SHORT AND LONG TERM EFFECTS OF SUSTAINABLE MOBILITY POLICY: AN EXPLORATORY CASE STUDY

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Abstract
The aim of the present paper is to offer an exploratory contribution to the general debate on sustainable transport, in particular from the perspective of impact assessment of sustainable transport policy. Specifically, starting from data available from different public sources in the United States, two different types of analyses are conducted: (1) comparison of the declared short term results of the most practical policies applied (e.g. ramp metering, HOV lanes, etc.); and (2) an analysis of mobility data to interpret long term effects of policy previously and semi-unconsciously applied. In particular, the latter point has a more innovative character with respect to the former. It is based on the assumption that, specifically in the West Coast of the United States, at a local scale (e.g. states), policies that would be defined as sustainable today, have already been applied in the past.

KEY WORDS: sustainable mobility, Clean Air Act, transport policies, California

1. INTRODUCTION

In 1987, the Bruntland Commission report (WCED, 1987), shed light on the need for society to practice sustainable development. According to the report, sustainable development should meet the needs of the present without compromising the possibility of future generations to do the same. The debate on sustainable development is therefore, already more than two decades old. It has focussed in more recent years in particular on sustainability governance (e.g., Jordan, 2008), especially from a regional (local) and/or sectoral perspective. The transportation sector is one of the prominent sectors that is often addressed in this context. Under this context sustainable transport should work to guarantee the transport needs of future generations are met emphasizing equity. This includes the ability of individuals to reach the activities desired (Farrington and Farrington, 2005)

Transport is a necessary activity in a modern society, as it acts as the lubricant for consumption and production in the world. It is an input for production processes, but may also be an output (e.g. leisure activities). The rise in globalization has reinforced the international importance of transportation. Transport is one of the world's largest industries and in many countries it accounts for up to 20 per cent of the nation's gross domestic product. As such transport has stirred up environmental debates throughout recorded history. The problems of reconciling the transport needs of modern society with the noise, fumes, and, often, ugliness of transport remain a major issue today which in some areas is seemingly becoming more intractable (Nakamura et al., 2004).

This should not necessarily be taken to imply that the environmental costs of transport are all rising. In many areas public policy has been extremely successful in reducing some problems. The introduction of catalytic converters has considerably reduced acid rain gas emissions in many countries and lead in gasoline has largely been removed in many states. Technology has allowed policies that now make commercial aircraft quieter and ships less likely to leak oil after a collision. However, fresh issues are emerging as new information becomes available and as the population's preferences change. Also, not all of the more traditional problems have entirely vanished and others have taken new forms; planes, for instance may be quieter but there are now more of them (Robert and Jonsson, 2006).

There is, however, a cost associated with this. The history of motorized transport is one of large scale environmental intrusion and in many respects is becoming even more harmful with its extensive use of fossil fuel. Transport poses many operational and logistic policy problems but the environmental implications of the motor car, trucks, aircraft and the like are some of the most challenging (Banister and Button, 1993; Button and Nijkamp, 1997; Button and Stough, 1998; Button et al., 1996). The projected trend in growth in motorized land-based traffic, aviation and shipping into the next century means that current policies will need refining to cope with the situation.

One problem is the diversity of impacts associated with modern transport (Button, 1993). It has local and immediate effects – noise nuisance and local atmospheric pollution – that have major public health implications as well as being unpleasant; regional effects – for example 'acid rain' gas emissions (such as sulphur and nitrogen oxides) and oil spills – that transcend the immediate areas where the transport is undertaken; and global effects – for example, greenhouse gas emissions such as CO_2 – that may affect global warming. Unlike a power generating station for example, there are therefore inevitably large numbers of environmental trade-offs that have to be made when designing policy.

Transport is also often demanded in close proximity to where people live, work and spend their leisure time. Indeed, it is the very access afforded by transport that permits the modern lifestyle found in the developed world (Button and Nijkamp, 1997). This again poses many more problems when contrasted with other major sources of environmental damage.

In developed countries, populations find limited incentive to use less environmentally intrusive modes of transport and policy makers are finding it difficult to obtain anything but minimum shifts from the use of the motor car and trucks. The car affords a number of private benefits over public transport. In practice, the lure of the motor car is much stronger than most transport forecasting models predict and many efforts to foster more environmentally-benign public transport use ignore the massive quality differences involved. Getting people to switch to public transport requires sticks as well as carrots (Banister et al., 2000).

Public policy with regard to tackling the conflict between narrow economic considerations and the environmental costs of transport differ between countries (Barde and Button, 1990) and have inevitably changed with time. In particular, many countries now realize that is not tenable in the longer term to construct the infrastructure needed to cater for projected car traffic into the next century and instead are seeking ways of restraining the growth (for example, UK Department of Environment and Transport, 1998).

These policy changes have not been entirely the result of a practical inability to cater for unrestrained demand but are also due to a combination of influences. First, more is known about the environment and with this knowledge has come the social demand for new policy initiatives aimed at meeting these freshly discovered challenges. The discovery of the implications of emission of nitrogen oxides (NO_x) on trees and water courses is an illustration of this. Equally, there have been important reassessments of social priorities, partly due to new scientific insights but also due to such factors as rising income, which bring forth demands of a better quality of environment for current and future generations. The ongoing concern with sustainable development is a manifestation of these interacting forces (World Commission on Environment and Development, 1987).

At the micro level, where environmental concerns with noise, fumes and the like have more traditionally been focused, there is also the issue that while some policy have proved to be very successful, many problems still remain or have been created. For example, the adoption of the 'zero emissions cars' policy in California may introduce a small number of electric cars into the system but of itself it simply moves the location of much of the pollution from the streets to other power generation sites.

There are a number of detailed policy approaches that can, and have, been used to tackle the problems associated with transport. In broad terms these can be divided between technological, institutional and enlightening policies.

Technological policies are direct and consist of measures that make the vehicle or infrastructure more environmentally benign. They embrace, for example, improved vehicle/vessel technology (including improvements to the gasoline engine, electric and hybrid low emission vehicles and the development of alternative fuels), infrastructure structure, design and construction technology (including new techniques for building tunnels, bridges and earth embankment and cuttings) and infrastructure management (including air traffic control systems, urban traffic demand management, junction controls and intelligent transport systems). Technical solutions have been widely used and with considerable success. Some have got to the root cause of the problem (for example, the removal of lead from gasoline) while others represent end-of-pipeline treatments (such as catalytic converters and noise suppressers on aircraft engines). There is, however, potentially a limit to what technology can do. Also technology often involves tradeoffs (for example, catalytic converters reduce acid rain emission but increase fuel consumption with implications for greenhouse gas emission) and solving one problem can, therefore, lead to others. Finally, technology has to be implemented and there are a number of policy instruments that may do this.

The supply and management of transportation is too important to be left to the market, especially given that transportation is a sector where the free market doesn't necessarily bring the optimal social outcome. The challenges posed on transportation planning have continuously grown over the years due to mounting problems of congestion, new concerns with environmental degradation and global warming, enhanced awareness of safety, and increasing complexity of travel behaviour patterns associated with modern life. Policies have been set in place to account for these facts, some proposed by the federal government (e.g., Clean Air Act), while others by the state and local government (e.g., telecommuting, parking fees, and alternative transport modes). It is difficult to measure the resulting impact of each one of these policies given that they haven't been set in place independently. Policies have overlapped in time, creating a holistic effect that makes very difficult to disentangle how effective each policy has been. Even more, effects of enlightening policies, which have as an objective to make population aware of the effects of transport in the environment and the urban landscape, are equally difficult to isolate (e.g., recycling, public transport subsidies). Although, it should be added, that the tools available for implementing transportation plans have at the same time advanced as computerization and hence information systems (especially geographical information systems) have emerged (Shiftan et al., 2007).

Transportation system developments in past decades followed a non-sustainable trend, notwithstanding the application of several measures. This resulted in (i) air quality pollution caused by transportation infrastructures and services (directly by vehicle emissions and indirectly by vehicles that use energy produced elsewhere); (ii) an increased number of deaths and injuries provoked by accidents every year (Nijkamp and Black, 2002); (iii) a constant increase of the cost needed to make the transportation system work (during the last year the petroleum cost almost doubled) and (iv) the consumption of an enormous amount of individuals' available time (Goldman and Gorham, 2006). In addition, considering that transportation decisions strongly influence economic growth (Goldman and Gorham, 2006), it is easily arguable how much it affects all sustainability spheres (economical, social and environmental) (Van Geehhuizen et al., 2002). Moreover, due to the current transformations taking place in developing countries (it has been estimated that in China resource consumption will increase seven times by 2030 (Borken et al., 2008)), the horizon does not look too promising.

Regardless of the scenario, by using different approaches, Europe and North America, have made efforts to promote and study sustainable development. In fact, several projects have been funded on this topic and plenty of work exists in the literature proposing policies and actions (e.g. Nijkamp et al. (2007), Soderlund et al. (2008) and Zietsman et al. (2008) as recent works). Research has been mainly devoted to exploring three areas: (i) implementing new technologies for sustainable transport, (ii) carrying out sustainable mobility policies and (iii) promoting integrated transport and land use planning (Greene et Wegener, 1997).
In spite of the large volume of research available, very few policies have been actually implemented. Moreover, when implemented, results obtained have not been known to have a significant impact. As a consequence, the idea of "sustainable development" has a more theoretical than practical implication. This issue has claimed the attention of researchers on how to use the term "sustainability" in order not to weaken its meaning (Hatzopoulou et Miller, 2008 and Gudmundsson et Hojer, 1996). Recently, work on the information necessary to evaluate sustainable policies has started to emerge (May, 2008, Johnstone, 2008 and Jeon et al., 2008).
The aim of the present paper is to offer an exploratory contribution to the general debate on sustainable transport, in particular from the perspective of impact assessment of sustainable transport policy. Specifically, starting from data available from different public sources in the United States, two different types of analyses are conducted: (1) comparison of the declared short term results of the most practical policies applied (e.g. ramp metering, HOV lanes, etc.); and (2) an analysis of mobility data to interpret long term effects of policy previously and semi-unconsciously applied. In particular, the latter point has a more innovative character with respect to the former. It is based on the assumption that, specifically in the West Coast of the United States, at a local scale (e.g. states), policies that would be defined as sustainable today, have already been applied in the past.

2. SUSTAINABLE TRANSPORT AS A SOCIETAL CHALLENGE

For more than a decade, there has been a recognition that transport as it is offered today is non-sustainable. The twenty-first century will see a variety of new social and technological trends that will influence the way in which transport is supplied and utilized. At present a wide range of social phenomena, including rising incomes, increased leisure time, new communication technologies, an aging population, and a declining role for the traditional family, are changing the nature of the demands placed on transport. In response to new techniques of production, shipping, and the growth of markets, economic activities are also changing. The long-term sustainability of current transport systems is increasingly being questioned as rates of motor vehicle fatalities and injuries as well as congestion continue to rise. These trends raise questions about whether our current transport systems are sustainable beyond the next half-century (Black and Nijkamp, 2002).
Knowledge about the transport systems is still limited. A transport system may show rather unexpected turbulence as a result of interacting forces between dynamic behavior and limits to capacity. Unexpected behavior also happens as a result of policy-making. There is a shortage of insights into how actors in transport respond to policy measures, particularly costs measures, at the same time that there is a need to fine-tune goals, measures, and social acceptance.
For these reasons, transport cannot be properly analyzed in isolation from its context; on the contrary, the driving forces in mobility and communication are a direct result of broader social, economic, technological, and policy developments. Figure 1 demonstrates the integrative approach by including in a comprehensive way major direct and indirect influences on transport and communication from driving forces in the economic and social system and policy frameworks. The figure equally underlines the interaction of the spatial organization of society, transport infrastructure and industry, and new transport technology with transport and communication. Furthermore, it makes explicit reference to the natural environment, which is strongly influenced by land use, transport and transport infrastructure, and new technology solutions, but has only weak reverse impacts. The same is true for social cohesion (exclusion) on various geographical scales.
Driving forces such as individualization and preferences for suburban lifestyles are important in influencing the rising mobility of households and individuals. There seems to be an ongoing move

toward the mobile society away from the homebound society, although there still seems to be a difference between the rich and the poor.
However, the actual and accurate assessment of environmental impacts of the transportation sectors is still fraught with many uncertainties. The same holds also for the assessment of sustainable transport policies, at various geographical scales ranging from local to global.

3. METHODOLOGY

An exploratory study on the effects of sustainable policies is conducted for the State of California, USA, for which there are several data available and at the same time, different policies have been implemented in the past. One of the most important policies set in place which directly affects transportation is the Federal Clean Air Act Amendments of 1990 (CAAA) and the original Clean Air Act of 1977. These laws significantly affect transportation decision-making not only in terms of air quality, but also in relation to land use, travel mode choice, and reductions in vehicle miles traveled (Shrouds, 1995). Associated to these laws are policies implemented as mandatory controls such as transport control measures (TCM) which include restricting on-street parking, setting parking fees, establishing bus/car pool lanes, building and use of bike paths, mass transit, and others. In the case of California, besides the Clean Air Act, telecommuting (telework), and mass transit use are closely examined in this paper.
Data used to study the effects of such policies are retrieved from the extensive number of databases available on households' information and the transportation system in the United States. By using these datasets it is possible to monitor the changes not only in congestion but also in travel patterns over the years. Data available from the US Urban Mobility Study Website (http://mobility.tamu.edu/ums/ and http://www.epa.gov/air/data/index.html), which includes data from US National surveys (HPMS and other state and local agencies surveys) stores congestion trends from 1982 to 2005 for all major California cities, with different population levels such as: Bakersfield, Fresno, Los Angeles, Oxnard, Riverside, Sacramento, San Diego, San Francisco and San Jose.
Congestion data, from 1982 to 2005, includes: inventory measures, urban area information (population, density, peak travelers), private mode traffic volume indicators (Daily VMT and Lane Miles for freeway and arterial streets), public mode traffic volume indicators, and cost components (value of time, commercial cost and fuel cost). System performance measures included are: aggregate origin/destination trips, congestion indicators (e.g. congested time), excess fuel consumed indicators (e.g. annual total fuel consumed), delay indicators (e.g. total delay or delay per peak traveler), travel time index, and congestion cost.
It is possible to relate this data with data regarding air quality from the National Air Quality Database, in which Aerometric Information Retrieval System (AIRS) data is available from the U.S. Environmental Protection Agency (EPA), annually from 1996 to 2001, for various American cities. This paper will go even further and relate the two previous datasets with data from the National Household Travel Survey (NHTS) (http://nhts.ornl.gov/) to determine if these measures of congestion and emissions have had a significant impact on individuals travel patterns, and therefore are contributing to a more sustainable environment. The objective is to identify if there are any benefits in terms of congestion levels, polluting emissions, and other relevant indicators, and if so, can benefits be attributed to the sustainable mobility policies mentioned earlier or if they are just the result of a statistical trend.
In the following section the data sources considered will be described, and an analysis of the data will be presented and discussed.

4. Data analyses

4.1 The Urban Mobility Report

The Texas Transportation Institute (TTI) is an institution whose aim is to provide solutions and suggest policies to solve traffic congestion problems. Yearly, it publishes an Urban Mobility Report that captures the existing trends throughout the USA. It provides long-term congestion trends, congestion comparisons, and strategies to account for congestion problems.

The Urban Mobility Report 2007 (Shrank and Lomax, 2007) is based on 2005 data (the most recent year for which complete information is available). At a national level, it shows that traffic congestion continues to worsen in all American cities. This causes a $78 billion annual loss in the U.S. economy in the form of 4.2 billion lost hours and 2.9 billion gallons of wasted fuel. In addition it notes that congestion causes the average peak period traveler to spend an extra 38 hours of travel time and consume an additional 26 gallons of fuel, amounting to a cost of $710 per traveler. Moreover, the report also focuses on the problems presented by occasional events (crashes, stalled vehicles, work zones, weather problems other) that cause unreliable travel times and contribute significantly to the overall congestion problem.

Starting from data available on the TTI website attention is given to cities in California. Figure 2 (a)-d)) shows the trends of the "performance" indicators selected for each urban area in California. Each area is identified based on their size. In particular four groups of urban areas are considered, very large urban areas (vlg), large urban areas (lrg), medium size urban areas (med) and small size urban areas (sml).

The figures show that most of the urban areas in California suffer from congestion related problems. This was expected, since it is known that in California urban sprawl is particularly evident and thus the need for travel is very high. However there are two cases where trends have followed an opposite direction: San Francisco and Fresno (see Figure 2c for Fresno example). All the selected indicators show that, for these two areas, the absolute values are less than the ones corresponding to the other Californian areas and always less than the national average. The difference between these two cities is mainly related to the time period of trend inversion. In San Francisco, the situation started to improve in early 1990s and now they are still taking advantage of the interventions of that period (long term effect). In Fresno, on the contrary, the most important inversion trend seems to be related to policies applied during the last years (short term effects). In addition, in the San Francisco Area these effects seem to be more connected to the existing Public Transport System, while in Fresno they seem more related to demand reduction policies. The San Francisco Bay Area benefits from the existence of the BART system (Bay Area Rapid Transit) and its services to the community. In Fresno a similar system does not exist, therefore it is harder to pinpoint one particular cause for demand reduction. This could be related to a reduction in the number of trips, in the adoption of more environmentally friendly cars, or in the use of alternative modes like bikes or the bus.

Additional information in the Urban Mobility Report is reported regarding traffic calming policies applied in 85 American Urban Areas and their short term effects. Traffic measures considered are freeway ramp metering, freeway incident management, arterial signal coordination, arterial access management and the institution of HOV lanes. All these measures aim at maximizing the road system capacity by optimizing its performances. In Figure 3 the global impact of these policies is shown, in terms of hours gained by each traveler each year. It is worth noting that the effectiveness of these policies is as large as the size of the urban area considered. However, combining all the information it is possible to conclude that this kind of measures have a quite negligible impact on the congestion reduction if they are not coupled with other policies which have a bigger impact on the transportation demand or supply systems.9

4.2 The National Air Quality Database

The U.S. Environmental Protection Agency (EPA) is the American Agency devoted to monitoring the quality of the environment throughout the Nation. Regarding air quality, EPA has filtered guidelines provided by the Clean Air Act (http://epa.gov/air/caa/) setting standard limits and a uniform control procedure in the whole country. As a result, the National Air Quality Database, has been systematically updated annually by EPA, from 1996 until today, for various American cities. In particular, the database used in this study is the one derived from the Air Quality Report of 2003, available from: http://www.epa.gov/oar/aqtrnd03. Such report exploits concentration measures of polluting factors in correspondence to monitoring stations located throughout the US, using the same criteria and instruments. From the two pollution classes (criteria and hazardous pollutant) recognized by EPA, this paper focuses only on values of ordinary pollutants (i.e. CO, NH_3, NO_x, PM_x etc.).

According to EPA reports, throughout the US the quantities of emission levels of the six principal polluting factors have been decreasing since 1970 (in 48%), of course with differences among the various pollutants. This is in spite of increases in gross product and traffic congestion. One of the most common indicators used to assess air quality and its consequences on people is the Air Quality Index (AQI) classified in correspondence with different classes of pollutants. In particular the acceptance threshold of the AQI is 100, where lower values indicate good air quality. In the State of California, the number of days in which such index has been more than 100, has been decreasing in more than 50% from 1992 to 2001. Despite the overall good trend of the state, there is still an unhealthy factor that is the $PM_{2.5}$, generated mostly due to power plants and vehicle emissions.
In Figure 4 emission values related to the road transport sector are shown for three pollutants in the Californian Metropolitan Statistical Areas (MSA). It is worth noticing that data of total emissions due to the transportation sector are available at a county and not at an MSA level. For this reason where necessary, MSA statistics have been retrieved by aggregating county data. This was necessary for Riverside-San Bernardino (composed by the respective counties) and for San Francisco (composed by the counties of San Francisco, Alameda, Contra Costa, Marin, Napa, Santa Clara, Santa Cruz, San Mateo, Solano and Soloma). Trends for all the pollutants show a decrease on the global emission values confirming that even the transport sector at a local level positively follows the overall national trend. Looking at the figures in more detail it is noteworthy that the global emission values obviously depend on the size of the urban area. In addition, the similarity of the trends in all the cities show that the general reduction of pollutant emissions is more connected to a wider tendency (more general technological development that produce for example cleaner engines) than to the application of local measures that, on the contrary as stated previously, seem to have a fairly negligible impact on the sector evolution.

4.3 National Personal Travel Survey (NPTS) and National Household Travel Survey (NHTS)

The two data sets, the 1990 National Personal Travel Survey (NPTS) and the 2001 National Household Travel Survey (NHTS), are a comprehensive collection of personal travel data including information about households, individuals, vehicles, and trips conducted during a 24 hour period. It was collected by the U.S. Department of Transportation as part of an effort which started in 1969 and continued in 1977, 1983, 1990, 1995, and 2001. The years 1990 and 2001 are chosen given that they are the only ones (also 1995), which include a geographic identifier necessary to do a selection by state. This is a requirement given the focus of this analysis is on the State of California. For details on how the data was collected the reader is referred to the user's guide of the 1990 NPTS (U.S. 1990) and the 2001 NHTS (U.S. 2004).
The objective is to compare the data from the two decades in regards to their mobility characteristics. The similarity or difference between these characteristics will support or reject the hypothesis proposed that many of the measures that have been either implemented or suggested to promote a sustainable environment in California, have implicitly or unconsciously had an effect on the way people travel. Particular measures of mobility include among others the number of vehicles in the household, stage in the life cycle, number of alternative modes of transport besides the car, age of the vehicle, vehicle type, occupancy per vehicle, work from home, transport mode, number of trips made by the household, miles driven, and the length of the trips.
To set the context for the empirical analysis of the State of California it is important to present some of the national trends in regards to some of the mobility characteristics listed above. The statistics have been compiled from multiple sources and reports, which have analyzed in detail the same data sets (i.e. NPTS and NHTS) at the national level (Collia et al., 2003; COMSIS, 1994; Hu and Reuscher, 2004; Polzin, 2006; U.S., 1990, 2004). The left side of Table 1 presents a summary in terms of mode (Pucher and Renne 2003) and vehicle ownership (Hu and Reuscher 2004) for the United States. The dramatic increase in walking is attributed by various researchers to the difference in survey methodology in 2001 where questions were designed to account for walking trips that were ignored in previous surveys (Collia et al., 2003; McGuckin and Liss, 2005; Pucher and Renne, 2003, 2005). Regardless of this difference it is still important to point out that the Pacific region which California is a part off, has the highest percentage in walking (10.6%) and biking (1.1%) in the United States (Pucher and Renne 2003). Hu and Reuscher (2004) present a summary of some important mobility characteristics for the two years which are summarized in the

right side of Table 1. The numbers in this table show that there is an increase in each between years, except for transit use which under a sustainable context would be expected to increase. This does not portray a promising horizon in terms of sustainability at the national level. However, it is important to highlight that different regions in the country have different practices at the state level and can be promoting better results that are not evident when the country is examined as a whole. To examine if this is the case, the State of California is selected. It is well known that California has suffered pollution problems and has had to work harder in protecting their environment when compared to other regions in the United States. Also in terms of transportation, California has been a testing site for multiple projects and a leader in sustainable transport measures (Hughes 2004). The next section looks in detail at some of these mobility characteristics for the State of California.

4.3.1 Mobility Indicators for the State of California

Using the 1990 NPTS and the 2001 NHTS surveys the records that correspond to the State of California are extracted. The results presented are based on the analysis of these sub samples. The results are discussed based on the households, the vehicles, and the trips.

4.3.1.1 Households

California's population has increased in 13% in the last decade from 29,760,021 to 33,871,648 (source US Census Bureau). When looking at the household indicators in the sample presented in Table 2 it can be seen that the number of drivers has increased, household size has decreased, there is an increase in the number of households with children between 16 and 21, there is also an increase in the number of retired households, and vehicle ownership has substantially increased. There are on average 1.56 drivers per household for 1990 and 1.81 for 2001. In general, these indicators reflect the age increase in the population and the presence of the baby boomers, except for the number of vehicles. It is surprising to see this increase, in particular in owning 4 or more vehicles. However, it is California and given its primary industries (e.g. Cinema, wine, software development) it is clear that per capita income is very high resulting in a high purchasing power (per capita income for 1990 was $21,882 and for 2000 was $32,149, source www.hcd.ca.gov). It is important to point out in this table that the NHTS survey for 2001 considered important to record the number of bikes per household. It is not possible to make a comparison with 1990 because this data was not collected as part of that year's survey. However, it provides and indication of potential changes in transport mode. Based on these indicators it would be expected that more trips be made by households, therefore contributing to the negative effects of increased auto dependency and mobility.

4.3.1.2 Vehicles

It is assumed that older vehicles will produce more emission therefore having a more severe effect on creating a less sustainable environment. Table 3 shows the age of the vehicles and their type. It can be seen that in general Californians drive newer vehicles. For 1990 almost 50% of the vehicles are less than five years old, while for the year 2001 is around 45%. Considering the invention of catalytic converters in 1975 and their effects in contributing to a cleaner environment, the table shows a larger percent of vehicles without for 1990 (11.14%) than for 2001 (5.12%). In terms of vehicle type the survey for 2001 shows the emergence of sport utility vehicles (SUV). If automobiles are grouped with SUVs the changes in vehicle types are not substantial. The vehicle fleet has remained the same. However, SUVs are less fuel-efficient burning more gas for the same mileage than smaller vehicles.

In the sample the vehicle occupancy for 1990 is 1.6 persons per vehicle, while in 2001 is 1.7. This is a slight improvement that follows the national average. The number of vehicles per household is 1.97 for 1990 and 2.04 for 2001, which is a reflection of what was discussed on Table 2.

4.3.1.3 Trips

Regarding mode choice, Table 4 on the left presents the different alternatives used by Californians in the years 1990 and 2001. As in the case of the vehicles, SUVs appear as a new mode, as do water based modes. There is a big increase in the use of passenger vans and on walking. The other modes either decrease or are very similar to the uses of 1990. As explained earlier the changes in walking

to some extent are attributed to changes in the survey design. However, it is still possible that part of this increase can be attributed to other reasons, such as people's desire to stay healthy, change transport modes, or not drive. The passenger van increase is an encouraging surprise. This means that multiple people are traveling only in one vehicle potentially reducing the number of vehicles on the road. Transit, which is an alternative in tune with environmental sustainability, in 2001 still maintains the same lower levels of use than in 1990. It is important to notice the percentage increase in the number of trips between 1990 and 2001. This is a very substantial increase especially when the number of vehicles and households did not increase at that same level (refer to tables 2 and 3). However, the table shows that these trips are not the result of privately owned automobile trips, which is a plus when considering a sustainable environment.
Just looking at the trips by mode is not enough to get a complete picture of what the scenario is in terms of sustainability. It is also important to look at the length of the trips. Table 4 on the right, shows the average trip length by mode for the two years. When looking at privately owned vehicles the average trip length in miles and in minutes are very similar, even when the SUV category is grouped with autos. When using transit, individual's trips increase in length, but more importantly in time. This means that people taking the bus, subway, commuter train, or trolley spend much more time on their trips than individuals using any other mode. This might deter the use of these modes and make people to switch to more efficient modes in terms of travel time. Obviously this is a situation that needs to be avoided. However, it is possible that individuals that have no other choice and are forced to use transit are making these trips. Other modes that are not consider often like biking and walking have decreased in the average length of the trip but increased in time. Therefore people are spending more time reaching closer destinations. This can be due to a matter of safety, where individuals cannot walk or bike at fast speed due to traffic or other obstacles they might find in their way.
The number of trips per household increases on average almost 50% for 2001 (1990: 6.56; 2001: 9.78). However, it is important to note that the number of miles driven in the last 12 months is reduced in 5%. As shown by the modes, it seems people are looking for alternatives to not drive alone. However, it is still not obvious that this is creating a big change overall. When looking at the distribution of the miles driven in the last 12 months, it is evident that the majority of individuals who owned a vehicle drove less than 24,000 miles. The length of the trip in miles when all modes are considered is reduced in 9% from 1990 to 2001, while in terms of time it increases 16%. This supports the results presented in Table 4.
Even though an analysis of the commute trip was not conducted here, it is important to note that for 2001 individuals were asked if they worked from home. This can be considered a form of telecommuting and 5% said they did.

5. CONCLUSIONS

After analyzing the data there is not enough evidence to say without doubt that people unconsciously have adopted a more sustainable approach to transportation in the decade between 1990 and 2001. There have been some slight changes that might suggest that in the decade that is coming to an end results will be more obvious. However, it is also not possible to say that the opposite has occurred. Transportation has not taken a negative turn where it is not possible to return from. The situation in 2001 is very similar to that of 1990. The increases can be attributed to changes in population and age, which is happening at the national level as well. Sustainable mobility policies are not as strong as needed to accelerate this process and as shown in the paper, it is not possible to directly derive their influence on the system. For this reason it would be advisable to have more specific measures aimed at achieving precise quantifiable objectives, whose effects could be systematically monitored both in the short and in the long term.
In this light, several efforts are being made in order to set up and organize suitable methodologies and information systems both in the American and European context (Bejleri et al. 2006 and Ballis 2006). Hence, there is still hope that in the near future a more sustainable environment can be achieved, especially given the new laws (Hughes 2004) and governmental efforts to promote change.

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Table 1: Household and mobility characteristics at the national level

	Mode of Transport*					Vehicle Ownership								
	A	T	W	B	O	0	1	2	3 >	Vehicles per HH	Avg. trips per HH	Avg. person trip length (miles)	Percent that use transit	Vehicle occupancy
1990	87.1	2	7.2	0.7	3	9.2	32.8	38.4	19.6	1.77	7.32	9.45	1.80%	1.51
2001	86.4	1.6	8.6	0.9	2.5	8.1	31.4	37.2	23.2	1.89	9.66	10.04	1.56%	1.63

- A: auto, T: transit, W: walking, B: bike, O: other

Source: Pucher and Renne, 2003; Hu and Reuscher, 2004.

Table 2: Household indicators

	1990	2001	Percentage Change
Number of drivers in HH			
0	8.44	3.68	-56.398
1	40.75	29.77	-26.945
2	39.86	52.85	32.589
3	8.39	9.99	19.070
4	2.06	3.14	52.427
5	0.44	0.35	-20.455
6	0.05	0.23	360.000
Average per HH	1.56	1.81	16.02
HH Size			
1	18.07	20.94	15.883
2	31.96	36.35	13.736
3	19.39	16.34	-15.730
4	16.49	15.18	-7.944
5	7.90	7.12	-9.873
6 or more	6.18	4.07	-34.142
Average per HH	2.86	2.65	-7.34
HH vehicles			
0	5.74	5.34	-6.969
1	29.01	28.34	-2.310
2	39.72	39.14	-1.460
3	17.53	16.72	-4.621
4	4.86	6.81	40.123
5 or more	3.15	3.64	15.556
Life Cycle			
Single adult, no children	12.86	12.81	-0.389
Two or more adults, no children	28.82	23.42	-18.737
Single adult, youngest child age 0-5	1.62	1.08	-33.333
Two or more adults, youngest child age 0-5	17.38	15.41	-11.335
Single adult, youngest child age 6-15	2.45	2.67	8.980
Two or more adults, youngest child age 6-15	14.09	14.91	5.820
Single adult, youngest child age 16-21	0.98	1.05	7.143
Two or more adults, youngest child age 16-21	5.50	4.49	-18.364
Single adult, retired, no children	5.65	7.98	41.239
Two or more adults, retired, no children	10.06	16.18	60.835
Not Ascertained	0.59		
Number of Bikes in HH			
0		50.91	
1		20.09	
2		18.47	
3		6.16	
4		3.06	
5		0.74	
6 or more		0.5	
Total HH	2037	2583	26.804

Table 3: Vehicle indicators

	1990	2001	Percentage Change
Vehicle Year			
1919-1959	0.84		
1960-1964	1.29	3.31	156.59
1965-1969	3.63		
1970-1974	5.38	1.81	-66.36
1975-1979	13.09	2.66	-79.68
1980-1984	21.7	4.83	-77.74
1985-1989	41.91	14.05	-66.48
1990-1994	7.03	22.48	219.77
1995-1999		31.07	
2000-2002		16.11	
Various reasons no answer	5.02		
Vehicle Type			
Automobile (including station wagon)	73.09	57.85	-20.85
Passenger Van	4.82	8.25*	71.16
Cargo Van	0.47		
SUV		12.63	
Pickup Truck	18.04	16.79	-6.93
Other truck	0.35	0.38	8.57
RV or motor home	1.17	1.21	3.42
Motorcycle	1.54	2.57	66.88
Moped (motorized bicycle)	0.22		
Other	0.20	0.3	50.00
Various reasons no answer	0.1		
Total Vehicles	4025	5288	31.38

*: includes cargo

Table 4: Mode choice

	1990	2001	Percentage Change
Mode			
Auto (including station wagon)	69.14	50.11	-27.524
Passenger van	5.7	11.33	98.772
SUV		13.53	
Cargo Van	0.16		
Pickup Truck	11.39	10.15	-10.887
Other truck	0.72	0.41	-43.056
RV or motor home	0.14	0.01	-92.857
Motorcycle	0.5	0.20	-60.000
Moped (motorized bicycle)	0.13		
Other privately owned vehicle	0		
Bus	1.47	1.42	-3.401
Amtrak	0	0.02	
Commuter train	0.10	0.07	-30.000
Streetcar / Trolley	0.06	0.07	16.667
Elevated rail/ subway	0.15	0.12	-20.000
Ship/ cruise		0	
Passenger line/ ferry		0.01	
Sailboat/ motorboat/ yacht		0.01	
Airplane	0.13	0.13	0.000
Taxi	0.15	0.14	-6.667
Limousine		0.01	
Hotel/ airport shuttle		0.04	
Bicycle	1.20	1.04	-13.333
Walk	7.59	10.13	33.465
School bus	1.02	0.72	-29.412
Other	0.19		
Total Trips	13380	25267	88.842

Average Trip Length by Mode

Mode	1990	2001	% Change
Auto	11.28*	10.15	-10.018
	17.41+	19.57	12.407
SUV		10.75	
		19.42	
Transit	8.99	10.76	19.689
	31.44	53.77	71.024
Walk	1.6	0.74	-53.750
	11.04	17.704	60.362
Bike	2.53	2.26	-10.672
	11.38	23.40	105.624

*: in miles

+: in minutes

Figure 1: An integrative view of transport

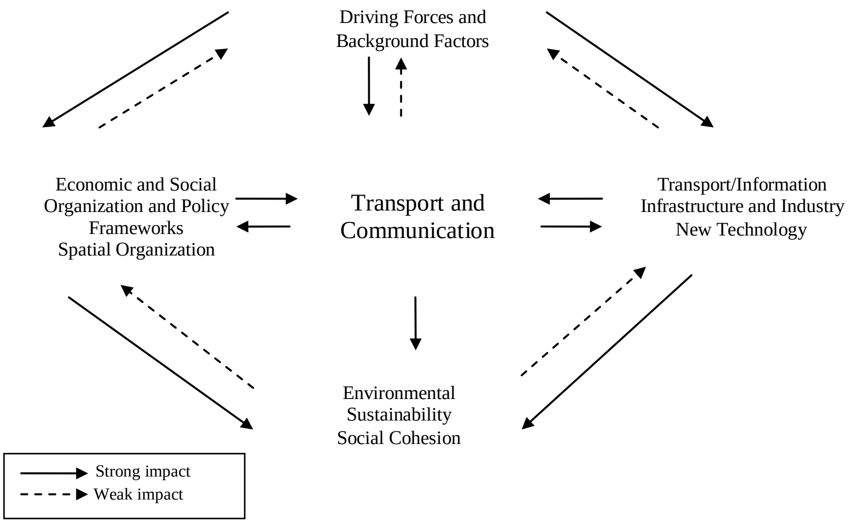

Figure 2: Summary of urban mobility indicators; a: travelers during peak period, b: vehicle miles traveled, c: vehicle miles traveled for medium size urban areas, d: passenger miles traveled

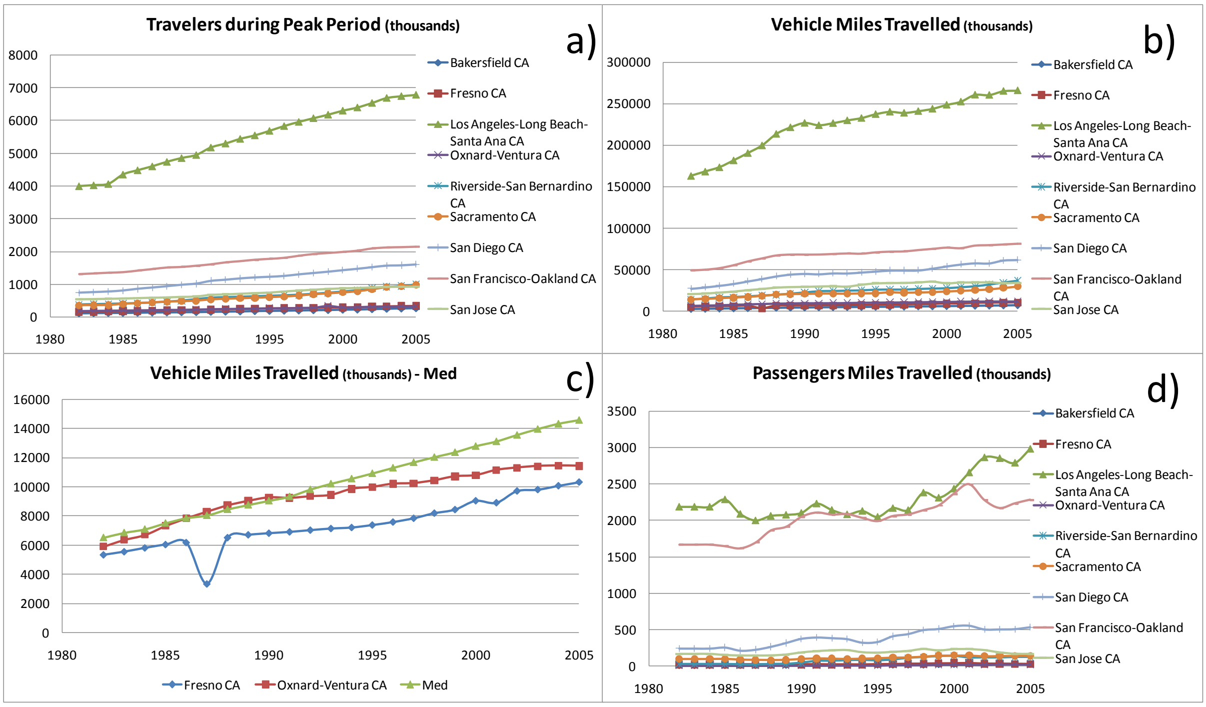

Figure 3: California urban areas annual delay saved per peak traveler

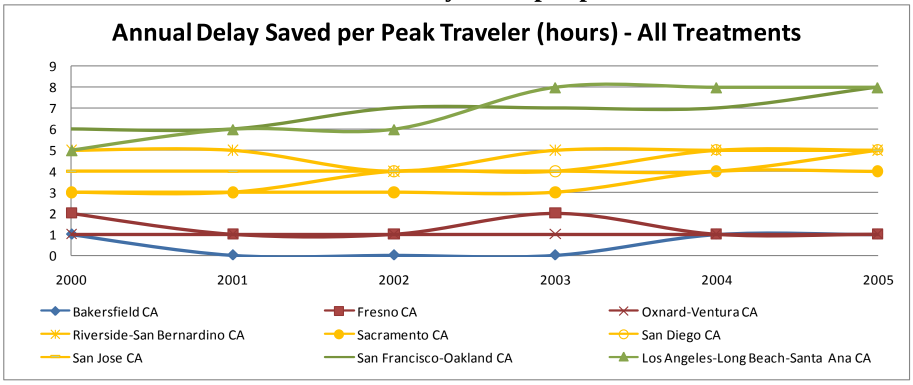

Figure 4: California urban areas air pollutants trends