.13	2,491	1.86
519.09	1,699.1	1.76	2,114	3,340	1.24	1.97	0.72	1,960	1.15
519.11	4,113.0	0.66	1,857	3,252	0.45	0.79	0.34	10,772	2.62
519.12	3,309.6	0.08	701	834	0.21	0.25	0.04	2,793	0.84
519.13	964.5	0.74	1,168	1,448	1.21	1.5	0.29	222	0.23
519.14	855.1	0.17	1,305	1,466	1.53	1.71	0.19	189	0.22
519.15	1,020.5	0.75	1,605	2,129	1.57	2.09	0.51	512	0.5
519.16	688.8	-0.02	1,210	1,295	1.76	1.88	0.12	638	0.93
519.17	719.5	0.95	1,233	1,530	1.71	2.13	0.41	271	0.38
519.18	1,053.1	1.78	1,119	1,940	1.06	1.84	0.78	1,035	0.98
519.19	1,550.9	1.36	2,070	3,027	1.33	1.95	0.62	1,871	1.21
519.2	1,561.1	3.21	1,535	4,052	0.98	2.6	1.61	1,822	1.17
520.03	1,428.0	1.55	375	1,017	0.26	0.71	0.45	275	0.19
520.04	768.0	1.78	1,682	2,335	2.19	3.04	0.85	948	1.23
520.05	944.2	1.97	1,827	2,500	1.93	2.65	0.71	336	0.36
520.06	504.8	3.13	888	1,407	1.76	2.79	1.03	152	0.3
520.07	516.6	0.9	1,070	1,313	2.07	2.54	0.47	1,044	2.02
521.04	10,985.1	0.11	556	935	0.05	0.09	0.03	583	0.05
521.05	12,925.1	0	615	693	0.05	0.05	0.01	736	0.06
521.07	3,119.7	0.02	978	1,105	0.31	0.35	0.04	678	0.22
521.08	5,756.2	0.27	1,535	2,141	0.27	0.37	0.11	1,300	0.23
521.1	2,457.3	3.29	1,248	4,101	0.51	1.67	1.16	869	0.35
521.11	2,726.7	1.16	773	1,894	0.28	0.69	0.41	240	0.09
521.12	3,629.4	0.16	692	939	0.19	0.26	0.07	170	0.05
521.13	5,437.0	0.2	584	982	0.11	0.18	0.07	120	0.02
522.03	4,054.9	0.67	674	1,759	0.17	0.43	0.27	2,052	0.51
522.04	2,405.5	2.07	184	1,708	0.08	0.71	0.63	2,518	1.05
522.05	2,636.5	1.33	1,678	2,673	0.64	1.01	0.38	4,555	1.73
522.06	12,767.6	0.12	739	1,314	0.06	0.1	0.05	416	0.03
522.07	16,514.2	0.06	1,355	1,735	0.08	0.11	0.02	228	0.01
523.01	9,733.8	0.1	1,210	1,661	0.12	0.17	0.05	455	0.05
523.02	8,405.3	0.08	996	1,284	0.12	0.15	0.03	499	0.06
524.01	979.1	0.71	1,302	1,630	1.33	1.66	0.34	2,027	2.07
524.02	592.5	1.81	1,315	1,837	2.22	3.1	0.88	1,693	2.86
525.02	3,439.2	0.18	1,242	1,561	0.36	0.45	0.09	711	0.21
525.03	1,244.7	2.9	975	2,287	0.78	1.84	1.05	726	0.58
525.04	1,965.1	0.12	805	968	0.41	0.49	0.08	579	0.29
526.03	1,875.8	0.37	556	832	0.3	0.44	0.15	173	0.09
526.04	934.4	1.4	1,057	1,604	1.13	1.72	0.59	1,748	1.87
526.05	1,173.0	2.1	1,198	1,980	1.02	1.69	0.67	1,322	1.13

Table 16 continued

526.06	3,240.2	0.61	1,710	1,565	0.53	0.48	-0.04	317	0.1
526.07	2,501.8	1.21	617	1,641	0.25	0.66	0.41	628	0.25
527.01	5,064.6	0.05	467	570	0.09	0.11	0.02	125	0.02
527.03	2,556.4	1.61	716	2,160	0.28	0.84	0.56	507	0.2
527.04	5,746.9	0.97	840	2,700	0.15	0.47	0.32	166	0.03
527.05	3,841.6	1.05	601	1,957	0.16	0.51	0.35	199	0.05
528.03	3,528.4	0.63	1,181	2,006	0.33	0.57	0.23	4,185	1.19
528.04	1,739.6	0.71	1,735	2,272	1	1.31	0.31	791	0.45
528.05	1,122.6	0.49	1,394	1,709	1.24	1.52	0.28	1,640	1.46
528.06	782.0	4.04	1,168	2,313	1.49	2.96	1.46	255	0.33
529.01	1,116.0	1.61	2,751	3,517	2.47	3.15	0.69	2,084	1.87
529.03	720.3	0.63	1,665	1,820	2.31	2.53	0.22	2,832	3.93
529.04	861.6	2.79	1,218	2,049	1.41	2.38	0.96	525	0.61
530.01	9,555.7	0.14	2,120	1,687	0.22	0.18	-0.05	235	0.02
530.02	12,890.4	0.08	1,906	2,103	0.15	0.16	0.02	5,330	0.41
531.01	6,761.0	0.26	651	1,372	0.1	0.2	0.11	222	0.03
531.02	6,043.2	0.27	1,230	1,861	0.2	0.31	0.1	606	0.1
532.01	11,478.7	0.09	1,085	1,588	0.09	0.14	0.04	411	0.04
532.02	5,513.2	0.37	1,101	1,818	0.2	0.33	0.13	245	0.04
533.01	6,312.8	0.44	1,050	2,191	0.17	0.35	0.18	3,165	0.5
533.02	21,903.8	0.07	1,357	1,930	0.06	0.09	0.03	700	0.03
534	32,032.3	0.06	1,270	2,007	0.04	0.06	0.02	654	0.02
535.03	6,949.2	0.96	1,538	4,006	0.22	0.58	0.36	5,722	0.82
535.04	2,978.8	1.02	1,171	2,398	0.39	0.81	0.41	2,592	0.87
535.05	12,433.9	0.18	989	1,819	0.08	0.15	0.07	286	0.02
535.06	63,526.2	0.02	1,268	2,062	0.02	0.03	0.01	393	0.01
536.01	14,127.3	0.23	1,718	2,857	0.12	0.2	0.08	928	0.07
536.02	132,044.7	0.02	1,460	2,221	0.01	0.02	0.01	607	0
537	41,677.1	0.01	1,108	1,455	0.03	0.03	0.01	695	0.02
538.01	28,106.5	0.04	1,471	1,960	0.05	0.07	0.02	242	0.01
538.02	5,545.3	0.41	1,127	1,953	0.2	0.35	0.15	962	0.17
538.03	67,392.9	0.03	1,368	2,294	0.02	0.03	0.01	442	0.01
601.02	1,154.0	1.72	1,342	2,094	1.16	1.81	0.65	824	0.71
601.03	977.2	1.74	949	1,639	0.97	1.68	0.71	185	0.19
601.04	759.7	5.9	715	2,487	0.94	3.27	2.33	346	0.46
602	3,839.1	0.23	196	495	0.05	0.13	0.08	13,377	3.48
603	1,410.3	0.17	1,529	1,878	1.08	1.33	0.25	816	0.58
604	635.3	-0.09	1,724	1,742	2.71	2.74	0.03	288	0.45
605	538.0	-0.01	1,723	1,764	3.2	3.28	0.08	1,248	2.32
606	521.4	-0.62	2,854	2,827	5.47	5.42	-0.05	837	1.61

Table 16 continued

607	513.9	0.13	2,449	2,379	4.77	4.63	-0.14	2,203	4.29
608	633.4	-0.44	2,262	2,258	3.57	3.56	-0.01	825	1.3
609.03	583.6	-0.29	1,299	1,390	2.23	2.38	0.16	809	1.39
609.04	481.0	0.34	2,332	2,379	4.85	4.95	0.1	428	0.89
609.05	768.1	0.05	3,060	3,095	3.98	4.03	0.05	1,119	1.46
609.06	388.0	0.01	959	922	2.47	2.38	-0.1	1,099	2.83
610.01	713.4	1.13	1,449	1,962	2.03	2.75	0.72	423	0.59
610.02	741.7	0.69	2,195	2,457	2.96	3.31	0.35	3,394	4.58
611	1,093.2	0.62	2,761	2,943	2.53	2.69	0.17	5,176	4.73
612	468.7	0.31	2,200	2,223	4.69	4.74	0.05	1,027	2.19
613	390.8	1.03	2,014	2,054	5.15	5.26	0.1	1,083	2.77
614	229.1	1.65	1,503	1,422	6.56	6.21	-0.35	7,112	31.04
615	287.4	0.12	3,254	3,528	11.32	12.28	0.95	7,070	24.6
616.01	191.0	1.01	1,026	1,054	5.37	5.52	0.15	10,508	55.01
616.02	259.5	-0.4	390	386	1.5	1.49	-0.02	2,956	11.39
617	646.6	0.6	1,724	1,799	2.67	2.78	0.12	3,379	5.23
618	340.8	-0.27	1,185	1,136	3.48	3.33	-0.14	614	1.8
619	257.8	0.23	789	878	3.06	3.41	0.35	1,441	5.59
620	507.9	0.28	1,695	1,766	3.34	3.48	0.14	634	1.25
621	614.1	0.9	991	1,122	1.61	1.83	0.21	725	1.18
622	451.0	-0.16	879	917	1.95	2.03	0.08	272	0.6
623	605.7	1.1	1,529	1,662	2.52	2.74	0.22	222	0.37
624	561.7	0.31	2,135	2,204	3.8	3.92	0.12	784	1.4
625	709.9	0.4	2,867	2,934	4.04	4.13	0.09	832	1.17
626	1,714.4	-0.25	1,262	1,027	0.74	0.6	-0.14	17,509	10.21
628.01	936.8	0.99	2,665	2,977	2.84	3.18	0.33	1,944	2.08
628.02	747.0	0.66	1,311	1,522	1.75	2.04	0.28	886	1.19
629	729.6	1.47	2,621	3,071	3.59	4.21	0.62	1,487	2.04
630	530.0	-0.01	1,192	1,208	2.25	2.28	0.03	1,628	3.07
631	585.6	0.48	1,568	1,634	2.68	2.79	0.11	916	1.56
632	585.5	0.27	1,840	1,938	3.14	3.31	0.17	507	0.87
633	817.6	1.83	1,866	2,301	2.28	2.81	0.53	1,153	1.41
634	954.9	0.81	2,594	2,822	2.72	2.96	0.24	1,664	1.74
635.01	483.8	0.83	1,590	1,659	3.29	3.43	0.14	762	1.58
635.02	475.6	2.63	1,284	1,736	2.7	3.65	0.95	295	0.62
701	47,149.0	0.03	1,134	1,445	0.02	0.03	0.01	423	0.01
702.03	8,913.3	0.22	959	1,662	0.11	0.19	0.08	243	0.03
702.04	1,286.1	0.25	1,199	1,438	0.93	1.12	0.19	87	0.07
702.05	4,749.3	0.25	785	1,300	0.17	0.27	0.11	671	0.14
702.06	9,821.1	0.18	891	1,608	0.09	0.16	0.07	284	0.03

Table 16 continued

702.07	8,116.7	0.17	1,258	1,890	0.15	0.23	0.08	2,070	0.26
703.03	5,088.2	0.79	1,976	3,577	0.39	0.7	0.31	1,447	0.28
703.06	3,599.5	1.95	1,410	4,070	0.39	1.13	0.74	982	0.27
703.07	5,945.9	0.29	856	1,575	0.14	0.26	0.12	289	0.05
703.08	809.4	1.96	896	1,397	1.11	1.73	0.62	430	0.53
703.09	2,646.3	0.96	1,152	2,058	0.44	0.78	0.34	1,014	0.38
703.1	1,355.6	2.19	707	1,666	0.52	1.23	0.71	1,679	1.24
703.11	1,216.5	2.58	592	1,765	0.49	1.45	0.96	260	0.21
704.01	2,463.4	0.1	708	852	0.29	0.35	0.06	636	0.26
704.02	4,757.6	0.94	991	2,497	0.21	0.52	0.32	1,124	0.24
705	2,175.6	0.41	1,548	2,240	0.71	1.03	0.32	2,499	1.15
706	2,707.8	-0.1	234	180	0.09	0.07	-0.02	5,207	1.92
707.01	4,097.5	0.19	2,314	2,765	0.56	0.67	0.11	1,164	0.28
707.03	1,485.9	0.74	1,981	2,632	1.33	1.77	0.44	1,670	1.12
707.04	1,970.6	0.03	1,047	1,112	0.53	0.56	0.03	916	0.46
708	765.1	1.01	863	1,303	1.13	1.7	0.58	159	0.21
709	4,334.6	0.31	2,944	3,437	0.68	0.79	0.11	13,006	3
710	4,431.2	-0.01	2,369	2,665	0.53	0.6	0.07	1,373	0.31
711	1,617.1	-0.01	938	1,018	0.58	0.63	0.05	576	0.36
712.05	1,927.3	0.95	1,057	1,788	0.55	0.93	0.38	646	0.34
712.06	1,953.0	0.98	1,439	2,653	0.74	1.36	0.62	4,116	2.11
712.07	1,203.0	2.38	1,333	2,634	1.11	2.19	1.08	3,216	2.67
712.08	923.8	2.8	1,737	3,160	1.88	3.42	1.54	1,496	1.62
712.09	560.8	1.44	1,076	1,439	1.92	2.57	0.65	273	0.49
712.1	2,146.8	0.6	1,095	1,627	0.51	0.76	0.25	336	0.16
713.04	1,326.3	1.86	1,151	2,415	0.87	1.82	0.95	1,940	1.46
713.05	2,484.6	0.31	1,024	1,546	0.41	0.62	0.21	2,280	0.92
713.06	3,004.8	0.61	1,325	2,191	0.44	0.73	0.29	628	0.21
713.07	1,281.8	1.2	897	1,770	0.7	1.38	0.68	693	0.54
713.08	2,607.7	1.36	1,532	2,979	0.59	1.14	0.55	1,226	0.47
714.03	1,279.3	0.17	1,482	1,661	1.16	1.3	0.14	650	0.51
714.06	4,069.0	0.61	1,010	1,993	0.25	0.49	0.24	2,025	0.5
714.07	2,092.2	1.5	956	2,012	0.46	0.96	0.5	662	0.32
714.08	720.8	-0.12	1,291	1,419	1.79	1.97	0.18	732	1.02
714.09	524.5	0.25	1,370	1,532	2.61	2.92	0.31	331	0.63
714.1	1,458.2	1.23	1,120	1,820	0.77	1.25	0.48	1,699	1.17
714.11	843.3	2.97	593	1,514	0.7	1.8	1.09	410	0.49
715.03	1,384.6	0.03	1,915	2,213	1.38	1.6	0.22	2,603	1.88
715.04	658.0	-0.53	1,558	1,809	2.37	2.75	0.38	2,298	3.49
715.05	1,099.2	0.69	1,656	2,131	1.51	1.94	0.43	181	0.16

Table 16 continued

715.06	960.3	1.58	1,371	1,914	1.43	1.99	0.57	144	0.15
716.01	997.0	1.13	1,240	1,772	1.24	1.78	0.53	916	0.92
716.02	1,164.2	2.73	1,444	2,779	1.24	2.39	1.15	1,886	1.62
717.03	212.7	1.57	1,595	1,642	7.5	7.72	0.22	953	4.48
717.04	332.8	4.26	902	1,715	2.71	5.15	2.44	540	1.62
717.05	589.4	0.71	1,103	1,376	1.87	2.33	0.46	919	1.56
717.06	404.2	-0.18	724	830	1.79	2.05	0.26	720	1.78
717.07	315.0	0.79	880	1,142	2.79	3.62	0.83	710	2.25
718.03	1,142.0	1.27	1,727	2,408	1.51	2.11	0.6	1,888	1.65
718.04	1,504.1	0.87	2,708	3,343	1.8	2.22	0.42	7,998	5.32
718.05	339.4	-0.64	1,516	1,489	4.47	4.39	-0.08	1,729	5.09
718.06	411.7	-1.55	2,045	1,997	4.97	4.85	-0.12	508	1.23
719.01	1,032.9	0.16	1,945	2,268	1.88	2.2	0.31	4,357	4.22
719.02	1,503.3	-0.11	2,181	2,338	1.45	1.56	0.1	1,227	0.82
720	727.6	-1.23	2,365	2,236	3.25	3.07	-0.18	635	0.87
721.05	1,151.6	-0.16	1,591	1,977	1.38	1.72	0.34	2,661	2.31
721.06	855.2	0.77	2,614	3,035	3.06	3.55	0.49	1,682	1.97
721.07	1,178.2	0.08	1,583	1,759	1.34	1.49	0.15		
721.08	794.3	-0.38	2,109	2,180	2.66	2.74	0.09	377	0.47
721.09	1,085.2	0.18	1,458	1,674	1.34	1.54	0.2	482	0.44
721.11	485.2	1.08	796	1,059	1.64	2.18	0.54	103	0.21
721.12	582.0	-0.29	1,834	2,029	3.15	3.49	0.34	283	0.49
723.05	998.8	0.07	2,447	2,608	2.45	2.61	0.16	1,137	1.14
723.06	1,225.9	2.44	2,479	3,796	2.02	3.1	1.07	1,024	0.84
723.07	475.0	-0.03	1,899	1,978	4	4.16	0.17	477	1
723.08	1,971.3	0.74	2,269	2,935	1.15	1.49	0.34	909	0.46
723.09	857.4	1.17	2,132	2,660	2.49	3.1	0.62	291	0.34
723.1	515.3	1.1	1,302	1,660	2.53	3.22	0.69	1,159	2.25
723.11	602.9	0	1,945	1,986	3.23	3.29	0.07	2,420	4.01
724.05	3,116.4	0.29	1,252	1,652	0.4	0.53	0.13	373	0.12
724.06	4,146.3	0.5	1,145	2,065	0.28	0.5	0.22	511	0.12
724.07	1,390.6	1.2	1,287	2,123	0.93	1.53	0.6	1,956	1.41
724.08	3,817.6	0.49	1,488	2,373	0.39	0.62	0.23	2,857	0.75
724.09	1,463.4	0.48	676	1,010	0.46	0.69	0.23	180	0.12
724.1	3,473.9	0.41	866	1,387	0.25	0.4	0.15	122	0.04
725.03	4,226.2	0.27	1,123	1,639	0.27	0.39	0.12	403	0.1
725.04	3,792.3	0.43	1,007	1,465	0.27	0.39	0.12	1,287	0.34
725.05	5,329.6	0.61	1,361	2,751	0.26	0.52	0.26	1,938	0.36
725.06	3,769.0	0.31	837	1,409	0.22	0.37	0.15	92	0.02
725.07	1,055.8	0.34	1,195	1,491	1.13	1.41	0.28	2,336	2.21

Table 16 continued

726.01	11,081.4	0.2	1,264	2,070	0.11	0.19	0.07	200	0.02
726.02	10,540.4	0.13	1,428	2,033	0.14	0.19	0.06	396	0.04
726.03	18,534.6	0.14	1,552	2,769	0.08	0.15	0.07	236	0.01
727	4,528.6	0.06	56	31	0.01	0.01	-0.01		
728	4,258.9	1.09	267	2,179	0.06	0.51	0.45	2,479	0.58
729.01	4,498.9	-0.28	967	1,014	0.21	0.23	0.01	1,801	0.4
729.03	6,472.1	-0.07	518	567	0.08	0.09	0.01	1,530	0.24
729.04	62,428.7	-0.01	3,016	3,111	0.05	0.05	0	7,772	0.12
730.01	16,058.2	0.16	1,281	2,275	0.08	0.14	0.06	371	0.02
730.05	13,254.6	0.17	1,174	2,041	0.09	0.15	0.07	202	0.02
730.06	29,724.8	0.06	680	1,390	0.02	0.05	0.02	622	0.02
731.07	1,506.9	2.69	1,249	2,787	0.83	1.85	1.02	1,938	1.29
731.08	2,466.3	1.44	1,004	2,393	0.41	0.97	0.56	1,623	0.66
731.09	2,800.2	3.44	1,129	4,558	0.4	1.63	1.22	908	0.32
731.1	1,432.3	0.45	995	1,381	0.69	0.96	0.27	439	0.31
731.11	935.3	0.39	1,063	1,465	1.14	1.57	0.43	446	0.48
731.12	3,596.0	1.67	535	2,807	0.15	0.78	0.63	1,575	0.44
731.13	4,591.9	0.98	485	2,012	0.11	0.44	0.33	540	0.12
731.14	1,712.3	1.62	1,103	1,991	0.64	1.16	0.52	361	0.21
731.15	1,726.2	0.92	924	1,565	0.54	0.91	0.37	348	0.2
731.16	4,022.7	0.31	696	1,210	0.17	0.3	0.13	361	0.09
731.17	12,216.1	0.12	811	1,397	0.07	0.11	0.05	274	0.02
731.18	7,760.1	0.23	953	1,730	0.12	0.22	0.1	193	0.02
731.19	24,133.1	0.05	807	1,365	0.03	0.06	0.02	259	0.01
732	138,125.9	0.02	1,793	2,806	0.01	0.02	0.01	1,300	0.01
733.01	978.6	0.81	1,731	2,151	1.77	2.2	0.43	4,210	4.3
733.02	733.9	1.11	1,349	1,756	1.84	2.39	0.55	1,041	1.42
734.01	1,838.2	1.64	2,136	3,499	1.16	1.9	0.74	5,992	3.26
734.03	1,264.7	0.52	3,105	3,455	2.46	2.73	0.28	3,659	2.89
734.04	1,559.1	0.32	2,407	2,614	1.54	1.68	0.13	1,623	1.04
801.01	556.9	0.6	961	1,177	1.73	2.11	0.39	270	0.48
801.02	578.5	1.07	1,639	1,907	2.83	3.3	0.46	1,253	2.17
802	615.0	-0.49	1,453	1,513	2.36	2.46	0.1	1,571	2.55
803	411.0	-3.35	1,944	1,649	4.73	4.01	-0.72	3,557	8.65
804	698.9	0.25	1,556	1,754	2.23	2.51	0.28	327	0.47
805	260.4	-0.41	1,595	1,543	6.13	5.93	-0.2	2,603	10
806	592.9	-0.21	2,267	2,298	3.82	3.88	0.05	1,280	2.16
807	906.4	0.07	1,455	1,620	1.61	1.79	0.18	924	1.02
808	237.9	-1.34	670	769	2.82	3.23	0.42		
809	3,373.6	0.2	1,645	2,079	0.49	0.62	0.13	3,059	0.91

Table 16 continued

810	737.3	-0.04	2,102	2,274	2.85	3.08	0.23	1,644	2.23
811	367.6	-1.31	1,447	1,231	3.94	3.35	-0.59	2,015	5.48
812	214.8	-0.58	1,426	1,467	6.64	6.83	0.19	324	1.51
814	370.3	-5.49	72	42	0.19	0.11	-0.08	9,928	26.81
901.01	12,146.4	0.17	1,561	2,551	0.13	0.21	0.08	1,009	0.08
901.02	12,654.2	0.16	1,519	2,494	0.12	0.2	0.08	1,377	0.11
902	17,538.4	0.19	2,080	3,473	0.12	0.2	0.08	2,146	0.12
903	7,108.2	0.38	800	1,319	0.11	0.19	0.07	4,158	0.58
904	5,553.4	0.18	1,216	1,704	0.22	0.31	0.09	833	0.15
905	3,186.0	0.82	2,446	3,472	0.77	1.09	0.32	5,655	1.77
906.01	7,031.6	0.19	1,891	2,560	0.27	0.36	0.1	1,469	0.21
906.02	3,297.7	0.51	796	1,459	0.24	0.44	0.2		
907	4,270.3	0.28	1,544	2,047	0.36	0.48	0.12	657	0.15
908	4,724.8	0.32	1,046	1,664	0.22	0.35	0.13	762	0.16
909	1,964.7	1.13	2,035	3,082	1.04	1.57	0.53	4,172	2.12
910	7,294.4	0.22	1,991	2,650	0.27	0.36	0.09	642	0.09
911	5,041.3	0.23	1,409	1,950	0.28	0.39	0.11	1,723	0.34
912.01	1,432.7	0.55	1,138	1,546	0.79	1.08	0.28	7,793	5.44
912.03	1,426.5	5.07	244	3,088	0.17	2.16	1.99	472	0.33
912.04	1,005.3	-1.56	2,041	1,411	2.03	1.4	-0.63	2,305	2.29
913.01	8,557.4	0.19	1,000	1,677	0.12	0.2	0.08	293	0.03
913.02	8,530.2	0.22	1,250	2,044	0.15	0.24	0.09	520	0.06
914	2,034.9	0.03	1,170	1,358	0.57	0.67	0.09	223	0.11
915	1,272.3	0.04	1,198	1,394	0.94	1.1	0.15	474	0.37
916	1,264.4	1.02	1,824	2,691	1.44	2.13	0.69	975	0.77
917	1,864.2	0.43	2,200	2,797	1.18	1.5	0.32	443	0.24
918	1,652.1	-0.16	1,211	1,264	0.73	0.77	0.03	1,416	0.86
919	978.9	1.34	995	1,587	1.02	1.62	0.6	1,680	1.72
920	47,768.9	0.04	1,337	2,171	0.03	0.05	0.02	235	0
921	17,307.4	0.11	1,426	2,258	0.08	0.13	0.05	2,358	0.14
922	1,380.5	1.82	1,722	2,709	1.25	1.96	0.71	2,447	1.77
923	1,832.0	0.28	1,741	2,176	0.95	1.19	0.24	2,490	1.36
924	1,507.4	-0.02	2,278	2,545	1.51	1.69	0.18	774	0.51
925	3,065.8	0.44	1,577	2,254	0.51	0.74	0.22	1,867	0.61
926	3,022.5	0.41	1,666	2,425	0.55	0.8	0.25	327	0.11
927	10,594.4	0.22	2,036	3,067	0.19	0.29	0.1	487	0.05
928.01	2,947.5	0.44	1,093	1,683	0.37	0.57	0.2	1,017	0.35
928.02	6,690.2	0.27	879	1,553	0.13	0.23	0.1	363	0.05
928.03	4,501.2	0.17	798	1,136	0.18	0.25	0.08	119	0.03
929.01	17,412.0	0.12	1,242	2,116	0.07	0.12	0.05	207	0.01

Table 16 continued

929.02	6,718.9	0.18	1,407	1,938	0.21	0.29	0.08	365	0.05

BIBLIOGRAPHY

1990 data to 2000 areas weighting methodology. (n.d.). Retrieved September 9, 2012, from http://www.geolytics.com/Pages/CensusCD708090/WeightingMethodology.htm

2001 Community Profiles. (n.d.). Retrieved September 9, 2012, from http://www12.statcan.ca/english/profil01/CP01/Details/Page.cfm?Lang=E&Geo1=CSD&Code1=5915022&Geo2=PR&Code2=59&Data=Count&SearchText=van&SearchType=Begins&SearchPR=01&B1=All&Custom=

Alberti, M. (1999). Urban Patterns and Environmental Performance: What Do We Know? *Journal of Planning Education and Research*, *19*(2), 151–163. doi:10.1177/0739456X9901900205

Atlanta Regional Commission. (n.d.). *2011 Livable Centers Initiative Implementation Report*.

Bhat, C. R., & Eluru, N. (2009). A copula-based approach to accommodate residential self-selection effects in travel behavior modeling. *Transportation Research Part B: Methodological*, *43*(7), 749–765.

Bicknell, L. (2007, January 22).

Boer, R., Zheng, Y., Overton, A., Ridgeway, G. K., & Cohen, D. A. (2007). Neighborhood design and walking trips in ten US metropolitan areas. *American journal of preventive medicine*, *32*(4), 298–304.

Brewster, D. (1999, October 29). This Family Feud We Call Seattle's Gestural Politics. *Seattle Times*.

Calthorpe, P., & Fulton, W. (2001). *The Regional City* (1st ed.). Island Press.

Cambridge Systematics. (2007). *PSRC 2006 Household Activity Survey Analysis Report*.

Cao, X. (Jason), Mokhtarian, P. L., & Handy, S. (2009). Examining the impacts of residential self-selection on travel behaviour: A focus on empirical findings. *Transport Reviews*, *29*(3), 359–395.

Census Bureau Homepage. (n.d.). Retrieved September 9, 2012, from http://www.census.gov/

Center for Climate and Energy Solutions. (2011). *Climate Change 101: State Action*.

Center for Climate and Energy Solutions. (n.d.). VMT-Related Policies and Incentives. Retrieved September 6, 2012, from http://www.c2es.org/us-states-regions/policy-maps/vehicle-miles-traveled

Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: density, diversity, and design. *Transportation Research Part D: Transport and Environment*, *2*(3), 199–219.

Cervero, R., & Murakami, J. (2010). Effects of built environments on vehicle miles traveled: evidence from 370 US urbanized areas. *Environment and Planning A*, *42*(2), 400–418.

Chatman, D. G. (2003). How density and mixed uses at the workplace affect personal commercial travel and commute mode choice. *Transportation Research Record: Journal of the Transportation Research Board*, *1831*(-1), 193–201.

Chung, E., Ohtani, O., Warita, H., Kuwahara, M., & Morita, H. (2005). Effect of rain on travel demand and traffic accidents. *2005 IEEE Intelligent Transportation Systems, 2005. Proceedings* (pp. 1080 – 1083). Presented at the 2005 IEEE Intelligent Transportation Systems, 2005. Proceedings. doi:10.1109/ITSC.2005.1520201

City of Seattle. (2012). Seattle's Comprehensive Plan: Toward a Sustainable Seattle.

Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, National Research Council. (2009). *Driving and the Built Environment:The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions -- Special Report 298*. Washington, D.C.: The National Academies Press.

Crane, R. (2000). The influence of urban form on travel: an interpretive review. *Journal of Planning Literature*, *15*(1), 3–23.

ESRI. (2007). *ESRI Data & Maps 2006*.

ESRI. (n.d.). ArcGIS - Mapping and Spatial Analysis for Understanding Our World. Retrieved September 10, 2012, from http://www.esri.com/software/arcgis

Ewing, R., & Cervero, R. (2001). Travel and the built environment: a synthesis. *Transportation Research Record: Journal of the Transportation Research Board*, *1780*(-1), 87–114.

Ewing, R., & Cervero, R. (2010). Travel and the built environment. *Journal of the American Planning Association*, *76*(3), 265–294.

Ewing, R., DeAnna, M. B., & Li, S. C. (1996). Land use impacts on trip generation rates. *Transportation Research Record: Journal of the Transportation Research Board*, *1518*(-1), 1–6.

Ewing, R., Nelson, A. C., Bartholomew, K., Emmi, P., & Appleyard, B. (2011). Response to Special Report 298 Driving and the built environment: the effects of compact development on motorized travel, energy use, and CO2 emissions. *Journal of Urbanism*, *4*(1), 1–5.

Ewing, Reid, Bartholomew, K., Winkelman, S., Walters, J., & Chen, D. (2008). *Growing Cooler: The Evidence on Urban Development and Climate Change*. Urban Land Institute.

Executive Order No. G-11-024 Attachment 4. (2011, February 15). State of California Air Resources Board.

Frank, L. D., & Engelke, P. (2005). Multiple impacts of the built environment on public health: Walkable places and the exposure to air pollution. *International Regional Science Review*, *28*(2), 193–216.

GeoLytics Inc. (n.d.). *CensusCD 1990 Long Form in 2000 Boundaries*.

Gilmore Research Group. (1990). *1989 Travel-Diary Recruitment for the Puget Sound Transportation Panel: Methodology and Sample Report*.

H.B. 2815, Pub. L. No. H.B. 2815 (2008).

Handy, S. (1993). Regional versus local accessibility: Implications for nonwork travel. *Transportation research record*, 58–58.

Handy, S. (2005a). Critical assessment of the literature on the relationships among transportation, land use, and physical activity. *Department of Environmental Science and Policy, University of California, Davis. Prepared for the Committee on Physical Activity, Health, Transportation, and Land Use. Washington: Transportation Research Board*. Retrieved from http://onlinepubs.trb.org/onlinepubs/archive/downloads/sr282papers/sr282handy.pdf

Handy, S. (2005b). Smart growth and the transportation-land use connection: What does the research tell us? *International Regional Science Review*, *28*(2), 146–167.

Handy, S., Cao, X., & Mokhtarian, P. (2005). Correlation or causality between the built environment and travel behavior? Evidence from Northern California. *Transportation Research Part D: Transport and Environment*, *10*(6), 427–444.

Handy, Susan, Weston, L., & Mokhtarian, P. L. (2005). Driving by choice or necessity? *Transportation Research Part A: Policy and Practice*, *39*(2–3), 183–203. doi:10.1016/j.tra.2004.09.002

Hinshaw, M. L. (1999). *Citistate Seattle: Shaping a Modern Metropolis*. American Planning Association (Planners Press).

Holtzclaw, J., Clear, R., Dittmar, H., Goldstein, D., & Haas, P. (2002). Location efficiency: neighborhood and socio-economic characteristics determine auto ownership and use-studies in Chicago, Los Angeles and San Francisco. *Transportation Planning and Technology*, *25*(1), 1–27.

IBM. (n.d.). IBM SPSS Statistics. Retrieved September 10, 2012, from http://www-01.ibm.com/software/analytics/spss/products/statistics/

Iowa Department of Transportation. (2004). *Iowa Department of Transportation Strategic Plan*.

Keene, L., & Nelson, R. T. (1997, April 11). Rice Leaving Mark as Mayor. *Seattle Times*.

Kim, S. (2007). Changes in the Nature of Urban Spatial Structure in the United States, 1890-2000. *Journal of Regional Science*, *47*(2), 273–287.

Kitamura, R., Mokhtarian, P. L., & Laidet, L. (1997). A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area. *Transportation*, *24*(2), 125–158.

Kockelman, K. M. (1997). Travel behavior as function of accessibility, land use mixing, and land use balance: evidence from San Francisco Bay Area. *Transportation Research Record: Journal of the Transportation Research Board*, *1607*(-1), 116–125.

Kostyniuk, L. P., & Kitamura, R. (1986). House Lifecycle: Predictor of travel expenditure. Presented at the Behavioural Research for Transport Policy. Retrieved from http://trid.trb.org/view.aspx?id=651168

Krizek, K. J. (2003). Residential relocation and changes in urban travel: Does neighborhood-scale urban form matter? *Journal of the American Planning Association*, *69*(3), 265–281.

Kuzmyak, J. R., Baber, C., & Savory, D. (2006). Use of walk opportunities index to quantify local accessibility. *Transportation Research Record: Journal of the Transportation Research Board*, *1977*(-1), 145–153.

Kuzmyak, J. R., Pratt, R. H., Douglas, G. B., & Spielberg, F. (2003). Land Use and Site Design-Traveler Response to Transportation System Changes. Retrieved from http://www.worldtransitresearch.info/research/3057/

Kuzmyak, J. Richard. (2012). *Land Use and Traffic Congestion* (No. SPR 618). Phoenix, Arizona: Arizona Department of Transportation.

Lawrence, G. (2005, October 10).

Leinberger, C., & Alphonso, M. (2012). *Walk this Way: The Economic Promise of Walkable Places in Metropolitan Washington, D.C.* Brookings Institution.

Levine, J., & Frank, L. D. (2007). Transportation and land-use preferences and residents' neighborhood choices: The sufficiency of compact development in the Atlanta region. *Transportation*, *34*(2), 255–274.

Levine, J., Inam, A., & Torng, G. W. (2005). A Choice-Based Rationale for Land Use and Transportation Alternatives Evidence from Boston and Atlanta. *Journal of Planning Education and Research*, *24*(3), 317–330.

Licata, N. (2005, September 21).

Litman, T. (2010). Are Vehicle Travel Reduction Targets Justified? Evaluating Mobility Management Policy Objectives Such As Targets To Reduce VMT And Increase Use Of Alternative Modes. Retrieved from http://trid.trb.org/view.aspx?id=906977

McMullen, B. S., & Eckstein, N. (2011). The Relationship Between VMT and Economic Activity. Retrieved from http://trid.trb.org/view.aspx?id=1127465

Meyer, M., & Miller, E. J. (2001). *Urban Transport Plan* (2nd ed.). Mcgraw Hill Higher Education.

Millard-Ball, A., & Schipper, L. (2011). Are We Reaching Peak Travel? Trends in Passenger Transport in Eight Industrialized Countries. *Transport Reviews*, *31*(3), 357–378. doi:10.1080/01441647.2010.518291

Nelson, A. C. (2004). *Toward a new metropolis: The opportunity to rebuild America*. Brookings Institution Washington, DC. Retrieved from http://marketstreet.sitewrench.com/assets/1024/brookings_housing_report.pdf

Nelson, A. C. (2006). Leadership in a New Era: Comment on "Planning Leadership in a New Era." *Journal of the American Planning Association*, *72*(4), 393–409.

Newman, P., & Kenworthy, J. (2006). Urban design to reduce automobile dependence. *Opolis*, *2*(1). Retrieved from http://escholarship.org/uc/item/2b76f089.pdf

Newman, Peter, & Kenworthy, J. (1999). *Sustainability and Cities: Overcoming Automobile Dependence* (1st ed.). Island Press.

Newman, Peter, & Kenworthy, J. (2011). "Peak Car Use": Understanding the Demise of Automobile Dependence. *World Transport Policy & Practice*, *17*(2). Retrieved from http://trid.trb.org/view.aspx?id=1106687

Office of Corporate Communications Operations, Projects & Corporate Services. (2007). *Sound Transit History and Chronology*. Sound Transit.

Oregon Sustainable Transportation Initiative (OSTI). (n.d.).*Oregon.gov*. Retrieved September 3, 2012, from http://cms.oregon.gov/ODOT/TD/OSTI/pages/targets.aspx

Pisarski, A. (2009). The Nexus of Energy, Environment and the Economy: A Win, Win, Win Opportunity. *ITE Journal*, *79*(1). Retrieved from http://trid.trb.org/view.aspx?id=884547

Pitkin, J., & Myers, D. (2008). US housing trends: Generational changes and the outlook to 2050. *Transportation Research Board*, 4.

Polzin, S. (2006). *The Case for Moderate Growth in Vehicle Miles of Travel: A Critical Juncture in U.S. Travel Behavior Trends*. Center for Urban Transportation Research, University of South Florida. Retrieved from http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCIQFjAA&url=http%3A%2F%2Fwww.cutr.usf.edu%2Fpdf%2FThe%2520Case%2520for%2520Moderate%2520Growth%2520in%2520VMT-%25202006%2520Final.pdf&ei=aBxEUJPwF9SpqQHZsoDgBg&usg=AFQjCNGPaK8xqEMZ0MvTlhjEawNVLiC0bw&sig2=bi7U4-h_U3Xlg4xiqTVv-A

Population and Housing Estimates. (n.d.). Retrieved September 9, 2012, from http://psrc.org/data/pophousing/pophousing-estimates

Puentes, R., & Tomer, A. (2008). The Road…Less Traveled: An Analysis of Vehicle Miles Traveled Trends in the U.S. Retrieved from http://trid.trb.org/view.aspx?id=884014

Puget Sound Regional Council. (2007). *Population, Household and Housing Estimates*.

Puget Sound Regional Council. (2009). *From Vision 2020 to Vision 2040: A Report on the Update Process*.

Puget Sound Regional Council. (2012). *Transportation 2040 Prioritization Measures*.

Puget Sound Regional Council. (n.d.-a). *2006 Covered Employment Estimates*. Puget Sound Regional Council.

Puget Sound Regional Council. (n.d.-b). PSRC Surveys. Retrieved September 10, 2012, from http://psrc.org/data/surveys

Puget Sound Regional Council. (n.d.-c). *Power Washington Final Report: Puget Sound Transportation Panel and Decision Data*.

Puget Sound Regional Council. (n.d.-d). *2006 Activity Survey Codebook*.

Puget Sound Regional Council. (n.d.-e). GIS and Maps. Retrieved September 10, 2012, from http://www.psrc.org/data/gis

R. L. Polk & Co. (2012, January 17). Average Age of Vehicles Reaches Record High, According to Polk. Retrieved September 10, 2012, from https://www.polk.com/company/news/average_age_of_vehicles_reaches_record_high_according_to_polk

Regional Growth Centers. (n.d.). Retrieved September 9, 2012, from http://psrc.org/growth/centers

ReSHB 1025 (1991).

Ruder, K. (2006, October 23).

S.B. 1059, Pub. L. No. S.B. 1059 (2010).

S.B. 375, Pub. L. No. S.B. 375 (2008).

Seattle Department of Design, Construction, and Land Use. (2003). *Urban Village Case Studies*. City of Seattle.

Seattle Streetcar. (n.d.). The Seattle Streetcar Network. Retrieved September 9, 2012, from http://www.seattlestreetcar.org/network.htm

SHB 2929 (1990).

Skelton, J. (2007, January 22).

Sound Transit. (2009, July 18). Link light rail launches new era of mobility for central Puget Sound. Retrieved September 9, 2012, from http://www.soundtransit.org/About-Sound-Transit/News-and-events/News-releases/News-release-archive/LinkInService.xml

State Smart Transportation Initiative. (n.d.). Land Use and Transportation Scenario Analysis and Microsimulation (LUTSAM) Tool. Retrieved September 9, 2012, from http://www.ssti.us/2012/06/lutsam/

Tu, C. C., & Eppli, M. J. (1999). Valuing new urbanism: The case of Kentlands. *Real Estate Economics*, *27*(3), 425–451.

U.S. Census Bureau. (n.d.). Historical Statistics - The 2012 Statistical Abstract. Retrieved September 3, 2012, from http://www.census.gov/compendia/statab/hist_stats.html

U.S. Department of Housing and Urban Development. (n.d.). HUD Estimated Median Family Incomes in Region X. Retrieved September 10, 2012, from http://www.hud.gov/local/shared/working/r10/emas/medianinc.cfm?state=wa

U.S. Federal Highway Administration. (n.d.). Travel Volume Trends. Retrieved from http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

US Census Bureau, C. H. S. (n.d.). Metropolitan Areas - History - U.S. Census Bureau. Retrieved September 6, 2012, from http://www.census.gov/history/www/programs/geography/metropolitan_areas.html

US Census Bureau Geography Division. (n.d.). 2010 Urban Area FAQs. Retrieved September 6, 2012, from http://www.census.gov/geo/www/ua/uafaq.html

US Department of Transportation. (2010). *Transportation's Role in Reducing Greenhouse Gas Emissions: Volume 1: Synthesis Report*.

Van De Coevering, P., & Schwanen, T. (2006). Re-evaluating the impact of urban form on travel patternsin Europe and North-America. *Transport policy*, *13*(3), 229–239.

Vancouver Engineering Services/Strategic Transportation Planning. (n.d.). *City of Vancouver Transportation Plan Progress Report*.

VMT per capita in King County. (n.d.). Retrieved September 9, 2012, from http://www.kingcounty.gov/exec/PSB/BenchmarkProgram/Environment/EN12_VMT/VMTTable.aspx

Wisconsisn Governor's Task Force on Global Warming, Wisconsin Dept. of Natural Resources, & Public Service Commission of Wisconsin. (2008). Wisconsin's strategy for reducing global warming final report to Governor Jim Doyle. Retrieved September 3, 2012, from http://psc.wi.gov/initiatives/globalWarming/index-globalWarming.htm

Wooldridge, J. (2002). *Introductory Econometrics: A Modern Approach* (2nd ed.). South-Western College Pub.

Zegras, C. (2010). The built environment and motor vehicle ownership and use: Evidence from Santiago de Chile. *Urban Studies*, *47*(8), 1793–1817.

Zhou, B. B., & Kockelman, K. M. (2008). Self-selection in home choice: Use of treatment effects in evaluating relationship between built environment and travel behavior. *Transportation Research Record: Journal of the Transportation Research Board*, *2077*(-1), 54–61.