UNRAVELING TIES TO PETROLEUM:

HOW POLICY DRIVES CALIFORNIA'S DEMAND FOR OIL

Understanding how policies determining everything from mortgage tax deductions to parking lots are intertwined with California's demand for oil

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California's energy paradigm is shifting in this new Millennium. The prior paradigm, energy use that tends to promote near-term economic development, no longer serves the state's economic and environmental policy goals. Thus, the state has evolved a new paradigm: energy use capable of sustaining long-term quality of life goals and economic security. As this paradigm shifts, the state, regions, counties, and municipalities have the opportunity to reevaluate legacy policies and their direct or indirect impact on energy use.

Moderating petroleum's effect on the state's economic and social systems will assist the transition to a clean economy, where the state can increase economic output while protecting limited natural resources. Rising fuel prices burden all Californians, especially those with little wealth or alternative transportation options. Understanding the connection between petroleum use and anthropogenic climate change provides an additional impetus to reduce California's consumption of petroleum.

Unraveling Ties to Petroleum presents an approach to understanding policy implications in a highly complex, layered and interwoven system. Urban form and travel activity is the result of the complex interactions over time, shaped by past policy choices. We seek to unravel path dependencies, interconnectedness, and multiple feedback loops in order to link petroleum consumption with policy decisions that, at first blush, may seem unconnected to energy use.

As policymakers pursue ever-more sophisticated goals, they must consider how pre-existing policies may erode the effectiveness of new policies. Incremental decision-making approaches often fail to address these adverse effects, which can undermine new policymaking efforts. *Unraveling Ties to Petroleum* supports policymakers looking to develop innovative new policies that support these goals, while at the same time actively addressing path-dependency.

In 2006, California resolved to reduce greenhouse gas emissions to 1990 levels by the year 2020. Seven years later in 2013, the state is now midway through implementing the Global Warming Solutions Act of 2006 (AB 32). In addition to developing new policies, the state can reevaluate existing policies in order to ascertain the direct and indirect effects that implicit and explicit policy choices have on California's petroleum use. As California works to meet the emission reduction goals of AB 32, the transportation sector, accounting for nearly 40 percent of the state's energy consumption and 86.4 percent of its petroleum use, will play a key role.

SUMMARY OF FINDINGS

In this report, we consider 15 specific measures that affect petroleum used in transportation, analyzing how choices to add to, eliminate, or change an existing policy can impact statewide petroleum use. We focus primarily on on-road surface transportation and light-duty, private vehicles, but also include aircraft.

The legacy policies we assess appear in the U.S. Code, the U.S. Code of Federal Regulations, the California Constitution, various sections of California Code and the California Code of Regulations, and in local code and directives approved without any legislative deliberation.

Some of the policy choices conceal the true cost of providing automobile infrastructure. For instance, **minimum parking requirements** create implicit user-subsidies when the cost of parking is bundled in the cost of other goods or services. In addition, **employer parking subsidies** hide parking costs from employees without always offering non-drivers a similar subsidy.

Other measures unintentionally perpetuate private passenger vehicle use – and associated petroleum consumption – while impeding the scope or quality of alternatives. For example, the methods that transportation departments employ to **assess the performance of the transportation system** continue to influence most traffic engineering decisions in favor of single-occupant automobiles. Furthermore, the **conventional approach to adding High-Occupancy Vehicle (HOV) lanes** through construction, rather than conversion of existing lanes, delays the implementation of HOV networks.

Among policy developments that help reduce California's petroleum dependence, the introduction of **new services allowing travelers to share rides** and even share cars is particularly promising. Behind both of these programs is the relatively new idea of transportation as a service, allowing consumers the choice of foregoing the purchase, maintenance, and storage of a private vehicle. The savings for the state could be huge: filling just ten percent of the excess capacity of private passenger vehicles currently operating in California could lead to an 18 percent reduction in motor vehicle fuel use. Nonetheless, current regulatory and market barriers threaten the growth of new, Internet-enabled peer-to-peer ridesharing services.

Some measures combine to increase California's reliance on oil. For instance, **minimum parking requirements** increase the number of parking spaces per acre in dense areas, with more parking spaces per acre leading to more traffic congestion. Policymakers then seek to mitigate this problem with **automobile-based transportation system performance standards.** These standards often seek to remedy congestion through roadway widening, but end up perpetuating traffic congestion in corridors where the public right-of-way is finite. Furthermore, these policies inhibit a shift toward transit use to increase the number of people traveling through congested corridors – even in high-quality transit areas.

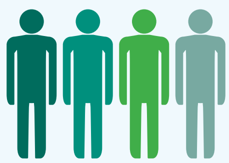
In some cases, policies distort land use, compelling drivers to make longer trips and diluting the attractiveness of alternative modes. The **home mortgage interest deduction** may contribute to larger homes and larger lot sizes. Local planners possess a greater range of **financing mechanisms for public infrastructure improvements** needed in greenfield areas than in infill areas, which have more complex financing needs. The location of **state enterprise zones** far from population centers may force workers to accept longer commutes. The **conventional approach to parking policy** – obliging each parcel to provide a minimum amount of parking – leads to large land areas devoted to parking, changing neighborhoods and transportation options.

Policies that govern how parking spaces are created and subsidized, how road space is allocated, how local governments fund infrastructure needed for infill development, and how automobile insurers charge premiums were found to be the most impactful in terms of driving petroleum demand in California. By addressing the top five policies listed above, California could reduce future petroleum use by at least 25 percent.

In some cases, reducing statewide petroleum use can be relatively simple, without any need for significant fiscal requirements, commitments or trade-offs. Caltrans or state legislature could allow transit buses to use highway shoulders. The Public Utilities Commission or state legislature could remove existing barriers for informal transportation systems, such as jitneys.

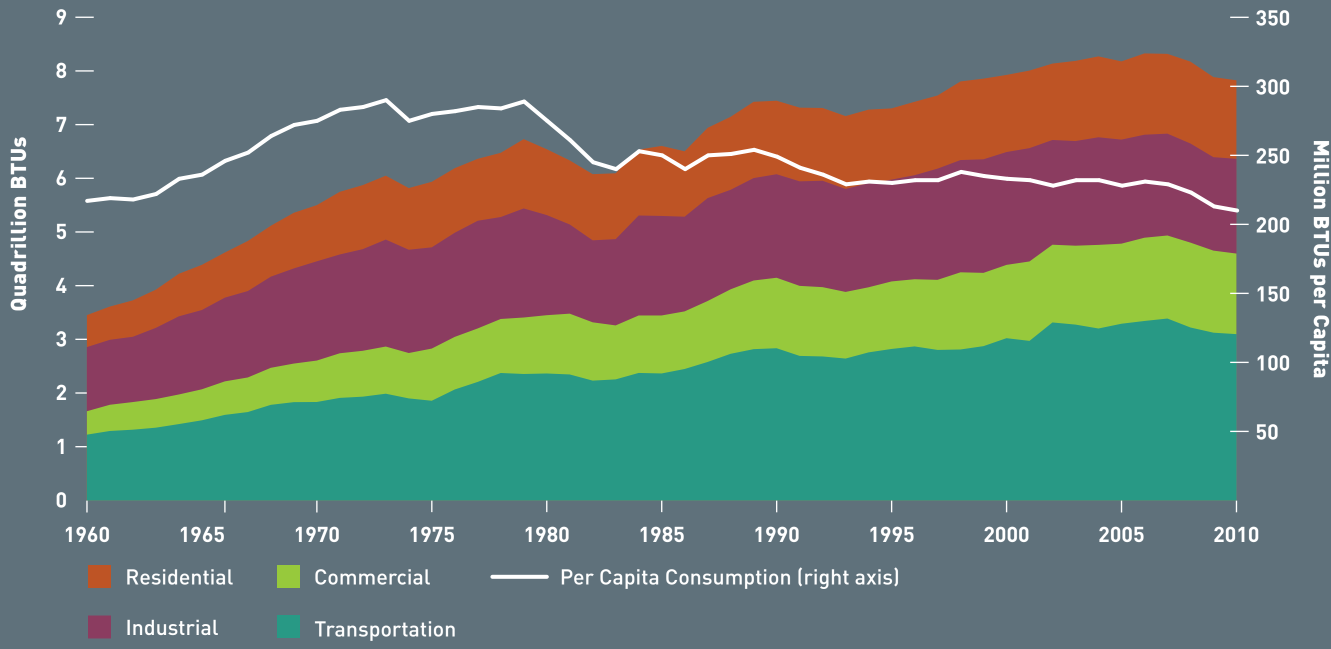
Meanwhile, many policies already underway are encouraging the state's move away from petroleum. Abundant state and federal incentives support the purchase of alternative fuel vehicles and construction of related infrastructure. The air transport sector is investing in ways to improve its efficiency. Parking cash-out programs, which offer commuters a payment in lieu of subsidized parking, have been required for two decades, although they have not been steadily enforced. And California law already allows insurers to assess automobile premiums on a variable, per-mile basis rather than a fixed annual cost. Further supporting consumers' transition to pay-as-you-drive policies could reduce statewide petroleum use by as much as eight percent while providing considerable savings for most Californians.

INTENDED AUDIENCE



Unraveling Ties to Petroleum will be useful to a range of readers, from voters to state legislators and regulators to city councilmembers and planning commissioners.

ES-1: CALIFORNIA ENERGY CONSUMPTION BY END-USE SECTOR



Next 10 Unraveling Ties to Petroleum. Source: (U.S. Energy Information Administration, 2012)

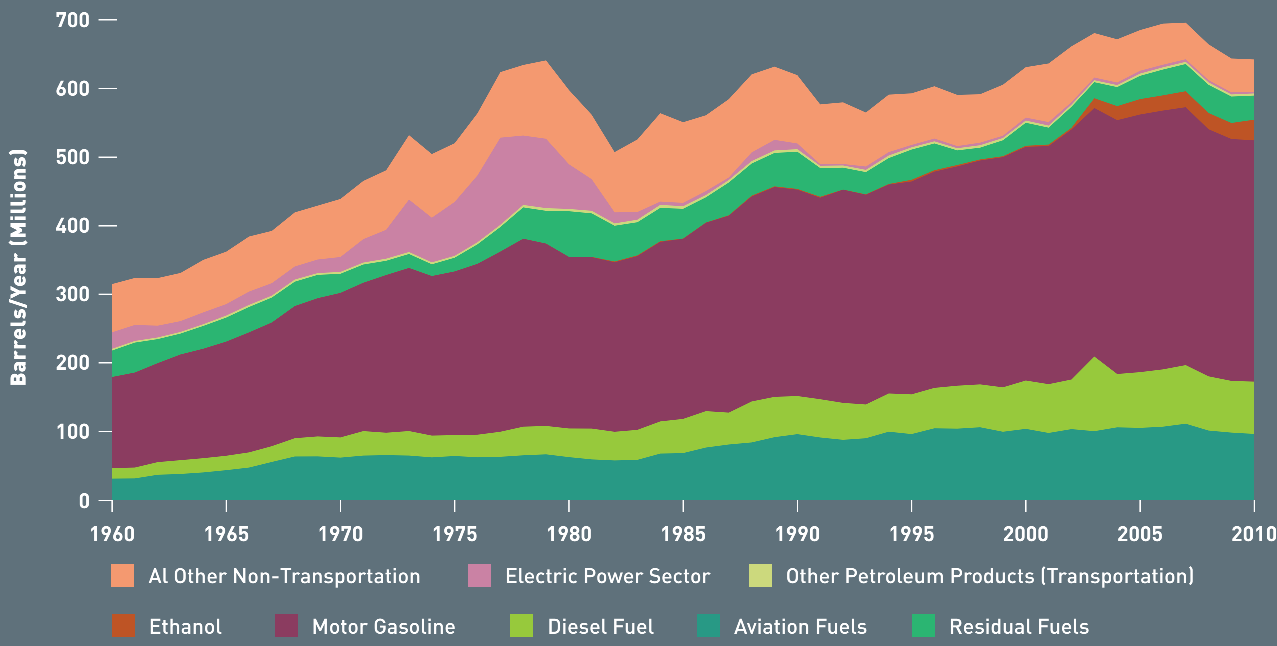
ENERGY USE IN CALIFORNIA

In 2010, California represented roughly eight percent of U.S, and 1.5 percent of global energy demand. Within California, the transportation sector accounted for 39.6 percent of energy consumption, followed by the industrial sector (22.6%), commercial sector (19.2%), and residential sector (18.7%) (U.S. Energy Information Adminstration, 2012). Transportation has been California's single largest energy consumer since the U.S. Energy Information Administration began tracking state-level data in 1960.

California energy comes from a range of fossil fuel and non-fossil fuel sources. Petroleum fulfills the greatest share (43.7%) of the state's energy demand. Natural gas (29.3%), renewables (10.1%), and nuclear (4.2%) are other principal sources of energy generated within California. A significant amount (10.6%) of California's energy supply comes from imported electricity.

Understanding the connection between petroleum use and anthropogenic climate change provides an additional impetus to reduce California's consumption of petroleum as an energy source.

ES-2: PETROLEUM PRODUCT CONSUMPTION IN CALIFORNIA



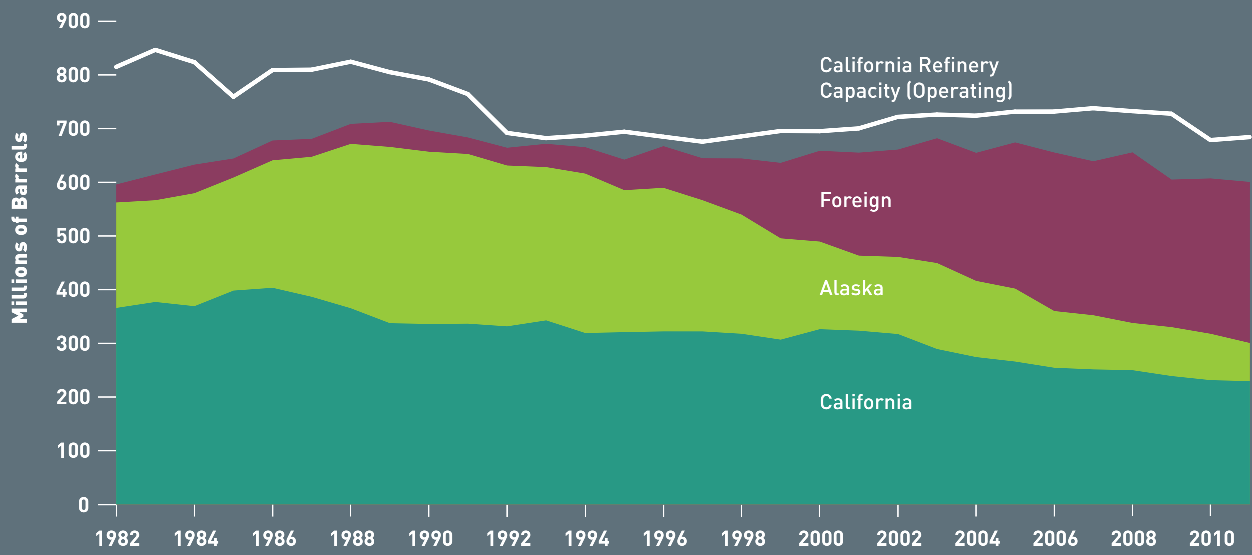
Next 10 Unraveling Ties to Petroleum. Source: (U.S. Energy Information Administration, 2012)

PETROLEUM USE IN CALIFORNIA

California currently uses roughly 1.4 percent less petroleum than it did in 1979. However, the proportion of petroleum used for transportation has increased from 64.2 percent to 86.4 percent during that time. The industrial sector, which includes construction, accounts for most (11.2% of use across all sectors) of the non-transportation petroleum use in California, down from 18.2 percent in 1979. Motor gasoline makes up the bulk of petroleum consumption. Aviation fuels loaded in California, including aviation gasoline and jet fuel, follow. Bunker fuel, a heavier of residual fuel oil, is loaded at California ports for use in marine freight transportation. Asphalt and road oil are used primarily in construction, including for roofing materials and pavement. Other petroleum products, such as motor oil, make up an insignificant amount of California petroleum demand.

The proportion of petroleum used in transportation has increased largely due to the electric power and industrial sectors transitioning away from petroleum as an energy source. Oil price shocks beginning in 1974 and peaking in 1980 created a substantial incentive for large users to invest in alternatives. Use of petroleum by the state's electric power

ES-3: CALIFORNIA REFINERY CRUDE SOURCES AND OPERATING CAPACITY

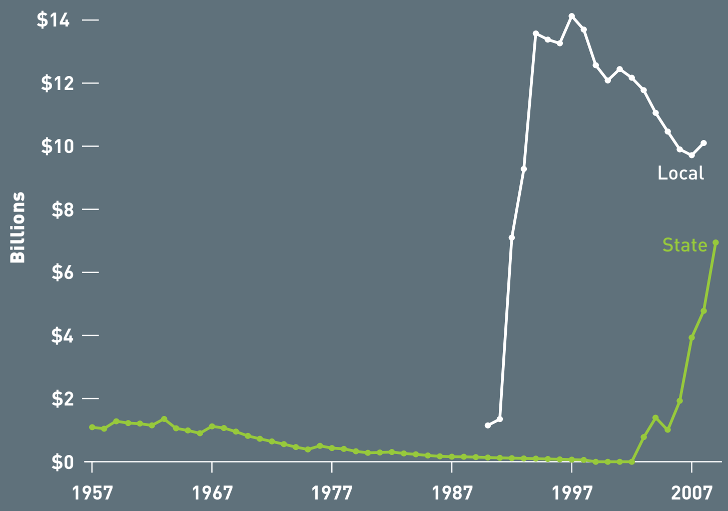


sector peaked at 19.9 percent in 1977. By 1984, less than one percent of California petroleum was used to generate in-state electricity. The Electric Power Sector now accounts for less than 0.4 percent of California petroleum demand. Industrial petroleum use as a proportion of statewide demand is down from 18.2 percent in 1979 to 11.2 percent in 2010.

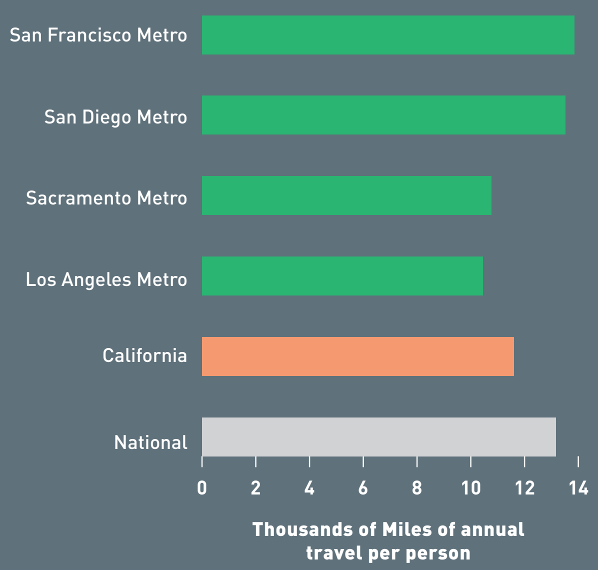
Californian and Alaskan oil production peaked in the mid-to-late 1980s. Since that time, the largest growth in petroleum receipts has been from foreign sources. Petroleum consumption in California has been in decline, as is the state's capacity to refine petroleum into finished products (see Figure ES-3).

Debt is an increasingly popular source of highway spending, growing substantially since 1990 (see Figure ES-4). This trend reflects stagnation in State and Federal taxes on gasoline, which remained unchanged since 1994.

ES-4: CALIFORNIA STATE AND LOCAL HIGHWAY BONDS OUTSTANDING, END OF YEAR (adjusted for inflation)



ES-5: PER CAPITA MILES OF TRAVEL BY REGION IN CALIFORNIA



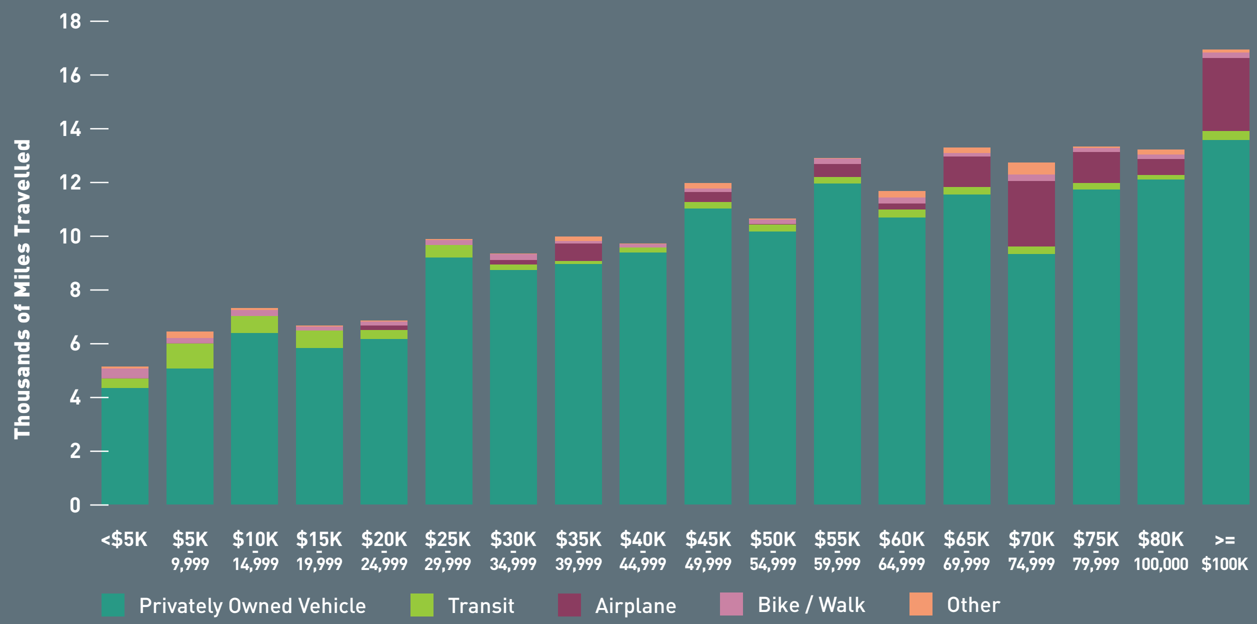
Next 10 Unraveling Ties to Petroleum. Source: (U.S. Federal Highway Administration, 2011) tables LGB-2 and SB-2 adjusted for inflation using Bureau of Economic Analysis state and local aggregate expenditrures (2005=$1.)

REGIONAL AND STATEWIDE TRAVEL

Differences in travel among California's major regions are largely a result of variations in a region's area and incomes. Higher rates of air travel among Bay Area and San Diego residents means that, across all modes, residents of these areas travel greater distances in a year than the statewide average. Los Angeles and Sacramento area residents average fewer miles than the statewide average.

While Bay Area residents travel greater distances than the average Californian, they don't drive more. Bay Area residents travel a greater proportion their annual distance on public transit (3.5% versus 2.5%) and airplanes (19.2% versus 8.3%) versus the statewide average. Thus, personal vehicle travel demand between the state's two largest regions is more balanced, with most estimates showing greater per-capita vehicle distance traveled among Los Angeles area residents. Estimates vary in methodology and regional boundaries.

ES-6: CALIFORNIA ANNUAL PER CAPITA MILES TRAVELED BY MODE AND HOUSEHOLD INCOME

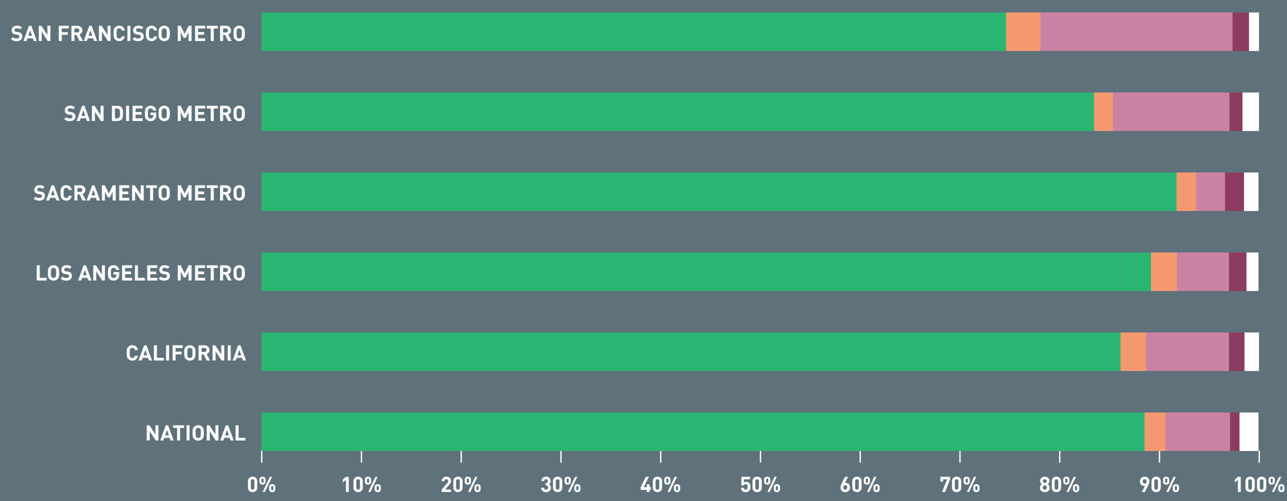


Next 10 Unraveling Ties to Petroleum. Source: (U.S. Federal Highway Administration, 2011) - 2009 National Household Travel Survey

Existing and planned measures to reduce petroleum use for transportation largely rely on technological substitution and increases in efficiency at the margins. The effects of such measures are likely to be inequitably distributed: leading to reductions in energy use but also in quality of life for some groups. An overreliance on vehicle fuel switching and efficiency versus alternatives to automobility can increase the burden for lower-income Californians. Nationally, the bottom 20 percent of households by income spend a significant share of their income (12.5%) on motor vehicle fuels.

Between 1991 and 2011, the average per capita vehicle travel distance increased by only two percent. Much of the relative increase in transit use corresponds with increases in gasoline prices.

ES-7: PERCENT OF MILES TRAVELED BY MODE



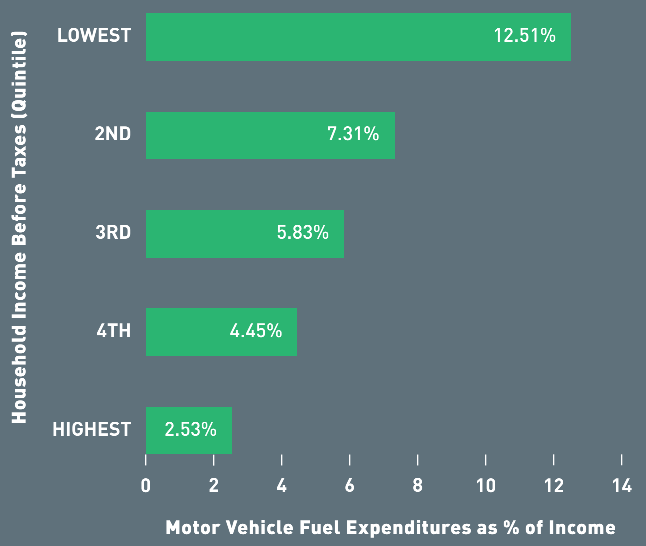
	National	California	Los Angeles Metro	Sacramento Metro	San Diego Metro	San Francisco Metro
Privately-Owned Vehicle	88.47%	86.09%	89.13%	91.70%	83.45%	74.60%
Public Transit	2.12%	2.53%	2.60%	1.94%	1.86%	3.46%
Airplane	6.45%	8.33%	5.26%	2.92%	11.72%	19.24%
Walk / Bike	0.99%	1.58%	1.71%	1.89%	1.28%	1.69%
Other	1.90%	1.43%	1.24%	1.49%	1.67%	0.99%

Next 10 Unraveling Ties to Petroleum. Source: (U.S. Federal Highway Administration, 2011) - 2009 National Household Travel Survey

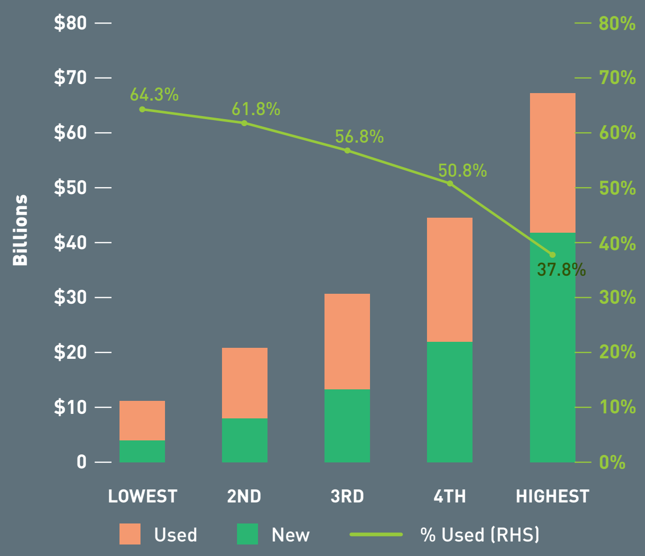
Nationally, low-income households are far more likely to purchase used vehicles than are median and higher income households. Such purchasing behavior delays their access to new, alternative fuel and highly efficient vehicles which could mitigate their exposure to fuel price increases.

Volatile global energy markets, increases in California's state excise tax, and the incorporation of transportation fuels within California's cap and trade system can all increase this burden, signaling the need for robust alternatives to automobility in order to mitigate inequitable quality

ES-8: 2011 MOTOR VEHICLE FUEL EXPENDITURES AS PERCENTAGE OF HOUSEHOLD INCOME, U.S.



ES-9: 2001-2011 VEHICLE PURCHASE EXPENDITURES BY INCOME QUINTILE, U.S.



Next 10 Unraveling Ties to Petroleum. Source: (Bureau of Labor Statistics, 2012)

of life impacts related to California's energy intentions.

Many Californians have already sought alternatives to personal vehicle travel. In 2010, the average Californian traveled about 15 percent more distance on transit than in 1990, down from 21 percent in 2009. Between 1991 and 2011, the average per capita vehicle travel distance increased by only two percent. Much of the relative increase in transit use corresponds with increases in gasoline prices.

The next few years will illuminate whether travel and energy trends observed during the Great Recession were part of a broader transition away from petroleum and automobility or largely the result of economic circumstance.

ES-10: RELATIVE CHANGE IN CALIFORNIA DRIVING AND TRANSIT USE VERSUS REAL GASOLINE PRICES SINCE 1991

Next 10 Unraveling Ties to Petroleum. Source: (U.S. Federal Highway Administration, 2011), U.S. Federal Transit Administration, 2012), and (U.S. Energy Information Administration, 2012)

15 POLICY BRIEFS UNRAVELING PETROLEUM DEMAND FROM POLICY

The electric power sector's transition away from petroleum took less than a decade. This transition resulted from a concerted effort to reduce the state's exposure to global petroleum supply and price volatility. Transitioning the transportation system away from petroleum will be substantially lengthier and more complex.

Amidst this system complexity, we aim to highlight the implications of explicit and implicit planning and policy choices. We endeavor to bridge the gap between academic research and practice in order to create accessible, actionable information. We do so to provide new information and evaluative metrics for researchers, policymakers, and analysts at all jurisdictional levels. These assessments are not intended to be terminal tomes. Policymakers interested in implementation should seek additional information on how effects may vary based on their local conditions. Scholars prompted to new research opportunities will undoubtedly seek additional information on their subjects. We developed a list of twenty-five policy factors we believe to have a direct or indirect effect on petroleum consumption in the state. After initial discussion with Next 10 and consideration of the potential value new information on each topic would have to the public and decision-makers, we narrowed this list down to a more manageable fifteen. We summarize each in order of how important we consider them to supporting California's transition away from petroleum use. We developed a list of twenty-five policy factors we believe to have a direct or indirect effect on petroleum consumption in the state. After initial discussion with Next 10 and consideration of the potential value new information on each topic would have to the public and decision-makers, we narrowed this list down to a more manageable fifteen. We summarize each in order of how important we consider them to supporting California's transition away from petroleum use.

Unlike the electric power sector–where decision-making is concentrated and generators and utilities are subject to strict, direct regulatory control, the transportation system is comprised of millions of loosely-regulated individual actors. Changing policies and implementing new measures to indirectly influence how California's 35,209,430 registered motor vehicles travel will have uncertain outcomes. Government has little direct control over these vehicles, other than through use of official traffic control devices and enforcement of the California Vehicle Code.

These assessments transcend the technical demands of California's transportation energy transition. Transportation requires dense, mobile energy storage – something that gasoline and diesel provide, but alternative fuels have struggled to match. The transition to electric propulsion makes energy storage and range a significant cost driver – a substantial departure from petroleum-based propulsion.

Moreover, travel is rarely an end in and of itself – but rather a means for an individual or group to access some economic or social opportunity – typically occurring at a fixed location. Thus, understanding the complex, integrated transportation and land use system – and the incentives it produces – is crucial to creating sustained changes that support policy goals. Each of the fifteen policy factors is described below.

1. CONVENTIONAL APPROACHES TO NON-RESIDENTIAL PARKING POLICY

Many cities are unwilling or unable to use market controls to manage a finite resource: on-street parking. Instead, they use minimum parking requirements in an attempt to manage scarcity and avoid the tragedy of the commons — spillover parking demand. Conventional parking approaches, which seek to predict and provide for peak parking demand in order to avoid parking spillover, greatly subsidize the true cost of driving and distort urban form.

Several alternatives to conventional parking policy exist. They include adaptive reuse of existing buildings without the need for additional parking, shared parking among many buildings in a district, in-lieu fees that fund alternative transportation and reduce the demand for parking, wayfinding to increase utilization of existing parking infrastructure, and the market-based allocation of parking spaces.

The transition away from conventional parking policy would occur gradually over the long-term, based on future changes to the built environment. Existing parking supply would likely remain. Changes in urban form would occur most rapidly in areas where current parking policy most constrains the built environment.

2. USE OF PERFORMANCE MEASURES THAT PRIORITIZE AUTOMOBILES OVER OTHER MODES IN CONGESTED AREAS

Most transportation departments in California use performance metrics that explicitly or implicitly ignore modes other than the automobile. The result is that many projects to expand the transportation network focus on adding automobile capacity at bottlenecks, rather than using alternatives to move additional persons. Because the scope of analysis excludes alternative modes, many transportation decisions impair the service quality of transit, walking, and biking. The implications are a profound effect on urban travel and motor vehicle fuel use.

Use of automobile-centric methods often leads a crowded bus to share equal weight with a single-occupant automobile. This leads the benefits of a bus-only lane – reduced delay for transit passengers and increased throughput through corridors – to be ignored. The method only considers delay for automobile drivers, a relic of such methods initial intent to proxy a driver's perception of roadway service quality. Thus, cost-benefit analyses often favor decisions that support drivers over passengers, leading to land use and transportation decisions that reinforce low-occupant vehicle use.

Local governments are largely free to transition to new methods on their own, provided that they amend their general plans to revise their transportation performance goals and prescribed methods for determining those goals. However, few understand the implications of current methods, and even fewer have made the transition. Transitioning to new methods to assess and optimize the performance of California's transportation network will lead to rapid increases transit, walking, and biking amenities.

3. BUNDLING OF RESIDENTIAL PARKING IN HIGH-QUALITY TRANSIT AREAS

On-street parking is perceived to be a scarce resource in many areas of California. Conventional parking policy, used by many California local governments to mitigate competition for on-street parking resulting from new development, prioritizes conflict avoidance over other goals – such as reducing vehicle trips. Changes in parking policy can make transportation alternatives attractive in areas where they are likely to be more robust. The state may be able to achieve substantial reductions in fuel use simply by separating the price of parking from the price of housing in areas where high quality transit exists.

Local governments can unilaterally employ unbundled parking in high quality residential areas through changes to zoning codes. Alternatively, the State legislature can mandate this change – something policymakers have twice proposed. Such a policy change could have a high magnitude effect on petroleum use as the state's four major regions expect 1.3 million new housing units in high quality transit areas over the next three decades.

4. AUTOMOBILE INSURANCE RATE STRUCTURE

Californians spend about half as much on automobile insurance premiums as they do on gasoline. A transition to per-mile insurance premium calculations would increase the variable cost of each mile driven and lead to lower premiums for a majority of drivers and lead to a significant reduction in driving per capita.

The State's Department of Insurance now allows insurers to offer pay-as-you-drive programs. The transition could be a virtuous adoption cycle as low-mileage drivers shifting to per-mile plans triggers rate increases for drivers on annual plans. Faced with premium increases, more low-mileage drivers will switch to per-mile plans.

However, California faces two challenges in triggering this adoption cycle. First is consumer awareness. Second is a critical mass of per-mile policyholders in order for insurers to calculate per-mile actuarial risk, where early uncertainty may increase per-mile premiums. Early incentives may be necessary to induce early adoption of per-mile plans.

5. COMPENSATED AND REAL-TIME RIDESHARE BARRIERS

Sharing the ride is the elusive holy grail of options to reduce congestion and petroleum use. Each matched ride can take one vehicle off the road. However, sharing the ride is inherently more difficult than driving alone. Matching shared rides faces structural, communications, and incentive barriers that existing publicly-sponsored rideshare programs have addressed, but have yet to fully overcome.

Recent innovations in transportation service delivery can increase the utilization of existing transportation assets, including empty seats in private vehicles. New market entrants are in part responding to a structural shift in the market for automobility–a transition from reliance on privately-owned transportation assets to increased reliance on transportation as a service retained by the traveler. New private services directly address existing rideshare barriers, but their potential to fully overcome them is still undetermined. The new services require the blessing of the California Public Utilities Commission, which as of spring 2013 is considering applicable regulations.

6. INFRASTRUCTURE AND COST BARRIERS TO ALTERNATIVE FUEL VEHICLE ADOPTION

Most federal, state, and local policies to promote alternative fuel vehicles attempt to influence consumer and firms' vehicle purchase decision. These policies include financial subsidies for vehicle or equipment purchases, supply-side incentives for manufacturers of alternative fuel vehicles, and special privileges for users of alternative fuel vehicles.

The vehicle fleet replacement cycle limits the time frame over which policies to support alternative fuel vehicle acquisition will take effect. The California Air Resources Board estimates that a 50 percent of automobiles sold in California in 2011 will still be on the road in 13 years (California Air Resources Board, 2011). As alternative fuel vehicles currently make up a small percentage of new vehicle sales in California, achieving 50 percent or greater market share of alternative fuel vehicles is a long-term proposition.

Increasing the share of alternative fuel vehicles in the fleet will reduce consumption of petroleum, but increase consumption of energy from other sources. Switching to alternative fuel vehicles is unlikely to have a one-to-one effect on petroleum demand as petroleum is often used to process or distribute alternative fuels.

7. FUNDING PUBLIC INFRASTRUCTURE IMPROVEMENTS FOR NEW DEVELOPMENT

In post-Proposition 13 California, developers pay for much of the additional infrastructure required to support new development: schools, sewage systems, water delivery, and transportation improvements. While California law provides several options to finance public infrastructure improvements, most financing mechanisms are more applicable to greenfield development than to urban infill and brownfield development. The net result is likely a distortion of land use patterns that favors additional distance traveled.

State legislatures need not amend or repeal Proposition 13 to level the playing field. However, making the transition will likely require the reinstatement of tax-increment financing as an option for public infrastructure improvements required for infill development, particularly in high quality transit areas.

8. CARSHARE BARRIERS

Carshare is an emerging service category that fills existing gaps in travel choice for individuals and households seeking to shed or delay purchase of personal automobiles. Evolution in carshare service offerings will expand the market for the service by reducing the price and providing a greater range of options to meet consumer needs. Because carshare converts a fixed cost to a variable cost, it can reduce driving at the margins.

Carshare is currently available in California and there are few state-level regulatory barriers to its expansion. Local governments can support carshare by providing dedicated parking spaces for carshare services, either on-street, in public lots, or inside private development. Local governments must grant special parking privileges to attract point-to-point carshare services, which do not require dedicated spots and allow for one-way rentals.

9. LACK OF AWARENESS AND ENFORCEMENT AROUND PARKING CASH-OUT PROGRAMS

Existing California law requires many employers of more than 50 to offer employees a cash payment in lieu of any parking subsidy. Such a program allow employers to reduce the number of parking spaces they purchase or lease and gives employees an additional economic incentive to carpool, cycle, walk or use transit for their commute. Although the law is almost two decades old, a lack of information about which employers must offer cash-out impedes oversight and enforcement.

10. HIGH-OCCUPANCY VEHICLE NETWORK EXPANSION THROUGH LANE CONVERSION RATHER THAN NEW CONSTRUCTION

Policymakers expect HOV lanes to encourage rideshare by providing a benefit, time savings and reliability, to those in high occupancy vehicles. Nearly all HOV lanes implemented in California have been newly constructed rather than converted from existing general purpose lanes. Constructing rather than converting lanes delays the implementation and increases the expense of a complete HOV network. The result is the delayed effectiveness and lost opportunities to reduce petroleum use.

If California policymakers decided to permanently convert existing lanes to HOV lanes rather than constructing them anew, the benefits of a completed metropolitan HOV network lanes would begin nearly instantaneously, reaching a steady state in the near term as individuals adjust their travel behavior. If transportation system users perceive a conversion as temporary, they may seek to wait out the change rather than adjust travel behavior.

11. BARRIERS TO IMPROVING EXPRESS BUS SERVICE

Allowing transit buses to use highway shoulders would lead to immediate efficiency benefits for express buses. Express bus ridership would increase in the mid-to-near term as more commuters are attracted to the service's reliable travel times. The Twin Cities region has a successful bus on shoulder program that is more than 20 years old. Attempts at pilot projects in California have not seen enduring success, but changes in state law could spur new trials.

Allowing transit buses the use of shoulders on controlled-access highways would affect only a small portion of transit route-miles in the state. Its effect on statewide motor vehicle fuel use would be similarly small. However, bus on shoulder treatments may be a viable option to improve the reliability of express and commuter bus transit service.

12. AVIATION PRACTICES AND PROCEDURES

Existing air traffic regulations and procedures are greatly limited by imprecise information about aircraft location and delayed command and control of aircraft. These limitations manifest in a multi-segment approach procedure that requires aircraft to level off at various stages. Continuous descent approach would allow aircraft to glide in for landing, reducing fuel consumed during the approach phase of flights.

13. DEDUCTIBILITY OF HOME MORTGAGE INTEREST AND STATE AND LOCAL REAL PROPERTY TAXES FROM TAXABLE INCOME

Though most scholars agree these interest deductions do little to affect home ownership rates, there is less agreement about their effects on land use. Some believe interest and property tax deductibility leads to larger lot size and larger houses. Others think they increase the price households are willing to pay for neighborhood amenities. Regardless of the land use impacts, the strongest effects are felt in California.

Transitioning to new methods to assess and optimize the performance of California's transportation network will lead to rapid increases transit, walking, and biking amenities.

Californians who itemize mortgage interest on their tax returns claim a higher value than in any other state, and growth limitations exacerbate any effects the deductions may have. California legislators can discontinue the home mortgage and local tax deduction from taxable income considered for state purposes. However, as federal income tax rates are higher than state rates, any effects on real estate markets would likely be muted without a federal legislative change.

14. LOCATION OF STATE ENTERPRISE ZONES

California provides employer incentives to encourage employment in certain geographic areas of the state. If enterprise zones change the location of employment, they only do so slightly: firms that would have located near the enterprise zone locate within the enterprise zone instead. However, one State Enterprise Zone provision may slightly impact the distances employees travel to work. Employers are eligible for tax credits when they hire residents of targeted employment areas. Because this tax incentive is not restricted to a given enterprise zone's targeted employment areas, a potential result is additional distance by employees who travel between enterprise zone areas.

15. BARRIERS TO ENTRY FOR INFORMAL TRANSIT SERVICE

California law requires informal transit operators to obtain a state or local license in order to operate. The licensing and insurance requirements serve as barriers to entry for informal transit services, such as jitneys, which frequently compete on cost. Reducing or eliminating regulatory barriers to jitney service would likely formalize existing, unlicensed operations in the state. However, increases in informal transit services would attract passengers otherwise served by existing shared transportation services or who are currently unserved, negating any petroleum-related benefits.

Brief Title and Relevant Topics	Magnitude (estimated effect on fuel use from decision to address factor)	Certainty	Primary Effect on Fuel Use	Secondary Effect on Fuel Use	Applicable Level of Government	Time-Horizon for Implementation and Effectiveness
1. Conventional Approaches to Non-residential Parking Policy parking, zoning, urban form	High (5.7% to 24.9% reduction)	Medium	Distance Traveled	Mode Choice and System Operations Efficiency	Local	Long-Term
2. Use of Performance Measures that Prioritize Automobiles over Other Modes in Congested Areas level of service, traffic congestion, transit priority, roadway expansion	High (3% to 15% reduction)	Medium	Improved System Operations Efficiency with offsetting increase in Distance Traveled	Mode Choice	Local	Near-Term
3. Bundling of Residential Parking in High-Quality Transit Areas parking, transit, housing	High (3% to 7% reduction)	Medium-High	Mode Choice	Distance Traveled	State, Local	Near-Term
4. Automobile Insurance Rate Structure automobile insurance, marginal cost of driving	High (8% reduction)	High	Distance Traveled	System Operations Efficiency	State	Medium-Term
5. Compensated and Real-time Rideshare Barriers rideshare, taxi, e-rideshare	High (0.04% increase to 18.35% reduction)	Medium	Vehicle Miles Traveled	Mode Choice	Local, State, Federal	Near-Term
6. Infrastructure and cost barriers to Alternative Fuel Vehicle Adoption electric vehicles, hydrogen vehicles, natural gas vehicles, incentives, tax expenditures	High (not evaluated, approved policy in process)	High	Fuel Composition		Federal, State, Local	Near-Term
7. Funding Public Infrastructure Improvements for New Development municipal finance, impact fees, infrastructure finance	Medium-High (2% to 5% reduction)	Low-Medium	Distance Traveled		Local, State	Near-Term
8. Carshare Barriers automobile ownership, transportation services, technology	Medium (0.05% to 7% reduction)	Medium	Mode Choice	Distance Traveled	State, Local, Federal	Near-Term

Brief Title and Relevant Topics	Magnitude (estimated effect on fuel use from decision to address factor)	Certainty	Primary Effect on Fuel Use	Secondary Effect on Fuel Use	Applicable Level of Government	Time-Horizon for Implementation and Effectiveness
9. Lack of awareness and Enforcement around Parking Cash-out Programs	Low-Medium (0.6% to 2.5% reduction)	High	Mode Choice		State, Air District, Local	Near-Term
10. High-Occupancy Vehicle Network Expansion through Lane Conversion rather than New Construction carpool, rideshare, transportation network expansion, incentives	Low-Medium (0.1% to 0.5% reduction)	Medium	Mode Choice	System Operation Efficiency	County, Regional, State, Federal	Near-Term
11. Barriers to Improving Express Bus Service transit, controlled-access highway	Low (0.004% to 0.063% reduction)	Medium-High	Mode Choice		State	Near-Term
12. Aviation Practices and Procedures aviation, next generation air transportation system	Low-Medium (for aviation) (1% to 3% reduction in aviation fuel use)	Medium-High	System Operation Efficiency		Federal	Near-Term
13. Deductibility of Home Mortgage Interest and State and Local Real Property Taxes from Taxable Income mortgage, income tax, deduction, financial incentives, tax expenditures, home ownership, housing	Low-Medium (0.1% to 2.6% reduction)	Low-Medium	Distance Traveled	Other-building energy demand	Federal, State	Near-Term
14. Location of State Enterprise Zones tax expenditures, economic development, employment	Low (0 to 0.1% reduction)	Medium	Distance Traveled		State, Local	Near-Term
15. Reducing Barriers to Entry for Informal Transit Service jitneys, dollar vans, entrepreneurship in mass transportation	Low (0 to 0.15% reduction)	Medium-High	Mode Choice		State, Local	Near-Term

ABOUT

THE AUTHORS

As Director of the UCLA Local Climate Initiative, **Juan Matute** researches performance measurement in transportation and land use systems and non-linear change in dynamic, complex urban systems. As a Lecturer in Environmental Science at UCLA, Juan teaches a systems-based approach to local climate planning and policymaking. He co-authored a chapter in the Oxford Handbook of Urban Planning that explains the role of multi-level governance and accounting frameworks in climate planning.

Juan seeks to translate academic research into a form useful to those charged with managing California's transition to a low-carbon economy. He has advised several local government greenhouse gas inventories and climate action plans in California – he wrote the method that most now use to estimate greenhouse gas emissions from passenger vehicles. He managed UCLA's work on California's Statewide Transit Strategic Plan and created TransitWiki.org, a best-practices sharing website for transit practitioners. He is a member of the American Institute of Certified Planners.

Stephanie Pincetl is Adjunct Professor and Director of the California Center for Sustainable Communities at UCLA. Dr. Pincetl conducts research on environmental policies and governance and analyzes how institutional rules construct how natural resources and energy are used to support human activities. She is an expert in bringing together interdisciplinary teams of researchers across the biophysical and engineering sciences with the social sciences to address problems of complex urban systems and environmental management.

She has received funding from the California Energy Commission PIER program to develop a methodology to understand energy use in communities in California using urban metabolism methods coupled with social policy considerations. Her book, Transforming California, the Political History of Land Use in the State, is the definitive work on land use politics and policies of California. Dr. Pincetl is the Faculty Director of the Los Angeles Regional Collaborative for Climate Action and Sustainability (LARC), a Los Angeles regional organization dedicated to working across jurisdictions to achieve a better future.

THE ORGANIZATIONS

Next 10 is focused on innovation and the intersection between the economy, the environment, and quality of life issues for all Californians. Next 10 creates tools and provides nonpartisan information that fosters a deeper understanding of the critical issues affecting all Californians. Through education and civic engagement, we hope Californians will become empowered to affect change.

Next 10 was founded and is funded by venture capitalist and philanthropist F. Noel Perry.

The California Center for Sustainable Communities (CCSC) is a statewide University of California collaboration, funded and supported by the Public Interest Energy Research Program of the state Energy Commission. The Center conducts work on topics important to the transition toward greater urban sustainability, bringing together the leading edge researchers and centers from across several campuses. CCSC provides research, insights, data, methods, models, case studies, tools and strategies to address land use and transportation challenges facing California communities, and serves as a resource for policy makers, stakeholders and the residents of the state. Our mission is to assist the state's communities in the transition to greater sustainability on multiple fronts.

The Center is housed at UCLA and is a collaboration between the UC Berkeley's Center for Resource Efficient Communities, UC Davis Extension's Land Use and Natural Resources Program, UC Davis' Plug-in Hybrid and Electric Vehicle Center, UC Davis' Center for Regional Change, and UCLA's Institute of the Environment and Sustainability.

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We would like to recognize those who have worked to communicate complexity research for use in the social sciences and to understand urban systems. We are particularly grateful for the work of the Santa Fe Institute, Sustainability Institute, and the late Donella Meadows.

Ha Hyun Chung served as a research and administrative assistant for this project and co-author of the aviation-focused brief on continuous descent approach. He is a student in UCLA's environmental science program and considering a career in law. Zoe Elizabeth of the Center for Sustainable Communities at UCLA also provided invaluable review and administrative support.

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Lastly, we'd like to thank our outside reviewers who made the briefs more pertinent to practice. Any remaining errors or emissions are our own.

DESIGNED BY JOSÉ FERNANDEZ

Introduction

California's energy paradigm is shifting in this new Millennium. The prior paradigm, energy use as a means to near-term economic development, no longer serves the state's economic and environmental policy goals. Thus, the state has evolved a new paradigm: energy use capable of supporting long-term social, economic, and environmental sustainability goals. As this paradigm shifts, the State must re-evaluate its legacy policy choices that directly or indirectly drive energy use and make changes to consistently support the evolved goals.

Moderating petroleum's effect on the State's economic and social systems compels the transition away from petroleum use. Rising fuel prices burden all Californians, especially those with little wealth or alternative transportation options. Understanding the connection between petroleum use and anthropogenic climate change provides an additional impetus to reduce California's consumption of petroleum as an energy source.

Many of these effects are indirect and uncertain, but real. *Unraveling Petroleum* outlines an alternative approach to understanding policy implications in a highly complex, layered and interwoven system. Urban form and travel activity is the result of the complex interactions over time, shaped by past policy choices. We seek to unravel path dependencies, interconnectedness, and multiple feedback loops in order to link petroleum consumption with policy decisions that, at first blush, may not seem connected to energy use. In doing so, we produce new information on linkages and policy alternatives that can support the State's energy transformation.

As policymakers pursue evolved goals, they must consider how pre-existing policies may erode the effectiveness of new policies. Incremental decision-making approaches often fail to address these detrimental effects, which can undermine new policymaking efforts. *Unraveling Petroleum* supports policymakers looking to actively address inertia and path-dependency through a zero-based decision-making approach.

The State of California and its local and regional governments can use the information in this report as they implement new policies to transition away from petroleum in statewide energy consumption while maintaining quality of life goals. As policymakers pursue evolved goals, they must consider how pre-existing policies may erode the effectiveness of new policies. Policymakers may also consider the policy alternatives detailed in this report, most of which extend beyond existing and planned statewide measures. Existing and planned statewide measures largely rely on technological substitution and increases in efficiency at the margins. The effects of such measures may be inequitably distributed, leading to reductions in energy use but also in quality of life for some populations.

Intended audience

We intend *Unraveling Petroleum* to be useful to a range of audiences:

- A city councilmember, planning commissioner, or staff member can use *Unraveling Petroleum* to better understand available options to address their community's petroleum use.
- A state legislator or regulator can use *Unraveling Petroleum* to learn of additional opportunities to ease California's transition from petroleum.
- Researchers can identify the need for impactful research where current knowledge is limited.

- The public and organizations can learn about complex, often counter-intuitive, dynamics present in California's energy and transportation systems. Such knowledge may inform advocacy at the local, regional, and state levels.

California's petroleum goals

California seeks reductions in statewide petroleum use for two primary reasons. Firstly, the state's greenhouse gas goals, as set forth in the Global Warming Solutions Act of 2006 (AB 32), require that greenhouse gas emissions decline to 1990 levels by 2020. Secondly, the state seeks to mitigate the adverse effect that price increases and volatility in transportation fuel market has on quality of life and economic productivity in California.

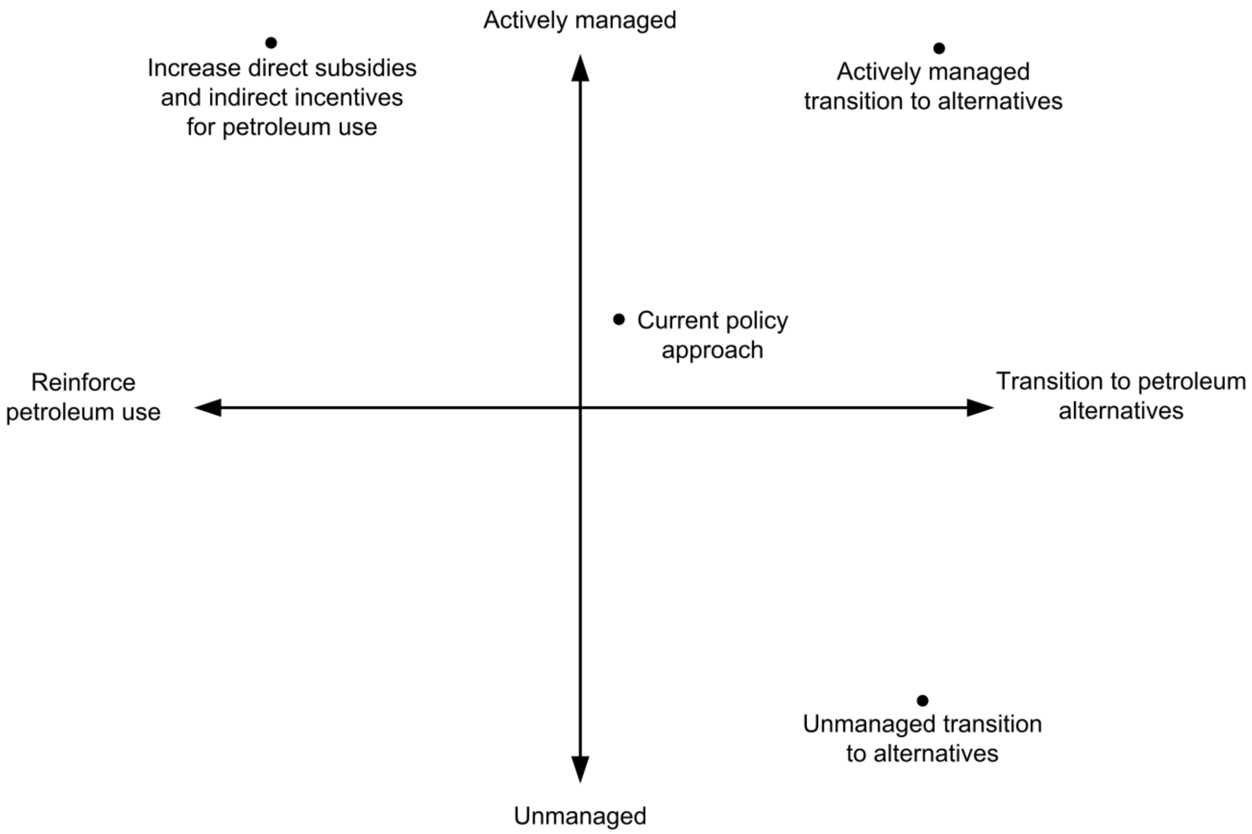
The transportation sector emits 38% of the greenhouse gases in the state. Transportation accounts for 36% of consumption-based emissions, which consider how activities inside the state produce emissions both within the state and elsewhere. Fossil fuel extraction and refining are responsible for an additional 14% of consumption-based emissions (California Air Resources Board, 2008). The State has implemented or planned various measures to reduce greenhouse gas emissions from transportation (see Table 1).

California cannot achieve its energy efficiency goals without addressing petroleum use. Petroleum accounts for 98.9% of total transportation energy use in California. Transportation accounts for 86.4% of statewide petroleum use and petroleum comprises 43.7% of California's total energy consumption. Since 1995, retail gasoline prices in California exceed national averages by an average of 7.2%. This gap will increase when the state caps greenhouse gas emissions from transportation in 2015.

Policy approaches for achieving California's petroleum goals

The state can pursue a range of petroleum-related policy approaches to achieve its petroleum goals. We categorize four possible approaches along two dimensions (see Figure 1). The first dimension is the extent to which government must intervene under the approach. We are careful not to confuse the status quo, the path-dependent consequence of past and current government interventions, with a laissez-faire or unmanaged approach. The second dimension is the degree to which the approach addresses petroleum's role in statewide energy use. This continuum ranges from efforts to reinforce petroleum use (a double-down approach) to efforts to transition toward petroleum alternatives. We discuss these approaches in the following section.

Figure 1: California's petroleum-related policy approaches



1. Current policy approach

We characterize California's current policy approach as somewhere on the continuum between no policy change and an actively managed transition. Under this approach concept, the state does not implement new policies beyond those already underway or planned (see Table 1).

Another noteworthy concern is the potential equity impact of the state's current policy approach, which we discuss in a following paragraph.

Existing policies will likely obstruct the transition to petroleum alternatives. Pre-existing policies such as minimum parking requirements and automobile level of service prevent or undermine transition-supportive changes to the transportation and land use system. These relative performance standards would continue to apply to all system changes, perpetuating existing conditions and reinforcing petroleum use.

Table 1: Existing statewide measures to reduce petroleum use

Measure(s)	Affected intermediate indicator[1] of petroleum demand	Description
Advanced Clean Car Program	Vehicle fuel efficiency, fuel composition	The program is an umbrella for California's implementation of the Federal Corporate Average Fuel Economy mandate and the State's Zero Emission Vehicle program.
Low Carbon Fuel Standard/ Renewable Fuel Standard	Fuel composition	These state and federal standards will reduce the petroleum content of motor vehicle fuels supplied in California.
Regional Transportation-Related Greenhouse Gas Targets	Distance traveled	The Sustainable Communities and Climate Protection Act of 2008 (SB 375) sets regional transportation greenhouse gas targets and allows regional and local governments flexibility in achieving the targets. Some regional and local governments may elect to implement measures detailed in this report as part of their Sustainable Communities Strategies.
Medium/heavy duty vehicle measures	Vehicle fuel and operation efficiency	Various measures affect vehicle aerodynamics and tire resistance.
Light-duty vehicle efficiency measures	Vehicle operation efficiency	Includes the low friction oil program, the tire tread program, and the tire pressure regulation. The tire pressure regulation requires automotive service providers to check tire pressure for vehicles under 10,000 pounds and inflate as appropriate.
High Speed Rail	Mode choice	High speed rail will reduce petroleum use by shifting trips from air and car travel. Its effects on greenhouse gas emissions and life-cycle energy use are still under debate.
Ship electrification	Fuel composition	Some other power source, usually grid electricity, is used to replace auxiliary diesel power for ocean-going vessels docked in California ports.

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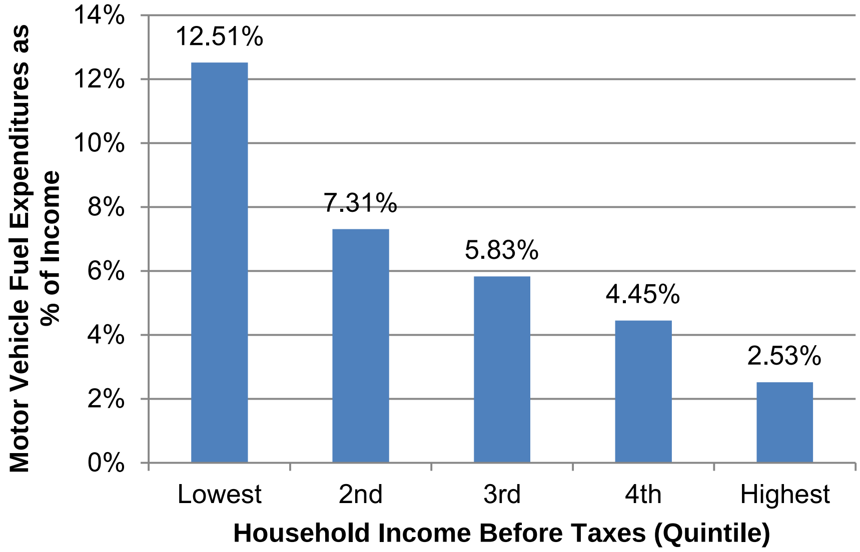
[1] for details on these intermediate factors of petroleum demand, see Chapter 3 of this report

Equity concerns with current policy approach

The state's present policy approach does not actively address those Californians for whom petroleum prices and automobility costs currently create a hardship. As these costs increase, it is likely that low-income Californians will be most burdened. In 2011, the poorest 20% of U.S. households spent an average of 12.5% of their pretax incomes on motor vehicle fuels (U. S. Bureau of Labor Statistics, 2012).

Figure 2: 2011 motor vehicle fuel expenditures as percentage of household income, U.S.

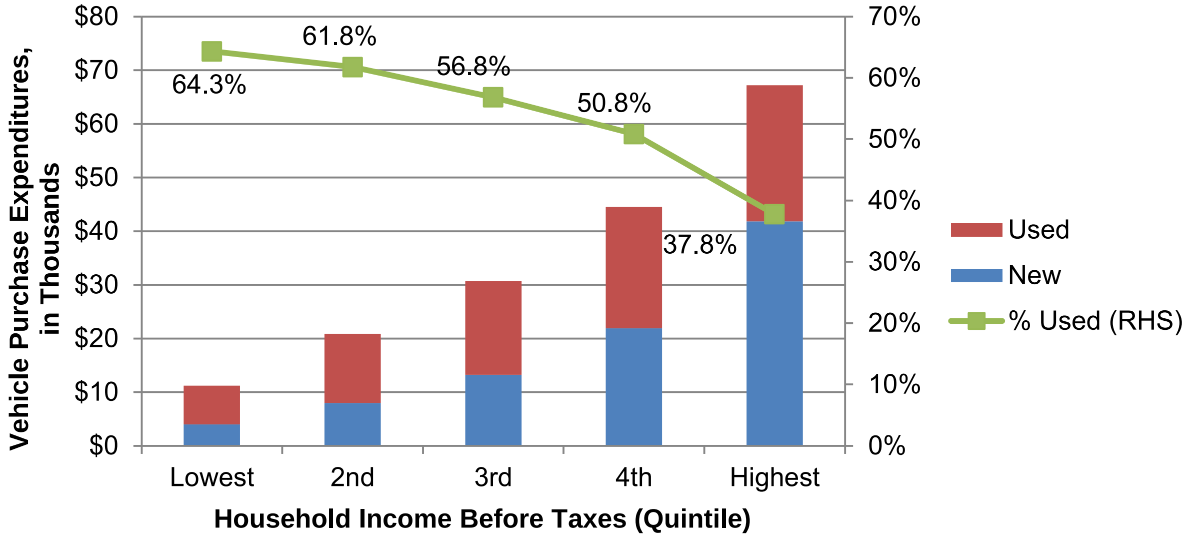


Source: (U. S. Bureau of Labor Statistics, 2012)

Measures to increase the fuel efficiency of new vehicles sold in California will not substantially mitigate this hardship in the short-run. If current vehicle purchase trends persist, it is likely that state-level policy will widen the fuel efficiency gap between the vehicles held by lower-income households and those held by upper-income households. Lower-income households are more likely to purchase used vehicles than are upper-income households (see Figure 3). In 2009, the vehicles available to California households making less than $25,000 per year were, on average, 12.8 years old (U. S. Federal Highway Administration, 2011). Vehicles available to California households earning over $100,000 annually were, on average, 8.1 years old (U. S. Federal Highway Administration, 2011). As a vehicle from the current model year becomes significantly more fuel efficient than the median used vehicle, it is likely that the fuel efficiency gap between vehicles held by lower-income households and higher-income households will also grow.

Lower-income Californians could be less likely to obtain alternative fuel vehicles. In particular, electric vehicles may pose a unique challenge to the traditional model of older vehicles trickling down to lower-income households. Internal combustion engine vehicles depreciate in value over time, making older vehicles more affordable to lower-income households. However, if batteries in vehicles with partially or fully-electric powertrain degrade over time and require replacement, this added cost will create a barrier to low-income household acquisition of mid-life electric vehicles. Low-income households living in or suburban or exurban areas may also avoid purchasing electric vehicles with degraded batteries due to range limitations.

Figure 3: 2001-2011 vehicle purchase expenditures by income quintile, U.S.



Source: (U. S. Bureau of Labor Statistics, 2012)

If vehicles owned by low-income households are more reliant on petroleum than the median vehicle, these households will have a more severe exposure to future fuel price increases and volatility. We believe that these concerns merit future research on the ownership cycle of emerging alternative fuel vehicles.

Mitigating this exposure for lower-income households will require alternatives to the traditional model of automobile ownership and operation. These alternatives include carshare, rideshare, improvements to transit service, and increased affordability of housing near high-quality transit service and job centers.

2. Actively managed transition to petroleum alternatives

Under this approach, government manages society’s transition away from petroleum use with active intervention and a firm understanding of the direct and indirect effects of past and future policy options. Elements of government’s intervention in the transportation and land use system largely fall into three categories:

1. Efforts to increase the energy efficiency of mobility (more person-miles per unit of energy consumed)
2. Efforts to swap out petroleum for alternative sources of energy (lower proportion of energy from petroleum)
3. Efforts to increase accessibility (fewer person-miles per desired travel outcome)

Implementing this approach would require additional policy intervention. Present petroleum-reduction measures are largely focused on preserving automobility. Under the actively-managed policy approach, government would place a greater focus on the third measure and incorporate a multimodal approach in addressing the first.

The state may seek a new policy approach to achieve/preserve the quality-of-life outcomes that petroleum use has historically provided Californians. Under the status quo, Californians must purchase and maintain a privately-owned automobile in order to realize the full mobility and accessibility benefits of the publicly-funded or government-influenced transportation system. Accessing the majority of the roadway network and utilizing government-mandated parking supply requires vehicle ownership. Under the actively-managed approach, government would support a greater diversity of mobility choices for individuals seeking to meet their accessibility needs. As the costs of petroleum use and automobility increase, such an approach may be preferable to the current approach in mitigating equity impacts while easing the State's transition away from petroleum.

For decision-makers pursuing such an approach, this report offers an understanding of the system's structure and dynamics, identifies pre-existing policies that must be dismantled, and presents future policy options to pursue.

3. Increase direct subsidies and indirect incentives for petroleum use

One policy response to mitigate equity impacts from petroleum price increases and volatility is to increase direct subsidies and indirect incentives for petroleum use. While some policies can be targeted at specific vulnerable populations, some cannot be. Such an approach may be difficult to sustain over the long-term, as it will require ever-increasing government intervention, likely including a commitment to increase fiscal subsidies at a rate higher than inflation.

System-wide performance standards cannot be targeted at specific users without introducing new regulatory controls. As we explain below, such policies can lead to subsidies that grow in perpetuity. The vulnerable proportion of the population will increase if petroleum prices and automobility costs increase at a faster rate than incomes.

Many pre-existing policies serve to increase indirect incentives for petroleum use. For example, uniform minimum parking requirements call for ever-increasing per-space subsidies in dense areas. Providing required parking amounts in denser areas necessitates subterranean or above ground parking structures, where per-space costs increase with each additional level of the structure.

The pursuit of level-of-service standards leads to ever-increasing costs to mitigate congestion. As the width of public rights-of-way is finite and largely fixed, supply-side congestion mitigation options require the acquisition of additional right-of-way or engineering solutions to increase vehicle capacity. Such costs are higher in dense areas with higher land values and extensive underground utility networks that require relocation.

Some existing measures actively contradict one another. Minimum parking requirements increase the number of parking spaces per acre in dense areas. More parking spaces per acre leads to more traffic congestion, which policymakers seek to mitigate using automobile-based transportation system performance standards. The combination of these two factors perpetuates traffic congestion in corridors where the public right-of-way width is finite, inhibiting increased person throughput from transit use – even in high-quality transit areas.

In the case that decision-makers wish to pursue this policy approach, they can use this report to identify existing measures should remain, where subsidy increases will be required, and which future measures might be avoided.

4. Unmanaged transition to petroleum alternatives

Lastly, we consider an unmanaged transition to petroleum alternatives. We are careful not to conflate the status quo with an intervention-free approach. An unmanaged approach would in fact require sweeping changes to the status quo.

Governments at all levels would, at least initially, abandon existing transportation and land regulations use that indirectly affect petroleum use. Such an approach would eliminate zoning, performance standards, and rules governing how the public sector funds and finances improvements. Local decision-making bodies would be unencumbered by laws from superior jurisdictions. This approach would necessitate the repeal of Articles 13A and 13C of California's Constitution, several state laws, and other legislation and regulations identified in this report.

Initial control and authority would be based on ownership, rather than legal authority as granted by a superior jurisdiction. Local governments owning public rights-of-ways would be free to unilaterally determine if and how to fund transportation system maintenance and expansion. They could choose, based on their own rules, whether to use user fees as revenues. Over time, the state could establish new authority for itself and subordinate jurisdictions to intervene, such as the power to levy taxes on non-users.

If implemented, this approach would likely lead to a disorganized, largely market-driven transition to a new transportation equilibrium. Many path dependencies, such as the legacy of existing infrastructure, would persist. This report offers decision-makers pursuing the unmanaged approach insight into potential distortions that must be dismantled to allow a laissez-faire evolution in transportation, land use, and energy markets.

Report Overview

Overview of California's energy and transportation systems

Chapter 2 of this report details past and current trends in California's energy and transportation systems. Per capita energy consumption in California has been on the decline since the 1970s. Absolute statewide energy use began to decline in the mid-2000s, primarily due to a dip in transportation energy consumption.

We examine petroleum's role in the California transportation system, where it is primarily refined and used as aviation fuel, diesel fuel, and motor gasoline. We show the changes in refinery operating capacity and the increase in foreign-sourced oil as Alaskan production has declined. We argue that declining statewide motor vehicle fuel consumption and volatile global petroleum markets will lead to greater price volatility in the future.

We then turn to financial flows to and from California's transportation system. Adjusting for inflation, California now spends more public money on capital improvements to its public roads and transit systems than it has at any time since the 1950's freeway boom. Debt obligations for highways are at an all-time high, and the proportion of expenditures for maintenance has steadily declined since the 1980s. Since 1990, roughly 30% of the state's combined transit and highway spending has gone to transit. Inflation expenditures on transit facilities have increased since 1990, reflecting expansion of light rail, commuter rail, and heavy rail routes in the state. Private transportation expenditures greatly exceed public expenditures – by at least 350%.

Next, we detail the use of California's transportation system. In 2009, Californians traveled an estimated 395 billion miles. We show differences in travel consumption among California's metropolitan areas and household income groups. We detail changes in vehicle miles traveled, which began decreasing in 2005, preceded by declines in miles traveled per registered vehicle and licensed driver. We then show that statewide per capita transit use has increased since 1990, largely correlated with increases in gasoline prices.

Methodology used in the assessments

We focus our analysis on changes in petroleum used in transportation system operations. We then detail our methods and data in Chapter 3. We employ forecasting methods and seek to responsibly handle uncertainty in order to produce useful information about a complex, interconnected system. We seek to identify system structures, feedback loops, and critical thresholds in order to assess the potential for non-linear changes in the transportation and land use system. We aim to produce new information to avoid a vicious cycle of policymaking, where governments avoid potentially effective policies because they lack information on their implementation. Travel models currently employed in California are not capable of validly assessing potential system changes that aren't rooted in previously-observed behavior. Thus any novel, untested policy is inherently uncertain.

For each brief, we present our high-level results in a summary table. In this table, we declare the magnitude of the factor's effect on statewide fuel use. We base this magnitude on the median range in our quantitative assessments. We also declare our estimate of the assessment's uncertainty. We do so in order to responsibly present uncertainty in recognition that our understanding of California's transportation and land use system continues to evolve over time.

Assessments

In each of fifteen briefs, we assess the connection between a current or possible future policy option and statewide petroleum use. In doing so, we answer one of two generalized questions. What would happen if California made a certain policy change? What effect might an existing policy have on statewide petroleum or motor vehicle fuel demand?

The briefs are intended to be widely accessible, bridging the gap between research and practice. We intend that a diversified set of readers—interested residents, policymakers, professional staff, and policy analysts—will find the briefs useful for their wide-ranging objectives. As such, we seek to balance accessibility and complexity by understanding and explaining the intricacies of the transportation and land use system. This is not an easy endeavor; policy is so often made without an understanding of possible consequences, even when based on previously observed behavior. This is because unintended systemic impacts extend beyond the scope of most policy evaluation.

Unlike the electricity system – where generators and utilities are subject to strict, direct control – the transportation system is comprised of millions of loosely-regulated individual actors. Changing policies and implementing new measures to indirectly influence the travel California's 35,209,430 registered motor vehicles will have uncertain outcomes. Government has little direct control other than official traffic control devices and enforcement of the California Vehicle Code.

Moreover, travel is rarely an end in of itself – but rather a means for an individual or group to access some economic or social opportunity – typically occurring at a fixed location. Thus, understanding the complex, integrated transportation and land use system – and the incentives it produces – is crucial to creating sustained changes that support policy goals.

Amidst this system complexity, we aim to highlight the implications of explicit and implicit planning and policy choices. We endeavor to bridge the gap between academic research and practice in order to create accessible, actionable information. We do so to provide new information and evaluative metrics for researchers, policymakers, and analysts at all jurisdictional levels. These assessments are not intended to be terminal tomes. Policymakers interested in implementation should seek additional information on how effects may vary based on their local conditions. Scholars prompted to new research opportunities will undoubtedly seek additional information on their subjects.

We initially developed a list of twenty-five policy factors which we believed to have a direct or indirect effect on petroleum consumption in the state. After initial discussion with Next 10 and consideration of the potential value new information on each topic would have to the public and decision-makers, we narrowed this list down to fifteen.

Several policies exceeded this study's scope. These include those which directly affect the price and supply of crude oil or finished petroleum products, those which primarily affect population or economic growth, and immoderate government interventions.

Works Cited

California Air Resources Board. (2008). Climate change scoping plan.

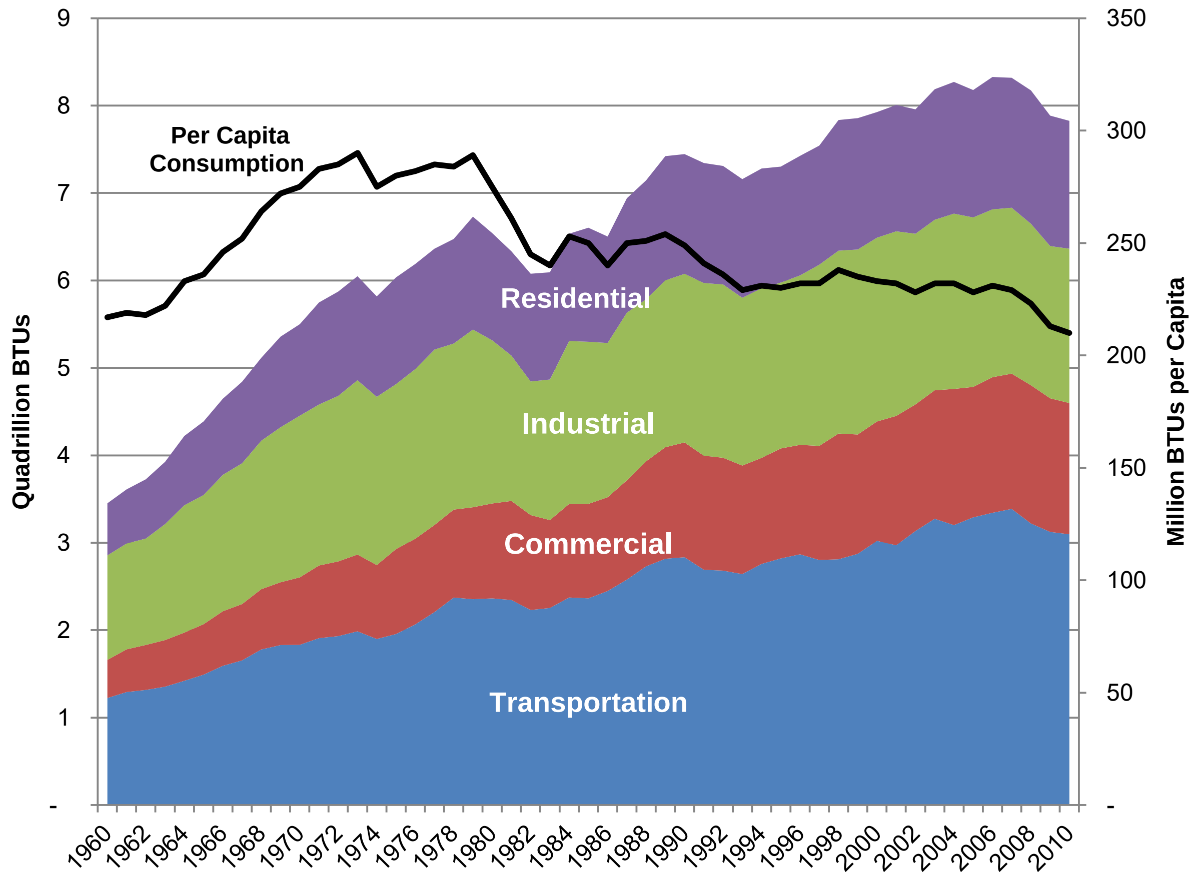
U.S. Bureau of Labor Statistics. (2012). Consumer Expenditure Survey. Washington, DC.

U.S. Federal Highway Administration. (2011, February). National household travel survey. Retrieved from http://nhts.ornl.gov

Energy Production and Use in California

The transportation sector accounts for the plurality of statewide energy consumption. Its per capita energy use has been declining since California began to pursue energy efficiency policies in the 1970s. Absolute statewide energy use began decreasing in the mid-2000s, primarily due to a dip in transportation energy consumption.

Figure 1: California energy consumption by end-use sector



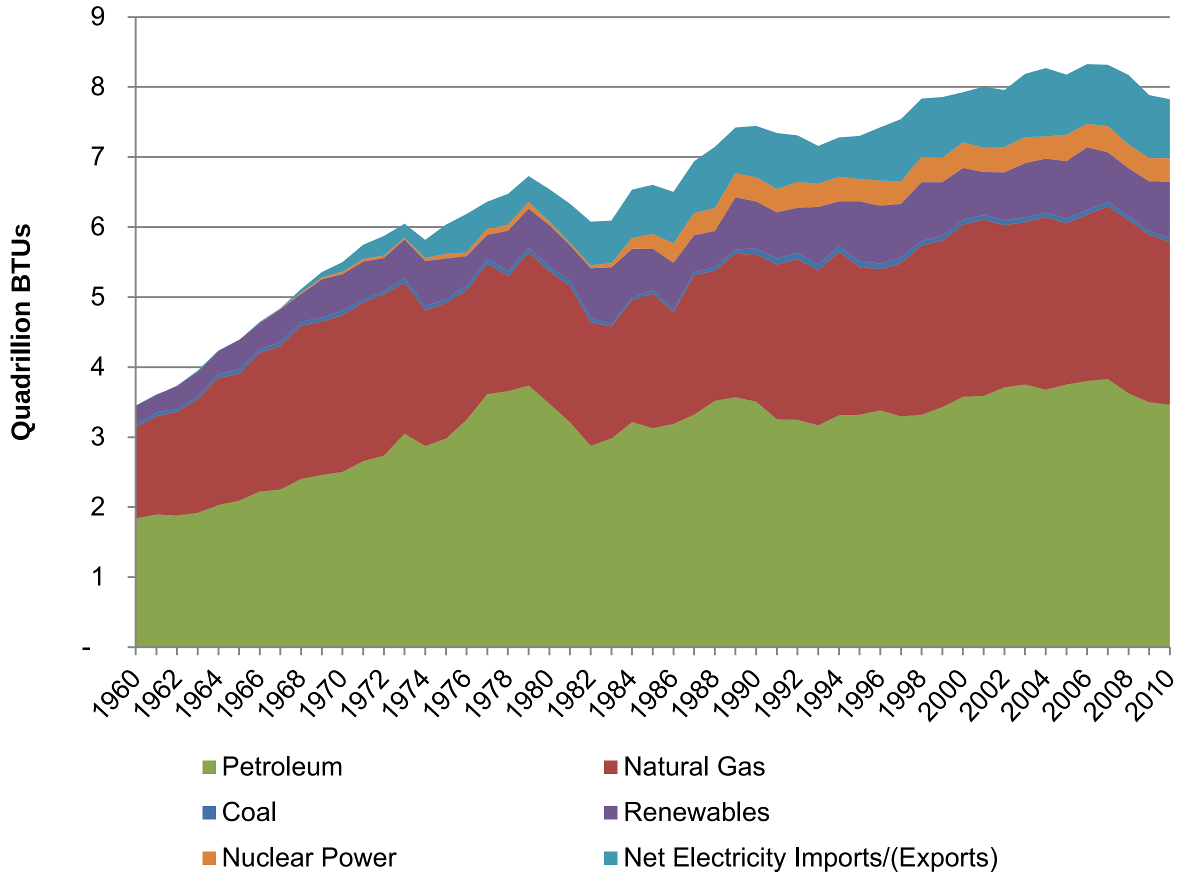
Source: (U.S. Energy Information Adminstration, 2012)

In 2010, California made up about 8% of U.S.-wide and 1.5% of worldwide energy consumption. Within California, the transportation sector accounted for 39.6% of energy consumption, followed by the industrial sector (22.6%), commercial sector (19.2%), and residential sector (18.7%) (U.S. Energy Information Adminstration, 2012). The transportation sector has been the state's largest consumer of energy since the U.S. Energy Information Administration began tracking state-level data in 1960.

California energy comes from a range of fossil fuel and non-fossil fuel sources. Petroleum fulfills a plurality (43.7%) of the state's energy demand. Natural gas (29.3%), renewables (10.1%), and nuclear (4.2%) are other principal sources of energy generated within

California. A significant amount (10.6%) of California's energy supply comes from imported electricity.

Figure 2: California energy consumption by source

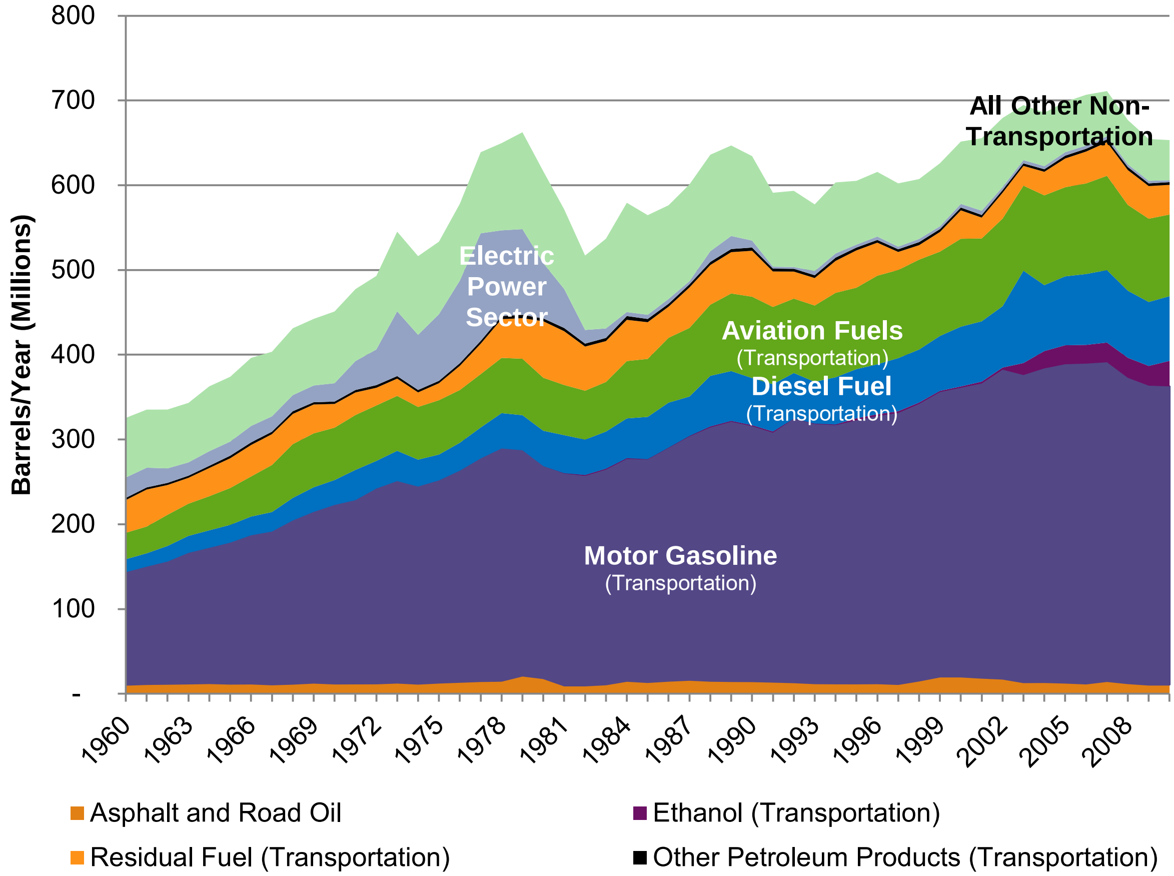


Source: (U.S. Energy Information Adminstration, 2012)

Petroleum Use in California

Most petroleum (86.4%) consumed in California is used in transportation. The industrial sector, which includes construction, accounts for most (11.2% of use across all sectors) of the non-transportation petroleum use in California. While 37% of the crude oil processed in California comes from within the state, the balance comes from Alaska, and, increasingly, foreign sources. Motor gasoline, sometimes blended with ethanol from petroleum and non-petroleum sources, makes up the bulk of petroleum consumption. Aviation fuels loaded in California, including aviation gasoline and jet fuel, follow. Bunker fuel, a heavier of residual fuel oil, is loaded at California ports for use in marine freight transportation. Asphalt and road oil are used primarily in construction, including for roofing materials and pavement. Other petroleum products, such as motor oil, make up an insignificant amount of California petroleum demand.

Figure 3: Petroleum product consumption in California

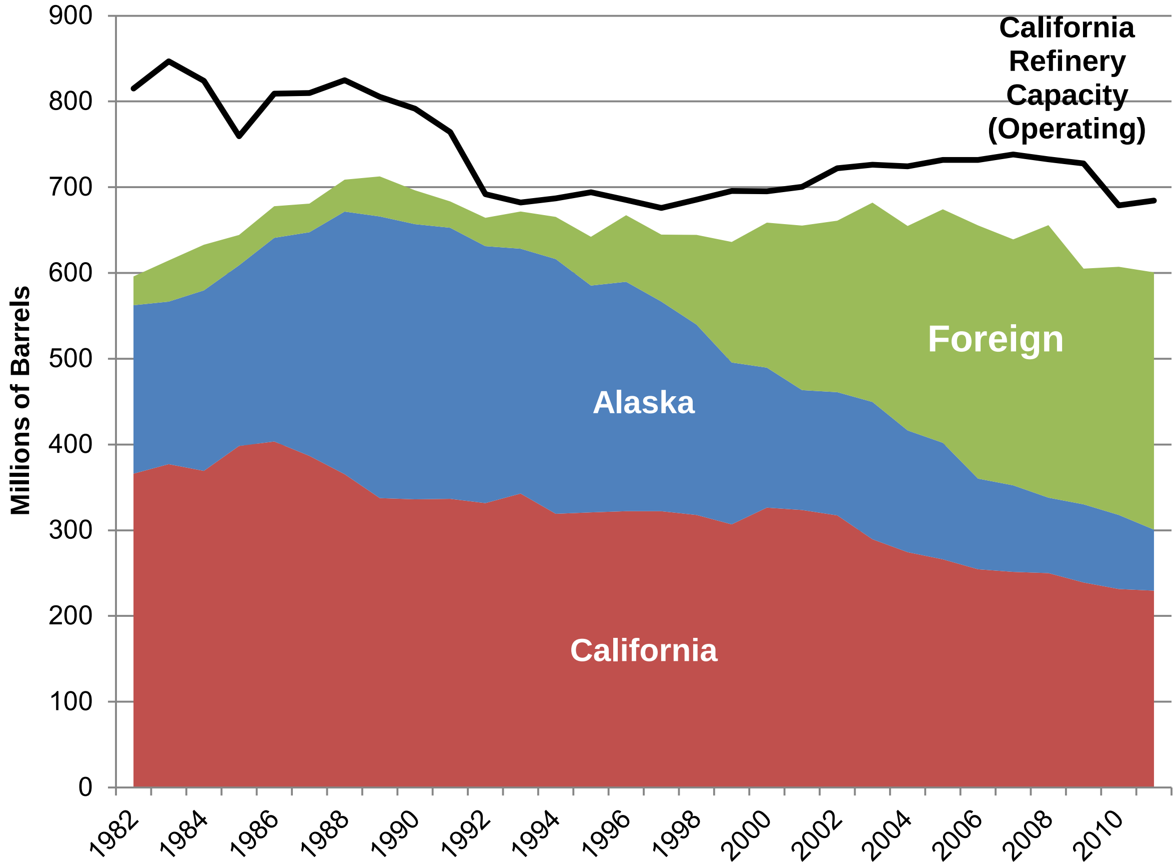


Source: (U.S. Energy Information Adminstration, 2012)

Sources of California petroleum

California receives an increasing amount of petroleum from abroad as supplies from California and Alaska decrease. In 1982, about 6% of the crude oil refined in California was imported from foreign sources. In 2011, 50% came from abroad. Saudi Arabia, Ecuador, and Iraq are the top sources of imported crude oil. Nationally, 62% of crude oil is imported, with Canada, Saudi Arabia, and Mexico being the top countries of origin. See Figure 5 for a detailed look at the origin of petroleum refined in California in 2010.

Figure 4: California refinery crude sources and operating capacity

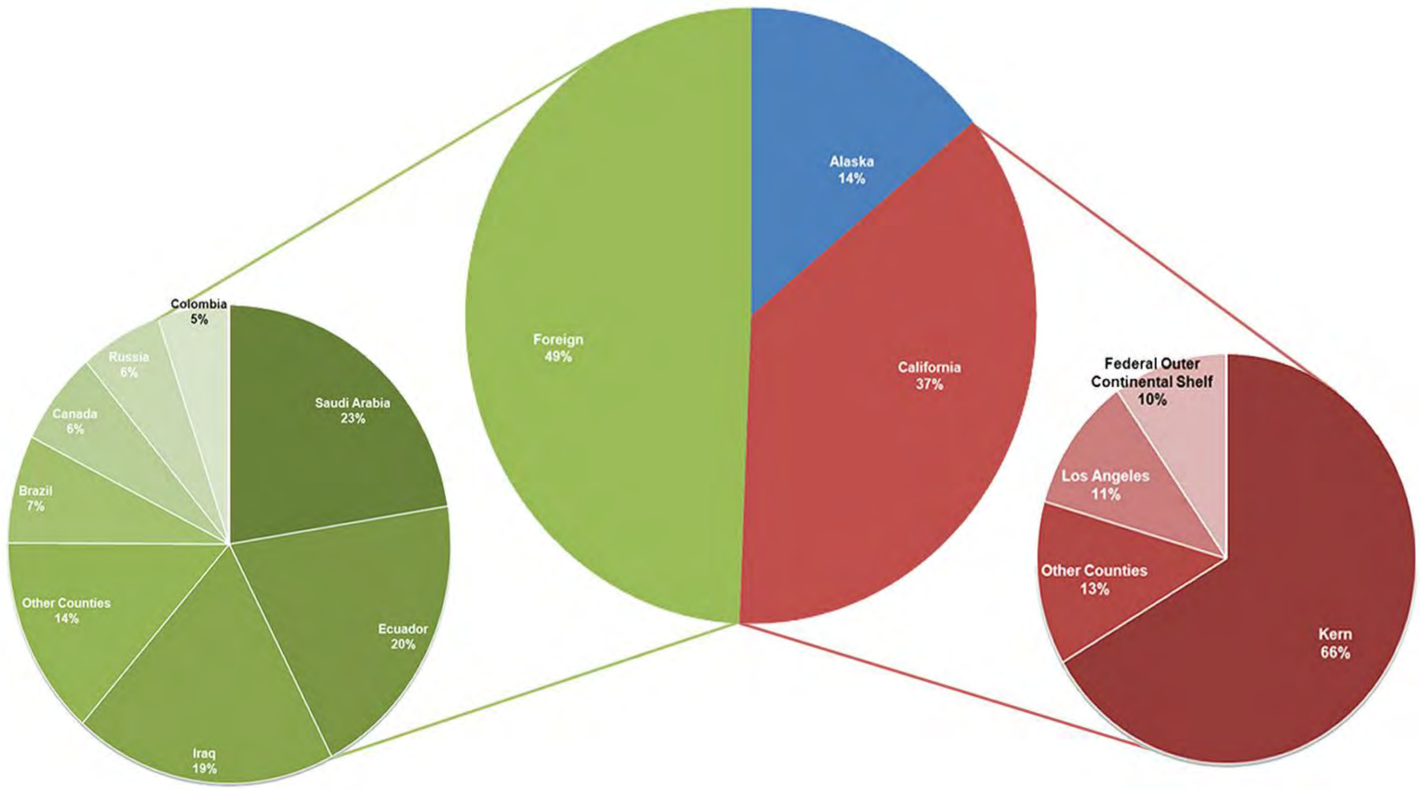


Sources: (California Energy Commission, 2011), (California Energy Commission, 2012), (U.S. Energy Information Administration, 2012)

Although the amount of petroleum coming from California oil fields is declining, local crude continues to make up a significant portion of petroleum processed by California refineries - 37% in 2010. Only Alaska, Texas, and Louisiana produce more crude oil, and only these states plus Kansas, Mississippi, Montana, New Mexico, North Dakota, Oklahoma, Utah, and Wyoming produce a greater percentage of the crude oil they use.

Kern and Los Angeles Counties are the top local sources of California petroleum. The remaining 63% of the crude oil arrives by ocean tanker. The West Coast region has not seen crude oil transfers by pipeline, tanker, or barge from other U.S. regions since 2000 (U.S. Energy Information Administration, 2012).

Figure 5: Origin of crude oil received by California refineries, 2010



Sources: (California Energy Commission, 2012), (California Department of Conservation, 2011), (U.S. Energy Information Administration, 2012),

Petroleum refining in California

California is home to 18 operable petroleum refineries. Crude oil destined to become transportation fuel is processed in one of 14 refineries before being sold by one of seven major fuel marketers or an independent station.

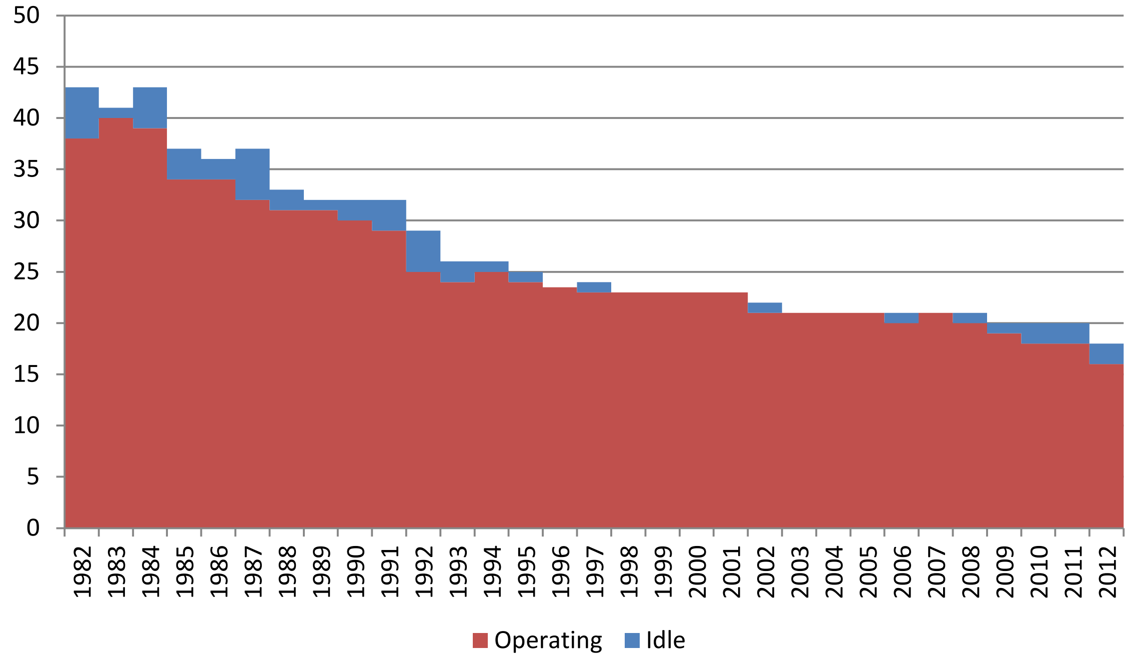
Table 1: Operable California petroleum refineries (and ownership)

Northern (5)	Central (4)	Southern (9)
Benicia (Valero) Martinez (Tesoro) Martinez (Shell) Richmond (Chevron) Rodeo (ConocoPhillips)	Bakersfield (Alon Israel) Bakersfield (Kern) Bakersfield (San Joaquin) Santa Maria (Greka)*	Carson (BP) El Segundo (Chevron) Paramount (Alon Israel)* Long Beach (Alon Israel)* South Gate (World Oil/Lunday Thagard)* Torrance (ExxonMobil) Wilmington (ConocoPhillips) Wilmington (Tesoro) Wilmington (Valero)

** does not produce finished motor vehicle fuels*
Source: (U.S. Energy Information Administration, 2012)

The number of operable and operating refineries in California has been decreasing over the past 30 years. A company may elect to temporarily shut down a refinery for business reasons or major maintenance. At the beginning of 1982, 38 out of 43 operable refineries in the state were in active operation. Thirty years later in 2012, only 16 refineries were operating. Total production capacity in operating refineries peaked at 847 million barrels per year in 1983 (see Figure 4). The capacity of the refineries operating in California at the beginning of 2012 was 684 million barrels of crude oil per year.

Figure 6: California refineries – number and status

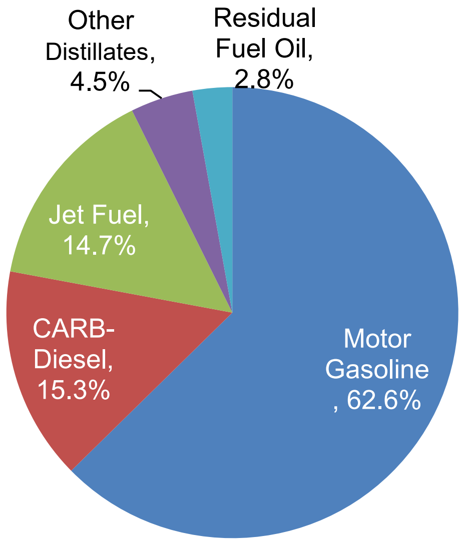


Source: (U.S. Energy Information Administration, 2012)

California's petroleum refineries produce a range of products. Transportation fuels – gasoline, diesel, and jet fuel – make up the vast majority of production, but the state's refineries also produce asphalt and road oil and other products for industrial uses. This report focuses primarily on transportation fuels.

Since 1960, California has consumed 698,127,000 barrels of asphalt (U.S. Energy Information Adminstration, 2012). This product, also known as bitumen, is used to bind rock aggregate in asphalt concrete, the primary pavement material used in California. It is also used for roofing materials and other construction applications. Paving roads with asphalt concrete requires additional energy to heat the asphalt onsite, in addition to the energy required to extract, manufacture, and transport the materials.

Figure 7: California refinery production, 2010



Source: (California Energy Commission, 2012)

In 2010, California refineries produced all or nearly all of the motor vehicle fuels consumed in the state. The balance of reformulated gasoline not produced by the state's refineries is due to ethanol blending. Reformulated gasoline blends now contain up to 10% ethanol, up from 5.7% after the state phased out MTBE as an oxygenate (California Energy Commission, 2012).

Table 2: 2010 motor vehicle fuel production and consumption in California

	Reformulated Gasoline	CARB Diesel
Produced (bbls)	328,646,000	94,517,000
Consumed (bbls)	356,396,000	93,404,000
Percent Produced	92.2%	101.2%

Data Source: (California Energy Commission, 2012), (U.S. Energy Information Adminstration, 2012)

Vulnerability in the market for transportation fuels

California as a price-taker

California is a price-taker in the global petroleum marketplace. The implication is that the state and companies operating within it have minimal ability to affect the price they pay for petroleum, beyond the use of financial instruments to hedge against future price changes. Even operating as a single actor, the state would lack the buyer power to significantly affect petroleum prices. California petroleum consumption has declined from 2.68% of worldwide consumption in 1982 to 2.05% in 2010 (U. S. Energy Information Administration, 2012). This proportion will continue to decline as economically developing countries approach or exceed California's levels of per-capita petroleum use.

California's own oil supply, though significant, is not large enough to greatly reduce the price California refineries pay for the oil they purchase. Though the state produced 37% of the oil it demanded in 2010, California is not insulated from price changes in worldwide petroleum markets. The 63% of crude oil that currently arrives by ocean tanker can divert to foreign ports willing to pay higher prices, with the barriers being contractual rather than logistical.

Existing California petroleum pipelines, which are currently used to connect oil refineries with crude oil supply, span between the oil fields in Kern in Los Angeles Counties to tanker terminals in Goleta, Morro Bay, and the Los Angeles area (California Department of Conservation, 2000). Exporting California's 37% of supply extracted within California would encounter some added costs and logistical challenges to reverse elements of the supply chain (e.g. loading rather than unloading tankers in California ports). However, private oil production and distribution companies operating in California may elect to export oil if global prices were ever high relative to California prices. This phenomenon, known as spatial arbitrage, keeps California prices in line with global prices.

A 2009 RAND Corporation report on imported oil and U.S. national security cites a number of national concerns with reliance on imported oil for a high proportion of U.S. petroleum demand (Crane, 2009). The potential for supply disruptions, sudden and prolonged price increases, and market manipulation could harm the U.S. economy. Additionally the political ramifications of wealth transfer to countries such as Venezuela and Iran and potential support for terrorist groups place added strain on the U.S. military's efforts to protect the supply and distribution of oil from the Persian Gulf.

California motor fuel market isolation and disincentives to expand or maintain capacity

California refineries have installed advanced equipment and use special processes capable of meeting the state's reformulated gasoline and ultra-low sulfur diesel fuel standards (Worrel & Galitsky, 2004). California was a pioneer in efforts to clean the air, and because of that, the U.S. Clean Air Act allows the state to set its own motor vehicle emission standards and fuel regulations. Because California's standards are more stringent than its neighbors, the state's market for motor vehicle fuels is largely isolated from the national market. The vast majority of motor vehicle fuels consumed in California were refined in the state.

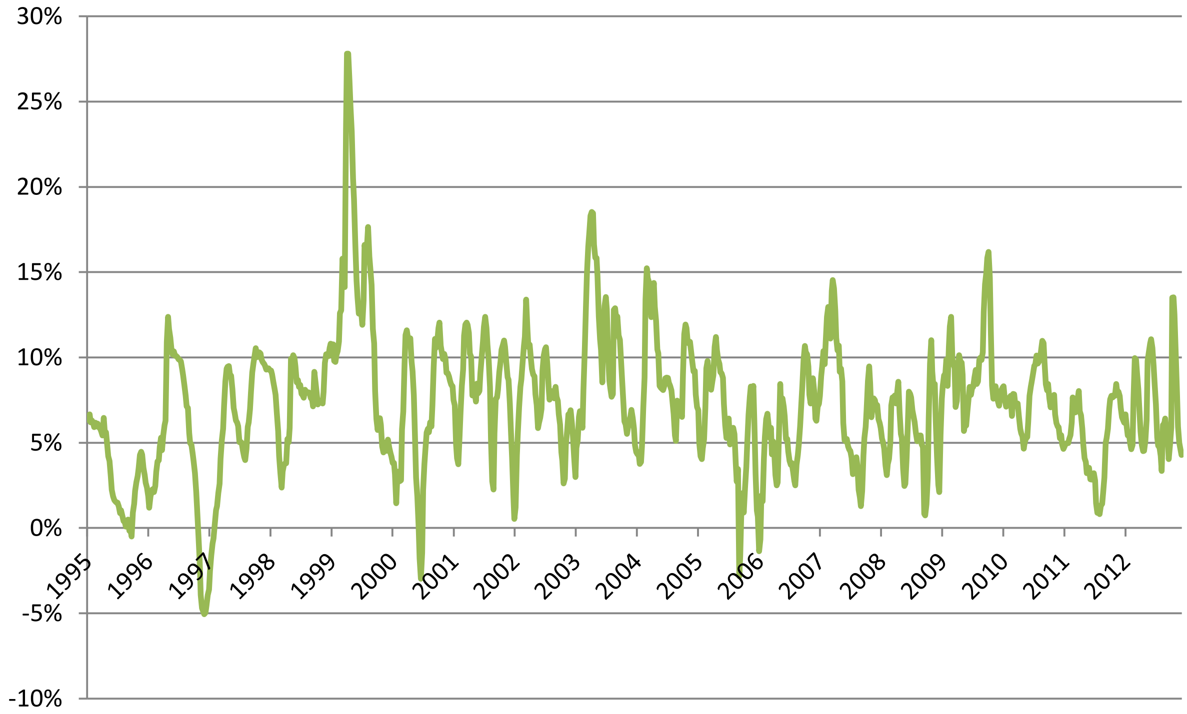
California retail fuel prices reflect the need for advanced equipment and special processes. Statewide prices for reformulated gasoline have national averages by an average of 7.2% since 1995 (see Figure 8).

California's relative isolation makes the market for finished transportation fuels vulnerable to local supply shocks and market power. Borenstein, et al (2004) argue that the potential for participants to exercise market power increases with reductions in excess refinery capacity and as suppliers consolidate their control. Control over refining capacity in California is somewhat concentrated. Fourteen of the state's 18 refineries produce motor vehicle fuels. Ten companies own these 14 refineries.

California's demand for gasoline is currently in decline. The California Energy Commission predicts that this decline may continue due to various state and federal policies. The state's latest energy policy report predicts between an 8% increase and 15.6% decrease in statewide gasoline consumption between 2009 and 2030. (California Energy Commission, 2012).

Because the state's existing refinery infrastructure can meet declining demand California's refineries have little incentive to expand capacity or make substantial upgrades. If a refinery owner expects statewide demand to fall over the next two decades, they may even elect to forgo repair of an unexpected breakdown. If the owner expects the cost of the repair to exceed the return on investment, they may elect to forgo repairs and reduce their production capacity. This disincentive to maintain production margins – the ratio of unutilized capacity to utilized capacity – makes the state more vulnerable to future supply shocks and sudden refining disruptions.

Figure 8: Reformulated gasoline prices, California versus U.S.

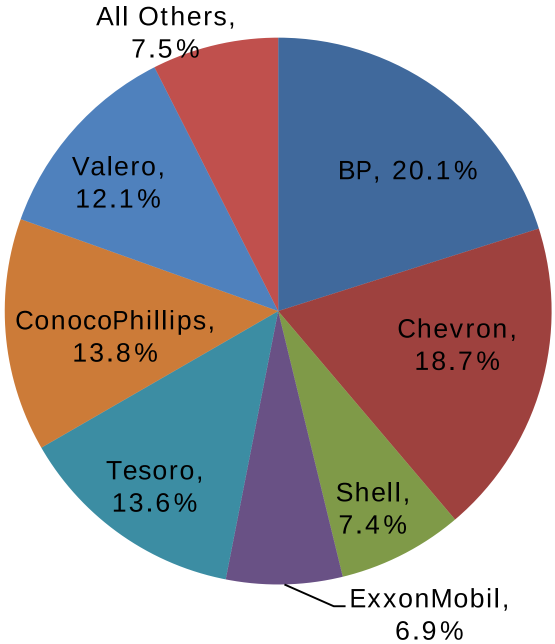


Source: Prices for all grades (U.S. Energy Information Administration, 2012)
Notes: Mean: 7.21%; Standard Deviation: 3.96%

California retail gasoline market

Seven companies control over 90% of the retail gasoline market in California. By market share, they are: ARCO (BP), Chevron, ConocoPhillips, Tesoro, Valero, Shell, and ExxonMobil (California Energy Commission, 2012). These branded retail outlets maintain long-term supply contracts with refineries and distributors, many of which are business units of the same vertically-integrated companies. However, unbranded retail outlets often purchase fuel on the spot market, which is supplied by fuel remaining after distributors meet existing contractual obligations. When refineries and distributors have low levels of unclaimed inventory and demand remains unchanged, the spot price reacts quickly.

Figure 9: California retail gasoline market share, 2010

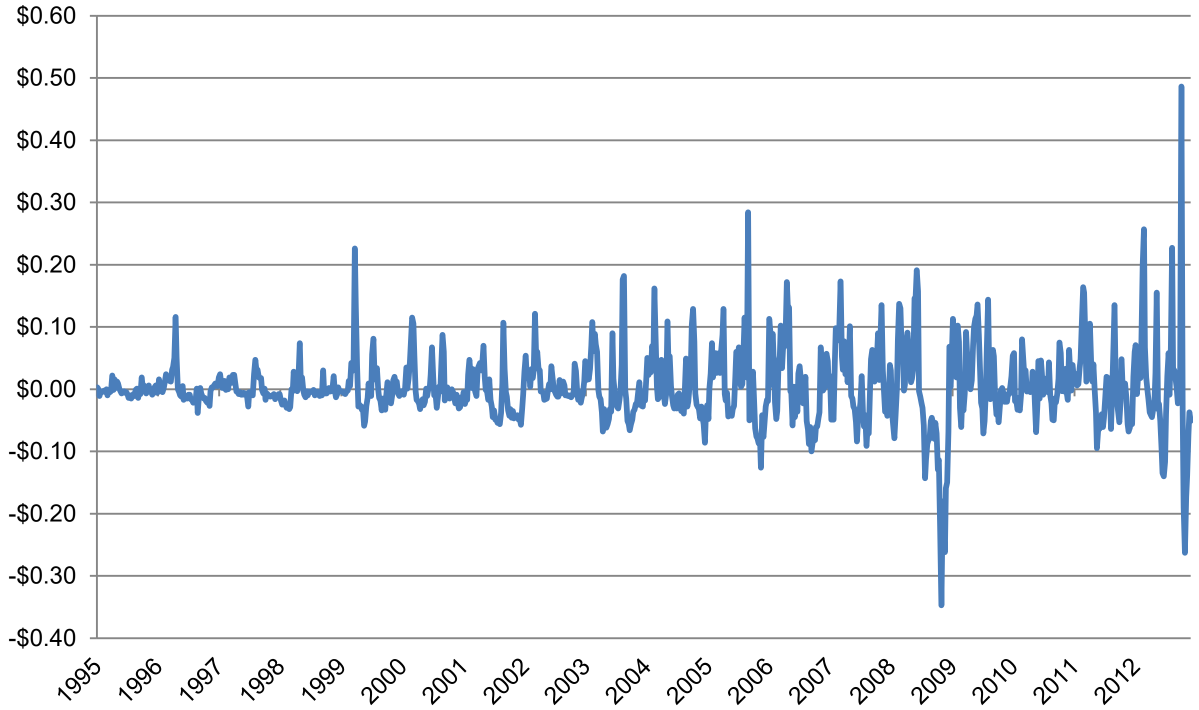


Source: (California Energy Commission, 2012)

Price volatility case study

Two events that occurred in the fall of 2012 illustrate the effects of refinery disruptions on California gasoline prices when inventories are below average. In early August of 2012, a fire in a crude distillation unit of the Chevron Richmond refinery shut down all production for days and a portion of production through the end of the year. Average statewide prices increased $0.227 in one week. Then, before prices had fully recovered, in early October of 2012, an electricity outage at ExxonMobil's Torrance refinery disrupted production for one week. Average statewide gasoline prices increased $0.486 in one week.

Figure 10: California reformulated gasoline, price change vs. prior week



Source: (U.S. Energy Information Administration, 2012)

One reason for the price shock could be that inventories of reformulated gasoline on-hand at California refineries were low relative to historical averages. Between 2006 and 2011, California refineries had an average of 6.0 days of reformulated gasoline inventory (Table 3).

Table 3: Product inventory at California refineries

	Crude Oil	Reformulated Gasoline	CARB-Diesel
Low	6.2 days	4.3 days	6.6 days
Mean	9.1 days	6.0 days	9.8 days
High	12.4 days	9.8 days	18.7 days
StDev	1.04 days	0.824 days	0.943 days

Calculations are days of production / stock

Source (California Energy Commission, 2012)

Refineries had 5.7 days of reformulated gasoline on hand before the Richmond incident in August. However, by the time the second refinery disruption occurred in Torrance, inventories were 5.2 days—somewhat lower than average stocks.

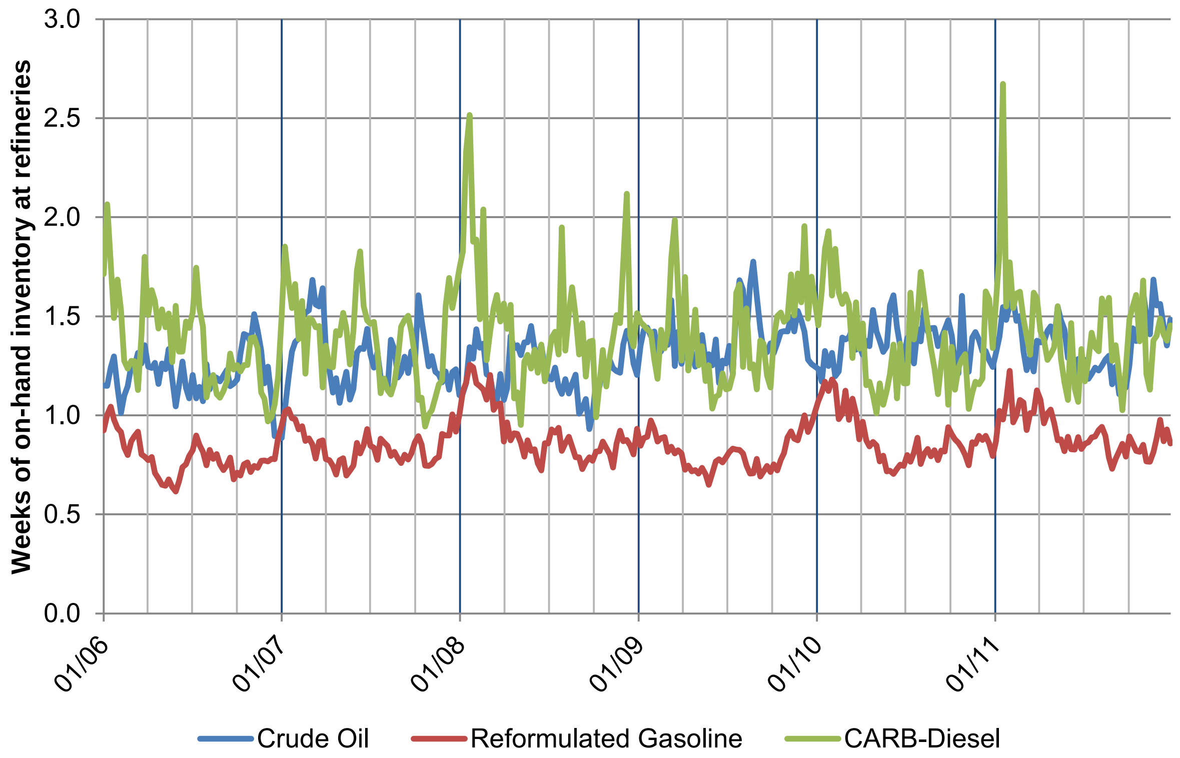
Table 4: Effect of Fall 2012 Refinery Disruptions on California Reformulated Gasoline

Disruptive Event	Date	Days of Inventory	Change in production	Change in price
Richmond Chevron- fire	8/6/12	5.7 days	+748,000 BBL +11.02%	+$0.227 +5.7%
Torrance ExxonMobil–electricity outage	10/1/12	5.2 days	-369,000 BBL -5.6%	+$0.486 +11.5%

Calculations versus prior week. Sources: Author's calculations based on (California Energy Commission, 2012), (U.S. Energy Information Administration, 2012)

Refinery reformulated gasoline stocks are highest in the winter months and lowest in the mid-spring and late summer. The state's market for finished petroleum products is more vulnerable to supply disruptions when crude oil stocks are relatively low. The state's gasoline market is more vulnerable to sudden refinery disruptions when reformulated gasoline stocks are lower.

Figure 11: California refinery inventory on-hand, 2006-2012



Source: (California Energy Commission, 2012)

There's currently no statistical evidence that refinery stocks are decreasing over time. However, state policymakers must continue to assess how possible decreases in gasoline demand will affect refinery decision-making, and whether or not historic inventory levels will appropriately mitigate risk of future price shocks.

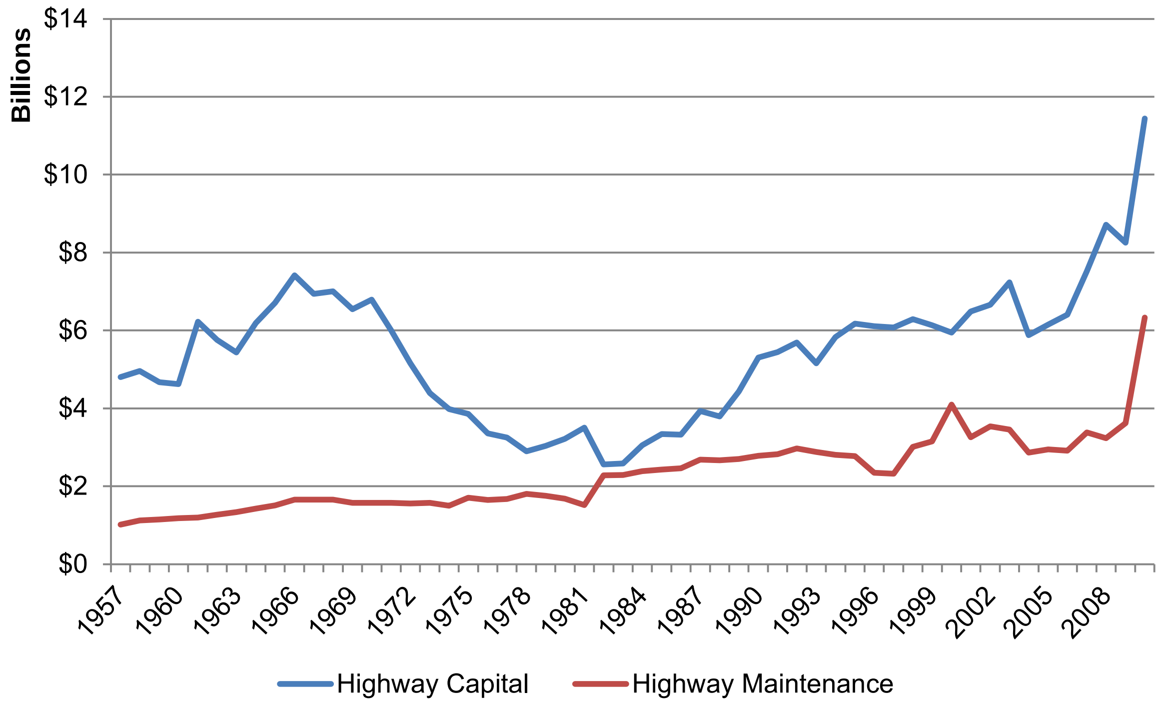
Financing the California Transportation System

Whereas the previous section detailed flows of crude oil and petroleum products to and within California, this section examines flows of funds to and from California's transportation system. California now spends more public money on capital improvements to its public roads and transit systems than it has at any time since the 1950's freeway boom.

California's current capital outlay for highways exceeds the inflation-adjusted levels observed during the 1950s and 1960s, when California built much of its national and state highway system. Various fiscal measures account for observed changes between 1981 and 2006. These include changes in the gasoline tax (increases in 1983, 1991, and 1993), changes in how gasoline taxes were allocated (Proposition 42 of 2002), changes in the vehicle license fee (fluctuated between 2% and 0.65% of a vehicle's value between 1998 and 2003), which affected revenues available for highway improvements.

Capital spending increases since 2006 can be attributed to Proposition 1B of 2006 and the 2009 American Recovery and Reinvestment Act. Proposition 1B authorized $19.925 billion in general obligation bonds to fund certain transportation construction projects started before December 31, 2012. Since 2009, projects in California have been awarded $7.35 billion in funds from the American Recovery and Reinvestment Act (U. S. Recovery Board, 2012).

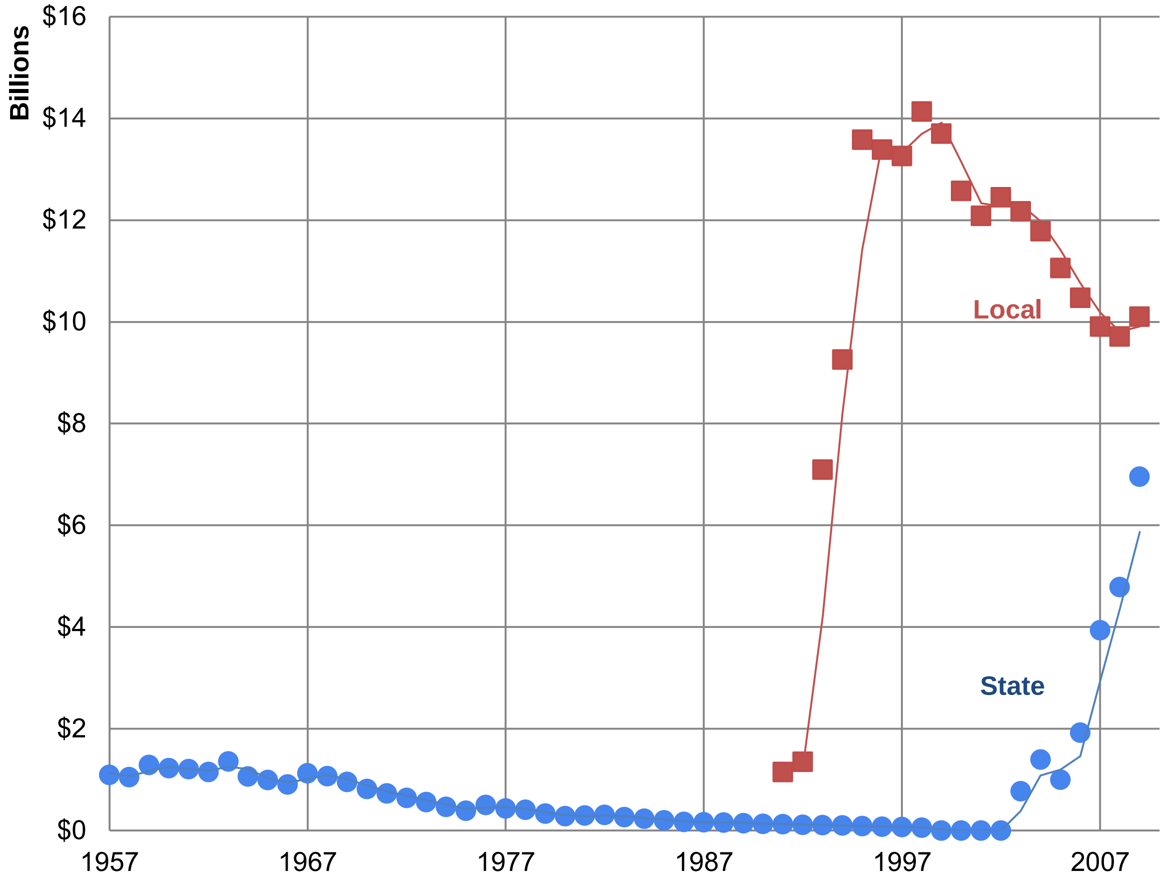
Figure 12: Real state and local capital and maintenance outlay for California highways



Source: (U. S. Federal Highway Administration, 2011) tables HF-2, LGF-2, and SF-2 adjusted for inflation using (Bureau of Economic Analysis, 2012) table 1.5.4 state and local aggregate expenditures (2005=$1), with author's calculations to fill reporting gaps.

California's reported debt obligations for highways reflect the use of bond measures to finance transportation expenditures. Inflation-adjusted state and local outstanding debt obligations for highways have increased precipitously over the past two decades (Figure 13). Reductions in outstanding local bond obligations have offset sharp increases in state bond obligations, which began to increase in 2003 due to a project to replace the eastern span of the San Francisco-Oakland Bay Bridge.

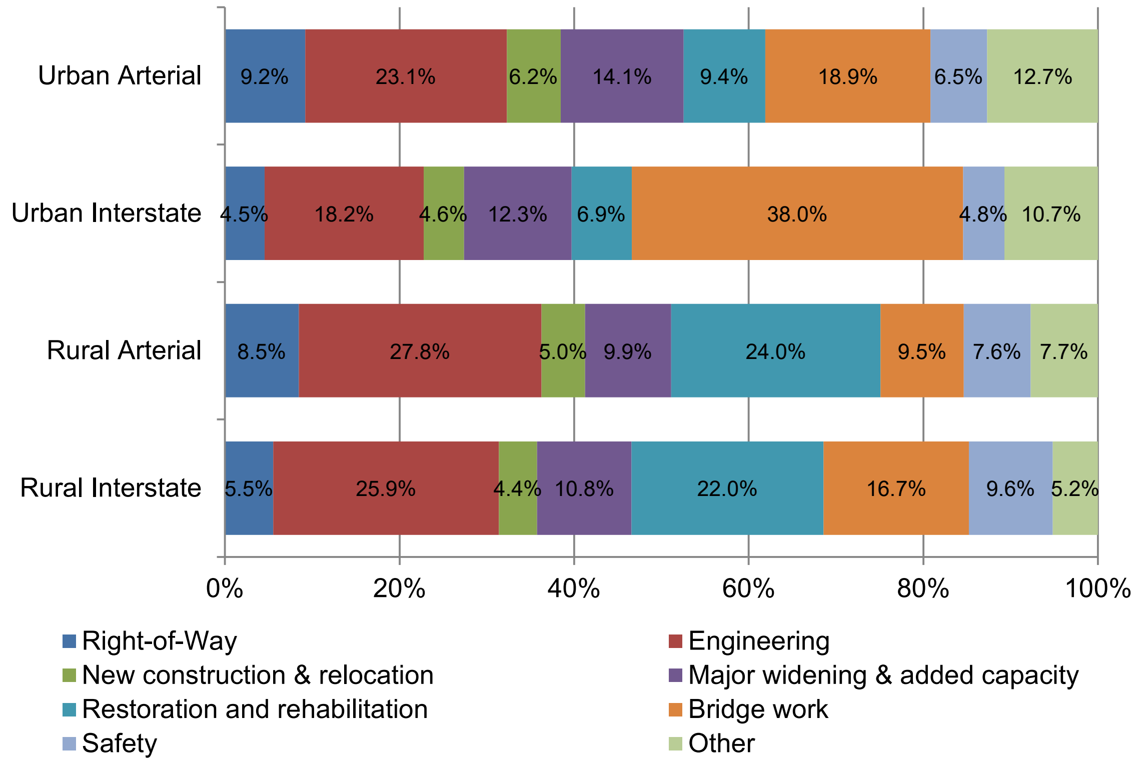
Figure 13: California state and local highway bonds outstanding, end of year



Source: (U. S. Federal Highway Administration, 2011) tables LGB-2 and SB-2 adjusted for inflation using Bureau of Economic Analysis state and local aggregate expenditures (2005=$1).

Highway capital costs in California include purchasing right-of-way, design and engineering work, new construction as well as major rehabilitation, resurfacing, and reconstruction activities designed to increase the design-life of the roadway or bridge. High expenditures on bridge work in urban areas reflect the number of grade separations needed to segregate highway traffic in a denser environment.

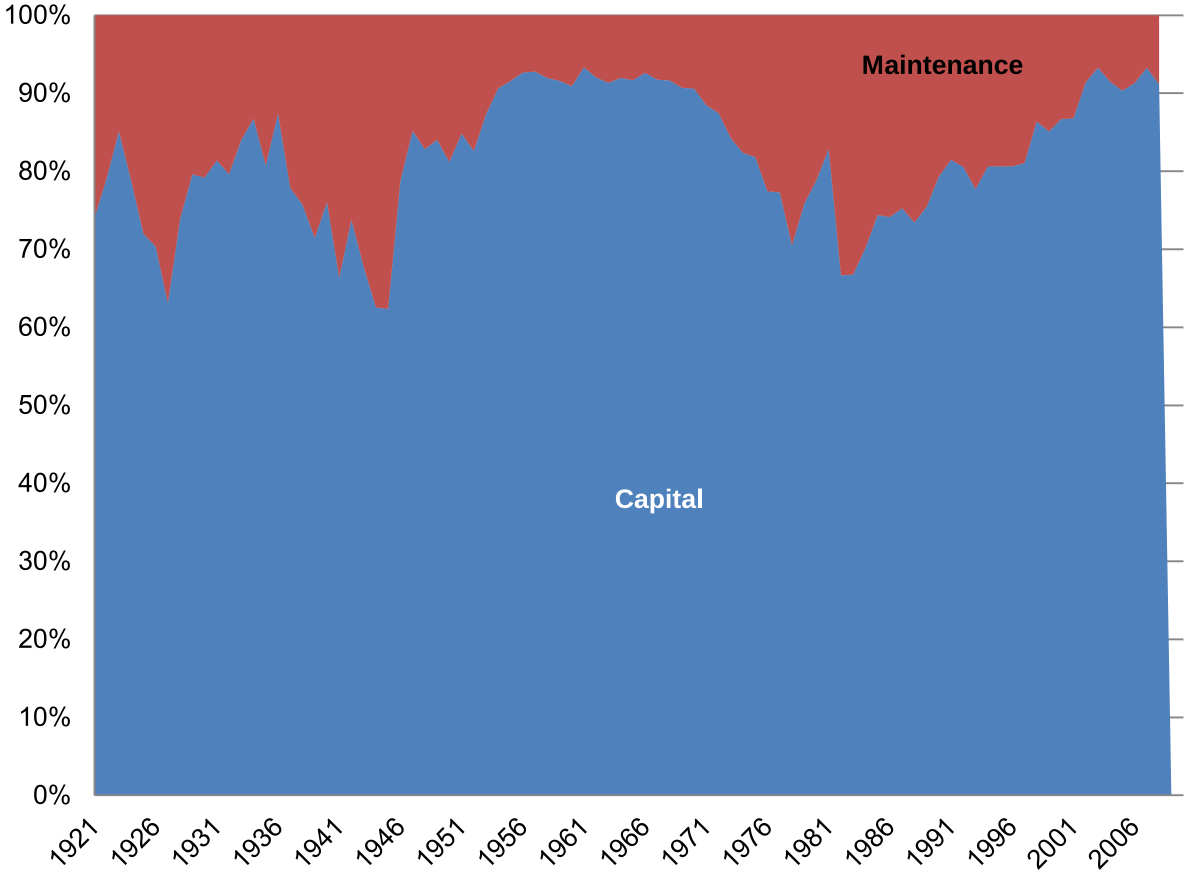
Figure 14: Breakdown of capital costs for California interstates and arterials



Source: (U.S. Federal Highway Administration, 2009)

The proportion of California highway expenditures for maintenance activities has steadily decreased since the 1980s. Maintenance expenditures are designed to delay the need for major rehabilitation work in order to meet, but not exceed, the design life of the roadway or bridge. Maintenance expenditures include patching spots, sealing cracks, repairing signs and guardrails, and structural maintenance for bridges.

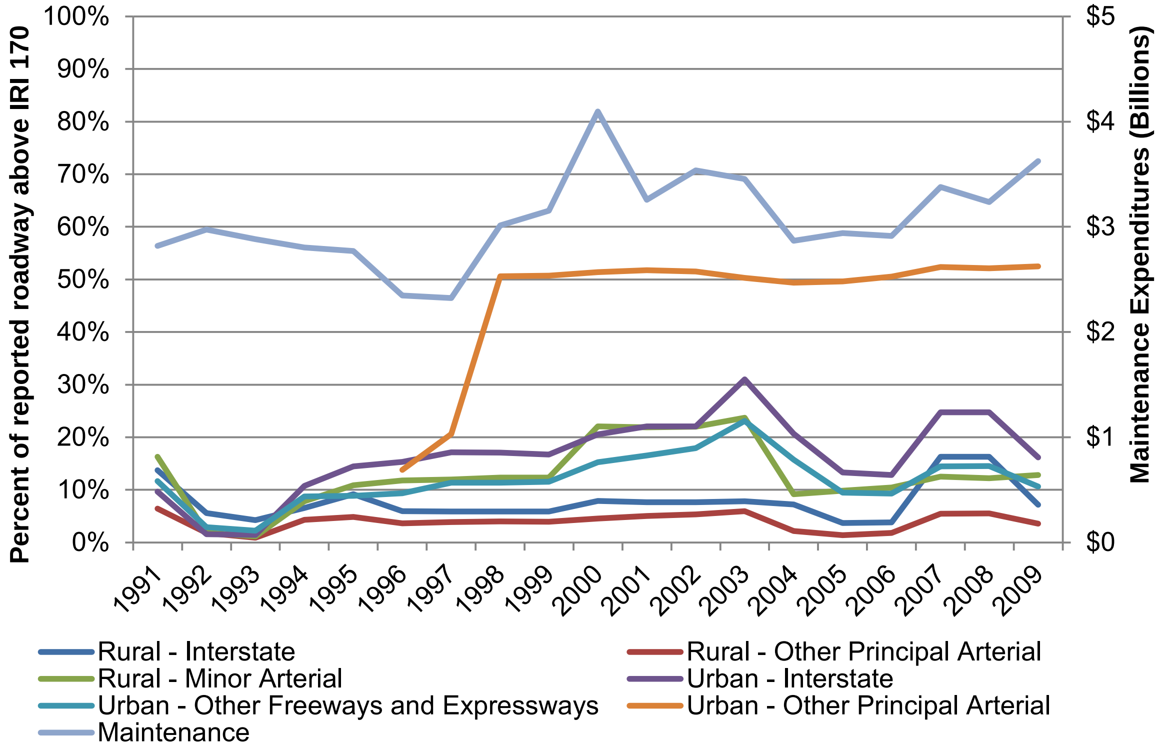
Figure 15: Proportion of California state highway expenditures for roadway capital versus maintenance



Source: U.S. Federal Highway Administration Highway Statistics (various years) table SB-12

Despite reductions in maintenance spending, data on the state's roadways does not indicate significant deterioration. Transportation engineers use the International Roughness Index as one measure of roadway user experience. Scores above 170 indicate a deficient roadway. The percentage of roadway with a reported score above 170 has not significantly increased over the years.

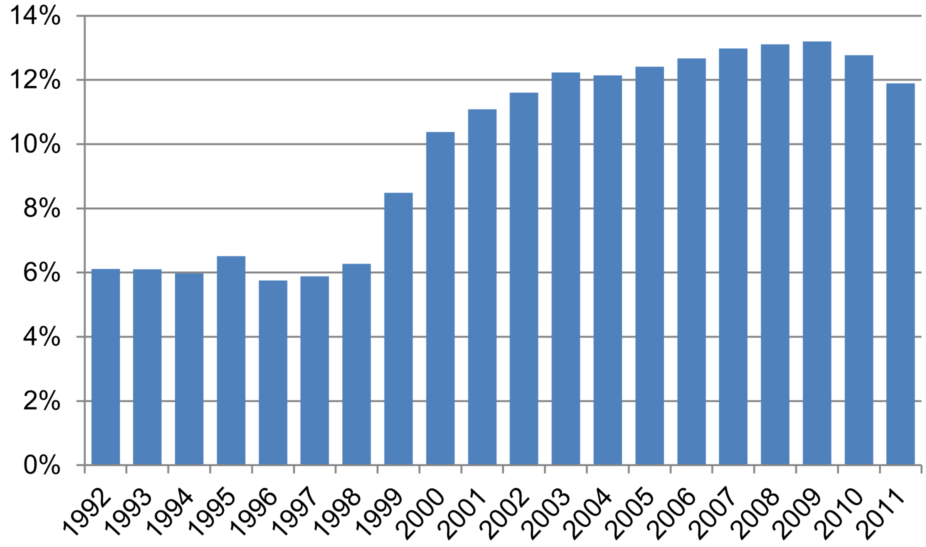
Figure 16: California reported roadway roughness and real maintenance expenditures



Source: (U. S. Federal Highway Administration, 2011), maintenance figures adjusted for inflation (2005=$1)

While roadway pavement quality has not significantly deteriorated over time, the percentage of deficient bridges has increased. Engineers consider a bridge structurally deficient when it has a significant defect that limits safe use. Structurally deficient bridges may have weight limitations or seismic deficiencies that could increase the probability of failure in an earthquake. The U.S. Federal Highway Administration's National Bridge Inventory reports bridges that are both structurally deficient and structurally sound but functionally obsolete. The percentage of structurally deficient bridges reported in California has begun to decline since 2009.

Figure 17: Percent of California bridges rated structurally deficient



Source: (U.S. Federal Highway Administration, 2012)

California, like most states, receives more money from the Federal Highway Trust fund than it contributes. In fiscal year 2010, California contributed $2.99 billion to the Federal Highway Trust Fund and, in return, received $4.0 billion in allocations and apportionments. Between 1957 and 2010, California has paid $74.6 billion into the fund and received $76.9 billion in apportionments and allocations.

User fees include taxes levied on gasoline, diesel fuel, tires, truck trailers, and overweight vehicles. Revenues from these fees are used for highway and mass transit purposes. In 2010, California receipts from user fees covered 46% of its highway disbursements. The balance of funding came from general funds, dedicated sales taxes, miscellaneous sources, and debt issues. Though the most recent data available is from 2010, the year is a historical anomaly because of American Recovery and Reinvestment Act expenditures. In 2008, prior to the American Recovery and Reinvestment Act, user fee revenues covered 79% of highway and road expenditures.

Figure 18: Sources and uses of California highway and road funds, 2010

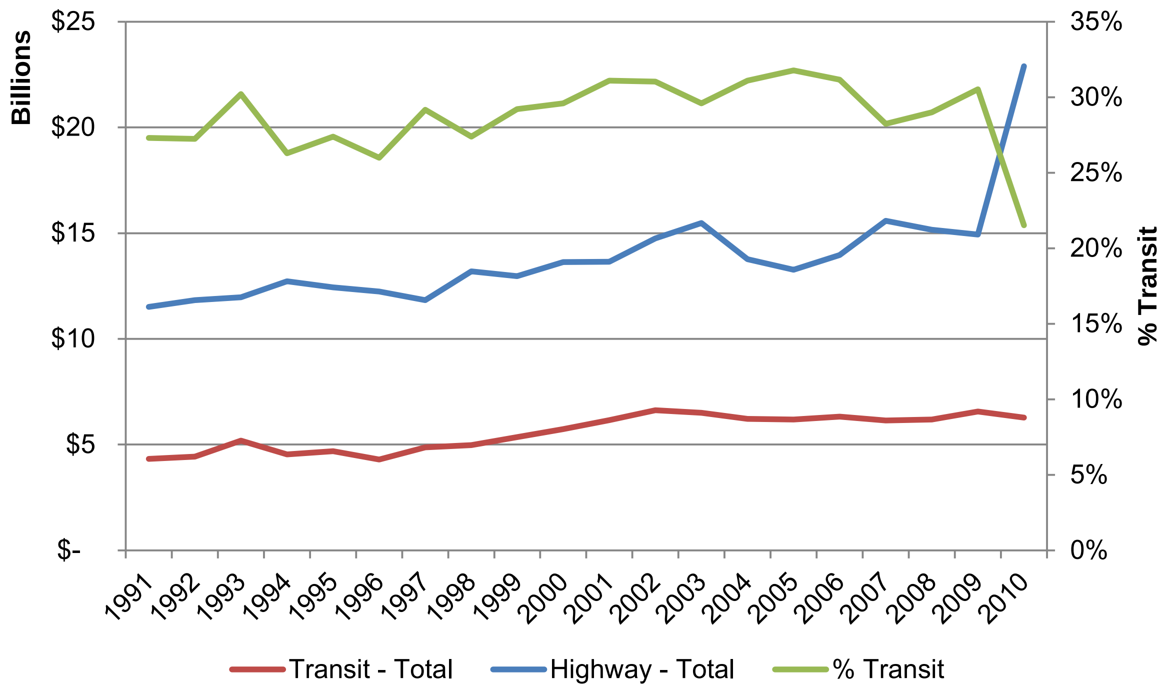
Sources (Revenues, billions)		**Uses** (Disbursements, billions)	
Federal User Fees	$1.9	Capital – State highways	$5.9
State User Fees	$10.3	Capital – Local roads	$7.7
Tolls	$0.6	Maintenance – State Highways	$2.7
Appropriations from General Funds	$5.9	Maintenance – Local roads	$4.9
Property Taxes	$0.3	Administration	$2.0
Other Imposts (e.g. sales tax)	$1.2	Law Enforcement and Safety	$3.0
Misc.	$2.0	Interest on Debt	$0.9
Bond Receipts	$3.0	Bond Retirement	$0.6
Total	**$25.2**	**Total**	**$27.7**

Source: (U. S. Federal Highway Administration, 2011) Highway Statistics Tables HF-1 and HF-2, nominal dollars

California transit expenditures

Expenditures for transit facilities and operations are also on the rise in California. Figure 19 shows inflation-adjusted expenditures for highways and transit since 1991. Historically, roughly 30% of combined transit and highway expenditures have gone to transit.

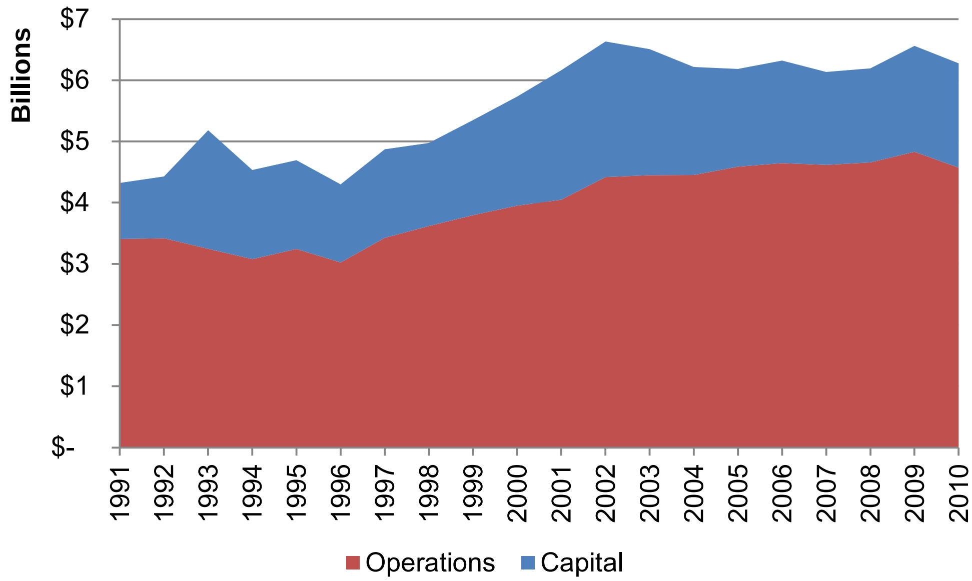
Figure 19: Real California highway and transit expenditures



Sources: (U. S. Federal Transit Administration, 2012), (U. S. Federal Highway Administration, 2011), adjusted for inflation, (2005=$1)

Most transit funding in the state is spent on operating service and maintaining vehicles rather than on capital projects, such as vehicle purchases and facility construction.

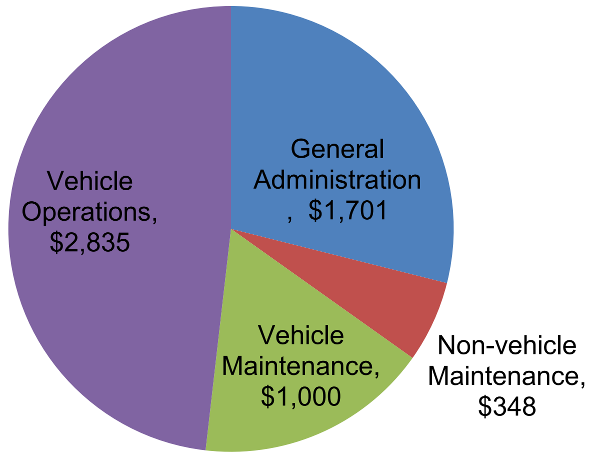
Figure 20: California inflation-adjusted transit expenditures



Source: National Transit Database (U. S. Federal Transit Administration, 2012) with adjustments for inflation based on (Bureau of Economic Analysis, 2012), (2005=$1)

Direct vehicle operations costs in 2010 were $70.84 per vehicle revenue hour and $4.71 per vehicle revenue mile. With overhead and maintenance, total operating costs were $147.04 per vehicle revenue hour and $9.78 per vehicle revenue mile. General Administration is the second largest expense category, which includes management and planning functions.

Figure 21: California transit operational expenses, 2010 (in millions)



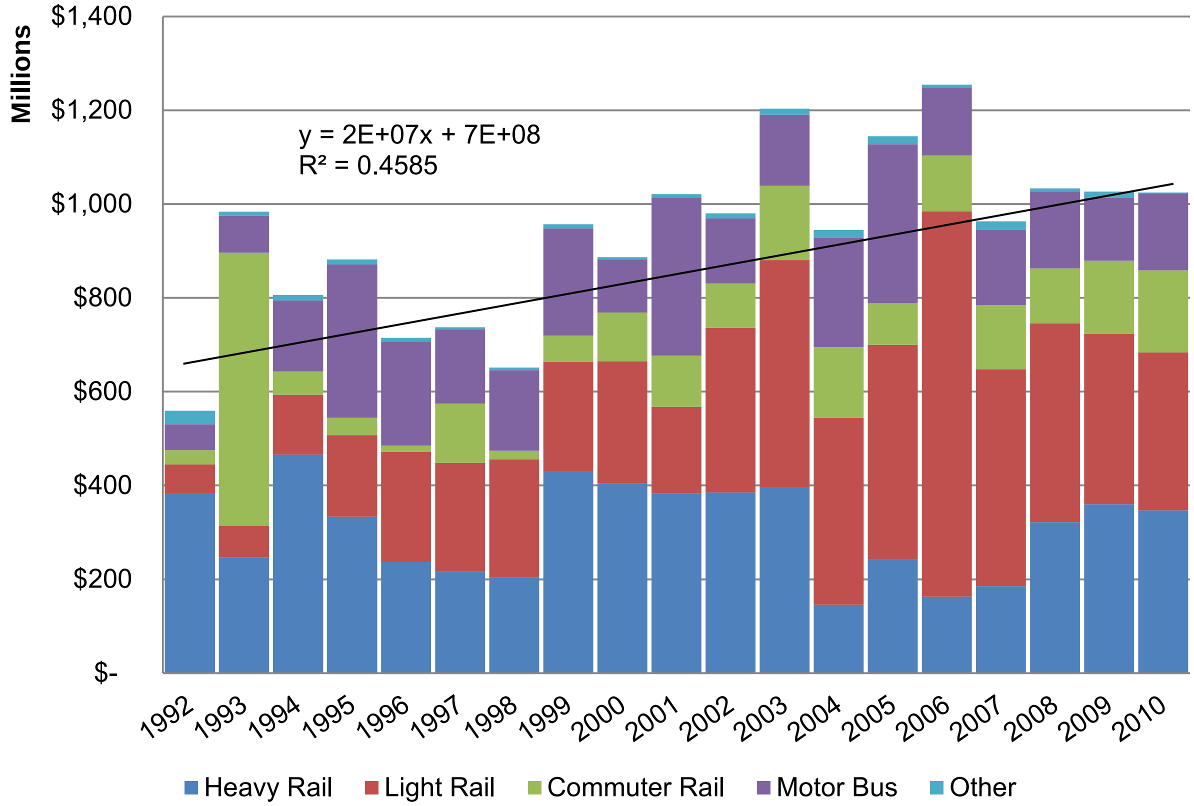
Source: (U. S. Federal Transit Administration, 2012)

In 2010, California transit agencies spent $1.257 billion on facilities and $0.608 billion on vehicles. Roughly 79% of the vehicle expenditures, or $479 million, were for buses. Capital expenditures for transit facilities have outpaced inflation in the past two decades, as several California cities are constructing new rail lines. In 2010, California agencies spent $1.054 billion, 51.5% of all capital expenditures, on rail facilities projects.

Transit Agency	2010 Rail Capital Facilities Expenditure
Bay Area Rapid Transit	$333,001,594
Los Angeles Metro (LACMTA)	$302,981,617
Metrolink (SCCRA)	$141,273,126
Santa Clara VTA	$106,373,034
Caltrain (PCJPB)	$59,850,625
San Francisco Municipal Railway	$56,756,685
Sacramento RTD	$27,637,504
Others	$25,343,801
Total	**$1,053,581,986**

Source: (U. S. Federal Transit Administration, 2012)

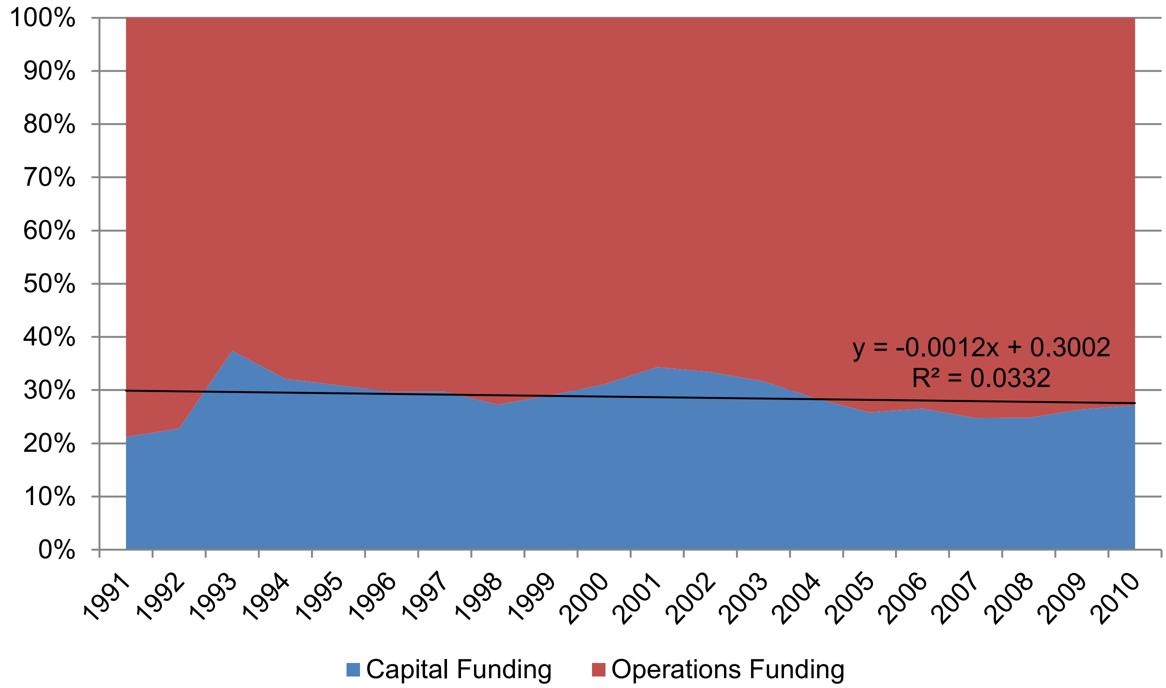
Figure 22: California inflation-adjusted capital expenditures on transit facilities, by mode



Source: Federal Transit Administration National Transit Database (2009) adjusted for inflation using Bureau of Economic Analysis state and local gross investment (2005=$1)

Funding for operations has not increased at the same pace as capital funding, and the proportion of transit funding for operations has declined slightly since 1991. A 2011 survey of California transit stakeholders identified the need for stable operating funding as the top priority for California transit agencies and stakeholders (Matute, et al., 2012).

Figure 23: Proportion of statewide transit funding for capital and operations



Source: (U. S. Federal Transit Administration, 2012)

Private transportation expenditures

The figures in Table 5 represent the majority, but not the whole, of transportation expenditures. In 2010, fuel expenditures made up the plurality of statewide transportation expenditures, but this is not the case every year. California's motor vehicle dealers reported a lower value of taxable sales in 2010 than in 2007, when a boisterous economy aided in a reported $59.755 billion in taxable sales (California Board of Equalization, 2008). Insurance premiums contribute significantly to private transportation expenditures. These selected 2010 private transportation expenditures, roughly $124 billion, greatly exceed the $33.5 billion in 2010 public expenditures on roads, highways, and transit.

Table 5: Selected private transportation expenditures in California

Expenditure type (and year)	Expenditure
Gasoline purchases (2010)	$45,932,260,000
Diesel purchases (2010)	$4,463,998,000
Automobile insurance premiums (2010)	$21,178,197,027
Transit fares (2010)	$1,519,349,469
Automobile repair & maintenance (2007)	$11,838,655,000
New & used car taxable sales (2010)	$38,986,980,000

Source: Author's calculations based on (U. S. Federal Transit Administration, 2012), (California Department of Insurance, 2011), (U.S. Energy Information Administration, 2012), and (U. S. Federal Highway Administration, 2011), (U.S. Census Bureau, 2009), (California Board of Equalization, 2012).

Structural deficit in transportation funding

The California Transportation Commission identified $341.1 billion in needed rehabilitation and maintenance expenditures to preserve existing transportation facilities in a state of good repair between 2011 and 2020 (California Transportation Commission, 2012). The Commission projects an additional $197 billion in needed expenditures to expand and manage the system during the same time period. With only $242.4 billion in projected future revenues, the State faces a $296 billion (55%) capital and maintenance funding deficit.

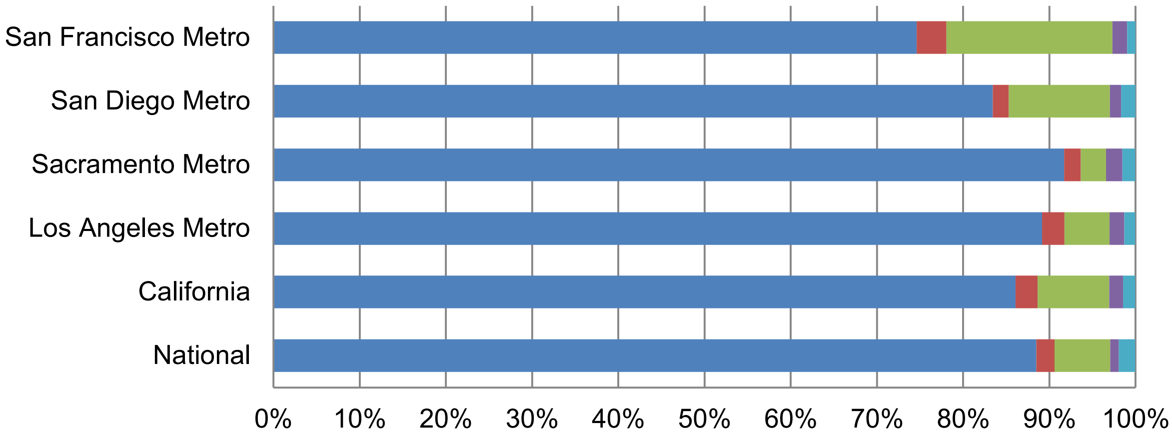
Use of the California Transportation System

Californians traveled an estimated 395 billion miles in 2009 (U.S. Federal Highway Administration, 2011). This figure equals:

- Approximately 10,300 miles per capita
- One out of every 9.4 miles traveled in the U.S.
- 2,125 round trips to the sun

Most of these miles were traveled in privately-owned automobiles. Air travel takes second place, followed by public transit, walking and biking. The proportion of miles traveled by mode varies by metro area, as do miles traveled per capita.

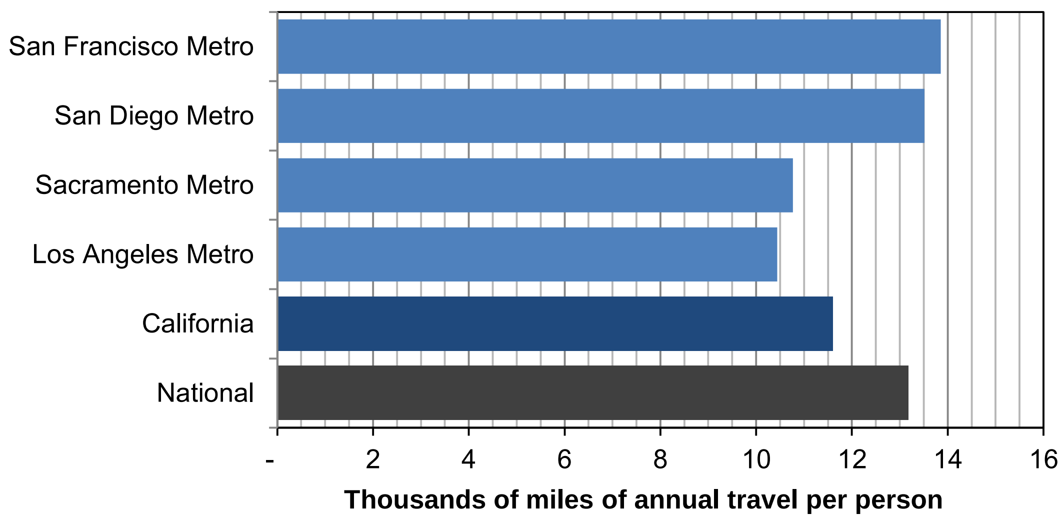
Figure 24: Percent of miles traveled by mode



	National	California	Los Angeles Metro	Sacramento Metro	San Diego Metro	San Francisco Metro
Privately-Owned Vehicle	88.47%	86.09%	89.13%	91.70%	83.45%	74.60%
Public Transit	2.12%	2.53%	2.60%	1.94%	1.86%	3.46%
Airplane	6.45%	8.33%	5.26%	2.92%	11.72%	19.24%
Walk/Bike	0.99%	1.58%	1.71%	1.89%	1.28%	1.69%
Other	1.90%	1.43%	1.24%	1.49%	1.67%	0.99%

Source: (U.S. Federal Highway Administration, 2011) - 2009 National Household Travel Survey. Note: While the 2009 National Household Travel Survey is the best recent estimate of multimodal travel by Californians, it will soon be supplanted by the 2012 California Household Travel Survey.

Figure 25: Per capita miles of travel by region in California

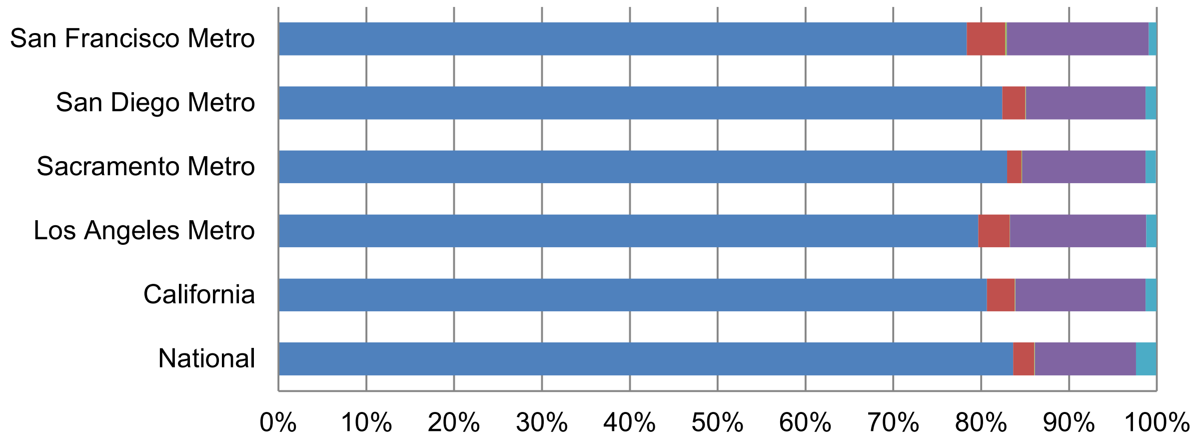


Source: (U.S. Federal Highway Administration, 2011) National Household Travel Survey

Average annual travel for Sacramento and Los Angeles metro residents was below the statewide average (See Figure 25). Higher reported rates of air travel among San Diego and San Francisco residents account for much of the disparity (See Figure 24).

While walking and biking trips make up a small proportion of distance traveled, these shorter trips amount to 14.8% of all trips in California. Census data for commutes (Figure 27) shows higher rates of public transit use and driving, as travel between home and the workplace is typically one of the longer trips an individual takes. Transit and driving are typically better suited for longer distances than are walking and biking.

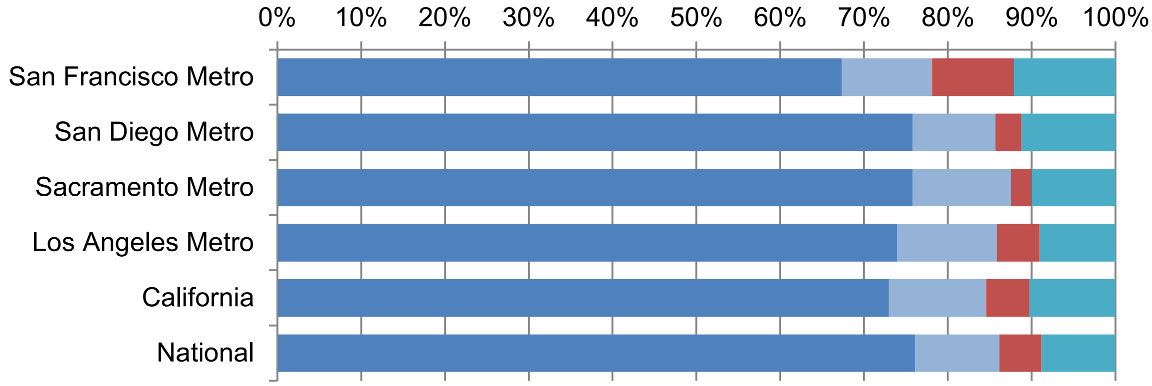
Figure 26: Percent of all trips by mode



	National	California	Los Angeles Metro	Sacramento Metro	San Diego Metro	San Francisco Metro
Privately-Owned Vehicle	83.65%	80.65%	79.66%	82.93%	82.41%	78.37%
Public Transit	2.39%	3.16%	3.57%	1.65%	2.61%	4.34%
Airplane	0.08%	0.07%	0.05%	0.07%	0.08%	0.18%
Walk/Bike	11.51%	14.83%	15.49%	14.04%	13.61%	16.19%
Other	2.31%	1.24%	1.18%	1.20%	1.21%	0.89%

Source: (U.S. Federal Highway Administration, 2011) - 2009 National Household Travel Survey

Figure 27: Percent of commute trips by mode



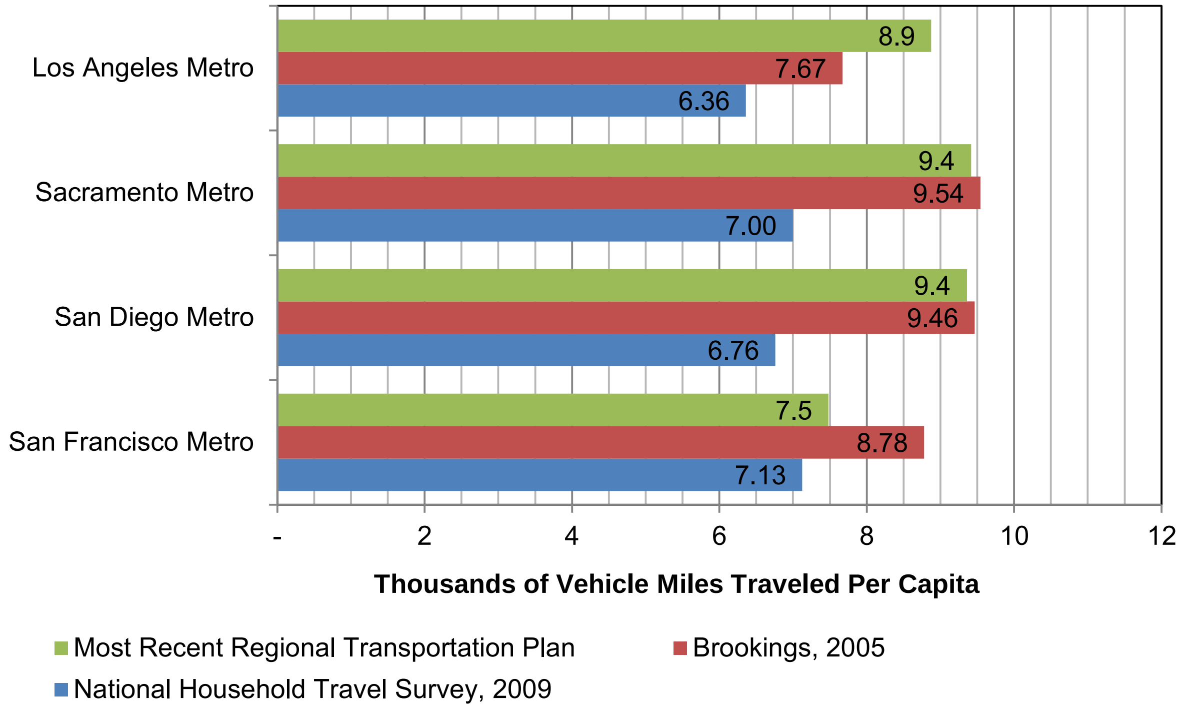
	National	California	Los Angeles Metro	Sacramento Metro	San Diego Metro	San Francisco Metro
Drove Alone	76.1%	73.0%	74.0%	75.8%	75.8%	67.4%
Carpooled	10.0%	11.6%	11.9%	11.7%	9.9%	10.7%
Transit	5.0%	5.2%	5.0%	2.5%	3.1%	9.8%
Other	8.9%	10.2%	9.1%	10.0%	11.3%	12.1%

Drove Alone Carpooled Transit Other

Source: Author's calculations based on (U.S. Census Bureau, 2010) (ACS 2009 1-year S0802)

Estimates of regional per-capita vehicle travel differ depending on the source and base year. The 2009 National Household Travel Survey is based only on privately-owned vehicle travel, and excludes certain trips and population groups from its analysis. The result is lower per-capita vehicle travel results versus other estimates.

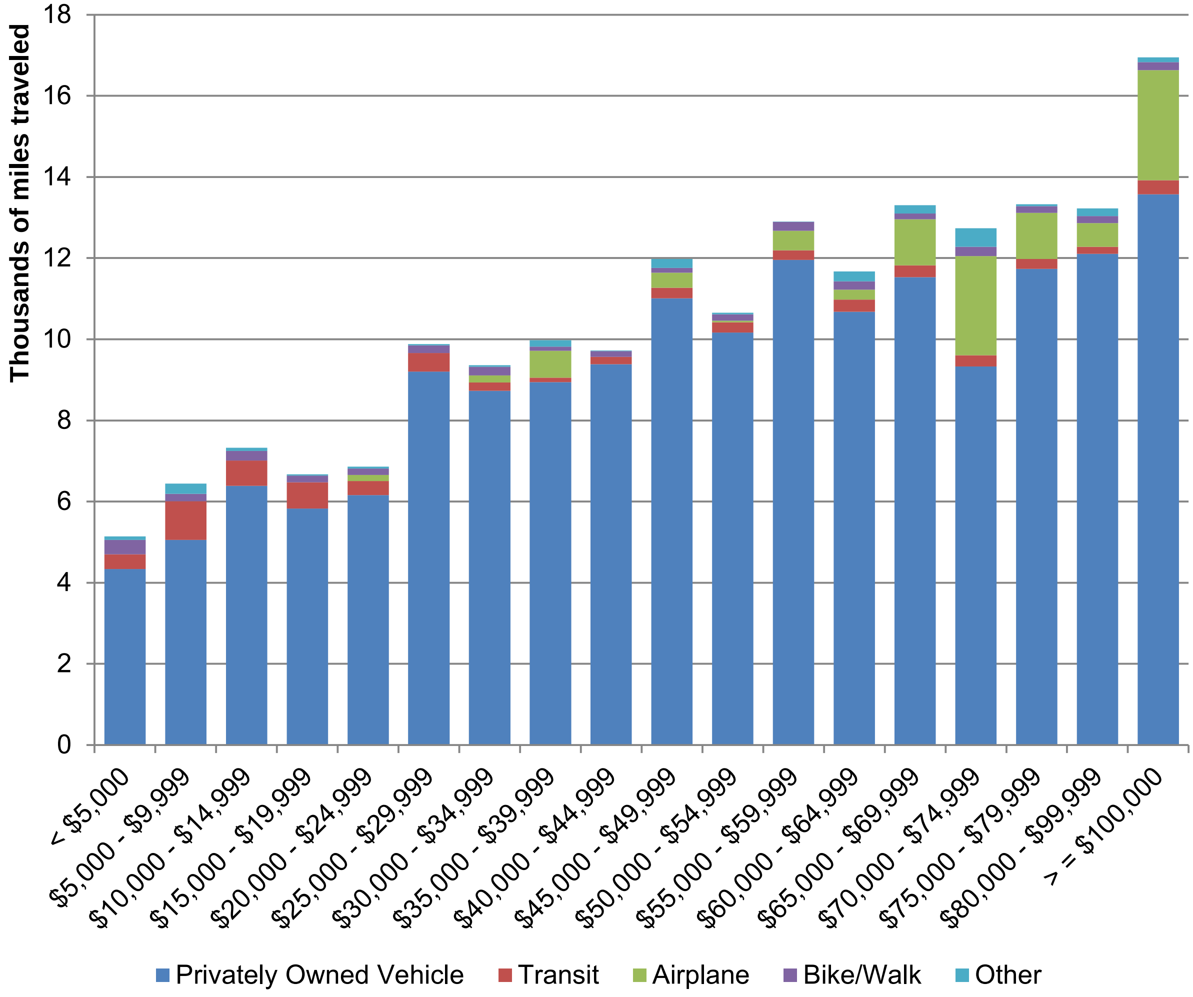
Figure 28: Estimates of California VMT per capita, by region



Source: (U.S. Federal Highway Administration, 2011), Brookings data based on (Southworth, Sonnenberg, & Brown, 2008), and Regional Transportation Plan appendices from SACOG (2008 estimate), SANDAG (2008 estimate), SCAG (2010 estimate), and MTC (2010 estimate)

One reason that the average San Francisco Bay Area and San Diego residents travel greater distances than the average statewide resident is that travel demand correlates with income. Figure 32 below shows how California per capita miles traveled by mode vary by income. The San Francisco metro area had the nation's highest median income in 2011.

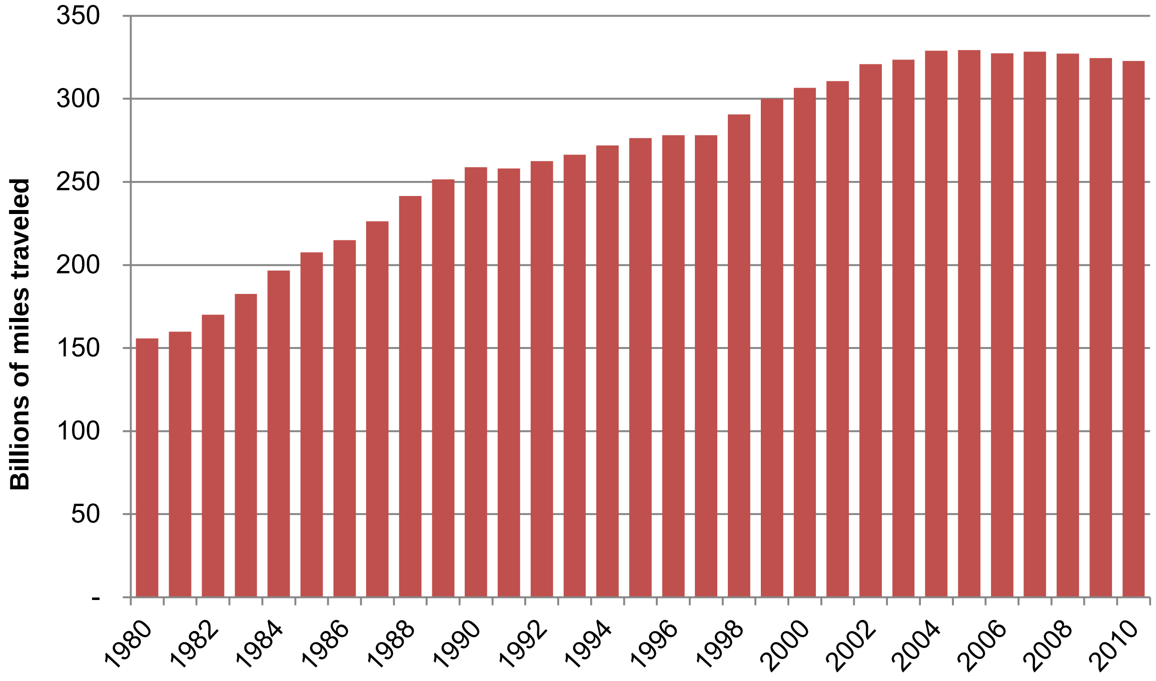
Figure 29: California annual per capita miles traveled by mode and household income



Source: (U.S. Federal Highway Administration, 2011) – 2009 National Household Travel Survey

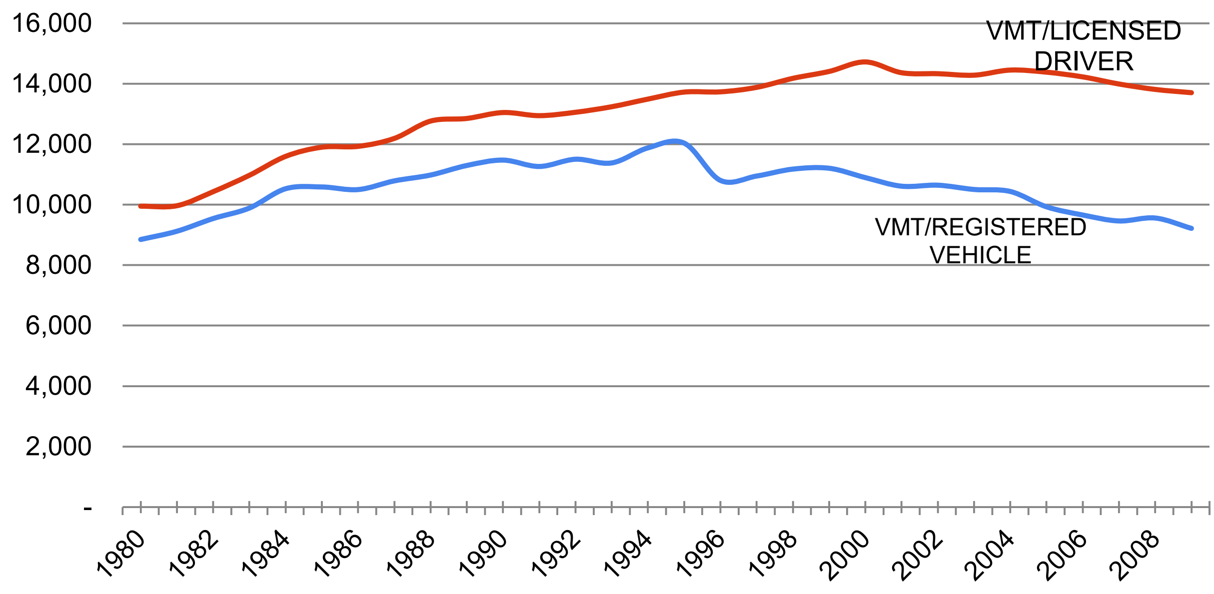
Statewide vehicle travel has been on the decline since 2005 after a multi-decadal increase. Two precursors to this trend occurred over the decade prior to 2005. First, vehicle miles traveled per registered vehicle began to decline in 1995. Then, vehicle miles traveled per licensed driver began to decline in 2000 (See Figure 30).

Figure 30: Vehicle miles traveled in California



Source: (U. S. Federal Highway Administration, 2011)

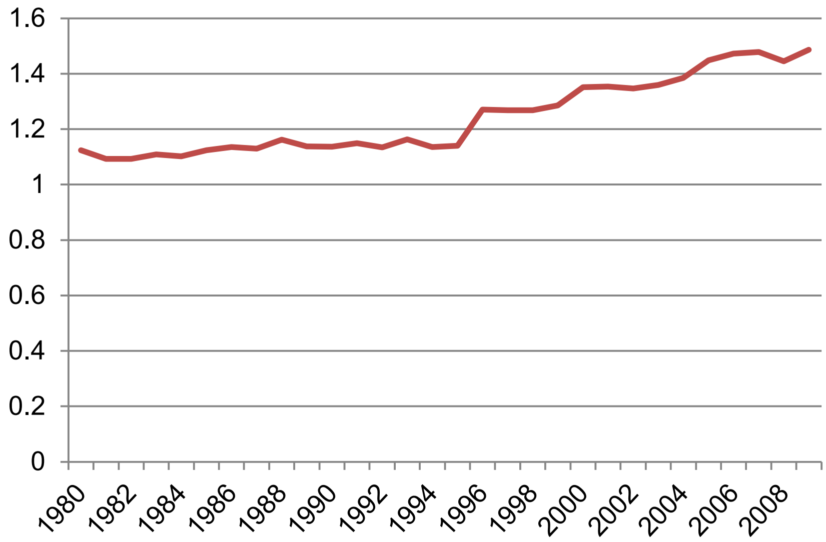
Figure 31: California vehicle miles traveled per registered vehicle and licensed driver



Source: (U. S. Federal Highway Administration, 2011)

Despite reductions in driving per capita, the number of vehicles registered in California continues to outpace growth in the number of licensed drivers. Data on California licensed drivers may not be fully indicative of the number of active drivers in the state due to domestic and international migration.

Figure 32: Registered vehicles per licensed driver in California



Source: (U. S. Federal Highway Administration, 2011)

Urban and suburban roads and highways are more heavily utilized than rural roads and highways. Vehicle traffic in California is spatially concentrated. In 2010, 82.0% of vehicle traffic was in urban areas and 70.8% of statewide vehicle traffic occurred on urban interstates, freeways, and arterials. These urban highways and roadways represent just 18.8% of the lane miles and 11.6% of centerline miles in the state.

Figure 33: Vehicle miles traveled per lane mile in California

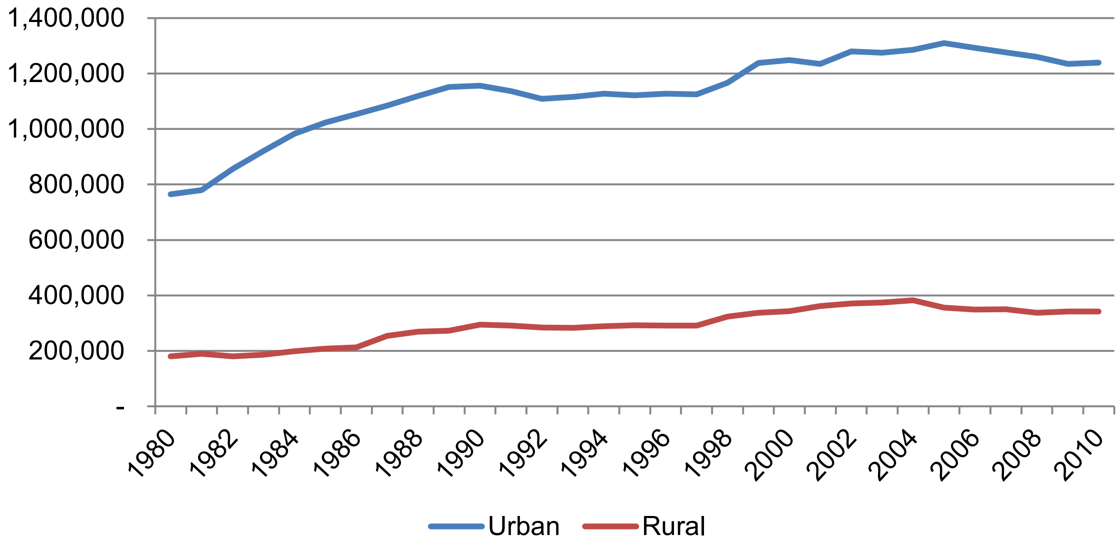
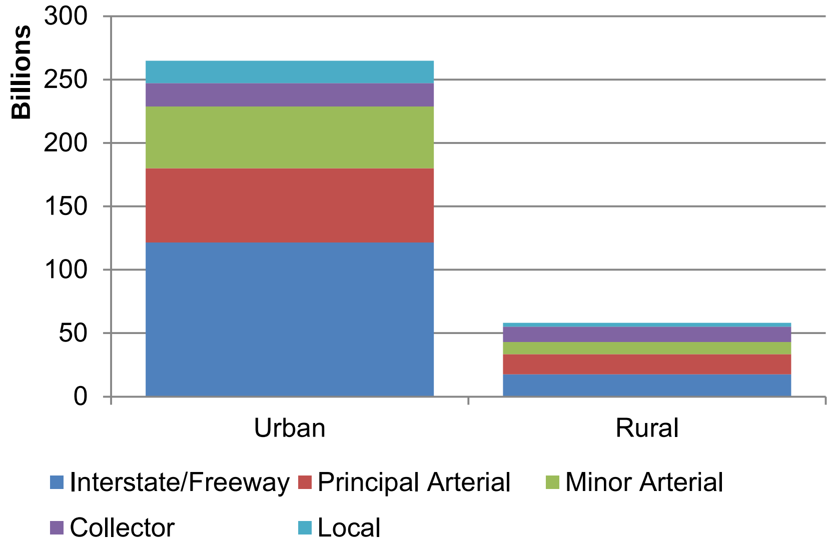


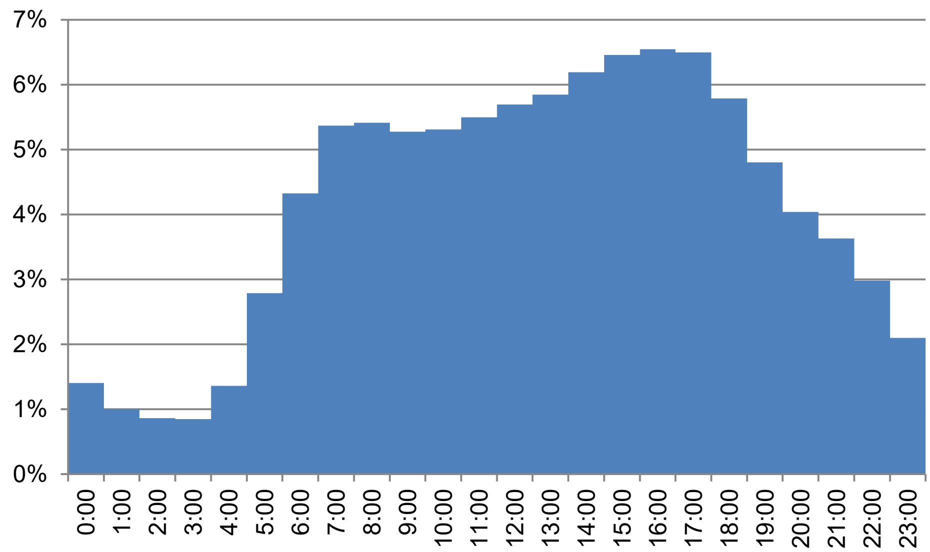
Figure 34: Miles traveled in California, by facility and urbanization



Source: (U. S. Federal Highway Administration, 2011)

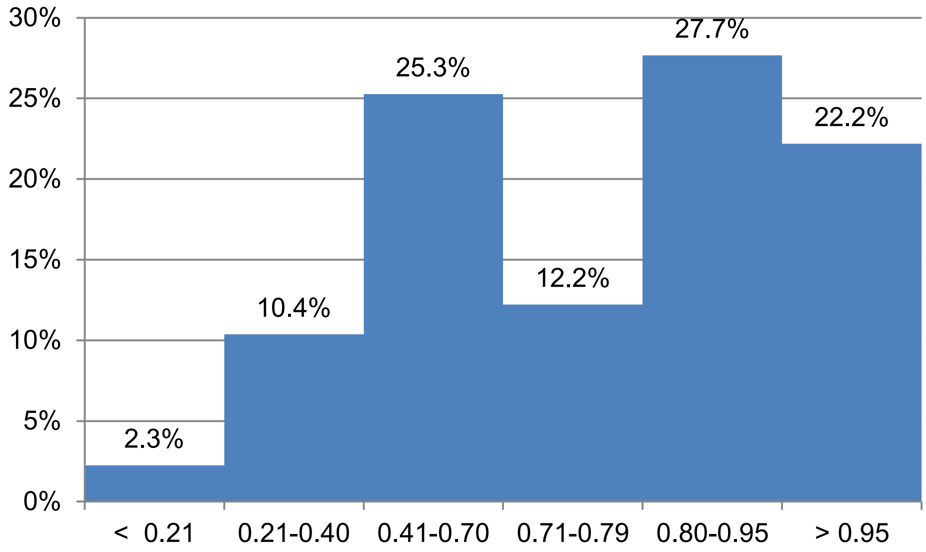
In addition to being spatially concentrated, motor vehicle traffic in California is temporally concentrated. The result of spatially and temporally concentrated vehicle travel in California is localized traffic congestion.

Figure 35: Percentage of California freeway miles traveled by hour of day



Source: (California Department of Transportation, 2012), using all PeMS data from 2007 to 2011

Figure 36: Percent of California urban highway miles by peak volume/service flow ratio



Source: (U.S. Federal Highway Administration, 2009) table HM-42.

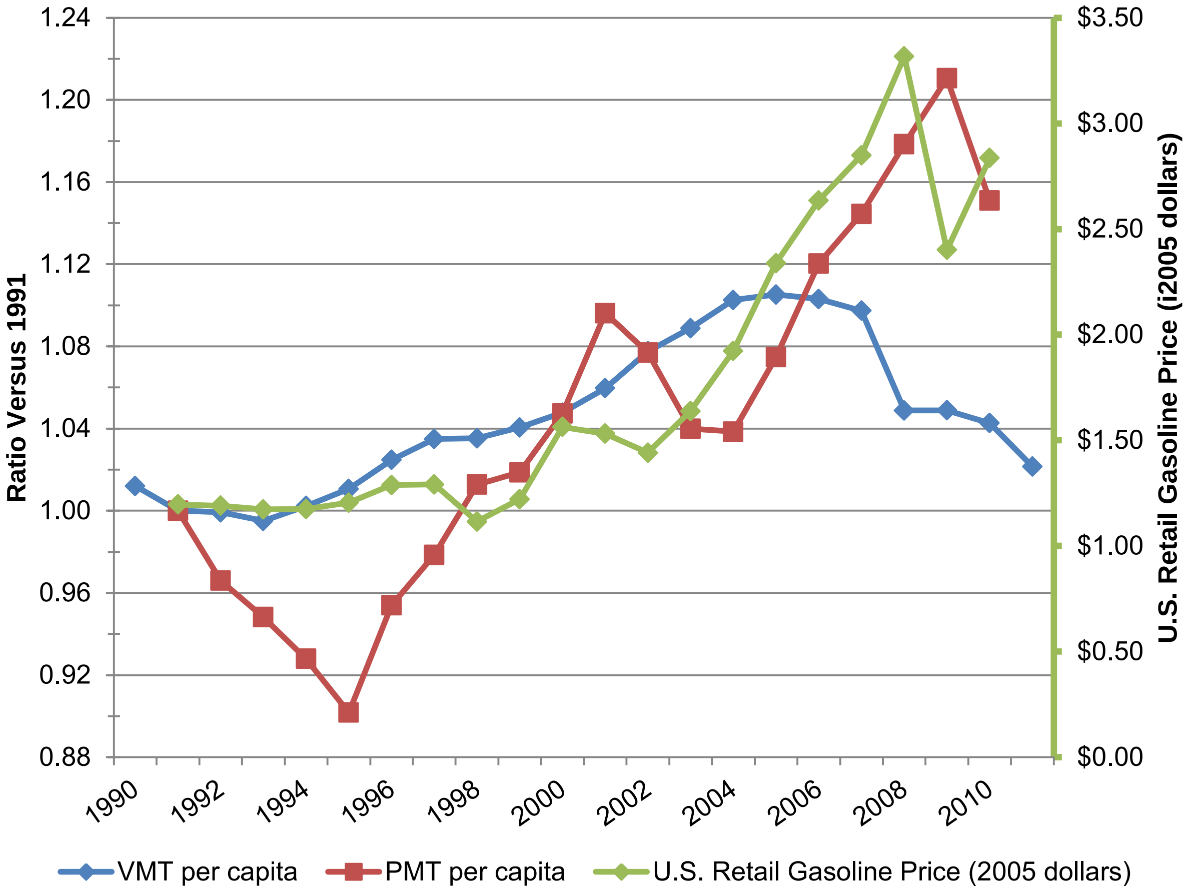
The volume to service flow ratio is a coarse measure of highway utilization and congestion. Volume is observed peak vehicles per hour. Service flow is the maximum hourly rate at which vehicles can flow through the facility. Many California interstates and freeways operate below a 0.80 volume to service ratio during peak hours due to traffic congestion.

California travel trends

Per capita transit use in California has increased over the past 15 years, largely associated with increases in fuel prices. Per capita driving, which increased through 2005, is now on the decline. Figure 37, below, shows this relationship.

This trend shows reductions in vehicle miles traveled and increases in transit use prior to legislated efforts to reduce vehicle miles traveled. The Sustainable Communities and Climate Protection Act of 2008 (SB 375) uses regional planning processes to curb increases in per capita vehicle miles traveled. Though passed in 2008, the Act did not take effect until 2011. Even so, it will likely be several more years before the state can attribute changes in travel activity to the Act.

Figure 37: Relative change in California driving and transit use versus real gasoline prices since 1991



Sources: (U. S. Federal Highway Administration, 2011), (U. S. Federal Transit Administration, 2012), and (U.S. Energy Information Administration, 2012)

Works Cited

Boarnet, M. G., & Bogart, W. T. (1996). Enterprise zones and employment: Evidence from New Jersey. *Journal of Urban Economics, 40(2)*, 198-215. doi:10.1006/juec.1996.0029

Borenstein, S., Bushnell, J., & Lewis, M. (2004). *Market Power in California's Gasoline Market.* Berkeley, CA: University of California Energy Institute.

Bureau of Economic Analysis. (2012). Price Indexes for Gross Domestic Product. Washington, DC.

California Energy Commission. (2012, October 12). *Weekly Fuels Watch Report.* Retrieved from Energy Almanac: http://energyalmanac.ca.gov/petroleum/fuels_watch/

California Air Resources Board. (2008). *Climate Change Scoping Plan.* Sacramento, CA: State of California.

California Board of Equalization. (2008). *Statewide Taxable Sales, By Type of Business, 2007.* Retrieved from http://www.boe.ca.gov/news/pdf/t1_a07.pdf

California Board of Equalization. (2012, February 16). Table 1. Statewide Taxable Sales, By Type of Business, 2010. Sacramento, CA.

California Department of Conservation. (2000). *Energy Map of California.* Retrieved from ftp://ftp.consrv.ca.gov/pub/oil/maps/Map_S-2.pdf

California Department of Conservation. (2011). *Producing wells and production of oil, gas, and water by county - 2010.* Retrieved from ftp://ftp.consrv.ca.gov/pub/oil/temp/NEWS/Producing_Wells_OilGasWater_10.pdf

California Department of Insurance. (2011, April 25). *2010 California P&C Premium and Loss Summary.* Retrieved from http://www.insurance.ca.gov/0400-news/0200-studies-reports/0100-market-share/2010/upload/MktShrSummary2010.pdf

California Department of Transportation. (2012). California Freeway Performance Measurement System. Sacramento, CA.

California Energy Commission. (2011). *Oil supply sources to California refineries.* Retrieved from California Energy Almanac: http://energyalmanac.ca.gov/petroleum/statistics/crude_oil_receipts.html

California Energy Commission. (2012, February 15). *2011 Integrated Energy Policy Report.* Retrieved from http://www.energy.ca.gov/2011publications/CEC-100-2011-001/CEC-100-2011-001-CMF.pdf

California Energy Commission. (2012). *Foreign sources of crude oil imports to California.* Retrieved from California Energy Almanac: http://energyalmanac.ca.gov/petroleum/statistics/2011_foreign_crude_sources.html

California Energy Commission. (2012, April 9). *Gasoline market share in California.* Retrieved from California Energy Almanac: http://energyalmanac.ca.gov/gasoline/market_share/index.html

California Transportation Commission. (2012). *2012 Annual Report to the California Legislature.*

Federal Transit Administration. (2012). National Transit Database. Washington, DC.

Ham, J. C., Swenson, C., İmrohoroğlu, A., & Song, H. (2011). Government programs can improve local labor markets: Evidence from state enterprise zones, federal empowerment zones and federal enterprise community. *Journal of Public Economics, 95(7)*, 779-797. doi:10.1016/j.jpubeco.2010.11.027

Matute, J. M., Yoh, A. C., Curry, M., Bergstein, S., Campbell, J., Craciun, F., . . . Taylor, B. D. (2012). *One state, many visions: Transit stakeholder views on planning for the future of California's mobility.* California Department of Transportation.

Neumark, D., & Kolko, J. (2010). Do enterprise zones create jobs? Evidence from California's enterprise zone program. *Journal of Urban Economics, 68(1)*, 1-19.

O'Keefe, S., & Dunstan, R. (2001). Evaluation of California's Enterprise Zones. *California State Library, California Research Bureau*.

Southworth, F., Sonnenberg, A., & Brown, M. A. (2008). *The Transportation Energy and Carbon Footprints of the 100 Largest U.S. Metropolitan Areas.* Georgia Tech.

U. S. Energy Information Administration. (2012). *International Energy Statistics.* Retrieved from http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm

U. S. Federal Highway Administration. (2011). Highway Statistics. Washington, DC.

U. S. Recovery Board. (2012, November 28). *Recipient Projects.* Retrieved December 11, 2012, from Recovery.gov: http://www.recovery.gov/Transparency/RecoveryData/Pages/RecipientReportedDataMap.aspx?stateCode=CA&PROJSTATUS=NPC&AWARDTYPE=CGL#

U.S. Census Bureau. (2009). 2007 Economic Census. Washington, DC.

U.S. Census Bureau. (2010). 2009 American Community Survey. Washington, DC.

U.S. Census Bureau. (2012, December). Longitudinal Employer-Household Dynamics: OnTheMap. Washington, DC.

U.S. Energy Information Administration. (2012, December 3). *California Gasoline and Diesel Retail Prices.* Retrieved from http://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sca_w.htm

U.S. Energy Information Administration. (2012, September 27). *Federal offshore PADD 5 field production of crude oil (thousand barrels).* Retrieved from http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRFP5F1&f=A

U.S. Energy Information Administration. (2012, September 27). *Movements by tanker, pipeline, and barge between PAD districts.* Retrieved from http://www.eia.gov/dnav/pet/pet_move_ptb_dc_r50-r30_mbbl_a.htm

U.S. Energy Information Administration. (2012, June 22). Number and Capacity of Petroleum Refineries.

U.S. Energy Information Adminstration. (2012, June 29). *State Energy Data System*. Retrieved from http://www.eia.gov/beta/state/seds/

U.S. Energy Information Adminstration. (2012, June 29). *State Energy Data System*. Retrieved from http://www.eia.gov/beta/state/seds/

U.S. Federal Highway Administration. (2009). Highway Statistics. Washington, DC.

U.S. Federal Highway Administration. (2011, February). National Household Travel Survey. Retrieved from http://nhts.ornl.gov

U.S. Federal Highway Administration. (2012). National Bridge Inventory. Washington, DC.

Worrel, E., & Galitsky, C. (2004). *Profile of the petroleum refining industry in California.* Berkeley, CA: Lawrence Berkeley National Labratory.

Chapter 3: Methodology

Introduction

This report's role in California policy-making is to provide accessible information to the State and leading local and regional governments. The policy briefs are designed as a starting point as these governments consider their options to reduce statewide and regional transportation greenhouse gas emissions, and by extension, petroleum use.

With each assessment, we seek to describe how explicit or implicit policy choices directly or indirectly affect petroleum demand in California. To do this, we use forecasting rather than modeling. Forecasting uses different assumptions and information than models. Forecasting is an analytical method that emphasizes understanding feedback loops and examining connections (linkages, interactions) among events. Forecasting differs from modeling, which uses prior statistical correlations as an indicator of future performance.

A secondary goal of the report is to avoid a vicious policy-making cycle, where a lack of information on some policy options relative to others forecloses potentially effective policymaking. Risk aversion produces an inherent tendency to select policies and measures that can be easily evaluated or predicted over those that cannot. Prior observational data does not exist to quantitatively evaluate some policy choices. However, hard-to-evaluate, interconnected measures may be those that are the most effective and efficient at making desired changes to a complex system. Due to risk aversion, decision-makers will often choose policies for which more information is available. Yet, this foreshortened decision-making horizon may broaden the gap between selected policies and less understood but potentially-effective policies that are excluded from a model's simple statistical analysis.

Thus, some governments must engage in some level of risk-taking in order to create and evaluate real-world examples of new and expanded policies and measures. To assure progress, some actors must lead irrespective of the availability of high-certainty information. Low- and medium-certainty information on potential effects includes the use of simplified forecasting tools, the use of empirical studies from successful applications elsewhere (without a thorough understanding of a measure's sensitivity to local conditions), and theoretical consideration of system dynamics. Consideration of system dynamics is a means for understanding the evolution of complex systems over time.

Use of low- and medium-certainty information will support governments that wish to implement potentially effective and efficient policies. Once California gains more experience with such policies, policymakers can then vary the geographic location or intensive range of the scale of implementation, enabling the collection of multi-dimensional panel data needed to model each measure and estimate the effectiveness of related measures.

Modeling and forecasting

These briefs make extensive use of simplified forecasting tools instead of relying on comprehensive local or regional travel models. Many stakeholders are unaware of the differences between modeling and forecasting tools, and the uncertainty of their outputs.

By Juan M. Matute and Stephanie S. Pincetl

Modeling involves a statistical approximation of past system behaviors. Planners use models to understand how potential system changes would affect the existing system, provided that those changes are within the range of previously observed behavior.

Forecasting involves the estimation of future system behavior based on current conditions, an understanding of the system's structure, and how the system may respond to any changes that extend beyond the range of previously observed behavior

It's possible to model a system without understanding its structure. Modeling only requires a statistical approximation of the interrelatedness of past observations. Forecasting relies far more on understanding a system's dynamics and potential for non-linear changes. We discuss both modeling and forecasting in the following sections.

About planning models

Regional transportation, land use, and emissions planning processes all use models. They do so in part due to regulatory requirements, but also to aid decision-making. Travel models have evolved considerably over the past two decades, with large regions in California transitioning from legacy "four-step" models to advanced activity and tour-based models. Land use models have made similar advances, generally moving from linear estimation to a dynamic market-based or agent-based approach. (For an overview of advanced travel and land use modeling practices see National Highway Cooperative Research Program, 2010).

In order for planners to highlight the differences among policy and infrastructure choices, the model they use must be sensitive to the various changes in policy, infrastructure, and other factors considered. A model is sensitive to a factor if the built-in methodology and statistical variable relationship are able to validly assess the potential range of factors under consideration. Often models are validated by seeing if they will accurately predict past conditions, a process known as backcasting. This does not, however, ensure they will be able to accurately predict future system conditions.

Modeling in California

Because California has some of the nation's most extreme air quality and traffic congestion problems, the state typically employs some of the nation's most advanced statewide and regional planning models. Advanced travel demand models currently under development in California include SimAGENT, used in Southern California and Travel Model One, under development in the Bay Area. The state uses two advanced land use models, UrbanSim and PECAS, and is the only state to maintain its own emissions model, EMFAC.

However, despite California's progress in developing and using planning models, these tools are highly limited in their ability to forecast future conditions when planners expect substantial policy changes. An advanced model's sensitivity, or ability to capture individual and household response to transportation infrastructure and policy changes, depends on a narrow range of factors present in observational data. These factors include income and other household characteristics (number of persons, school-age dependents, workers, vehicle availability), work location, and the extent of the transit and highway network. Many of the advanced model's sensitivities are based on single-dimensional linear estimation methods–meaning that these advanced models will produce highly uncertain forecasts if expected conditions vary substantially from past conditions.

One advancement from the move toward activity-based and tour-based travel models is that models now integrate a driver's synthesized demographic characteristics into decisions that affect their travel behavior throughout the day, not just for home-based trips. Wealthier drivers will be less sensitive to changes in costs than will poorer drivers. However, a model may be sensitive to the overall cost of the trip, but not individually sensitive to elements like parking, congestion charges, changes in gasoline prices.

While the advanced models are limited in their ability to forecast the effects of new policy options, they are the best tools currently available for comprehensive transportation and land use planning. However, legislation such as the Clean Air Act Amendments of 1990 and California's SB 375 (2008) has somewhat blurred the line between modeling and forecasting. These policies add a future-year emissions constraint to planning processes, necessitating the use of forecasts and implementation measures to keep future emissions below constraints. As modeling becomes a more important part of regional transportation and land use policy making, communities and regions are hesitant to implement policies which they cannot forecast, or can only forecast with a low degree of certainty.

Evolving models into better forecasting tools for energy and climate planning requires a multifaceted program to improve data and methods. For a discussion of such a program for California, see Matute (2011). Implementing such a program will require significant time and investments. In summary, forecast tools will need to be integrated as modules within the existing modeling framework. Integration as a module will allow the forecast tool to adjust for indirect feedback, for instance, how real estate growth patterns change in response to the elimination of minimum parking requirements and movement towards market-allocation of parking resources. Once multidimensional panel data is available to describe how observations at various locations depend on local conditions, then models can incorporate some of the functionality of forecasting tools.

Forecasting in complex systems

Forecasting requires many more assumptions than modeling, and thus forecasting results are typically far more uncertain than modeling estimates. However, the most important assumptions are not the coefficients, or sensitivities (as is the case with modeling), but rather the system's structure and potential for non-linear outcomes. In forecasting policies or measures for this report, we have taken steps to recognize system structure and the potential for dynamic change.

California's transportation and land use system is both dynamic and highly complex. One implication of its complexity is that the system is highly sensitive to positive feedback loops that reinforce existing behavior. This leads to non-linear changes in the transportation and land use system, which we demonstrate produce significant changes in petroleum use. With such policies and factors, past observations are not indicative of future performance, either because of a disruptive innovation or arriving at critical "tipping-point" thresholds in the transportation land use system. Disruptive innovations and critical thresholds are notoriously difficult to forecast.

Traffic congestion is a prime example of the role of feedback loops in system dynamics. Congestion provides negative feedback to travelers—a warning that the system is over capacity and unable to accommodate additional use without degradation in service quality. In response, some travelers will avoid discretionary trips through congested areas and times, or seek alternatives to vehicular traffic congestion, such as transit with a dedicated right-of-way. Because traffic congestion causes individuals to seek alternatives to congestion, it acts as a self-balancing feedback loop for the transportation system.

Rideshare as an example of non-linear system change

Rideshare provides an example of the potential for non-linear adoption of measures that reduce petroleum use. Publicly-sponsored rideshare programs have been available for many decades. Current rideshare rates are largely stable, with some fluctuations due to increase in gasoline prices. Even expanding the HOV network may do very little to increase the proportion of travelers who share the ride. This is because the critical incentive threshold needed to vastly increase carpooling in California is likely above current vehicle operation costs (including gasoline price, parking costs, vehicle maintenance, etc.) and transaction costs required to successfully match and complete a shared ride.

However, a change in one or more rideshare factors may trigger large increases in California rideshare. Such changes could include substantial reductions in participants' transaction costs, driver compensation, and rides arranged in real-time to preserve driver and passenger flexibility. Because rideshare benefits from a network effect–the value of rideshare increases not only with the extent of the HOV lane network but also with the number of rideshare options available to users–increased utilization could trigger a critical threshold that leads to a virtuous cycle of rideshare adoption.

Our approach

With each of the fifteen assessments, we study the link between a factor—a measure that creates some system change—and outcomes, intermediate indicators of petroleum demand. We use a combination of qualitative and quantitative methods for each assessment.

We developed a list of twenty-five policy factors which we believed to have a direct or indirect effect on petroleum consumption in the state. After initial discussion with Next 10 and consideration of the potential value new information on each topic would have to the public and decision-makers, we narrowed this list down to fifteen.

Review of the literature

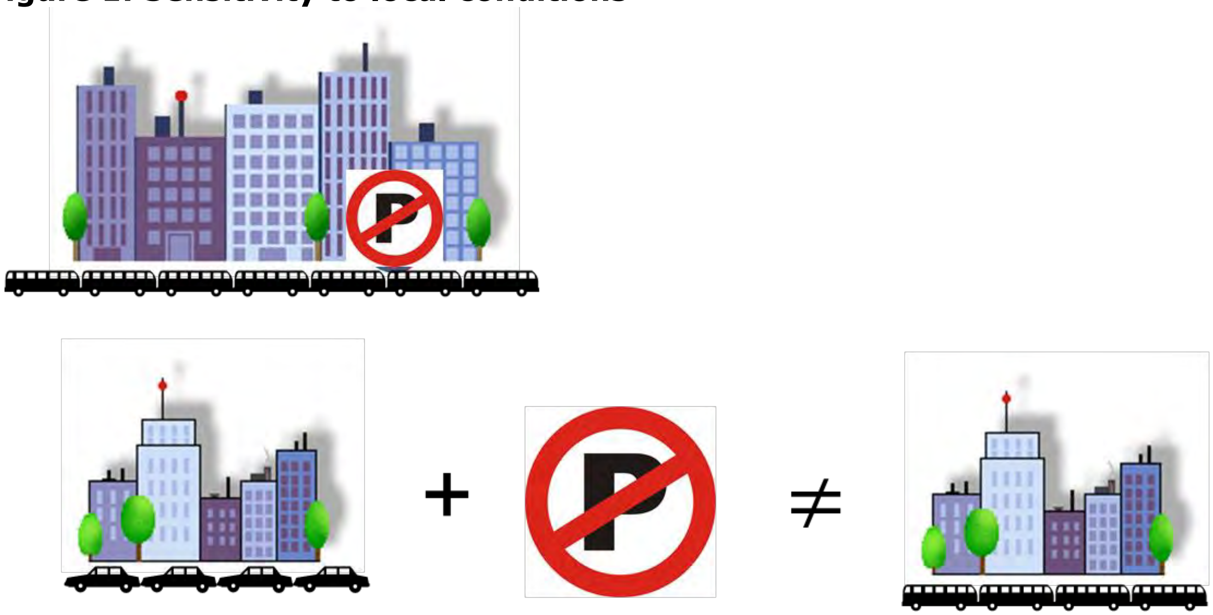
We begin each assessment with a thorough review of the literature in search of factor sensitivities from past case studies or statistical analysis. Factor sensitivities link a measure or outcome, such as an increase in the quality of transit service, with an intermediate indicator, such as mode choice propensity. Direct effects are typically better documented in the literature than are indirect effects. A measure that has a direct effect on vehicle miles traveled, such as increasing the variable cost of vehicle travel, is well documented. Indirect effects have little documentation, such as how a measure affects real estate market and how those changes in turn affect locational decisions and vehicle miles traveled.

Identification of system complexity and dynamics

Indirect effects often arise from complex system structures–which show potential for non-linear dynamics if certain conditions are met. We assess the structure of the system under study: the flows, stocks, and feedback loops. In particular, we look for the potential for non-linear change: similarities with past measures, network effects, virtuous adoption potential, and the weakening or strengthening of feedback.

We also assess how a factor's path dependency and sensitivity to local conditions may affect outcomes in California. This involves a conceptual assessment of how a system evolves over time with respect to local conditions. We consider how an implementation measure's sensitivity to local conditions may affect information collected from one area's applicability to other areas. The transition that results from measure implementation will not involve the same local conditions or the same evolutionary processes, and the transition will likely have differing results. A conceptual understanding of the system's sensitivity to initial conditions allows us to identify which factors show potential in California.

Figure 1: Sensitivity to local conditions



For example, consider an attempt to import Manhattan's parking policy to a California urban center. Manhattan has and has always had a very low level of automobile parking spaces per capita relative to other North American cities. An urban area of California, which currently has higher per capita levels of parking spaces, might seek to reduce the ratio to Manhattan-like levels. However, parking supply is only one element of the transportation and land use system. First, because Manhattan has always had low parking ratios, it has evolved substitute transportation options over hundreds of years. Because the California urban center is transitioning from different initial conditions, because complementary factors may not yet be in place, and because different alternatives are available today relative to when Manhattan developed its transportation options, it's not valid to assume that the California urban center will experience Manhattan-like travel behavior even if it succeeded in matching the island's parking ratios. What might be expected today is an increased reliance on a new technology, such as driverless taxi trips enabled by autonomous vehicles, maintaining current levels of automobile miles traveled without the need for present-day parking ratios.

In assessing the potential for non-linear system dynamics, such as those that arise from network effects, we aim to deconstruct and clearly explain the structure of the system. While clarity is not a perfect substitute for certainty, it can help engender a broader understanding of the system under study.

Identification of legislative barriers

Next, we assess the extent to which the presence or absence of legislation or regulation acts as a barrier. If the legal barrier is removed or amended, non-linear change could be expected. Where possible, we connect our assessments with specific legislation or regulations at applicable levels of government.

Quantitative assessment

Based on the literature review, an understanding of the system's structure, and a broad set of data, we estimate the connection between the assessed factors and intermediate indicators of petroleum demand (see Table 1). In general, the quantitative assessment methods use simple spreadsheet models that employ a wide range of existing data.

Table 1: Intermediate indicators of petroleum demand

Intermediate Indicator	Discussion
Distance Traveled	A change in total distance traveled, regardless of mode. Most assessments focus on automobile use.
Mode Choice	Changes in the proportional use of privately-owned single-occupant automobiles, shared rides, transit, walking, bicycling and other modes.
Vehicle Fuel Efficiency	Changes in a vehicle's rated fuel efficiency, typically locked-in at the vehicle purchase decision.
Vehicle Operation Efficiency	How changes in a vehicle's condition affect fuel efficiency, for example: the quality of the air filter or the adequacy of tire inflation.
System Operation Efficiency	Transportation system factors external to the vehicle, such as traffic congestion or unsynchronized traffic lights, that can affect fuel efficiency.
Fuel Composition	The petroleum content of motor vehicle fuel varies. Electricity and hydrogen fuels require little or no petroleum. One-hundred percent gasoline or diesel blends are solely comprised of petroleum. Most future gasoline and diesel sold in California will have some non-petroleum content, either from bioethanol or biodiesel. We do not assess upstream or lifecycle petroleum use from varied petroleum stocks in this report.

We use two methods in our quantitative assessments. The method employed depends on the requirements of the factor being studied. We also employ ad-hoc assessments as necessary.

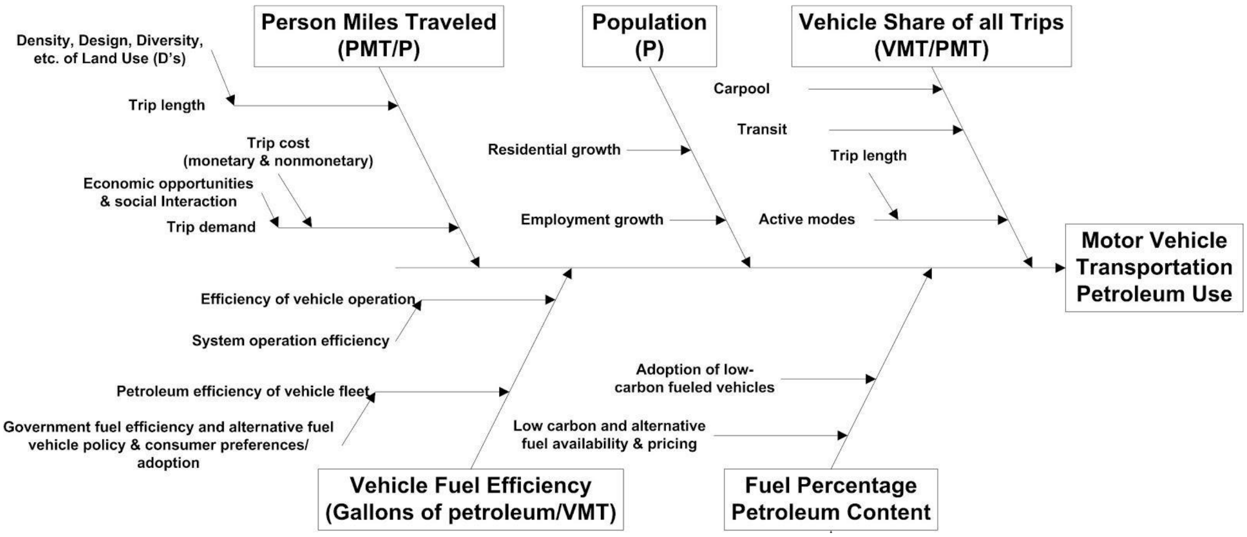
Equation 1: Four-legged stool method

$$Petroleum\ Use = VMT \times Vehicle\ Fuel\ Efficiency \times Fuel\ Percentage\ Petroleum\ Content \times Vehicle\ Operation\ Efficiency \times System\ Operations\ Efficiency$$

Equation 2: Fishbone method

$$Petroleum\ Use\ (gallons) = Population \times \frac{Person\ Miles\ Traveled}{Population} \times \frac{Vehicle\ Miles\ Traveled}{Person\ Miles\ Traveled} \times \frac{Gallons}{Vehicle\ Miles\ traveled} \times Fuel\ Percentage\ Petroleum\ Content$$

Figure 2: Framework for fishbone method



Framework based on Millard-Ball (2008)

Table 2: Data used in assessments

Name	Description
American Community Survey (U.S. Census Bureau) census.gov	This annual Census product provides estimates of a wide range of socio-demographic and housing indicators. Data for states, regions, and large cities is produced annually. Data for neighborhoods (Census block groups) is based on 5-year averages.
Annual Planning Survey Results (California Governor's Office of Planning and Research) opr.ca.gov	The California Governor's Office of Planning and Research annually surveys California's cities and publishes the results.
California Energy Almanac (California Energy Commission) energyalmanac.ca.gov	The California Energy Almanac is the state's outlet for energy supply and consumption statistics. The Almanac combines data from many sources, including the Public Utilities Commission, the Department of Conservation, and the Board of Equalization. The Almanac publishes many datasets that are unique to California, including the Weekly Fuels Watch and historical retail sales data.
California Greenhouse Gas Emission Inventory (California Air Resources Board) arb.ca.gov	The California Air Resources Board inventories statewide greenhouse gas emissions each year. The Board reports emissions, allocated by Intergovernmental Panel on Climate Change category and economic sector.
California Historical Expenditures (California Legislative Analyst's Office) lao.ca.gov	The California Legislative Analyst's Office's California Historical Expenditures data sets provide historical information about statewide expenditures, including those specific to transportation.
California Performance Measurement System (Caltrans) pems.dot.ca.gov	The California Performance Measurement System reports real-time and historical data from sensors embedded in California's highway system and other sources.
Energy	The U.S. Energy Information Administration publishes a variety

Information Administration U.S. Department of Energy eia.gov	of energy-related datasets. Those used in this project include various datasets related to petroleum production, use, and refining.
Fuel Taxes Statistics & Reports California Board of Equalization boe.ca.gov	California's Board of Equalization manages the collection and distribution of various taxes levied on gasoline and diesel fuel. The Board issues monthly and annual reports on the taxable volume of motor vehicle fuels distributed in California.
Highway Statistics (Federal Highway Administration) fhwa.dot.gov	The Federal Highway Administration's Highway Statistics database has been published annually since 1945. We used these annual reports to create time-series datasets for California. As the data is of limited use in its published form, we processed and refined the data from multiple tables across multiple years, interpolating some missing data, to create an extensive time-series of transportation data for California. The Highway Statistics dataset covers topics ranging from drivers licensing, vehicle registrations, extent and characteristics of the street and highway system, and transportation finance.
Longitudinal Employer-Household Dynamics (U.S. Census Bureau) census.gov	The U.S. Census Bureau's Longitudinal Employer-Household Dynamic program is a partnership between the Bureau and individual states. Using data from California's Employment Development Department, the Census Bureau creates annual employment indicators at several geographic levels. One of these indicators, employee origin-destination data, is synthetically created to balance privacy concerns with data integrity. The OnTheMap tool aggregates employer and household data to Census geographies.
National Bridge Inventory (Federal Highway Administration) fhwa.dot.gov	This annual dataset contains current and historical information about the nation's bridges, including obsolescence or deficiency rating, year built, and materials type.
National Household Travel Survey (Federal Highway Administration) nhts.ornl.gov	The National Household Travel Survey (NHTS) is the premier national dataset for information about individual travel correlated with household demographics. Unlike Census data which tracks travel activity only for one day's trip to work, the National Household Travel Survey asks participants to track their activity and purpose for trips over an entire 24-hour period. This dataset allows for a more complete picture of how Americans and Californians travel. The Federal Highway Administration conducted the most recent survey in 2009 and we use data for California. California conducts a State Household Travel Survey, the most recent results available at

	the time of this study were published in 2001. Macroeconomic conditions and petroleum prices changed significantly between 2001 and 2009, motivating our choice to use the 2009 dataset. The final report from the State's 2012-2013 survey will be published in June 2013. NHTS data includes only household travel and excludes firm travel (business, freight, etc.). We used national ratio of vehicle occupancy from 2009 National Household Travel Survey and 2009 & 2010 Highway Statistics 2010 to estimate Person Miles Traveled by firms in California.
National Income and Product Account Tables (Bureau of Economic Analysis) bea.gov	The U.S. Department of Commerce produces a vast array of economic indicators. For purposes of this project, we used their price indices to adjust historical expenditures for inflation. Specifically, we employed lines 57 through 59, State and local aggregate, consumption, and investment expenditures.
National Transit Database (Federal Transit Administration) ntdprogram.gov	The National Transit Database publishes information from over 600 transit providers receiving federal Urbanized Area Formula funds. This information includes statistics on operating and capital funding and expenses, service metrics, and an inventory of vehicle assets. Included in the database is information from transit agencies that directly operate service, those that purchase transit service from a private company, and those that do both.
RAND California Statistics (RAND Corporation) ca.rand.org	RAND California Statistics contains state-, county-, and city-level data on business and economics, education, government finance, health, and energy. The data sources includes original data as well as data combined from other sources.
Regional Transportation Plans (Various Metropolitan Transportation Planning Organizations)	California's Metropolitan Planning Organizations must produce and adopt a Regional Transportation Plan every four years. These plans contain estimates of past and future activity, and enumerate future transportation policy and investments. The estimates are the best available source of information on regional and sub-regional travel activity.
State Energy Data System (Energy Information Administration) eia.gov	The State Energy Data System tracks estimates of California production, price, and consumption data for all energy sources and economic sectors since 1960. The Energy Information Administration is the U.S. Department of Energy's official source for energy statistics.

TOD Database (Center for Transit-Oriented Development) toddata.cnt.org	The TOD Database facilitates accessing information from the U.S. Census Bureau's American Community Survey and Local Employment Dynamics in areas around transit-stations. The database processes data reported for Census geographies, which are drawn irrespective of transit, in order to produce estimates for land within ¼ or ½ miles of an existing or planned transit station.

Establishing baselines for each quantitative assessment

We assess each factor's isolated effect on statewide petroleum use versus current conditions. Future implementation of planned policy instruments, such as California's low carbon fuel standard, or concurrent implementation of other assessed policies, do not affect our outcomes. Forecasting the interdependencies of other policies or measures would introduce additional uncertainty into the assessments. Additionally, because predicting future changes unrelated to the factor under study produces considerable additional uncertainty, we ignore any implementation lag in the quantitative analyses and address these time-horizons in the summary. To assess the effects of factors currently present, such as the mortgage interest tax deduction, we consider a counterfactual in which the factor does not exist.

Table 3: California-specific baseline assumptions

Constant	Value	Source (date)
Population	37,691,912 people	U.S. Census Bureau (July 2011)
Vehicle Miles Traveled	322,849,000,000 vehicle miles	U.S. Federal Highway Administration Highway Statistics (2010)
Person Miles Traveled	449,828,250,080 miles	Estimate using National Household Travel Survey (2009)
Average Vehicle Fuel Efficiency	18.32 miles per gallon	U.S. Federal Highway Administration Highway Statistics (2010)
Gallons of Motor Vehicle Fuel Used	17,623,342,000 gallons	U.S. Federal Highway Administration Highway Statistics (2010)
Transit Person Miles Traveled	7,542,689,012 miles	U.S. Federal Transit Administration National Transit Database (2010)

Brief Summary

Each brief begins with a summary table, including statements of magnitude and uncertainty to be used in comparing the factors assessed in different briefs.

Magnitude

Stakeholders can at times confuse precision with accuracy. Precision is the degree to which a measurement or prediction is specific, while accuracy is the degree to which a measurement or prediction is correct. Thus, while the text of most briefs may contain a more precise estimate of how some measure affects statewide motor vehicle (or aviation) fuel use, we give a less precise assessment in the summary table. Where we expect range of possible effects in the text, we choose the median case for the summary. One of the fifteen briefs assesses a factor that contributes to aviation fuel use.

Table 4: Magnitude scale used in assessments

Level	Implication
Low	Factor effects statewide motor vehicle (or aviation) fuel use by 0.5% or less
Medium	Factor effects statewide motor vehicle (or aviation) fuel use by around 2.5%
High	Factor effects statewide motor vehicle (or aviation) fuel use by 5% or more

Uncertainty

In the summary for each assessment, we declare a subjective, qualitative estimate of uncertainty. Unless we perfectly understand the system's organization, it's impossible to accurately, validly, and precisely predict future system behavior. The spread between predicted and real outcomes is likely to grow over time, meaning that the longer range the forecast, the more uncertain the projections. Most forecasts, including those in this report, are perhaps most accurately referred to as "informed estimates".[1]

Table 5: Uncertainty scale used in assessments

Level	Meaning
Low	The assessed system is highly complex with uncertain feedback and flows; and little data exists to aid in evaluation.
Medium	If sufficient data exists, the system's interconnections may not be well understood, making the evaluation uncertain. Or, the systems are well understood, but sufficient data is unavailable.
High	Other research has evaluated the effects with a high degree of certainty, or sufficient data exists to evaluate the potential to a high degree of confidence.

[1] for a popularly-accessible of uncertainty in forecasting see Silver, Nate. (2012). *The signal and the noise: Why most predictions fail – but some don't.* New York: Penguin.

Table 6: Fields in policy brief introduction

Field	Description
Affects petroleum demand through intermediate indicators	The primary and secondary intermediate indicators through which the assessed factor affects petroleum demand, see Table 1 for details.
Applicable level of government	Whether any regulation or legislation affecting the assessed factor or measure is present at the local, regional, state, federal or other levels.
Relevant laws or cases affecting factor	A list of the most pertinent laws, regulations, and court cases identified in the policy brief.
Time horizon for implementation and maturity	A discussion of the time-frame in which the factor can be changed in order to reduce petroleum use.
Relevant topics	A list of keywords pertaining to the assessment.
Summary	A brief summary of the assessment.

A comprehensive summary of all fifteen assessments appears in this report's Executive Summary.

Works Cited

Matute, J. (2011). Measuring Progress toward Transportation GHG Goals. UCLA Luskin Center Working Paper.

Millard-Ball, A. (2008). Municipal Mobility Manager: New Transportation Funding Stream from Carbon Trading?. *Transportation Research Record: Journal of the Transportation Research Board*, *2079*(-1), 53-61.

National Highway Cooperative Research Program. (2010). Advanced Practices in Travel Forecasting. Transportation Research Board. Synthesis Report #406.

Conventional Approaches to Non-residential Parking Policy

Overall effect on California petroleum use		**Affects Petroleum Demand Through Intermediate Indicators:**	
Magnitude	High	**Primary**	Distance Traveled
Certainty	Medium	**Secondary**	Mode Choice and System Operations Efficiency
Applicable Level of Government	Local		
Relevant Laws or Cases Affecting Factor	1926 Supreme Court *Euclid v. Ambler* (272 U.S. 364) and various local codes		
Overall Time-Horizon of Reversal	The transition away from conventional parking policy would occur gradually over the long-term, based on future changes to the built environment. Changes in urban form would occur most rapidly in areas where current parking policy most constrains the built environment. Even so, the change would occur gradually at the margins, rather than through sweeping redevelopment of existing neighborhoods.		
Relevant Topics	Parking, zoning, urban form		
Summary	Many cities are unwilling or unable to use market controls to manage a finite resource: on-street parking. Instead, they use minimum parking requirements in an attempt to alleviate scarcity and avoid the tragedy of the commons — spillover parking demand. Conventional parking approaches, which seek to predict and provide for peak parking demand in order to avoid parking spillover, greatly subsidize the true cost of parking and distort urban form. Several alternatives to conventional parking policy exist. They include allowing for adaptive reuse, shared parking, in-lieu fees, wayfinding to increase utilization of existing parking infrastructure, and the market-based allocation of parking spaces.		

Introduction

Under a conventional parking policy approach, a local government mandates a minimum number of spaces that must be included with new developments. The goal of such policy is to satiate parking demand in order to reduce the potential for conflicts that result from on-street parking scarcity. To accomplish this goal, a local government must predict parking

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demand and provide (or require the provision of) a sufficient number of spaces to meet that demand.

The primary challenge local governments face in implementing the conventional "predict and provide" parking approach is forecasting the number of spaces needed to meet demand. Just as demand for roadway space varies by time and location, demand for parking varies by time, location, and a building's purpose. In many cases, local governments require that buildings provide sufficient parking to meet peak annual demand. This means that a restaurant cannot open unless it provides sufficient parking to meet demand for Mother's Day brunch. It also means that a retail store cannot open unless it provides sufficient parking to meet demand for the Friday after Thanksgiving.

While this constraint leads to fewer restaurants and retail stores, those driving to those locations that do exist will not be subject to parking scarcity *if* parking demand manifests as predicted. However, parking demand does not always manifest as predicted in areas where an automobile can park in a lot designated for one building and its occupants can walk to another building, especially if such behavior is more convenient or cheaper for the occupants. Available parking spaces may be out of sight and undiscoverable by the potential user. The complexity of neighborhoods increases with density and diversity of uses. In general, the more complex the area, the less certain parking demand forecasts will be.

Rather than develop neighborhood- and site-specific parking demand forecasts, many local governments use national averages from the Institute of Transportation Engineers *Parking Generation* manual, now in its 4th edition (2010).

Criticisms of conventional parking policy

To the parking user, scarcity is the most salient parking problem. Under the predict-and-provide parking paradigm, the solution to scarcity is more supply. To the non-user, community, and stakeholders seeking reductions in petroleum use, more parking supply creates new challenges. We detail and discuss several assumptions that we believe are implicit in a local government's decision to provide or ensure the provision of "adequate" or "enough" parking in an attempt to alleviate scarcity. These are subjective, relative terms, and their use often:

- assumes that parking should be free, or implicitly ignores the role of economic incentives in making choices;
- treats parking and land as an abundant resource, ignoring the negative feedback imposed by scarcity
- unintentionally discourages walking as a policy goal by requiring parking be provided as near as possible to an intended use;
- assumes that the quality of all parking spaces is uniform: that all are equally-discoverable and accessible;
- and assumes that individuals lack any other means of accessing a property other than traveling in and storing an automobile.

Furthermore, we argue that conventional parking policy only functions as intended where these conditions are met — and that minimum parking requirements become a self-fulfilling prophecy. If an area does not meet the above conditions, it will approach or attempt to approach these conditions after several decades of applying parking standards to all new development and changes in use.

Conventional parking policy attempts to suspend or ignore the role of market economics in managing scarcity. Fundamentally, because cities have underpriced public on-street parking, they require developers and business owners to underprice private off-street parking. This has larger ramifications in areas where parking is relatively more expensive to provide: dense areas and areas with higher land values.

Most implementations of conventional parking policy ignore parking prices, or assume that parking will be free. In the Institute of Transportation Engineers *Parking Generation* manual, national observations of parking demand by land use are based on samples where parking is unpriced. The Institute and others (Wilson, 1995 and Shoup, 2005) warn that parking demand varies by local conditions and implore local governments to seek additional information about how parking demand is sensitive to community and site-specific conditions, including prices. In practice, many local governments disregard these cautions. Doing so ignores an individual's sensitivity to transparent prices – an incentive forming the foundation of microeconomics – in areas where nearby on-street or off-street parking is priced or has time limitations.

Conventional parking policy assumes land is an abundant resource and thus distorts urban form and produces additional traffic congestion. Floor area ratio is a zoning control to limit density by only allowing a specified amount of building square footage on a given lot size. Providing required parking with surface parking can serve as an additional density constraint (Willson, 1995). Surface parking is cheapest to construct, but the land costs are not amortized over other, revenue-producing uses. Thus, structured and subterranean parking are popular in many suburban and urban settings with higher land values. However, because stacking parking has far fewer barriers than stacking roadways, the tendency to construct multi-level parking in denser areas increases parking spaces per acre without any increase in roadway capacity (Manville and Shoup, 2005). The result in a land-constrained area is additional traffic congestion.

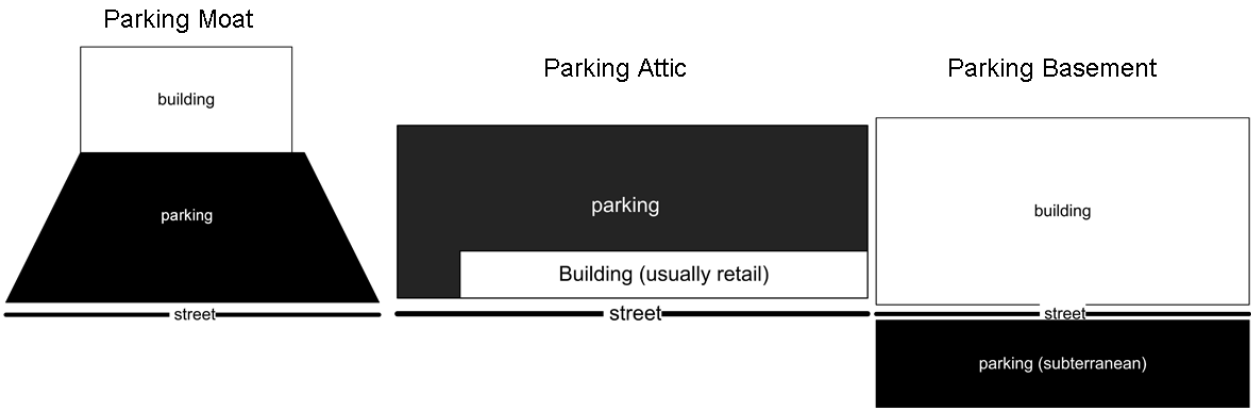
While discouraging walking is not an explicit objective of conventional parking policy, this goal is implicit when a local government requires that a building's required parking be nearby. Dedicating parking to individual uses, typically as an attempt to avoid conflicts produced by incentives to park closer or cheaper, discourages (and in some cases, prohibits) walking between several uses or parcels. Regardless of conventional parking policy's effect on petroleum use, present public health concerns necessitate the reconsideration of parcel-specific parking requirements, as obesity is now far more prevalent than when California cities first amended their zoning codes to require parking.

Conventional parking policy treats parking quality as uniform. However parking design, accessibility, and other attributes vary by implementation. Mukhija & Shoup (2006) point out that planners typically regulate parking quantity but not parking quality. They argue that planners should be more concerned with parking's impact on urban design, including the location of parking and its interfaces with pedestrian facilities. Others point out that users perceive parking to be scarce if they cannot discover or access it. While regular users may be able to locate available parking in a distant corner of a lot or structure, unfamiliar users may be unable to do so. Smith (2005) suggests that better parking lot and structure design can improve access and discoverability.

Conventional parking policy approaches often assume that individuals lack any other means of accessing a property other than traveling in and storing an automobile. This assumption is implicit in most parking requirements. Traffic engineers can have difficulty observing parking needs in complex environments where on-street or nearby off-street parking is priced because any excess off-street parking capacity may be used by those responding to price incentives. As such, many of the Institute of Transportation Engineer's parking observations are for isolated uses disconnected from other demand generators – a rarity in dense, urban environments. The Institute now encourages engineers to submit parking observations from sites with a variety of characteristics, but collecting these observations is more complicated (Institute for Transportation Engineers, 2010). Policy based on these figures implicitly ignore many local conditions, like residences within walking distance, transit service, and cycling amenities. Instead, conventional approaches distill a complex question – the peak number of a building's occupants that will require vehicle storage – into a linear function dependent on national observations for a use: how square footage for each use relates to parking demand. Such an approach requires implicit tradeoffs with the quality and viability of transportation alternatives (Willson 1995, Shoup 2005).

In areas where one or more of the conditions do not apply, conventional parking policy is inappropriate without local or site-specific modifications. Generally, these conditions only apply in exurban environments with large parcels and where all off-street spaces are more accessible than on-street spaces (a parking moat). In more complex, urban and inner-ring suburban environment with smaller lot sizes and occasional structured parking (a parking attic) and subterranean parking (a parking basement), conventional policy can prove a less effective means of avoiding on-street scarcity than in exurban and outer suburban settings.

Figure 1: Parking moat, attic, and basement



Self-fulfilling parking policy prophecy

Figure 2: Self-fulfilling parking policy: a reinforcing cycle

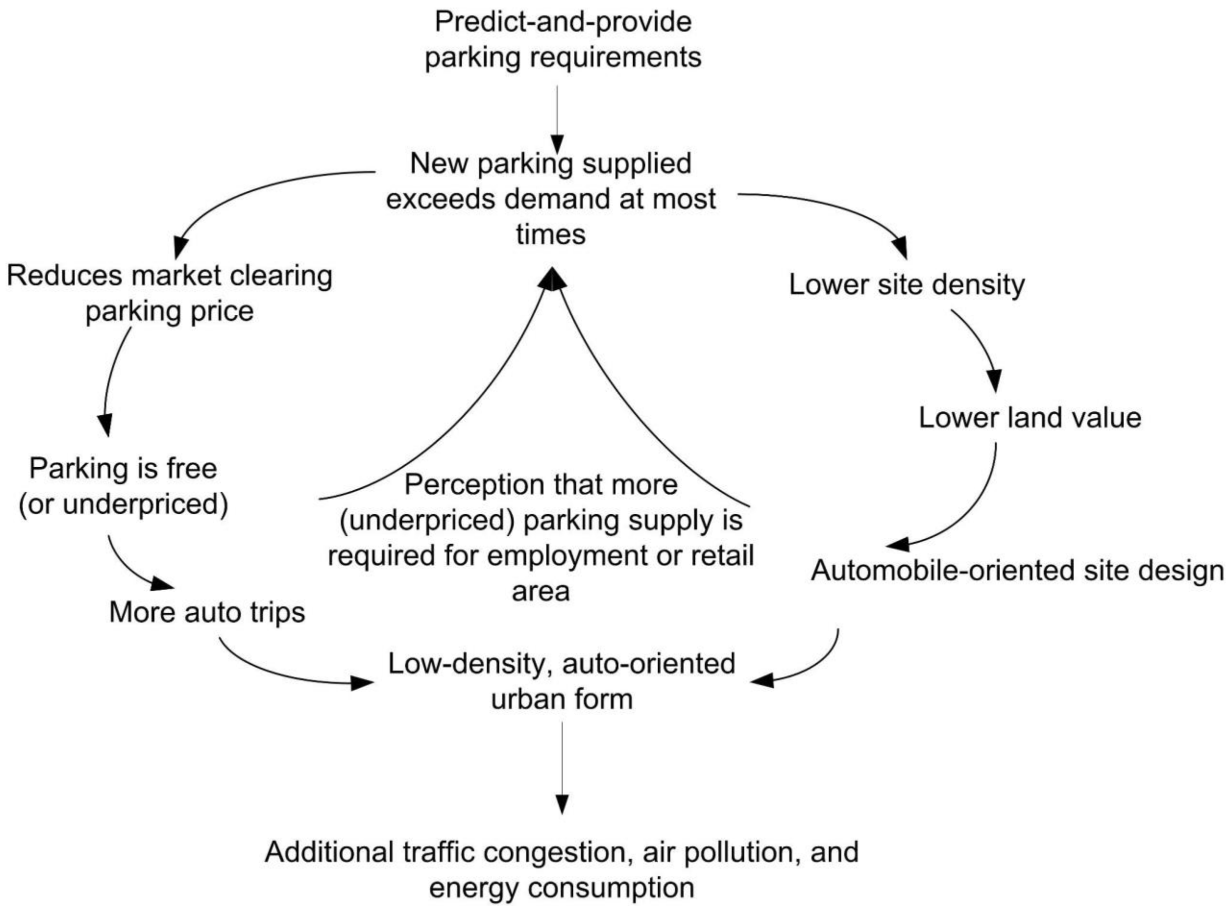


Figure adapted from Willson (1995)

Because parking policy applies to every zoning decision, it's one of the more powerful factors we assess in *Unraveling Petroleum*. The feedback this cycle produces amplifies demand for subsidized parking over time. Every new development reinforces the predict-and-provide paradigm, a path-dependency that makes parking policy changes less and less acceptable to parking users over time.

History of conventional parking policy approach

Local governments derive their ability to mandate parking provision from their authority to regulate land uses through zoning. A 1926 U.S. Supreme Court case, *Euclid v. Ambler* (272 U.S. 364) authorized zoning as a police power implicitly granted to states and people under the Tenth Amendment to the U.S. Constitution. Police power allows states and local governments to issue regulations that protect the health, safety, morals, and general welfare of their residents.

The legal rationale behind requiring a minimum amount of parking with a land use is that:

(1) mandating off-street parking supply in the zoning code mitigates the traffic that would occur if drivers were forced to search the streets for an available parking space.

(2) existing uses have a greater right to on-street parking than do new uses

The first rationale is short-sighted in a multi-round repeated game where participants adjust their behavior in response to feedback.

Zoning for parking was rare before World War II but proliferated between 1946 and 1969 as an incrementalist approach to resolving conflicts brought about by increasing automobile storage needs (Ferguson, 2004). California cities played a leading role in incorporating minimum parking requirements within their zoning codes: Los Angeles was the first major city to require off-street parking for multifamily housing (1935), Fresno was the first to require off-street parking for non-residential uses (1939), and Pasadena was the first city to require off-street parking for most developments (1945) (Ferguson, 2004). Historically, many parking standards have used supply-side measurements, such as the number of required spaces per housing unit, beds, or bowling alley lane. Ferguson (2004) points out that new policies often use demand-side and spatial measures, such as required spaces per person, employee, or square foot of building use.

Santa Monica case study

We use Santa Monica, California as an example of local parking policy. While each local government with zoning authority has discretion over its own parking policy, many use a conventional approach with few substantive variations.

The bulk of Santa Monica's growth occurred between 1920 to 1970, when the city's population grew from 15,252 to 88,289 – just under the 2011 estimated population (90,377). The city's period of growth spanned the introduction of parking requirements—it's 1950 population was 71,595. As such, the city has nonresidential buildings in traditional neighborhoods which were not subject to parking-related zoning controls, and some nonresidential buildings which were subject to the requirements. Santa Monica has also tried several of the alternatives to conventional parking policy discussed later in this brief, providing real-world examples of their implementation.

The city's current parking policy, Municipal Code 9.04.10.08, applies minimum parking requirements to every change of use and every building erected or substantially remodeled after 1993. The purpose of these requirements is to:

- "provide parking in proportion to the needs generated by varying types of land use"
- "reduce traffic congestion and hazards",
- "protect neighborhoods from the effects of vehicular noise and traffic generated by uses in adjacent non-residential districts,"
- "ensure the maneuverability of emergency vehicles," and
- "provide accessible, attractive, and well-maintained off-street parking facilities"

Santa Monica's parking policy is largely conventional, and its minimum parking requirements are largely based on the national observations presented in *Parking Generation*. Santa Monica has made a few changes to support local policy objectives. For instance, new buildings over 15,000 square feet must provide bicycle parking at 5% the required number of auto spaces. All of the bicycle parking shall be shall not be further than ½ the distance from the furthest off-street auto parking space to the main entrance of the building. New buildings over 50,000 square feet must provide 50% of bicycle parking for long-term commuters, and 10% of required automobile parking spaces must be dedicated to vanpool or carpool vehicles. Like many conventional policies, Santa Monica's parking policy implicitly discourages walking by requiring that all spaces be located on the parcel or building site or, in commercial and industrial districts, within one thousand feet of the perimeter or the parcel (SMMC 9.04.10.08.190(a)).

Costs of parking

A Whole Foods Market, at 2201 Wilshire Boulevard in Santa Monica provides an example of the true cost of off-street parking. The building provides all of the parking the city requires for a supermarket of its size – 130 subterranean spaces in two levels below the store's basement.

In Table 1, we calculate the hourly per-user parking subsidy at different per-space construction costs and average annual utilization rates. All figures are amortized over 10 years, 15 hours per day (the store is open from 7am to 10pm), and 365 days per year.

Table 1: Hourly per-user parking subsidy

	Average annual utilization during business operating hours			
Per Space Construction Cost	33%	50%	75%	90%
$25,000.00	$1.38	$0.91	$0.61	$0.51
$40,000.00	$2.21	$1.46	$0.97	$0.81
$55,000.00	$3.04	$2.01	$1.34	$1.12

The 130 off-street spaces under the Whole Foods are less-easily-accessible than the surrounding on-street spaces. Thirteen metered on-street parking spaces border the store. Santa Monica charges $1 per hour for parking at these metered spaces between 9am and 6pm. Note that many hourly per-user estimates exceed this cost. Metered parking is free for 6 of store's operating hours, including the busy, congested dinnertime hours. A preferential parking district in the surrounding neighborhood allows 2 hours of free parking for any vehicle without a permit.

Whole Foods Market is a for-profit venture: it passes on the cost of parking, just as it passes on the cost of kale. The Whole Foods Market at 2201 Wilshire Boulevard does not charge users directly for parking, nor does it discriminate between those that arrive via the subterranean parking structure or some other means. Therefore, the store indirectly charges all shoppers for the cost of providing the 130 subterranean parking spaces, regardless of how they arrived at the store.

Alternative parking policy approaches

Allow adaptive reuse of existing buildings

Because Santa Monica has commercial buildings developed both before and after the onset of parking requirements, the city provides an example of how conventional parking policy can limit the adaptive reuse of existing buildings. Conventional parking policy often requires a minimum number of parking spaces for each change in use. Existing uses are grandfathered in – the parking requirements only apply when a new use differs from the previous use.

This is the case in Santa Monica, where the hypothetical conversion of a 5,000 square foot bookstore to a restaurant would require additional parking spaces.

Santa Monica requires that retail uses provide 3 ⅓ parking spaces per 1,000 square feet of gross floor area. The city could seek a more precise parking demand estimate for book superstore, which *Parking Generation* presents at 0.89 spaces per 1,000 square feet of floor area. However, this ratio is based on only one observation in Seattle – hardly a sufficient sample to make valid statistical inferences (Institute of Transportation Engineers, 2010).

Though the existing bookstore may not be required to provide any parking if in a building constructed prior to parking requirements, we'll assume that it provides all the parking required: 17 spaces. Santa Monica Municipal Code requires that the hypothetical restaurants provide 3 ⅓ spaces for 1,000 square feet of support area, 46 ⅔ spaces for 3,500 square feet of service and seating area open to customers, and 10 spaces for 500 square feet of separate bar area: 60 spaces in total.

The restaurant cannot open until it finds an additional 43 parking spaces within 1,000 feet (if located in a commercial district) or obtains a variance or conditional use permit that allows it to operate without code required parking. The variance or conditional use permit is offered on a case-by-case basis and may be contingent on the restaurant obtaining off-site parking and offering valet services.

In addition to creating a business plan and lining up investors, the restaurateur must wait several months for the uncertain outcome of a discretionary decision regarding the variance or conditional use permit. This adds an additional risk that is insurmountable for many projects, likely reducing the scope and scale of uses that require high levels of parking in Santa Monica and other cities, and increasing vacancies among former uses that require fewer parking spaces.

A by-right pathway for changes in building use reduces the risk of opening a new business. Adaptive re-use and in-lieu fees provide such a pathway. Specifically, adaptive reuse policies allow existing buildings to change in use without necessitating additional parking. A local government may combine adaptive reuse with a fee in-lieu of providing parking. In downtown Santa Monica, the restaurateur can pay a fee instead of providing 43 additional parking spaces.

In-lieu fees

When a local government requires a parcel to supply parking, they implicitly require the parcel owner or developer to subsidize the creation of new parking spaces. If the local government offers the parcel owner or developer the opportunity to pay a fee in-lieu of providing parking, it can use these revenues for almost anything. Under California law, there must be a substantial nexus between the fee and its use. However, local governments can use these revenues to manage parking demand: constructing additional spaces, subsidizing transit, providing bicycle share or bicycle parking, or investing in systems that help users locate available parking spaces.

Shoup (2005) claims in-lieu fees allow flexibility. Rather than requiring that each use provide its own parking, in-lieu fees can support shared parking and park-once districts. Rather than pressuring the destruction of historic structures to provide additional parking, in-lieu fees can support historic preservation and adaptive re-use.

In 1986, Santa Monica established an in-lieu fee in the Bayside District, the downtown neighborhood around the city's pedestrian-oriented shopping street, the Third Street Promenade. The city assesses an annual parking developer fee of $1.50 per gross square foot of floor area on uses that do not provide the required amount of parking. The city has not adjusted the fee since 1986. The roughly $605,000 annual revenues fill a financing and operating deficit not covered by directly-assessed parking fees (Nelson\Nygaard Consulting Associates, 2012).

As of this writing, the city is considering an update to the parking development fee that would impose a one-time charge of $20,000 rather than the annual assessment (Nelson\Nygaard Consulting Associates, 2012). The fee would be used for transportation demand strategies in addition to expanding, operating, and maintaining publicly-owned parking facilities. As such, use of in-lieu fees allows Santa Monica to support other transportation policy goals. The city officially promotes walking, carpooling, vanpooling, biking, use of transit, and other transportation demand management measures through its transportation management ordinance, first adopted in 1991 (SMMC 9.16)

Shared parking

Under conventional parking policy each use must provide sufficient parking to meet peak or near-peak demand. For a mall, minimum parking requirements are based on a December weekend. For a movie theater, the June/July blockbuster season. For a sit-down restaurant and bar, a weekend evening. For an office building, the work-day. However, because each individual use provides its own spaces, a mall with restaurants, a movie theater, and office space may cumulatively provide far more free parking than ever used at any one time.

A shared parking approach considers variation in parking demand across uses and time, accommodating aggregate peak demand rather than the sum of individual peak demand. The idea behind shared parking is to use existing infrastructure more efficiently rather than construct new infrastructure that isn't needed. The Urban Land Institute's *Shared Parking* outlines a shared parking approach (Smith, 2005). While the shared parking approach generally recognizes that land for parking is scarce and that space quality is not uniform, implementations that fail to consider local conditions often assume that parking should be free and implicitly discourage walking and use of alternative modes.

Shared Parking outlines two approaches to creating a shared parking agreement. The first requires contractual agreements between adjacent uses to make one property's spaces available to the other's parkers. If allowed by a local government, this ad-hoc approach can lead to the proliferation of shared parking agreements without formal government intervention. The second approach is a parking management district, which is actively managed by a business improvement association or the local government. This approach can establish park-once districts, where individuals are encouraged to park once and walk to multiple land uses. Park-once is common where buildings and parking have a single owner, such as a mall, but is less common in areas where buildings and parking have multiple owners. Santa Monica's downtown parking district behaves as a park-once district, though it does not use the shared parking time-of-use formulas.

Shared parking policy can be the foundation for a multi-use district. As part of a strategy to revitalize downtown areas to promote a greater span of activity after business hours and on weekends, shared parking can help balance an area's parking demand over time. Existing parking infrastructure in an office district may accommodate restaurants and retail, creating a by-right pathway that encourages developers and entrepreneurs to find the right mix of uses within parking constraints.

Shared Parking emphasizes the need for good parking facility design, as many users perceive a parking facility to be at capacity even when 10% or more spaces remain unoccupied (Smith, 2005). While frequent parkers may be familiar with a parking facility's layout and the probable location of available spaces, infrequent parkers may not be. One option is to offer monthly parkers discounts to use spaces in the less-accessible portion of a parking facility to enable frequent turnover of easily-accessible spaces. Structure design and management can maximize the effectiveness of shared parking arrangements. Santa Monica requires spaces in a mixed-use development be accessible during operating hours and prohibits building managers from assigning shared parking spaces to individuals (SMMC 9.04.10.08.220).

Wayfinding

Wayfinding, including real-time parking information, is an important tool for infrequent parkers. Static and dynamic signage can aid in parking discovery, alleviating the inability of infrequent parkers to find available spaces.

New online-enabled services help with locating and accessing available parking. Parking Panda is a smartphone application and web-based platform that allows individual parking space owners to rent their spaces by the hour or day. The system allows for advanced reservations — reducing parking discovery and pricing uncertainty (Yglesias, 2012). ParkMe is a Santa Monica-based company that offers a smartphone application and website to display real-time occupancy and pricing for public off-street parking structures and on-street metered parking in Santa Monica and other cities. ParkMe offers static information on parking rates for facilities that do not provide real-time information

Transportation Sustainability Fee

San Francisco's Transportation Sustainability Fee is a proposed element of the city/county's Transportation Sustainability Program (San Francisco Planning Department, 2012). The Program advances on in-lieu fees, which use minimum parking requirements as a basis for assessing fees. San Francisco's proposed program abandons parking as an enforcement mechanism and instead imposes a fee on new developments based on square footage and use. As with fees remitted in-lieu of providing parking, the revenues can be used to fund transportation options other than parking. San Francisco plans to use the majority of revenues for transit capital and operations, with some revenues for bicycle and pedestrian infrastructure and services. The Transportation Sustainability Fee will replace the city's Transit Impact Development Fee, which the city currently uses to mitigate new development's impact on the transit system. Other cities in California could consider such a program as an alternative to in-lieu fees and traffic impact fees. As of this writing, the San Francisco program is under environmental review.

Let prices do the planning

Shoup (2005) believes the best way for cities to manage parking is to let prices do the planning: eliminate minimum off-street parking requirements for non-residential uses and adjust the prices of on-street parking to achieve an 85% occupancy rate. Such an approach would reduce parking subsidies over time and eliminate parking-related congestion. Though the technical requirements for implementation are simple, the market-based approach requires a substantial shift from the conventional parking policy paradigm.

Quantifying the effects of a conventional approach to non-residential parking policy

We limit the scope of our analysis to non-residential parking policy, which we expect to affect mode choice and distance traveled but not vehicle availability. Even so, our estimated effect on statewide motor vehicle fuel use is substantial. Below, we detail assumptions for our assessment of how conventional parking policy affects mode choice, distorts land use and distances traveled, and leads to cruising for parking and congestion.

We then estimate the proportion of statewide motor vehicle fuel use that is attributable to conventional parking policy under low-case, mid-case, and high-case assumptions.

Some energy and environmental effects of conventional parking policy are beyond the scope of our analysis. Life-cycle greenhouse gas emissions associated with the construction of parking spaces do not affect our assessment, but are significant nonetheless. Chester, Horvath, and Madanat (2010) estimate lifecycle greenhouse gas emissions for various types of parking spaces. They estimate on-street parking at about 730 kg of CO_2-equivalent per space, surface parking at about 1,300 kg of CO_2-equivalent per space, and structured parking space at about 5,000 kg CO_2-equivalent per space. As a comparison, the average per-capita emissions in California are 12,200 kg of CO_2-equivalent across all sectors and about 4,672 kg of CO_2-equivalent kg per person for transportation. We're not alone in ignoring construction energy and emissions: community-scale greenhouse gas emissions inventories typically ignore emissions from construction – shifting these emissions out-of-scope in many climate planning activities.

Mode choice

The decision to require parking as a condition of building leads to less walking, biking, public transit use, and ridesharing versus a counterfactual case in which nonresidential uses aren't subject to parking mandates. In California 1.58% of person miles traveled are by walking and biking, and 2.53% are by public transit (U. S. Federal Highway Administration, 2011). In our assessment, we multiply the existing 4.1% of person-miles traveled via these modes by a factor of 1.5 (low case) 2 (mid-case) and 4 (high-case) to estimate mode choice effects. We believe these estimates may be conservative, as we do not consider changes in ridesharing.

Effects of land use distortions on distance traveled

Next, we consider how parking policy distorts land use to make vehicle trips longer than they would otherwise be.

Manville and Shoup (2005) point out how little scholars about the amount of land area devoted to parking. Despite parking's effects on cities, people, and travel, few empirical studies have inventoried parking spaces and area. Estimates of the proportion of land devoted to both parking and the roadway network range from one-third in suburban areas to two-thirds in central business districts. Estimates of parking coverage – defined as the ratio of parking surfaces to land area – in California central business districts range from 18% in Sacramento, to 31% in San Francisco, to 81% in Los Angeles (Manville and Shoup, 2005). Parking coverage is a better measure of parking density – and by extension the effects that concentrated vehicle trip ends can have on roadway network congestion – than a measure of the extent to which surface parking distorts land use and distance traveled. While all parking in central business districts serves as a magnet for vehicle travel, only surface parking and single-purpose parking structures distort land uses.

Using aerial photography, Akbari, Rose, and Taha (2003) calculated that that 11.8% of all urbanized land area in Metropolitan Sacramento is devoted to parking. Within the central business district, about 10.5% of surface area is devoted to parking; 31% to roads; and about 26% to buildings. Region-wide, the authors found the ratio of surface area devoted to be higher in commercial/service (31.1%), industrial (20.0%), and industrial/commercial (31.8%) areas than in residential areas (4.9%), and that non-residential areas comprised just over half (50.7%) of the built-up land area.

We use the urbanized area of Sacramento as a proxy for statewide distortions due to parking areas. Although urbanized areas made up only 4.7% of the total land area in the

Sacramento region, the vast majority of travel activity is based in these areas. Statewide, about 88.5% of all household vehicle travel occurs by households located in urbanized areas (U. S. Federal Highway Administration, 2011). As of Census 2010, about 95% of California residents live in urbanized areas.

We use a low-end estimate of 5% and high-end estimate of 20% for differences in travel distances attributable to conventional policy approaches to non-residential parking. In the low case, a 5 mile trip from home to a grocery store is one-quarter mile longer because of required parking. In the high case, the trip is 1 mile longer.

We apply this distance distortion only to the 72.1% of statewide vehicle travel we estimate to be based in urbanized areas (88.5% of all VMT) and between home and shopping, recreation, and work or not home-based (76% of trips and 81% of vehicle miles traveled) (U. S. Federal Highway Administration, 2011).

Cruising for parking

Cruising for parking accumulates additional travel distances while drivers search for available parking spaces. Though oft-cited as an effect of conventional parking policy, cruising for parking alone has a small effect on statewide petroleum use. Cruising results not from the decision to provide off-street parking, but the incentives created when on-street parking is underpriced relative to off-street parking.

Shoup (1997) estimated that one underpriced metered parking space in Westwood Village generates about 1,825 additional vehicle miles traveled annually. Most of California is dissimilar from Westwood Village and most parking spaces do not generate similar levels of cruising.

We were not able to find data on the number of metered street spaces for all California cities. Additionally, not all metered spaces in cities generate significant cruising. We use a range of estimates for spaces statewide that achieve Westwood-like cruising levels (from 25,000 to 200,000); the high-end assumes cruising also occurs at some non-metered spaces. Our overall estimate is not sensitive to cruising, as we estimate searching for parking to have a very small effect on statewide motor vehicle fuel use (only 0.11% in the high case).

Table 2: Number of metered spaces for selected California cities

City	On-Street Metered Spaces	Source
Los Angeles	37,000	(Los Angeles Department of Transportation, n.d).
San Francisco	23,000	(San Francisco Municipal Transportation Agency, 2013)
Santa Monica	5,967	(Santa Monica, n.d.)
San Diego	5,262	(City of San Diego, n.d.)
San Jose	2,600	(San Jose, n.d)

Berkeley	1,600	(City of Berkeley, n.d.)
Pasadena	1,200	(City of Pasadena, n.d)
Sum of sample	75,029	

Additional congestion due to conventional parking policy

Conventional parking policy has two types of congestion-related effects. The first effect is from additional distance traveled. Vehicles that are cruising for parking generate additional traffic congestion, typically during peak hours and in areas with that are already congestion-prone. However, the additional distance generated from cruising is small in relation to the additional miles traveled because of land use distortion. Secondly, conventional parking policy creates additional parking spaces in a dense area without increasing the capacity of roadway networks – leading to additional congestion independent of distanced traveled.

The Texas A&M Transportation Institute's oft-cited Urban Mobility Report lists 2011 excess fuel consumed in California metropolitan areas due to traffic congestion at 389,943,000 gallons — about 2.2% of statewide motor vehicle fuel use. Considering the second effect, perhaps all or most of the congestion in California could be attributed to nonresidential minimum parking requirements. However, we apportion this loss in system operations efficiency somewhat conservatively — based solely on the first effect. We assume that system operations efficiency losses are uniformly distributed over expected changes in vehicle miles traveled rather than disproportionately caused by the decision to concentrate parking spaces.

Cumulative effect on California motor vehicle fuel use

The low and high cases are presented as possible lower and upper bounds, with the mid-case being our best estimate, shying slightly conservatively due to data limitations.

Table 3: Cumulative effect on California motor vehicle fuel use

Case	Mode choice effect	Land use distortion - additional distance traveled	Spaces affected by cruising behavior	System operation efficiency loss	Cumulative effect on California motor vehicle fuel use
Low	150%	5%	25,000	0.12%	5.7%
Mid	200%	10%	100,000	0.24%	11.2%
High	400%	20%	200,000	0.53%	24.9%

Works Cited

Akbari, H., Shea Rose, L., & Taha, H. (2003). Analyzing the land cover of an urban environment using high-resolution orthophotos. *Landscape and urban planning*, *63*(1), 1-14.

California Air Resources Board. (2013). *Greenhouse gas inventory data.* Retrieved from http://www.arb.ca.gov/cc/inventory/data/data.htm

Chester, M., Horvath, A., & Madanat, S. (2010). Parking infrastructure: energy, emissions, and automobile life-cycle environmental accounting. *Environmental Research Letters*, *5*(3), 034001.

City of Berkeley (n.d.). *Parking Meters.* Retreived from http://www.ci.berkeley.ca.us/Public_Works/Transportation/Parking_Meters.aspx

City of Pasadena (n.d.). *Parking in Pasadena.* Retreived from http://www.cityofpasadena.net/transportation/ParkingServices/

City Of San Diego (n.d.). *Prepaid parking cards.* Retreived from http://www.sandiego.gov/parking/enforcement/meters/cards.shtml

City of San Jose (n.d.). *Parking meters.* Retreived from http://www.sanjoseca.gov/index.aspx?nid=1871

City of Santa Monica (n.d.). *Santa Monica parking.* Retreived from http://www.smgov.net/departments/transportation/parking.aspx

Ferguson, E. (2004). Zoning for parking as policy process: A historical review. *Transport Reviews*, *24*(2), 177-194.

Institute of Transportation Engineers. (2010). *Parking generation* (4th ed.). Washington, DC: Institute of Transportation Engineers.

Los Angeles Department of Transportation (n.d). *Parking meters.* Retreived from http://ladot.lacity.org/tf_Parking_meters.htm

Manville, M., & Shoup, D. (2005). Parking, people, and cities. *Journal of Urban Planning and Development*, *131*(4), 233-245.

Mukhija, V., & Shoup, D. (2006). Quantity versus quality in off-street parking requirements. *Journal of the American Planning Association*, *72*(3), 296-308.

Nelson\Nygaard Consulting Associates. (2012). *Downtown parking in-lieu fee* (draft report). Retreived from http://www.smgov.net/departments/council/agendas/2012/20120911/s2012091104-A-1.pdf

San Francisco Planning Department. (2012). *Transportation sustainability program.* Retreived from http://www.sf-planning.org/index.aspx?page=3035

San Francisco Municipal Transportation Agency (2013). *Parking meters.* Retreived from http://www.sfmta.com/cms/pmeter/13449.html

Smith, M. (2005). *Shared parking* (2nd edition). Washington, DC: The Urban Land Institute.

Shoup, D. C. (2005). *The high cost of free parking* (Vol. 7). Chicago: Planners Press, American Planning Association.

U.S. Federal Highway Administration. (2011, February). *National Household Travel Survey.* Retrieved from http://nhts.ornl.gov

Willson, R. W. (1995). Suburban parking requirements: A tacit policy for automobile use and sprawl. *Journal of the American Planning Association*,*61*(1), 29-42.

Willson, R. W. (2005). Parking Policy for Transit-Oriented Development: Lessons for Cities, Transit Agencies, and Developers. *Journal of Public Transportation*, *8*(5).

Yglesias. M. (2012). *Can this startup turn your unused parking space into cash?* Slate. Retreived from http://www.slate.com/articles/business/small_business/2012/12/parking_panda_rent_your_unused_parking_space.html

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Bundling of Residential Parking in High-Quality Transit Areas

Overall effect on California petroleum use		**Affects Petroleum Demand Through Intermediate Indicators:**	
Magnitude	High	**Primary**	Mode Choice
Certainty	Medium-High	**Secondary**	Distance Traveled
Applicable Level of Government	State, Local		
Relevant Laws or Cases Affecting Factor	California Government Code §65470, Public Resources Code §21155 and §21064.3		
Time-Horizon	Concentrating new development in high-quality transit areas will bring new trip demand to such areas. If, by historical contexts, cities and developers add relatively few parking spaces with this new development, then the existing supply will make up a large proportion of total available parking. Parking prices will quickly increase, leading to near-term use of alternatives among new residents.		
Relevant Topics	Parking, transit, housing		
Summary	On-street parking is perceived to be a scarce resource in many areas of California. Conventional parking policy, used by many California local governments to mitigate competition for on-street parking resulting from new development, prioritizes conflict avoidance over other goals – such as reducing vehicle trips. Changes in parking policy can make transportation alternatives attractive in areas where they are likely to be more robust. The state may be able to achieve substantial reductions in fuel use simply by separating the price of parking from the price of housing in areas where high quality transit exists.		

Introduction

Most local governments in California manage parking supply through the use of minimum parking requirements. Local governments require a developer to include a specified amount of on-site parking spaces with a new building. Two unintended consequences of this parking allocation system are becoming more salient over time. The first is that the price of parking is frequently bundled into the price of other goods or services. Property owners bundle the price of parking due to consumer expectations and low market-clearing prices given supply mandates. As the price of constructing new parking increases, the price distortions from bundling become larger. The second is that hiding the cost of parking makes individuals less likely to seek alternatives to driving. These two unintended consequences from

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conventional parking policy can lead to additional traffic congestion while diluting public investment in transit, carpooling, walking, and bicycling infrastructure.

California's four major regions plan to concentrate 53% of their development in high quality transit areas over the next three decades. The goal of such transit-oriented development is typically to affect travel behavior and trip distances as a means to reduce regional greenhouse gas emissions. Much of this new housing product will be multi-story and require above-ground or subterranean parking structures. Such structures are more expensive per space than surface parking.

Bundled parking means that those who purchase or lease property in transit-adjacent developments may be required to pay for parking spaces they do not need. Construction cost estimates for a subterranean or structured parking space in a multifamily residence range from $25,000 or $125 per month up to $85,000 or $425 per month.

Shoup (2005, 568-569) argues that the result of bundling these high parking costs is Tiebout-like sorting. Households willing to pay this amount, regardless of whether the cost is transparent, likely place a high value on driving. Households unwilling to purchase parking at this price will seek units in buildings with limited parking supply, typically older buildings constructed before current parking requirements. However, under conventional parking policy, this choice limits car-free and car-light households to a limited set of older buildings constructed before current parking requirements. An unintended consequence of conventional parking policy and bundling is that it attracts households that place a relatively high value on driving to new housing in high quality transit areas. Such policy will inevitably lead to future increases in driving and petroleum use versus an alternative approach to parking allocation.

Policy approaches to parking allocation

While conventional parking policy is most common in California, other policy approaches may be better suited to the state's broad goals of transit oriented development and greenhouse gas reduction. Barter (2010) outlines three approaches to parking policy. Under a conventional parking policy, the local government mandates the minimum number of spaces to be included by private developments. The goal is to satiate parking demand and reduce potential conflicts that could result from scarcity and demand spill-over. Under a parking management approach, a local government actively regulates area-specific parking supply and demand through shared parking and permit parking arrangements. Active management is one option to reduce total parking supply while avoiding conflict. Market-based parking approaches seek to remedy conflicts of scarcity and spill-over through variable pricing.

Deconstructing automobile parking & alternatives

According to Shoup (1999), minimum parking requirements affect the market clearing price that drivers pay for parking, but not the cost to provide a parking space. Instead, building density and neighborhood density drive the cost to construct parking exactly where viable transportation alternatives exist.

Building density drives the number of parking spaces per acre and their cost. As developers attempt to fit a greater number of parking spaces on a fixed-sized lot, the price per space increases. Surface parking spaces are cheapest to construct, but their applicability is limited to servicing single story buildings that occupy less than three-fourths of a parcel.

Above-ground structured parking is expensive relative to surface parking, but less expensive than subterranean parking. However, above-ground parking can reduce the number of usable building floors in areas with height limits. Above-ground parking can also present a challenge to pedestrian-oriented design. Subterranean parking, arguably the most desirable construction type for denser neighborhoods, is the most expensive. Each additional level of underground parking results in a nonlinear increase in excavation costs.

Neighborhood density drives the viability of alternatives to driving and parking. In general, the number of trip-ends per acre correlates positively with building density. This is a natural extension of the definition of density - more usable building square footage per acre. Fundamentally, trip-making is a function of space and time: individuals seek to move between two discrete points in space at a discrete time. Because more individuals travel to and from a high-density acre than a low-density acre, it's more probable that a two or more individuals will seek to make similar trips at similar times. Group trips can be served by carpools and transit, which serve a larger share of trips to denser areas than sparser areas. Walk and bicycle trips become more viable when trip origins and destinations are concentrated, as is the case in high-density areas. Diversity of land use is also important, as much travel is between disparate uses. Relatively few trips are directly between residences, and most daily travel begins or ends at a residence. Parking and alternatives to driving are also substitutes, and demand for alternatives such as car share increases with parking prices.

Minimum parking requirements limit density. Shoup (1999) found that parking requirements, rather than floor-to-area ratios and height restrictions, can limit building density on a parcel. Cutter (2010) found that minimum parking requirements act independently of other zoning restrictions to indirectly cap density, significantly increasing the area of Los Angeles County dedicated to parking.

Manville, Beata, and Shoup (2013) contend that by treating vehicle density as an inevitable effect of population density, minimum parking requirements restrict population density in order to accommodate vehicles. In their study of residential parking requirements in the U.S.'s two largest cities, they found that although the average Los Angeleno is poorer than the average New Yorker, he or she is more likely to have a vehicle because Los Angeles housing is more likely to include a parking space. Those living in the ten densest census tracts in Los Angeles have 2.5 times the vehicles per person than those in New York City's ten densest tracks. This is despite average per-capita income in the city's densest ten census tracts being $9,300 in Los Angeles and $36,500 in New York.

By requiring parking for all residential units, policymakers in Los Angeles implicitly seek to subsidize vehicle ownership among all households, especially low-income households. Such policy is counter to the goal of transit-oriented development: to promote density near high quality transit service in order to enhance automobility alternatives. As Manville, Beata, and Shoup (2013) state, "When local governments require on-site parking with all new housing, they make room for vehicles in the name of fighting congestion. This approach is unlikely to work."

Past parking requirements reduce market-clearing parking prices in denser areas, even after an area transitions to market allocation of parking. While a local government can change its parking policy from conventional to market-based allocation, it cannot directly affect its previously-mandated parking supply. A transition to market allocation, through unbundling and eliminating or capping parking requirements, will only apply to new building supply. The obdurateness of existing parking infrastructure floods neighborhoods and districts with parking supply. These past spaces were not created based on market demand, but rather as an ancillary cost of constructing a building's primary use. Owners of existing parking can participate in a neighborhood parking market as prices increase. The result is that neighborhood parking prices will lag parking construction costs for some time.

Relevant Legislation

California law defines unbundled parking as "renting a parking space for the residential units separately from the residential units, or [allowing the developer to pay] a fee to the appropriate local transit management fund to cover one-half of the cost to provide a parking space" (Government Code §65470(d)(12)). As of this writing, only one section of California Code references unbundled parking. SB 310 (2011) amended Government Code § 65470 to establish a Transit Priority Project Program, an infrastructure financing district to reimburse developers of housing projects that meets certain affordable housing and sustainable transportation conditions. Among the sustainable transportation conditions is a requirement for unbundled parking and that the project be located in a high quality transit area.

Public Resources Code §21155 establishes the areas in which certain developments, known as transit priority projects, can be eligible for streamlined environmental review. The first area, a high-quality transit corridor, is within one-quarter mile of a bus route providing service every fifteen minutes or less during peak service. The second such area is the land within one-half mile of a major transit stop: a rail transit station, a ferry terminal, or intersection of two high quality transit corridors specified in a regional plan (Public Resources Code §21064.3).

Decisions about parking policy are typically left to local governments. In recent years, the California legislature has twice attempted to restrict local discretion over parking policy in high quality transit areas. Assembly Bill 710 (2011) attempted to limit parking to one space per thousand square feet of nonresidential property and one space per residential unit in high quality transit areas. Opponents of AB 710 argued that a one-size-fits-all approach eliminates local government discretion and that the bill would reduce incentives to construct affordable housing (Senate Governance and Finance Committee, 2011). In response to the 2011 defeat of AB 710, Nancy Skinner introduced AB 904, which maintained parking-related incentives for developers of affordable housing units. Cities and the American Planning Association opposed the bill, and it did not pass the Senate Government and Finance Committee.

Estimate of Effects on Petroleum Use

While policymakers can do very little to change the historical supply of parking, future policy changes can affect overall parking supply in areas with viable alternatives. This section evaluates the potential effects of a parking policy change for high quality transit areas in California, specifically:

- eliminating parking requirements for residential units located in high quality transit areas,
- requiring that developers sell or lease parking separately from housing units (unbundling), and
- restricting or prohibiting new residents' use of on-street parking spaces.

Shoup (2005, 570) estimates that a price of $150 per month for a single residential parking space will reduce new car VMT by 15%, and median car VMT by 90%. Shoup offers a varied estimate as the proportional cost of parking relative to the other fixed costs differs. All drivers pay insurance and registration, but drivers of newer, more valuable cars are likely to pay more for those costs. Additionally, loan payments for a new car will exceed those for an older (median) car. Unbundled residential parking costs are more significant to the driver of an older (median) car than to the driver of a newer car, regardless of their economic circumstances.

Shoup also estimates that average drivers of median cars will reduce VMT by 60% at $100/month and 30% at $50/month. These reductions are borne primarily from shedding vehicles, not from a reduction in travel per vehicle. Thus, the estimates provide insight into the aggregate effects of parking unbundling rather than an individual case.

Transit availability affects California travel behavior. California's 925,777 households living within one-half mile of an existing transit station have an average of 1.278 cars available (Center for Neighborhood Technology, 2013). This is lower than the statewide average of 1.85 vehicles available per household. Workers living near transit stations are 3.21 times more likely to commute by foot, bike, or transit than those not living near transit stations. Many housing units in transit-rich areas predate minimum parking requirements or are located in cities that limit parking supply, such as San Francisco. Thus, some of these housing units have fewer parking spaces available per resident.

Statewide, the policy effects amount to about 4.5% of existing VMT, and a roughly equivalent reduction in fuel use. The analysis makes several assumptions:

- Unbundled parking in high quality transit areas costs $150 per space per month, or approximately $30,000 per space in purchase price
- 50% of households moving to new housing in high quality transit areas are "new car" type households - meaning that the household's fixed automobile costs are high relative to the cost of parking. Shoup (2005, 570) estimates that unbundling leads to a 15% VMT reduction from such households.
- 50% of households moving to new housing in high quality transit areas are "median car" type households, meaning that the household's fixed automobile costs are low relative to the costs of parking. Shoup (2005, 570) estimates that unbundling leads to a 90% VMT reduction from such households.
- Projected growth and percentage of new housing units in high quality transit areas are from each region's Regional Transportation Plan/Sustainable Communities Strategy
- Per capita VMT in high quality transit areas averages 75% of regional per capita VMT
- Results are above and beyond effects of concentrating new households near transit alone
- Residents of new developments are prohibited from using on-street parking spaces

Table: Estimate of unbundling policy effects on future VMT

Region	Region-wide: percent commuting by transit, bicycling, and walking	Workers living within ½ mile of transit station: percent commuting by transit, bicycle, or walking	Future housing units expected in HQTAs	Projected reduction in regional VMT due to residential unbundling in HQTAs
Los Angeles	8.2%	20.7%	610,441	4.1%
Sacramento	5.4%	14.4%	103,700	5.3%
San Diego	6.8%	12.8%	267,735	8.5%
San Francisco	15.6%	33.0%	373,278	5.6%
Four Major Regions	9.6%	25.6%	1,355,153	5.0%

Note: Reduction percentage is versus projected future VMT
Source: Center for Neighborhood Technology TOD Database

The above analysis is sensitive to the proportion of new households that are "new car" households. For instance, if only 10% of new households in high quality transit areas are "new car" households, then the percentage jumps to 7.9% of future four-region VMT.

Managing the Transition to Unbundled Parking

Assuming that unbundling is possible for analysis is much easier than actively managing the transition to unbundled parking and market allocation. Many practical barriers impede a smooth transition to unbundled parking. This section addresses those barriers and strategies to overcome them.

First, unbundling is most applicable to multi-family residences, and is an unlikely policy mechanism for detached single-family residences. For single-family residences, land and improvements are bundled—as a parcel. Unbundling parking would require unbundling the parcel: separating land from improvements or garages from other improvements.

Even in multi-family residences, unbundling will require changes to real estate practices. Parking areas in most multi-family residential buildings are considered common areas, owned by a distinct legal entity. With apartment buildings, building ownership is not divided, and a single legal entity owns the land, parking, and housing units. In such a case, a property owner or manager could choose to lease parking spaces separately from a housing unit. Indeed, this practice is frequent in buildings with greater demand for parking than available spaces.

In condominiums and housing cooperatives, a distinct legal entity typically owns the on-site parking. Often, the board that governs this entity grants a unit owner or shareholder the exclusive use of a parking space. Such arrangements are recorded in the proceedings of the legal entity, usually a co-op board or homeowners' association. Unbundling parking spaces would require that over-the-counter market transactions be tracked informally between parties or in the official proceedings of the legal entity.

Another option to unbundle parking from housing units would be to develop air-space maps that define ownership of individual parking spaces. These maps, like those that delineate the boundaries of housing in multi-story condominiums, would allow the county to record the transfer of fee simple ownership of individual parking spaces. Surveying parking air-space could become common practice for future developments in high quality transit areas. A homeowners' association would likely maintain ownership of parking lanes.

Those involved in residential lending, and particularly title insurers, would likely prefer the air-space map and county-recording arrangement as this would enable them to lend using parking spaces as collateral, as they do with other real property. If parking values are low relative to housing values, individual owners may not seek debt-backed acquisition of parking spaces, obviating some of the need for official transaction recording. It's possible that a private sector alternative could emerge to track ownership and clear transactions could emerge.

Another challenge of the transition to unbundled parking is managing how parking pricing affects demand for on-street parking spaces. In some denser areas of California, overnight on-street parking is restricted to an area's residents through the use of a preferential permit system. Residents may pay a processing fee for use of permits. The amount of any processing fee is likely to be substantially lower than cost of unbundled parking offered by area apartments and condominiums.

Cities have two options to manage the spillover demand from unbundled properties. The first is to charge use a market-based allocation system for publicly-owned parking in high quality transit areas. Cities would either meter public parking or conduct an auction for the annual right to park. Prices would eventually increase to the cost of constructing new on-site parking, less a premium for convenience and security. The second option, which protects incumbent residents, would be to legally restrict residents of a building or unit that offers unbundled parking from on-street parking permit eligibility. Such prohibition could be possible with property-level deed restrictions or by changing a city's official policy and grandfathering incumbent residents.

Works Cited

Barter, P. A. (2010). Off-Street parking policy without parking requirements: a need for market fostering and regulation. *Transport Reviews*, *30*(5), 571-588.

Center for Neighborhood Technology (2013). TOD database. Retrieved from http://toddata.cnt.org

Franco, S., Cutter, B., & DeWoody, A. (2010). Do parking requirements significantly increase the area dedicated to parking? A test of the effect of parking requirements values in Los Angeles County. *Transportation Research Part A*, 46, 901-925.

Manville, M., Beata, A., & Shoup, D. (2013). Turning housing into driving: Parking requirements and density in Los Angeles and New York. *Housing Policy Debate*, (23):2, 1-26.

Senate Governance and Finance Committee. (2011). *AB 710 bill analysis*. California legislature. Retrieved from http://leginfo.ca.gov/pub/11-12/bill/asm/ab_0701-0750/ab_710_cfa_20110630_164004_sen_comm.html

Shoup, D. C. (1999). The trouble with minimum parking requirements. *Transportation Research Part A: Policy and Practice*, *33*(7), 549-574.

Shoup, D. C. (2005). *The high cost of free parking*. Chicago: Planners Press, American Planning Association.

Willson, R. (2005). Parking policy for transit-oriented development: lessons for cities, transit agencies, and developers. *Journal of Public Transportation,* (8):5.

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Use of Performance Measures that Prioritize Automobiles over Other Modes in Congested Areas

Overall Effect on California Petroleum Use		**Affects Petroleum Demand Through Intermediate Indicators:**	
Magnitude	High	**Primary**	Improved system operations efficiency with offsetting increase in distance traveled
Certainty	Medium	**Secondary**	Mode Choice
Applicable Level of Government	Local		
Relevant Laws or Cases Affecting Factor	California Government Code §65088.3, §65089, §65460.4 Various local and county planning documents		
Time horizon for implementation and maturity	Shifting to an alternate measure of transportation system performance will have an immediate effect on future decision-making. However, the obdurateness of past transportation infrastructure decisions means that the full effects of such a change would take decades to mature.		
Relevant Topics	level of service, traffic congestion, transit priority, roadway expansion		
Summary	Many commonly-employed performance metrics for transportation system analysis explicitly or implicitly ignore modes other than the automobile. The result is that many projects to expand the transportation network focus on adding automobile capacity at bottlenecks, rather than using alternatives to move additional persons. Because modes other than the automobile are excluded from the scope of analysis, many transportation projects impair the service quality of transit, walking, and biking. The implications are a profound effect on urban travel and motor vehicle fuel use.		

Introduction

Local governments throughout the United States use transportation system performance metrics and set performance goals that guide transportation and land use decision-making. The goal of performance management in transportation is to provide the public with a high-quality transportation network. This is generally interpreted as a mandate to reduce vehicular traffic congestion. In this brief, the authors assess the implications of methodological choices on public decision-making and long-run system impacts.

By Juan M. Matute and Stephanie S. Pincetl

The use of current or projected performance levels is a key driver of decisions to expand transportation system capacity at bottlenecks. As explained below, this practice causes traffic congestion, which would ordinarily provide negative feedback to drivers, to become a positive feedback loop on the transportation system. In absence of performance targets, traffic congestion would provide negative feedback to signal the need for alternatives, such as increased vehicle occupancy, alternative routes, or shifting of trips to different times. However, for a local government constrained by automobile-centric performance metrics, the potential for traffic congestion signals a need to expand bottlenecks and reduce densities. Such measures spread traffic outside the scope of a localized analysis and induce additional driving trips and distance traveled. The long-run, cumulative effects of such decisions in a land-constrained environment can be traffic congestion that is dispersed rather than concentrated, reducing planners' ability to address congestion through alternative measures.

In practice, very few state or local governments incorporate level of service methods that consider modes other than the automobile. A myopic focus on automobile travel often precludes alternatives to increase a roadway's effective capacity through use of high-occupancy vehicles. When tied to land use approvals, the analysis of transportation system performance can lead to reductions in density and diversity of land use that increase trip distance and urban design trade-offs that reduce walkability. When modes other than automobile travel are ignored by transportation performance analysis methods, improvements made in support of automobile travel can adversely impact other modes.

Because automobile-centric performance analysis metrics drive continual decisions to reinforce driving at the expense of other modes, their effect on California petroleum use is large.

Level of service

Level of service methodologies attempt to estimate a driver's perception of service quality. Traffic engineers give an intersection or roadway segment a grade—A through F—as a proxy for drivers' perception of service quality.

In general, two types of methods exist: those that apply to signalized intersections and those that apply to open roadways. As it is impractical to directly query drivers' reactions to a roadway segment, traffic engineers substitute input data that is easier to collect. Automobile level of service methods for roadways use one or more of the following inputs: theoretical capacity, observed volumes, observed speeds, number of stops, and presence of roadway amenities and disamenities. Automobile level of service methods for intersections typically use average delay at the intersection or ratio of observed volumes to theoretical capacity.

Recent studies question the ability of existing auto-based methods to accurately estimate drivers' perception of service quality. The current state-of-the-practice method is somewhat lacking in precision and accuracy. When evaluated against recorded video, the method outlined in Highway Capacity Manual 2010 correctly identified automobile level of service grade in 77% of cases (Transportation Research Board, 2010). A study by Pécheux, et al (2000) suggests that drivers perceive a maximum three or four, rather than six, different levels of service quality at signalized intersections. These two studies are just a sampling of those which have questioned the validity of automobile level of service analysis.

Various alternative methods exist to analyze transportation system performance across modes. In 2010, the Transportation Research Board's National Highway Cooperative Research Program published Multimodal Level of Service Analysis for Urban Streets which details methods that can be used to assess user perception of service quality for a variety of modes: transit, bicycling, and walking, in addition to driving (Transportation Research Board, 2010b). Other metrics that can be used to assess system performance include person-delay (Milam, 2009), automobile trips generated, motorized trips generated (Hiatt, 2006), or all trips generated.

Criticisms of automobile-only transportation system analysis

First, many automobile level of service methods consider delay experienced by drivers, with no consideration of passengers, including public transportation passengers. Methods use vehicles rather than people as the key unit of measurement. The shortcomings of an automobile-centric method are especially pronounced when a city or transportation agency seeks to prioritize movement of high-occupancy vehicles and transit as a means to increase the flow of people through a congested area. When a traffic engineer applies any method that employs the vehicle as the primary unit of analysis, a crowded bus shares equal weight with a single-occupant automobile. If the project under consideration includes a transit priority treatment, such as bus-only lanes or signal priority, the traffic engineer would expect reduced delay for transit passengers and increased delay for automobile drivers in parallel traffic (in the case of repurposing a general lane to transit) or cross-traffic (in the case of prioritizing transit vehicles at signalized intersections). However, automobile-centric methods measure costs borne by vehicle drivers but ignore the benefits that accrue to passengers on transit and in high-occupancy vehicles. The additional delay experienced by automobile, bus, and transit drivers would be captured as an adverse impact, but the primary benefit of the project—reduced delay for transit passengers—is excluded from the analysis. The result of the automobile level of service calculations could indicate that the project would degrade level of service—which in many cases must be mitigated by eliminating the HOV or bus-only lane.

The result is similar when a proposed bicycle treatment will reduce automobile capacity, either by removing a mixed-flow vehicle lane or adding amenities for non-motorized modes. Henderson points out that many of the treatments used to make bicycling and walking safer degrade level of service (2011). These include pedestrian amenities such as wider sidewalks, street trees, raised crosswalks, and intersection bulb-outs to reduce crossing distances; and bicycle amenities such as dedicated lanes and physical separation of bicycle paths from vehicle paths. Traffic engineers seeking to optimize a roadway for level of service have removed such multimodal amenities over the years.

Secondly, mitigating adverse impacts, as identified by automobile-centric methods, leads to additional driving at the expense of alternative travel modes. Under the California Environmental Quality Act, a local government must assess the potential environmental impacts of a development project, change in roadway configuration, or other discretionary action. If an initial analysis projects some potential environmental impact, the local government must conduct further study of those impacts. Further study is typically conducted at the developer's expense for private projects and at government's expense for public projects like bus and bicycle lanes. When the local government determines that there will be a traffic impact—specifically that the project will cause delay at intersections to exceed the goals expressed in their general plan—then they must either mitigate this impact or detail the overriding considerations that outweigh the environmental impact. Traffic engineers have a few options to reduce delay at intersections: adding through lanes, adding turn lanes, widening lanes, synchronizing traffic signals, adding left-turn traffic signal phases, and reducing vehicle and pedestrian cross-traffic. Once such options are implemented, the roadway can accommodate additional traffic before delay again exceeds the goals expressed in the community's general plan.

These options often improve the automobile user experience at the expense of the pedestrian user experience. After a local government implements these measures to mitigate impacts to the transportation network, pedestrians must usually travel further to crosswalks to wait longer to cross wider streets. In built-up areas with no space to expand the right-of-way, roadway widening may come at the expense of sidewalk width.

If a local government has exhausted measures to mitigate automobile impacts in a corridor, all future development projects in a congested corridor will have a significant unmitigatable impact. While increasing transit service, which operates more effectively in denser environments, may be one possible measure to increase the number of people who can travel through a corridor—vehicle occupancy is not intrinsic to the automobile level of service model. Thus, a common mitigation measure is to downscale or reject new land use projects in the corridor.

A third common criticism is that level of service is frequently measured based on fifteen minute peak weekday demand, which may not accurately represent the average drivers' experience and could mislead investment decisions. Many methods fail to distinguish between a roadway that is congested for seven hours a day, and roadway that is otherwise uncongested but experiences significant delays for 15 minutes at the end of the school day. At which location should the local government prioritize investment? With many existing methods, the answer lies outside of the standard performance metrics. To better categorize performance and prioritize investment decisions, Caltrans incorporates duration into its level of service metrics. For example, LOSF4 means a highway segment that is severely congested for 4 hours per day (Hiatt, 2006).

Transportation System Performance Analysis in California

Transportation system performance analysis is incorporated into two California planning processes: The California Environmental Quality Act and the Congestion Management Program.

The California Environmental Quality Act requires that lead agencies assess the environmental impacts of their decisions. When it appears that a decision will have a significant environmental impact, the lead agency must prepare an environmental impact report that studies—and proposes mitigation alternatives for—significant environmental impacts. Local governments have the option of mitigating the impacts so that they're no longer significant or claiming that the benefits of the decision outweigh the environmental impacts, known as a statement of overriding considerations.

Municipalities and counties act as lead agencies for land use decisions within their jurisdictions. In general, cities and other lead agencies define thresholds for what constitutes a significant impact in their general plans. However, through statutes and regulations, the State of California also sets many thresholds of significance for certain impacts, such as air quality and water quality. The state affords lead agencies discretion in assessing impact levels and in defining significant impacts.

Many of the environmental factors protected in the California environmental review process pertain to the ability of an area's infrastructure to accommodate a decision, usually a land use decision such as the approval of a new development project. Lead agencies must assess if existing infrastructure (electricity, telecommunications, water delivery, and sewage) and services (public safety) in the area can support the project without exceeding significance standards. Lead agencies must also assess how a project will impact an area's ecological resources, such as species, water, air, and noise.

Transportation and traffic impacts are analyzed as infrastructure impacts rather than ecological impacts - the air quality and noise impacts of vehicles are analyzed separately. Neither the CEQA Statute (Public Resources Code §§21000-21177) nor its Implementation Guidelines (14 CCR, Division 6, Chapter 3, §§15000-15387) require use of a specific method or require the use of a specific methodology. The Guidelines instead require that lead agencies assess whether or not a decision will conflict with an existing plan, ordinance, policy, or congestion management program.

Under CEQA, local governments maintain the ability to choose the specific level of service estimation method employed and which modes should be included in the analysis of transportation network performance. Henderson (2011) notes that San Francisco, like many jurisdictions in California, adopted automobile level of service in the 1970s as a response to the California Office of Planning and Research's CEQA implementation guidelines. In many cases, level of service was adopted by city traffic engineers with no input from the public or city council (Henderson, 2011).

In 1990, the California Legislature established the Congestion Management Program (Government Code §65089). The statute requires Congestion Management Agencies in areas with a population of 50,000 or more to set thresholds and monitor level of service standards for highways and arterials in order to receive gasoline taxes. Thresholds must be no lower than E, unless an intersection or segment experienced level of service F when the bill was passed. If an intersection falls below a threshold, the Congestion Management Agency must develop a deficiency plan to improve level of service. Infill opportunity areas (defined in §65460.4) are exempt from the deficiency plan requirement. Additionally, the program does not apply to counties where local governments representing a majority of the population adopt resolutions seeking exemption (§65088.3).

In contrast with CEQA, the Congestion Management Program statute requires agencies to use automobile level of service, as presented in the Transportation Research Board's Highway Capacity Manual (Transportation Research Board, 2010) or Circular 212 (Transportation Research Board, 1980).

Los Angeles case study

Since local implementations of transportation system performance analysis vary across the state, examining a singular implementation can aid in understanding the potential effects. Los Angeles City and County are the largest in the state, and thus their policies have the largest potential to affect statewide petroleum demand.

The City of Los Angeles has codified "level of service" through ordinance, but has not codified a specific methodology for calculating level of service. The City of Los Angeles Municipal Code (Chapter I, Article 4) requires that public benefit projects do not degrade transportation level of service. The City's adopted General Plan (Transportation Element - Chapter VI - Street Designations and Standards) establishes standards for spot widening streets operating at level of service D or worse in order to gradually widen rights-of-way as abutting properties are redeveloped.

The City of Los Angeles Department of Transportation publishes Traffic Study Policies and Procedures (2012) to provide guidance for independent engineers conducting traffic impact studies/transportation impact assessments. In this document, the Department establishes the required traffic study methodology, Critical Movement Analysis, and defines "significant" impacts. Critical Movement Analysis is a 33-year old methodology for intersection level of service that uses volume to capacity calculations to rate service quality (Transportation

Research Board, 1980). This method differs from the state-of-the practice intersection methodology, which uses observed delay at the peak period (Transportation Research Board, 2010b). The Department acknowledges that this method is inaccurate for corridors where congestion at intersections reduces capacity at upstream intersections or when pedestrian activity in crosswalks reduces intersection capacity. Additionally, the Department acknowledges that the method is not appropriate for evaluating transit, bicycle, and pedestrian enhancements as it is "primarily an automobile-oriented measure" (City of Los Angeles Department of Transportation, 2012). The Department continues to evaluate other options to measure the performance of other transportation modes.

The 2010 Congestion Management Program for Los Angeles County establishes monitoring procedures and performance standards for segments and intersections in the County (Los Angeles County Metropolitan Transportation Authority 2010). These standards apply to both vehicle movements and transit system performance at certain intersections and in certain corridors. The Program allows local governments to use one of two methods for intersections: Intersection Capacity Utilization and Critical Movement Analysis (as used by the Los Angeles Department of Transportation) for intersections. Because several intersections and roadway segments in the county exceed the minimum standard of LOS "E", the county must prepare a deficiency plan to analyze the cause of the deficiency, propose mitigation measures, and prepare an action plan. The Program cross-references other transportation planning documents that include specific mitigation measures, such as freeway widening and system management plans.

Effect on Fuel Use

The net fuel-use effect of automobile-centric performance metrics and targets depends on the net result of three effects. First, if distance traveled is held constant, congestion reduction efforts that smooth traffic flow will lead to increases in system operations efficiency and reductions in fuel use. Second, any increase in distance traveled attributable to the congestion reduction efforts will increase fuel use. Third, congestion mitigation measures often reduce accessibility and the quality of non-auto mobility, shifting individual mode choice decisions toward automobile use.

It may be difficult for traffic engineers to observe smoothed traffic flow, even in the short-run. Scholars agree that traffic congestion affects travel behavior. Most famously, Anthony Downs argues that relieving peak period congestion causes travelers to shift from other modes (such as carpools), from other roads (usually parallel routes), and other times (Downs, 2004). When traffic congestion is mitigated, triple convergence and the expression of previously latent demand occurs almost immediately. This causes the benefits of capacity expansion or system management to accrue not only to those previously using the transportation facility during peak hours, but to those who had previously adjusted their travel in response to congestion. Thus, the congestion reduction effects are somewhat muted when observing the facility during peak demand, but are more observable on other routes and at non-peak times. Thus, the system operations efficiency benefits on fuel use are likely to be *de minimis* or immeasurable.

More important in determining the net fuel-use effect are any increases in distance traveled due to latent and induced demand. Most existing studies address induced demand: trips resulting from changes in land use enabled by vehicle capacity expansion or congestion reduction efforts. The case of suburban freeway expansion enabling additional development is easy for scholars to study.

Few studies have examined latent demand, or trips avoided due to congestion. These are discretionary trips—such as a trip across town for dinner with friends—that a traveler elects to forgo or substitute an inferior trip in response to traffic congestion. Because latent demand is not expressed, it is difficult measure. Even if latent demand is measured in one study, this information is unlikely to apply to other areas with varied, but unmeasured levels of latent demand.

The net effect automobile-centric performance standards have on petroleum use in a corridor depends on the level of latent demand relative to total travel. In a congested urban area with significant latent demand, congestion reduction will be small and the observed changes in petroleum demand are likely to range from a relatively small reduction to a relatively moderate increase. Those who respond to congestion mitigation by shifting from other modes (e.g. transit to single occupant vehicle) and those who express latent demand will produce net increases in distance traveled.

In areas where latent demand is insignificant relative to peak travel volumes, then congestion reduction efforts will produce more observable reductions in congestion. If latent demand is combined with low rates of mode shift to single occupant vehicles, then the short run effects will be a net reduction in congestion and a net reduction in petroleum use. However, it's possible (but not certain) that growth-inducing impacts could generate additional travel demand in the long-run, leading to higher levels of motor vehicle fuel demand versus a counterfactual in which the lack of the transportation facility stimulated additional demand for infill development near existing trip ends. In such cases, use of automobile-centric performance metrics is a contributing factor to sprawl.

Furthermore, anecdotal evidence from Henderson (2011) suggests that use of automobile-oriented level of service methods affect transportation planning in ways other than those included in CEQA studies and Congestion Management Program documents. In San Francisco, traffic engineers have discouraged adding new pedestrian crosswalks in certain instances because additional vehicle delay to allow pedestrian crossings could degrade level of service. The City of San Francisco originally focused on implementing bike lanes that would not significantly impact level of service—meaning that bike lanes were located in areas that had fewer bicycle/vehicle conflicts.

While the use of automobile-centric performance metrics affects system operations efficiency, distance traveled, and mode choice, it's quite difficult to quantify these effects. However, it's possible to estimate the effects of street widening using Highway Statistics data (U.S. Federal Highway Administration, 2010). Because they carry large volumes of surface street traffic, principal arterials are often targets of efforts to reduce congestion through widening. Additionally, principal arterials often appear in congestion management plans and have performance targets. In 1980, the average width of a principal arterial in California was 3.374 lanes. In 2010, the average width was 3.886 lanes. If, in 2010, principal arterials were as wide as in 1980, but carried the same amount of vehicles per lane as they do in 2010, the result would be a 2.1 billion mile (0.65%) decrease in statewide vehicle travel.

Factoring in less observable effects on other aspects of the transportation system for which automobile-centric performance metrics are a contributing factor - the distribution of land uses, and density, and the combined effect of land use and transportation infrastructure on mode choice - the total effect on motor vehicle fuel use is likely greater than 3%, perhaps as high as 15%. Changing performance measurement methods to better support multimodal solutions as mitigation measures in congested areas, rather than roadway expansion and reducing project density and intensity, could be expected to have a similar magnitude reduction in long-run fuel use.

Works Cited

California Governor's Office of Planning and Research. (2012). *Annual planning survey results 2012.* Retrieved from http://www.opr.ca.gov/docs/2012_APSR.pdf

City of Los Angeles Department of Transportation. (2012). *Traffic study policies and procedures.* Retrieved from http://www.ladot.lacity.org/pdf/pdf223.pdf

Downs, A. (2004). *Still stuck in traffic: Coping with peak-hour traffic congestion.* Washington, DC: Brookings Institution Press.

Henderson, J. (2011). Level of service: the politics of reconfiguring urban streets in San Francisco, CA. *Journal of Transport Geography, 19(6)*, 1138-1144. doi:10.1016/j.jtrangeo.2011.05.010

Hiatt, R. (2006). An alternative to auto LOS for transportation impact analysis. *In Transportation Research Board 85th Annual Meeting (No. 06-2306).* Retrieved from http://trid.trb.org/view.aspx?id=777382

Milam, R. (2009). Transportation impact analysis gets a failing grade when it comes to climate change and smart growth. *Fehr & Peers*. Retrieved from http://ntl.bts.gov/lib/31000/31900/31925/LOS_Climate_Change_Smart_Growth.pdf

Pecheux, K., Pietrucha, M., & Jovanis, P. (2000). User perception of level of service at signalized intersections: Methodological issues. *Transportation Research Circular E-C018: Proceedings of the Fourth International Symposium on Highway Capacity*, 322-335. Retrieved from http://onlinepubs.trb.org/onlinepubs/circulars/ec018/28_43.pdf

Transportation Research Board. (1980). Interim materials on highway capacity. *Transportation Research Circular No. 212*. Retrieved from http://trid.trb.org/view.aspx?id=153315

Transportation Research Board. (2010). *Highway capacity manual 2010.* Washington, DC. Retrieved from http://www.trb.org/Main/Blurbs/164718.aspx

Transportation Research Board. (2010b). *Multimodal level of service analysis for urban streets.* Washington, DC. Retrieved from http://www.trb.org/Main/Blurbs/160228.aspx

U.S. Federal Highway Administration. (2010). *Highway statistics.* Washington, DC.

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Automobile Insurance Rate Structure

Overall effect on California petroleum use		Affects Petroleum Demand Through Intermediate Indicators:	
Magnitude	High	**Primary**	Distance Traveled
Certainty	High	**Secondary**	System Operations Efficiency
Applicable Level of Government	State		
Relevant Laws or Cases Affecting Factor	10 CCR § 2632.5		
Overall Time-Horizon of Reversal	Medium-term, with some short-term support needed to facilitate the transition. In 2009, the California Department of Insurance finalized regulation that specifies how insurance companies may charge per mile, based on either estimated or verified reports of distance traveled. As of September 2012, five California insurers offer pay-as-you-drive programs (California Department of Insurance, 2012).		
Relevant Topics	Automobile insurance, marginal cost of driving		
Summary	A transition to per-mile insurance premium calculations would increase the variable cost of each mile driven and lead to lower premiums for a majority of drivers and lead to a significant reduction in driving per capita.		

Introduction

In 2010, Californians spent $21.2B on automobile insurance premiums and $45.9B on gasoline (California Department of Insurance, 2011) and (U.S. Energy Information Administration, 2012). By comparison, California's new and used car dealers brought in $39.0B in taxable sales (California Board of Equalization, 2012). Because automobile insurance is a significant transportation expenditure, the rate structure has significant implications for travel in California.

Automobile insurance rates rarely factor actual distance traveled. When insurers do consider annual distance traveled in setting rates, the insured has an incentive to underreport this estimate. Thus, many insurance agencies underweight distance traveled versus other risk factors when setting insurance rates. Underweighting distance traveled reduces the variable cost of each mile driven and increases the fix cost of automobile ownership, increasing distance traveled per automobile. Transitioning to per-mile automobile insurance rates would increase the variable cost of each mile driven and reduce distance traveled.

Scholarly studies highlight how per-mile, or pay-as-you-drive insurance, can lead to reductions in distance traveled. Parry (2005) finds that "[Pay-As-You-Drive] provides incentives to drive less, but not to improve fuel economy" and that nationally, reductions in distance traveled due to per-mile insurance rates would reduce gasoline demand by 9.1% and improve social welfare by a value of $19.3B annually. A transition to per-mile insurance compares favorably with Parry's analysis of raising the federal gasoline tax from 18 to 45 cents per gallon. While the gasoline tax increase would produce a similar reduction in gasoline demand, it would only result in $6.2B in welfare gains. Bordoff and Noel (2008a) estimate transitioning to per-mile automobile insurance would lead to an 8% reduction in national vehicle travel. Cambridge Systematics (2009) estimates that requiring all policies nationwide to be priced per mile by 2025 would reduce GHGs by 2,233 million metric tons of CO_2-equivalent, making it one of the top ten most potent policies the firm analyzed.

At least two researchers have studied to quantify how a shift to per-mile insurance in would impact California. California-specific and national studies consistently find the impact to be an 8% to 10% reduction in vehicle miles traveled. Most of the studies are based on economic analysis of broad national data, so it's possible that future studies based on more precise local data will improve projections.

Bordoff and Noel (2008b) project that saturating the California market with pay-as-you-drive policies would produce several changes. Sixty-four percent of California households would pay lower insurance premiums. Vehicle miles traveled would decline by 8% and statewide gasoline consumption would reduce by 1.338B gallons in 2020. The transition would generate 7 to 9% of total reductions needed to meet AB 32 greenhouse gas emissions reduction targets for 2020. Congestion-related costs would decline by $1.446B, versus 2006 conditions. Bordoff and Noel estimate the total social benefits to be $21.1B in 2020, or $658 per car.

Edlin (1998) estimates that California's per-mile insurance charge would be between 3.7 and 4.1 cents (in 1995 dollars) and lead to a 9.0 to 9.8% reduction in vehicle reductions. He also estimates $5.7B in national congestion reduction benefits, again in 1995 dollars (Edlin, 2003).

Potential rebound effect on vehicle ownership

One concern with the transition to per-mile automobile insurance rates is that it could increase the number of vehicles available. Reducing fixed costs for low-mileage, low-income drivers may support their retention or acquisition of additional automobiles. Because annual *ad-valorem* vehicle license fees are lower for older, depreciated vehicles, the insurance premiums may be a high proportion of annual fixed costs. A transition to per-mile insurance could cause households at the margins of automobile ownership to acquire an additional vehicle or retain a vehicle they planned to dispose. While such households may have more vehicles available relative to the status quo, they would have a greater disincentive to drive. Demand for residential parking will likely increase if the transition occurs in absence of measures that will reduce household demand for vehicle ownership, such as robust carshare.

California Regulations

A July 31, 2009 amendment to the California Code of Regulations (10 CCR § 2632.5) allows insurers to use estimated and verified mileage data in adjusting premiums. Specifically, (2) F vii, allows insurers who verify vehicle mileage to advertise per-mile rates.

Edlin and Karaca-Mandic argue that assessing insurance premiums not only on distance based on distance traveled, but also other risk factors such as travel in highly dense areas, would create further disincentive for driving in congested areas (Edlin & Karaca-Mandic, 2006). The result would be akin to insurer-assessed congestion pricing, reducing traffic congestion beyond what would occur under reduced travel distances alone.

Two clauses in California's regulations reduce the potential for additional congestion reduction and fuel savings. First, 10 CCR § 2632.5(c)(2).F.5.B prohibits insurers from collecting vehicle location information. However, 10 CCR § 2632.5(d)(15-16) allows insurers to set premiums, including per-mile premiums, based on the relative frequency and severity of accidents in the zip code where the vehicle is garaged. The result is that per-mile premiums could be lower for a vehicle garaged in a suburban location versus a vehicle garaged in an urban location, even as the vehicles travel through the same congested area at the same time. Though these vehicles may have identical per-mile risk profiles when traveling through the congested area, the suburban driver could pay less per mile. While the suburban driver on a per-mile rate would have some incentive to reduce driving, this incentive would remain constant for trips into congested areas for which robust transit alternatives may exist. A driver residing in a congested area but traveling to the suburban area could pay a higher total premium for the same automobile trip than the suburban driver. However, the higher per-mile charge might cause the driver to seek out travel alternatives for local trips within the congested urban area.

Adoption in California

Research indicates the potential for exponential adoption rates for pay-as-you-drive insurance policies in California. Bordoff and Noel (2008a) show that low-mileage drivers cross-subsidize high-mileage drivers under the status quo. Because driving per capita is not normally distributed, more than half of California's drivers travel fewer annual miles than the statewide average (Parry, Walls, & Harrington, 2006). These drivers have a financial incentive to switch to per-mile policies. Because of this incentive, State Farm anticipated that 25% of its 3.3 million auto policyholders would make the switch when it began offering per-mile policies in 2011 (California Department of Insurance, 2010).

The virtuous adoption cycle will continue as low-mileage drivers shifting to per-mile insurance rates will raise premiums for the remaining drivers on traditional premiums plans. Faced with premium increases, more will switch to per-mile plans. Bordoff and Noel (2008b) estimate 64% of Californians will save money if they switch to a per-mile plan. The adoption cycle will continue as drivers at the margins continue to switch and drivers on legacy plans face annual premium increases as the risk pool narrows.

Early support may be necessary to overcome initial adoption barriers. First, consumers must learn about pay-as-you-drive options in order to enroll in programs. Second, insurers need data from real-world experiences in order to calculate actuarial risk and per-mile premiums. Third, Edlin and Karaca-Mandic (2006) claim an inter-insurer externality exists: an insurer offering per-mile pricing will see their customers drive less. The reduction in driving lowers risks and claims for all drivers, benefit other insurers and those on legacy plans. The insurer offering the per-mile policy cannot internalize this benefit, indicating the potential need for policy intervention.

To overcome these barriers, Bordoff and Noel (2008a) suggest $15 million in federal funding for a 5-year pilot program and a $100 per-policy tax credit for the first 5 million per-mile policies issued. California could look toward similar measures to induce statewide adoption.

Works Cited

Bordoff, J. E., & Noel, P. J. (2008a). *Pay-as-you drive auto insurance; a simple way to reduce driving-related harms and increase inequality.* Brookings Institution.

Bordoff, J. E., & Noel, P. J. (2008b). *The impact of pay-as-you-drive auto insurance in california.* Brookings Institution.

California Board of Equalization. (2012). Table 1. Statewide taxable sales, by type of business, 2010. Sacramento, CA.

California Department of Insurance. (2010, December 2). *Insurance commissioner poizner approves california's first-ever pay-as-you-drive auto insurance program.* Retrieved from http://www.insurance.ca.gov/0400-news/0100-press-releases/2010/release138-10.cfm

California Department of Insurance. (2011, April 25). *2010 California P&C premium and loss summary.* Retrieved from http://www.insurance.ca.gov/0400-news/0200-studies-reports/0100-market-share/2010/upload/MktShrSummary2010.pdf

California Department of Insurance. (2012). *Insurance commissioner Jones announces approval of esurance filing to offer pay-drive program.* Retrieved from http://www.insurance.ca.gov/0400-news/0100-press-releases/2012/release120-12.cfm

Cambridge Systematics. (2009). *Moving Cooler: An analysis of transportation strategies for reducing greenhouse gas emissions.* Washington, DC.: Urban Land Institute.

Edlin, A. (1998). *Per-mile premiums for auto insurance (No. w6934).* National Bureau of Economic Research.

Edlin, A. (2003). Per mile premiums for auto insurance. In *Economics for an Imperfect World, Essays in Honor of Joseph Stiglitz.* Cambridge: MIT Press.

Edlin, A., & Karaca-Mandic, P. (2006). The accident externality from driving. *Journal of Political Economy, 114*(5), 931-955. Retrieved from http://ideas.repec.org/a/ucp/jpolec/v114y2006i5p931-955.html

Parry, I. (2005). Is pay-as-you drive insurance a better way to reduce gasoline than gasoline taxes? *American Economic Review 95:2*, pp. 288-293.

Parry, I., Walls, M., & Harrington, W. (2006). *Automobile externalities and policies.* Washington, DC: Resources for the Future.

U.S. Energy Information Administration. (2012, December 3). *California gasoline and diesel retail prices.* Retrieved from http://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sca_w.htm

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Compensated and Real-time Rideshare

Overall Effect on California Petroleum Use		**Affects Petroleum Demand Through Intermediate Indicators:**	
Magnitude	High	**Primary**	Vehicle miles traveled
Certainty	Medium	**Secondary**	Mode choice
Applicable Level of Government	Local, State, Federal		
Relevant Laws or Cases Affecting Factor	California Public Utilities Code § 5353 and §5360, 23 USC § 101(a)(3),		
Time horizon for implementation and maturity	Rideshare will lead to immediate reductions in petroleum use, however the potential of new services to quickly induce rideshare adoption lacks empirical study		
Relevant Topics	Rideshare, taxi, e-rideshare		
Summary	Sharing the ride is the holy grail of options to reduce congestion and petroleum use. Each matched ride can take one vehicle off the road. However, sharing the ride is inherently more difficult than driving alone. Matching shared rides faces structural, communications, and incentive barriers that existing publicly-sponsored rideshare programs have addressed, but have yet to fully overcome. New private services directly address these barriers, but their potential to fully overcome them is still undetermined.		

Disclaimer: This policy brief examines the market adoption and petroleum reduction potential of compensated and real-time rideshare services rather than safety or liability of the category or individual firms.

Introduction

Recent innovations in transportation service delivery can increase the utilization of existing transportation assets, including empty seats in private vehicles. New market entrants are in part responding to a structural shift in the market for automobility–a transition from reliance on privately-owned transportation assets to increased reliance on transportation as a service retained by the traveler. New services are described in the table below:

By Juan M. Matute and Stephanie S. Pincetl

Types of new rideshare services

Type of Service	Description	Firms in CA or U.S.
Internet-enabled Rideshare	Regular or long-distance rideshare arranged in advance via internet with social media component, possibly with a fee or donation remitted to the driver	PickupPal, Zimride
Real-time Rideshare	Ad-hoc internet-enabled rideshare arranged immediately prior to pick-up using a mobile device, typically with a fee or donation remitted to the driver	Avego, Lyft, Sidecar, Tickengo, Uber

As with previous rideshare innovations, these new rideshare services can provide options to increase vehicle occupancy and reduce vehicle trips. Past innovations have largely failed to close the attractiveness gap between rideshare and single-occupancy vehicles. Unlike previous innovations, these innovations have been privately-sponsored and have emerged in a relatively short period of time. These new rideshare services can make rideshare more flexible and offer new incentives to drivers and passengers. Whether these new services can close the rideshare gap, and the extent to which century-old transportation service regulations will accommodate these new services remains undecided as of this writing. However, rideshare shows continued promise as a strategy to substantially reduce California's petroleum use.

Rideshare

Rideshare involves combining one or more individual trips in a single privately-operated vehicle. Rideshare faces several inherent obstacles versus single-occupant vehicle travel. In order to share a ride, two or more individuals need to be make trips with similar origins and destinations at similar times. Connecting individuals with similar trip making requirements has been a focus of past publicly-sponsored rideshare innovations. Because registering trip making requirements and communicating with matches is often a burdensome process, the past focus has been on regular rideshare, wherein two or more individuals share a ride weekly or more frequently. Slugging or casual carpool is a form of ad-hoc rideshare wherein trip origins and destinations are standardized, reducing information and communication barriers.

Even when rideshare is able to overcome information and communication barriers, a lack of driver incentives can thwart rideshare opportunities. Drivers in regular rideshare arrangements may share the costs of vehicle operations, parking, and tolls with passengers. In the long term, compensation from such arrangements can offset a significant portion of vehicle ownership and operations cost. Financial compensation from irregular, ad-hoc rideshare arrangements may be insignificant compared to annual vehicle ownership and operations costs. Slugging or casual carpool arrangements typically arise in response to some incentive, such as HOV lane access or a reduced toll.

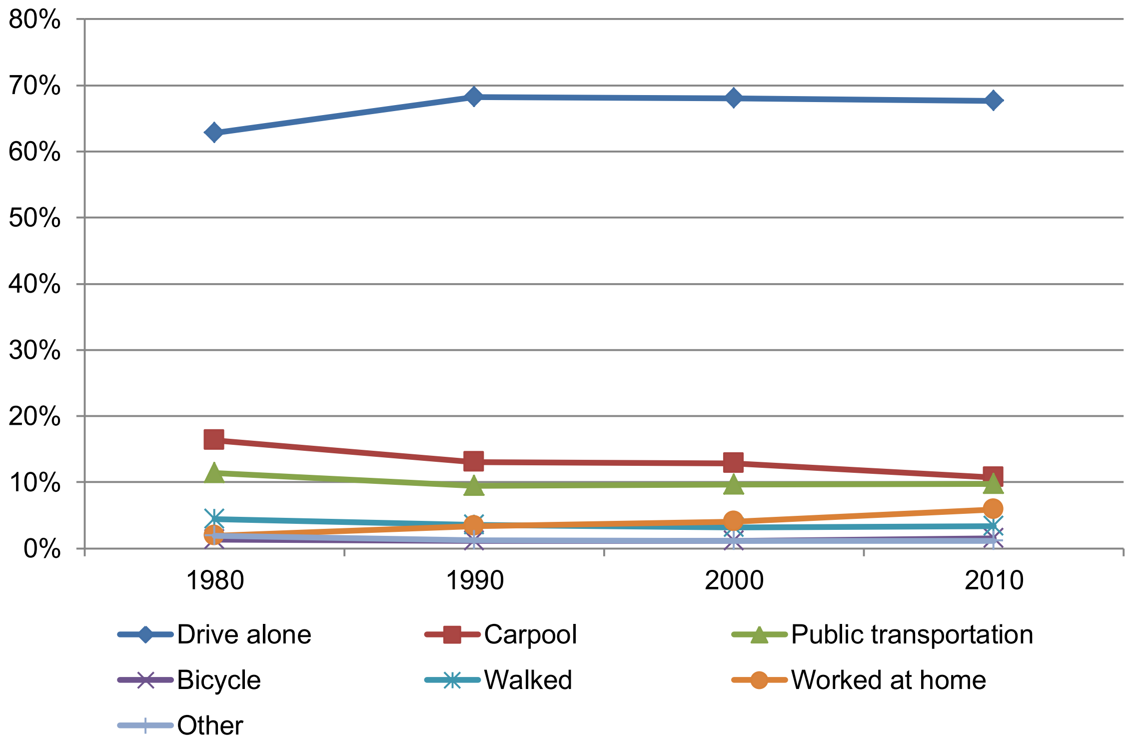
A third barrier to rideshare is a perceived and real loss of flexibility versus single-occupant vehicle travel. Regular rideshare schedules may not accommodate the travel requirements of potential rideshare participants. In cases where regular rideshare schedules are successful, passengers may fear the possibility of unplanned stranding in the case of a personal or family emergency. To increase the flexibility of regular rideshare services, public institutions and large employers sometimes offer guaranteed ride home programs to regular ride sharers. In such a program, the stranded ride sharer is typically compensated for taxi costs incurred.

Rideshare in the Bay Area

Structural barriers make sharing the ride inherently difficult in areas with dispersed trip origins and destinations. Rideshare is typically an option only when two or more individuals are making similar trips at similar times. Looking at the number of possible daily trip combinations in the San Francisco Bay area illustrates the significant barriers to sharing the ride. The Metropolitan Transportation Commission (MTC), a regional body that forecasts travel demand among other duties, divides the 9-county Bay area into 1,454 traffic analysis zones. Zones range in size from a few blocks in urban areas with higher density of trip origins and destinations to dozens of square miles in rural areas with lower density of trip origins and destinations. With 1,454 potential areas to begin and end trips and a thirty minute window for beginning each trip segment, there are 101,477,568 possible trip segments in the Bay Area. Those who share the ride must match for at least two of these segments – one segment from the origin to the destination and another back to the origin. Matching trips is not guaranteed: of the 100+ million possible trip segments, Bay Area residents make just over 40 million trip segments per weekday.

However, these trips are not uniformly distributed across time and between zones. Far more trips occur during the morning and afternoon peak periods than in the middle of the night. Many peak period trips begin or end at work. Because these trips are spatially and temporally concentrated, they're often targeted for carpool programs. The MTC estimates over 750,000 rideshare trips to work, or about 14.7% of all work trips.

Rideshare to work in the San Francisco Bay Area CSA, 1980-2010



The share of carpool commutes has been declining in the Bay Area since 1980, when 16.3% of workers carpooled to work. In 2010, 10.7% of commuters carpooled.

Reducing structural, incentive, and communication barriers has been the goal of public rideshare investment. Park and ride lots concentrate trip origins, reducing structural barriers. The Bay Area has 150 free park and ride lots. High-occupancy vehicle lanes provide time savings and reduced tolls provide financial savings – creating additional incentives to share the ride. The Bay area has 340 miles of HOV lanes and plans to build another 280 miles. All Bay Area bridges provide a 50% discount for carpools and vanpools during peak hours. Computer-based services, where potential drivers and passengers state their intentions and seek matches, help overcome communication barriers. RideMatch service is the Bay Area's latest generation of publicly-sponsored rideshare matching services.

Real-time and compensated rideshare

Amey, et. al. (2010) define "real-time rideshare" as a service with stored user profiles, social network integration, and participant feedback that supports ad-hoc ride matching and automated financial transactions between users (Amey, 2010). These services can overcome common rideshare barriers arising from information, communication, transaction costs, incentives, and the need for both flexibility and reliability. However, real-time rideshare services can also displace conventional rideshare and transit trips. If such displacement is large, real-time rideshare's potential to reduce congestion and petroleum use may be muted.

Compensated and real-time rideshare service providers act as exchanges, or peer-to-peer marketplaces, connecting approved drivers and passengers for a ride. Like other peer-to-peer marketplaces, the service's value is in a buyer's ability to successfully find what they seek at a price they are willing to pay. Sellers will participate in a market with active buyers, continuing a virtuous cycle that brings liquidity to the marketplace. For real-time rideshare, liquidity means a greater volume of potential trips. Increasing rideshare volume increases the probability that two or more individuals will match an origin and destination at the specified time.

New rideshare services face barriers to virtuous adoption cycles. First, service providers must offer value to customers: quality, reliable service. Service providers use a combination of offline and online service quality controls. Services typically require that potential drivers be approved prior to their participation in the rideshare marketplace. Uber considers drivers of black car limousines and taxis, who are licensed but wish to work independently. Lyft, Sidecar, and Tickengo consider drivers who own private vehicles. Second, the services face competition from within their own market that may prevent or delay any one service from garnering a critical mass of participants. Because each provider benefits from a network effect to provide liquidity, or volume, fragmenting users between competing services can reduce market-wide adoption. Because a real-time rideshare trip's departure time is fixed, these services' success may require a greater baseline volume than compensated or internet-enabled regular rideshare. Finally, the emerging regulatory environment will have a profound effect on real-time and compensated rideshare growth.

Real-time Rideshare Regulations

Real-time rideshare is an emerging service category and most existing regulations do not directly address the practice. While real-time rideshare has been defined in U.S. Code, the practice is not directly addressed by California law or regulations.

The 2012 transportation reauthorization bill (MAP-21) amended U.S. Code to include a definition for real-time rideshare: "projects where drivers, using an electronic transfer of funds, recover costs directly associated with the trip provided through the use of location technology to quantify those direct costs, subject to the condition that the cost recovered does not exceed the cost of the trip provided" (23 USC § 101(a)(3)). Defining real-time rideshare in U.S. Code does not formalize the practice in individual states, but rather makes real-time rideshare projects eligible for federal carpool funds. The Internal Revenue Service considers rideshare income in excess of actual trip costs or its standard mileage reimbursement rate as taxable income.

Rideshare faces two primary regulations in California. The first regulation is individual city and county taxi regulations, which differ by city, but primarily exist to support safe, accountable, and quality taxi service.

The second regulation is the California Passenger Charter-Party Carriers' Act. Compensated rideshare trips that operate on a commercial enterprise basis PUC § 5353(f) or are not between home and work PUC § 5353(h) are subject to the Act. The Act primarily regulates pre-arranged transportation services such as black cars and charter buses, as well as airport shuttle vans.

The Act defines "charter-party carrier of passengers" as "every person engaged in the transportation by person by motor vehicle for compensation, whether in common or contract carriage, over any public highway in" California, including "includes any person, corporation, or other entity engaged in the provision of a hired driver service when a rented motor vehicle is being operated by a hired driver" (PUC § 5360).

The Act establishes two types of charter services: passenger stage corporations and charter-party carriers. A passenger stage corporation operates services on an individually-arranged fixed-route scheduled service or certain flexible services. Intercity buses and airport shuttles fall within this definition. A charter-party carrier offers pre-arranged transportation for exclusive use of individuals or groups and charges based on mileage, time of use, or a combination of both. Chartered buses, contracted employer-based shuttles, and tour buses fall within this definition. In practice, real-time and compensated rideshare can exhibit elements of a passenger-stage corporation (shared rides can be priced per-seat) and a charter-party carrier (flexible routing).

Businesses wishing to operate as a charter-party carrier in California must obtain a Class P permit and:

- obtain $750,000 in liability insurance for vehicles 7 passengers or less; $1,500,000 for vehicles 8 to 15 passengers,
- if workers are employed, provide need evidence of workers' compensation insurance,
- enroll drivers in the Department of Motor Vehicles Employer Pull-Notice System, which allows an ongoing review of driver records,
- require drivers to participate in the Public Utilities Commission's drug and alcohol testing program,
- remit fees to the Commission equaling 0.25% of revenue, assessed quarterly.

On November 13, 2012, the California Public Utilities Commission fined Lyft, Sidecar, and Uber $20,000 each for four counts of violating the Charter-Party Carrier Act. On December 20, 2012, the Commissioned announced its intention to engage in rulemaking to evaluate this service type, which the Commission refers to as "New Online-Enabled Transportation Services." In late January of 2013, the Commission entered into operating agreements with Lyft and Uber.

Case study: San Francisco & Lyft

Lyft, Sidecar, Tickengo, and Uber have concentrated their California operations in San Francisco, providing an opportunity to examine the regulatory environment facing these new services.

San Francisco's taxi regulation has three main themes: safety, accountability, and service quality (San Francisco Transportation Code, Articles 1100 et seq.). First and foremost is safety: vehicles must be properly maintained and expected regularly and individual drivers are subject to added safety requirements beyond those required of non-commercial drivers. Taxi operators and owners must be accountable: color-scheme permit holders must maintain insurance for the drivers and maintain a principal place of business staffed during regular business hours. Some of the regulations address service quality: vehicle cleanliness, service level guidelines, driver's appearance, etc.

San Francisco's taxi regulations have been somewhat tumultuous over the past decade. The San Francisco Metropolitan Transportation Agency replaced the city's Taxi Commission in 2009. The SFMTA has sought to reform the medallion transfer system, which was seen as inequitable (Lam, Leung, Lyman, Terrel, & Willson, 2006). Previously, the Taxi Commission issued medallions only to full-time drivers and transfer was prohibited, meaning that older drivers lacked a means of retiring their permit. Prior regulations limited the number of authorized medallions to 1,500. This cap artificially limited supply, allowing medallion holders to earn economic rents, or abnormal profits. As of October 2012, there were 1,416 individuals on the official waiting list, with those most recently receiving medallions having joined the list in the late 1990s (San Francisco Municipal Transportation Agency, 2012).

The taxi shortage has also impacted the quality of service, creating frustration and long waits for those seeking a taxi during times of peak demand. San Francisco's Taxi regulations prohibit color-scheme permit holders or drivers from charging different rates based on variations in demand. As a result of shortages, many consumers have sought alternatives. Some have used Charter-Party Carriers vehicles known as black cars, which must be arranged in advance, for their real-time transportation needs. Others simply used unlicensed vehicles (Baume, 2010).

It is into this environment that Uber, San Francisco's first smartphone-based real-time trip service, entered in 2010. Tickengo, Sidecar, and Lyft soon followed.

Lyft & Zimride

Lyft shares many similarities with other peer-to-peer marketplaces, like eBay. On Lyft, drivers are sellers and passengers are buyers. As with eBay, participants may rate each other after a transaction. A participant's reputation influences transactions, and individual reputation information is one of the differentiating assets: a lone female passenger riding alone at night may feel more comfortable riding with a male driver with a high reputation score than she would in a hailed taxi. Drivers and passengers with low reputation scores will likely find it difficult find counterparties for their transactions, or may be blocked from the service altogether.

In addition to reputation information, buyers have some assurance that service quality is commensurate with costs: while Lyft will automatically deduct and transfer a suggested donation between the passenger and driver, the passenger can change or eliminate the donation within 24 hours after the trip (Lyft, 2012). The transaction is cashless and processed electronically.

As of this writing, Lyft suggests a fixed, per-mile donation rate. The total donation amount varies based on trip distance, but not on other factors like the time of day, day of week, and revenue potential of the backhaul trip. The company may move to a demand-based dynamic pricing scheme in the future (Green, 2012). Dynamic pricing would allow price premiums during times of peak demand and offer steep discounts for trips the Lyft driver would make anyway, such as backhauls.

Lyft is a product of Zimride, Inc., a national provider of internet-enabled social rideshare services. Zimride facilitates regular rideshare for commute trips and occasional pre-arranged rideshare for longer distance trips. Zimride can limit participation to defined communities, such as universities or employers. Zimride trips can be compensated or uncompensated, with payments handled between participants. Zimride integrates with social networks in order to match participants with friends or friends of friends, or to enable users to learn information about other participants prior to entering the vehicle.

Logan Green, CEO of both Zimride and Lyft, described the primary difference of the two services as the lead-time for the trip: Zimride rides are pre-arranged, but rides arranged at the last minute, as is the case with Lyft, command a price premium (Green, 2012). The two services can be complements: those who rely on regular pre-arranged rideshare may occasionally need an emergency ride home or elsewhere. Driving alone in a privately-owned vehicle preserves this flexibility, but real-time rideshare can provide additional flexibility for regular rideshare passengers.

Evaluating effects of new rideshare services

Because real-time and compensated rideshare services are currently in an early market phase, they have yet to display their full potential to reduce petroleum use and traffic congestion. Existing services operate as technology startups and are largely focused on developing a scalable and administratively efficient service as they build a customer base. Because the services have entered the California market through San Francisco, a high-income city with a tech-savvy population and existing peak-period shortage of taxis, initial prices are high.

Because compensated real-time rideshare and pre-arranged regular rideshare are complimentary services, their petroleum reduction potential should be evaluated jointly. Compensated real-time rideshare and regular rideshare's potential to reduce California congestion and petroleum use depends on the long tail: the mass market adoption of rideshare trips at much lower per-mile prices. At high prices, it's likely that many passengers will shift to using real-time rideshare services in-lieu of taxis. It's also likely that many drivers will seek passenger-serving trips for which they have no purpose at the destination, leading to overall increases in VMT. At lower prices, the probability that passengers will shift from driving alone increases, as does the probability of attracting former conventional ride sharers and transit users. A high price for the service, whether brought about by regulations or profit motive, could shorten the long tail and dampen potential reductions in statewide petroleum use.

The long tail of users also enhances the value of the service to all users—through a network effect that provides liquidity into the marketplace—increasing the probability that a passenger match with a driver's premeditated trip. Such drivers will likely be willing to offer the trip at a lower price, as the compensation is ancillary to their primary trip purpose of providing for their own mobility. Consistent ride matching rides requires a large threshold of users and transaction activity. Trips arranged in near-real time reduce flexibility in departure times, necessitating even larger transaction to provide reliable matching. Compensation serves to attract additional drivers to participate in the market.

Estimating the potential of new rideshare services to reduce petroleum use in California depends on the total possible market size and new rideshare's ability to convert single-occupant vehicle trips to multi-occupant vehicle trips. This estimation involves a key assumption, that the low-hanging fruit – existing rideshare potential not enabled by new services – has stabilized. Those that would like to share a ride using pre-existing services or arrangements have already done so. New, privately-enabled technology-based rideshare services and compensation arrangements will facilitate new rideshare trips

Estimating excess seat capacity in California's privately occupancy vehicles is possible using 2009 National Household Travel Survey data (U.S. Federal Highway Administration, 2011). The table below presents an estimate of excess seat-mile capacity for personal travel in private vehicles by California households in 2009.

Estimating excess seat-mile capacity for California household private vehicle travel (2009)

Vehicle Type	Household Person Miles Traveled by Vehicle Type *(NHTS 2009)*	Assumed Average Passenger Capacity for Vehicle *(authors)*	Estimated Excess Seat-mile Capacity *(authors)*	Household Vehicle Miles Traveled by Vehicle Type *(NHTS 2009)*
Car	182,328,000,000	3	384,353,000,000	129,829,000,000
Van	32,439,000,000	5	88,661,000,000	17,269,000,000
SUV	68,033,000,000	4	171,133,000,000	42,830,000,000
Pickup Truck	46,559,000,000	2	52,757,000,000	35,163,000,000
Total ***(above modes only)***	**329,359,000,000**		**696,904,000,000**	**225,091,000,000**

Estimated excess seat-mile capacity is calculated based on trip-level data on respondent's mode and the number of people traveling with the respondent on the trip.

Filling excess seat-miles with new rideshare services

Rideshare's potential to fill excess seat-miles depends on two factors – the share of excess seat miles that new rideshare services can fill and the conversion rate of single-occupancy vehicle drivers to rideshare.

Sharing the ride is nothing new in California. About 57.3% of household passenger miles traveled and 55.9% of trips in cars, vans, SUVs, and pickup trucks occurred in a vehicle with more than one occupant (U.S. Federal Highway Administration, 2011). For 46% of these trips, at least one of the additional occupants was a household member. At assumed average vehicle occupancies, approximately 31% of available seat miles are already filled. However, by filling excess seat-miles, California can make significant strides toward reducing statewide consumption of motor vehicle fuels.

The table below estimates reductions in petroleum use at various market saturation intervals and conversion rates. The conversion rate – the ratio of reduced single-occupant vehicle trips to rideshare miles – accounts for rideshare trips that shift from other modes (e.g. taxi and transit). Because little empirical study exists on new rideshare services, the authors assume this rate conservatively. Additionally, because the new rideshare services involve driver compensation, the estimates account for a rebound effect – an increase in VMT due to some exclusively-passenger-serving rideshare trips – chauffeuring. The long-tail phenomenon is expressed through increased conversion rates at higher levels of saturation.

Estimates of fuel savings from rideshare

Additional Ride-share Market Share	Con-version Rate	Ride-share PMT (Millions)	Estimated Induced Passenger- Serving VMT (Millions)	Estimated Reduction (Increase) in VMT (Millions)	Reduction (Increase) in Fuel Use (millions of gallons)	Reduction (Increase) in Motor Vehicle Fuel Use (percent)	Fuel savings (millions of dollars at $3.14 dollars/gallon)
0.10%	20%	96	278	(139)	(7)	(0.04)%	($23.9)
0.50%	33%	3,484	1,161	0	0	0.00%	0
1%	50%	6,969	1,742	1,742	95	0.54%	$299.4
2%	67%	13,938	2,323	6,969	380	2.16%	$1,197.5
3%	75%	20,907	2,613	13,066	713	4.05%	$2,245.4
5%	83%	34,845	3,048	25,698	1,402	7.96%	$4,415.8
10%	90%	69,690	3,484	59,236	3,233	18.35%	$10,178.9

Data is authors' calculations based on 2009 National Household Travel Survey and 2010 Highway Statistics 2010 data. Effects in reducing auto-ownership are excluded from the analysis. Fuel price is 2010 annual average, which is lower than more recent annual averages.

New rideshare services may increase petroleum use in the short run. This is primarily because limited supply results in market skimming and high prices – creating an incentive for chauffeuring trips. If the market attracts a sufficient number of participants to create liquidity in ride-matching, the price will drop, increasing the conversion rate of rideshare trips from single-occupant vehicle trips.

Whether or not emerging or future rideshare services can achieve sufficient participation to create a virtuous cycle of adoption requires analysis that is beyond the scope of this policy brief. This offers an opportunity for future research that introduces a compensated and real-time rideshare mode into a travel demand model to understand how price may affect rideshare for matched routes and departure times.

However, if real-time and compensated rideshare can succeed in expanding ride share by 1% or more, these services' effect on petroleum use will be substantial.

Works Cited

Amey, A. M. (2010). *Real-time ridesharing: exploring the opportunities and challenges of designing a technology-based rideshare trial for the MIT community.* Cambridge: Massachusetts Institute of Technology. doi:10.3141/2217-13

Baume, M. (2010, September 17). Why doesn't SF have enough cabs? *NBC Bay Area*. Retreived from http://www.nbcbayarea.com/the-scene/cars/Why-Doesnt-SF-Have-Enough-Cabs-103148044.html

Chan, N. D., & Shaheen, S. (2012). Ridesharing in North America: Past, present, and future. *Transport Reviews, 32(1)*, 93-112. doi:10.1080/01441647.2011.621557

Green, L. (2012, November 12). Personal communication.

Lam, D., Leung, K., Lyman, J., Terrel, S., & Wilson, R. (2006). *The San Francisco taxicab industry: An equity analysis.* University of California, Berkeley. Retreived from http://128.121.89.101/cms/rtaxi/documents/GoldmanStudyFINAL2006.pdf

Lyft. (2012). *Lyft terms of service*. Retrieved from http://lyft.me/terms

San Francisco Municipal Transportation Agency. (2012, October 29). *Taxi Medallion Waiting List.* Retrieved from http://www.sfmta.com/cms/xind/documents/RedactedWaitlist2012-10-29.pdf

U.S. Federal Highway Administration. (2011, February). National household travel survey. Retrieved from http://nhts.ornl.gov

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Carshare Innovations

Overall Effect on California Petroleum Use		Affects Petroleum Demand Through Intermediate Indicators:	
Magnitude	Medium	**Primary**	Mode Choice
Certainty	Medium	**Secondary**	Distance Traveled
Applicable Level of Government	State, Local, and Federal		
Relevant Laws or Cases Affecting Factor	49 USC . § 30106, California Vehicle Code §22507.1, California Insurance Code §1150.24, San Diego Municipal Code §86.23		
Time horizon for implementation and maturity	Carshare is currently available in California and there are few regulatory barriers to its expansion. Carshare expansion is a near-term strategy to reduce statewide fuel use.		
Relevant Topics	Automobile ownership, transportation services, technology		
Summary	Carshare is an emerging service category that fills existing gaps in travel choice for individuals and households seeking to shed or delay purchase of personal automobiles. Evolution in carshare service offerings will expand the market for the service by reducing the price and providing a greater range of options to meet consumer needs. Because carshare converts a fixed cost to a variable cost, it can reduce driving at the margins.		

Introduction

The range of available transportation options continues to evolve as technology reduces information barriers and transaction costs. Carshare separates the flexibility and convenience associated with personal vehicles from the ownership requirement, providing a close substitute to service users. The latest evolutions in carshare have potential to greatly expand use of the service category. The presence and use of carshare services can lead to reductions in the number of vehicles available to each household and shift the fixed costs of personal vehicle transportation to variable costs. Shifting fixed costs to variable costs lowers the relative incentive for driving versus other modes.

By Juan M. Matute and Stephanie S. Pincetl

Types of carshare services

Type of Service	Description	Firms in U.S. or CA
Carshare	Short-term rentals, returned to pick-up location, billed by half hour, vehicles owned by corporation	City CarShare, Hertz on Demand, WeCar, Zipcar,
Point-to-Point Carshare	Short-term rentals, returned anywhere within zone, billed by minute, vehicles owned by corporation	Car2Go
Peer-to-Peer Carshare	Short-term rentals, returned to pick-up location, vehicles owned by individuals	Getaround, JustShareIt, RelayRides, Wheelz

Carshare

Carshare makes automobile access more convenient than with legacy car rental providers. Carshare services typically place vehicles in locations that are more accessible legacy car rental outlets. These locations include within neighborhoods, commercial districts, and other locations – often closer to trip origins than legacy car rental outlets, which zoning in some cities relegates to light manufacturing areas. Carshare services allow users to rent for periods less than 24 hours, which is often the minimum term for legacy car rental services. Transaction times are lower with carshare services than legacy car rental services. An annual membership fee covers member assessment and approval, eliminating the need for a new rental agreement at the time of the rental. Smart card or smart phone access makes entering carshare vehicles only slightly slower than entering a privately-owned automobile.

Carshare services expand the range of transportation options available to individuals and households. For households with automobiles available, the presence of carshare can reduce the vehicle's existence value – the value placed on having the vehicle available when needed, above and beyond the value derived directly from its use. Informal car clubs have for years brought shared automobile access to lower-income communities where automobile ownership and maintenance costs would prohibit household or individual ownership.

If the presence of carshare allows individuals and households to voluntarily reduce the number of vehicles they maintain, it will succeed in shifting travel toward other modes. Some may walk or bike knowing that carshare is available for trips when an automobile would better meet their needs. For walkers, bikers, and those who pre-pay transit with a weekly, monthly, or annual pass, travel is free at the margins and carshare is always more expensive – creating an disincentive to use carshare when viable alternatives exist. Those who typically carpool to work may seek carshare for trips when their personal vehicle is not available and transit alternatives do not met their needs. Even households that own or have access to vehicles may use carshare for times they need an additional vehicle.

Point-to-Point carshare

Point-to-point carshare offers several additional features that regular carshare does not. Point-to-point carshare allows users to only pay for minutes they've used. This can substantially reduce the price of carshare trips where a low proportion of the rental is spent waiting—such as meetings or appointments. Point-to-point carshare also offers the ability for split-mode travel tours, in which a traveler uses carshare for one segment and transit, real-time rideshare, taxi, or walking in another. The ability to split-modes on a travel tour is common among users of taxis, transit, and rideshare. However, the ability to split-modes on a travel tour is a distinct advantage over regular carshare or privately owned vehicles.

Point-to-point carshare faces several limitations. Point-to-point carshare rentals are currently limited to beginning and ending in a home area where the service provider has formalized a parking arrangement with the municipality. This limits the number of viable trips and increases the time to expand the service to new markets. A model ordinance, sponsored by a county transportation commission or other transportation planning agency, could accelerate the pace of market expansion.

Peer-to-Peer carshare

Peer-to-peer carshare vehicles are owned by individuals, but a service provider coordinates rentals. Peer-to-peer carshare services have a potential to greatly expand the carshare market. Peer-to-peer services can lower the price of carshare services by introducing older, more depreciated vehicles into the market. Commercial carshare operations have a greater incentive to offer newer cars at a higher price point. New vehicles are more marketable and require less staff time for fleet maintenance. Peer-to-peer carshare vehicle owners may assign a lower cost to the time they invest in the operation, seeking to recoup a portion of their own vehicle ownership costs rather than earn a profit. Because of this, individual vehicle owners can introduce peer-to-peer carshare into areas where anticipated willingness to pay and/or utilization levels are too low be profitable for carshare companies. In this way, peer-to-peer carshare can reduce transaction and management costs in order to increase carshare use in lower-income communities and among users with a low willingness to pay.

Carshare Regulations

Carshare and Point-to-Point carshare

California Vehicle Code § 22507.1 defines carshare vehicles as those “operated as part of a regional fleet by a public or private car sharing company or organization” and allows local governments to restrict marked publicly-owned parking spaces to carshare vehicles. State law makes no mention of point-to-point carshare services, which are typically regulated locally.

Car2Go is a subsidiary of Daimler AG that, as of late 2012, operates in Austin, Miami, Portland, San Diego, and Washington, DC and other cities in Canada and Europe. Prior to establishing service in a new city, Car2Go works to pass local legislation to grant point-to-point carshare vehicles special privileges. San Diego (Municipal Code §86.23) allows carsharing vehicles to be parked on public streets when not under lease, to be parked for longer than 72 hours, and creates a special markings for a carshare parking zone. Without such privileges, carshare vehicles would be prohibited from parking at meters and in preferential permit zones. Washington, DC’s point-to-point carshare regulations (DC Municipal Code, various amendments to Title 18) establish rules for preferential and permit parking areas, parking at meters, the geographic distribution of vehicles around the city, and sharing operational data with the District Department of Transportation. Local policymakers in Washington, DC wished to assure carshare vehicle coverage in lower income areas of the district.

Because Car2Go and other market entrants must negotiate municipal code changes with each city, point-to-point trip ends are often limited to a home area. In Washington DC, the home area is the entire District, excluding land subject to federal control. In San Diego, the home area is a small portion of the sprawling 372 square mile city—limited to denser neighborhoods with relatively low curb-parking availability.

Peer-to-Peer carshare

In many states, peer-to-peer carshare faces significant liability risks. In response to these risks, existing peer-to-peer carshare services require all vehicles offered through the service to meet minimum requirements and provide insurance during the rental.

Federal law limits liability to vehicle owners. The 2005 transportation reauthorization act eliminates the vicarious liability of rental vehicle owners when customers engage in negligent driving (49 USC . § 30106). The law does not limit the liability of vehicle owners that are negligent in vehicle maintenance and inspection. Though states have protested this national law as usurping their ability to regulate insurance and liability, courts have upheld the provision on the commerce clause. This federal law is believed to extend to carshare corporations like Zipcar, but it has yet to be applied in a peer-to-peer carshare case. A February 2012 fatal traffic collision involving a car rented through the peer-to-peer carshare service RelayRides may provide the first legal test for the federal law's applicability to peer-to-peer carshare. The parties hit by the now-deceased renter have sued the vehicle's owner and her insurance company (Lieber, 2012).

Californians need not wait for the outcome of this case to understand their liability. A 2010 update to the Insurance Code (§1150.24) explicitly allows individuals to share their personal vehicles under the umbrella of a personal vehicle sharing program, provided that their annual revenue does not exceed the annual cost of owning and operating the vehicle. The personal vehicle sharing program must provide insurance coverage.

Carshare in California

Few academic studies exist to aid in the estimating the potential of new and emerging carshare services to change California's travel demand. Martin, et. al. (2010) estimate that between 9 and 13 vehicles are taken off the road for every carshare vehicle. They also found that the average fuel economy of carshare vehicles was greater than vehicles previously available to members who shed vehicles, and that carshare members drove 8,200 miles per year versus the U.S. average of 12,300.

In a two-year study of City CarShare in San Francisco, Cervero found the following usage rates:

Carshare usage rates, San Francisco study

Month of membership	Percentage of member trips using car share	Percentage of member vehicle miles traveled using carshare
3	2.2%	2.1%
9	8.1%	21.6%
24	6.5%	10.1%

Source: (Cervero & Tsai, 2004) and (Cervero, 2003)

This study occurred in the early market for carshare in San Francisco – between 2001 and 2003. Cervero et. al, (2004) suggest that the novelty of the program wore off after month

9 of the study, resulting in declines in usage between month 9 and 24.

Existing studies are subject to a strong selection bias. Individuals were not randomly assigned to participate in the carshare program—they self-selected. It's likely that the individuals who participate in carshare were already driving less and less reliant on a personal vehicle than the median individual in the carshare's service area.

To estimate carshare's potential to motor fuel use, it's first necessary to determine if potential increases in driving by those at the margins of automobile ownership will offset reductions from other carshare users. It appears that only a small proportion of California households are at the margins of vehicle ownership primarily for economic reasons. After dropping between 1990 and 2006, the percentage of carless Californians increased in 2011. This variation likely has more to do with the real costs of owning and operating a vehicle relative to incomes than the range of transportation options available to Californians. However, the low variation gives some indication that only a small proportion of California households may be at the margins of vehicle ownership – perhaps less than 1.5%.

California households with no Vehicles available

Year	Value	Data Source
1990	8.89%	Decennial Census (SF-3, H7)
2000	7.75%	Decennial Census (SF-3, HCT033A)
2006	7.42%	2006 American Community Survey (1-year sample, B08201)
2011	8.02%	2011 American Community Survey (1-year sample, B08201)

In addition, workers in households without vehicles available drive far less often than the average Californian. In 2011, workers without a vehicle available to their household were 8.7 times more likely to take public transportation to work than were workers with a vehicle available to their household. These workers were 34% as likely to commute alone.

Means of transportation to work for California workers by household vehicle availability, 2011

Means of Transportation to Work	No Household Vehicle Available	Household Vehicle Available	Relative Frequency
Drove Alone	25.68%	75.49%	34.0%
Carpooled	12.21%	11.08%	110.2%
Public Transportation	34.78%	3.99%	871.0%
Walked	12.67%	2.15%	588.8%
Taxicab, Motorcycle, Bicycle, or Other Means	9.16%	2.11%	434.4%
Worked at Home	5.52%	4.99%	110.6%

Source: 2011 American Community Survey (1-year sample, B08141)

The variable cost of carshare use moderates carshare's potential to increase private car use among low income individuals. While carshare trips by low income individuals have a great social benefit, their effects on fuel demand are expected to be minimal as most price-sensitive limited-income individuals are more likely to use carshare only when other, cheaper alternatives do not meet their trip-making needs. California's lower income individuals and households currently demonstrate well below-average-rates of vehicle use.

Evaluating Carshare's Effects on California's Fuel Use

Several factors will encourage or potentially limit carshare's effect on California motor fuel demand.

Factors encouraging car share use and potential reductions in motor vehicle fuels

- Peer-to-peer carshare services will rapidly increase carshare supply, with supply of carshare vehicles spatially correlated to residential and employment density, transit service quality, and university neighborhoods.
- Expanding carshare supply will improve the spatial and temporal coverage carshare networks, attracting more adoption. The virtuous adoption cycle will also increase demand for other transportation options, like walking, biking, and transit.
- The primary effect of carshare availability on fuel use is not expressed through carshare use, but rather through how carshare alters individual and household travel behavior. Carshare provides a pathway for individuals and households that exhibit below-average vehicle travel to travel even less. Carshare availability improves such household's quality of life by providing a new transportation option.

Factors limiting reductions in motor vehicle fuel use

- Carshare is unlikely to alter the travel behavior of high-driving individuals and households. However, as the transportation network evolves in the long run, the factors which influence car ownership will adjust and adoption will continue.
- Carshare's effects to reduce vehicle ownership will be borne by individuals and households that exhibit below-average vehicle use.
- Carshare services will compete with real-time rideshare and other emerging service categories for each trip. Robust real-time rideshare options could reduce demand for all carshare trips, including point-to-point trips.

As the relative magnitudes of these factors have not been studied, a range of outcomes are possible as California transitions to carshare.

Carshare adoption scenarios and corresponding change in California petroleum use

	Low-Case	Mid-Case	High-Case
Percentage of registered automobiles participating in carshare	0.25%	1%	2.5%
Carshare vehicles in California	49,932	199,728	499,320
Personal automobiles eliminated per carshare vehicle	3	6	11
Average net reduction in miles traveled per eliminated vehicle	1,000	2,300	4,100
Reduction in California motor vehicle fuel demand	0.05%	0.85%	6.98%

The low-case describes minimal adoption of carshare in California—its relegation as niche service used in the densest downtowns and near universities. The high-case scenario describes widespread adoption, with large increases in carpooling and transit use spurred by availability of carshare. The high-case data uses values from Martin, et. al. (2010). The mid-case scenario shows that limited petroleum reductions could occur even with substantial increases in the number of carshare vehicles available.

Works Cited

Cervero, R. (2003). City CarShare: First-year travel demand impacts. *Transportation Research Record: Journal of the Transportation Research Board, 1839*(1), 159-166. doi:10.3141/1839-18

Cervero, R., & Tsai, Y. (2004). City CarShare in San Francisco, California: second-year travel demand and car ownership impacts. *Transportation Research Record: Journal of the Transportation Research Board, 1887*(1), 117-127. doi:10.3141/1887-14

Cervero, R., Golub, A., & Nee, B. (2007). City CarShare: longer-term travel demand and car ownership impacts. *Transportation Research Record: Journal of the Transportation Research Board, 1992(-1)*, 70-80. doi:10.3141/1992-09

Lieber, R. (2012, April 14). Fatal collision makes car-sharing worries no longer theoretical. *New York Times*, p. B1. Retreived from http://www.nytimes.com/2012/04/14/your-money/relayrides-accident-raises-questions-on-liabilities-of-car-sharing.html?pagewanted=all

Martin, E., Shaheen, S. A., & Lidicker, J. (2010). Impact of carsharing on household vehicle holdings. *Transportation Research Record: Journal of the Transportation Research Board, 2143(-1)*, 150-158. doi:10.3141/2143-19

Shaheen, S. A., Rodier, C., Murray, G., Cohen, A., & Martin, E. (2012). *Carsharing and public parking policies: assessing benefits, costs, and best practices in North America.* Alexandria, VA: Transportation Research Board. Retreived from http://trid.trb.org/view.aspx?id=929240

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Policy to Induce Adoption of Alternative Fuel Vehicles

Overall Effect on California Petroleum Use		Affects Petroleum Demand Through Intermediate Indicators:	
Magnitude	High	**Primary**	Fuel Composition
Certainty	High	**Secondary**	

Applicable Level of Government	Federal, State, and Local
Relevant Laws or Cases Affecting Factor	See description section for specific laws, codes, and regulations. The American Recovery and Reinvestment Act (Pub. L. 111-5, 123 Stat. 115) authorized or extended many of the federal incentives available today.
Time horizon for implementation and maturity	In the short term, policy and financial incentives provide support for the early adopter market. This leads to real, but minimal, reductions in petroleum demand. Support for the early market is intended to develop a critical mass of fueling infrastructure and choice of vehicles to support wider adoption of alternative fuel vehicles in the future. The vehicle fleet replacement cycle limits the time frame over which policies to support alternative fuel vehicle acquisition will take effect. The California Air Resources Board estimates that a 50% of automobiles sold in California in 2011 will still be on the road in 13 years (California Air Resources Board, 2011). As alternative fuel vehicles currently make up a small percentage of new vehicle sales in California, achieving 50% or greater market share of alternative fuel vehicles is a long-term proposition.
Relevant Topics	Electric vehicles, hydrogen vehicles, natural gas vehicles, incentives, tax expenditures
Summary	Increasing the share of alternative fuel vehicles in the fleet will reduce consumption of petroleum, but increase consumption of energy from other sources. Switching to alternative fuel vehicles is unlikely to have a 1-to-1 effect on petroleum demand as petroleum is often used to process or distribute alternative fuels.

Introduction

Most federal, state, and local policies to promote alternative fuel vehicles attempt to influence consumer and firms' vehicle purchase decision. These policies include financial subsidies for vehicle or equipment purchases, supply-side incentives for manufacturers of alternative fuel vehicles, and special privileges for users of alternative fuel vehicles.

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Other policies affect the supply of alternative fueling infrastructure. The availability of alternative fueling infrastructure affects both the vehicle purchase decision and subsequent decisions to utilize alternative fuels. Drivers of flex-fuel, plug-in hybrid electric, and biodiesel-capable vehicles can choose to refuel with petroleum or alternative fuels. The availability and price of alternative fuels will affect the proportion of petroleum these drivers use.

In the academic literature, scholars discuss the relative effectiveness of policy versus non-policy forces at inducing advanced technology and alternative fuel vehicle purchases. Kahn (2007) found that hybrid vehicle registrations in California correlate with Green Party registrations, inferring that green behavior influences vehicle choice. Diamond (2009) argues that gasoline prices have the strongest effect on hybrid vehicle adoption nationwide, with upfront purchase subsidies being the most effective policy incentive. A 2011 study of the Los Angeles electric vehicle market found that monetary subsidies that lower a vehicle's purchase price and total cost of ownership are more effective at inducing vehicle purchases than are special privileges for vehicle users (Dubin, et al., 2011).

Several incentives reduce the purchase price for alternative fuel vehicles in California. These include:

Alternative fuel vehicle purchase incentives

Incentive	Administration	Authorization
Up to $7,500 Federal Tax Credit for eligible plug-in electric drive vehicles	U.S. Internal Revenue Service	Enacted by Energy Improvement and Extension Act of 2008, Pub. L. 110-343, 122 Stat. 3765. Amended and extended by American Recovery and Reinvestment Act of 2009, Pub. L. 111-5, 123 Stat. 115). Codified in 26 USC § 30D. Requires IRS Form 8936.
Up to $4,000 in Federal Tax Credit for eligible hydrogen fuel cell vehicles	U.S. Internal Revenue Service	Codified at 26 USC § 30B. Requires IRS Form 8910. Expires in 2014
Up to $2,500 rebate per eligible vehicle from California Clean Vehicle Rebate Project	California Center for Sustainable Energy	Enacted in AB 118 (2008), vehicle license fee funding authorization codified in California Health and Safety Code Section 44060.5 and expenditure guidelines codified in California Health and Safety Code Section 44270-44274. Applies to Zero Emissions Vehicles, Plug-In Hybrid Electric Vehicles, Neighborhood Electric Vehicles, and Zero Emissions Motorcycles.

Additionally, incentives for the purchase and installation of alternative fueling infrastructure and charging equipment help increase the supply of this infrastructure:

Alternative fueling infrastructure purchase and installation incentives

Incentive	Administration	Authorization
Up to $2,000 for Compressed Natural Gas home refueling equipment	South Coast Air Quality Management District	Funded by Clean Fuels Program, collection authorized by California Vehicle Code Section 9250.11 and eligible expenditures defined under California Health and Safety Code Sections 40448.5 and 40512
Subsidies for installation publicly-accessible electric vehicle supply equipment	U.S. Department of Energy	ChargePoint America and EV Project (ARRA Funded)
Subsidies for home installation of chargers for Nissan Leaf and Chevy Volt owners in San Diego, and LADWP territory		EV Project (ARRA funded)
Up to $1,200 in installation credit for residential electric vehicle supply equipment for BEV owners	Bay Area Air Quality Management District and the EV Project	EV Project (ARRA funded) and BAAQMD funds
Tax credit for consumers and businesses who purchase and install qualified hydrogen fuel infrastructure	U.S. Internal Revenue Service	26 USC § 30B and 38. Requires IRS Form 8911.

Inasmuch as these incentives increase the availability of alternative fueling infrastructure and reduce the costs of alternative fuels, they serve to reduce the proportion of petroleum used by dual-mode and flex-fuel vehicles.

Special privileges for advanced technology and alternative fuel vehicles may also increase demand. The California Department of Motor Vehicles issues decals to qualifying vehicles, which makes them eligible for special privileges:

California vehicle decals and special privileges

Decal	Qualified Vehicle Types	Privileges
Yellow	Hybrid-electric vehicles	Most privileges have expired
Green	Plug-in hybrid electric vehicles	HOV lane access for vehicles displaying decal
White	Hydrogen fuel cell, battery electric, and natural gas powered vehicles	HOV lane access for vehicles displaying decal Free parking in Santa Monica, Hermosa Beach, and San Jose

Many California electric utilities offer a special rate structures for sub-metered electric vehicle service equipment and time-of-use rates to discount charging during off-peak hours. These unique rate structures reduce the cost of refueling electric vehicles.

In addition to demand-side incentives that affect the vehicle purchase decision, federal production incentives serve to support the U.S. manufacture of electric vehicles. The U.S. Department of Energy has issued grants and loans to manufacturers through its Advanced Technology Vehicle Manufacturing Loan Program (10 CFR Part 611), authorized by Energy Independence and Security Act of 2007 (Pub L. 110-140), and extended by the American Recovery and Reinvestment Act (Pub L. 111-5, H.R. 1-24, 26). This program has awarded $8.4B in loans to vehicle manufacturers including Ford, Fisker, Nissan, and Tesla (U.S. Department of Energy, 2012). These loans are used to re-configure manufacturing plants to produce battery electric vehicles and plug-in hybrid electric vehicles. As of 2012, U.S. Department of Energy has provided $2.375B in grants for battery manufacturing and related activities through its Electric Drive Vehicle Battery and Component Manufacturing Initiative (U.S. Department of Energy, 2011).

Effect on Fuel Use

It is likely that the California market for alternative fuel vehicles would develop without policy incentives as petroleum becomes more scarce. However, policy serves to expedite and ease this transition, leading to reductions in California petroleum use before and beyond what would occur in absence of policy.

The California Energy Commission analyzed the effect of various policies to reduce petroleum demand in the state, including the proliferation of flex fuel, plug-in hybrid, natural gas, and zero emissions vehicles. Overall, the Commission estimates total annual gasoline consumption in California will fall to 11.7 billion gallons in 2030, a 21% reduction from 14.8 billion gallons in 2009 (California Energy Commission, 2011). Only a portion of these gains are due to a projected switch to alternative fuel vehicles.

Anticipated increases in ethanol demand are due to both the expected proliferation of flex-fuel vehicles and the low-carbon fuel and renewable fuel standards. Specifically, the Energy Commission (2011) forecasts that an increase in new or retrofitted flex-fuel capable vehicles will lead E85[1] demand to increase from 13.2 million gallons in 2010 to between 2.17 billion and 3.19 billion gallons in 2030. E85 will make large contributions toward the state's low carbon fuel standard. The Energy Commission (2011) also projects an increase in B20[2]

[1] 85% ethanol blended with gasoline
[2] 20% biodiesel blended with diesel

demand to 765 million gallons in 2020, in part to meet the low carbon fuel and renewable fuel standards.

The California Energy Commission (2010) expects the state will be home to 1,563,632 plug-in capable vehicles in 2020 and 2,847,580 in 2030. Electric vehicles demanded 120 million kWh of electricity in 2009, but the Commission (2011) expects 2030 demand to increase to 1.07 billion kWh, a 10.9% compound annual growth rate.

The Energy Commission (2010) expects the number of compressed natural gas vehicles in California to grow from 17,569 in 2007 to 206,071 in 2030. The Commission (2011) also expects demand for natural gas as a transportation fuel expected to increase from 130.6 million therms in 2009 to between 243.7 and 256.1 therms in 2030.

The Energy Commission did not predict future demand for hydrogen and hydrogen-powered vehicles.

Use of alternative fuels for transportation propulsion directly displaces petroleum, though alternative fuels often require petroleum for extraction, processing, and transportation. Thus, the ratio of alternative fuel consumption to petroleum displacement is not energy-equivalent, and can differ fuel-by-fuel. California uses the CA-GREET lifecycle analysis model in implementing its Low Carbon Fuel Standard to assess these differences. Nevertheless, the shift to alternative fuel vehicles will directly offset a tremendous portion of the state's demand for petroleum-based motor vehicle fuels.

Works Citied

California Air Resources Board. (2011). *EMFAC 2011: Technical documentation*. Figure 3-1. Retrieved from http://www.arb.ca.gov/msei/emfac2011-documentation-final.pdf

California Energy Commission (2011). Transportation energy forecasts and analyses for the 2011 Integrated Energy Policy Report. *Report CEC-600-2010-002*. Retrieved from http://www.energy.ca.gov/2010publications/CEC-600-2010-002/CEC-600-2010-002-SF.PDF

California Energy Commission. (2011). Transportation energy forecasts and analyses for the 2011 Integrated Energy Policy Report. *Report CEC-600-2011-007.* http://www.energy.ca.gov/2011publications/CEC-600-2011-007/CEC-600-2011-007-SD.pdf/

Diamond, D. (2009). The impact of Government incentives for hybrid-electric vehicles: Evidence from U.S. states. *Energy Policy* (37):3. 972-983. doi:10.1016/j.enpol.2008.09.094

Dubin, J., Barney, R., Csontos, A., Um, J., & Wu, N. (2011). *Realizing the potential of the Los Angeles electric vehicle market.* Luskin Center for Innovation. Retrieved from http://luskin.ucla.edu/sites/default/files/LA%20EV%20Final%20Report%20-%20Formatted%20-%20Final%20-%20High%20Quality%20for%20printing.pdf

Kahn, M.E. (2007). Do greens drive hybrids or hummers? Environmental Ideology as a determinant of consumer choice. *Journal of Environment Economics and Management* (54):2. 129-145. doi:10.1016/j.jeem.2007.05.001.

U.S. Department of Energy. (2011). *Recovery act awards for electric drive vehicle battery and component manufacturing initiative.* Retrieved from http://www1.eere.energy.gov/recovery/pdfs/battery_awardee_list.pdf

U.S. Department of Energy (2012). *Loans program office projects.* Retrieved from https://lpo.energy.gov/?page_id=45

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Funding Public Infrastructure Improvements for New Development

Overall Effect on California Petroleum Use		**Affects Petroleum Demand Through Intermediate Indicators:**	
Magnitude	Medium-High	**Primary**	Distance Traveled
Certainty	Low-Medium	**Secondary**	
Applicable Level of Government	Local, State		
Relevant Laws or Cases Affecting Factor	California Constitution Article 13A California Health and Safety Code §34161 California Government Code §53311-53368.3		
Time horizon for implementation and maturity	Changing state policy to better accommodate infill project financing needs would have an immediate effect on new development projects. However, as with any land use change, the legacy effects of past decisions will remain for decades.		
Relevant Topics	Municipal finance, impact fees, infrastructure finance		
Summary	In post-Proposition 13 California, developers pay for much of the additional infrastructure required to support new development: schools, sewage systems, water delivery, and transportation improvements. While California law provides several options to finance public infrastructure improvements, some financing mechanisms are more applicable to greenfield development than to urban infill and brownfield development. If there are fewer barriers to financing infrastructure in greenfield areas than infill areas, the net result would be a distortion of land use patterns that favors additional distance traveled.		

Introduction

Proposition 13 (California Constitution Article 13A) amended California's constitution and significantly changed California's financing system for a variety of public services, including the infrastructure required for new development. Before 1978, local governments often financed the infrastructure improvements needed for new development with the current year's property tax receipts. Proposition 13 limited *ad valorem* property tax assessments to 1% of a property's assessed value. The constitutional amendment rolled back each property's assessed value to 1975 levels and limited increases to a 2% annually. While the state initially backfilled local government coffers with other sources of revenues, today the

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constitutional amendment significantly strains local government's ability to finance public services.

Proposition 13's passage likely stimulated growth in suburban communities and reduced options to finance infrastructure needed for infill developments. In the years since Proposition 13, cities and counties have become increasingly reliant on impact fees and alternative property assessments to finance public infrastructure improvements.

Brueckner (1997) evaluated a city's transition from current sharing to impact fees. Current sharing describes a financing structure where the cost of infrastructure expansion is shared equally among all of the city's landowners, as was typical in California prior to Proposition 13. Impact fees, common in California after Proposition 13, charge new development for most or all infrastructure expansion costs.

Brueckner found that the transition's effect on real estate markets depends on the growth rate of a community's property tax rolls. If, under a current sharing system, annual property tax increases exceeded interest rates, a switch to impact fees would stimulate growth. Where property tax payments grew at a lower rate than mortgage interest, growth would temporarily cease. The late 1970s and early 1980s were a time of great suburban expansion in California. Thus, Proposition 13 may have provided fast-growing suburban areas with an additional stimulus.

Proposition 13 had a greater effect on property prices in cities with higher property tax rates. A 1982 study of the Northern California real estate market found that every one dollar in property tax reduction lead to a seven dollar increase in a home's purchase price (Rosen, 1982). This finding indicates that the effect property tax reduction was capitalized into the purchase price of homes—meaning Proposition 13 provided a one-time boost captured by those who owned property at the time it took effect. The author notes that this study, conducted while the state was still able to backfill local revenues, did not capture housing price changes that would result from deteriorating public services. The backfill has waned in the 30 years since, leading variations in community service levels that may now be captured in housing prices.

New Financing Mechanisms

A new system of public infrastructure finance emerged in California after Proposition 13.

Impact fees

Impact fees internalize much of new infrastructure's cost through an upfront payment, paid by developers of new buildings. Though levied on the developer, the fees are most often absorbed by subsequent landowners, homebuyers and renters (Delaney & Smith, 1989). After Proposition 13 passed, many California cities transitioned towards using impact fees to finance new development.

Mello-Roos

The Mello-Roos Community Facilities Act of 1982 (California Gov't. Code Ch. 2.5, §53311-53368.3) was a direct response to the revenue limitations imposed by Proposition 13.

Communities or property owners that establish a Mello-Roos District can use special tax revenues to fund services or finance debt incurred for facilities that benefit the district (Raineri, 1987). Establishing a Mello-Roos district requires two-thirds approval of registered voters living within the district, with equal weighting of each vote. If fewer than twelve persons are registered to vote within the proposed district, then landowners can vote. Landowner's votes are weighted proportional to the acreage each holds. Some Mello-Roos districts use this to their advantage—a group of fewer than twelve developers can issue debt to create new schools, parks, and other facilities that is then paid off by future landowners (Bort, 2006).

Mello-Roos financing doesn't give these developers a free lunch—but rather enables easy access to low-cost borrowing. Mello-Roos district assessments, like most property assessments, are reflected in real estate values. A 1994 study of Mello-Roos districts found that differences in tax payments are capitalized into purchase prices at an implied 4% discount rate (Do & Sirmans, 1994). This means that though the improvements funded by a Mello-Roos district are financed over time, the assessment is reflected in lower purchase prices for new homes and re-sales.

Assessment District

Assessment Districts are a long-standing option to fund public benefits using special assessments added to property tax bills. The legal requirements to establish an assessment district depend on the "special benefit" to be funded. The California Legislature has enabled nearly 20 different types of Assessment Districts covering a variety of facilities and services ranging from business improvement districts to pedestrian malls to fire protection. In general, the amount of the property tax assessment must be based on the benefit derived from the improvement—rather than the value of a property.

After Proposition 13, stakeholders quickly questioned whether Assessment Districts skirted the new limits to *ad valorem* property taxes. State Courts ruled that Assessment Districts are not subject to the one percent *ad valorem* property tax limitation and are not subject to a two-thirds approval mandate[1]. However, Proposition 218 (1996, California Constitution Article 13C - D) narrowed the definition of "special benefit" to prohibit new special assessments from funding any existing services or infrastructure.

Special Districts

Special Districts are limited purpose local governments that provide services or maintain facilities for several communities. Because they serve a larger geographic area, the formation of new special districts is more applicable to greenfield areas than infill areas. The Metropolitan Water District, the Sacramento Municipal Utility District, and the Los Angeles County Transportation Authority are the state's largest special districts, by expenditures.

Special districts can fund ongoing expenses or finance capital projects with property taxes, which require a two-thirds voter approval. Proposition 13's reduction in property tax revenues caused declines in special district revenues. Between 1978 and 1992, the state backfilled the declines using a Special District Augmentation Fund. These revenues were diverted to the Educational Revenue Augmentation Fund, part of a growing trend to redirect property and income tax revenues to K-12 education in the wake of 1988's Proposition 98[2], which set constitutional mandates for state education funding.

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[1] See (*Fresno County v. Malmstrom* (1979) 94 Cal.App.3d 974; *Solvang Municipal Improvement District v. Board of Supervisors* (1980) 112 Cal.App.3d 545; *County of Placer v. Corin* (1980) 113 Cal.App.3d 443)

[2] Proposition 98 Amended various sections in Articles XVI and XIIIB of the California Constitution, and §§41300.1, 14020.1, 14022, 41302.5 of the Education Code

Redevelopment - tax increment mechanisms

Until 2011, California cities were able to establish Redevelopment Agencies and designate redevelopment areas. After a city dedicated an area for redevelopment, future increases in property tax revenues would be diverted to the redevelopment agency. The redevelopment agency would borrow against this funding stream to finance public benefits for the area—usually infrastructure and services, but also developer incentives to catalyze redevelopment. The practice, known as tax increment financing, was quite popular in California because it did not require approval from voters or the special districts whose tax revenues were diverted. Redevelopment, along with tax increment financing, was dissolved in California on October 1, 2011 by AB1X 26 (Health and Safety Code §34161).

Geographic Applicability of Financing Mechanisms

Impact fees and tax increment financing do not require the approval of existing property owners, making these mechanisms easier to implement in infill areas. Mello-Roos and Assessment Districts are most easily formed in greenfield areas with few property owners, and most have been formed in such areas (Orrick & Datch, 2008).

Infill development projects often face a challenging infrastructure scenario that greenfield developments do not. This scenario limits a community's reliance on impact fees to fund infill infrastructure improvements.

The California Environmental Quality Act requires local governments to analyze new development's effects on existing infrastructure before approving a new project or plan. When a local government studies infrastructure needs on a project-by-project basis, as is common in California, planners evaluate a project's incremental impact on existing infrastructure. Planners examine the existing infrastructure's ability to accommodate the new project using thresholds of significance, or infrastructure performance standards. If the incremental effects of new development will cause infrastructure to fail to meet performance standards, then the developer must often pay the full cost of required infrastructure improvements. For example, an incremental increase in sewage load due to a new development may necessitate replacing an existing 12-inch sewage pipe with a 16-inch sewage pipe.

When infrastructure impacts are analyzed incrementally on a development-by-development basis, a single development project triggers the threshold. The last project to be approved pays the fee, even if other recently approved or constructed projects added more sewage load. If the required infrastructure improvements are costly relative to the developer's anticipated profit, then the impact fee may lead to project delays or termination.

If local governments analyzed the infrastructure impacts of all development expected in the next 15 years, planners might conclude that a 24-inch pipe is required. For example, a local government might expect a significant increase in density around a transit station. However, this new development may occur over several years, requiring uncertain future impact fees to finance current infrastructure improvements. Local governments often used tax increment financing to overcome this infrastructure financing gap.

Local governments cannot use Mello-Roos Community Facility Districts for transit station areas because the deficient infrastructure or service is preexisting – an expansion does not bring a novel special benefit. Assessment Districts may be applicable to such areas, but obtaining approval from existing property owners is more difficult in infill areas than in greenfield areas. Few existing property owners may want to subsidize improvements that will primarily benefit new developments.

Financing needed infrastructure improvements is more complicated in infill areas than in greenfield areas. However, fewer financing mechanisms are practical in infill areas. The net result is likely an increase in greenfield development versus infill development versus what would occur under a level playing field. The consequence is additional development in suburban and exurban greenfields and additional vehicle miles traveled.

Estimated Effects on Motor Vehicle Fuel Use

Existing academic literature has not estimated the change in travel activity attributable to the post-Proposition 13 funding environment. This is not because of any disinterest in the subject, but rather because academics lack data to perform a high-certainty estimate. A best-guess estimate is possible using statewide travel activity between 1980 and 2010. During this time, Vehicle Miles Traveled (VMT) per licensed driver rose 3,982 miles, from 7,265 miles to 11,147 miles. Controlling the number of registered vehicles available per licensed driver, even if only 10% to 25% of the increase were attributable to changes in infrastructure finance, then the result would be a significant increase in statewide VMT. At 10%, 2.2% of current VMT and motor fuel use could be attributed. At 25%, 5.5% could be attributed.

Works Cited

Bort, D. (2006). *An introduction to California Mello-Roos community facilities districts.* Orrick, Herrington & Sutcliffe, LLP. Retreived from http://www.orrick.com/fileupload/1180.pdf

Brueckner, J. (1997). Infrastructure financing and urban development: The economics of impact fees. *The Journal of Public Economics, 3*(1), 383-407. doi:10.1016/S0047-2727(97)00036-4

California Governor's Office of Planning and Research. (1997). *Special assessments. A planner's guide to financing improvements.* Sacramento: California Governor's Office of Planning and Research. Retrieved from http://ceres.ca.gov/planning/financing/chap3.html#chap3

Delaney, C. J., & Smith, M. T. (1989). Impact fees and the price of new housing: An empirical study. *Real Estate Economics, 17*(1), 41-54.

Do, A., & Sirmans, C. (1994). Residential property tax capitalization: discount rate evidence from California. *National Tax Journal, 42*(2), 341-48.

Orrick, J., & Datch, D. (2008). Special district financing for infrastructure - sharing the credit with local government. *Journal of Taxation and Regulation of Financial Institutions, 21*(6).

Raineri, L. (1987). Mello-Roos bonds-California's answer to financing public infrastructure in developing Areas. *Government Finance Review, 3*(4).

Rosen, K. T. (1982). The impact of Proposition 13 on house prices in Northern California: A test of the interjurisdictional Capitalization Hypothesis. *Journal of Political Economy, 90*(1), 191-200. doi:10.1086/261050

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Parking Cash-out Programs at Employment Sites

Overall effect on California petroleum use		**Affects Petroleum Demand Through Intermediate Indicators:**	
Magnitude	Low-Medium	**Primary**	Mode Choice
Certainty	High	**Secondary**	
Applicable Level of Government	State, air district, local		
Relevant Laws or Cases Affecting Factor	California Health and Safety Code §§ 39608, 43016, and 43845 South Coast Air Quality Management District Rules 2202 and 1504 and other air district and local regulations		
Overall Time-Horizon of Reversal	California could achieve the full potential of existing parking cash-out law with improved compliance in the near-term. Expanding cash-out policy to require unbundled parking leases at certain employment sites and multi-employer program administration offers a mid-term option to increase the program's fuel use and air-quality benefits.		
Relevant Topics	parking, employment, monetary incentives, fringe benefits, existing policy		
Summary	Existing California law requires many employers of more than 50 to offer employees the option to choose a cash payment in lieu of any parking subsidy offered. Such a program allows employers to reduce the number of parking spaces they purchase or lease and offers employees an additional economic incentive to carpool, cycle, walk or use transit for their commute. Although the law is almost two decades old, a lack of information impedes oversight and enforcement.		

Introduction

Employer-based programs are a potentially effective means to implement trip reduction measures and improve air quality. Commutes in California are, on average, longer than most other trips. Because commutes occur during peak travel times, they contribute to additional traffic congestion and spikes in air pollution. Commutes also make up a large proportion of total statewide vehicle travel (about 23%).

The extent of air pollution varies by air basin, a low-level atmospheric boundary formed by geographic features. The U.S. Environmental Protection Agency has established acceptable thresholds for an air basin's ambient levels of carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. When air basins fail to meet these thresholds, states must develop a basin or statewide implementation plan to reduce ambient air pollution levels below acceptable thresholds. Deficient air basins are known as non-attainment areas. California has established stricter air quality standards (Health and

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Safety Code § 39608), and some air basins that meet federal attainment status fail to meet state attainment status.

Table 1: Air basin non-attainment in California

Air Basin	U.S. EPA Non-Attainment Status
Chico	PM 2.5[1]
Coachella Valley	PM 10[2], Ozone 8 hour (severe 15)
Imperial Valley	PM 10, PM 2.5
Mammoth Lake, Mono Basin, Owens Valley	PM 10
Sacramento Valley	Ozone 8 hour (severe 15), PM 10, PM 2.5
San Diego County	Ozone 8 hour (marginal)
San Francisco Bay Area	PM 2.5
San Joaquin Valley	Ozone 8 hour (extreme), PM 2.5
South Coast Air Basin	Lead, Ozone 8 hour (extreme), PM 10, PM 2.5
Ventura County	Ozone 8 hour (serious)
West Mojave	Ozone 8 hour
Yuba	PM 2.5

Source: (U.S. Environmental Protection Agency, 2012)

All air basins in California currently meet carbon monoxide attainment status. The South Coast Air Quality Management District basin achieved attainment status in 2004 (California Air Resources Board, 2011).

Employee commute reduction programs

Employer-based programs are a potentially effective means to improve air quality and implement trip reduction measures. Employer-based programs offer several advantages over government-based programs, as employers can better tailor programs to individual or departmental needs.

Commutes are some of longest trips Californians take. Work-related vehicle trips to and from home average 13.2 miles per day versus a daily average of less than 7 miles for all

[1] Fine particulate matter smaller than 2.5 micrometers in diameter
[2] Particulate matter between 2.5 and 10 micrometers in diameter, such as soot and dust

non-work trips (U.S. Federal Highway Administration, 2011). In California, trips between home and work make up an estimated 24.3% of annual VMT (U.S. FHWA National Household Travel Survey, 2010). Commutes are regular and repeated, so changing patterns can have a pronounced effect on annual vehicle activity.

Employers have unique, proprietary information available on employees' commuting patterns. For instance, employers can match employees with similar schedules living in a similar area for ridesharing. Additionally, employers control many of employees' economic incentives (e.g. salary and benefits) and can subsidize parking or alternative mobility options as a fringe benefit.

Employers have a variety of travel demand management options available, including vanpool, transit subsidies, telecommuting, shifted start times (to avoid peak hour congestion), and flexible-time work schedules (to reduce the number of commuting days). We focus on parking cash-out because its effects are well-understood and California has required some employers to offer cash-out programs for over 20 years.

Parking cash-out in California

California Health and Safety Code § 43845 requires certain employers located in an air basin that doesn't meet the stricter California attainment status for any pollutant to offer a parking cash-out program. The law applies to employers of 50 or more persons that obtain parking spaces under a separate arrangement from their primary lease, or when the cost of parking is a separate line item in the primary lease. Employers must offer a cash allowance to all employees eligible for free or subsidized parking as a fringe benefit equivalent. Those who do not take the parking benefit can take the cash allowance, which is the same as the employer's parking subsidy, defined as the employer's parking cost less any employee contributions. An employer's cash-out program should incorporate measures to ensure employees don't take the parking cash-out allowance and then park in a nearby neighborhood with underpriced or under regulated parking.

The California Air Resources Board may impose a civil penalty of up to $500 per violation on noncompliant employers (Health and Safety Code § 43016). A city, county, or air district may adopt its own implementation measure, provided it complies with state law. A city, county, or air district may also enact its own enforcement and penalty mechanism, provided it includes notice of employer violation and an appeals process.

South Coast Air Quality Management District's parking cash-out implementation

The South Coast Air Quality Management District manages the Los Angeles metropolitan air basin. The District has issued a number of employer-based rules designed to improve regional air quality.

The District's Rule 2202 outlines options for employers with more than 250 employees to mitigate motor vehicle emissions. The rule gives each employer an emissions reduction target for ozone precursors, nitrogen dioxide, and carbon monoxide and affords the employer flexibility in how they achieve the target. Employers may scrap old vehicles they own, implement an employee commute reduction program, invest in off-site air quality improvements, or pursue some combination of these three options.

Within the employee commute reduction program, employers are subject to average vehicle ridership requirements, defined as the ratio of employees arriving at the site to the number of vehicles arriving at the site during the morning peak commute time. Employment sites in downtown Los Angeles must achieve 1.75 average vehicle ridership, those in urbanized portions of the Los Angeles metropolitan area must achieve 1.5 average vehicle ridership, and those located elsewhere in the air basin must achieve a 1.3 ratio.

Employers can increase their average vehicle ridership ratios through carpooling, vanpooling, schedule-shifting, and employee use of transit and other modes. Employers that fail to meet the District's targets must develop a transportation demand management and clean fleet plan and offer a parking cash-out program. Those that fail to do so are subject to fines.

The South Coast Air Quality Management District details their parking cash-out program in Rule 1504. The District's cash-out program is consistent with the state cash-out law, but adds a requirement that employers keep compliance records, including the allowance amount and names of employees accepting the cash-out allowance. The Rule 1504 cash-out program applies to employers of 50 or more, while the increased oversight of Rule 2202 applies only to employers of 250 or more.

Enforcement of and expansion employee commute reduction programs and parking cash-out

UCLA Professor Donald Shoup (2013) believes that parking cash-out is seldom enforced, as regulators do not know which employers are required to participate. The law applies only to employers that obtain parking separately, through a private contract not typically recorded by or reported to government. Without information on how each employer obtains parking, regulators are unable to enforce cash-out regulations. Legislators attempted to eliminate this knowledge barrier by requiring new or renewed commercial leases for employers of 50 or more to list parking costs as a separate line item (AB 1186, 2009). Governor Schwarzenegger vetoed the bill.

In the SCAQMD, employers with more than 250 employees must conduct an annual survey to determine average vehicle ridership for peak hours and determine compliance. Failing to meet average vehicle ridership targets does not require that employers implement any measures, just that they signal a good faith effort from the highest ranking official at the worksite, establish a plan, and name an employee transportation coordinator. An employer can demonstrate good faith by sending staff to a marketing class, promoting transportation demand management measures among new and existing employees, and offering alternative mode commuters a guaranteed ride home.[3] Employers that don't meet motor vehicle emissions reductions targets can submit 110% of their required compliance credits, typically by investing in off-site air quality improvements. The Southern California Air Quality Management District has little or no enforcement mechanism for employers with between 50 to 249 employees.

Multi-employer program administration and additional data collection can expand employee commute reduction programs, including parking cash-out. Multi-employer administration may be an effective trip reduction option for office parks or districts with multiple employers, even if few have more than 50 or 250 employees. Transportation management associations are not-for-profit, multi-employer organizations that can administer employee commute reduction programs, including cash-out, freeing individual employers from the administrative burden. Expanding the pool of employees participating in a commute

[3] For more on guaranteed ride home programs, see the brief on Compensated and Real-time Rideshare

reduction program has additional benefits, such as improved rideshare matching and increased purchasing power for vanpool and transit pass programs.

Shoup (2013) believes that local governments could improve enforcement by collecting cash-out related information as part of other business processes. Shoup proposes that cities ask employers of more than 50 people whether they comply with § 43845 on annual business permit forms or other official documents. This question would alert employers to the cash-out law, and probably ensure compliance because most employers probably do not want to certify that they violate a state law.

How cash-out affects statewide demand for motor vehicle fuels

Willson (1991) estimates that employees drive between 25% and 34% fewer automobiles to work when cash-out is implemented in a central business district. Shoup (1997) found a range of 5% to 24% reductions in commute miles traveled one year after eight employers began offering a cash-out program. Shoup that the share of commuters who carpool to worked increased from 14% before cash out to 23% with cash out; the transit mode share increased from 6% before cash out to 9% with cash out. Shoup also believed that commute miles traveled would continue to decrease over time as more employees adjusted their travel patterns in response to parking cash out.

California's Legislative Analyst's Office estimates a 0.1% to 0.2% reduction in weekday vehicle miles traveled if 15% of an estimated 290,000 employees eligible for parking cash-out programs took the offer (Hill, 2002).

According to the state's Employment Development Department (2011), in 2011 roughly 8.7 million employees statewide work for businesses with over 50 employees, and about 4.3 million work for business with over 250 employees.

Within urbanized, transit-intensive counties of California, about 6 million employees work at employers of 50 or more, and about 3 million work at employers of 250 or more. [4] To assess cash-out's effects, we calculated what would happen if 25% of firms between 50 and 250 employees and 50% of firms over 250 employees located in these counties offer a parking cash-out program. These assumptions produce roughly a 2.7% to 7.8% reduction in automobile commutes in urbanized, transit-intensive counties.

Statewide, we expect better enforcement of existing regulations would to lead to a 0.6% to 2.5% reduction in motor vehicle fuel use due to a reduction in vehicle travel and an increase in system operations efficiency due to fewer peak hour trips. We would expect a 2% to 5% reduction in statewide motor vehicle fuel use from an expanded cash-out program with separated leasing of parking and multi-employer administration Through transportation management associations. Reductions in fuel use would be even higher (5% to 15%) if cash-out programs caused individuals or households to shed vehicles and seek other modes for non-work trips.

[4] Specifically, we use Alameda, Contra Costa, Los Angeles, Orange, Sacramento, San Diego, San Francisco, San Mateo, and Santa Clara Counties

Works Cited

California Air Resources Board. (2011). *Chronology of state carbon monoxide designations.* http://www.arb.ca.gov/desig/changes/co.pdf

California Employment Development Department. (2011). *Size of business data.* http://www.labormarketinfo.edd.ca.gov/Content.asp?pageid=138

Hill, E. G. (2002). A commuter's dilemma: Extra cash or free parking? California Legislative Analyst's Office. Sacramento, CA. Retrieved from http://www.lao.ca.gov/2002/parking/031802_cash_or_parking.pdf

Kneisel, R. (2001). Voluntary Ridesharing After Deregulation: Findings from Work Sites Exempted from California Rule 2202, On-Road Motor Vehicle Mitigation Options. *Transportation Research Record: Journal of the Transportation Research Board*, *1765*(1), 20-26.

Shoup, D. C. (1997). Evaluating the effects of cashing out employer-paid parking: eight case studies. *Transport Policy*, *4*(4), 201-216.

Shoup, D. (2013). Personal communication, April 4.

U.S. Environmental Protection Agency. (2012). *The green book nonattainment areas for criteria pollutants.* Retrieved from http://www.epa.gov/oaqps001/greenbk/ (last updated December 14, 2012)

U.S. Federal Highway Administration. (2011, February). *National Household Travel Survey.* Retrieved from http://nhts.ornl.gov

Wilson, R. W. (1992). Estimating the travel and parking demand effects of employer-paid parking. *Regional Science and Urban Economics*, *22*(1), 133-145.

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High-Occupancy Vehicle Network Expansion through Lane Conversion rather than New Construction

Overall effect on California petroleum use		**Affects Petroleum Demand Through Intermediate Indicators:**	
Magnitude	Low-Medium	**Primary**	Mode Choice
Certainty	Medium	**Secondary**	System Operation Efficiency
Applicable Level of Government	County, Regional, State, Federal		
Relevant Laws or Cases Affecting Factor	23 CFR §810.108(b), 23 USC § 166 (b)(4-5), 23 USC § 166 (d)(2), California Vehicle Code §21655.5-6, Public Resources Code §21080(b)(11)		
Overall Time-Horizon of Reversal	If California policymakers decided to permanently convert existing lanes to HOV lanes rather than constructing them anew, the benefits of a completed metropolitan HOV network lanes would begin nearly instantaneously, reaching a steady state in the near term as individuals adjust their travel behavior. If transportation system users perceive a conversion as temporary, they may seek to wait out the change rather than adjust travel behavior.		
Relevant Topics	carpool, rideshare, transportation network expansion, incentives		
Summary	Policymakers expect HOV lanes to encourage rideshare by providing a benefit, time savings and reliability, to those in high occupancy vehicles. Nearly all HOV lanes implemented in California have been newly constructed rather than converted from existing general purpose lanes. Constructing rather than converting lanes delays the implementation and increases the expense of a complete HOV network. The result is the delayed effectiveness and lost opportunities to reduce petroleum use.		

Introduction

Transportation planners use high-occupancy vehicle (HOV) lanes to create an additional incentive for rideshare. Sharing travel costs among vehicle occupants creates a monetary incentive for rideshare across all routes, but time savings and reliability on routes with HOV lanes can augment rideshare incentives. The incentive is a function of perceived time-savings and reliability: dependent on relative attractiveness of HOV lanes versus general purpose lanes. When general lanes are congested or unpredictable and HOV lanes are less congested and more predictable, drivers are likely to perceive a benefit from ridesharing. Transportation planners can manage an HOV users' time savings by adjusting vehicle

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occupancy requirements at certain times of day. If poorly-managed HOV lanes lose their relative advantage, they are unlikely to augment rideshare incentives.

A complete well-managed HOV network can provide benefits that exceed the sum of individual HOV segments. While adding segments creates immediate time savings and system operations efficiency gains for ridesharers whose current routes include segments without HOV lanes, a complete network will create the perception of consistent ridesharing benefits throughout the highway system.

One question transportation planners face is whether to convert HOV lanes from existing general purpose lanes or to construct new, additional HOV lanes. Converting lanes can create nearly-instantaneous ridesharing benefits, as an inexpensive, low-delay implementation option. Constructing a new HOV lane or facility can attract additional federal highway capital funding versus converting an existing lane. HOV construction can also avoid political backlash associated with removing a general purpose lane for restricted access by high occupancy vehicles. It's likely the perceived costs of removing a general purpose lane will be higher where the segment experiences congestion during some times of the day – precisely where the rideshare-inducing benefits of the HOV lane will be higher.

Since a failed experiment on the Santa Monica Freeway in Los Angeles in 1976, every new high-occupancy vehicle (HOV) lane-mile in California has been constructed rather than converted from existing lanes. This has significantly slowed the pace and increased the cost of expanding and completing high-occupancy vehicle network. An incomplete network limits rideshare incentives, and constructing rather than converting HOV lanes requires additional construction emissions and energy use.

HOV lane conversion attempts in California

The Santa Monica Freeway experiment began on Adriana Gianturco's first day as Director of the California Department of Transportation. Governor Jerry Brown appointed her to broaden the agency's focus beyond highway-building and bring greater balance to the state's transportation system. However, the Santa Monica Freeway project was planned under Governor Ronald Reagan's administration as a measure to reduce air pollution in order to conform to the Clean Air Act's standards (Levine, 1994). Failing to comply with the Clean Air Act can jeopardize a region's federal highway funding.

The HOV 3+ lanes operated between 6 to 10 AM and 3 to 7 PM (Riker, 1976). On the first morning, the *Los Angeles Times* reported that commuters waited 15 to 20 minutes to get on the freeway, only to travel 5 miles per hour (Kendall, 1976). The lane conversion was not the sole cause if this delay, as ramp meters that control freeway access weren't adjusted for the HOV lane implementation (Herbert, 1976c). The conversion brought some benefits to certain system users. Travel time for one carpooler reduced from 35 minutes to 20 minutes (Kendall, 1976). On the first day, only 814 passengers used 59 buses from park-and ride lots on the Westside (Kendall, 1976).

Over the five month project, Caltrans never saw the degree of shift to carpools and transit that they expected. Some carpoolers may have been discouraged by the nails scattered in protest on the HOV lanes (Herbert, 1976c). The experiment lasted 110 days - from 6AM on Monday, March 15th to 7PM Friday, August 13th. In the end, the Federal 9th Circuit Court of Appeals ruled that Caltrans erred in not conducting an environmental review for the pilot project (Herbert, 1976a). Caltrans contended the pilot project was categorically exempt from the environmental review process.

HOV lanes briefly returned to the Santa Monica Freeway after the 1994 Northridge Earthquake (Murphy 1994). However, the 1976 Santa Monica Freeway experiment stands as California's only attempt to permanently convert a general purpose lane to a high-occupancy vehicle lane.

Conversion attempts elsewhere

Since the Santa Monica Freeway experiment, a few other U.S. regions have attempted HOV lane conversions. In 1977, the Massachusetts Department of Transportation converted a general lane to an HOV lane during the AM peak period. The conversion lasted over 5 months—between May 4th and October 17th (Simkowitz, 1977). The Massachusetts Department of Transportation later converted a general purpose lane on I-93 to a 0.8 mile reversible "zipper lane", a permanent conversion (Kim, 1995).

In 1991, the Metropolitan Washington Airports Authority nearly finished constructing a new HOV lane on the Dulles Toll Road. The Authority decided to open completed portions of this lane to general purpose traffic on October 15, 1991. The plan at the time was to restrict the lane to high occupancy vehicles when construction crews completed the lane in December (Fehr, 1991). Public opposition to this HOV 3+ lane delayed implementation until September 1, 1992. The HOV 3+ lane operated for a month before Virginia's Governor terminated it in response to federal legislation that would have done the same (Bates, 1992).

In November, 1993, the Washington State Department of Transportation converted a general lane to an HOV lane on an uncongested portion of I-90. The Department extensively studied public opinion and prior conversion attempts before implementing the conversion (Manning 1995). The project has not been reversed and was deemed a qualified success (Kim, 1995).

Regulations governing HOV lane conversion

Federal law and regulations govern the construction, conversion, and operation of HOV lanes. Under current regulations, the Federal Highway Administrator may approve the conversion of an existing general-purpose lane to a high-occupancy vehicle lane on any public road provided that the change facilitates more efficient use of any Federal-aid highway (23 CFR §810.108(b)). Most provisions in federal law restrict the conversion of HOV lanes to general purpose lanes, rather than the other way around. 23 USC § 166 (b)(4) allows for conversion of HOV lanes to high-occupancy toll (HOT) lanes, which allow low-occupant vehicles to pay for access, unless facility is degraded. 23 USC § 166 (b)(5) allows for low-occupant low-emissions vehicles to access HOV lanes unless facility is degraded. 23 USC § 166 (d)(2) defines a degraded facility as a facility with a minimum average operating speed under 45 mph.

States are mostly prohibited from converting an HOV lane to a general purpose lane if it used Congestion Mitigation and Air Quality (23 USC §149) funding to construct the HOV lane. The Congestion Mitigation and Air Quality program is a major source of federal funding for regions seeking to comply with the Clean Air Act.

In California, various laws place somewhat greater restrictions on the conversion of general purpose lanes to HOV lanes. Vehicle Code §21655.5 permits Caltrans to implement high-occupancy vehicle lanes, Public Resources Code §21080(b)(11) establishes the statutory CEQA exemptions for projects to institute or increase utilization of high occupancy vehicle lanes. Vehicle Code 21655.6(a) requires Caltrans to obtain permission from a County Transportation Commission or other local authority prior to implementing a carpool lane, (b) requires Caltrans to obtain 2/3rds majority approval from the Los Angeles County Metropolitan Transportation Authority Board prior to establishing an HOV lane on the 101 freeway within Los Angeles city limits, and (c) requires evaluation of any HOV lanes implemented in unincorporated Alameda County.

How the incomplete HOV network affects fuel use

First, there are the differences in vehicle operations efficiency of HOV facilities versus general purpose facilities. Single-lane HOV facilities in California have lower maximum effective per-lane vehicle capacity than do multiple general purpose lanes (Kwon 2008). This has nothing to do with vehicle occupancy, but rather occurs because throughput in a single-lane facility is subject to the speed of the slowest vehicles, whereas traffic in a multiple-lane facility can pass slow-moving vehicles. Other physical characteristics of the HOV facility matter, as vehicles operating in continuous-access HOV lanes achieve higher operational efficiency than those in limited access HOV lanes (Boriboonsomsin, 2008). One scholar found that the capacity of the general purpose lanes is not affected by the HOV lane (Menendez, 2007).

A primary goal of all HOV projects is to provide travel time savings to users. This goal is operationalized through congestion-avoidance measures, the most imperative of which is reducing the demand for a lane below a critical threshold that would lead to forced vehicle movements. The result is that many, but not all HOV lanes have fewer vehicles that operate more efficiently than do vehicles in the general purpose lanes. Furthermore, although a single-lane HOV facility has a lower maximum vehicle capacity than each lane in a multiple-lane general purpose facility, this is not the case when traffic in the HOV lane is free flowing and traffic in the general purpose lanes is congested.

Second, the presence of HOV lanes can induce ridesharing. This incentive is larger when the HOV lane provides significant time savings over the general purpose lanes and when the carpool can utilize HOV lanes over a greater portion of their trip (Guiliano, 1990). Thus, the effectiveness of regional HOV lanes is subject to a network effect: the carpool-inducing effect becomes larger as HOV facilities appear on a greater proportion of a region's freeway network. By inducing carpools, HOV lanes can reduce vehicle trips.

The net effect of greater operations efficiencies and induced rideshare depends on the unit of analysis: the vehicle, the person, the facility, the corridor, or the travel-shed. Johnston (1996) found that the construction of a new HOV lane increases vehicle miles traveled, increasing petroleum use. The same is true for any addition in capacity. The net travel effects of converting a general purpose lane to high-occupancy will depend on each corridor's conditions. Such a conversion can lead to substantial increases in person-throughput through use of carpools, transit, and vanpools (Kwon, 2008). Inducing traffic congestion and providing a congestion-free alternative is a powerful long-term strategy to reduce discretionary single-occupant vehicle trips, but has significant non-petroleum effects.

Because relatively little California travel occurs on HOV lanes, completing the HOV network would have a small effect on motor vehicle fuel demand. If California's HOV network were fully built out, with 2,330 miles rather than the current system length of 1,391 miles, then the lanes would accommodate roughly 2.5% of all vehicle travel in the state. Converting HOV lanes from general purpose lanes rather than constructing them anew would lead to a greater reduction in motor vehicle fuel use. Even if the effect HOV lanes have on vehicle occupancy and operating efficiency led to a 20% reduction in motor vehicle fuel use, the statewide effect of a complete network would be roughly 0.5%, or 0.21% larger than the current network.

2011 statistics for HOV and freeway network

	Directional Miles	Vehicle Miles Traveled (2011 or projected)	Percent of Statewide VMT
HOV	1,391	4,743,672,034	1.45%
General Purpose Lanes where HOV exists	1,391	45,819,037,501	13.98%
HOV Buildout (*projected)	2,330	8,000,000,000*	2.5%*
All Public Roads		327,800,000,000	

Source: (Federal Highway Administration, 2012).
Note: This analysis does not account for the petroleum use and emissions needed to construct new HOV lanes, or differences in vehicle fuel type for priority access.

Works Cited

Bates, S. (1992, October 3). Wilder ends HOV restrictions on Dulles Toll Road motorists. *The Washington Post*, p. B3.

Breiland, C., Chu, L., & Benouar, H. (2006). Operational effect of single-occupant hybrid vehicles in high-occupancy vehicle lanes. Transportation Research Record: Journal of the Transportation Research Board, 1959(-1), 151-158. doi:10.3141/1959-17

Boriboonsomsin, K., & Barth, M. (2008). Impacts of freeway high-occupancy vehicle lane configuration on vehicle emissions. Transportation Research Part D: Transport and Environment, 13(2), 112-125. doi:10.1016/j.trd.2008.01.001

California Department of Transportation. (2012) Executive Fact Booklet. Available Online.

Elliot, W. (1986). Fumbling toward the edge of history: California's quest for a road-pricing experiment. Transportation Research Part A: General, 20(2), 151-156. doi:10.1016/0191-2607(86)90042-7

Fehr, F.C. (1991). Car-pool restrictions coming soon for new lanes on Dulles Toll Road. The Washington Post

Fuhs, C., & Obenberger, J. (2002). Development of high-occupancy vehicle facilities: review of national trends. Transportation Research Record: Journal of the Transportation Research Board, 1781(-1), 1-9. doi:10.3141/1781-01

Giuliano, G., Levine, D. W., & Teal, R. F. (1990). Impact of high occupancy vehicle lanes on carpooling behavior. Transportation, 17(2), 159-177. doi:10.1007/BF02125334

Johnston, R. A., & Ceerla, R. (1996). The effects of new high-occupancy vehicle lanes on travel and emissions. Transportation Research Part A: Policy and Practice, 30(1), 35-50. doi:10.1016/0965-8564(95)00009-7

Kendall, J. (1976, March 15). Chaos on a freeway: New system jams west side traffic." Los Angeles Times, p. A1

Kim, S.G., Koehne, J., & Mannering, F. (1995). I-90 lane conversion evaluation. Washington State Department of Transportation. Available Online.

Kwon, J., & Varaiya, P. (2008). Effectiveness of California's high occupancy vehicle (HOV) system. Transportation Research Part C: Emerging Technologies, 16(1), 98-115. doi:10.1016/j.trc.2007.06.008

Levine, B. (1994, Febuary 22). A driven woman: Adriana Gianturco fought a lonely battle for car-pool lanes in 1976. Los Angeles Times.

Mannering, F., Koehne, J., & Kim, S. G. (1995). Statistical assessment of public opinion toward conversion of general-purpose lanes to high-occupancy vehicle lanes. Transportation research record, 1485, 168-176. LINK

Menendez, M. & Daganzo, C.F. (2007). Effects of HOV lanes on freeway bottlenecks. Transportation Research Part B. (41)8: 809-822. doi:10.1016/j.trb.2007.03.001

Murphy, D.E. (1994, January 26). The long road back: A diamond lane in the rough. Los Angeles Times, p. 8.

Herbert, R. (1976, August 15). Diamond lane demise may halt other projects: Unpopular freeway experiment concerns officials of Caltrans. *Los Angeles Times*, p. A1.

Herbert, R. (1976, August 10). Diamond lane halt ordered. *Los Angeles Times*, p. 6

Herbert, R. (1976, March 23). Freeway fiasco: The diamond lane: Newest Caltrans bust an analysis the diamond lane. *Los Angeles Times*, p.B1.

Riker, B. (1976, March 11). Concern over diamond lane: Freeway drivers fret freeway lane. *Los Angeles Times*, p. WS1

Simkowitz, H.J. (1978). Southeast expressway high occupancy vehicle lane evaluation report. *Urban Mass Transit Association report* UTMA-78-25.

U.S. Federal Highway Administration (2003) *A guide for HOT lane development*. Available Online.

Bus on Shoulder Treatment on Controlled-Access Highways

Overall Effect on California Petroleum Use		Affects Petroleum Demand Through Intermediate Indicators:	
Magnitude	Low	**Primary**	Mode Choice
Certainty	Medium-High	**Secondary**	
Applicable Level of Government	State		
Relevant Laws or Cases Affecting Factor	Vehicle Code §21755 and 21718, and §34500 et seq.		
Time Horizon for Implementation and Maturity	Allowing transit buses to use highway shoulders would lead to immediate system operation efficiency benefits for express buses. Express bus ridership would increase in the mid-to-near term as more commuters are attracted to reliable travel times and reduced delay.		
Relevant Topics	transit, controlled-access highway		
Summary	Allowing transit buses the use of shoulders on controlled-access highways would affect only a small portion of transit route-miles in the state. Its effect on statewide motor vehicle fuel use would be similarly small. However, bus on shoulder treatments may be a viable option to improve the reliability of express and commuter bus transit service.		

Introduction

California's transit agencies operate three basic types of fixed-route bus service. Local buses, which make multiple stops per mile throughout the length of their route, are the most common. Rapid buses make less frequent stops than local buses – no more than twice per mile outside of dense urban centers. Express buses make frequent stops at the ends of a route, but few or no stops in the middle. Commuter bus routes are a special type of express bus route that:

- connects outlying areas with a central city,
- operates with at least five miles between stops,
- typically uses motor coaches instead of transit buses, and
- features peak scheduling and multiple-trip tickets (National Transit Database, 2013).

Because express buses make few or no stops in the middle of a route, these services may be able to use controlled-access highways for a portion of their routes. Commuter bus routes operating on metropolitan controlled-access highways in the peak travel directions and peak travel times may be prone to congestion delays. Prioritizing the mobility of these

By Juan M. Matute and Stephanie M. Pincetl

transit vehicles can produce travel time savings for transit users if buses are able to avoid traffic congestion.

High-occupancy vehicle lanes are one option to prioritize express bus service on controlled-access highways. However, high-occupancy vehicle lanes do not exist on all congested highways, and accessing these far-left lanes can be operational difficult for express buses that occasionally exit the controlled-access highway to serve stops.

Use of the right-hand shoulder is one option to prioritize transit vehicles on routes without high-occupancy vehicle lanes or where use of the far-left lane is impractical for transit operations. However, any plan to use the right-hand shoulder for transit buses must address emergency access and safety concerns. These lanes are often used for breakdowns and first responder access to emergencies during congested traffic. A large speed differential between buses and congested highway traffic could lead to high-risk collision events. Narrow shoulder widths and varied pavement quality also raise safety concerns.

Minnesota's Twin Cities region is home to the nation's longest-running and most successful bus on shoulder network. The bus-only shoulder network has grown to 295 miles since beginning in 1992 (Minnesota Department of Transportation, 2010). To mitigate safety risk, the Minnesota Department of Transportation established guidelines that allow the shoulders to be used only when highway speeds drop below 35 miles per hour and prohibit transit vehicles from exceeding highway traffic speeds by more than 15 miles per hour (Minnesota Department of Transportation, n.d.). Engineers in the Twin Cities developed and deployed a lane-assist system to aid operators in maintaining lane and avoiding obstacles (Cheng et. al., 2004). A subsequent study showed that the system succeeded in enhancing safety in narrow lanes and under crowded roadway conditions (Ward et. al., 2006).

Prioritizing express buses through use of highway shoulders is a highly cost-effective option when compared with the addition of a high-occupancy vehicle lane. The Minnesota Department of Transportation estimates per-mile implementation costs range from $1,500 for restriping to $100,000 if major repairs are needed. This range of per-mile capital costs is so low that savings from operator labor savings may earn the agency a positive return on its capital investment.

Bus on Shoulder Experience in California

In 2005, Caltrans and San Diego's Metropolitan Transit System implemented a trial bus on shoulder program modeled after the Twin Cities' experience. Planners' goals were to keep costs low and increase the reliability of transit services along the corridor (San Diego Association of Governments, 2005). After ten months, transit vehicles operating on the shoulder achieved 99 percent on-time performance; the project had improved travel times and raised levels of customer satisfaction (Leiter, 2006). Similarly, a survey conducted by the San Diego Association of Governments found that the percent of transit riders who agreed with the statement, "traffic congestion is a daily problem for this route" fell from 79 percent before the trial to 46 percent during the trial. The trial program, although successful from the point of view of the Metropolitan Transit System and the San Diego Association of Governments, was terminated after two years with no plans for permanent implementation.

Also in 2005, California Assemblywoman Shirley Horton introduced AB 461, which was originally a bill to formalize the bus-on shoulder demonstration program within California law. The bill was stripped, amended and later passed without the bus-on shoulder provisions.

Regulation in California

No law grants transit buses permission to use highway shoulders in California. Vehicle Code § 21755 prohibits use of the shoulder to pass on any California street or highway. Vehicle Code § 21718 prohibits transit buses from stopping on freeways unless sidewalks are provided and the bus exits mixed flow traffic for the stop. California law may provide a pathway for future legislation or regulations that supports shoulder use by qualified transit bus drivers. California law does provide for stricter vehicle safety and driver qualification requirements for transit buses than for passenger vehicles. Bus operators in California must obtain a Commercial Class B driver's license with a passenger transportation endorsement. Transit agencies and bus operators must comply with applicable laws and regulations outlined in Vehicle Code 34500 et seq. California policymakers could consider a bus-on-shoulder operations endorsement, either within the existing passenger transportation endorsement or as a separate process. Such a measure would assist in the dissemination of safety guidelines for transit's use of highway shoulders.

Effects on Statewide Petroleum Use

Few Californians currently use express bus services. Even with considerable ridership growth, it's likely that the fuel-use reductions directly attributable to bus on shoulder treatments would be small. The National Transit Database first allowed agencies to differentiate commuter bus service in the 2011 reporting year. The figures below include reported commuter bus service, plus 50% of bus service from Golden Gate Transit, which provides commuter service in the Bay area but did not differentiate this service in reporting.

2011 California commuter bus statistics

	Commuter Bus	All Bus	All Transit Modes
Unlinked Passenger Trips	6,502,417	1,006,578,229	1,379,293,128
Passenger Miles Traveled	95,249,932	3,881,760,559	7,609,800,786
Average Passenger Trip Distance	14.64 miles	3.86 miles	5.52 miles

Commuter service comprised 0.65% of all transit bus trips and 2.45% of all transit bus miles traveled

In 2011, California agencies that reported commuter bus services used diesel (91.2%), compressed natural gas (5.2%), and gasoline (3.4%) (Federal Transit Administration, 2011). The commuter bus vehicles averaged 3.92 miles per gallon-equivalent across these three fuels. All California motor vehicles averaged 18.32 miles per gallon across all fuels (Highway Statistics, 2011). Given the assumptions below, one would expect minimal fuel-use reductions if state policy allowed transit buses to use highway shoulders.

Table of assumptions and results

Assumption/Result	Low	High
Additional passengers attracted to commuter buses due to bus on shoulder treatment	50%	600%
Conversion rate - of new passengers, what percentage represent a foregone vehicle trip?	75%	90%
Vehicle and system operations efficiency benefits for transit buses freed of congestion	5%	15%
Change in commuter bus service to accommodate new passengers	25%	300%
Net change in gasoline and diesel fuel use (in gallons)	-740,000	-11,090,000
Net change in statewide motor vehicle fuel use, percent	-0.004%	-0.063%

However, bus on shoulder implementation could be one of several complementary strategies that, in combination, attract single occupancy vehicle commuters to high-occupancy vehicles and mass transit buses. However, such speculative effects are beyond the scope of this analysis.

Works Cited

Alexander, L., Cheng, P. M., Donath, M., Gorjestani, A., Newstrom, B., Shankwitz, C., & Trach Jr, W. (2004, October). DGPS-based lane-assist system for transit buses. In *Proceedings of The 7th International IEEE Conference on Intelligent Transportation Systems.* (pp. 755-760).

Berry, Jessica. (2010). Bus on shoulder: Local assessment of shoulder transit lane for regional buses in San Luis Obispo County." Cal Poly Pomona Digital Commons. http://digitalcommons.calpoly.edu/theses/263/

Leiter, Bob. (2006). Freeway transit lane demonstration project statusrReport." San Diego Association of Governments. http://www.sandag.org/uploads/newsid/newsid_427_5940.pdf

Minnesota Department of Transportation. (n.d.) Bus-only shoulders – A transit advantage. www.dot.state.mn.us/metro/teamtransit/docs/bosupdate.pdf.

Minnesota Department of Transportation. (2010) "Bus only shoulders in the Minneapolis/St. Paul area." http://www.dot.state.mn.us/metro/teamtransit/docs/bus_only_shoulders_revised_mn.pdf

San Diego Association of Governments . (2005) "Buses on shoulders demonstration project." http://www.sandag.org/index.asp?projectid=283&fuseaction=projects.detail.

U. S. Federal Transit Administration. (2012). National transit database. Washington, DC.

U. S. Federal Transit Administration (2013). NTD glossary. Accessed 23 February 2013. Available at http://www.ntdprogram.gov/ntdprogram/Glossary.htm

Ward, N. J., Shankwitz, C., Gorgestani, A., Donath, M., de Waard, D., & Boer, E. R. (2006). An evaluation of a lane support system for bus rapid transit on narrow shoulders and the relation to bus driver mental workload. *Ergonomics*, *49*(9), 832-859.

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Deductibility of Home Mortgage Interest and State and Local Real Property Taxes from Taxable Income

Overall Effect on California Petroleum Use		Affects Petroleum Demand Through Intermediate Indicators:	
Magnitude	Low-Medium	**Primary**	Distance Traveled
Certainty	Low-Medium	**Secondary**	Other- building energy demand

Applicable Level of Government	Primarily federal, however deductions pass-through to state income tax returns and subsidize services and amenities funded by property tax.
Relevant Laws or Cases Affecting Factor	Mortgage Interest Deduction: 26 USC § 163 Deduction of State and Local Property Taxes: 26 USC § 164(a)(1)
Time horizon for implementation and maturity	If the U.S. Internal Revenue Code is changed, prices of new homes and resales would quickly adjust to reduce distortions. However, the effects on prior housing decisions would linger for many years.
Relevant Topics	mortgage, income tax, deduction, financial incentives, tax expenditures, home ownership, housing
Summary	Though most scholars agree these interest deductions do little to affect home ownership rates, there is less agreement about their effects. Some believe interest and property tax deductibility leads to larger lot size and larger houses. Others think they increase the price households are willing to pay for neighborhood amenities. Regardless of the impacts, the strongest effects are felt in California. Californians who itemize mortgage interest on their tax returns claim a higher value than in any other state, and growth limitations exacerbate any effects the deductions may have.

Introduction

Federal tax treatment of mortgage interest and local real property tax payments has some effects on housing and locational choices. These effects likely lead to an increase in statewide petroleum demand.

While housing scholars are not in universal agreement, most believe that the mortgage interest deduction does nothing to increase homeownership rates and may have an overall negative effect on social welfare. Most scholars also believe that the mortgage interest deduction encourages additional spending by those who would already be homebuyers in the absence of the policy.

By Juan M. Matute and Stephanie S. Pincetl

The Home Mortgage Interest Deduction is an itemized deduction of taxable income equal to the amount of interest paid on the first $1,000,000 in principal of qualified mortgage debt and the first $100,000 in principal of qualified home equity debt. To qualify, mortgage debt must be secured by a qualified asset—a primary residence and up to one "second home" that meet certain conditions.

In practice, many low and moderate income homeowners elect to take a standard deduction rather than itemizing deductions, a practice which precludes their deduction of mortgage interest.

At one time all interest paid on debt was tax deductible, including interest paid on consumer credit cards. In 1986, Congress eliminated deductions of non-mortgage interest and capped the principal value eligible for mortgage interest deductions at $1,000,000 for home acquisition mortgages and $100,000 for home equity mortgages (Lowenstein 2006).

In California, the Franchise Tax Board allows for the many of the same deductions as on federal returns. A study of 2008 tax returns found the average mortgage interest deduction, which appeared on California 29.24% of tax returns, was $18,876. This amount is the highest of the 50 states (Fleenor, 2010).

Glaeser and Shapiro (2002) claim that the home mortgage interest deduction "creates tax savings overwhelmingly for the top deciles of the income distribution" and "impacts a subset of the population that almost never rents." Furthermore, because of the distribution of owners within housing types, the benefits are most likely to accrue to owners of single family detached homes: "85.5% of people living in single family detached homes are owners and 85.9% of people living in multi-family units are renters."

Voith (1999) argues that the home mortgage interest deduction has induced larger home sizes and, therefore, location choices at the periphery of regions. Glaeser and Kahn (2004) stop short of this claim, that the mortgage interest deduction induces people to consume more housing, but agree that subsidizing homeownership supports the move to sprawl. Glaeser and Shapiro (2002) argue that the price increase goes toward neighborhood amenities other than lot and unit size—effectively capitalizing amenities like parks, coastal access, education quality, and employment accessibility into housing prices.

Hilber and Hunter (2010) looked at the geographic distribution of the mortgage interest deduction effects on higher prices and larger homes: in areas where regulations and scarce land constrain the provision of additional housing units, the effects of federal tax policy are mostly capitalized into housing prices—leading to higher prices. However, in areas with fewer regulatory and land constraints to new development, federal tax policy leads to an increase in lot and unit sizes. Voith and Gyourko (1998) found similar results.

Voith (1999) claims that the deductibility of property taxes and mortgage interest may contribute to conditions which exclude low- and moderate-income residents in high-income areas. Because the deductions have a higher value in high-income areas, they may lead higher income residents to choose larger lot sizes and the deductions disproportionately subsidize public amenities in these areas. Larger lot sizes correlate with increases in travel distances, and larger lots within a neighborhood correlate with higher housing prices. Excluding low- and moderate-income residents may lead to additional displacement and travel by the excluded households.

The effects for California likely lead to greater increases in petroleum demand than the nationwide average effects. First, California's income tax rates are high relative to other states. Second, California property values, and therefore mortgage values, are higher relative to the rest of the country. Because the deductions also apply to state tax returns, the result is that mortgage and property tax deductions have a higher value in California than in other states. When these higher-than-average magnitude effects are combined with California's tendency to restrict housing supply through regulations—the overall result is that the average effect that federal housing-related tax policy has on petroleum demand will be higher in California than in the rest of the nation. This is because the tax treatments are likely to lead to higher prices in areas with growth constraints (typically larger cities in Coastal California with lower-than-average driving), and the tax treatments are likely to lead to demand for larger lots and housing units contributing to sprawl in inland areas with fewer constraints (suburban, exurban, and some rural communities with higher-than-average driving).

Effects on Petroleum Demand

Research suggests that the Home Mortgage Interest Deduction has two effects: it leads to more expensive homes in areas with development constraints and to larger home and lot sizes in areas with lower development constraints. However, the magnitude of these effects is somewhat disputed, with some researchers thinking the mortgage interest deduction does very little in practice.

Some research combines analysis of mortgage interest and real property tax payment deductions—as many of those who utilize one deduction also utilize the other. Combined, the two deductions appear to create incentives for exclusionary zoning in high-income areas.

Increased unit and lot sizes on the in suburban and exurban areas contributes to increased sprawl and travel distances. Higher housing prices in high-income areas and areas with development constraints would lead to increased income segregation, causing low- and middle-income individuals to travel greater distances to jobs located in areas with inflated housing prices.

Inasmuch as the mortgage interest deduction leads households to consume larger homes, a secondary the result would be an increase in household energy use. In addition, the geographic distribution of the price effect within California (in general, there are greater growth constraints in Mediterranean climates near the coast) means that the larger homes are more likely to be in areas with in areas with higher-than-average annual cooling degree days, compounding the effects of the attributable marginal size.

Attributing all differences in residential and transportation energy demand from new suburban and exurban housing to the federal tax treatment of mortgage interest would not be valid, as other policies have greater effects on the spatial distribution of new residential construction in California. An educated, but arbitrary guess, would be that the policy has had a 1% to 20% effect on observed growth in VMT per licensed driver since it took effect in 1986. Possible outcomes on statewide vehicle fuel use range from 0.1% to 2.6%.

Estimating effects on statewide vehicle fuel use

Effect on VMT Growth	Change in VMT	Change in %VMT
1%	420,195,779	0.1%
3%	1,260,587,338	0.4%
5%	2,100,978,897	0.7%
10%	4,201,957,795	1.3%
20%	8,403,915,589	2.6%

While the policy may have had a secondary effect on household energy use, only 2.2% of California's residential energy use comes from petroleum-based sources. Thus, it's unlikely that the effect on residential petroleum use is significant.

Works Cited

Fleenor, P. (2010, May 25). Tax savings from mortgage interest deduction vary significantly from state to state. *Tax Foundation. #230.* Retrieved from http://www.taxfoundation.org/sites/taxfoundation.org/files/docs/ff230.pdf

Glaeser, E. L., & Shapiro, J. M. (2002). *The benefits of the home mortgage interest deduction* (No. w9284). National Bureau of Economic Research. Retrieved from http://www.nber.org/papers/w9284.pdf

Glaeser, E. L., & Kahn, M. E. (2004). Sprawl and urban growth. *Handbook of Regional and Urban Economics*, *4*, 2481-2527. doi:10.1016/S1574-0080(04)80013-0

Gyourko, J., & Voith, R. (1997). *Does the US tax treatment of housing promote suburbanization and central city decline?* (No. 97-13). Federal Reserve Bank of Philadelphia. http://knowledge.wharton.upenn.edu/papers/311.pdf

Hilber, C.A.L., & Hunter, M. (2010). The Mortgage Interest Deduction and its Impact on Homeownership Decisions. *SERC Discussion Paper 55. September 2010.* Retrieved from http://eprints.lse.ac.uk/31759/1/sercdp0055.pdf

Lowenstein, R. (2006, March 5). Who Needs the Mortgage-Interest Deduction. *New York Times Magazine*. Retrieved from http://www.nytimes.com/2006/03/05/magazine/305deduction.1.html?pagewanted=print&_r=0

Voith, R. & Gyourko, J. (1998). The Tax Treatment of Housing: Its Effects on Bounded and Unbounded Communities. *Working Paper 98-23.* Federal Reserve Bank of Philadelphia. Retrieved from http://realestate.wharton.upenn.edu/research/papers/full/314.pdf

Voith, R. (1999). Does the tax treatment of housing create an incentive for exclusionary zoning and increased decentralization? *Working Paper 99-22*. Federal Reserve Bank of Philadelphia. 1999. Retrieved from http://www.philadelphiafed.org/research-and-data/publications/working-papers/1999/wp99-22.pdf

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Continuous Descent Approach for Aviation

Overall effect on California petroleum use		Affects Petroleum Demand Through Intermediate Indicators:	
Magnitude	Low-Medium	**Primary**	System Operation Efficiency
Certainty	Medium-High	**Secondary**	
Applicable Level of Government	Federal		
Relevant Laws or Cases Affecting Factor	14 CFR Part 97		
Overall Time-Horizon of Reversal	Medium-term, with the implementation of the Next Generation Air Transportation System.		
Relevant Topics	aviation, next generation air transportation system		
Summary	Existing air traffic regulations and procedures are greatly limited by imprecise information about aircraft location and delayed command and control of aircraft. These limitations manifest in a multi-segment approach procedure that requires aircraft to level off at various stages. Continuous descent approach would allow aircraft to glide in for landing, reducing fuel consumed during the approach phase of flights.		

Introduction

Aircraft fuels account for 14.7% of statewide petroleum consumption, up from 10% in 1979 (Energy Information Administration, 2012). Air travel accounts for about 8.3% of total miles traveled by Californians (U.S. Federal Highway Administration, 2011). However, because air trips travel over longer distances than most surface transportation trips, air travel only accounts for 0.07% of all trips Californians make.

U.S. airlines average around 45 passenger miles per gallon and around 53 available passenger seat miles per gallon (Airlines for America, 2011, Air Transport Association, 2005). As such, U.S. commercial aircraft provide slightly better per-passenger fuel economy than an average-occupancy automobile for equivalent trip lengths. In a parallel to surface transportation, high-capacity aircraft generally provide more available seat miles per passenger gallon than do low-capacity aircraft.

With fuel costs increasing as a proportion of total operation and capital costs, airlines have a strong incentive to increase the fuel efficiency of their fleets. Newer aircraft are becoming more fuel efficient per available seat mile.

By J.M. Matute, H. H. Chung, and S. Pincetl

Short-term strategies to reduce petroleum use include reducing flight distances – more point-to-point travel and fewer diversions due to weather or waypoints – and increasing occupancy, resulting in fewer flights per day. Airlines can also make existing aircraft more fuel efficient by reducing weight and retrofitting the airframe to add devices such as winglets.

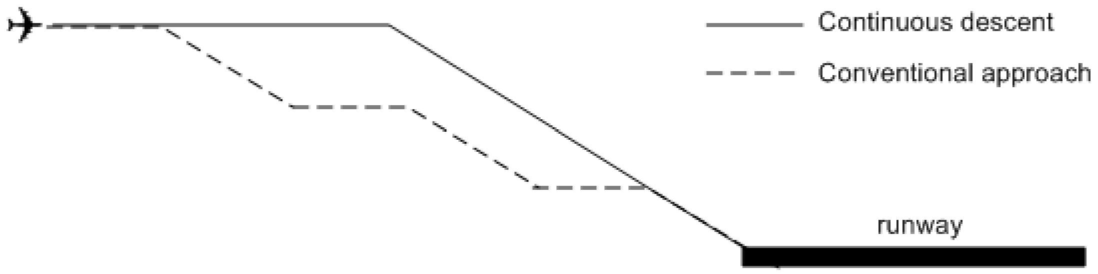
Medium and long-term strategies to reduce petroleum from aviation include gains in aircraft efficiency: more efficient engines and more aerodynamic aircraft. Long-term strategies largely focus on fuel switching—to biofuels—and mode-switching – replacing shorter aircraft trips with high-speed rail.

Continuous descent approach

Changing the operating rules for aircraft landings offers one near-term strategy to reduce aviation petroleum use from the existing aircraft fleet. Continuous descent approach, or optimized profile descent, allows aircraft to glide to the runway at a near-constant slope, in a seemingly straight line.

Current approach rules require an aircraft proceed to and level-off at predefined waypoints and altitudes – creating a descent reminiscent of descending a staircase. Descending to new altitudes and leveling off consumes additional fuel versus gliding at a near-constant slope.

Figure 1- Continuous descent versus conventional approach



FAA approach regulation

Safety considerations and the limitations of existing situational awareness and communications infrastructure limit current approach rules. 14 CFR Part 97 outlines the U.S. Federal Aviation Administration's authority to regulate instrument aircraft approach. The U. S. Federal Aviation Administration's Instrument Procedures Handbook (2007) details these guidelines. The instrument approach procedure involves several segments, each with different rules and minimum altitudes. Each approach segment is segregated by a waypoint (fix) and specifies a minimum altitude. If an aircraft reaches the minimum altitude prior to passing a waypoint, the pilot must level off the aircraft. This leveling off requires additional fuel use versus a continuous descent approach.

Existing regulations require some tradeoffs with aircraft and system operations and efficiency. One challenge to continuous descent approach is that gliding aircraft have higher ground speeds at higher altitudes – motivating the need for active air traffic management in order to maintain minimum aircraft separation. The current U.S. air traffic control system produces imprecise information about aircraft locations from radar-based systems and centralized commands are limited by delays in voice communications. As such, the rules for approach and aircraft separation attempt to accommodate imprecise information and control delays within an acceptable margin of safety.

The U.S. Federal Aviation Administration and airlines operating in U.S. airspace are implementing a Next Generation Air Transportation System. The system will produce more precise information on real-time aircraft location through use of GPS-enabled aircraft positioning. The system will also reduce communications and control delays through use of data communications – obviating the need for voice controls to issue certain aircraft positioning commands. With the Next Generation Air Transportation System, controllers will be able to issue multiple instructions simultaneously.

Real-time identification of aircraft positioning and communication of control instructions will also allow commercial aircraft to take shorter routes between origin and destination, traveling along more direct routes versus the flight paths currently instituted to ensure proper separation of cross-traffic.

Continuous descent approach in California

The FAA began testing continuous descent approach at Los Angeles International Airport (LAX) in September of 2007. A study used a combination of real-world observations and modeling results to consider the environmental benefits and logistical challenges of implementing continuous descent approach in one of the nation's busiest air spaces (Dinges, 2008). Because the existing air traffic control system poses a logistical challenge to implementing continuous descent approach across all flights, only a portion of flights used the approach technique at the time of the study.

The study highlighted marked decreases in noise levels in neighborhoods along approach corridors. These noise reductions would be become more significant as more flights used the approach technique: reducing 45 dB exposure by as much as 20.2% with all flights using the approach technique (Dinges, 2008).

The study also considered fuel use under a variety of continuous descent approach implementation scenarios. With 100% of aircraft using the approach technique, the study expected fuel savings of up to 24.2% for the arrival phase. However, because of a low proportion of aircraft using the continuous descent approach technique, actual observed fuel savings were low: about 0.3%. According to the study's author, the lower observed value was due in part to differences between real-world implementation and the hypothetical modeled scenarios (Dinges, 2008).

One challenge to maintaining proper aircraft separation is controlling the speed of the approach. Approach rules require minimum separation distances at high altitudes and minimum in-trail separation distances prior to landing. Nikoleris, Chatterji, and Coppenbarger (2012) recommend reducing descent speed as much as possible and then reducing cruise speed in order to maximize fuel savings amidst approach congestion. Boeing 757 aircraft have unique wake characteristics, which also present a challenge for separating aircraft on approach in congested airspace.

Estimating fuel savings from statewide use of continuous descent approach

Researchers have considered both modeling and real-world data to estimate the fuel savings benefits from continuous descent approach.

The study at Los Angeles International Airport estimated up to a 24.2% reduction in fuel use for the landing phase (aircraft operations under 10,000 feet) (Dinges, 2008).

An aircraft's takeoff phase uses the most energy per aircraft mile of travel. The cruise phase uses less. The approach phase is generally the most efficient, because the aircraft can gain speed on descent. Amortizing the approach savings over the entire flight produces estimates for the overall aviation fuel savings that would result from implementation. Robinson, et al. (2010) find national fuel savings potential to be 3% of total fuel consumption. Alcabin, et al. (2010), find similar results.

In California, aviation fuels comprise 14.7% of statewide petroleum consumption, 3% of which equals 0.4% of statewide petroleum use.

Potential fuel savings could be somewhat muted in California due to complex airspace in the San Francisco and Los Angeles areas – which each have several commercial airports with flight patterns that may constrain an aircraft's ability to make the most fuel-efficient glide-in on approach (Alcabin et al, 2009). Additionally, it's possible that this constraint will reduce the proportion of aircraft that can utilize continuous descent approach. Jin, et al. (2013) recommend that limited applications of continuous descent approach prioritize heavy aircraft in order to maximize overall fuel savings.

Works Cited

Air Transport Association. (2005) 2005 economic report: Thinking for a new century. www.airlines.org/Documents/economicreports/2005.pdf

Airlines for America. (2011) 2011 economic report: We connect the world. http://www.airlines.org/Documents/economicreports/2011.pdf

Alcabin, M., Schwab, R. W., Soncrant, C., Tong, K.-O., and Cheng, S. S., (2009). Measuring vertical flight path efficiency in the national airspace system. 9th AIAA Aviation Technology, Integration, and Operations Conference (ATIO), Hilton Head, SC, Sep. 21-23, 2009, AIAA-2009-6959.

Dinges, E. P. (2008). Determining the environmental benefits of implementing continuous descent arrival procedures. ATAC Corporation. Paper #593. http://www.faa.gov/about/office_org/headquarters_offices/apl/research/science_integrated_modeling/media/Environmental%20Benefits%20of%20Continuous%20Descent%20Arrivals.pdf

Jin, L., Cao, Y., & Sun, D. (2013). Investigation of potential fuel Savings due to continuous-descent approach. *Journal of Aircraft*, 1-10.

Nickoleris, T., Chatterji, G, & Coppenbarger, R. (2012). Comparison of fuel consumption of descent trajectories under arrival meeting. American Institute of Aeronautics and Astronautics.

Peeters, P., Middel, J., & Hoolhorst, A. (2005). Fuel efficiency of commercial aircraft: An overview of historical and future trends. National Aerospace Laboratory. NLR-CR-2005-669

Robinson, J., & Kamgarpour, M. (2010, September). Benefits of continuous descent operations in high-density terminal airspace under scheduling constraints. In *10th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference, Fort Worth, TX* (pp. 13-15).

U.S. Energy Information Administration. (2012). *State energy data system*.

U.S. Federal Aviation Administration. (2007). *Instrument procedures handbook*. Department of Transportation. Washington, DC.

U.S. Federal Highway Administration. (2011). *Highway statistics*.

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Location of State Enterprise Zones

Overall Effect on California Petroleum Use		Affects Petroleum Demand Through Intermediate Indicators:	
Magnitude	Low	**Primary**	Distance Traveled
Certainty	Medium	**Secondary**	

Applicable Level of Government	State, Local
Relevant Laws or Cases Affecting Factor	California Revenue and Taxation Code § 17053.74(b)(4)(A)(iv)(IX) California Government Code § 7072(i) 25 California Code of Regulations § 8466(p)
Time horizon for implementation and maturity	Reversal would be possible in the short term if the Legislature changed state law to match the targeted employment area with the specified local enterprise zone. This change would have immediate effects on new employment.
Relevant Topics	Tax expenditures, economic development, employment
Summary	California provides employer incentives to encourage employment in certain geographic areas of the state. If enterprise zones change the location of employment, they only do so slightly: firms that would have located near the enterprise zone locate within the enterprise zone instead. However, one State Enterprise Zone provision may slightly impact the distances employees travel to work. Employers are eligible for tax credits when they hire residents of targeted employment areas. Because this tax incentive is not restricted to a given enterprise zone's targeted employment areas, a potential result is additional distance by employees who travel between enterprise zone areas.

Introduction

Enterprise zones, which provide incentives to businesses that locate within certain areas of California, are one tool policymakers can use to increase employment in economically depressed areas of California. Scholars debate the zones' effectiveness in generating new employment, but their potential effects on statewide petroleum use are small.

Enterprise zones offer benefits to for-profit businesses that locate within a specified area. The highest value benefit is a state income tax credit equivalent to 150% of minimum wage

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or actual wages for hiring workers meeting certain requirements[1]. Additionally, firms located within the zone can carry forward losses for up to 15 years versus 10 outside of the zones. Firms are eligible for reimbursements of the sales and use tax for purchases of qualified machinery, computers, film production, and other equipment.

State law authorizes up to 42 enterprise zones. Each zone is valid for 15 years, and can be reauthorized. Some cities have several zones, and some zones comprise large portions of cities or counties.

Studies by many scholars ((Boarnet & Bogart, 1996), (Neumark & Kolko, 2010), and others) suggest that enterprise zones do not create new area-wide employment, but rather shift employment into the zone. Some studies ((Ham, Swenson, İmrohoroğlu, & Song, 2011), (O'Keefe & Dunstan, 2001), and others) suggest that enterprise zones increase the number of jobs within the zone and the employment rates of those living in targeted employment areas. There's also some evidence that businesses locating in enterprise zones have more employees than the statewide average. This finding is consistent with survey respondent's view that smaller businesses find the process to obtain enterprise zone benefits to be burdensome (Neumark & Kolko, 2010). Enterprise zones may also induce businesses to substitute lower-skilled labor for higher-skilled labor. Additionally, benefits targeting capital equipment investments may attract capital-intensive firms to enterprise zones. Such firms have fewer employees per unit of revenue.

Effects on Petroleum Use

Enterprise zones could have two main effects on California's petroleum use. The first is by changing employment's spatial distribution and changing travel patterns versus the baseline where a business would have otherwise located. The second is by changing commute lengths for eligible residents of targeted employment areas.

With a few exceptions, enterprise zones are typically in or around a region's central—a location generally consistent with lower-than-average employee commute distances. Of the 40 authorized enterprise zones[2], 14 are in urban centers, 11 are in suburban areas, 10 are in exurban or rural areas within the travel shed of a larger population center, and 5 are in isolated population centers.

Of those within the sphere of influence of a larger population center, only three Kern County zones—Arvin, Delano, and Taft—are within the travel shed of a larger population center that does not have an enterprise zone. Bakersfield's enterprise zone expired in 2006 and has not been renewed. These zones are discussed further in a following section.

One concern with the second effect is that businesses in an enterprise zone can hire residents of targeted employment areas in other enterprise zones. If this occurs in practice, it would mute the effects of local hiring preference on distance traveled and petroleum use. Targeted employment areas are census tracts within the enterprise zone or within the same community as the enterprise zone. A census tract must have 51% or more of the population earning below 100% of the area median income in order to qualify as a targeted

[1] Criteria include: workers on certain job training or public assistance programs, dislocated workers, those who have been permanently laid off due to a plant shutdown, the long-term unemployed, those affected by base realignment/closure, active members of the military, veterans, ex-offenders, or residents of a targeted employment area.

[2] As of December, 2012

employment area. Government Code § 7072(i) defines targeted employment area, and the Revenue and Taxation Code § 17053.74(b)(4)(A)(iv)(IX) establishes eligibility guidelines based on targeted employment area. 25 CCR §8466(p) established acceptable documentation for targeted employment area eligibility guidelines, without specifying whether a targeted employment area is zone-specific.

Quantifying the effect on statewide fuel use

If the three Kern County zones are successful in shifting employment from Bakersfield, they could induce longer commutes in Kern County. 64.1% of Arvin's workers commute from distances of greater than 10 miles (U.S. Census Bureau, 2012). However, with an estimated 5,383 jobs between Arvin and Taft, the effect of distorted commute distances is likely small. Delano is home to an estimated 15,652 primary and secondary jobs. While an estimated 53.4% of Delano workers commute from distances greater than 25 miles, only around 3,000 of those come from the Bakersfield area. Delano also attracts workers from Tulare, Visalia, and Porterville, which are part of the Sequoia Enterprise Zone.

With over 14 million primary and secondary jobs in California, the effect the three Kern County enterprise zones have on travel distances is likely very small. Furthermore, zones located in populated areas on the periphery of larger employment centers, such as Merced, could reduce commute distances.

In 2004, approximately 8.4% of statewide employment was located within enterprise zones (Neumark & Kolko, 2010). Because the data on targeted employment area eligibility vouchers is not public, it is not possible to evaluate the effect of this eligibility criterion on travel demand. Not all employment within enterprise zones is eligible for vouchers, and a very small percentage of granted vouchers would be for residents of outside targeted employment areas. Thus, the total effect of enterprise zone policy on California petroleum use is likely to be negligible.

Works Cited

Boarnet, M. G., & Bogart, W. T. (1996). Enterprise zones and employment: Evidence from New Jersey. *ournal of Urban Economics, 40(2)*, 198-215. doi:10.1006/juec.1996.0029

Ham, J. C., Swenson, C., İmrohoroğlu, A., & Song, H. (2011). Government programs can improve local labor markets: Evidence from state enterprise zones, federal empowerment zones and federal enterprise community. *Journal of Public Economics, 95(7)*, 779-797. doi: 10.1016/j.jpubeco.2010.11.027,

Neumark, D., & Kolko, J. (2010). Do enterprise zones create jobs? Evidence from California's enterprise zone program. *Journal of Urban Economics, 68(1)*, 1-19. doi:10.1016/j.jue.2010.01.002

O'Keefe, S., & Dunstan, R. (2001). Evaluation of California's enterprise zones. *California State Library, California Research Bureau*. Retrieved from http://134.186.55.80/crb/01/12/01-012.pdf

U.S. Census Bureau. (2012, December). Longitudinal employer-household dynamics: OnTheMap. Washington, DC.

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Reducing Barriers to Entry for Informal Transit Service

Overall effect on California petroleum use		**Affects Petroleum Demand Through Intermediate Indicators:**	
Magnitude	Low	**Primary**	Mode Choice
Certainty	Medium-High	**Secondary**	
Applicable Level of Government	State, Local		
Relevant Laws or Cases Affecting Factor	Public Utilities Code §5353(h), §5371, §12067(c), 23 U.S.C. 166(b)(3)		
Overall Time-Horizon of Reversal	Near-term, with regulatory changes at the state and local level		
Relevant Topics	Jitneys, dollar vans, entrepreneurship in mass transportation		
Summary	California law requires informal transit operators to obtain a state or local license in order to operate. The licensing and insurance requirements serve as barriers to entry for informal transit services, such as jitneys, which frequently compete on cost. Reducing or eliminating regulatory barriers to jitney service would likely formalize existing, unlicensed operations in the state. However, increases in informal transit services would attract passengers otherwise served by existing shared transportation services or who are currently unserved, negating any petroleum-related benefits.		

Introduction

Globally, informal transit is a popular form of transport in places where government fails to meet the basic mobility needs of lower-income individuals. Such places demonstrate a high demand for mass mobility services, and typically have the economic drivers necessary for entrepreneurs to serve this demand. Individually owned and operated transit vehicles can use decentralized decision-making to more responsively serve customer demand - such as identifying new routes or service spans and providing value-added services.

We define informal transit as privately-provided, unsubsidized five-or-more passenger vehicles that operate in fixed or semi-fixed routes. Jitneys, share taxis, and dollar vans, are all examples of informal transit services. In California such services could potentially fill gaps between existing mass transportation services: Charter-Party Carrier Act-licensed services, locally-regulated taxicabs, publicly-subsidized transit services, and employer-based or publicly-subsidized vanpool and shuttle programs.

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Widespread adoption of such services faces several constraints in California. Because informal transit is privately held and unsubsidized, entrepreneurs must be capable of profiting in order for the service to exist. While existing regulations may permit some types of informal transit service, they serve as barriers to entry, by increasing fixed costs for individual entrepreneurs, the primary suppliers of informal transit service.

Informal transit in the U.S.

Informal transit services operate elsewhere in the U.S., where they augment or replace publicly-managed transit services.

In Atlantic City, a nearly-century old association manages service provided by over 190 individually owned and operated jitney buses (The Atlantic City Jitney Association, 2013). Since 1997, the Association has used funding from New Jersey Transit to provide a rail shuttle connection (New Jersey Transit, 2007). Three additional, unsubsidized routes operate throughout the city.

In New York City, dollar vans operate in the outer boroughs, primarily catering to immigrant passengers who are familiar with informal transit. Only some of the vehicles are licensed and insured, and all are prohibited from picking up passengers at curbs (Margonelli, 2011). Powered by decentralized decision-making, the individual entrepreneurs operating the dollar vans can offer value-added services, such as waiting for a mother and child to arrive safely at their destination before proceeding with the route (Margonelli, 2011).

Informal transit in California

While California has a rich history of urban jitney service, only one licensed vehicle continues to operate in San Francisco. Jitney Number 97, a 1978 GMC minibus, connects San Francisco's Market Street with the Caltrain station for a $2 fare. A 1997 newspaper feature on the service and its owner-operator, Jesús Losa, suggests that profits are slim (Fernandez, 1997).

History of informal transit in California

In Los Angeles, unregulated Jitneys competed with privately-owned and operated streetcar services in the mid 1910's. In 1917 Los Angeles voted to heavily regulate Jitney service, and service mostly disappeared by 1918 (Roger & Nerner 1986).

Los Angeles's modern-day jitney experiment began in July of 1982, when the California Public Utilities Commission approved a pilot project. Roger and Nerner (1986) studied this experiment.

The timing of the experiment, months before the Public Utilities Commission approved the pilot project, the California Supreme Court upheld Proposition A, a half-cent sales tax for transit that provided substantial new operating subsidies. This slashed Southern California Rapid Transit District (RTD) base fares from $0.85 to $0.50, making it more difficult for unsubsidized private jitneys to profit.

The jitney experiment lasted approximately seven months. Roger and Nerner made several findings from their study. Many of the jitney drivers and riders were Latino, and Latinos demonstrated loyalty for the jitneys over RTD buses. Many of the drivers were willing to invest with no guarantee of return because they had few other options to generate income.

Riders holding monthly RTD passes were far less likely to use the jitneys, as the jitney fare would impose an additional cost. Others used jitneys if they perceived time savings or an opportunity to have a seat for their trip. The jitneys' average speed was faster than public buses because the smaller vehicles made fewer stops and were more maneuverable. Jitneys diverted 3% of RTD passengers on the six affected routes.

The modern-day jitney experiment discovered at least one service gap that informed RTD's provision of public transit service. The jitneys demonstrated demand for additional public transit service on Gage Avenue.

Los Angeles's modern-day jitney experience suggests that a two-tiered system where fixed-route jitneys compete directly with publicly-subsidized transit is unlikely to succeed. Jitneys require a minimum demand threshold in order to provide cost-effective service. Many corridors where transit demand exceeds this threshold already offer public transit service - meaning that jitneys must compete head-to-head with publicly subsidized service. In such cases, they will compete on price, either slashing fares or by attracting low-wage workers who often have few alternatives for income-generating work (Roger & Nerner, 1986). In 1982, RTD's 35 cent fare decrease precluded the former strategy.

Jitneys, or other informal transit, may be more successful in markets with significant gaps in publicly-subsidized transit service, or markets in which public subsidy is not customary.

One study examined Latino's use of *camioneta* minivan services. While the *raiteros*, or entrepreneurial owner-operators, offered some intra-city commuter services, they primarily provided intercity and international trips (Valenzuela, et al., 2005). In these markets, licensed and unlicensed transport services compete with privately-provided Greyhound-like scheduled, fixed-route services. The researchers found that "entrepreneurs within the immigrant community in Los Angeles have spotted a poorly served group in the travel market and capitalized on it" (Valenzuela, et al., 2005, 909). In the views of users, the *camionetas* offered several advantages over Greyhound-type services, including Spanish-speaking drivers, route-deviation, lower price, and Spanish language entertainment.

Regulation

Commute trips are exempt from the most stringent state regulations. Public Utilities Code §5353(h) allows individuals to collect fares in order to transport passengers between home and work, provided that the primary purpose of the service is not to make a profit. *Raiteros,* who offer fare-based commute services, may not meet these requirements, and thus may require a license to operate. Public Utilities Code §5371 requires all private passenger transportation services not meeting this and other exemptions to obtain a license from the Public Utilities Commission.

California regulations provide a path for informal transit service, but only between unincorporated areas and cities in San Diego County (PUC §12067(c)). In this provision, California defines "passenger jitney service" as "every corporation or person engaged as a common carrier, for compensation, in the ownership, control, operation, or management of a passenger transportation service by motor vehicles of not more than 15 passenger capacity, excluding the driver, which operate between fixed termini and over a regular route and generally on short, nonscheduled, headways" (PUC §12067(c)).

Any informal transit service would lack at least one mobility privilege afforded to publicly-sponsored transit systems. Informal transit service would be prohibited from deadheading, or traveling to and from revenue services, in HOV lanes on the federal highway system.

While Federal law (23 U.S.C. 166(b)(3)) allows public transit vehicles to deadhead, it does not afford this opportunity for private mass transportation services not operated under contract with a public agency.

How do informal transit barriers affect California petroleum use?

In this section, we consider a reduction in costs associated with obtaining state licenses (insurance, knowledge, time). We exclude community-based rideshare programs focused on commute trips, as few regulatory barriers to such services currently exist. We find that it's unlikely that relaxing barriers to entry for informal transit services would lead to a large increase in mass transit use in California.

Informal transit is likely to be most viable in areas of California where publicly-subsidized transit doesn't exist or substantially fails to meet the mobility needs of the poor. This includes the aforementioned *camioneta* service, grocery shuttles, or where publicly-subsidized routes are so consistently crowded that informal transit options offer the only guarantee of a seat. Where informal transit co-exists with adequate publicly-subsidized transit, it's likely informal transit will compete on cost – both fares and drivers' wages.

The greatest opportunity for reducing barriers for informal transit is likely in intercity and interregional trips. Publicly-subsidized mass transportation does not exist in many of these markets, and it's possible that individual and organized entrepreneurship will lead to more intercity services. The additional market for such services is likely small - between those already using unlicensed services and individuals who can afford private mobility or would prefer to utilize licensed services. Expanding the informal transit market for intercity trips would likely serve the mobility needs of those not currently traveling, leading to net increases in petroleum demand. Reducing barriers to entry would formalize existing unlicensed services, providing a non-petroleum benefit to service operators.

We also find limited opportunity in the commuter services market. Commuter vanpools whose driver is also transporting himself or herself to employment are exempt from state licensing requirements. State licensing costs are not currently a barrier to premium, employer-based shuttles, which are provided as a fringe benefit to higher-than-median-wage workers. Publicly-subsidized transit is expanding into areas that are traditional strongholds of informal *camioneta* or *raitero* services – agricultural worker transportation. The California Vanpool Authority and Agricultural Industries Transport Service offer a publicly-subsidized vanpool model for agricultural worker trips – both daily commute trips and long-distance repositioning. The expansion of such services limits the opportunity for changes in licensing costs to affect informal, for-profit commuter services.

Informal transit largely serves as a substitute for existing transit service rather than private automobiles. Because of this, we forecast that reducing barriers to entry for informal transit use will have a negligible effect on statewide motor vehicle fuel use. This doesn't mean that informal transit service can't play a role in California's future mobility. When increasing transit fares, government could relax enforcement or allow a pilot program for jitney-type services to enable the potential emergence of lower priced transit for low-income Californians, albeit not without consequences.

Works Cited

Fernandez, M. (1997, July 28). A one-man traffic buster: jitney makes quick trips to Caltrain station. *San Francisco Chronicle*. Retrieved from http://www.sfgate.com/news/article/A-One-Man-Traffic-Buster-Jitney-makes-quick-2832137.php

Margonelli, L. (2011, Nov 17). Thinking outside the bus. *New York Times*. Retrieved from http://opinionator.blogs.nytimes.com/2011/11/17/thinking-outside-the-bus/

Mohan, V., & Cassady, D. (2002). Supermarket shuttle programs: A feasibility study for supermarkets located in low-income, transit dependent, urban neighborhoods in California.

New Jersey Transit. (2007). Contract extended for A.C. Rail Terminal Shuttle Service." http://www.njtransit.com/tm/tm_servlet.srv?hdnPageAction=PressReleaseTo&PRESS_RELEASE_ID=2328

Teal, Roger F. & Terry Nemer. (1986). Privatization of urban transit: The Los Angeles jitney experience. *Transportation* (13): 5-22.

The Atlantic City Jitney Association. (2013). About us. http://www.jitneyac.com/about.php

Valenzuela, A., Schweitzer, L., & Robles, A. (2005). Camionetas: Informal travel among immigrants. *Transportation Research Part A: Policy and Practice*, *39*(10), 895-911.

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