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Caroline Rodier, Farzad Alemi, Robert A Johnston

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16. ABSTRACT

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Exploring Unintended Environmental and Social-Equity Consequences of Transit Oriented Development

A National Center for Sustainable Transportation and

California Department of Transportation Research Project

Final Report

Caroline Rodier

Farzad Alemi

Robert A. Johnston

National Center for Sustainable Transportation

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ABSTRACT

Communities throughout the U.S. are pursuing land use and transportation plans that locate high density, mixed-use development near high quality rail and bus transit service. The objective of these plans is to meet important community goals, such as economic development, reduced congestion, greater transportation choice, and improved public health. These plans may also be critical to managing the growth in passenger travel necessary to meet greenhouse gas (GHG) reduction goals and avoid the most devastating damage to human and natural systems from climate change. Increasingly, however, there is concern that these plans may have unanticipated consequences that could undermine the well-being of low-income groups and GHG reductions. This study uses a spatial economic model developed for the Sacramento region (Sacramento PECAS) and an advanced travel demand model to simulate a land use and transportation plan from 2014 to 2030. We examine the plan's effect on population, housing, rents, and consumer surplus by location and income class over time and changes in travel behavior. We use the EMFAC emissions model with the travel behavior output to measure changes in on-road vehicle GHG emissions. In addition, a lifecycle assessment model uses the economic activity output from the simulated scenario to estimate changes in upstream and downstream GHG emissions.

INTRODUCTION

Communities throughout the U.S. are increasingly pursuing coordinated land use and transportation plans that locate high density, mixed-use development near high quality rail and bus transit, commonly known as transit oriented development (or TODs). It is widely believed that such plans will meet important community goals such as economic development, reduced congestion, greater transportation choice, and improved public health. TODs may also be critical to manage the growth in vehicle travel necessary to reduce greenhouse gas (GHG) emissions to levels that may keep at bay the most serious climate change damage to human and natural systems (Kay et al., 2014).

Recently, however, there is concern that TODs may have some unanticipated consequence that could undermine the well-being of low-income groups and GHG reductions. Housing costs may rise in TODs (as neighborhoods gentrify) forcing low-income residents to relocate (displacement) into less transit rich communities farther away from employment opportunities and other essential activities. As a result, low-income households may purchase less expensive older cars that emit high levels of GHG emissions and travel longer distances to engage in everyday activities (Dominie, 2012). Moreover, higher income residents living in TODs may be less likely to take transit and more likely to drive because they can afford vehicle ownership, operation, and parking costs.

Very little research examines the effect of TODs on low-income households. The methodological challenge and costs of conducting such research over time are well known. The relationship between gentrification and station location is explored in two studies (Pollack et al., 2010; Chapple, 2009) and displacement is examined in other studies (e.g., Newman and Wyly, 2006; Mckinnish et al., 2010). We are aware of no study that examines the relationship among TODs, gentrification, travel, and GHG emissions.

The current study evaluates the effects of a TOD scenario from 2014 to 2030 on population, housing, rents, and consumer surplus growth by location and income class over time as well as changes in travel behavior. California requires MPOs to develop such plans, known as Sustainable Communities Strategies or SCSs, under Senate Bill 375. This scenario does not represent the region's current Sustainable Communities Strategy. However, the scenario does include a significant expansion of TODs in the region in order reduce GHGs from passenger travel.

The study employs the PECAS model developed for the Sacramento region and the advanced Sacramento regional travel demand model. Both models are well suited for the analysis. The structure of the PECAS model explicitly represents bid-rent dynamics in the real estate market. The Sacramento advanced travel demand model has a good representation of the TOD environment including land use (mix and density), transit accessibility (bus and rail), and pedestrian and bike facilities (measures of network connectivity and an explicit bike network). The EMFAC emissions model uses the travel model's outputs to measure changes in vehicle GHG emissions. The economic activity output from the Sacramento PECAS model is input into an economic lifecycle assessment model, developed for use with an earlier version of the Sacramento PECAS model as part of another project (Rodier et al., 2012), to estimate changes in upstream and downstream GHG emissions.

The PECAS model developed for the Sacramento region is currently undergoing testing and reasonableness checking by the Sacramento Area Council of Governments (SACOG). This report includes research results only, but may be helpful to SACOG as they continue to test, evaluate, and improve their model for potential application in the region. It is not appropriate to use the results of this study to inform local and regional Sacramento policies. However, study results are generally useful in that they provide insight into the potential effects TOD development polices on the larger economy and on specific socio-economic groups. The paper also illustrates the range of measures that are possible from a spatial economic policy.

LITERATURE REVIEW

Background

Understanding the complete system effects of regional land use and transportation policies is critical to meeting national and state level GHG goals. The transportation sector is the single greatest contributor to GHG emissions in the U.S. It accounts for about 30% of all GHG emissions and 86% of those are attributable to on-road sources. GHG emissions must be 50% to 85% of 1990 levels by 2050 to avoid irreparable damage to human and natural systems (Kay et al., 2014). In California, the Global Warming Solutions Act (Assembly Bill 32, 2006) and an Executive Order (S-3-05, 2005) mandate similar GHG reductions. The weight of the empirical evidence demonstrates that measures to reduce passenger vehicle travel are necessary to achieve these goals (Kay et al., 2014; Small, 2012; Kromer et al., 2010; Brisson et al., 2012; Skippon et al., 2012; US DOT, 2010; Morrow et al., 2010; McCollum and Yang, 2009; Yang et al., 2009; Lazarus et al., 2013; and Deetman et al., 2013). California passed Senate Bill 375 (SB 375, 2008), which requires regions to develop land use and transportation plans (or Sustainable Communities Strategies) that meet regional GHG targets deemed necessary to meet overall state level GHG goals.

However, understanding the equity and GHG effects of TODs is not only important to meeting national and state GHG goals. It is also critical to meeting federal environmental justice requirements for funding of transportation projects. U.S. Executive Order 12898 (1994) codified concerns about the effects of the government's activities on minority and low-income populations. The federal surface transportation acts of the 1990s emphasized the importance of citizen participation in regional transport planning and funded programs to improve the mobility of disadvantaged and low-income populations. At the end of the decade, the United States Department of Transportation (USDOT) and the Federal Highway Administration (FHWA) issued Orders (5610.2 and 6640.23, respectively) articulated environmental justice principles for the transportation planning and decision-making process. These included the need "to avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations."

The Federal government charged state transportation departments and metropolitan planning organizations (MPOs) – the functional conduits for significant infusions of federal transport dollars to states, cities, and counties – to develop data, tools, and measures to evaluate the achievement of environmental justice principles in their transportation planning processes (Castiglione et al., 2006; Klein, 2007; Sanchez and Wolf, 2005). For example, USDOT asks state transportation departments to "develop the technical capability to assess the benefits and adverse effects of transportation activities among different population groups and use that capability to develop appropriate procedures, goals, and performance measures in all aspects of their mission" (USDOT:FHWA, 2006). They also urge MPOs to "identify residential, employment, and transport patterns of low-income and minority populations so that their needs can be identified and addressed, and the benefits and burdens of transport investments can be fairly distributed" (USDOT: FHWA, 2006).

Today, 20 years after the issuance of Executive Order 12898, the literature documents MPOs' attempts to evaluate environmental justice and equity effects in transport plans as well as various challenges to such analyses. Sanchez and Wolf (2005) conducted a survey of 50 large MPOs and found that several used geographic analysis tools to map the location of transport improvements and the spatial distribution of low-income and minority households to "illustrate the distributional equity of MPO plans" (p.12). For instance, the major MPOs in California evaluate the environmental justice effects of regional transportation plans and/or Sustainable Communities Strategies (SCSs) by quantifying changes in accessibility (e.g., distance and time by mode to access different destination types) experienced by disadvantaged groups by locations as simulated by their regional travel demand model. MPOs also use model and off-model data to estimate the percent of income consumed by transportation and housing costs. Such analyses are a start, but they do not fully capture the benefits and costs of new transport projects for low-income or minority populations dispersed geographically, over both the short- and long-term. These limitations include distortions arising from geographic and demographic aggregation, incomplete representation of modal travel time and cost (Klein, 2007; Duthie et al., 2007), and minimal representation of the role and impact of the transport system within the larger spatial economic system (Lucas et al., 2007).

We can use typical four-step and advance travel demand models to calculate the distributions of travel time and cost impacts of land use and transport plans. However, estimating the distributions of wider impacts on the economy – including wages, rents, productivity and/or changes in consumer and producer surplus – require models that include explicit representation of the transportation system and the spatial economic regional system. The integration of advance travel models and recent generations of land use models, such as PECAS, allows analysts to answer a broader range of questions about the economic and equity effects of transportation and land use plans and policies. These include demand for goods, services, labor, and space; cost of producing and purchasing goods and services; industry and labor transportation costs; wages by employment type; rents and values for housing and employment space by type; and consumer and producer surplus measures.

Theory and Evidence

In this section, we summarize the available research on gentrification and displacement, transit access and land values, and transit station areas. Currently, the authors are aware of no available study that directly assesses the effects of TODs (specifically, rather than transit areas) on gentrification, displacement, relocation, and travel behavior.

Gentrification and Displacement

Urban economic theory predicts that preference for a neighborhood by higher income groups will tend to increase rents or property values until lower income groups can no longer afford them – a process known as gentrification. As a result, lower income groups may relocate to less expensive areas, often further from employment centers (displacement). A limited number of studies examine this issue. Most counter the prediction of urban economic theory and find that lower income groups are more likely to stay in gentrified neighborhoods over a ten-year period (Vigdor, 2002; Freeman, 2005; Newman and Wyly, 2006; McKinnish et al., 2010; Gould and O'Regan, 2011). Only one recent study, conducted over a 20-year period, supports the prediction of gentrification on displacement. Waights (2014) finds that significant displacement of low-income renters occurs early in the gentrification process.

Transit Station Areas, Land Values, and Gentrification

Urban economic theory predicts that transit investments will increase property values (or rents) in neighborhoods in close proximity to stations. Among those who value it and are willing to pay for it, greater accessibility will increase demand for housing and property values. As a result, transit neighborhoods may be more likely to experience gentrification and displacement. Empirical evidence tends to support this prediction (Al-Mosaind et al., 1993; Landis et al., 1994; Cervero et al., 2002; Kilpatrick et al., 2007; Lin, 2002).

However, the magnitude of housing price increases can vary greatly (e.g., 6% to 25% in Cervero et al.'s 2004 literature review). Some studies also explore factors that may explain this variation. Debrezion et al. (2007) found that increases are greater around commuter rail stations compared to light and heavy rail stations. Other studies suggest that increases vary with income levels of neighborhood residents prior to the investment (Immergluck, 2009; Kahn, 2007; Hess and Almeida, 2007; Bowes and Ihlanfeldt, 2001; Gatzlaff and Smith, 1993). Another study found price increases in some years but not all years (Lin, 2002).

A limited number of studies examine the effect of transit station areas on gentrification and find mixed results. In some areas transit investments produce no significant change in resident household income levels, while in other areas income levels decline or increase

(Pollack et al., 2010). Chapple (2009) argues that although gentrification is not all that common (7.3% of Bay Area census tracts between 1990 and 2000), it most frequently occurs in transit station areas (83%). Kahn (2007) examines the relationship in 14 metro areas and finds significant relationships in some areas but not in others. Interestingly, "walk and ride" stations are more likely to gentrify than "park and ride" stations. Pollack et al. (2010) examines census data from 1990 to 2000 in 42 transit station areas in 12 metro areas and finds that gentrification is the most common outcome. Heres et al. (2014) also finds an increase in the income of residents in areas near transit stations following the opening of a new transit system in Bogota, Columbia.

METHODS

Sacramento PECAS Model

PECAS stands for Production, Exchange, and Consumption Allocation System. Overall, it uses an aggregate, equilibrium structure with separate flows of exchanges (including goods, services, labor, and space) going from production to consumption based on variable technical coefficients and market clearing with exchange prices. It provides an integrated representation of spatially distinct markets for the full range of exchanges, with the transportation system and the development of space represented in more detail with specific treatments. Nested logit models allocate flows of exchanges from production to exchange zones and from exchange zones to consumption zones according to exchange prices and generalized transportation costs (expressed as transportation utilities with negative signs). The model then converts these flows to transportation demands that are loaded to transportation networks in order to determine congested travel utilities for the next time-period. Exchange prices determined for floorspace types inform the calculation of changes in floorspace attractiveness thereby stimulating developer actions. The model represents developer actions at the level of individual land parcels or grid cells using a microsimulation treatment. The model simulates each year over time, with the travel utilities and changes in floorspace for one year influencing the flows of exchanges in the next year. The model includes current zoning rules and permissions, transition costs by space type, and developer fees.

The PECAS model creates the marginal new populations, households, employees, and floorspace in each year, while retaining most of these stocks from the previous year, in each zone. However, it does not identify and track individuals, households, and employees over time. As a result, we cannot identify displaced households over time, just the changes in households by income. Given the long time intervals involved in building rail stations, rezoning and building TODs, and the frequent normal household moving behavior, this method is adequate for studying gentrification and the displacement of low-income households. We do not identify people by race and ethnicity, as these characteristics are very difficult to project, given recent history where in most regions more non-Caucasian households seem to be moving into diverse census tracts. The high incomes of some non-Caucasian households (Asian) can also make spatial projection difficult. In this study, the PECAS model runs every year from 2014 to 2030.

Sacramento Travel Demand Model

The SACMET model is typical of an urban transportation system (UTP) model improved to meet the demands of air quality regulations in the 1990s. Developed in the late 1960s and early 1970s, the UTP determined the need for additional roadway lanes or segments to relieve traffic congestion. The model represents the effect of changes in travel time and/or cost on destination, mode, and route choice (depending on trip purpose and sub-model), change in transit accessibility on auto ownership and thus trip-making, and changes in the "walk- and bike-ability" of an area on mode choice. The mode choice sub-model represents a relatively wide range of choices including drive-alone, shared-ride, transit (walk and drive access), walk, and bike modes. The model's representation of geographic detail is relatively fine. The model uses detailed transportation networks (over 10,000 links) and over 1000 travel analysis zones. The travel model runs every 5 years and uses PECAS demographic inputs and PECAS uses the generalized cost of transportation from the model.

Economic Input-Output Lifecycle Assessment Model

The Sacramento PECAS outputs include forecasts of consumption and production activity within a comprehensive set of economic sectors. These outputs are in units of production and consumption dollars, employees, floorspace, and housing units and can serve as inputs to a lifecycle assessment model to evaluate the change in emissions that result from different transportation and land use scenarios. As part of a previous study (Rodier et al., 2012), the Economic Input-Output Lifecycle Assessment Model (EIOLCA), made publicly available by the Green Design Institute of Carnegie Mellon University, was run on outputs from an earlier version of the Sacramento PECAS model. The EIOLCA model uses input-output tables published by the Bureau of Economic Analysis within the Department of Commerce (DOC). Dollars spent within a specific economic sector (such as home construction) result in the producers of that sector taking a portion of their earned income and spending it to obtain critical inputs from other sectors (e.g., lumber, cement manufacturing, and pipe manufacturing) that supply its core value-added activity. These sectors in turn must spend on their inputs (e.g., oil, energy, and land) to produce inputs to the sector that they are supplying. The DOC input-output tables effectively map out this chain of activity to articulate how dollars spent within any given sector of the economy propagate through the rest of the economy. The resulting economic activity within each sector results in some quantity of energy spent and sector-specific emissions.

On-Road Emissions

On-road CO_2 emissions were estimated with EMFAC 2011SG (Ver. 1.1). This model uses loaded networks for the 2014 and 2030 horizon years (for morning, midday, afternoon, and evening periods).

SCENARIOS

Table 1 describes total population, households, employment, and transportation network attributes for 2014 and 2030. The 2030-year scenario represents a TOD scenario designed to reduce per capita vehicle miles traveled (VMT) and GHGs. However, there is considerable expansion of the roadway network over this time-period, especially high occupancy vehicle (HOV) lanes, in this plan.

Table 1: Description of Demographic and Transportation Network Attributes

	2014	2030	% change
Population	2,076,594	2,641,634	27.2%
Households	863,698	1,067,043	23.5%
Employment	1,019,893	1,233,934	21.0%
Light rail stations	97	126	29.9%
Bus routes	252	334	32.5%
Freeway and highway lane miles	2,290	2,400	4.8%
Arterial and collectors lane miles	9,118	10,122	11.0%
HOV lane miles	103	189	84.4%

Figure 1 is a map of the Sacramento region and show the traffic analysis zones within one mile of transit stations (hereafter, TOD areas).

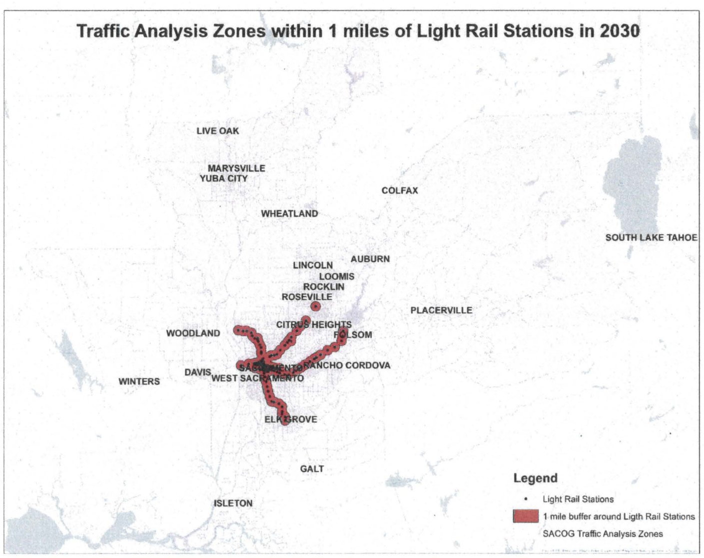

Figure 1: Map of the Sacramento Region and TOD Areas

Tables 2 and 3 describe the degree of land use intensification and mix of employment and housing from 2014 to 2030 in the TOD zones. The 2014 and 2030 comparisons include the land use in areas are currently TODs in 2014 and will become TODs by 2030. Total average zonal density is higher in the TOD zones than in the region and the difference from 2014 to 2030 is larger by a relatively large margin (28% to 99%).

Table 2: Average Zonal Density per Square Kilometer

Region	2014	2030	Difference
Population	995	1,221	226
Employment	763	891	128
Population and Employment	1,758	2,112	354
TOD	**2014**	**2030**	**Difference**
Population	1,511	1,801	290 (28%)*
Employment	1,581	1,836	255 (99%)
Population and Employment	3,092	3,637	545 (54%)

* Percentage changed from regional difference from 2014 to 2030.

We measure the mix of employment and housing from 2014 to 2030 within the one-mile TOD areas with an entropy index (see equation 1 below). Five different land use categories (n=5) are used, including single-family, multi-family, retail, medical, and education floorspace. The proportion of floorspace type *j* in each TAZ is P_j. The entropy index varies from zero to one (least to greatest land use mix). Table 3 shows that land use mix has increased in the one-mile TOD areas relative to all regional zones.

(1) Entropy Index = $-\sum_j \ln P_j \times (\frac{\ln P_j}{\ln n})$

Table 3: Average Zonal Land Use Mix (Entropy Index)

	2014	2030	% change
Region	0.22	0.21	-2.61%
TOD	0.21	0.33	61.38%

Income Categories

In this study, we use three aggregate income categories based on the 2015 Federal Poverty Guidelines (http://familiesusa.org/product/federal-poverty-guidelines). Table 4 defines these categories. The low-income category includes households below the 150% poverty line, the medium income category is below the 400% poverty line, and the high-income category is greater than the 400% poverty line. Household incomes are constant with respect to inflation for all model years, and so these income categories stay the same. They do not change, nominally, but the percentage of households in each category changes, according to the SACOG macroeconomic projections, based on higher-level state and national projections.

Table 4: Definition of Income Categories

Income	Federal Poverty Line	Household Size	Income
Low	< 150%	1-2	< $16,000
		3+	< $33,000
Medium	150% - 400%	1-2	$16,000 - $58,000
		3+	$33,000 - $82,000
High	> 400%	1-2	> $58,000
		3+	> $82,000

RESULTS

What is the change in population and housing in the TODs compared to the region from 2014 to 2030 by income group?

There are fewer people and households in the low-income group, as defined in this study, than in the medium- and high-income groups in both the region and TOD areas. See Table 5. The size of population and household growth from 2014 to 2030 is higher in the region than in the TOD areas. Growth is lowest for the low-income group and highest for the high-income group in both the region and in the TOD areas. Relative to population and household totals in the region, TOD areas have more low-income people and households than medium- and high-income groups. The disparity between the size of growth in the TOD areas and the region is lowest for the low-income group and higher for the high- and medium-income groups. In sum, it does not appear that low-income populations and households in TODs are in decline relative to regional totals over time and compared to medium- and high-income groups.

Table 5: Population and Households by Income Class

	Population			Households		
Region	**2014**	**2030**	**% Change**	**2014**	**2030**	**% Change**
Low	386,664	446,191	15%	161,578	182,286	13%
Medium	847,762	1,027,262	21%	363,055	428,265	18%
High	842,168	1,168,181	39%	339,065	456,492	35%
Total	2,078,608	2,643,664	27%	863,698	1,067,043	24%
TOD	**2014**	**2030**	**% Change**	**2014**	**2030**	**% Change**
Low	148,599	165,745	12%	61,962	67,349	9%
Medium	289,386	337,709	17%	127,355	144,554	14%
High	240,997	316,215	31%	100,463	127,813	27%
Total	678,982	819,669	21%	289,780	339,716	17%
TOD/Region	**2014**	**2030**	**% Change**	**2014**	**2030**	**% Change**
Low	38%	37%	-3%	38%	37%	-4%
Medium	34%	33%	-4%	35%	34%	-4%
High	29%	27%	-5%	30%	28%	-6%
Total	33%	31%	-5%	34%	32%	-5%

How does the distribution of population, households by income group in the TODs change over time in the TOD areas compared to that of the region?

The shares of low- and medium-income population and households are higher in the TODs relative to the region and the opposite is true for high-income shares. See Table 6. Over time, the share of population and households in the low- and medium-income groups declines in both the TOD areas and the region; however, the decline is lower in the TOD or approximately equal. The share of population and households in the high-income group increases over time, but the increase is greater or approximately equal in the TOD areas compared to the region. In sum, all income classes fair better or equal over time in the TODs relative to the region.

Table 6: Distribution of Population and Households by Income Class

	Population			Households		
Region	**2014**	**2030**	**% pt.**	**2014**	**2030**	**% pt.**
Low	19%	17%	-2%	19%	17%	-2%
Medium	41%	39%	-3%	42%	40%	-2%
High	41%	44%	3%	39%	43%	4%
Total	100%	100%	0%	100%	100%	0%
TOD	**2014**	**2030**	**%**	**2014**	**2030**	**%**
Low	22%	20%	-2%	21%	20%	-1%
Medium	43%	41%	-2%	44%	43%	-1%
High	35%	39%	4%	35%	38%	3%
Total	100%	100%	0%	100%	100%	0%

How do multi-family housing values and rents in TODs compare to the region over time and across income groups?

Overall, differences between regional and TOD average rent and owned value across income groups and over time are small. See Table 7. The relatively small geographic area of the region contained in the TODs accounts of a large share of total multi-family value and rents. Average owned (by resident) value per multi-family housing unit in the TODs relative to the region, is higher for low-income occupants and lower for medium income occupants, which in consistent with the distributions presented in Table 6. This disparity is greater for low-income occupants relative to higher income occupants. Average rent per multi-family housing unit in the TODs relative to the region, is equal to or somewhat higher for low- and high-income occupants and somewhat lower for medium-income occupants. Over time, average owned value per unit increases faster for medium- and high-income households relative to low- income households. Average rents decline somewhat over time for high-income households and increase somewhat for low and medium households.

Table 7: Share of Multi-Family Owned Value and Rented in TODs Relative to the Region from 2014 to 2030

	Low			Medium			High		
TOD/Region	**2014**	**2030**	**%**	**2014**	**2030**	**%**	**2014**	**2030**	**%**
Total Value Owned MF	54%	47%	-13%	47%	42%	-10%	51%	46%	-10%
Total Rents MF	50%	47%	-6%	49%	46%	-5%	53%	48%	-10%
Mean per Unit Value Owned MF	102%	103%	1%	97%	99%	2%	100%	102%	2%
Mean per Unit Rent MF	100%	102%	1%	98%	99%	1%	105%	101%	-3%

How does consumer surplus in TODs compare to the region over time and across income groups?

Total TOD consumer surplus accounts for about 28% of total regional consumer surplus across all income groups. See Table 8. Average household consumer surplus is higher in TODs relative to the region for all income groups and the margin varies by only one percentage point.

Table 8: Share of Consumer Surplus from 2014 to 2030 in TODs Relative to the Region

TOD/Region	Low	Medium	High	Total
Total CS	28%	28%	28%	28%
Mean Household CS	105%	104%	106%	105%

CS=Consumer Surplus

How do regional VMT and GHGs change over time?

There is a 21% increase in total VMT from 2014 to 2030. See table 9. However, on a per capita basis, VMT declines by about 5%. Without California's Pavley clean-car standard and the Low Carbon Fuel Standard (LCFS), total on-road GHGs would increase by about 23%, but per capita GHGs is reduced by -0.3%. With Pavley and the LCFS, total on-road GHGs decline by about 5% and per capita GHGs by -0.4%. The Economic Input-Output Lifecycle Assessment (EIOLCA) analysis using the full outputs from the PECAS economic and land development model, estimated a total increase (cumulative from 2014 to 2030) in GHGs of 218,362,429 (CO_2-e tons) from 2014 to 2030. Note that the GHG calculations used for this report are not the SB 375 tests that SACOG must do for their SCS.

Table 9: VMT, On-Road GHGs, and Lifecycle GHGs for 2030.

	Total			Per Capita		
Region	**2014**	**2030**	**%**	**2014**	**2030**	**%**
Total VMT	58,898,319.26	71,472,376.39	21.3%	28.36	27.06	-4.6%
On-Road CO_2 tons	35,455.43	32,717.71	22.9%	0.02	0.01	-0.3%
On-Road CO_2 tons (Pavley I + LCFS)	43,568.07	31,189.44	-4.7%	0.02	0.01	-0.4%
16 Year (2014 to 2030) CO_2e tons (EICOLCA)	218,362,429		-	-	-	-

In 2007, the California Air Resources Board adopted the Pavley clean-car standards to reduce GHG emissions from passenger vehicles. In 2009, ARB adopted a Low Carbon Fuel Standard (LCFS) to reduce the carbon intensity of vehicle fuel.

CONCLUSIONS

Communities throughout the U.S. are pursuing land use and transport plans that locate high density, mixed-use development near high quality rail and bus transit service (TODs). Their objective is to meet important community goals, such as economic development, reduced congestion, greater transportation choice, and improved public health. These plans may be critical to managing the growth in vehicle travel necessary to meet GHG reduction goals necessary to avoid the most devastating damage to human and natural systems from climate change. Increasingly, however, there is concern that TOD policies may have unanticipated consequences that are inequitable and could undermine GHG reductions.

The scenario simulated in this study increases the number of light rail stations by about 30%, bus lines by 33%, freeway lane miles by 5%, and HOV lane miles by 84%. We examine the plan's effect on population, housing, rents, and consumer surplus by location and income class over time and changes in travel behavior. We use the EMFAC emissions model with the travel behavior output from the model to measure changes in on-road vehicle GHG emissions over time. We use an economic input-output lifecycle assessment model with the yearly economic activity outputs from the Sacramento PECAS model to estimate total changes in upstream and downstream GHG emissions over time.

The following is a summary of the major study conclusions:

1. Average zonal population and employment density and land use mix is larger in the TOD areas relative to the region and the difference grows from 2016 to 2030 (by 54% and 61%, respectively).

2. In general, more low-income people and households live in TOD areas than other income groups compared to the region. The disparity between the size of growth in the TOD areas and the region is lowest for the low-income group and higher for the high- and medium-income groups. Compared to the region, the share of population and households in the TOD areas is higher for low and medium income groups and lower for the high-income group. Over time, the change these shares are consistent or differ by only one percentage point across income groups. These results do not suggest displacement of low-income groups in the TOD areas.

3. From 2014 to 2030, medium income households' mean rents move closer to their regional mean while low income and high income households' mean rents move above their regional mean. These differences are relative small and within the margin of model error. However, they could suggest some upward pressure on rents over time for low-income households, which could possible lead to displacement in

the future. In general, all regions should monitor changes in TOD rents over time and take steps ensure affordable low-income housing.

4. Total and mean household consumer surplus in TOD areas suggest that all income groups experience disproportionately positive and approximately equal benefits relative households in the region.

5. Total VMT and GHGs for on-road emission without California clear-car and low carbon fuel standards increase over time in the region, but per capita levels decrease.

In sum, over a 16-year time horizon, the land use and transportation scenario does reduce per capita VMT and GHGs. In 2030, there is no evidence of low-income displacement from TOD policies.

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