Determinants of Automobile Use: A Comparison of Germany and the U.S.

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Abstract

Germany and the U.S. have among the highest motorization rates in the world. Yet Americans make a 40% higher share of their trips by car and annually drive twice as many kilometers per capita as Germans. Automobile use is linked to unsustainable trends such as climate change, oil dependence, traffic fatalities, congestion, and obesity. International differences in car use can be attributed to socioeconomic and demographic factors, spatial development patterns, transport policies and culture. Arguably, differences in socio-economic and demographic factors together with denser, more compact spatial development patterns, and more automobile restrictive transport policies in Germany can help explain less car use there. Using two comparable individual level national travel surveys this paper empirically investigates the role of socio-economic and demographic factors, spatial development patterns and transport policies in explaining differences in automobile use in Germany and the U.S.

In both countries higher population density, a greater mix of land uses, household proximity to a transit stop, fewer cars per household, and higher car operating costs are associated with shorter daily automobile travel distances. However, considerable differences remain: for example Americans in settlements of more than 5,000 people per square kilometer drive as many kilometers as Germans in settlements with five times lower density. A multivariate analysis shows that—controlling for socioeconomic factors—population density and automobile operating costs play a role in explaining differences in travel. This is good news for the U.S., since denser more mixed-use developments and more automobile restrictive policies can help increase the sustainability of the transport system. In Germany, travel behavior is more homogeneous across all groups of society and in all spatial settlement patterns than in the U.S. This is potentially related to historically higher gasoline prices and greater availability of alternative means of transport, which provide incentives for walking, cycling, and transit use.

1. Increasing Motorization in Both Countries, But More Sustainable Transportation in Germany

Over the last 50 years Germany and the U.S. have displayed similar trends of increasing car ownership and use. In 2006, the U.S. had the highest and Germany the fourth highest car ownership rate in the world (IRF, 2007; OECD, 2003-2007). Mobility in Germany and the U.S. have developed on two different levels, however. In 2005, Americans owned 760 cars and light trucks per 1,0000 population compared to 560 in Germany (BMVBS, 1991-2008; FHWA, 1990-2008). Moreover, Americans drove about 24,000 kilometers in a car per year, compared to only 11,000 kilometers for Germans. Even residents in dense U.S. states such as New Jersey drove roughly 60% more kilometers per year than Germans (BTS, 2006). In 2001, Americans made 87% of all trips by automobile, compared to 61% for Germans. This difference also holds for urban areas: most German cities have a car modal share of up to 55%, compared to roughly 80% for work trips in most U.S. metropolitan areas (FHWA, 2003; Socialdata, 2006).

Automobile use is at the center of many unsustainable trends such as air pollution due to tail pipe emissions, oil dependence, traffic fatalities and injuries, traffic congestion, urban sprawl, loss of open space, and obesity due to sedentary life-styles (Pucher & Lefèvre, 1996; TRB, 2001; Vuchic, 1999). Dissimilar levels of car use have resulted in differences in the sustainability of the two countries' transportation systems. Even though both countries have mandated the use of advanced technology, Germany has been more successful in limiting negative externalities of car use—mainly by influencing travel behavior through more automobile restrictive transport policies.

First, in 2005 there were about half as many traffic deaths per 1,000 population in Germany than the U.S. (6.5 vs. 14.7) (IRTAD, 2008). Even adjusting for vehicle kilometers of car travel, Germany was safer: 7.8 compared to 9.0 deaths per one billion vehicle kilometers of car travel in the U.S. (IRTAD, 2008). Second, the percentage share of obese adults was twice as high in the U.S. as in Germany in 2006 (32 vs. 13% of the population over 15 years old) (OECD, 2003-2007). Driving less and cycling and walking more could help burn more calories during daily life and reduce obesity. Third, energy use of automobiles and light trucks is less efficient in the U.S. than in Germany: 2.7 Mega Joules of energy per passenger kilometer in the U.S. compared to 2.0 Mega Joules for Germany (DOE, 2007; ORNL, 2008; UBA, 2005). Fourth, over 30% of all CO_2 emissions in the U.S. and about 20% in Germany are caused by the transportation sectors (BMVBS, 1991-2008; ORNL, 2008). Lastly, American households spend roughly 19% of their disposable income on transportation, compared to only 14% for Germans. This difference is mainly driven by ownership and depreciation costs for multiple cars in U.S. households.

The paper proceeds as follows. In the next section a literature review identifies four groups of independent variables as explanatory factors for differences in car use and sustainable transport in Germany and the U.S. Most studies are either descriptive or aggregate level statistical analysis. All comparative multivariate studies rely on strong assumptions about the comparability of the data and most focus on socioeconomic factors, but fail to include variables describing spatial development patterns and transport policies. The data for this analysis originates from two uniquely comparable national travel surveys, which were enriched with data capturing spatial development patterns and proxies for transport policy. Subsequently, descriptive and bi-variate statistics for independent and dependent variables show that for all groups of society and at all spatial development patterns Americans are more car dependent than Germans. After that, a multivariate regression approach for explaining international differences in travel behavior is introduced. The analysis finds that spatial development patterns and transport policies play a role in explaining differences in travel behavior even after controlling for socioeconomic and demographic factors.

2. Determinants of Car Use in Europe and North America

Only eight descriptive studies, which were all published before 1999, explicitly compare travel behavior in Germany and the U.S. Thus the literature review was expanded to contain international comparative studies of Western European and North American countries in general, which were published after 1980. A review of 50 international comparative studies shows that differences and similarities in travel behavior within and across countries are mainly attributed to (1) transport and land-use policies, (2) demographic and socioeconomic factors, (3) spatial development patterns, and (4) cultural preferences (Buehler, 2008).

Roughly 70% of the studies reviewed are descriptive, 20% are multivariate analysis based on city or country wide averages, and only 10% of the studies rely on individual level data. Most international comparative studies are plagued by dissimilarity in data and methods or by the aggregate nature of available travel data. Generally, strong assumptions are made about the comparability of data, and travel behavior is compared on the city or country level. However, individuals—not cities or countries—make daily travel choices and therefore individual level analysis is most appropriate. While most descriptive studies point to the importance of transport policies and spatial development patterns, many multivariate studies focus on socioeconomic and demographic factors. More recently some individual level studies have emerged that attempt to include spatial development and transport policy variables.

Table 1 summarizes major characteristics of individual level comparative studies that compare European with North-American countries and include measures of urban form. The table excludes other descriptive, aggregate level, and non-international comparative studies. Using a sample of 20,000 individuals, Giuliano and Narayan (Giuliano & Narayan, 2003, 2006) estimate linear regression models to measure factors influencing trip distance and trip frequency. They find that socio-economic and urban form variables work in the same direction in the U.S. and the UK. For example, car ownership is positively related to travel distance and number of trips per day. Metropolitan size only has a small effect on trip distance and frequency. Higher residential densities are associated with shorter trip distances in the U.S., but not in the UK, where densities of all settlements were more homogeneous. Based on the same data Giuliano and Dargay (Giuliano & Dargay, 2005) employ a structural model to disentangle the connection of land use, car ownership and travel. They conclude that car ownership is correlated with population density as well as policy variables not directly measured in their model—such as the costs of operating and owning a car.

Three studies by Axhausen and colleagues (Axhausen, et al., 2002; Axhausen & Simma, 2001; Simma & Axhausen, 2003) compare transit and car use in Holland, Switzerland, England, Germany, and the U.S. Timing, methods, data, and geographic coverage vary across the travel surveys used for the study. To overcome these differences the researchers rely on strong assumptions concerning the comparability of their data and results. They use Structural Equation Modeling (SEM) to distinguish between *direct effects* of certain variables on travel and *indirect* *effect* via other variables. The study finds that the connection of socioeconomic factors and travel are stable across countries. The only variable related to spatial development patterns is an urban vs. rural distinction, which yields lower automobile ownership levels in cities compared to rural areas. Transit season ticket ownership, a variable measuring policy, is related to more transit use.

Timmermanns and colleagues (Timmermanns, et al., 2003) compare the relationship of urban spatial development patterns, access to transit and travel behavior across five regions in five different countries. None of their spatial context variables are significant in explaining differences in travel behavior. Even though not part of their analysis, they conclude that within a society "psychological principles" seem to be more important in explaining travel behavior than measurable characteristics included in their analysis.

Overall, socioeconomic and demographic factors have been well established as explanatory factors for international differences in travel behavior in the literature. Empirical evidence for the connection of spatial development patterns and travel in international comparative studies is less clear. These variables are very often omitted from multivariate models, or when included, result in mixed, inconsistent or unexpected results. Especially the limited comparability of data can drive the results. Transport and land-use policies are mentioned in most studies of travel behavior, but rarely explicitly tested in individual level international comparative multivariate studies. Cultural differences are difficult to measure, but many authors allude to cultural differences in shaping spatial development, policies, and travel. This study tries to overcome some of these shortcomings and can help to shed more light on the role of socio-economic and demographic factors, spatial development patterns and policies in determining travel behavior.

Two Uniquely Comparable National Travel Surveys

Two national travel surveys, the *National Household Travel Survey 2001 (NHTS)* for the U.S. and the *Mobility in Germany 2002 (MiD)*, are the main data sources for this comparison. Both surveys are based on similar data collection methods and contain comparable variables. Similarities and differences of the two surveys are summarized in Table 2. Cells shaded in grey indicate comparability between the two surveys; cells in white display remaining differences. These two surveys are the most comparable national travel surveys that currently exist. The data allow a detailed investigation of the role of socioeconomic factors, spatial development patterns, and policies to explain similarities and differences of individual travel behavior. Some variables for the analysis were readily available for comparison. Several other variables had to be added to the datasets, and others had to be transformed or generated for the purpose of this comparison. The next section introduces a general model for explaining international differences in travel behavior.

TABLES 1 AND 2 ABOUT HERE

3. A Multivariate Approach For Comparing International Differences in Automobile Use

Car use is at the center of many unsustainable trends described above. Variability in car use within and across countries can be explained by dissimilarities in socioeconomic and demographic variables, spatial development patterns, transportation policies, and cultural preferences. Equation 1 summarizes these factors in a general model for comparing similarities and differences in travel behavior.

[Equation (1): TB=f (SE, SD, TP, CP)]
TB=travel behavior, SE=socioeconomics and demographics, SD=spatial development patterns, TP= transportation policies, CP=cultural preferences

These explanatory factors might have a different impact in each country, contributing to a unique transportation system. This analysis (1) explores differences and similarities in car use within and between the countries and (2) evaluates the contribution of explanatory factors to explained variability within countries. The models are based on a pooled sample of 87,635 individuals from Germany and the U.S. The following sections briefly summarize general differences in transport policy, spatial development patterns, and socioeconomics between the countries. The focus is, however, on a description of policy differences, the introduction of proxy variables to measure policy differences, and variables measuring land use. Tables 3 and 4 describe the variables in the analysis in more detail (including socio-economic and demographic factors) and list level of measurement, descriptive statistics, and data sources.

Transport Policies

Policies and institutions in the U.S. contribute to making car use cheaper, easier, and more common than in Germany. In contrast to Germany, all levels of government in the U.S. have prioritized funding for highways over all other modes of transportation. In 2005, for example, revenues from roadway user taxes and fees in Germany were 2.6 times larger than roadway expenditures by all levels of government, compared to net subsidies for roadways in the U.S. (BMVBS, 1991-2008; FHWA, 1990-2008). The retail price of gasoline is about twice as high in Germany than the U.S. Roughly 65% of the gasoline retail price in Germany is taxes compared to only 15% in the U.S. (EIA., 2008; IEA, 2008). Moreover, since the 1960s most German municipalities promote non-automobile travel and impose restrictions on driving, thus making car travel in cities slower and less attractive (Hass-Klau, 1993; Pucher & Buehler, 2008; Pucher & Lefèvre, 1996). In 2002, average car travel speeds in the U.S. were 25 percent faster than in Germany (41 vs. 33 km/h). Moreover, Germany has a longer history of subsidies for transit, walking and cycling, which has helped making those modes of transport a feasible alternative to the car. Even though total subsidies for transit are higher in Germany, the use of government funds is more efficient there. In 2002, for example, government subsidies comprised 35 percent of the operating budgets for public transit systems in Germany, but a full 60 percent of public transit operating budgets in the U.S. (APTA, 2006; Rönnau, 2004; Rönnau, Schalläböck, Wolf, & Hüsing, 2002; VDV, 2005).

It is difficult to include policy variables in individual level multivariate analysis. In this analysis policy differences towards the automobile in Germany and the U.S. are captured with proxy variables measuring (1) automobile operating costs and (2) household distance from a transit stop. Car operating costs per kilometer are added to the datasets based on type of automobile, fuel efficiency and prices, assuming a 55% share of urban travel. In 2001, average automobile operating costs were U.S. 4.2 cents in America and 9.5 cents in Germany. Two nominal variables capture access to transit by comparing households within 400m and 400-

1000m from a transit stop to households more than 1000m away. In the U.S. 31% of households lived within 400m of transit compared to 53% in Germany—thus capturing the more homogeneous distribution of transit service there compared to the U.S.

TABLES 3 & 4 ABOUT HERE

Spatial Development Patterns

Over the last 50 years Germany and the U.S. both experienced increasing suburbanization and decreasing population densities. However, the density of German settlements is two and a half to three times greater than that of their U.S. counterparts (Kenworthy & Laube, 2001). The difference in settlement densities of inner and outer suburbs between Germany and the U.S. are particularly pronounced (Buehler, 2008; Kenworthy & Laube, 2001; Stein, Wolf, & Hesse, 2005).

In Germany land-use policies are much stricter than in the U.S. making new developments outside of already built-up areas difficult, allowing more mixed use and thus limiting urban sprawl (Buehler, 2008; Hirt, 2007; Schmidt & Buehler, 2007). Moreover, the German spatial planning system prescribes coordination of transportation planning and land-use planning (BMVBS, 2008; Köhler, 1995; TRB, 2001). Local, regional and state spatial plans have to take transportation plans into account and vice versa. This integration of planning potentially allows aligning planning goals and minimizes adverse impacts.

For this analysis, population density and mix of residences and workplaces were added to the datasets and capture differences in spatial development patterns. In this particular sample population densities in Germany—measured as population over built-up area—are two and a half times higher than in the U.S. The distribution of the population density variable for Germany is much more homogeneous than that for the U.S., where densities vary from the rural Mid-West to downtown Manhattan, NY. Mix of land uses is measured as a variable ranging from zero to one. A value of one indicates a balanced mix of households and work places, while a zero stands for almost no mix of work and residential uses. The mean of both countries' distributions are relatively close together (0.31 vs. 0.34). This is unexpected, as Germany is thought to have more mixed-use than the U.S. (Hirt, 2007). A closer look reveals that the German distribution is more homogeneous than the U.S. distribution. The U.S. median for mix of uses was 22% lower than the mean and 30% lower than the median for Germany. Moreover, this quantitative measure does not capture the quality of the mix of use. There is no information available that would show if skill levels of residents match with jobs available in the area. This additional information would be useful, but was not available from the enriched datasets.

Bivariate analysis shows that higher population density and a greater land use integration of workplaces and housing reduce car use in both countries. However, Americans in any spatial setting are more car-dependent than Germans. For example, at any population density category Americans drive between 60 and 80% more kilometers per day (Figure 1). Americans who live in the highest population density category at over 5,000 people per km^2 only drive slightly fewer km per day than Germans in the lowest population density category at less than 1000 people per km^2. Similarly, Americans living in areas with a high mix of residences and workplaces drive more kilometers per day than Germans in areas with less mix. Some readers might assume that trip distance could help explain the difference in car use. Indeed, in Germany 34% of all trips were shorter than one mile and 54% of trips were shorter than two miles, compared to only 27%

(<1 mile) and 39% (<2 miles) in the U.S. But in the U.S. 67% of trips shorter than one mile and 90% of trips shorter than 2 miles were made by car compared to 27 and 61% in Germany.

FIGURE 1 ABOUT HERE

Socioeconomic and Demographic Factors

Variables controlling for socioeconomic and demographic factors are: household income, cars per household driver, age, gender, family life cycle status, and an indicator if the respondent has a driver's license. Bivariate analysis finds that in both countries higher incomes, more cars per household driver, and employment are related to more car travel. For all variables analyzed here, however, Americans are far more car-dependent than Germans. In many cases the most car-dependent group of society in Germany uses the automobile less than the least car-oriented group in the U.S. For example, higher income households drive more than poorer households; however households in the highest German income quartile drive fewer kilometers than American households in the lowest income quartile.

4. Results of the Models

Results of two sets of models are presented in Table 5. Both sets are based on a pooled sample including Germans and Americans. The first set of models investigates the importance of socioeconomic and demographic variables, spatial development patterns, and transport policies in explaining differences in travel behavior in the pooled sample. The second set uses *interaction effects* for Germany to determine the sign, magnitude and statistical significance of differences in coefficients between the two countries. Details of the two models are introduced in the respective sections below.

Combined Models

For the first three models, groups of independent variables are entered one after the other. All variables measuring spatial development patterns and proxies for transport policies are included in Model 1. Socioeconomic and demographic factors are added in Model 2; and the country dummy variable is added in Model 3. This allows controlling for changes in total variability explained (adjusted R^2) for different groups of independent variables. Proxies for transport policies and spatial development patterns reach an adjusted R^2 of 0.10. Once socioeconomic and demographic factors are included the adjusted R^2 increases to 0.17. Adding the country dummy does not significantly increase the percentage of variability explained. This method also identifies omitted variables bias through changing signs and magnitudes of coefficients across the different models. For example, the coefficient for operating cost per kilometer of car use drops significantly once the country dummy variable is included—indicating that the cost variable had picked-up other differences between Germany and the U.S. in Models 1 and 2.

The sequence of entering the variable groups is chosen based on theoretical interest, and novelty of independent variables for multivariate international comparative research. This approach has one weakness however: the order of entering groups of variables influences changes in adjusted R^2. In order to identify the unique contribution of each group of independent variables three separate models are additionally estimated; each with just one group of independent variables. The results are as follows: adjusted R^2 is 0.12 for a model with socioeconomic and demographic variables alone; 0.10 for spatial development patterns and policy proxy variables alone, and 0.07 for the dummy variable alone. Moreover, the groups of independent variables were entered in all possible sequences to control for differences in adjusted R^2 due to the order of entering the variables. Comparing adjusted R^2 for the full, reduced and individual models allows interpreting the magnitude of variability explained by each group of variable independently. Socioeconomic and demographic variables explain between seven to 12% of total variability in travel behavior. Transportation policies and spatial development patterns explain between three and ten percent of the variability in the data. The dummy variable captures between one and seven percent of the variability. Overall, adjusted R^2 reaches 17%—which might seem low to some readers, but is common for models with individual level travel survey data.

F-statistics for all models indicate that the independent variables had joint statistical significance in explaining the dependent variable. The standard tests for multicoliniarity (Variance Inflation Factor, Tolerance, and Condition Index) yielded satisfactory results. The overall VIF was 2.23, well below the suggested the critical value of 5. The smallest tolerance value was 0.2, double the suggested critical value of 0.1. Another test, the condition index, confirms these results. Robust coefficients and errors were estimated to control for potential spatial autocorrelation.

Interaction Effects to Capture Country Specific Differences

Coefficients of the independent variables for Models 1-3 all point in the theoretically expected direction, but hide differences in sign, magnitude, and statistical significance within each country. Therefore, a second set of models is estimated to capture differences *between* the countries. Here for every independent variable one additional *interaction variable* for Germany is included in the analysis. Equation 2 displays a general model for explaining international similarities and differences in travel behavior with interaction effects:

[Equation (2): TB=f (SE, SE(G), SD, SD(G), TP, TP(G), CP)]
Definitions as above. (G)=interaction effect for Germany.

The coefficients of the independent variables are evaluated according to three criteria: (1) sign, (2) magnitude, (3) and statistical significance. First, the signs of the coefficients show if theories of travel demand hold true in both countries. If so, signs of coefficients should point in the same and expected direction in both countries. Second, the magnitude of the coefficients is expected to vary between the countries. Third, the statistical difference of coefficients in Germany and the U.S. indicates dissimilarities in travel behavior and transport system.

Results of the OLS model with interaction variables are presented in the last two columns of Table 5. Models with interaction effects are somewhat difficult to interpret since the *interaction effect has to be added* to the main effect of the variable. To avoid confusion and for the convenience of the reader the interaction coefficients of the OLS regression *have already been added* and can be read-off the table *directly*.

One joint coefficient for both countries indicates coefficients that were not statistically different between the countries. Two different coefficients—one for each country—indicate statistically significantly different effects in Germany and the U.S. For example: Living within 400m of a transit stop reduces daily car travel distance by 6.5km in the U.S., but only by 3.2km in Germany. Differences in car travel distance between individuals living close and farther away from a transit stop are less pronounced in Germany than in the U.S. Traditionally high gas prices and more possibilities for walking and cycling might encourage Germans at all distances from transit to economize their driving.

Moreover, a one cent increase in the operating cost per km of car use leads to a 2.4km reduction in car kilometers traveled in the U.S., compared to 0.3km in Germany. The magnitude of these coefficients is unexpected, as theory would suggest a more elastic demand in Germany given higher gasoline prices, better accessibility without a car, and greater availability of other modes of transportation there. On the other hand, it is possible that traditionally higher gas prices in Germany have led to economizing of driving. Thus changes in the gas price will have a smaller effect on driving in Germany than in the U.S., where cheap gasoline encourages more trips by car.

Furthermore, a 1,000 people per km^2 increase in population density reduces daily car travel distance by 2.7km in the U.S. and 1.8km in Germany. Similar to transit access, the difference in daily travel distance between low and high density areas is less pronounced in Germany than in the U.S. Again Germans might economize their driving at all population densities. Mix of land uses has a similar impact in both countries, however.

One additional automobile per household driver increases total daily car travel distance by 3.0km in the U.S., and by 10.1km in Germany. Thus car-ownership has a stronger impact on daily automobile travel distance in Germany. The majority of U.S. households own multiple cars (60%). Thus most household members have easy access to a car when they need one. In Germany, the majority of households only own one car (53%), thus forcing household members to use other modes of transport once the car is taken by another household member. The dummy variable for Germany indicates that Germans drive 37.7 fewer kilometers per day than Americans.

TABLE 5 ABOUT HERE

Improvements for Future Analysis

The unique comparability of the German MiD and the U.S. NHTS surveys constitutes an unprecedented opportunity for individual level international comparisons. However, some recommendations for improvements of future travel surveys and analyses can be made. Most suggestions pertain to (1) better and more comparable data about policies, the built environment, and personal preferences and (2) more comparable time series data.

First, cross-sectional data are useful in providing a glimpse into differences in travel in both countries at one point in time. However, to capture the impacts of variables like gasoline prices, transit access, income, car access or population density, observations would have to be measured over time—ideally by a panel study.

Second, endogeneity and self-selection bias are always problems for analyses of travel behavior. Endogeneity bias can occur (1) if independent variables are also a function of the dependent variable or (2) if independent variables are correlated with omitted variables (Cao, Mokhtarian, & Handy, 2006). Some researchers argue that the choice of household location and car ownership is associated with travel preferences and attitudes. Not including specific variables about attitudes and travel preferences could also lead to biased coefficients. Several solutions exist to address these problems, such as statistical control, instrumental variable, sample selection models, or joint models (Cao, et al., 2006). All of these approaches come with stringent requirements for comparability of variables and measurements in both countries and are hard to implement with just two cross-sectional surveys.

Lastly, more and better variables capturing transport policies could improve the analysis. For example information about transit supply at different transit stops, car parking availability and cost, length of bike networks, speed limits, and road supply could be connected to the two travel surveys. Unfortunately this data or geographic identifiers did not exist at a disaggregate level for both countries.

5. Conclusion

Two enriched individual level national travel surveys, the NHTS for the U.S. and the MiD for Germany provide a unique opportunity to compare differences in car use between the countries. The multivariate analysis shows that—even after controlling for socioeconomic and demographic factors—spatial development patterns and transport policies play a role in explaining international differences in travel behavior. This is good news for transportation policy makers and planners in the U.S., since denser more mixed use developments and more automobile restrictive policies can help increase the sustainability of the transport system. If differences were solely driven by socioeconomic factors fewer policy levers would be available to affect changes in travel behavior.

Transportation and economic theory would suggest that people with similar social and economic attributes in Germany and the U.S. should display similar travel behavior. For example, households with higher incomes are expected to own more cars and to drive more, or, households in denser areas are predicted to drive less often and for fewer kilometers. The analysis shows that these theoretical expectations hold true within each country, but they do not hold true across countries. Similar people in both countries do not have identical travel behavior. For some distributions of socioeconomic and demographic and spatial development variables, car use in the two countries does not even overlap. For example, the highest income quartile in Germany travels less by car than the lowest income quartile in the U.S. And Americans in the highest population density categories drive more kilometers by car than Germans in the lowest density category. In the U.S. all groups of society are more reliant on the automobile than their German counterparts. Theories in travel behavior are correct, but they must consider other contextual factors that influence travel behavior.

These contextual factors include transportation policies. The analysis shows that all groups of society in all spatial settlement patterns in Germany drive less than Americans. This may be related to historically higher gasoline prices and greater availability of alternative means of transport, which has lead Germans to diversify and economize their travel behavior already. Spiking gasoline prices and declining vehicle miles of car travel in the summer of 2008 might have been a first indicator for economizing of driving in America. Combined with increased availability of transit service and better accessibility via walking and cycling facilities, Americans might be able to reduce care use and increase the sustainability of their transport system.

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List of Tables and Figures

Author(s)	Year of Publication	Dependent Variables	Explanatory Variables: *Socio-economic and Demographic Factors*	Explanatory Variables: *Spatial Development Patterns/Urban Form/Land Use*	Explanatory Variables: *Policy*	Explanatory Variables: *Culture*	Year of Data Collection and Countries Included
Giuliano/Narayan	2006	trips per day, miles of travel per day	sex, age, income, employment status, car ownership, car/driver per HH ratio	MSA size, population density	descriptive: gas price, tax, housing policy	dummy variable	1995 (US), 1995/97 (UK)
Giuliano/Dargay	2005	car ownership, miles traveled	sex, age, employment status, HH size, income, lifecycle HH, cars per HH	residential density, MSA size, distance to transit, house/apartment	descriptive: car ownership and operating costs	dummy variable	1995 (US), 1995/97 (UK)
Giuliano/Narayan	2003	trips per day, miles of travel per day	sex, age, employment status, income	residential density, MSA size	n.a.	dummy variable	1995 (US), 1995/97 (UK)
Simma/Axhausen	2003	car or transit trips per day	sex, age, employment status, HH size, car availability, transit season ticket owner, driver's license dummy	urban/rural dummy	n.a.	n.a.	1994-1998 (GER), 1984/89 (NL)
Timmermanns et. al.	2003	trips, tours per day	transport mode, income, HH size	urban/suburban indicator, transit access indicator	n.a.	n.a.	1994 (US), 1993 (J), 1992 (CA), 1994 (UK), 1997 (NL)
Axhausen et al.	2002	cars per adults per HH, daily trips, daily travel time	worker/not worker dummy, HH size, sex	urban/rural indicator	n.a.	n.a.	1994 (A, CH), 1995 (US), 1996-98 (UK)
Simma/Axhausen et al.	2001	trips per day by car/transit, miles traveled by car/transit	sex, age, employment status, car availability, # of children	urban/rural indicator	transit season ticket dummy	n.a.	1994 (CH), 1999 (UK), 1994-98 (GER)

Table 1. International Comparative Multivariate Statistical Analyses of Travel Behavior in Western Europe and North America with Individual Level Data (Note: national studies and comparative studies with aggregate data are excluded from this specific table) **(Axhausen, et al., 2002; Axhausen & Simma, 2001; Giuliano & Dargay, 2005; Giuliano & Narayan, 2003, 2006; Simma & Axhausen, 2003; Timmermanns, et al., 2003)**

	Range of NTS	*MiD (Germany)*	*NHTS (U.S.)*
Survey Period	*10 weeks to 14 months*	14 months (11/01 - 12/02)	14 months (03/01 - 04/02)
Collection Rhythm	*annually to irregularly*	76, '82, '89, '02	69, '77, '83, '90, '95, '01
Sample Size	*3,000 to 63,000 HH*	25,848 HH	26,082 HH
		61,729 individuals	60,228 individuals
		167,851 trips	248,512 trips
Survey Method	*phone, person, mail*	Computer Assisted Telephone Interview (95%; other 5% paper based)	Computer Assisted Telephone Interview (100%)
Target Population	*generally civilian population*	civilian	civilian
Eligibility of HH Members	*adults, children, age caps*	adults and children	adults and children
Sampling Technique	*RDD, population registry, or other lists*	stratified random sample from population register	list assisted random digit dialing
Survey Period	*1 to 7 days*	1 day travel diary	1 day travel diary
Response Rates	*often below 40% of HH*	42% of HH	41% of HH
Inclusion Criteria	*vary widely*	HH where at least 50% of HH members responded	HH where at least 50% of HH members over 18 years old responded
Nonresponse Treatment	*varies widely*	collection of HH data	collection of HH data
Weights	*vary widely*	selection reciprocal, non-response, HH size, weekday, month, regional characteristics	selection reciprocal, non-response, HH size, weekday, month, regional characteristics
Data Level	*HH, person, trip, or car*	HH, person, trip, car	HH, person, trip, car
Representativeness	*Country, regions, states, and other subsections*	Germany, States	U.S., Census Regions
Add-ons		Yes	Yes

Table 2. Potential Sources of Divergence in National Travel Surveys and Comparability of MID and NHTS (BMVBS, 2004; DIW, 2004; Kunert, et al., 2002; ORNL, 2005)

Variable	Measurement	Explanation	Source
Household distance to a transit stop	two nominal variables indicating if a household is located (1) within 400 meters or (2) between 400 and 1000 meters from transit	US: distance of a household from a rail station or bus corridor Germany: distance of a household from a bus stop or a rail station	ORNL MiD
Automobile operating cost	U.S. cents per kilometer	US: operating cost based on type and fuel economy of vehicle (assuming 55% urban) and average state gasoline prices Germany: operating cost based on type and fuel economy of vehicle (assuming 55% urban) and average gasoline and diesel prices	EPA ADAC
Population density	population per square kilometer	US: population per land area on census tract Germany: population per settled land area per municipality	NHTS DESTATIS
Mix of land uses	index ranging from 0 (no mix) to 1 (great mix)	US: index based on ratio of workplaces and residents Germany: index based on ratio of workplaces and residents	CTPP, Gazetteer DESTATIS, BAA
Household income	U.S. dollars	US: annual income before taxes Germany: annual income before taxes	NHTS MiD
Driver's license	nominal variable	US: value of 1 indicates individual with driver's license Germany: value of 1 indicates individual with driver's license	NHTS MiD
Car access	ratio	US: ratio of vehicles per household to household members with a driver's license Germany: ratio of vehicles per household to household members with a driver's license	NHTS MiD
Teenager/child	nominal variable	US: value of 1 for individuals younger than driving age Germany: value of 1 for individuals younger than driving age	NHTS MiD
Gender	nominal variable	US: value of 1 for male respondents Germany: value of 1 for male respondents	NHTS MiD
Household lifecycle and employment	series of nominal variables indicating household life cycle and respondent's employment status including: employed in single HH; unemployed in single HH; employed in adult only HH; unemployed in adult only HH; employed in HH with small children; unemployed in HH with small children; employed in HH with older children; unemployed in HH with older children; retired in HH of retired individuals	US: employed individual in hh with older children as reference category Germany: employed individual in hh with older children as reference category	NHTS MiD
Germany - U.S. dummy	nominal variable	value of 1 if respondent is from German sample	NHTS MiD

Table 3. Variables in the Regression Analysis: Measurement, Explanation, and Data Sources (ADAC, 2007; BMVBS, 2004; DESTATIS, 2005; German Federal Agency for Employment, 2006; ORNL, 2005; U.S. Census Bureau, 2006a, 2006b)

		Level of Measurement	Overall Mean	Min	Max	Mean Germany	Mean U.S.	Overall N	Correlation with Dependent Variable
Dependent variable									
	Car travel distance (km)	interval ratio	36.8	0	200	23.8	48.5	87,635	n.a
Independent variables									
Policy	Transit access <400m	nominal/dummy (1= hh within 400m of transit stop)	*n.a.*	0	1	*n.a.*	*n.a.*	87,399	-0.10
	Transit access 400-1000m	nominal/dummy (1= hh within 400-1000m of transit stop)	*n.a.*	0	1	*n.a.*	*n.a.*	87,399	-0.06
	Automobile operating cost per km in U.S. cents	interval ratio	*6.80*	1.3	19.1	9.5	4.2	87,635	-0.18
Spatial development patterns	Population density (pop. per sqkm)	interval ratio	1,732	0.1	9,979	2,495	1,038	86,810	-0.15
	Mix of use	interval ratio	0.33	0.01	9.99	0.34	0.31	86,790	-0.04
Socioeconomic and demographic variables	Household income in U.S. $	interval ratio	54,738	2,500	115,000	49,866	59,819	84,529	0.08
	Car access/availability per HH driver	interval ratio	0.91	0.166	4	0.74	1.15	87,616	0.15
	Driver's license	nominal/dummy (1=respondent has driver's license)	*n.a.*	0	1	*n.a.*	*n.a.*	87,549	0.14
	Younger than 16/18	nominal/dummy (1=respondent younger than 16/18)	*n.a.*	0	1	*n.a.*	*n.a.*	87,550	-0.12
	Employed in single HH	nominal/dummy (1=respondent with job in single HH)	*n.a.*	0	1	*n.a.*	*n.a.*	87,551	0.02
	Unemployed in single HH	nominal/dummy (1=respondent without job in single HH)	*n.a.*	0	1	*n.a.*	*n.a.*	87,552	-0.01
	Employed in adult only HH	nominal/dummy (1=respondent with job in 2 pers. HH)	*n.a.*	0	1	*n.a.*	*n.a.*	87,553	0.08
	Unemployed in adult only HH	nominal/dummy (1=respondent without job in 2 pers. HH)	*n.a.*	0	1	*n.a.*	*n.a.*	87,554	-0.04
	Employed in HH with small children	nominal/dummy (1=respondent with job in HH with child 0-5)	*n.a.*	0	1	*n.a.*	*n.a.*	87,555	0.06
	Unemployed in HH with small children	nominal/dummy (1=respondent without job in HH with child 0-5)	*n.a.*	0	1	*n.a.*	*n.a.*	87,556	-0.04
	Unemployed in HH with school children	nominal/dummy (1=respondent without job in HH with child 6-16/18)	*n.a.*	0	1	*n.a.*	*n.a.*	87,557	-0.08
	Retired HH	nominal/dummy (1=respondent retired in retired HH)	*n.a.*	0	1	*n.a.*	*n.a.*	87,558	-0.02
	Sex (Male=1)	nominal/dummy (1=male)	*n.a.*	0	1	*n.a.*	*n.a.*	87,559	0.05
	Germany(1/0)	nominal/dummy (1=Respondent from German sample)	*n.a.*	0	1	*n.a.*	*n.a.*	87,635	-0.20

Table 4. Descriptive Statistics of Dependent and Independent Variables

		Model 1	Model 2	Model 3	Model 4 U.S.	Model 4 Germany
	Constant	**68.34** (126.00)**	**49.31** (46.62)**	**45.72** (43.17)**	**57.55** (1.70)**	
Policy	Transit access <400m	**-7.56** (16.10)**	**-6.81** (14.47)**	**-5.95** (12.60)**	**-6.52** (9.26)**	**-3.22** (3.38)**
	Transit access 400-1000m	**-6.51** (12.63)**	**-6.01** (11.66)**	**-4.59** (8.77)**	**-5.27** (5.88)**	**-2.27** (2.64)**
	Operating cost per km of car travel	**-2.738** (42.54)**	**-2.278** (33.25)**	**-0.878** (7.79)**	**-2.40** (9.85)**	**-0.32** (7.15)**
Spatial development patterns	Population density	**-2.70** (19.36)**	**-2.50** (17.57)**	**-2.24** (15.81)**	**-2.73** (11.15)**	**-1.78** (3.20)**
	Mix of use	**-11.18** (12.61)**	**-11.29** (12.67)**	**-11.53** (12.96)**	**-12.76** (11.20)**	
Socioeconomic and demographic variables	Household income		**0.08** (11.15)**	**0.07** (9.92)**	**0.07** (7.48)**	
	Car access/availability		**5.74** (12.74)**	**4.67** (10.31)**	**3.01** (5.44)**	**10.07** (7.76)**
	Driver's license		**10.59** (20.62)**	**10.69** (20.98)**	**11.03** (11.52)**	
	Younger than 16/18		**-11.83** (19.24)**	**-12.03** (19.67)**	**-15.87** (15.07)**	**-7.90** (6.37)**
	Single HH with Job		**1.57** (1.80)	**1.18** (1.35)	**-1.74** (1.49)	**3.54** (2.99)**
	Single HH without Job		**-3.89** (1.77)	**-4.43** (2.01)*	**-8.90** (2.47)*	
	Couple HH with Job		**0.77** (1.41)	**0.38** (0.69)	**-1.26** (1.55)	**1.80** (2.80)**
	Couple HH without Job		**-7.35** (10.66)**	**-7.11** (10.35)**	**-6.92** (4.04)**	
	HH, Small Children with Job		**2.90** (4.39)**	**2.39** (3.62)**	**2.14** (2.24)*	
	HH, Small Children without Job		**-3.82** (4.30)**	**-4.06** (4.61)**	**-5.33** (3.58)**	
	HH, Older Children without Job		**-5.92** (8.31)**	**-5.96** (8.40)**	**-7.69** (5.81)**	**-3.94** (2.45)*
	Retired HH		**-4.90** (9.81)**	**-5.40** (10.77)**	**-8.97** (10.59)**	**-2.19** (6.55)**
	Sex (Male=1)		**3.24** (13.61)**	**3.16** (13.27)**	**3.15** (8.25)**	
	Germany(1/0)			**-11.09** (15.00)**	**-37.66** (15.76)**	
	Observations	**86144**	**83048**	**83048**	**83048**	
	R-squared	**0.10**	**0.17**	**0.17**	**0.17**	
	F-statistic	*0.000***	*0.000***	*0.000***	*0.000***	
	Robust t statistics in (), * significant at 5%, ** significant at 1%					

Table 5. Results of Multivariate Regression Analysis (Dependent Variable = Daily Car Travel Distance)

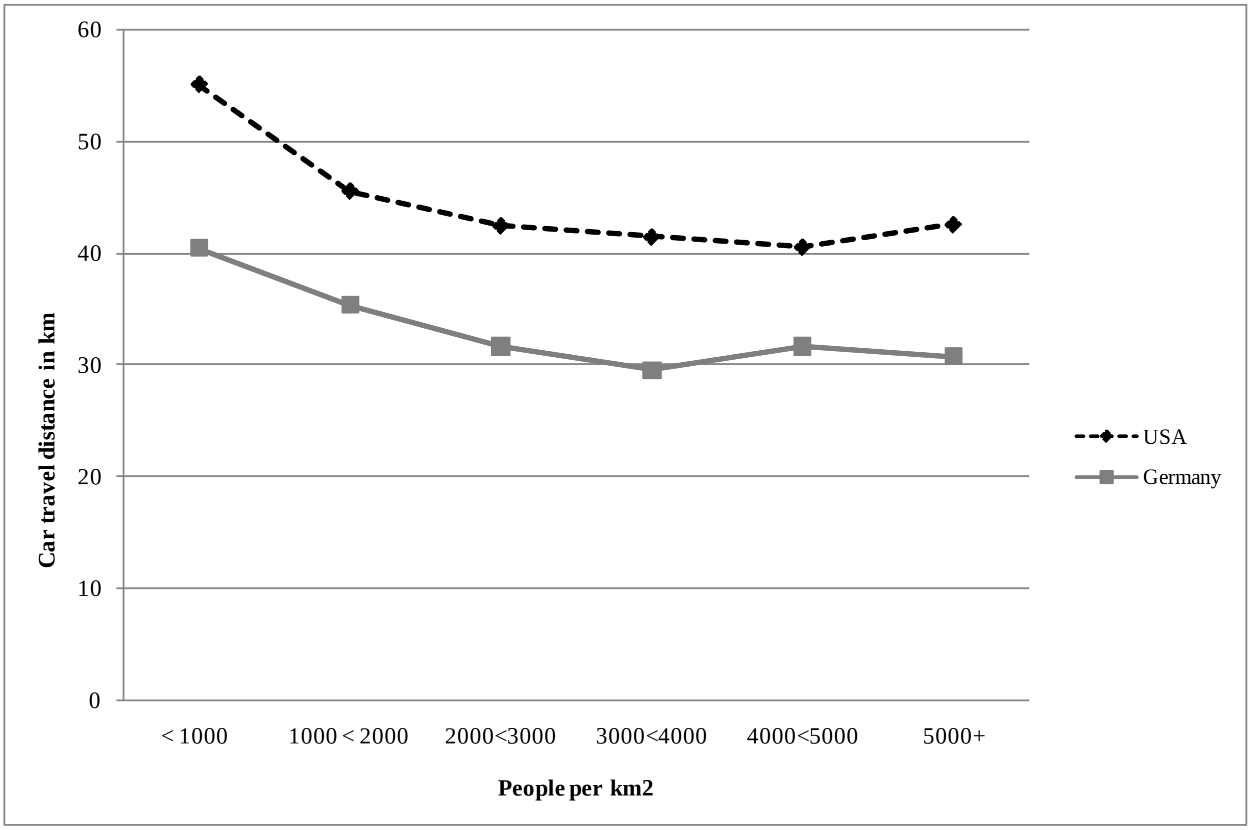

Figure 1. Population Density and Daily Car Travel Distance in Germany and the U.S.