9 Demand Simulations for California

9.1 Introduction

The purpose of the model presented in chapter 8 is to address "what if" questions regarding the demand and use of vehicles. Such questions take the form "what would happen to vehicle demand and fuel consumption if...," with the remainder of the sentence describing some event or set of events. Particular "what if" questions arise when, for example,

- government officials need to decide how or whether to employ policy tools that are under their control in an effort to affect the demand for vehicles and fuel;
- auto manufacturers see that they can profit by anticipating the impact of possible changes in socioeconomic or other external factors;
- government agencies are responsible for anticipating and, to the extent possible, mitigating the ill effects that changes in external factors can have on the market for autos and fuel;
- a manufacturer wants to know whether the introduction of a new type of vehicle would be profitable;
- other manufacturers need to know how such an introduction would affect the demand for their existing vehicles.

An ideal setting in which to illustrate the use of the model in addressing such questions has been provided by the California Energy Commission. The Commission is mandated by the California legislature to examine factors that affect energy consumption within the state and to assess the impact of policies and programs that are directed toward reducing energy consumption. Gasoline consumption by personal use autos has been a special concern of the Commission, partially in response to the economic and political disruption of past gasoline shortages, but more generally in recognition of the magnitude of this component of energy consumption and the power of the state to affect it, relative to other components. The Commission has been particularly interested in the impact of programs that will facilitate introduction and widespread acceptance of nongasoline automobiles. Divisions within the Commission are examining methanol, liquid propane gas (LPG), diesel, and electricity as potentially important substitutes for gasoline in personal transportation.

To aid the Commission in its investigations, and to provide an example of how the model presented in chapter 8 can be used, the demand in California for various gasoline and nongasoline automobiles was simulated with the model under a set of conditions (i.e., inputs) specified by the Commission. In recognition of the fact that simulated demands from the model are entirely dependent on the specified inputs concerning fuel prices, vehicle technology, demographics, and so on, the Commission requested a series of simulations as follows. First, "base case" simulations were produced with all the inputs set at particular values that the Commission's staff decided were reasonable. Second, various "sensitivity" simulations were produced, each of which involved changing one of the inputs (e.g., the growth rate in income) and resimulating demand. By examining the base case simulations, it is possible to see what the entire set of assumed conditions, when considered simultaneously within the model, produce in terms of vehicle demand, use, and fuel consumption. Then by comparing the sensitivity results with the base case figures, the impacts of changes in input variables (some of which are under state control) are assessed.

In the following sections, the base case inputs are described, the simulated vehicle demands and fuel consumption that result from these inputs are discussed, and finally sensitivity analyses are presented. It is important to note that throughout these sections the term "simulations" is used rather than "forecasts," to emphasize the fact that outputs of the model are answers to "what if" questions, rather than forecasts per se. In the case of the base case simulations, the question is, "What would vehicle demand and fuel consumption be if all the conditions specified below were to occur?" Each of the sensitivity simulations asks the same question with one of the conditions changed. These questions are answered by the model without regard to the probability that the specified conditions will actually occur. Since, inevitably, the future will bring about conditions other than those specified, the output of the model cannot constitute predictions. The purpose and value of these simulations is to examine the implications of sets of inputs and to understand the relative impacts of various changes in conditions.

9.2 Base Case Inputs

To simulate vehicle demands with the model, three sets of inputs are required. First, the types, or classes, of vehicles that are available, and the characteristics of each of these classes, must be specified for each simulation year. That is, to simulate for the years 1980–2000, the purchase price, fuel efficiency, shoulder room, etc., of each class of vehicle that is assumed to be available must be specified for each of the twenty years. Second, simulation with the model requires a sample of households from the area for which the simulations are being produced, plus projections of socioeconomic variables. These projections include the number of households in the area, household income, and the number of members and workers in households. Third, projections of fuel prices are utilized.

Each of these three sets of inputs will be described for the base case simulations for the California Energy Commission. More details on the implementation of the model with these inputs are given in appendix A.

Vehicle Classes and Characteristics

Reflecting its interest in nongasoline powered vehicles, the Commission specified various classes of diesel, electric, methanol, and LPG vehicles in addition to gasoline cars and trucks. A total of twenty-five classes of vehicles were included in the simulations. Since many of these vehicles (e.g., methanol cars) are not currently available, the Commission specified the year that each vehicle would, for the purposes of simulation, be assumed to be available. For simulation years prior to this specified year, the simulations excluded the vehicle from the set of vehicles among which households chose.

The list of twenty-five classes and the years at which each was specified to be available are given in table 9.1. Since the Commission was interested in simulating demand for the period 1980–2000, it projected the characteristics of each of these twenty-five classes of vehicles for each of the twenty simulation years. That is, for each year from 1980–2000, the Commission projected the purchase price, fuel efficiency, shoulder room, luggage space, horsepower, and so on, for each class of vehicle.[1] These projections are given in appendix B.

Household Sample and Socioeconomic Projections

The model presented in chapter 8 operates at the level of individual households, while, for the purposes of the California Energy Commission, simulations of statewide demand are required. A sample enumeration approach, as described in section 6.1, was used to obtain aggregate demand figures. In particular, the model was run on each household within a sample drawn from California, and the demands of each household were simulated. Statewide demands were calculated by taking the weighted sum over

Table 9.1
Classes of vehicles assumed to be available in simulations for the California Energy Commission

Class		First year available
1	Domestic and foreign gas mini car	1984
2	Domestic gas subcompact car	*
3	Domestic gas compact car	*
4	Domestic gas large car	*
5	Foreign regular gas car	*
6	Foreign luxury gas car	*
7	Domestic and foreign diesel mini car	1987
8	Domestic diesel subcompact car	1982
9	Domestic diesel compact car	1986
10	Domestic diesel large car	*
11	Foreign regular diesel car	*
12	Foreign luxury diesel car	*
13	Domestic and foreign electric car	1987
14	Domestic and foreign methanol compact car	1986
15	Domestic and foreign methanol large car	1986
16	Domestic and foreign LPG compact car	1984
17	Domestic and foreign LPG large car	1984
18	Small gas pickups and utility vehicles	*
19	Large gas pickups and utility vehicles	*
20	Small diesel pickups and utility vehicles	*
21	Large diesel pickups and utility vehicles	*
22	Small gas vans and other vehicles	1985
23	Large gas vans and other vehicles	1985
24	Small diesel vans and other vehicles	1985
25	Large diesel vans and other vehicles	1982

* Available from first simulation year.

households of these individual demands, with the weights representing the sampling probability of each household.

The sample consisted of 105 households drawn at random from a statewide household survey collected by the California Department of Transportation (Caltrans). The survey is described in detail in a report by Caltrans (1981). For each household, the following information was utilized: income, number of persons in household, number of workers, number of vehicles owned at time of survey, class and vintage of each vehicle, and a weight assigned to the household by Caltrans that reflects the sampling procedure that Caltrans used.

Since the model calculates statewide demands on the basis of a sample of household, simulations of statewide totals for future years require updating the sample for projected changes in demographic characteristics. In particular, the sample is adjusted for each simulation year so that it will "look like" a sample that would be drawn in that year. This updating is accomplished by (1) adjusting the characteristics of the households in the sample (e.g., changing their income to represent projected growth in income) and/or (2) adjusting the weight attached to each sampled household to reflect projected changes in the number of households of each type.

Both of these updating methods were used in simulations for the Commission. The income of each household was adjusted in each simulation year on the basis of a specified growth rate. For the base case, this rate was set by the Commission at 0.81% annually. That is, the income of each household was increased in each consecutive simulation year by 0.81% in real terms.[2]

The weight of each household was adjusted on the basis of projected changes in the number of households with each number of members and workers. Categorizing on the basis of the number of members and number of workers in a household, the Commission determined, using census data, that in 1980 the number of households in California in each category was as given in table 9.2. The Commission projected that by 2000 the number of households in each category would be as given in table 9.3. The Commission also specified that, for each simulation year between 1980 and 2000, the number of households in each category was to be calculated by linear interpolation between the numbers for that category in 1980 and 2000. Note that these projections represent a 1.7% average annual growth rate in the total number of households in California.

The weight assigned to each household was adjusted from one simula-

Table 9.2[a]
Number of households by category in California in 1980

	Number of workers		
Number of members	0	1	2+
1	1,140,946	1,146,135	—
2	708,862	966,483	988,154
3	196,324	534,548	749,057
4+	908,480[b]		1,291,209

a. Based on census data for 1980. Total number of households: 8,630,198.
b. There were 908,480 households with 4+ members and 0 or 1 worker. That is, there is only one cell including both 0 and 1 worker households with 4+ members.

Table 9.3[a]
Projected number of households by category in California in 2000

	Number of workers		
Number of members	0	1	2+
1	11,584,004	1,810,486	—
2	1,164,891	1,249,829	1,799,251
3	248,130	643,141	904,839
4+	1,251,696[b]		1,508,914

a. Based on projected census data for 2000. Total number of households: 12,165,181.
b. There were 1,251,696 households with 4+ members and 0 or 1 worker. That is, there is only one cell including both 0 and 1 worker households with 4+ members.

tion year to the next to reflect the projected changes in the total number of households in each category, where a category represents a particular number of members and workers. Denote the weight assigned by Caltrans to household n as c_n. The weighted number of sampled households in category k, labeled S_K, is the summation of c_n over all households in category k. Denote as N_K^t the number of households in the state that the Commission projects will be in category k in simulation year t. The weight attached to each household in category k in simulation year t is then $(N_K^t/S_K) \cdot c_n$. Thus, for each simulation year, the weighted number of households in each category in the sample will necessarily equal the projected number in the state. Stated intuitively, the weighted sample in each simulation year will "look like" a random sample of households taken that year.

Fuel Price Projections

Projections of fuel prices, inclusive of taxes, were specified by the Commission. Prices for 1980, 1981, and 1982 are from historical data. For years starting with 1983, the Commission calculated prices based on annual growth rates covering different periods of the simulation. The four liquid fuels, gasoline, diesel, methanol, and LPG, had the following annualized real price growth rates (exclusive of taxes):

1983–1987: 1%;
1988–1994: 3%;
1995–2000: 4.5%.

Electricity prices were projected throughout the period to increase at an average annual rate of 1.8% in real terms.

9.3 Base Case Simulations

Using the inputs specified by the California Energy Commission, personal use vehicle holdings, vehicle miles traveled (VMT), and fuel consumption were simulated with the model for California and the years 1980–2000. The salient results are presented and discussed in the following, with detailed outputs given in appendix C.

Total Vehicle Holdings and VMT

The total number of personal use vehicles and VMT on these vehicles are simulated to be as given in table 9.4. Vehicle holdings are simulated to

Table 9.4
Simulated number of vehicles and miles traveled

	1980	1990	2000
Number of vehicles (millions)	13.76	18.39	21.67
VMT (billions)	141.1	222.5	263.0

increase over the twenty year period at an average rate of 2.3% annually. Much of this growth can be attributed to the increased numbers of households projected for California. For the purpose of these base case simulations, the total number of households in California was projected by the Commission to grow at an average rate of 1.7% annually. Consequently, the growth in vehicle holdings is only slightly greater than the growth in the number of households. In fact, the average number of vehicles per household is simulated to increase only 12% over the twenty year period, from 1.59 in 1980 to 1.78 in 2000. This increase is due primarily to the projected increase in real incomes.

VMT is simulated to increase somewhat more rapidly than vehicle holdings. In particular, VMT is simulated to increase at an average rate of 3.2% annually, with annual VMT per vehicle increasing from 10,254 in 1980 to 12,136 in 2000. This increased vehicle use is a reasonable consequence of the vehicle technology inputs. As is evident from the data in appendix B, fuel efficiency for each class of vehicles is projected to improve substantially over time. Furthermore, new, more fuel efficient classes of vehicles (such as minis and methanol vehicles) are projected to be available in the future. These improvements in fuel efficiency translate into decreased operating costs. Since operating cost (which is in cents per mile) is the price attached to travel, decreases in operating cost will necessarily increase the amount that people drive their vehicles.

Both vehicle holdings and VMT are simulated to increase over time at decreasing rates. That is, the percentage increase in holdings and VMT from 1980 to 1990 is greater than that from 1990 to 2000. This growth pattern is attributable to the fact that improvements in fuel efficiency have a larger impact on the operating cost of vehicles with relatively poor fuel efficiency, so that as fuel efficiency for a class of vehicles steadily improves over time, the effect on operating cost becomes less and less. For example, assuming for convenience a fuel price of $1 per gallon, an increase in fuel efficiency from fifteen miles per gallon to twenty miles per gallon decreases

Table 9.5
Simulated vehicle holdings by fuel type

	1980	1990	2000
Gas	13,656,327	17,199,989	19,920,293
Diesel	100,346	1,068,320	1,463,319
Electric	—	8,503	66,581
Methanol	—	47,450	114,471
LPG	—	68,461	105,326

operating cost by 25% (from 6.7 cents per mile to 5 cents per mile), while an increase in fuel efficiency from twenty miles per gallon to twenty-five miles per gallon decreases operating cost by only 20% (from 5 cents per mile to 4 cents per mile). Since the impact of fuel efficiency improvements is greater during the earlier periods, the growth in vehicle ownership and VMT is also greater.

Vehicle Holdings by Fuel Type

The California Energy Commission was particularly interested in determining the potential demand for nongasoline powered vehicles and the extent to which the introduction of these vehicles would reduce gas consumption in the state. To examine this issue, various classes of diesel, electric, methanol, and LPG vehicles were included in the base case set of vehicle classes. Simulations of vehicle holdings by fuel type are shown in table 9.5.

The general conclusion to be drawn from the simulation results is that, given the projected characteristics of the vehicle and the projected fuel prices, gas vehicles would continue to dominate the market, even in the face of the introduction of alternative fueled vehicles. The only nongasoline vehicles to capture a nonnegligible portion of the market are diesels, which are simulated to comprise 6.7% of all vehicles owned in 2000. The demand for electric, methanol, and LPG vehicles is simulated to be very low: 0.3% for electric vehicles, 0.5% for methanol cars, and 0.5% for LPG cars by the year 2000.

The reason for the low demand for the alternative fueled vehicles can be seen by examining the vehicle technology data in appendix B. The prices of the electric, methanol, and LPG vehicles are considerably higher than those for comparable gas vehicles, while operating costs are only slightly lower (if

Table 9.6
Comparison of price and operating costs in 2000 for alternative fueled vehicles

Class	Price (in 1978 dollars)	Operating cost (cents per mile in 1978 dollars)
3 Compact gas cars	5,182	3.41
4 Large gas cars	7,618	3.72
13 Electric cars	9,606	1.29
14 Compact methanol cars	6,008	3.49
15 Large methanol cars	8,528	3.97
16 Compact LPG cars	6,344	3.04
17 Large LPG cars	8,938	3.20

at all). For purposes of comparison, relevant figures are given in table 9.6 for the year 2000. LPG vehicles cost over $1,000 more than comparable gas cars and have operating costs that are lower by only about half a cent per mile. Electric vehicles cost $4,428 more than compact gas cars, but are only about two cents per mile cheaper to run. Methanol cars both cost more and are more expensive to operate than comparably sized gas cars.

It is important to note that these results do not imply that alternative fueled vehicles will not be able to complete effectively with gasoline vehicles in the future. (Again, the results are simulations, not predictions.) What the results do imply is that vehicle characteristics and/or fuel prices must be **substantially** different from those projected by the Commission for alternative fueled vehicles to succeed in the marketplace. These vehicles can constitute an important portion of the market if (1) technology improvements allow these vehicles to be built much more cheaply than the Commission projects, (2) gasoline vehicles do not improve in fuel efficiency anywhere near as much as the Commission projects, or (3) gasoline prices increase much more than the Commission projected while other fuels' prices do not rise as quickly. In addition, the normal market mechanism can be affected by government intervention in various ways to increase demand for nongas vehicles; however, these interventions would need to be severe in order to have much impact. (Some of these issues are examined in section 9.4.)

A word of caution is in order regarding the use of the model to simulate demand for nongasoline vehicles. The simulations of vehicle ownership are based on the model described in chapter 8 in which consumers evaluate vehicles on the basis of their operating cost, price, seating capacity, horsepower, and other characteristics. Since the model was estimated on data from a period in which nongasoline vehicles were not generally available, characteristics that nongasoline vehicles possess, but gasoline vehicles do not, are not included in the model. Consequently, factors that could affect consumers' evaluation of nongasoline vehicles, such as uncertainty about the performance of the vehicles, are not incorporated into the results. Furthermore, the simulations are for demand only, and do not reflect any supply side constraints (such as limited production capacity for new vehicles or limited fuel availability for alternative fuels). These factors will cause the true demand for alternative fueled vehicles to be less than that simulated by the model. However, since the model already simulates very low demand for nongasoline vehicles, any biases caused by these factors will not affect the general conclusions drawn from the base case results.

Vehicle Holdings by Size and Class

Table 9.7 presents simulated vehicle holdings by size and class. The most interesting aspect of these data is that the share held by each class does not change much over time. For example, compact cars are simulated to comprise 12.7% of the vehicle stock in 1980 and 12.6% in 2000; large cars would comprise 35.5% in 1980 and 34.6% in 2000; and so on.

The only deviations from this pattern are the minis and foreign regular vehicles. Minis, which were not available in 1980, are simulated to capture a sizable 8% of the market by 2000, while foreign regular vehicles are simulated to fall from 22.3% of total holdings in 1980 to 15.4% in 2000. These results imply that the demand for minis will be drawn primarily from foreign regular vehicles, an implication that seems quite reasonable given that currently the most popular small vehicles are foreign.

Fuel Consumption by Personal Vehicles

The simulation results for fuel consumption are presented for each fuel type in table 9.8. The most notable result is that gas consumption is simulated to drop substantially, by 22% over the twenty year period. As discussed above, VMT per vehicle increases over the twenty year period and any shifts to nongasoline vehicles or smaller classes of gas vehicles is minimal. Consequently, the reduction in gas consumption can only result from increased fuel efficiency of gas vehicles. Examining the projections of vehicle char-

Table 9.7
Simulated vehicle holdings by size class

		1980		1990		2000	
Size class		Number	% of total	Number	% of total	Number	% of total
1, 7, 13	Mini	0	0	1,060,023	5.8	1,733,375	8.0
2, 8	Subcompact	1,200,234	8.7	1,525,333	8.3	1,801,959	8.3
3, 9, 14, 16	Compact	1,751,689	12.7	2,327,387	12.7	2,738,856	12.6
4, 10, 15, 17	Large	4,878,170	35.5	6,513,994	35.4	7,496,352	34.6
5, 11	Foreign regular	3,079,415	22.4	3,071,908	16.7	3,339,510	15.4
6, 12	Foreign luxury	482,297	3.5	659,163	3.6	854,060	3.9
18, 20	Small pickups and utility vehicles	706,531	5.1	809,076	4.4	871,235	4.0
19, 21	Large pickups and utility vehicles	1,106,302	8.0	1,587,104	8.6	1,824,846	8.4
22, 24	Small vans and other	0	0	19,397	0.1	32,763	0.2
23, 25	Large vans and other	557,036	4.0	819,339	4.5	977,033	4.5
Sum		13,756,673	100.0	18,392,723	100.0	21,669,990	100.0

Table 9.8
Simulated fuel consumption by personal use vehicles

	1980	1990	2000
Gasoline (billions of gallons)	8.75	7.76	6.80
Diesel (billions of gallons)	0.056	0.425	0.437
Electricity (billions of kilowatt-hours)	0	0.028	0.174
Methanol (billions of gallons)	0	0.037	0.064
LPG (billions of gallons)	0	0.036	0.041

acteristics in appendix B makes it clear that this is indeed the case. Fuel efficiency of gas vehicles is projected to double over the twenty year period; subcompacts are projected to improve from 21.02 miles per gallon in 1980 to 46.95 miles per gallon in 2000, compacts from 19.13 miles per gallon to 39.08 miles per gallon, and large domestic vehicles from 17.12 miles per gallon to 35.83 miles per gallon. It is important to note, of course, that gas consumption will not fall as dramatically, and could easily increase, if these projected improvements in fuel efficiency are not actually achieved.

Diesel consumption is simulated to increase sevenfold over the twenty year period. This result reflects the increased holdings of diesel vehicles. Similarly, consumption of methanol, LPG, and electricity is simulated to be small, reflecting the small demand for vehicles powered by these fuels.

9.4 Sensitivity Analyses

Perhaps the most valuable way to use a simulation model is to run it numerous times with changes in inputs. Comparing the results of these simulations provides information about the impact of each input in isolation from other factors. This information is an aid to government agencies and vehicle manufacturers in deciding whether a particular type of intervention is warranted (e.g., increasing gasoline prices through higher taxes, while all other factors remain the same; introducing a new vehicle in the market) and in anticipating the effects of demographic changes (e.g., larger than expected rises in income; lower employment than expected).

Recognizing the value of multiple simulations, the California Energy Commission requested that the model be rerun with various changes in the base case inputs. Specifically, six scenarios were simulated, each of which

Table 9.9
Simulated effects of greater income growth

Year 2000	VMT (billions)	Number of vehicles (millions)	Gas consumption (billions of gallons)
Base case	262.99	21.67	6.804
Scenario 1	299.05	22.70	7.845
Percent change	13.7	4.75	12.1
Implied income elasticity	0.29	0.10	0.31

provides information about the impact of an input variable in which the Commission was particularly interested. These scenarios, and their simulation results, are presented in the following.

Scenario 1: Greater Income Growth

Given the prominence of income in the economic decisions of households, an important question to address is, To what extent do vehicle holdings, vehicle miles traveled (VMT), and fuel consumption change in response to changes in income? To answer this question, the model was run with income projected to grow at an annual rate that is 2% higher than was used in the base case: 2.81% rather than 0.81%. The income of each household in 1980 is the same under the scenario and the base case but in each subsequent year is higher in the scenario. By the year 2000, each household's income under the scenario is 48% higher than under the base case.

Highlights of the simulation results for this scenario are given for the year 2000 in table 9.9, along with comparable base case figures. The detailed results are given in appendix D.1. The simulated responses are in the right direction and have plausible magnitudes. The elasticity[3] of VMT with respect to income is larger than the elasticity of the number of vehicles with respect to income, implying that households will adjust the amount that they drive on each vehicle for changes in income as well as adjusting the number of vehicles they own. Gas consumption is more sensitive to income than VMT. This result is due to the fact that, as incomes increase, households switch to larger, more expensive, and less fuel efficient vehicles, thus increasing their fuel consumption per mile. These shifts are evident in the detailed outputs in appendix D.1.

Table 9.10
Simulated effects of moderately higher gas price increases

Year 2000	VMT (billions)	Number of vehicles (millions)	Gas consumption (billions of gallons)
Base case	262.99	21.67	6.804
Scenario 2	243.22	21.03	5.903
Percent change	−7.5	−2.95	−13.24
Implied price elasticity	−0.27	−0.11	−0.47

Scenario 2: Moderate Gas Price Increases

In the base case, gas prices, in real terms, were assumed to rise at 1% each year from 1983 to 1987, 3% yearly from 1988 to 1994, and 4.5% yearly from 1995 to 2000. To assess the impact of moderately higher gas prices, the model was run with gas prices that rise 2% from 1983 to 1987, 4% for 1988–1994, and 5.5% for 1995–2000. With these higher growth rates, the price of gas in 2000 is 27.7% higher under the scenario than in the base case.

The highlights of the simulation results are shown in table 9.10, with details given in appendix D.2. The estimated responses are in the expected direction and have plausible magnitudes. The VMT elasticity is greater (in magnitude) than the vehicle holdings elasticity, implying that households adjust the amount they drive each vehicle, in addition to adjusting the number of vehicles they own, in response to gas price increases. The elasticity of gas consumption with respect to gas price is larger than the VMT elasticity. This reflects the fact that, when gas prices rise, households switch to nongas vehicles (such as diesel) and to smaller, more fuel efficient gas vehicles, thus reducing gas consumption more than VMT. The detailed results in appendix D.2 evidence these shifts explicitly.

Scenario 3: High Gas and Diesel Prices, with No Electric, Methanol, and LPG Vehicles

This scenario is intended to examine the response of households to fairly large, steady increases in fuel prices (both gas and diesel) when there is no possibility of switching to alternative fueled vehicles. In particular, gas and diesel prices are projected to rise at 7% per year, in real terms, starting in 1983, and electric, methanol, and LPG vehicles are removed from the set of

Table 9.11
Simulated effects of higher fuel price increases with no alternative fueled vehicles

Year 2000	VMT (billions)	Number of vehicles (millions)	Gas consumption (billions of gallons)
Base case	262.99	21.67	6.804
Scenario 3	179.56	18.71	4.232
Percent change	−31.7	−13.7	−37.8
Implied price elasticity	−0.27	−0.12	−0.32

vehicle classes available to the households. By the year 2000, gas prices under the scenario are 115% higher than in the base case, and diesel prices are 117% higher.

A summary of the simulation results is given in table 9.11, with details in appendix D.3. VMT and vehicle holdings drop considerably more, in absolute terms, than in scenario 2, in which gas and diesel prices rise less and the possibility of switching to alternative fueled vehicles is available. It is interesting to note, however, that the estimated elasticities of VMT and vehicle holdings are essentially the same as in scenario 2.

Gas consumption drops more in this scenario than in scenario 2, as would be expected with the higher gas price. However, the **elasticity** of gas consumption to price is lower (in magnitude) in this scenario than in scenario 2. This result reflects the fact that in scenario 2 households can reduce their gas consumption by switching to nongas vehicles. This option is not feasible in the current scenario since diesel prices are rising as fast as gas prices, making it not advantageous to switch to diesel vehicles, and alternative fueled vehicles are not available. Consequently, the normalized response (i.e., elasticity) is smaller in this scenario than in scenario 2.

Scenario 4: Reduced Employment

In this scenario the number of workers per household was reduced by reducing the number of households in categories with one or more workers and increasing the number of households with no workers. The number of households in each size/workers category for the year 2000 was changed from that given in table 9.3 to that in table 9.12. The total number of households is unchanged; households were simply shifted to categories for fewer workers. Also, as in the base case, the number of households in each

Table 9.12[a]
Alternative projection of number of households by category, representing reduced employment

	Number of workers		
Number of members	0	1	2+
1	2,010,577	1,383,913	—
2	1,455,383	1,386,692	1,371,896
3	396,766	703,690	695,654
4+	1,599,577[b]		1,161,033

a. Based on projections for the year 2000.
b. There were 1,599,577 households with 4+ members and 0 or 1 worker. That is, there is only one cell including both 0 and 1 worker households with 4+ members.

Table 9.13
Simulated effects of reduced employment

Year 2000	VMT (billions)	Number of vehicles (millions)	Gas consumption (billions of gallons)
Base case	262.99	21.67	6.804
Scenario 4	256.22	21.24	6.619
Percent change	−2.57	−1.98	−2.72
Implied employment elasticity	0.17	0.13	0.18

category for simulation years between 1980 and 2000 was calculated by linear interpolation between the numbers in the category in 1980 and 2000.

With the scenario defined in this way, the average number of workers per household in 2000 is 14.8% lower in this scenario than in the base case. Note that, while employment was reduced, income stayed constant. Thus, implicitly, earnings per worker increases in this scenario. The estimated effects of the scenario reflect both the reduced employment and increased earnings per worker. The results are summarized in table 9.13. The simulated responses are in the expected direction with plausible relative magnitudes. The VMT elasticity is greater than the vehicle holdings elasticity, implying that the households drive each vehicle less as their employment levels drop. Furthermore, gas consumption drops more than VMT, in percentage

Table 9.14
Simulated effects of eliminating alternative fueled vehicles

Year 2000	VMT (billions)	Number of vehicles (millions)	Fuel consumption (billions of gallons)	
			Gas	Diesel
Base case	262.99	21.67	6.804	0.436
Scenario 5	262.87	21.64	6.888	0.442
Percent change	−0.05	−0.14	1.24	1.25

terms, reflecting the fact that households switch to smaller, more fuel efficient vehicles as their employment levels reduce. This effect is small, however, as indicated by the fact that the reduction in gas consumption is only slightly greater than in VMT.

Scenario 5: No Alternative Fueled Vehicles

Under the base case, electric, methanol, and LPG vehicles were simulated to comprise, in combination, no more than 1.3% of vehicle holdings by the year 2000. The purpose of the current scenario is to determine what would happen in the market if these vehicles were eliminated. For example, would households that would choose these vehicles (if available) simply not own any vehicles, or would they switch to gas and diesel vehicles? If they switch, would they switch to diesel vehicles more than gas vehicles?

The model was run with electric, methanol, and LPG vehicles removed from the set of vehicle classes among which households choose. The results are shown in table 9.14. All of the simulated changes are small (as expected, given the small share held by alternative fueled vehicles in the base case) and in the correct directions. The magnitude of the changes indicates that nearly all the households that were simulated to choose alternative fueled vehicles in the base case were also simulated to switch to gas and diesel vehicles when the alternative fueled vehicles were not available. This implication is evident by the fact that 1.3% of the vehicles in the base case were alternative fueled, and yet the number of vehicles owned dropped by only 0.14%. Furthermore, since fuel consumption for gas and fuel consumption for diesel increase by nearly the same percentage, the simulations indicate that households that switched from alternative fueled vehicles switch to gas and diesel vehicles fairly proportionately.

Table 9.15
Simulated effects of reduced prices for electric vehicles

Year 2000	Number of EVs	VMT on EVs (millions)	Electricity consumption (millions of kilowatt-hours KWH)
Base case	66,581	813	173.6
Scenario 6	126,834	1,559	331.6
Percent change	90.5	91.8	91.0

Scenario 6: Reduced Prices for Electric Vehicles

In the base case, demand for electric vehicles (EVs) was simulated to be very small, with less than 67,000 EVs being held in 2000. Since the prices of EVs are very high, the Commission was interested in determining the impact on EV demand of reducing the purchase price of EVs by $4,000 (in 1978 dollars). This reduction could be accomplished through improvements in production processes, or, more directly, by rebates given by the government to households that purchase EVs.

The highlights of the simulation results of this scenario are given in table 9.15, with details given in appendix D.6. The $4,000 price reduction (which represents about 40% of the price of an EV) is simulated nearly to double the number of EVs owned, total VMT on EVs, and electricity consumption. While this is a large increase, the number of EVs as a proportion of all vehicle holdings is still simulated to be small (0.6%). The reason EVs are simulated not to be popular even with the price reduction is that (1) their price, with the $4,000 reduction, is still higher than most gas vehicles, and (2) their size is very small, while size, according to the estimates presented in chapter 8, is a very important factor in affecting households' choices of vehicles.

9.5 Conclusions

What can the California Energy Commission learn from the base case and scenario simulations? The most striking conclusion concerns the alternative fueled vehicles that the Commission is studying. If the Commission feels that the projections of fuel prices and vehicle technology that they specified for the simulations are reasonable, then it seems that an emphasis on alternative fueled vehicles would be misplaced and that programs directed toward improving the fuel efficiency of gasoline vehicles would probably be more effective in reducing gasoline consumption. Several aspects of the simulation results indicate this conclusion. First, given the projected characteristics of methanol, LPG, and electric vehicles, these vehicles are simulated to capture only a negligible portion of the market. The difference in gasoline consumption whether or not alternative fueled vehicles are available in the market is simulated to be very small, on the order of 1%. And offering rebates on the purchase of these vehicles does not, according to the simulations, improve the situation much (at least for electric cars). The basic problem is that, given the Commission's projections of fuel prices and vehicle characteristics, the alternative vehicles are too expensive to purchase for the small savings in operating cost that they offer the consumer.

Despite the limited impact of alternative fueled vehicles, gasoline consumption is nevertheless simulated to decrease substantially over time. This result is **not** due to changes in household behavior; vehicle holdings and miles traveled increase, and the distribution of vehicles by class stays approximately the same. Rather, the reduction in gasoline consumption is nearly entirely due to the increased fuel efficiency that the Commission projects for gasoline vehicles. This indicates (again, if the Commission believes its projections are reasonable) that programs directed toward assuring that the projected fuel efficiency improvements are actually attained would be quite effective in reducing gas consumption. The Corporate Average Fuel Efficiency standards, by which auto manufacturers are required to meet certain levels of average fuel efficiency for the fleet of vehicles that they sell, is an example at the federal level of such a program. The state government is less able than Congress to regulate manufacturers. However, incentives and funds for research and development in areas of gasoline vehicle technology would probably be more effective at reducing gasoline consumption than similar R&D in alternative fuels.

Related to these conclusions is the fact that, under the Commission's projected inputs, mini gasoline cars would be able to capture a sizable (though not large) part of the market if they were introduced on a widespread basis. These small, two-seater cars are new and relatively untested in the market; however, the technology clearly exists to produce them. Programs directed toward demonstrating and marketing these minis could be expected by the Commission to be more effective at reducing gasoline consumption than similar programs for electric or other alternative vehicles.

It is important to note that none of these conclusions is stated as a general, or absolute, fact. Rather, the conclusions are all of the form, "If the Commission feels that its projections of vehicle characteristics, demographics, and fuel prices are reasonable, then the model indicates that it should also think that ...." As stated at the beginning of this chapter, simulation models are not predictors of the future; they are means for addressing "what if" questions. Used in this way, they can be very effective as an aid to thinking and decisionmaking.