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Potential Economic Consequences of Local Nonconformity to Regional Land Use and Transportation Plans Using a Spatial Economic Model

MTI Report 10-10

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REPORT 10-10

POTENTIAL ECONOMIC CONSEQUENCES OF LOCAL NONCONFORMITY TO REGIONAL LAND USE AND TRANSPORTATION PLANS USING A SPATIAL ECONOMIC MODEL

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16. Abstract

To achieve the greenhouse gas (GHG) reduction targets that are required by California's global warming legislation (AB32), the state of California has determined that recent growth trends in vehicle miles traveled (VMT) must be curtailed. In recognition of this, Senate Bill 375 (SB375) requires regional governments to develop land use and transportation plans or Sustainable Community Strategies (SCSs) that will achieve regional GHG targets largely though reduced VMT. Although the bill requires such a plan, it does not require local governments to adopt general plans that conform to this plan. In California, it is local, not regional, governments that have authority over land development decisions. Instead, SB375 relies on democratic participatory processes and relatively modest financial and regulatory incentives for SCS implementation. As a result, it is quite possible that some local governments within a region may decide not to conform to their SCS. In this study, a spatial economic model (PECAS) is applied in the Sacramento region (California, U.S.) to understand what the economic and equity consequences might be to jurisdictions that do and do not implement SCS land use plans in a region. An understanding of these consequences provides insight into jurisdictions' motivations for compliance and thus, strategies for more effective implementation of SB375.

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EXECUTIVE SUMMARY

California led the United States by passing the first global warming legislation (AB32: The Global Warming Solutions Act). California is now tasked with reducing greenhouse gas (GHG) emissions to 1990 levels by 2020 and 80% below 1990 levels by 2050. Senate Bill 375 (SB375), commonly known as “California’s anti-sprawl bill’,“mandates regional GHG targets linked to land use and transportation plans (called Sustainable Community Strategies or SCSs). Thus, SB375 acknowledges the view that GHG reductions from the transportation sector can only be met by changing the way communities grow, switching from low-density auto-oriented development to compact transit-oriented development.

Although SB375 requires regions to develop SCSs to meet GHG goals, it does not require local governments to adopt general plans that are consistent with the land use plans included in SCSs. Instead, SB375 strengthens and places emphasis on a “bottom up” public participation process to enable the development of and support for land use and transportation plans that, not only meet the GHG goals, but also enable communities to meet goals related to affordable access to housing and economic opportunities. The bill also relies on incentives for implementation that include transportation funding and streamlining the California Environmental Quality Act.

This study was conducted to understand what the economic and equity consequences might be to jurisdictions that do and do not implement SCS land use plans in a region. An understanding of these consequences may provide insight into jurisdictions’ motivations for complying or not complying and, thus, strategies to improve jurisdictions’ compliance.

Using the Sacramento region (California, U.S.) as a case study, the 2035 build form (or floorspace) from the region’s land use and transportation visioning plan (the Preferred Blueprint Plan or PRB, which is treated as a straw SCS for the purposes of this study) and the business-as-usual scenario were input into the activity allocation module of the Sacramento spatial economic model (PECAS) along with the modal travel time and cost inputs from the Sacramento activity-based travel model (SACSIM).

The activity allocation module in PECAS allocates housing and employment activities into available built space based on prices for space and for every other commodity in each land use zone, including the transportation costs. The zonal activities then generate quantities of commodity flows between zones that are also influenced by transportation costs. Since the activity allocation model is based on the application of nested and additive logit theory, it represents the full composite utility (the economic benefit or consumer surplus in the case of household activities) of all the choices of where to locate, the quantity of interactions to undertake, and the transportation costs, prices, and opportunities for each of these interactions.

The application of the activity allocation model in PECAS enabled the simulation of the effects of non-conformity by a single jurisdiction with the regional land use and transportation vision (PRB/SCS) on the average cost of living for and economic benefit (or consumer surplus) to an average household (total and by income class) by geographic location (jurisdictions, groups of jurisdictions, and region). Four scenarios were constructed in which the effect of a jurisdiction’s non-conformity resulted in different combinations of centralization or decentralization of employment and housing in the region.

Table 1 below summarizes the overall region performance of the four scenarios. In this table, the cost of living includes housing and transportation costs; consumer surplus is the average total economic benefit for a household in the region (as described above); location equity identifies types of locations in the region where average consumer surplus declines; and income equity identifies household income groups that experience disproportionate losses as a share of income.

Table 1. Summary of Regional Performance

			Employment	
		Measures	Centralize	Decentralize
Housing	Centralize		Lincoln	El Dorado
		Cost of Living	↓	~=
		Consumer Surplus	↑	↓
		Locational Equity	↓↓ (non-conforming)	↓ (non-conforming)
		Income Equity	↑	↓↓
	Decentralize		Yuba	Sacramento City
		Cost of Living	↑	↑↑
		Consumer Surplus	↓	↓↓
		Locational Equity	↓↓ (conforming)	~=
		Income Equity	↓	↓↓

Note: ↓ decline, ↑ increase, ~= approximately equal

As illustrated in the table 1, in the Lincoln scenario, non-compliance contributes to centralization of housing and employment and increases economic benefits for the average household in all jurisdictions in the region. However, residents in more centrally located or urban jurisdictions benefit relatively more than outlying or rural jurisdictions due to geographical disparities in transportation costs. In rural areas, these disparities may have negative economic consequences for lower income residents because transportation costs compose a more significant share of their budget relative to higher income groups.

In the remaining three scenarios in which employment and/or households decentralize, the cost of living largely increases and consumer surplus decreases for the average regional household. In the Sacramento City scenario, where non-conformity contributes to decentralized housing and employment, average economic losses appear to be distributed, relatively evenly on average, across jurisdictions. However, as a share of household income, residents in the highest income group appear to experience losses that are relatively smaller than the lower income groups.

In the Yuba scenario, where housing decentralizes and employment centralizes, economic losses are an order-of-magnitude lower in Yuba than in conforming jurisdictions. Households in the highest income group in Yuba actually benefit by trading higher transportation costs for lower-cost luxury homes.

In contrast, in the El Dorado scenario, where employment decentralizes and housing centralizes, the non-conforming jurisdiction experiences economic losses due to high housing rents and transportation costs while the conforming jurisdictions benefit when increased transportation costs are offset by reduced rents (due to the greater housing supply).

The economic and equity consequences of an individual jurisdiction's failure to comply with the PRB/SCS, as simulated by the PECAS spatial economic model in the Sacramento region, provides deeper insight into the potential pitfalls, and thus suggests strategies for more effective implementation of SB375.

1. In the development of SCSs that increase the centralization of activities in a region, care should be taken to understand the particular transportation needs of rural and low-income residents. If plausible inequities are identified, then creative policy instruments should be developed to redress these inequities, without further encouraging decentralizing.

2. The potential risk of economic losses to communities that continue business-as-usual development patterns, as illustrated in the scenarios in which employment and/or household decentralized, should be explicitly addressed in the development and communication of SCSs. These include higher costs for business operations, which may diminish regions' ability to compete economically with other regions both nationally and internationally.

3. The possibility that non-conforming jurisdictions may benefit at the expense of other jurisdictions and the overall regional economy, as the Yuba scenario illustrated, suggests that the distribution of jurisdictional benefits should be explicitly examined and addressed in the development of SCSs.

4. The actual implementation of SB375 by local jurisdictions should be carefully monitored. If non-conformity becomes a significant problem, then the legislature should consider amending SB375 to include strong sanctions for non-compliance.

The study begins with background on the regional land use and transportation planning in the Sacramento region. Next, the relevant modeling literature is reviewed. The methods of analysis are then described including the application of the PECAS spatial economic model. This is followed by a discussion of the simulated scenarios and their results. Finally, conclusions are drawn from the results of the study.

I. BACKGROUND

SACRAMENTO REGION

In its 2004 “Blueprint Project,” the Sacramento Area Council of Governments (SACOG) established the basic participatory planning process that was later codified by SB375. This public participation planning process resulted in the creation of a common land use and transportation vision for the Sacramento region. A total of over 5,000 residents contributed to the effort to develop a plan to cope with an estimated doubling of the regional population by 2050 and the increasing air pollution that would result from current land-use patterns, transportation funding levels, and transportation investment priorities.

The outcome of this effort, the Preferred Blueprint (PRB), articulated levels and locations of redevelopment and new transit-oriented development linked to a list of preferred transportation projects. This was contrasted with the Business-As-Usual (BAU) plan that continued past land use and transportation trends, and lead to a larger area of urban coverage and lower densities of urban development relative to the PRB. The U.S. Environmental Protection Agency (EPA) permitted SACOG to use land use and transportation components of the PRB plan in their official regional transportation plan alternative and the BAU in their no-build scenario as part of their air quality conformity process.

Currently there are approximately one million jobs and 800,000 housing units in the Sacramento region. This is forecasted to grow by an additional 535,000 jobs and 433,000 housing units by 2050. The location and intensity of household and employment location is illustrated in figure 1 for both the BAU and the PRB scenarios. In the BAU scenario, transportation investments continue to focus on highway expansion and land development persists in low-density, auto-dependent patterns. In the PRB scenario, transportation investment emphasizes improvement in transit, sidewalks, and bike lanes over highway expansion. Significant housing development is located near existing employment centers near downtown Sacramento, Rancho Cordova, and Roseville to improve the overall jobs to housing balance and concentrate growth near high quality transit service. As documented in figure 2, there is a relatively large increase in multi-family dwelling units (10.9%) and decrease in luxury single-family dwelling units (6.3%); however, total single-family dwelling units decline by only 1.9%. The PRB scenario assumes that local jurisdictions honor their Blueprint Plan commitments through local land use controls.

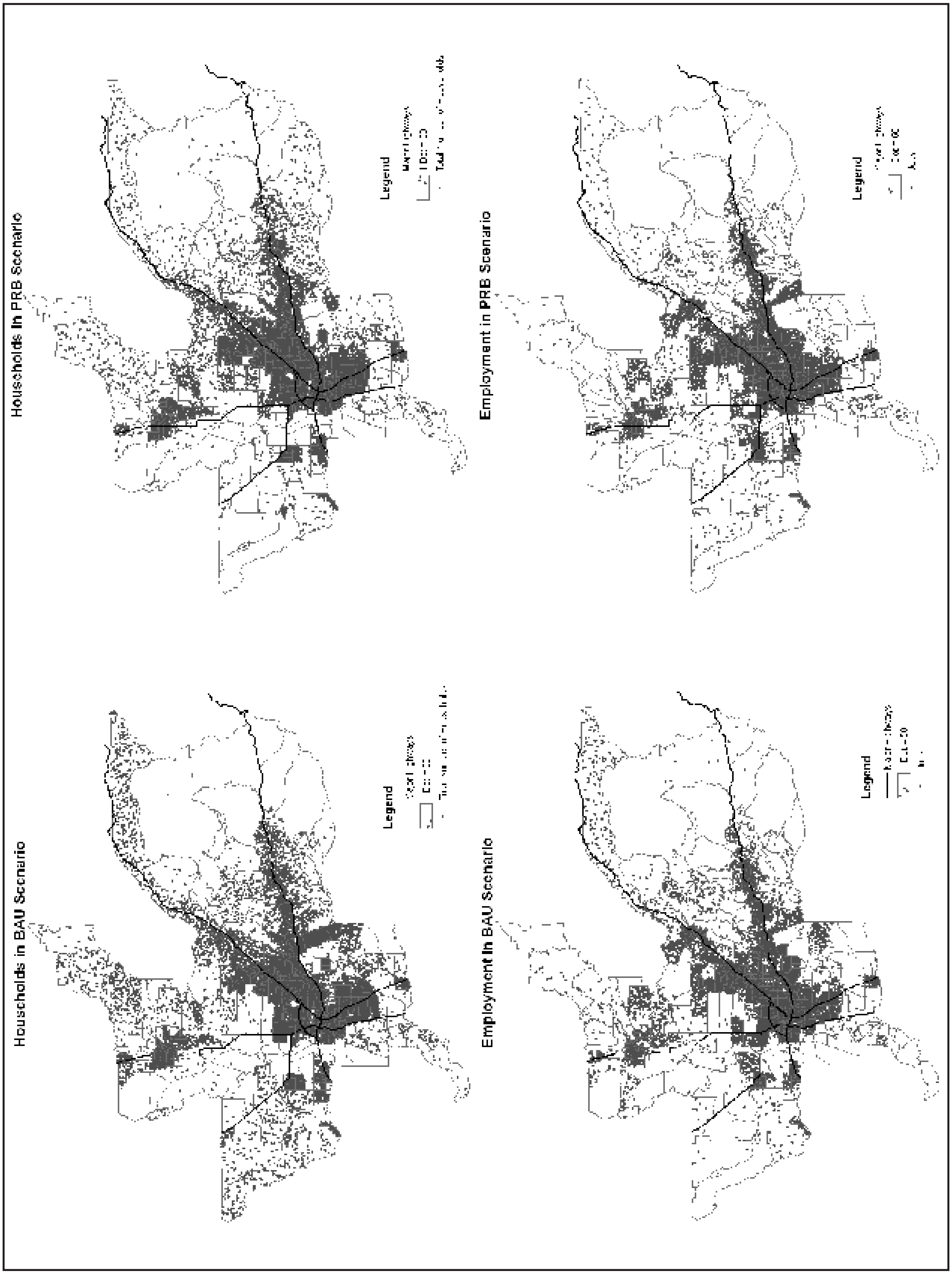

Figure 1. Household and Employment Location in the BAU and the PRB Scenario

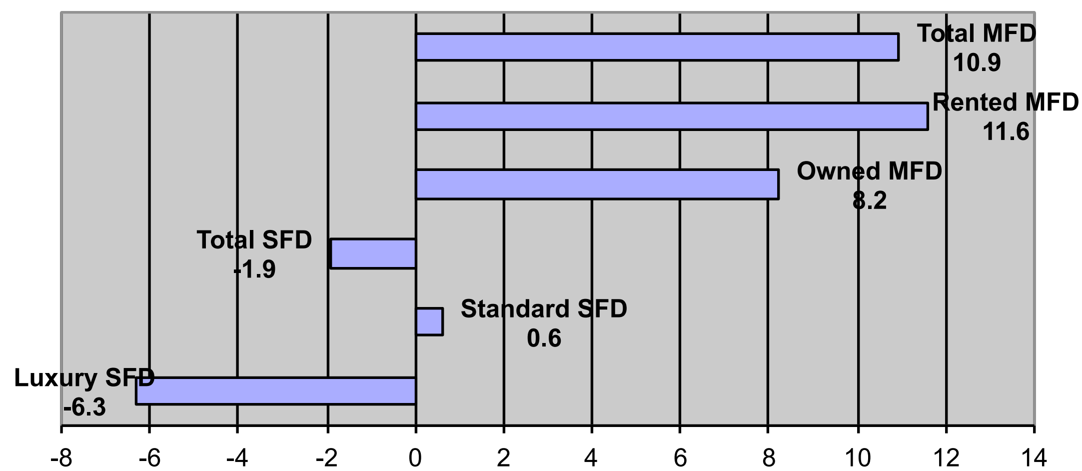

Figure 2. Percent Change in Dwelling Units by Type Between the BAU and the PRB

Note: SFD=single family dwelling units; MFD=multi family dwelling units

LITERATURE REVIEW

A number of U.S. studies use either aggregate travel demand models and, more recently, disaggregate activity-based travel models for regions and/or cities to examine the economic and equity effects of transportation and land use policies on the travel time and cost of travel for population segments by available modes, origin and destination locations, and trip purposes. Several studies use an aggregate travel demand model for the Sacramento region to measures total consumer welfare and consumer welfare by household income classes for transit, land use, and pricing scenarios[1] and in the Washington, DC area for gas tax policy scenarios.[2] Activity-based models can calculate the distribution of travel time and cost effects across a broader range of household and individual socio-demographic characteristics. Deakin and Harvey[3] develop an early activity-based model (STEP) that is used to evaluate the distributional effects of auto pricing policies in the major regions of California. More recent versions of the STEP model are applied in equity studies in Baltimore, Maryland and Las Vegas.[4] Most recently, the San Francisco activity-based travel model is used to evaluate the distribution of travel time savings from a proposed transportation plan among specific communities of concern.[6]

Other studies use aggregate land use and transportation models, which allow a partial representation of the spatial economy and an aggregate treatment of space use and development, to simulate the economic and equity effects of land use and transportation policies. Through linkages with a travel model, these models can represent the effect of changes in the transportation system on the allocation of activities and development in the built environment, which can then influence travel behavior. Economic and equity measures from these models typically include the travel time and cost effects of policies as do those from travel models. However, the travel time and cost effects are more inclusive in these studies because they include the trade-off between location decisions and travel time and cost. In the U.S., such studies use the MEPLAN framework in Sacramento[6] and the LUSTRE model in Washington, DC.[7] Internationally, such models are used for analyses in regions and cities in the United Kingdom[8] and in Europe.[9]

Both activity-based models and aggregate land use models can be used to calculate the distributions of travel time and cost impacts. But calculating 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 the transportation system and the rest of the spatial economic system.[10] The integration of activity-based models and recent generations of land use models, such as PECAS, allow 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 (household by household income class) and producer surplus measures.

In a previous study for the Mineta Transportation Institute,[11] the wider range of economic and equity measures available from such a spatial economic model is illustrated through the partial implementation of the Sacramento PECAS model. The 2035 land uses for the PRB and BAU scenarios generated from the Blueprint visioning process were input into the activity allocation module of the PECAS model along with network travel time and cost inputs generated from the Sacramento activity-based travel model (SACSIM) for each scenario. The current study expands the application of the Sacramento PECAS model and the PRB and BAU scenarios to consider the possible economic and equity effects of non-conformity by an individual jurisdiction on the region as a whole and on other jurisdictions that do conform. The authors were unable to find other published literature or reports that included similar economic and equity measures related to localized decisions to violate a regional land use plan. Two studies were conducted that employed the UrbanSim model, which is an advanced microsimulation land use model that captures the behavior of individual agents and at fine levels of geographic resolutions, to investigate localize employment decentralization in Amsterdam, The Netherlands and Tel Aviv, Israel;[12] however, the economic effects were largely confined to change in land values.

II. METHODS OF ANALYSIS

THE PECAS MODEL OF SACRAMENTO

In this study, the activity allocation module of the PECAS model for the Sacramento region is used to explore the distributions of impacts from the PRB scenario relative to the BAU scenario for the year 2035. PECAS is a generalized approach for simulating spatial economic systems. It is designed to provide a simulation of the land use component of land use transportation interactive modeling systems.

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.

Flows of exchanges from production to exchange zones and from exchange zones to consumption are allocated using nested logit models according to exchange prices and transportation generalized costs (expressed as transportation utilities with negative signs). These flows are converted to transportation demands that are loaded to transportation networks in order to determine congested travel utilities. Exchange prices determined for space types inform the calculation of changes in space attractiveness thereby simulating developer actions. Developer actions are represented at the level of individual land parcels or grid cells using a microsimulation treatment. The system is run for each year being simulated, with the travel utilities and changes in space for one year influencing the flows of exchanges in the next year.

BASIC MODEL SYSTEM MODULES

PECAS includes two basic modules that are linked together with two other basic modules to provide a representation of the complete spatial economic system. The set of four basic modules includes:

- Space Development module (SD module): This is one of the two PECAS modules. It represents the actions of developers in the provision of different types of developed space where activities can locate, including the new development, demolition, and re-development that occurs from one point in time to the next. This developed space is typically floorspace of various types and is called “space” in the PECAS framework.

- Activity Allocation module (AA module): This is the other of the two PECAS modules. It represents how activities locate within the space provided by developers and how these activities interact with each other at a given point in time.

- Transport Model (TR module): This is one of the “non-PECAS” modules. It represents the transportation system connecting locations, including at a minimum a transportation network, the transportation demands that load onto this network (as a result of the economic interactions represented in the AA module) and the congested times and costs for interactions between locations arising from the loading of these demands.

- Economic Demographic Aggregate Forecasting Model (ED module): This is the other of the “non-PECAS” modules. It is some form of model or approach used to develop aggregate economic forecasts for the study area being modeled. Typically, these forecasts include projected numbers of households or population by category and employment by type (as indications of expected economic activity) for specific points of time in the future. This model or approach may be able to adjust its forecasts in response to information from the AA and SD modules, as is represented in the descriptions included here, or it may provide a static set of forecasts. It may even be the case that there is no model per se that is available, merely the forecast values for the study area. It is also possible to use an extended form of the PECAS AA module to develop such aggregate forecasts by making some specific assumptions about the relative contributions to the study-area economy from inside and outside the study area. For the descriptions included here, all of these possibilities are included in the single “ED module” designation that is used.

The four basic modules listed above are linked together with information flows as shown in figure 3. This linked system works through time in a series of discrete, fixed steps from one point in time to the next, with the AA module running at each point in time and the SD module considering the period from each point in time to the next. In general, the fixed steps can be of any duration, but one-year time steps are recommended since they allow an appropriately quick response of land developers in the SD module to the space prices established in the AA module.

Ideally, the transportation model (TR module) used to calculate the congested travel times and associated transportation utilities is run for each year, after the AA module has been run for that year. If the overall model run time is too long and travel conditions are relatively stable, the TR module can be run less often to save computation time.

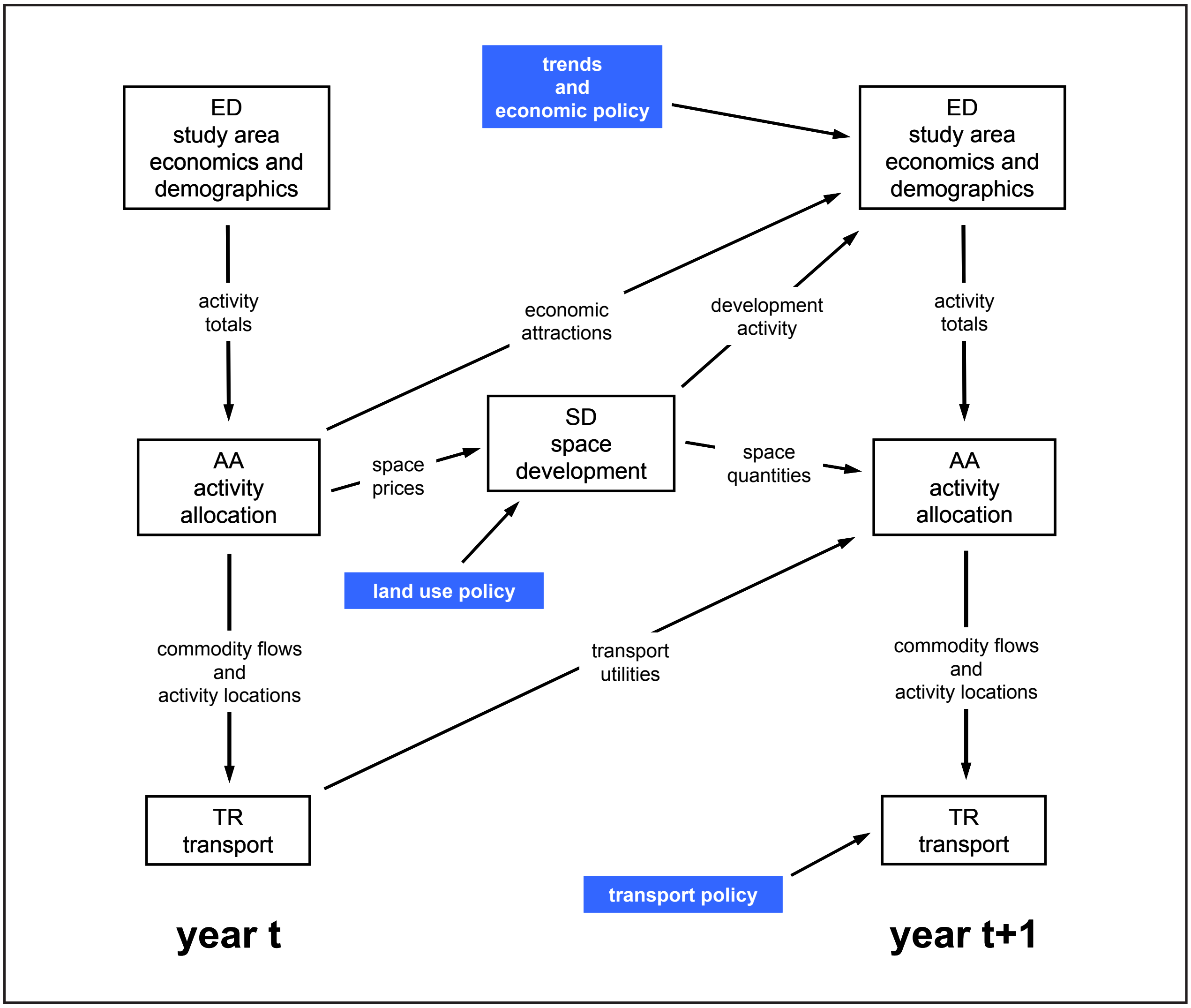

Figure 3. Modules and Information Flows Simulating Temporal Dynamics

The study area is organized into a set of land use zones (LUZs). In the AA module activities locate in these zones and commodities flow between them. Ideally these zones match the transportation zones (TAZs) used in the TR module or are aggregations of whole numbers of adjacent TAZs. The connectivity among the LUZs is based on the representation provided by the TR module, where the TR module establishes congested network times and costs and associated transportation utilities that the AA module uses in its consideration of the interactions between the LUZs in the next time period.

The land in each LUZ is further partitioned into smaller cells or parcels. The parcels can correspond to actual legal parcels or portions of legal parcels. The cells can be formed by superimposing a grid pattern over the land. The term “parcel” is used to refer to both cells and parcels in the descriptions below. In the microsimulation version of the SD module, developed space (called “space”) is located on these parcels, with only one type of space on a given parcel, and the total quantity of each type of space in the LUZs is the sum of the quantities on the parcels in the LUZs.

When an activity in the AA module is located in a zone, it consumes space in the zone, at rates consistent with the production technology or technologies it is using in the zone. Land is used in the provision of the space in the zone as an input to the development process, as represented in the SD module.

ACTIVITY ALLOCATION MODULE

The AA module is an aggregate representation. It concerns quantities of activities, flows of commodities and markets with aggregate demands and supplies and exchange prices. Activities are located in LUZs. Activities produce commodities and then transportation and sell these commodities; they also consume commodities after buying them and transporting them. There are different types of activities, including industrial sectors, government and households. Activity quantities can be measured in values (e.g., dollars of business repair industrial activity) or numbers (e.g., number of households with high income and two or less persons). The AA module allocates the study-area wide quantity of each activity among the LUZs as part of its allocation process.

Commodities flow, at specific rates, from where they are produced to where they are exchanged (from seller to buyer) and then flow from where they are exchanged to where they are consumed. Commodities are grouped into categories, including different types of goods and services, labor, and space. Commodities other than space in general flow across zone boundaries. Space is restricted in that it is “non-transportable” and must be exchanged and consumed in the LUZ where it is produced, which means that the space commodity categories receive some special additional treatments in PECAS as described further below. Commodity flows are measured in values per unit time (e.g., dollars of management services per year) or numbers per unit time (e.g., tons of coal per month). The movement of these flows of commodities from where they are produced to where they are consumed is the economic basis for travel and transportation in the modeling system. It is the travel condition—the distances, costs, times and associated (dis)utilities by mode—for the movement of these commodities that results in the influence of the transportation system on the interactions among activities and the attractiveness of locations for activities. The AA module allocates the flows of commodities from production location LUZ to exchange location LUZ and from exchange location LUZ to consumption location LUZ, and finds the corresponding set of prices at the exchange location LUZ that clears all markets, as part of its allocation process.

Activities produce commodities and consume commodities in the production process according to the technology they use. More specifically, an activity quantity in a given LUZ produces commodities at specific rates per unit of activity and consumes commodities at specific rates per unit of activity according to the technology being used by the activity. One or more “technology option” alternatives are defined for a given activity. Each of these technology options is a specific vector of production and consumption rates for different commodities per unit of the activity, representing a particular technology option for the production process available to the activity. The AA module allocates the quantity of the activity in each LUZ among these “technology options” as part of its allocation process.

The allocation process in the AA module uses a three-level nested logit model with a nesting structure as shown in figure 4.

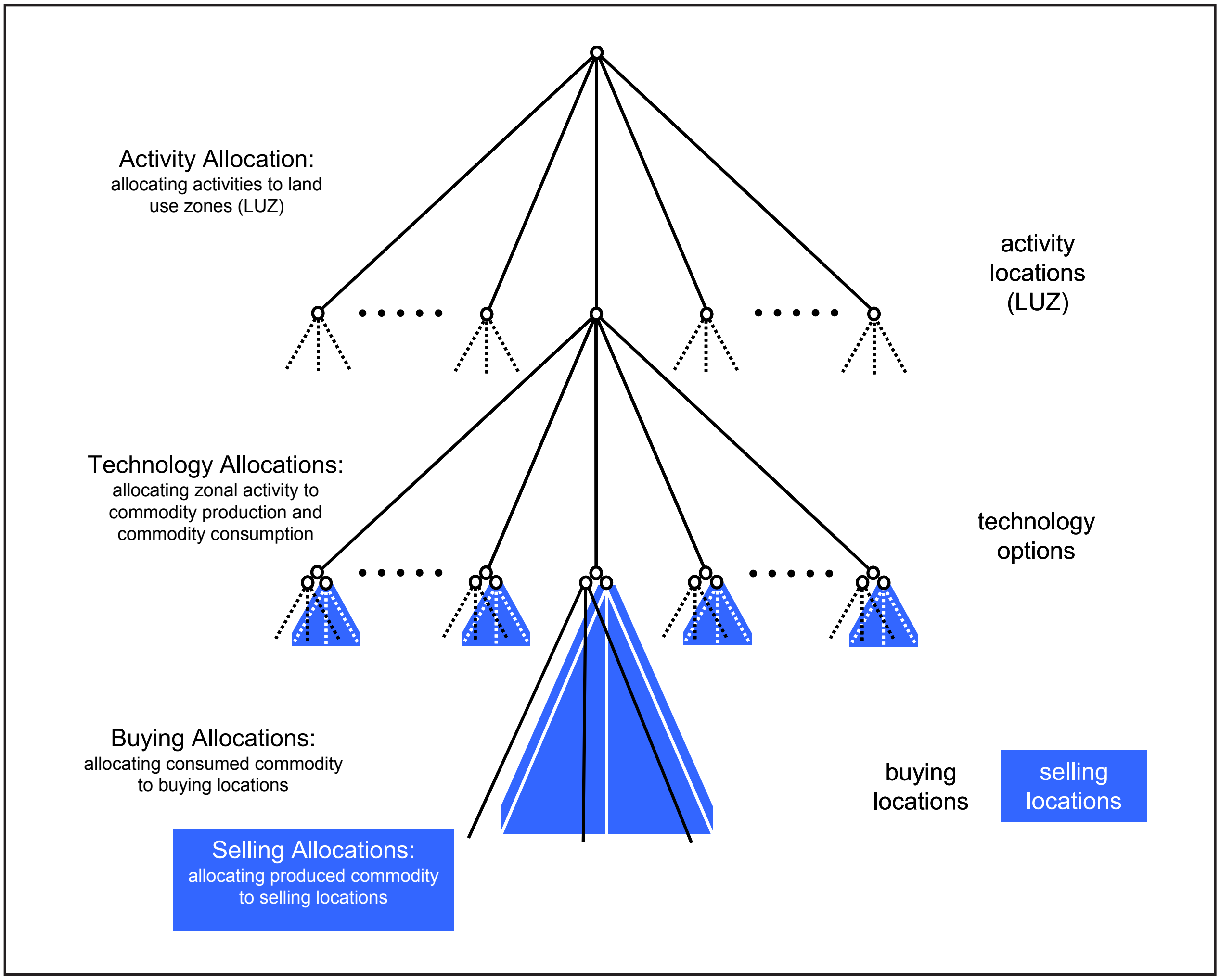

Figure 4. Three-Level Nesting Structure Used in AA Module Allocations

At the highest level of the nesting structure, the study-area total quantity of each activity is allocated among the LUZs. At the middle level, the quantity of each activity in each LUZ is allocated among the available technology options. At the lowest level, there are two logit allocations for each commodity in each LUZ. The first is an allocation of the produced quantities among the various exchange locations where they are sold to other activities. The second is an allocation of the consumed quantities among the various exchange locations where they are bought by other activities.

At the lowest level, the utility of each exchange location alternative is influenced by the price at the exchange location and the characteristics for transporting the commodity to or from the exchange location. The composite utility values from these two lowest-level logit models are called the “buying utility” and the “selling utility” for the commodity in the LUZs. They are used as the transport-related inputs in the middle-level for allocating the activities in the LUZs among the relevant technology options. The composite utility value for the range of technology options considered at the middle-level for an activity in a LUZ is part of the location utilities used at the highest-level.

The spatial aspects of the AA module allocation process are illustrated in figure 5. Buying and selling allocations link through the exchange locations to establish commodity flows from production to consumption locations in the LUZs.

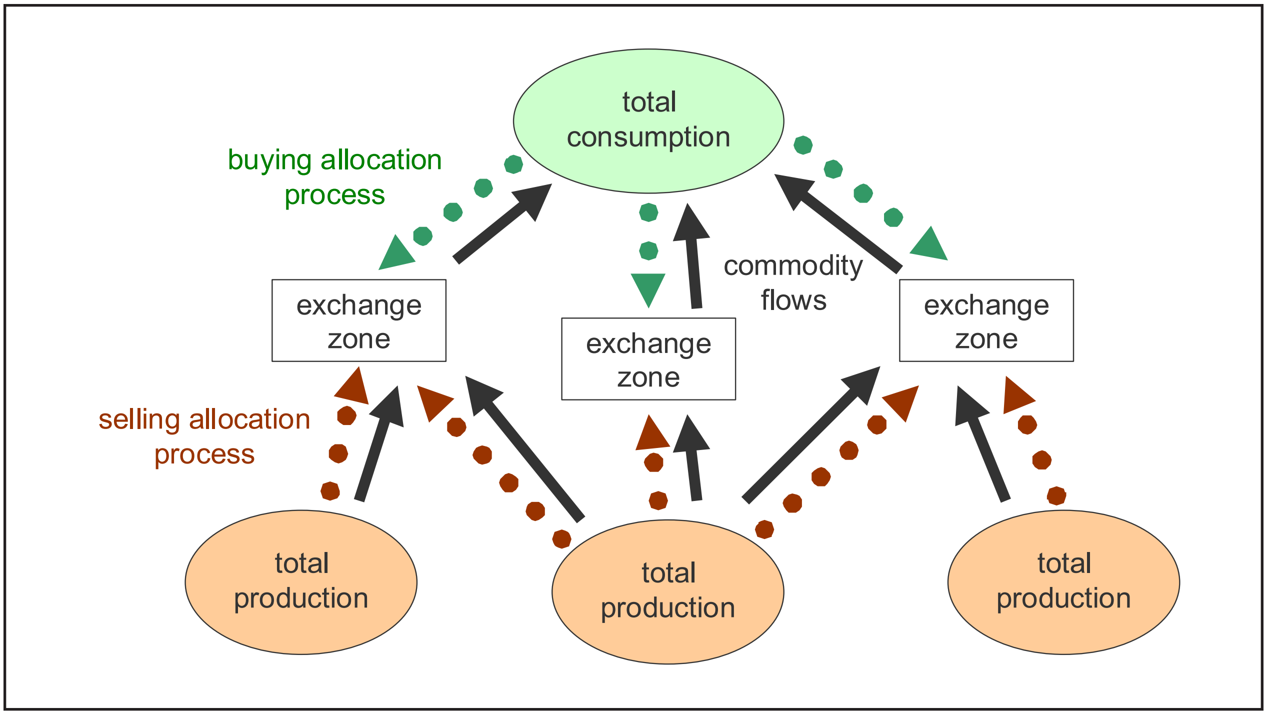

Figure 5. Buying and Selling Allocations Resulting in Commodity Flows from Production Zone to Consumption Zone via Exchange Location

The exchange locations are location-specific markets for commodities, where sellers sell commodities to buyers. Prices are established at exchange locations so that the quantity bought equals the quantity sold—thus the spatial allocation procedure in the AA module assumes short-run market equilibrium in commodities.

Activity Allocation Utility Equation

Since AA is based on random utility theory, it is based on a “utility function” describing the attractiveness of each option implied in figure 5. For one unit of activity type $\alpha \in A$, where A consists of the full set of types of activity under consideration, including households, business establishments, and other institutions, consider the joint choice of:

- Location, $l \in L$, that is the home location for the unit; being residential location for households, or establishment location for business establishments and other institutions (the top level of figure 5);

- Technology Option, $p \in P^{\alpha}$, described by a set of technical coefficients: $\alpha_p = \{\alpha_{p1}, \alpha_{p2}, ... \alpha_{pn}, ..., \alpha_{pN_p}\}$ and a corresponding list of commodities: $c_p = \{c_{p1}, c_{p2}, ..., c_{pn}, ..., c_{pN_p}\}$, each $c_{pn} \in C$. Each α_{pn} describes how much of commodity c_{pn} is produced (or consumed, if α_{pn} is negative) per unit of activity α, with indices n from 1 through N_p. P^{α} is the set of allowed Technology Option alternatives for activity α (the middle level of figure 5); and

- Exchange location, $e_n \in E_c$ for each commodity c_{pn} produced or consumed, being the choice of where to purchase, sell (or otherwise exchange as is the case for unpriced commodities) the quantity $|\alpha_{pn}|$ (the bottom level of figure 5).

The utility of this joint choice is given by:

$$U^{\alpha}_{lpe_1e_2 \cdots e_n} = V^{\alpha}_l + \varepsilon^{\alpha}_l + V_p + \varepsilon_{lp} + \sum_{n=1 \cdots N} |\alpha_{pn}| s_{pn} \left(V_{e_n l} + \varepsilon_{e_n lp} \right) \quad (1)$$

where:

V^{α}_l = the measurable component of utility associated with the location l and activity α

ε^{α}_l = a random component of utility associated with location l and activity α

V_p = the measurable component of utility associated with the technology option p

ε_{lp} = a random component of utility associated with the technology option p and location l

α_{pn} = the technical coefficients associated with technology option p as described above

s_{pn} = scaling adjusting associated with technical coefficient α_{pn} (non-negative and usually 1.0)

$V_{e_n l}$ = the measurable component of utility associated with exchanging the commodity c_{pn} associated with α_{pn} in exchange location given location l and technology option p

$\varepsilon_{e_n lp}$ = a random component of utility associated with exchanging the commodity c_{pn} at exchange location e_n given activity location l and technology option p.

The terms V_p and V^{α}_l are normally established in calibration, and do not change between years or between scenarios. Thus core policy-sensitivity of the model is in the $V_{e_n l}$ terms. Each of the $V_{e_n l}$ terms contains three sub terms:

- the cost of transporting commodities to or from the exchange zone,
- the prices of commodities in the exchange zone, and
- the relative size of the exchange zone.

Since prices are determined endogenously to clear the spatial markets, the dominant policy-related inputs to AA involve transportation costs and measures of zone size (normally quantities of space from SD), and the total quantity of each activity specified as a policy control total to be allocated according to equation 1 and figure 5.

See Hunt and Abraham[13] and Abraham and Hunt[14] for complete documentation of the theoretical formation and calibration methods of the PECAS model.

IMPLICATIONS

The intention of this study was not to forecast built-form and land use patterns, but rather to use the AA module of PECAS to evaluate patterns of built-form. Since the AA module is based on rigorous application of nested and additive logit theory, the top level expected maximum utility measure (the "logsum") at the top of figure 5 is a representation of the full composite utility (the consumer surplus in the case of household activities) of all the choices of where to locate, the quantity of interactions to undertake, and the transportation costs, prices, and opportunities for each of these interactions. Equation 1 is the utility of one particular option in the model regarding the choice of location, technology, and exchange locations. The expected maximum utility of choosing from amongst all the options of location, technology, and exchange location options provided by the built-form and transportation system is calculated by the activity allocation module and is available as an output benefit measure for each activity in the model.

For households in the Sacramento model in particular, the top level expected maximum utility takes into account the transportation costs for all of the households' interactions, the relative prices for every category of good, service, labor, and housing, as well as the willingness and ability of households to shift their location, their housing type, their occupation, and the destination of all of their trips. Benefits of increased opportunities are considered and weighted against transportation costs and other costs in this output measure from PECAS: if a policy or scenario reduces opportunities at any level of figure 5, costs may be reduced (because opportunities to spend money or travel time have been reduced), but benefits will also be reduced. Benefit calculation with transportation models alone, or with transportation models with land use models which are less rigorously consistent, can fail in this aspect: for instance closing down congested roads. The PECAS model allows this type of consistent rigorous analysis using random utility theory applied consistently to spatial choices for both supply and demand of goods, services, labor, and space in a complex economy.

This study uses the PECAS AA module to evaluate built-form scenarios and transportation scenarios. A transportation demand model was used to forecast transportation level of service. The SD model was not used in this study; as a result the input to the scenario is not a set of policies designed to shape future built-form and land use, but rather a specific future configuration of built-form. AA was used to allocate quantities of industry and households into the assumed space, with AA generating prices for space in each land use zone along with prices for every other commodity in each land use zone.

Calibration of the PECAS Activity Allocation Module

Calibration of the PECAS model has been ongoing as part of SACOG's model improvement program.[15] However further calibration is always possible given additional data and additional resources, especially in the case of PECAS because its scope is very deep, covering the whole of the spatial economy.

Additional calibration efforts were performed that were specific to the benefit analysis. Transportation cost functions, which translate travel model zone-pair travel attributes into disutility measures for each commodity in PECAS, were refined using improved data from the travel models, wage data by occupation, and from goods movement studies. The commodity flow distances were calibrated to trip length information, to establish the logit dispersion parameter in the models of buying or selling for each commodity. These dispersion parameters control the random term in the flow allocation (they are inversely related to the standard deviations of the $\varepsilon_{e_n lp}$ terms in equation 1). It is important to establish these parameters before undertaking benefit analysis, because they establish the value associated with variety in each commodity (recall that the other terms at this level of the model reflect price, transportation cost/disutility, and zone size). In the case of commodities with low dispersion parameters, additional opportunities for interaction are very valuable, even if they are poorly priced or a long distance away.

The choice model of household lifestyle (the middle level of figure 5, for household activities) was calibrated based on observed patterns of behavior from the U.S. Census Public Use Microsample (PUMS). This established the tendency of certain types of household to use certain types of housing and make certain types of labor, and the willingness (and/or the ability) to shift occupation and housing depending on conditions. Dispersion parameters for the higher level choices in figure 5 were refined with the help of the additive logit theory in Abraham and Hunt[16] which was not available when the Sacramento PECAS model was first developed.

Other elements of the model that were further calibrated include the treatment of imports and exports (more explicit in quantity and direction than in Abraham et al.), and the floorspace short-term supply function (which allow large vacancy rates if space demand in any zone is uncharacteristically low).

See Abraham et al.[18] for a description of the Sacramento PECAS model, its initial calibration and its planned ongoing calibration. It describes how the make and use coefficients (the α_{pn} in equation 1) were established for the various activity-commodity combinations from economic "input-output" relationships and census data, the classification systems applied to determine the categories of activities, commodities, and land use zones (LUZs), the strategies for establishing both alternative specific constants for particular production options (p in equation 1) and location options (l in equation 1), and strategies for calibrating the parameters controlling the size of the random components in equation 1.

Abraham et al.[19] also describes the development and calibration of the SD module, which would be used if land use policy over time were being used as an input to the model. (In this study land use patterns were being evaluated, not land use policy.)

2035 Input Data

SACOG provided employment, household, and land inputs for the BAU and PRB scenarios in the year 2035 that were used in their activity-based travel model (SACSIM) simulations. Employment and household locations were not used directly by PECAS, since one of PECAS's functions is to allocate employment and households. Rather, the expectations regarding employment and household locations from the two scenarios were used to develop the inputs on built-form (or floorspace) that would normally be provided by PECAS's space development module. A full version of PECAS, with both the space development and activity allocation models, would predict both the location of employment and households, and the location of built-form, with policy variables (such as zoning regulations) as inputs. A travel model, on the other hand, requires employment locations, household locations, and built-form as inputs. In this work, a middle road was taken, with built-form as an input, while employment and household locations are determined by the activity allocation model and thus output floorspace varied from input floorspace.

Zone-to-zone travel times and costs (generalized transportation costs or logsums) for all modes by trip purpose were obtained from the regional activity-based travel model (SACSIM) and were consistent with input floorspace for each scenario. Zone-to-zone travel times and costs were aggregated to PECAS zones using an approach that weighted values by trip frequency. Total economic growth by activity category was assumed to remain constant for both scenarios simulated with the PECAS AA model. Zone-to-zone travel times, but not distance traveled, were held constant in the transportation costs. As a result, travel costs may be underestimated somewhat if the land use changes in the scenarios increased congestion or overestimated is the land use changes reduced congestion. However, given the relatively small changes simulated in the scenarios the magnitude of this possible error is likely very small and not likely to change the order of magnitude and direction of change in the simulated results.

III. SCENARIOS

Scenarios were constructed in which all jurisdictions conform to the PRB with the exception of one jurisdiction. This jurisdiction follows the BAU development plan instead of the PRB. Four jurisdictions were selected for non-conformed to allow for the evaluation of the following changes pattern of regional development: (1) household and employment centralize, (2) housing and employment decentralize, (3) housing decentralizes and employment centralizes, and (4) housing centralizes and employment decentralizes. These four scenarios are described in table 2.

Table 2. Jurisdictional Scenario Type Descriptions

		Employment	
		Centralize	Decentralize
Housing	Centralize	BAU: Lincoln PRB: All other jurisdictions	BAU: El Dorado PRB: All other jurisdictions
	Decentralize	BAU: Yuba County PRB: All other jurisdictions	BAU: City of Sacramento PRB: All other jurisdictions

The changes in housing and employment land uses for the typical jurisdictional scenarios are shown in figure 6. These are consistent with the category definitions in table 1:

- In the Lincoln scenario there is a decrease in housing and a decrease in employment in an outlying jurisdiction that results in a centralization for housing and a centralization for employment;
- In the Sacramento City scenario there is a decrease in housing and a decrease in employment in a centrally-located jurisdiction that results in a decentralization for housing and a decentralization for employment;
- In the Yuba County scenario there is an increase in housing and a decrease in employment in an outlying jurisdiction that results in a decentralization for housing and a centralization for employment; and
- In the El Dorado scenario there is a decrease in housing and an increase in employment in an outlying jurisdiction that results in a centralization for housing and a decentralization for employment.

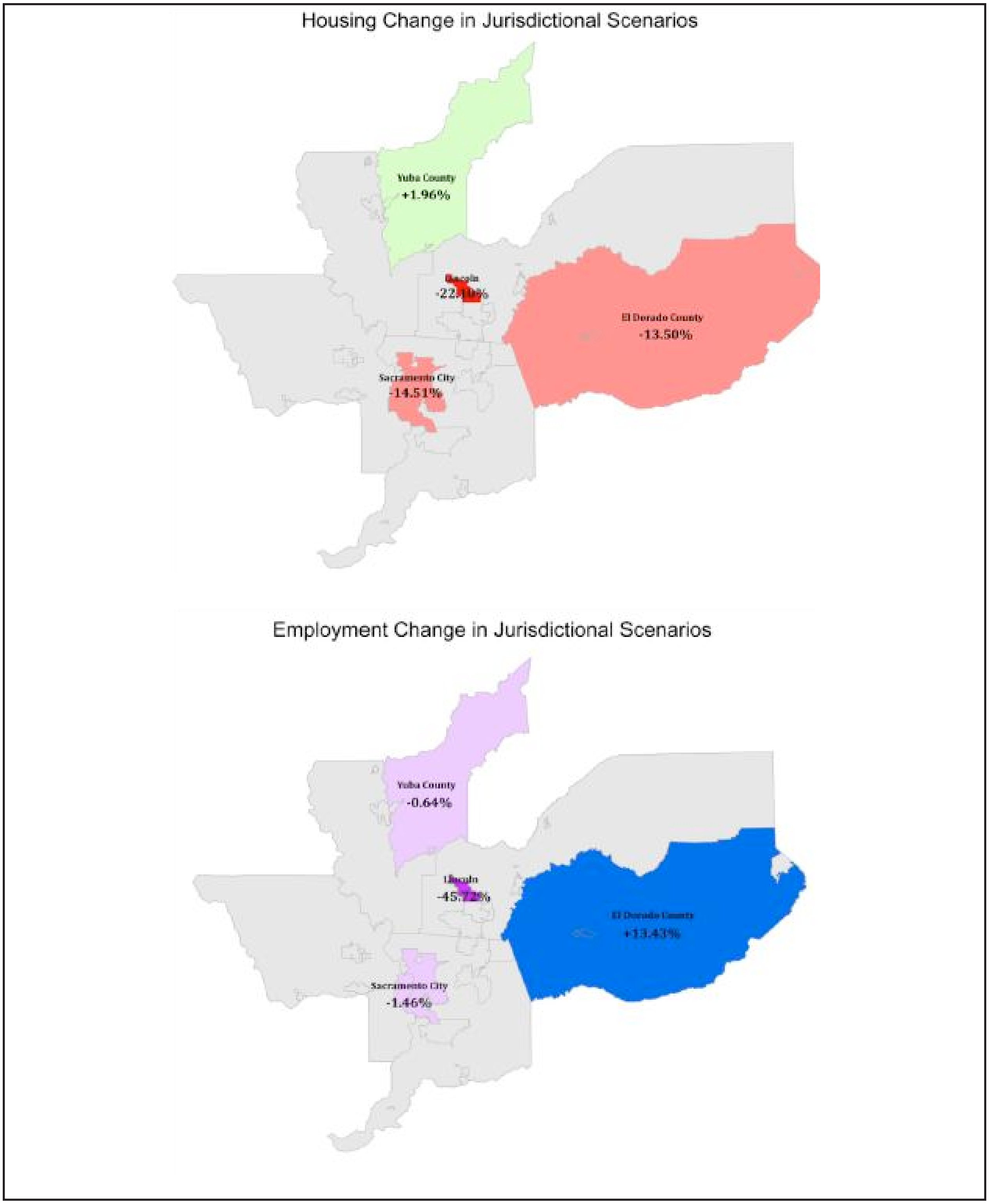

Figure 6. Household and Employment Changes in Jurisdictional Scenarios

The number of jurisdictions in the Sacramento region is 29, which is not large enough to generalize trends in equity and economic effects of non-conformity with the PRB within each of the four regional development types described above. In the second phase of this study, 150 non-compliance scenarios are developed in which randomly assigned jurisdictions develop 5%, 10%, 15% or 20% according to BAU. The larger number of cases in this study will allow for statistical analysis of likely equity and economic effects due to differences in jurisdictional non-conformity.

In each of the four scenarios, the total amount of industrial floorspace by sector and number of total housing units in the region were held constant at the levels established for the PRB scenario. However, the number of housing units by type (i.e., single-family and multi-family) were allowed to vary based on demand. The change in land use in each jurisdiction implementing the BAU scenario is allocated to zones representing the remaining jurisdiction. The allocation is weighted by relative share of zonal housing units and industry by sector in the PRB plan. As a result, zones with the more total land use supply obtain a larger share of the change in supply resulting from the implementation of the BAU plan in the jurisdiction. Simulations were conducted for different jurisdiction scenarios, each one with a different single jurisdiction switching from the PRB plan to the BAU plan.

Two scenarios were also simulated to investigate the impacts of regional housing needs allocation (RHNA) development patterns. The first scenario increased the amount of rented multi-family dwelling units in zones through which the region's light rail passes by 1%. The second scenario increased the amount of rented multi-family dwelling units in zones with high employment levels by 1% in order to simulate a jobs-housing balance policy. As with the jurisdictional scenarios, the total number of housing units in the region was held constant and the increase in rented multi-family housing units in the RHNA zones was subtracted from the non-RHNA zones using weighting approach described above. However, unlike the jurisdictional scenarios, the number of housing units by type was not allowed to vary based on demand.

IV. RESULTS

JURISDICTIONAL SCENARIOS

In the Lincoln scenario, housing and employment largely shift from the outlying Lincoln jurisdiction to more centrally located jurisdictions. Regionally, the number of lower-cost multi-family units increases somewhat relative to the PRB scenario (see table 3). In Lincoln, single-family units decrease by a larger share than multi-family units. As a result, rents decline in Lincoln, despite the decline in total housing units, and throughout the region (see table 4). Residents in Lincoln experience longer commute distances and thus costs due to the exodus of employment from the jurisdiction (10.3%). On average, however, the cost of living appears to decline and wages are reduced somewhat in both Lincoln and the region. The relative magnitude of the reduction in rents offsets the increase in travel costs for Lincoln residents.

The Lincoln scenario produces a net increase in consumer surplus relative to the PRB scenario for both Lincoln and the region (see table 5). However, the average consumer surplus for a resident in Lincoln is two orders of magnitude lower than experienced, on average, by residents region-wide. In general, residents in the urban jurisdictions gain higher average consumer surplus than rural residents and some rural areas even experience an average loss. Average rents are typically lower in rural areas, but urban areas benefit more from greater access to jobs, goods, and services.

In Lincoln, several low-income groups see an average loss in consumer surplus benefits. For these residents, savings in rent are offset by higher commute costs and lower wages. On average, residents of all income groups in jurisdictions outside of Lincoln benefit from this scenario. The average absolute benefit for residents in the highest income group are lower than other income groups because they are more sensitive to change in wages and experience minimal savings in rent.

In the Sacramento City scenario, employment and housing move out of the city and relocate largely in outlying areas of the region. Regionally, the number of higher-cost single-family housing units increases somewhat relative to the PRB scenario. In the city, single-family units decrease by a smaller share than multi-family housing. On average, rents increase by about 6% in the city and by less than 1% in the average outside of the city. Region-wide rents increase by 2.5%. Commute costs increase, on average, by about 1% in the city and, region-wide, by almost 2%.

Higher rents and commute costs increase the cost of living in the region, and wages rise overall as a result. However, the increased wages are not large enough to offset higher rents and travel costs and there are losses in consumer surplus, on average, throughout the region. Further, the highest income classes experience the lowest absolute losses of all the income groups because they benefit more from increased wages, experience lower rents, and travel costs occupy a smaller portion of their total budgets.

Table 3. Percentage Change in Dwelling Units by Type for Jurisdiction Reverting to BAU Land Use and Region by Scenario Type

		Dwelling Units (%)	Employment			
			Centralize		Decentralize	
Housing	Centralize		Lincoln	Region	El Dorado	Region
		Luxury Single-Family	-20.7	-0.1	-11.9	-0.2
		Single-Family	-24.3	0.0	-15.0	-0.2
		Owned Multi-Family	-15.0	0.2	-8.9	1.1
		Rented Multi-Family	-15.9	0.3	-8.3	1.2
		Total	-22.1	0.0	-13.5	0.0
	Decentralize		Yuba	Region	Sacramento	Region
		Luxury Single-Family	6.4	0.1	-8.7	2.0
		Single-Family	0.9	0.0	-12.6	0.5
		Owned Multi-Family	2.0	0.0	-22.1	-4.0
		Rented Multi-Family	-0.2	-0.1	-22.7	-5.3
		Total	2.0	0.0	-14.5	0.0

Table 4. Percentage Change in Average Rent by Income Group, Commute Costs, and Wages for Jurisdiction Reverting to BAU Land Use, the Average Outside Jurisdiction and the Region by Scenario Type

		Average % Change	Employment					
			Centralize			Decentralize		
Housing	Centralize		Lincoln	Outside	Region	El Dorado	Outside	Region
		Rent >10K	-2.1	0.0	-0.1	1.0	-0.8	-0.8
		Rent 10 – 19K	-2.7	0.0	-0.1	-0.1	-0.7	-0.8
		Rent 20 – 39K	-2.2	0.0	-0.1	0.3	-0.8	-0.9
		Rent 40 – 49K	-1.8	-0.1	-0.1	0.6	-0.7	-0.8
		Rent 50 – 199K	-1.0	-0.1	-0.1	0.9	-0.6	-0.7
		Rent 100 – 199K	0.0	0.0	0.0	0.9	-0.2	0.0
		Rent 200K+	-0.6	0.0	0.0	0.3	-0.1	0.0
		Total Rent	-1.6	0.0	-0.1	0.7	-0.5	-0.7
		Commute Costs	10.3	-0.3	-0.2	0.4	0.9	0.5
		Wages	-0.1	0.0	0.0	0.9	0.0	0.0
	Decentralize		Yuba	Outside	Region	Sacramento	Outside	Region
		Rent >10K	-9.9	0.4	0.0	6.4	1.3	2.7
		Rent 10 – 19K	-8.9	0.3	0.1	6.0	1.0	2.5
		Rent 20 – 39K	-8.9	0.4	0.1	6.7	1.7	3.3
		Rent 40 – 49K	-8.0	0.3	0.1	6.7	1.7	3.3
		Rent 50 – 199K	-5.5	0.3	0.1	6.5	1.2	2.8
		Rent 100 – 199K	-3.1	0.1	0.0	1.0	0.2	0.3
		Rent 200K+	-2.8	0.1	0.0	-0.2	-0.1	-0.3
		Total Rent	-6.6	0.3	0.1	6.4	0.8	2.5
		Commute Costs	11.0	0.0	0.2	0.9	1.1	2.0
		Wages	0.4	0.0	0.0	0.4	0.0	0.2

Table 5. Changes in Average Total Consumer Surplus (1000s of year-2000 $) and Consumer Surplus by Income Group for Jurisdiction Reverting to BAU Land Use, the Average Outside Jurisdiction and the Region by Scenario Type

		Year-2000 $	Employment					
			Centralize			Decentralize		
Housing	Centralize		Lincoln	Outside	Region	El Dorado	Outside	Region
		>10K	0.04	89	89	-208	61	-130
		10 – 19K	-2	152	151	-389	94	-265
		20 – 39K	-3	392	391	-186	176	5
		40 – 49K	-1	162	162	-141	64	-66
		50 – 100K	2	219	222	-554	93	-420
		100 – 200K	10	189	198	-670	83	-541
		200K+	4	62	66	-224	17	-192
		Total	2	226	228	-442	102	-285
	Decentralize		Yuba	Outside	Region	Sacramento	Outside	Region
		>10K	-4	-39	-43	-204	-158	-347
		10 – 19K	-7	-68	-75	-419	-280	-670
		20 – 39K	-10	-124	-134	-394	-596	-971
		40 – 49K	-4	-56	-59	-195	-241	-425
		50 – 100K	-5	-84	-88	-451	-296	-720
		100 – 200K	-1	-84	-85	-410	-175	-561
		200K+	0.08	-23	-22	-115	-33	-141
		Total	-5	-84	-88	-380	-312	-675

In the Yuba County scenario, housing moves to outlying Yuba County from more centrally located jurisdictions and employment moves in the other direction. In Yuba County, the supply of rented multi-family units decreases somewhat and all other housing units increase. The largest changes are increased luxury single-family housing (6.4%) and owned multi-family housing (2.0%). At the regional level, the supply of these housing types increases somewhat and the supply of single-family dwelling units and rented multi-family units decline somewhat. The average resident in Yuba sees significant declines in average rents (about 7%) and increases in commute costs (11%). However, average rents and commute costs increase somewhat outside of Yuba and regionally. Yuba residents are able to trade high travel costs for lower rents in larger homes. Wages increase somewhat regionally to cover higher rents and commute costs. Wage increases are an order of magnitude greater in Yuba. This is due to the influx of higher income residents who have a preference for luxury homes.

Changes in rents, wages and travel costs result in an average loss in consumer surplus for the region and for Yuba. However, on average, jurisdictions outside of Yuba experience losses that are an order of magnitude greater than those experienced in Yuba. Increased costs to access jobs, goods and services offset savings in rents in Yuba for all income groups, with the exception of the highest income group, which experiences a small gain. Outside of Yuba, all income classes experience a net loss; however, the absolute loss for the highest income group is lowest because of the increased supply of preferred luxury dwellings, a greater benefit from higher wages than other income groups, and commute costs being a smaller share of their total income.

In the El Dorado scenario, employment shifts from more centralized jurisdictions to outlying El Dorado and housing shifts from El Dorado to more centralized jurisdictions. The share of lower-cost multi-family housing units increases in this scenario by about 1% regionally. In El Dorado, the decline in single-family units is larger than multi-family units. On average, rents are inversely related to supply changes both in El Dorado and outside jurisdictions. Because of the greater separation between home and work in this scenario, commute costs increase in El Dorado and in outside jurisdictions. Average wages increase somewhat throughout the region and more significantly in El Dorado. The higher rents and travel costs in El Dorado are not offset by increased wages and the jurisdiction experiences a net loss in consumer surplus. However, on average, outside jurisdictions see an increase in consumer surplus due to savings in rent that more than offset somewhat higher commute costs and somewhat lower wages. At the regional level, the large consumer surplus losses in El Dorado offset the gains in the other jurisdictions producing a net loss. In El Dorado, the income groups within the $20,000 to $50,000 range experience relatively lower absolute losses compared to other income groups and on average, outside of El Dorado, the $20,000 to $40,000 income group benefits more than the other income groups. It appears that the relatively larger supply of lower-cost multi-family housing benefits these groups the most.

RHNA SCENARIOS

In the light rail scenario, rented multi-family dwelling units are moved to zones through which the region's light rail line passes. The increase in rented multi-family housing in light rail jurisdictions meant a decrease in multi-family housing for the remainder of the region. Residents of the light rail jurisdictions see a decrease in average rents as owned and rented multi-family dwelling units become more common; this average decrease results from decreased rent for residents earning less than $100,000 and increased rents for higher income groups who do not benefit from the increased supply of low-cost housing. In jurisdictions that are not near the light rail line, residents see an average increase in rents as the supply of owned and rented multi-family dwelling units is reduced; as in the light rail jurisdictions, rents for residents earning above $100,000 oppose this trend. Commute costs increase slightly in these jurisdictions, possibly due to high-income workers trading longer commutes for lower rents.

In the high jobs-housing scenario, rented multi-family housing is reallocated to zones in key regional employment center. The increased supply of this housing type decreases average rents. This decrease is a result of reduced rents for those earning under $100,000, while higher income groups (who prefer single-family dwelling units) face higher living costs. Residents see a slight reduction in average commute costs, which is the result of low-to middle-income workers being better able to afford living closer to their job. High-income worker groups, on the other hand (such as managers, professionals, and non-retail sales workers) faces longer commutes after the housing shift because, due to rent increases for high-income groups in the employment centers, they are less likely to live near their job.

V. CONCLUSIONS

The context of this study is the considerable uncertainty about whether local governments will actually implement land use plans included in SCSs that are developed by regional governments and are considered necessary to achieve GHG targets under SB375 and AB32. As previously discussed, regional governments are required to develop SCSs but local governments have the power to implement land use plans in the SCS for their jurisdiction. SB375 relies upon democratic participatory planning processes and relatively small financial and regulatory incentives to encourage implementation. As a result, there is a strong possibility that some local governments will not, in fact, implement the SCS land use plans for their jurisdiction.

The current study was conducted to understand what the economic and equity consequences might be to jurisdictions that do and do not implement SCS land use plans in a region. The results of the study provided insights into the potential pitfalls of jurisdictional non-conformity and thus suggest a number of strategies for more effective implementation of SB375.

1. In the development of SCSs that increase the centralization of activities in a region, care should be taken to understand the particular needs of rural and low income residents. If plausible inequities are identified, then creative policy instruments should be developed to redress these inequities, without further encouraging decentralizing.

2. The potential risk of economic losses to communities that continue business-as-usual development patterns, as illustrated in the scenarios in which employment and/or household decentralized, should be explicitly addressed in the development and communication of SCSs. These include higher costs for business operations, which may diminish regions' ability to compete economically with other regions both nationally and internationally.

3. The possibility that non-conforming jurisdictions may benefit at the expense of other jurisdictions and the overall regional economy, as the Yuba scenario illustrated, suggests that the distribution of jurisdictional benefits should be explicitly examined and addressed in the development of SCSs.

4. The actual implementation of SB375 by local jurisdictions should be carefully monitored. If non-conformity becomes a significant problem, then the California legislature should consider amending SB375 to include strong sanctions for non-compliance.

ABBREVIATIONS AND ACRONYMS

AA	Activity Allocation
AB32	California Assembly Bill 32 Global Warming Solutions Act
BAU	Business As Usual
ED Module	Economic Demographic Aggregate Forecasting Model
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
GHG	Greenhouse Gas Emissions
LUSTRE	Land Use, Strategic Transport and Regional Economy
LUZ	Land Use Zones
MTI	Mineta Transportation Institute
PECAS	Production, Exchange and Consumption Allocation (Sacramento spatial economic model)
PRB	Preferred Blueprint Plan
PUMS	Public Use Microsample
SACOG	Sacramento Area Council of Governments
SACSIM	Sacramento Activity-Based Travel Model
SB375	California Senate Bill 375
SCS	Sustainable Community Strategy
SD Module	Space Development Module
STEP	An early activity-based model used to evaluate the distributional effects of auto pricing policies in the major regions of California.
TAZs	Transport Zones
TR Model	Transport Model
ULTRANS	Urban Land Use and Transportation Center

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