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Simulating the Market for Automotive Fuel Efficiency: The SHRSIM Model

David L. Greene

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Energy Division

SIMULATING THE MARKET FOR AUTOMOTIVE FUEL EFFICIENCY: THE SHRSIM MODEL

David L. Greene

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ABSTRACT

This report describes a computer model for simulating the effects of uncertainty about future fuel prices and competitors' behavior on the market shares of an automobile manufacturer who is considering introducing technology to increase fuel efficiency. Starting with an initial sales distribution, a pivot-point multinomial logit technique is used to adjust market shares based on changes in the present value of the added fuel efficiency. These shifts are random because the model generates random fuel price projections using parameters supplied by the user. The user also controls the timing of introduction and obsolescence of technology. While the model was designed with automobiles in mind, it has more general applicability to energy using durable goods. The model is written in IBM BASIC for an IBM PC and compiled using the Microsoft QuickBASIC (trademark of the Microsoft corporation) compiler.

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1. THE MARKET FOR FUEL ECONOMY

1.1 INTRODUCTION

The chief source of uncertainty in the energy market is the unpredictable price of oil (Curlee, 1985). This uncertainty is particularly troublesome for producers of energy using durable goods, such as motor vehicles. Research, development, and production plans must be decided upon years in advance, based on a best guess about what the market will be like when the equipment is offered for sale. From the society's viewpoint, this equipment will remain in use for ten years or more, during which time still more fuel price fluctuations are likely.

In 1975 the federal government decided not to leave decisions about the fuel economy of light duty motor vehicles to the marketplace by including Corporate Average Fuel Economy (CAFE) standards for automobiles and light trucks in the Energy Policy and Conservation Act of 1975. After energy price deregulation, CAFE is, arguably, our Nation's most significant energy policy. From 1974 to 1985 the efficiency of passenger cars improved from 14 to 27 miles per gallon (MPG). The direct fuel savings to consumers has been estimated at over $10,000,000,000 per year, with a cumulative present value of over $90,000,000,000 in 1984 (1984 $'s, Greene, Meddeb, and Liu, 1986). Yet there is considerable disagreement over what the effect of CAFE has been and whether it is wise to continue automotive fuel economy standards (e.g., Crandall, et al., 1986;

Greene, 1986). In part, the question of automotive fuel economy policy depends on the existence of suitable technology for improving efficiency. The rest hinges on the operation of the market for automotive efficiency given tremendous uncertainty about the price of fuel. In a pioneering paper, Ford (1984) explored the effect of fuel price uncertainty on manufacturers' retooling strategies. Using an econometric model of automobile type choice and data on the costs and fuel economy benefits of specific technologies, he calculated optimal 1990 offerings, by size class, for a hypothetical manufacturer at three alternative fuel price levels ($0.90, $1.50, $2.10, in 1980 $'s). The problem of fuel price uncertainty was formulated by Ford as one of planning for the wrong mix of size classes, or "market mismatch", which occurs when the manufacturer retools for one price level but is confronted with another in 1990. The size class distribution of demand was predicted as a function of efficiencies, fuel price, and vehicle price. Ford concluded that the problem of market mismatch is of little consequence to a firm which has a monopoly on the market. The consequences of incorrect decisions became important, however, when a competitor was present. Assuming that competitors were aware of each other's retooling plans, he found that copying the competitors behavior was the least risky strategy.

The model presented here builds on Ford's work by using a simulation approach to allow future fuel price uncertainty to be characterized as a stochastic process and the consequences of manufacturers' decisions to be modeled sequentially over time. A model run produces a time series of expected market shares and variances for the manufacturer in question and his competitors. The following two sections explain the theory, struc-

ture, and implementation of the SHRSIM model. The paper concludes with an illustration based on the carlines and technologies available to three domestic automobile manufacturers.

1.2 THE SHRSIM MODEL

In deciding whether to change vehicle design, introduce new technology, or produce new carlines to improve fuel economy, manufacturers primary concern is how these changes will affect the success of their products in the marketplace. Uncertainty about the effects of fuel economy improvements arises primarily from the difficulty of predicting four key factors:

1. consumer willingness to pay for improved efficiency,
2. consumer reaction to changes in other vehicle characteristics which may accompany fuel economy improvements (e.g. weight, performance, etc.),
3. the price of fuel when the improvements will be introduced,
4. what actions competitors will take to improve fuel economy.

SHRSIM is a simulation model designed to quantify the influence of three of these four factors on a manufacturer's market share. The model includes willingness to pay, and uncertainty about fuel prices and competitors' actions but excludes the consumers' valuation of nonmonetary vehicle attributes (often referred to as hedonic value by economists).

Although the model was developed with the automobile market in mind, it could be used for any energy using equipment which can be characterized by an average usage rate and an average efficiency, and whose

efficiency can be improved in hedonically neutral (or nearly so) ways, either by introducing new products or modifying existing ones.

The heart of the model is the trade-off between initial costs and operating costs. These are translated into present value and used in a model of consumer choice to predict changes in market shares from an initial distribution. The model allows considerable flexibility in structuring the trade-off between initial cost and operating cost, allowing the user to vary the discount rate, the time horizon over which future savings are realized, and the rate of utilization.

Other options allow the user to specify random price fluctuations (up or down) from a baseline price projection, both in terms of their probability and potential size. The way in which consumers anticipate future prices based on current and past prices may also be varied. Finally, the probability that other manufacturers will "follow the leader" and introduce fuel economy improvements available to them may also be specified.

SHRSIM predicts both expected market shares and the standard deviation of market shares for every carline (or product line) and for each manufacturer. This allows one to explore the different effects of uncertainty about fuel prices versus uncertainty about competitors' behavior on the risk of introducing fuel efficient technology or product lines. The return to investments in fuel efficiency can then be evaluated not only based on their expected return, but from the perspective of entrepreneurs with differing degrees of risk aversion.

SHRSIM has been written in Advanced BASIC for the IBM PC (TM). It is intended to be executed in compiled form, since this reduces the time

required for Monte Carlo iterations to acceptable levels. The present version was compiled using the Microsoft QuickBASIC (TM) compiler. Even in compiled form a problem of moderate size (50 products, 10 technologies, 10 years, 100 iterations) may require half an hour for execution.

1.2.1 Theory

The essence of the SHRSIM model is the trade-off between the initial cost of a technology and the stream of operating cost savings it produces. While this may seem to be a perfectly straightforward calculation, there are several ways consumers can view this trade-off, with different implications for the desirability of fuel economy technology. These differences and the way they are represented in the model are explained in Section 1.2.1.1.

The desirability, with respect to fuel economy, of one product line versus another will be affected by changes in the current and expected price of fuel, changes in the fuel efficiency of the product line itself, and changes in the fuel efficiency of other product lines. Since SHRSIM focuses exclusively on cost differences, it ignores the multitude of other product characteristics which matter a great deal to consumers. It does so by assuming that the values of these other characteristics are captured in the base year shares distributions and that they will remain constant in the future. An appropriate modeling approach for such a problem is multinomial logit, pivot-point modeling. This technique is described in Section 1.2.1.2.

1.2.1.1 Trading-Off Initial Cost and Fuel Savings

Consumer choice of automobiles is indeed a complex decision involving psychological, sociological, demographic, and geographic factors, in

addition to economics. Attempts to econometrically model automobile choice using hedonic demand techniques (Goodman, 1983) and discrete choice models (Tardiff, 1980 and Mannering and Train, 1985 provide reviews) have achieved mixed success. Measuring the value of highly subjective automobile attributes such as performance or luxury has proven extremely difficult. Since this analysis focuses exclusively on fuel economy improvements, we will avoid such difficulties by dealing only with the simple cost efficiency of the choice between higher initial price and lower fuel costs. In so doing, it is assumed that the consumer is neutral with respect to all other aspects of the technology (or at least that he is able to capitalize the hedonic differences and view them as an asset price difference). Looking at this another way, we are assuming that manufacturers present consumers with cars which are identical to previous models in all respects except initial cost and fuel economy.

Even this simple trade-off problem has been formulated in at least three different ways, each with different implications for how much improvement in fuel efficiency consumers are willing to buy (Greene, 1986). The simplest approach results from assuming that all car buyers are well informed about the fuel economies of new and used cars, and that the new and used car markets are functioning perfectly. Under these conditions a new car buyer will believe that when he resells his automobile his investment in fuel economy will be repaid by the present value of remaining fuel savings (the discounted value of fuel savings over the remainder of the car's life). The new car buyer will purchase additional fuel economy improvements up to the point where the additional asset

price, C, equals the sum of discounted savings over his period of ownership plus what he will receive for the remaining savings when he resells his vehicle. This equation can be written,

$$C = \underbrace{\int_0^T s \exp\{-rt\}\, dt}_{\substack{\text{present value of} \\ \text{savings to time T}}} + \underbrace{\int_T^L s \exp\{-rt\}\, dt}_{\substack{\text{present value of} \\ \text{savings remaining at L}}} , \qquad (1)$$

where L is the vehicle's lifetime, T the time at which it will be resold, s the constant rate of savings per time (assuming, in effect, a constant rate of usage and fuel economy), and r the consumer's discount rate (time preference rate for money). Integrating equation (1), we can solve for the rate of return on investment the consumer will require for fuel economy equipment, s/C,

$$s/C = r/(1-\exp\{-rL\}) . \qquad (2)$$

The consumer requires an investment multiplier equal to,

$$m = 1/(1-\exp\{-rL\} , \qquad (3)$$

to compensate for the fact that his investment in fuel economy, unlike a savings account or bond, is sure to depreciate to zero value in L years. The multiplier can be quite important: $r = 0.1$ and $L = 10$ results in $m = 1.58$. Thus a consumer with a 10% discount rate would act as though he had a 16% discount rate when buying automotive fuel economy.

It is well known that vehicle usage tends to decrease with vehicle age. If we assume that this decline is exponential at a rate of 5%,

$$s_t = s_0 \exp\{-at\} \ , \ a = 0.05 \ , \tag{4}$$

then it is easy to show that the required rate of return becomes,

$$s_0/C = (a+r)/(1-\exp\{-(a+r)L\}) \ . \tag{5}$$

Assuming the same values for parameters, the consumer would behave as if he had a 19% discount rate when buying fuel economy.

An interesting alternative formulation has been proposed by Beggs, Cardell, and Hausman (1981; also used by Greene, 1983). This formulation assumes that conusmers do not believe they will receive the discounted present value of fuel savings for their initial investment in fuel economy upon resale. Instead, they assume that their investment in fuel economy will depreciate at the same overall rate as the rest of the vehicle. The consumer's apparent discount rate for fuel savings is equal to this actual discount rate (time preference rate for money) plus the asset depreciation rate for automobiles. The latter has been estimated to be in the vicinity of 20% per year (Wykoff, 1970). Thus, the apparent discount rate for a consumer with an actual discount rate of 10%, would be 30%. This can be formulated as an investment multiplier as well, but the value of the multiplier depends on how long the consumer expects to hold his vehicle before resale. Let d be the depreciation rate for automobiles. The investment multiplier can be shown to be,

$$m = (1-\exp\{-(d+r)T\})/(1-\exp\{-rT\}) \ . \tag{6}$$

For a consumer who intends to resell his vehicle immediately (or at any moment, i.e. T=0), m can be shown to be equal to (r+d)/r. If the

intention is to hold the vehicle for three years then m = 2.27. That is, a consumer with an actual discount rate of 10%, with d = 0.2, would behave as if his discount rate were 23%.

It is important to remember that the second formulation assumes a market failure. That is, buyers and sellers do not correctly perceive the true value of fuel savings; if they did they would use the first formulation.

Finally, the fuel economy - operating cost problem has been formulated in terms of payback periods. For example, suppose the consumer will accept all technologies with a simple payback period of less than T years, and reject all options with payback periods longer than T. The payback period is simply the initial asset price divided by the rate of savings. Thus, an option costing $300 and saving $100/year has a payback period of 3 years. This "rule of thumb" decision rule is consistent with both of the above formulations. Discount rates imply payback periods, and vice versa.

Of course, it is possible to formulate other decision rules. The three above have been used in the literature and cover a range of possibilities from perfectly operating markets to a range of market failures. Differences between them are questions of interpretation rather than of results, since discount rate formulations imply a payback period and payback periods imply discount rates. In order to maintain flexibility but still keep track of assumptions relevant to discounting approaches, SHRSIM uses a discounting approach which requires an apparent discount rate (which could be interpreted to include a multiplier), consumer time horizon (which could be interpreted as the time to resale

or the vehicle lifetime), and an average (constant) utilization rate (variable utilization rates may be added to subsequent versions). This representation is consistent with all of the above formulations.

1.2.1.2 Modeling Carline and Manufacturer Market Shares

The purpose of the market shares model is to predict changes in market shares due to changes in the net present value of the asset price vs. operating cost trade off, and changes due to the introduction or discontinuation of carlines. Changes in net present value can be caused by introducing efficiency improvements or simply by changes in the price (or expected future price) of fuel. Moreover, the market shares of one manufacturer will be affected by changes introduced by his competitors. A particularly simple and elegant model for such applications is the multinomial logit model (MNL).

The MNL model expresses the probability that an individual will select one of multiple alternatives, i, as a function of the utility, U_i, he associates with each.

$$P_i = \exp\{U_i\}/\sum_j \exp\{Uj\} \ . \tag{7}$$

If the utility functions, U, exactly represent each consumer's valuation of the alternatives, then the MNL model also predicts market shares for the total population.

If the utility function is linear and we are interested only in changes in one variable (net present value of cost), then a simple "pivot-point" approach can be used to compute changes from an initial set of market shares, S_i, (Manheim, 1979, p. 145). The new market shares,

S_i', are a function of the base market shares and the change in utility, δU_i,

$$S_i' = S_i \cdot (\exp\{\delta U_i\}/\sum_j S_j \exp\{\delta U_j\}) \ . \tag{8}$$

By accumulating the utility changes from the base year forward, future market shares for the entire forecast period can be predicted using base year shares, the change in net present value of operating costs, and the single parameter of the utility function which translates dollars into the utility measure. The value of this parameter must be specified to run the model. Fortunately, there are numerous studies in the econometric literature from which estimated values can be drawn.

1.3 IMPLEMENTATION OF THE MARKET SHARES MODEL

SHRSIM quantifies the effects of uncertainty about future fuel prices and competitor behavior on manufacturers' market shares. It does this by repeatedly calculating all market shares over simulated forecasts characterized by random price shocks and random competitor behavior. As the simulations proceed, SHRSIM computes the average and standard deviation of the market share for each carline for each forecast year. Both the expected market share and its variance will be affected by assumptions the user has made about the likelihood of future price shocks, their size, and the probability that other manufacturers will make use of the fuel economy technology available to them.

The iterative structure of SHRSIM is shown in Figure 1. A listing of the source code is provided as Appendix B.

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```
        SETUP <---------------------- KEYBOARD Input
          |
        READ FILES <----------------- SHARES, MPG, ID
          |                   |------- FUEL PRICES
          |                   |------- TECHNOLOGY
|------>| |
|       RANDOM PRICE SHOCKS
|         |
|         |
|       RANDOM MANUFACTURER BEHAVIOR
|         |
|   |--->| |
|   |     PRICE EXPECTATIONS
|   |       |
|   |     CAR PRICE, MPG CHANGES
|   |       |
|   |     UTILITY CHANGES
|   |       |
|   |     NEW SHARES
|   |       |
|   |     UPDATE STATISTICS
|   |-----<  | |
|-----------< |
              |
        CALCULATE MEANS, VARIANCES
              |
        WRITE DISK FILE ------------> SHARES' MEAN, STD. DEV.
              |
        PRINT RESULTS --------------> SCREEN OR PRINTER
```

Fig. 1. SHRSIM model structure.

1.3.1 Fuel Price and Expected Fuel Price Simulation

The model first prompts the user for information describing the case to be simulated (Table 1) and then reads data files. Once all data have been read, SHRSIM begins iterating by calculating a new, random price projection. For each forecast year a random number is drawn from a (0,1) uniform distribution. If this number is less than the probability of a price shock, a price shock is assumed to have occurred. During the SETUP of SHRSIM, the user supplied the probability (PROB) of at least one price shock during the NY-year forecast period. This is converted to an annual probability (PPROB) by assuming that price shocks are independent from year to year:

$$\text{PPROB} = 1 - ((1-\text{PROB})^{(1/\text{NY})}) \ . \qquad (9)$$

The size of the price shock is also random. Starting with a usersupplied maximum percent change, SHRSIM draws another (0,1) uniform random variable to determine how much of that change has actually occurred. Prices may go up or down.

SHRSIM next determines whether competitors will also implement mpg improvements. Again, SHRSIM draws a random number for each carline of competing firms. If the number is less than the user-specified probability that other firms will "follow the leader", then all appropriate mpg improvements will be made. If the random number is between the probability of following the leader and that probability plus the probability of adopting an alternative path, then the alternative technology path is chosen. If neither, no improvements will be made. These are all-or-nothing decisions made independently by each firm. On

Table 1. Parameters required for SHRSIM execution

FORECAST PARAMETERS

1. number of years in forecast (10)
2. number of iterations to be performed (100)
3. probability of at least one price shock during forecast period (0.80)
4. maximum size of a price shock (in percent) (100)
5. name of fuel price data file (FUEL)

MANUFACTURER AND TECHNOLOGY PARAMETERS

1. number of manufacturers (3)
2. number of carlines per manufacturer (11)
3. number of technologies per carline (5)
4. number of alternative technology paths (2)
5. probability other manufacturers will implement similar technology (.333 or .90)
6. probability other manufacturers will implement alternative technology (.333 or .05)
7. name of base year sales data file (SHARES)
8. name of technology data file (TECH)

CONSUMER PARAMETERS

1. discount rate (decimal) (0.30)
2. consumers' time horizon for fuel savings (10 yrs.)
3. average miles driven per year (15,000)
4. marginal utility of a dollar of increased cost (-0.0015)
5. choice of price expectation function (static)

any iteration a competitor will have either all carlines with MPG improvements or all without.

In general, car buyers do not know what future fuel prices will be. They will evaluate the savings of higher mpg based on what they expect future fuel prices to be. Some recent research on gasoline price expectations has indicated that consumers base expectations primarily on the past two years of history (EEA, 1983). For example, it was in 1976, two years after the 1973-74 price shocks, that consumers generally ceased to expect further gasoline price increases (Cambridge Systematics, Inc., 1979). Other work, however, suggests that past experience is used more in complex ways to evaluate recent price changes (Daly and Mayor, 1983). SHRSIM offers three choices of simple expectation models with the understanding that each is an oversimplification. The first is static expectations: prices will continue at their present levels. The second is linear expectations: the average increase or decrease of the past two years will continue for the length of the forecast. The linear model is most dangerous in that it could lead to negative fuel prices under certain, not too unusual conditions. The third option is declining exponential price change: the expected growth in a forecast year is equal to the average growth rate of the past two years, divided by the number of years ahead. If the average rate of growth in the previous two years were 5%, the expected growth rates in the first, second, and third forecast years would be 5%, 2.5%, and 1.67%, respectively.

The expected price path constitutes the fuel prices used to compute the expected savings of mpg improvements for the current year of the current iteration. For each year of each iteration a new expected price

path must be computed. Thus, a 10-year forecast with 100 iterations would generate 1,000 expected price paths. The randomness of these price paths, together with the randomness of competitor behavior generates the distribution of future market shares.

1.3.2 Carline Price and MPG Changes

The initial costs and mpg gains of improved technology are computed next. Initial cost is the sum of the retail markup of all technologies applied in the specific year by the manufacturer in question. MPG gains are computed multiplicatively for all applicable technologies.

$$MPG(i) = MPG_0(i) \cdot \prod_{j=1}^{NT} (1+DMPG(i,j)/100) \ . \qquad (10)$$

DMPG is the percent improvement in MPG gotten by technology j, applied to carline i, and NT is the number of technologies applicable. Costs and mpg improvements differ from year to year because certain technologies are not available until future years while others become obsolete. They differ from iteration to iteration because of the random behavior of competitors.

The dollar costs and benefits are used to compute the present value of mpg improvements by carline. First, the present value of fuel savings (PVS) are computed as follows,

$$PVS = \sum_j [(MI/(1+DR)^{j-1}) \cdot ((EP_0(j)/MPG_0) - (EP(j)/MPG))] \ . \qquad (11)$$

Note that the change in cost per mile of fuel (EP/MPG) compares the current year expected cost per mile with the expected cost per mile in

the base year (base year expected price j years ahead, $EP_0(j)$, divided by base year mpg). This is required by the pivot point technique which calculates new shares based on the difference in utility from the base year conditions.

1.3.3 Calculation of Market Shares

The change in utility required to compute new market shares using the pivot-point technique is gotten by subtracting the present value of fuel savings from the incremental initial cost and multiplying by a coefficient representing the marginal utility of a dollar of increased cost (since increased cost is undesirable, this coefficient will be negative). This coefficient must be supplied by the user. Sample values computed from the literature are shown in Table 2.

The pivot point formula (8) adjusts base year market shares according to these changes in utility. Occasionally, new cars will be introduced or older models discontinued. In such cases, the user must include an estimated market share for new models in the shares data bases. This estimate will be treated as a base year share. Whether a carline is introduced or deleted, the pivot-point formula normalizes shares so that they sum to one in every year. Sums and sums of squares are accumulated for each carline's market share, and for each manufacturer's market share. Once the iterations have been completed, these are used in standard formulas to compute the mean and standard deviation for the shares by carline and manufacturer.

At the same time statistics for market shares are being computed, the model also computes the mean and standard deviation of gallons per mile (1/MPG) for each manufacturer. The printed output includes average

Table 2. Marginal utility of vehicle price: selected values from the literature

Source	Coefficient estimates		
	Typical (median)	High	Low
Manski & Sherman, 1980	-0.00056	-0.00018	-0.00056
Train & Lohrer, 1982			
one vehicle	-0.00031	-0.00028	-0.00038
two vehicle	-0.00040	-0.00020	-0.00050
Berkovec, 1985			
one vehicle	-0.00130	-0.00065	-0.00224
two vehicle	-0.00070	-0.00015	-0.00095
three vehicle	-0.00150	-0.00086	-0.00255
Berkovec & Rust, 1985			
model A	-0.00009	0.00032	-0.00016
model B	-0.00056	0.00075	-0.00038
model C	-0.00100	-0.00011	-0.00041
Boyd & Mellman, 1980 (logit)	-0.00029		
Lave & Train, 1979	-0.00070	-0.00030	-0.00080
Beggs & Cardell, 1980			
model A	0.00006	0.00015	-0.00039
model C	-0.00056	-0.00047	-0.00101
Beggs & Hausman, 1981			
ordered logit	-0.00020		
individual logit	-0.00095		
Mannering & Mahmassani, 1985	-0.00021	-0.00013	-0.00051
Winston & Mannering, 1984	-0.00023	-0.00016	-0.00066
Greene, 1986			
weak model	-0.00142	-0.00029	-0.00205
strong model	-0.00179	-0.00038	-0.00210

(harmonic mean) MPG and the standard deviation of gallons per mile by manufacturer, for each forecast year.

Before the program terminates the user is given the option to create a disk file containing the results before they are printed.

1.4 COMPETITIVE UNCERTAINTY AND RISK: AN ILLUSTRATION

In his analysis of the effect of fuel price uncertainty on manufacturers' retooling decisions, Ford (1982) assumed that the manufacturer formulating a strategy knew what his competitor's retooling strategy would be. Not knowing what your competitors will do introduces another dimension of risk which can be modeled by SHRSIM. The data for this example come from a recent analysis of the capabilities of domestic automobile manufacturers to improve fuel economy, conducted for the U.S. Department of Energy (Energy and Environmental Analysis Inc., 1986; memorandum from Mr. K.G. Duleep of EEA, Inc., April 7, 1986). A listing of technologies considered is shown as Table 3. These were organized into "High" and "Low" technology strategies, consisting of time-phased introduction of bundles of options, for each car "platform" (a platform is a carline, e.g. "Plymouth Reliant," and its "twins," e.g. "Dodge Aries"). One such strategy for Chrysler's K cars is shown in Table 4. Technologies are listed by number, corresponding to Table 3, the year given is the first year in which the technology can be used in production, cost is tthe consumer's cost in 1981 dollars, and F/E is the percent improvement in MPG expected.

The parameters used in this example are shown in parenthesis in Table 1. The fuel price trend is illustrated by Figure 2. The probabi-

Table 3. Generic fuel economy technologies

01	Emissions penalty	19	Lean burn
02	Calibration	20	Fastburn combustion
03	Performance increase	21	Overhead cam engine
04	Body downsize	22	Roller cam folowers
05	Body upsize	23	Engine friction reduction
06	Body drop	24	Intake valve control
07	Front wheel drive	25	4valve/4 or 4V/6 cylinder
08	Tires I II III	26	4-6-8 Variable displacement
09	Oils I II III	27	Throttle body fuel injection
10	Accessories I II	28	Multipoint fuel injection
11	Material substitution I II III	29	Turbocharger
12	Aerodynamics I II III	30	Diesel
13	Torque converter lockup	31	DI diesel
14	AXOD or A4OD	32	Turbo diesel
15	Electronic transmission control	33	Shift indicator light
16	Continuously variable transmission	34	Supercharger
17	Manual overdrive (MOD)	35	Engine downsize/upsize
18	Engine drop	36	4 Wheel drive
		37	Electronic engine control

Table 4. High and low technology paths for Chrysler's K-car

Manufacturer: Chrysler
Size Class: Compact --> Intermediate (89)
Body Code: K
1985 Base Price: $6,030
1985 Base F/E: 29.3

Technology	Year	Cost	F/E (%)
High			
23, 27	1986	68	5.8
5, 8, 9, 11, 12, 13	1989	140	0.5
8, 9, 11, 12, 14, 15	1993	345	16.5
24	1995	40	2.0
Low			
23, 27	1986	68	5.8
5, 8, 9, 12, 13	1988	80	-3.0
8, 9, 12, 15	1993	70	6.3

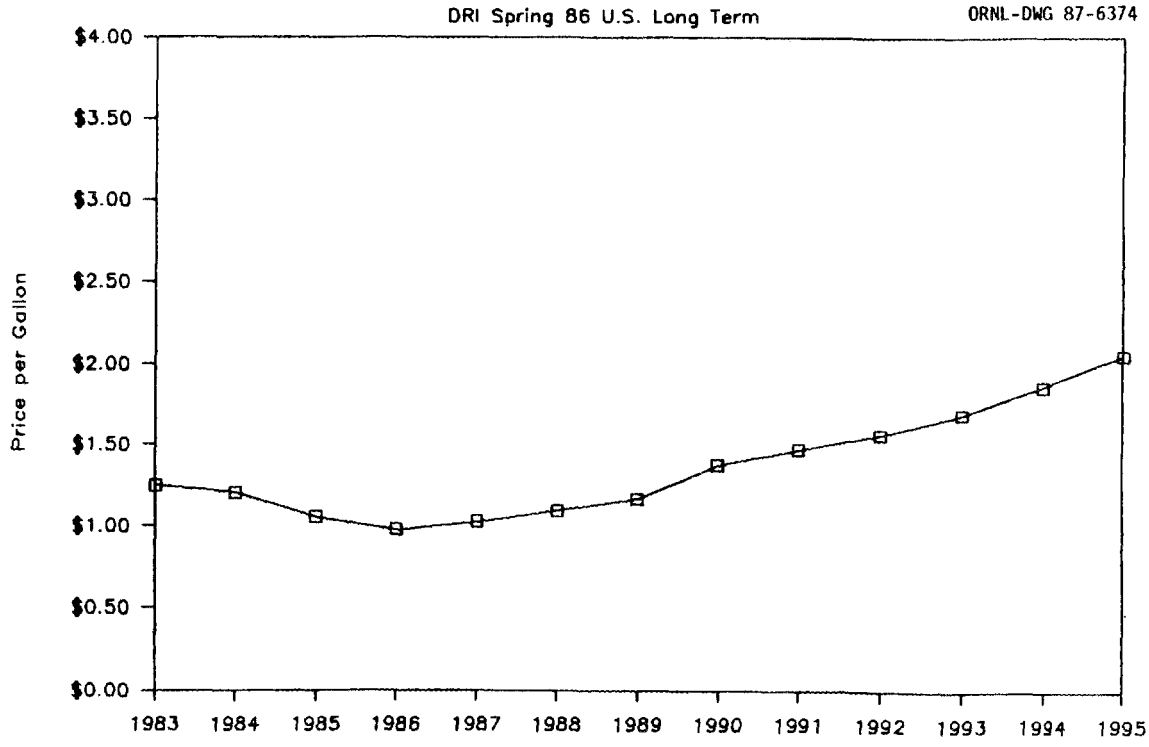

Fig. 2. Baseline gasoline price forecast, DRI spring 86 U.S. long term.

lity of at least one price shock during the ten-year forecast period is 0.8, so the independent probability in any given year is about 0.149. Price shocks may be up or down with a maximum size of 100% (thus an average size of 50%). This is about twice as large as recent experience, but was chosen to exaggerate the variance of market shares forecasts. A sample of randomized price paths is illustrated by Figure 3.

Manufacturers had three alternatives: 1) adopt the high technology path, 2) choose an alternative, lower technology path, or 3) do nothing. In the equal probability case, probabilities of 1/3 were assigned to each of these. In the "nearly certain" case, it was assumed that the other two firms would adopt the path chosen by the "leader" firm with probability 0.9, but might pick one of the other paths with probabilities 0.05 and 0.05. Results of several model runs for each of the three domestic manufacturers are illustrated in Figures 4-11. The presence of foreign competition was ignored, obviously something the domestic manufacturers cannot afford to do.

For the largest manufacturer, increased certainty about competitors' actions reduces uncertainty about future market shares but only a little. This is true whether the high or low technology option is pursued. Uncertainty increases markedly after 1991 (most of the improved technology for this manufacturer is added after 1990). The largest manufacturer tends to lose expected market share in all cases, but especially in the high technology case when its competitors are nearly certain to follow.

The smaller manufacturers suffer the greatest uncertainty about their future market shares. Faced with uncertainty about fuel prices and competition, both face, at least hypothetically, the possibility of being

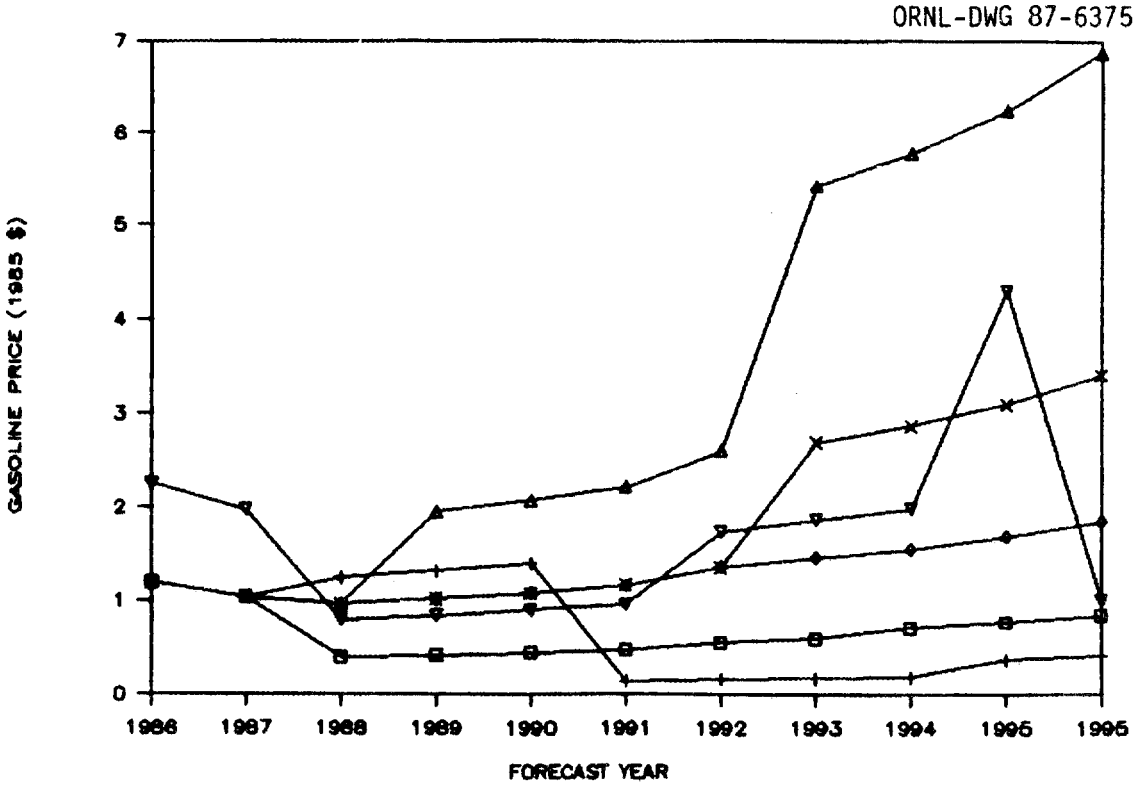

Fig. 3. A sample of random price forecasts.

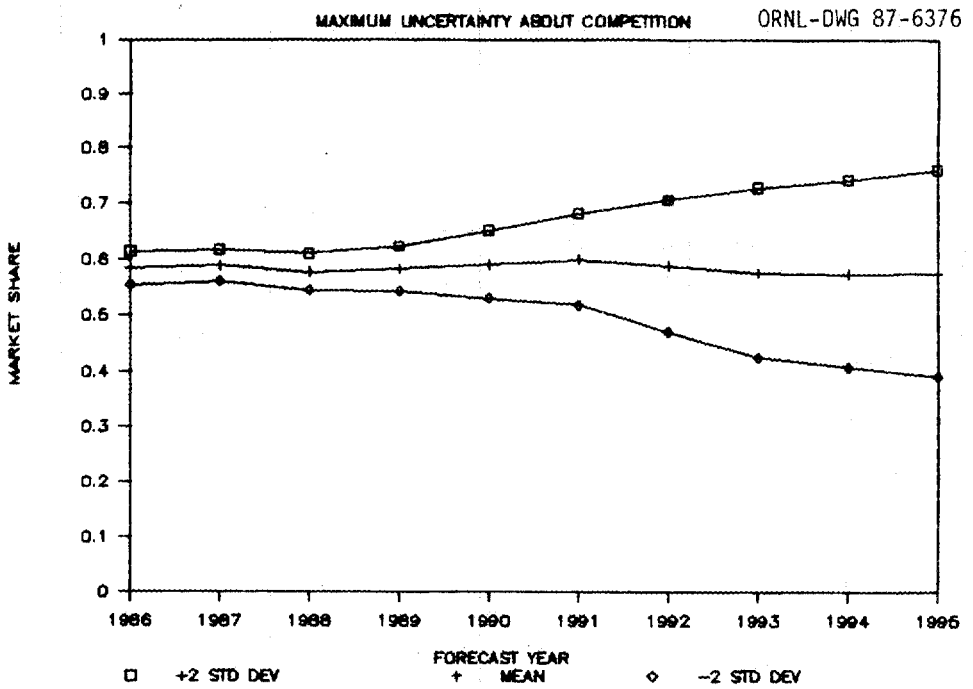

Fig. 4. Largest manufacturer, high tech option, maximum uncertainty about competition.

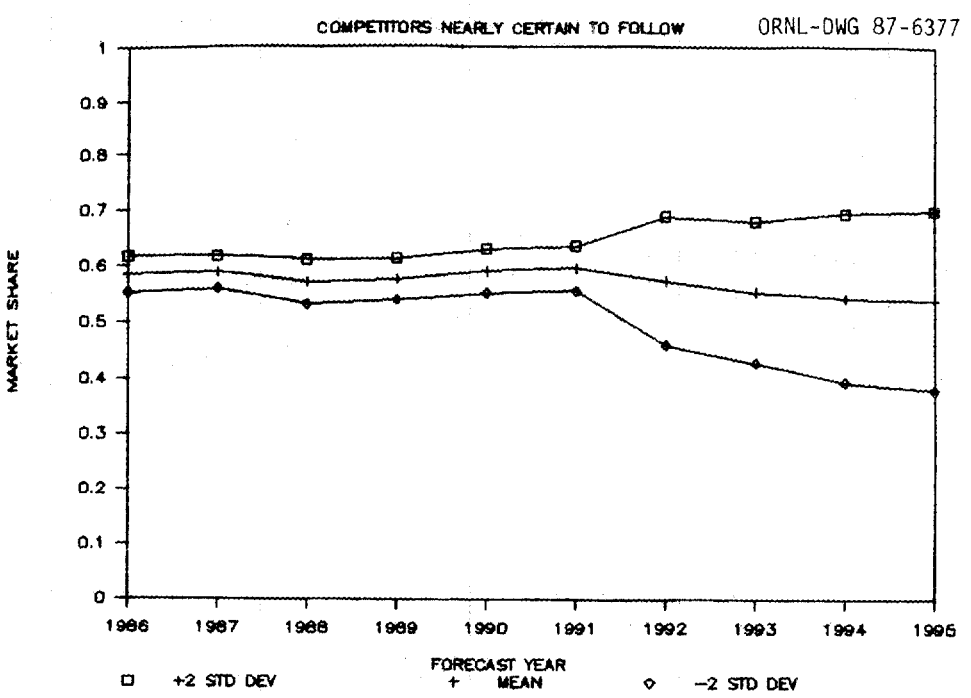

Fig. 5. Largest manufacturer, high technology, competitors nearly certain to follow.

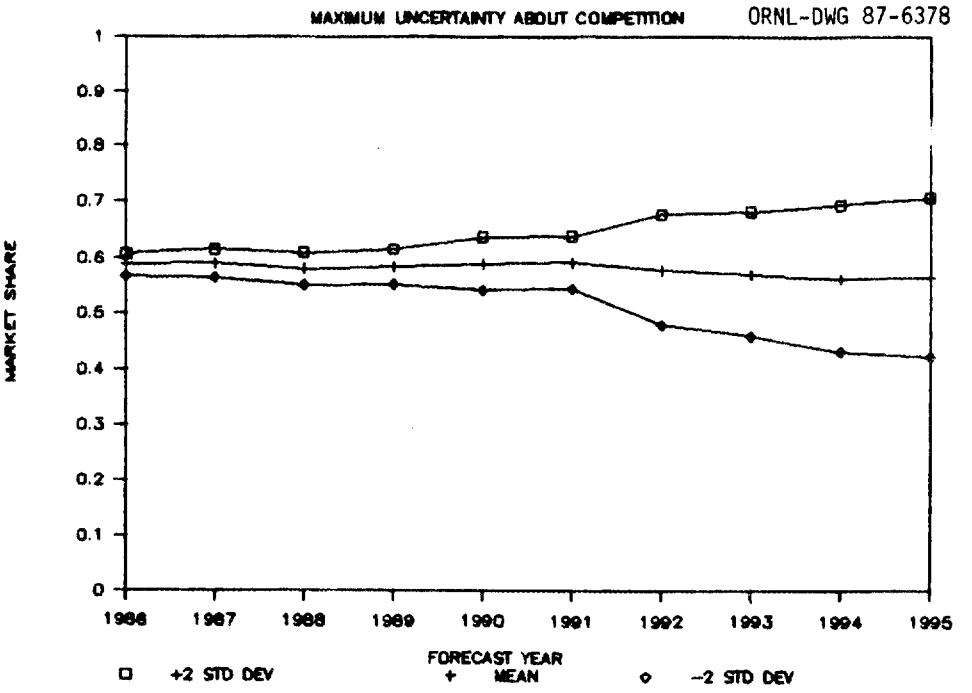

Fig. 6. Largest manufacturer, low technology, maximum uncertainty about competition.

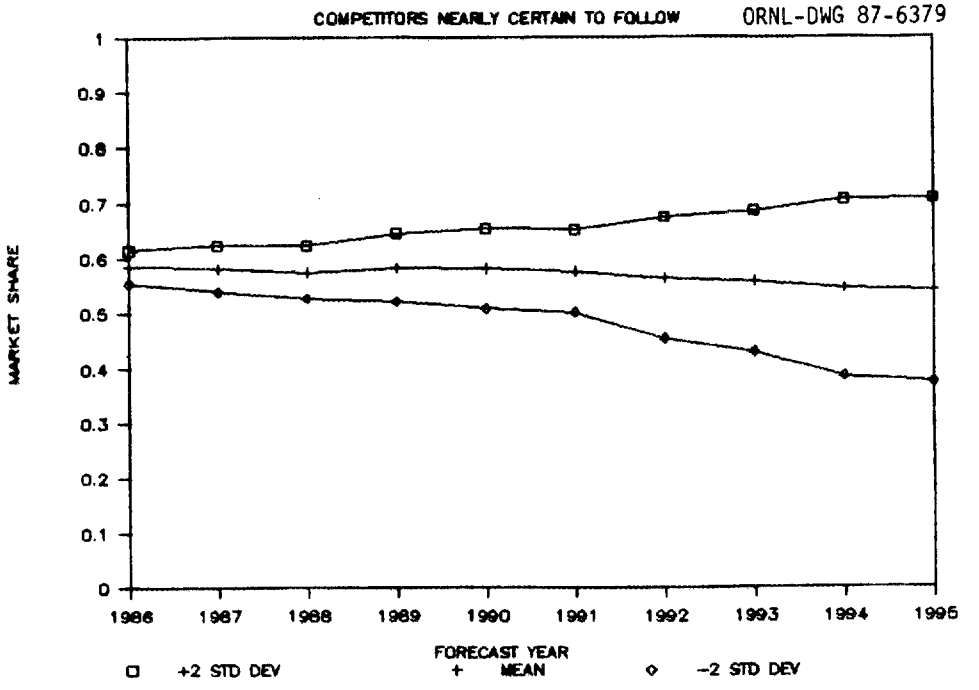

Fig. 7. Largest manufacturer, low technology, competitors nearly certain to follow.

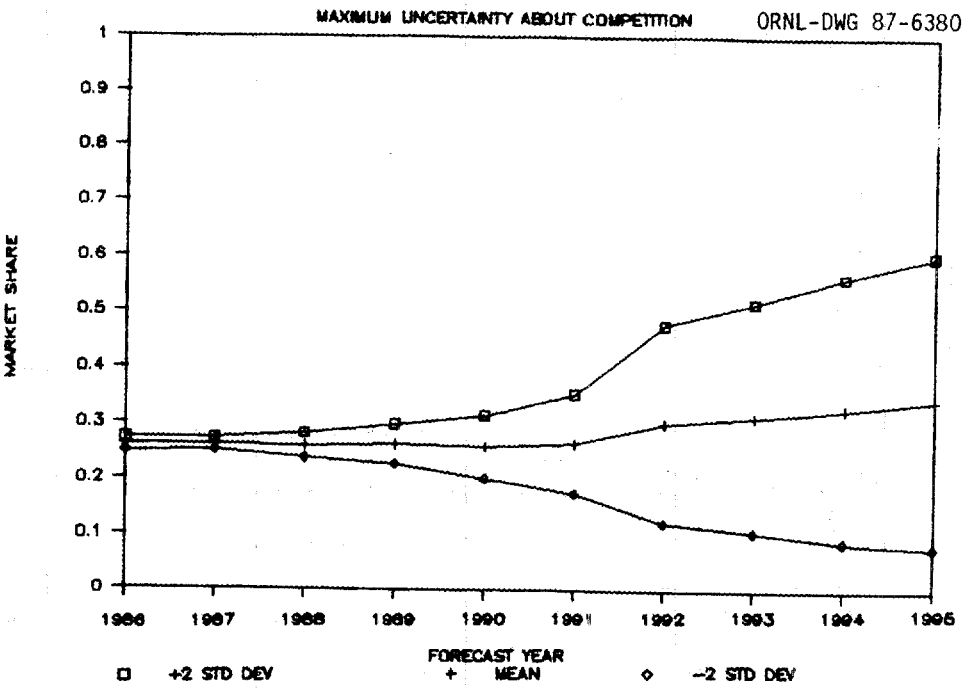

Fig. 8. Second largest manufacturer, high technology, maximum uncertainty about competition.

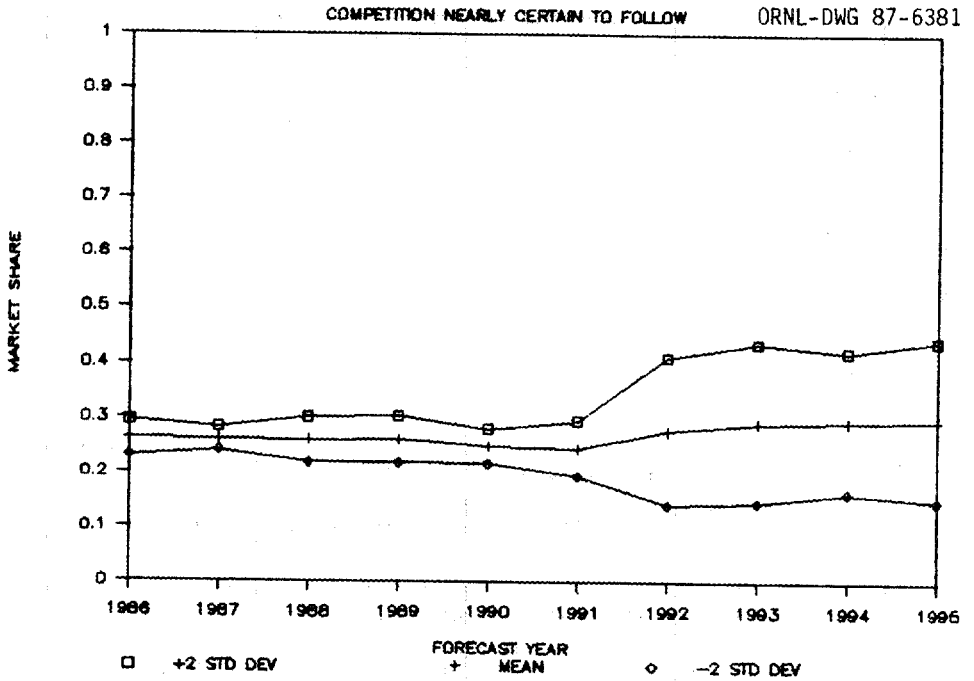

Fig. 9. Second largest manufacturer, high technology, competition nearly certain to follow.

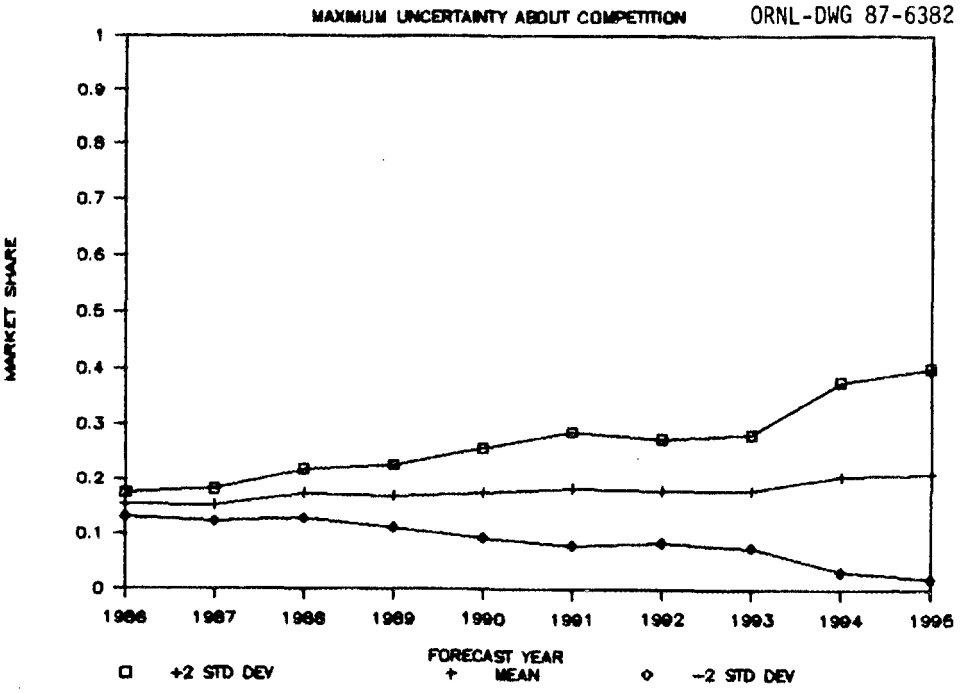

Fig. 10. Smallest manufacturer, high technology, maximum uncertainty about competition.

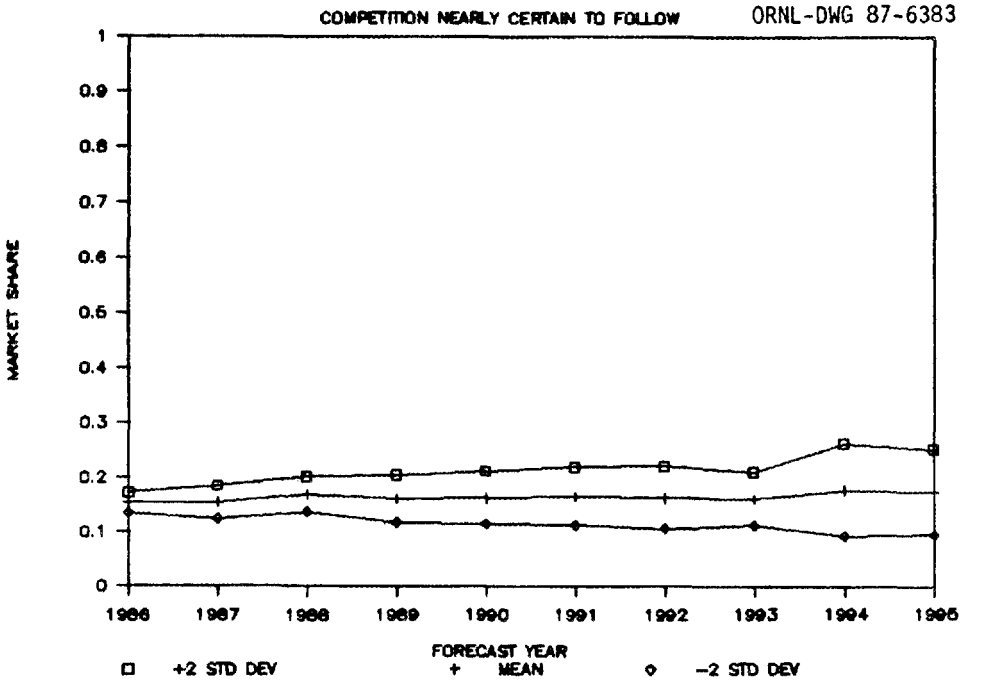

Fig. 11. Smallest manufacturer, high technology, competition nearly certain to follow.

nearly wiped out. These ranges of uncertainty are nearly cut in half by knowledge that their competition will almost certainly follow the same fuel economy improvement path. On the positive side, both have increasing expected market shares with or without knowledge of competitors' plans.

This example suggests a striking asymmetry in the market. If the largest manufacturer sneezes, the others catch a cold, but not the reverse. Perhaps most important is the clear indication that the effects of fuel price and competitive uncertainty depend greatly on the specific market position of the firm: how many and what types of carlines it markets, what fuel economy improvements it plans to introduce, when, and on which carlines, as well as what its initial market share is. This simple example indicates how much remains to be learned about the complex workings of the market for automotive fuel efficiency.

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APPENDIX A. INSTRUCTIONS FOR RUNNING THE SHRSIM MODEL

SHRSIM can be run either as an interpreted or compiled BASIC program. Experience suggests that the compiled version will execute approximately 15 times faster than the interpreted version. Use of the compiled version is strongly recommended for all but the smallest simulation problems.

A.1 Required Data Files

The user must create three data files, in addition to the key assumptions supplied during a model run. Sample files are shown in Appendix C. Any name desired can be given to these files, the names shown in Table 1 are merely illustrative. The first (SHARES.DAT) contains base year sales (or shares), the years in which the carline is introduced and discontinued, its base-year miles per gallon (mpg), and manufacturer and carline identifiers. For the shares and technology data sets the principal manufacturer (the one whose behavior is not to be random) must appear first. The second data set, FUEL.DAT, contains the base fuel price forecast. FUEL.DAT must begin two years before the base year to permit fuel price expectations to form. Fuel prices must be in constant dollars, consistent with the cost of fuel economy improvements. The third data set, TECH.DAT, contains technology data sorted by carline and manufacturer. The initial cost, percent improvement in fuel economy, year of introduction, and year of obsolescence must be provided for each technology. In this version of SHRSIM, technologies are assumed to be unique to carlines. Thus, if there are 3 manufacturers, 11 carlines per manufacturer, and 5 technologies per carline, TECH.DAT would contain 165 records.

SHRSIM allows multiple "technology scenarios" to be considered. If, for example, "high" and "low" technology scenarios were being considered, the technology data file would need twice as many records (3 manufacturers, 11 carlines each, 5 technologies per carline, and 2 technology scenarios for a total of 330 records). The records for second technology scenario must have the identical structure as the first and must be appended directly to the end of the records for the first. The user must specify the number of scenarios interactively or in a data file.

Both the SHARES and TECH data bases are assumed to be balanced. That is, every manufacturer has the same number of carlines, every carline has the same number of technologies. Since this is not likely to be the case in general, "missing" carlines or technologies must be filled in with zeros for each variable (except the identifiers, which can be anything BASIC allows for a character variable). In both the SHARES and TECH data bases the principal manufacturer's carlines must appear first. Furthermore, the order of carlines must be the same in both data sets. Which manufacturer is the principal manufacturer can be easily changed by rearranging the SHARES and TECH data files.

A.2 Running the Model

SHRSIM can be run in either compiled or interpreter BASIC. In either case, both the program and data files should be on the same diskette (or hard disk) which should be the default drive. This simplifies the specification of files and greatly reduces the chance of errors in file specification. To run the compiled program, type SHRSIM <enter> at the DOS prompt. To run the interpreter version, the BASICA inter-

preter must be in core. Type LOAD"SHRSIM <enter> and then type RUN <enter>.

SHRSIM prints a sign-on message and then asks whether the parameters needed to make a model run are to be entered from the keyboard or are on a disk file. For the initial run, parameters should be entered from the keyboard. SHRSIM lists all the required parameters and then prompts the user for each one.

Once all parameters have been entered, the user is offered the opportunity to store them in a disk file for future use. If this is declined, or after the filename has been given, SHRSIM asks whether the output is to be sent to the screen or printer. If output is sent to the screen a hardcopy cannot be created except by sending the output to a disk file and later printing it. SHRSIM then begins execution. As each iteration is completed a running count is kept on the screen.

When all calculations have been completed, SHRSIM asks whether the output is to be sent to a disk file. If so, the user is prompted for a name. Unlike previous file specifications, a file name, including disk drive but not extension, must be provided. This done, means and standard deviations of market shares for each carline and for fuel economy by manufacturer for each forecast year are sent to the designated device (screen or printer).

Sample model runs are exhibited in Appendix D. User inputs have been underlined. The sample data files contained in Appendix C have been utilized.

APPENDIX B. SHRSIM MODEL SOURCE CODE

```
1 'SHRSIM CREATED BY DAVID L. GREENE, TRANSPORTATION GROUP, OAK RIDGE NATIONAL L
ABORATORY, OAK RIDGE, TENNESSEE, APRIL 18, 1986, REVISED OCTOBER 29, 1986
4 '
5 '*****************************************************************
6 '*****************************************************************
7 '
10 ' SETUP
20 DEFINT I-L,N              'DEFINE INTERGER VARIABLE NAME CONVENTION
30 NOW=1
35 '
40     GOSUB 2000    'SETUP
99 '
100 ' READ PARAMETERS
110    GOSUB 3000    'INPUT FILES OF BASE SHARES & MPG, AND FUEL PRICES
199 '
200 ' READ TECHNOLOGY DATA
210    GOSUB 4000    'ASSET PRICE, OPERATING COST, APPLICABILITY BY CAR & YEAR
240 '
245 '**********************  BEGIN SIMULATION  **********************
249 '
250        FOR L=1 TO ITER      'DO OVER MONTE CARLO ITERATIONS
251 '
252                NOW=1      'INITIALIZE TIME COUNTER
259 '
260 ' FUEL PRICE SHOCK GENERATOR
262    GOSUB 4500  'CREATE NEW PRICE SERIES WITH RANDOM SHOCKS
264 '
270 ' MANUFACTURER BEHAVIOR GENERATOR
272    GOSUB 4200    'CREATE VECTOR TO RANDOMIZE OTHER MFGRS USE OF TECHNOLOGY
274 '
275 '* * * * * * * * * * *  DO ONE SIMULATION  * * * * * * * * * * *
279 '
280        FOR K=1 TO NY        'DO OVER ALL YEARS OF FORECAST
289 '
299 '
300 ' COMPUTE EXPECTED PRICE
310    GOSUB 5000    'FROM CURRENT YEAR TO LENGTH OF TIME HORIZON
399 '
500 ' COMPUTE MPG AND ASSET PRICE CHANGE
510    GOSUB 7000    'MPG & ASSET PRICE
599 '
600 ' COMPUTE PRESENT VALUE AND CONVERT TO UTILS
610    GOSUB 8000    'DELTA UTILITY
699 '
700 ' COMPUTE NEW SHARES
710    GOSUB 9000    'PIVOT POINT SHARES ROUTINE
799 '
800 ' UPDATE STATISTICAL CALCULATIONS
810    GOSUB 10000  'UPDATE STATISTICAL CALCULATIONS
879 '
880        NEXT K    'END OF LOOP OVER YEARS
884 '
885 '* * * * * * * * * * * END ONE SIMULATION  * * * * * * * * * * * *
886 '
889 PRINT L;
890        NEXT L    'END OF LOOP OVER MONTE CARLO ITERATIONS
894 '
895 '**********************  END SIMULATIONS  **********************
899 '
900 ' CALCULATE MEANS AND VARIANCES
910    GOSUB 11000  'MEANS AND VARIANCES OF MARKET SHARES
920 '
1000 ' OUTPUT A DISK FILE
1010    GOSUB 13000    'DISKOUT
1099 '
1900 ' SIGN OFF
1910    GOSUB 12000  'WRITE RESULTS OF CALCULATIONS AND SIGN OFF
1990 '
1991   END            'END OF MAIN PROGRAM
1992 '
1993 '*****************************************************************
1994 '*****************************************************************
```

```
1999 '
2000 '**********************  SUBROUTINE SETUP  **********************
2001 '
2005 KEY OFF:  WIDTH "SCRN:",80
2006 RANDOMIZE TIMER
2009 CLS
2010 PRINT: PRINT"                          AUTOMOBILE MARKET SHARES MODEL": PRINT
: PRINT"                                    VERSION 1
2020 PRINT: PRINT: INPUT "Do you wish to input data from the keyboard or file (K
/F)";A$
2025 IF A$="K" OR A$="k" GOTO 2030 ELSE IF A$="F" OR A$="f" GOTO 2030 ELSE GOTO
2020
2030 PRINT:PRINT: PRINT"REQUIRED DATA ARE:":PRINT
2032 PRINT"  FORECAST PARAMETERS":PRINT"     1. # of years in forecast":PRINT"
   2. # of Monte Carlo iterations":PRINT"     3. Probability of at least 1 price
 shock during forecast period"
2034 PRINT"     4. Maximum size of a price shock":PRINT"     5. Name of fuel pri
ce data file":PRINT
2040 '
2042 PRINT"  MANUFACTURER & TECHNOLOGY DATA":PRINT"     1. # of manufacturers":P
RINT"     2. # of carlines per manufacturer":PRINT"     3. Name of base year sal
es data file"
2044 PRINT"     4. Probability other manufacuters will follow leader":PRINT"
 5. Number of technology paths":PRINT"     6. Probability others will choose alt
ernative path"
2045 PRINT"     7. # of technologies":PRINT"     8. Name of Technology data file
":PRINT
2049 '
2050 PRINT"  CONSUMER DATA"
2052 PRINT"     1. Discount rate (decimal)":PRINT"     2. Consumer time horizon
(years)":PRINT"     3. Average miles driven per year"
2054 PRINT"     4. Marginal utility of a $ of increased cost (-)":PRINT"     4.
Choice of price expectation function":PRINT
2060 '
2099 '
2100 'KEYBOARD INPUT
2130 IF A$="K" OR A$="k" GOTO 2200
2140 ' INPUT FROM FILE
2150       INPUT "ENTER COMPLETE FILENAME (extension .DAT & free format assumed)
:",B$
2199 GOTO 2600 'END OF FILE INPUT
2200 ' INPUT PARAMETERS
2202     INPUT "Starting or base year for this analysis";IYR
2205     INPUT "Number of years in forecast";NY
2210     INPUT "Number of Monte Carlo iterations";ITER
2220     INPUT "Probability of at least 1 price shock (decimal)";PPROB
2222 '           CALCULATE 1-YEAR PROBABLILITY OF SHOCK OCCURRING
2224                 PPROB=1-((1-PPROB)^(1/NY))
2226 '
2230     INPUT "Maximum size of a price shock (percent)";PSIZE
2235             PSIZE=PSIZE/100
2240     INPUT "Name of fuel price data file";FP$
2250     INPUT "Number of manufacturers";NM
2255     INPUT "Number of carlines per manufacturer";NL
2260     INPUT "Name of base year sales data file";BYS$
2270     INPUT "Probability other manufacturers will follow leader (decimal)";FP
ROB
2275     INPUT "Number of technology paths (1 or 2)"; NP
2277 IF NP<2 GOTO 2285
2280     INPUT "Probability others will adopt alternative path (decimal)";APROB
2285     INPUT "Number of technologies";NT
2295     INPUT "Name of technology data file";TC$
2300     INPUT "Consumers' annual discount rate (decimal)";DR
2310     INPUT "Consumer time horizon (years)";NCTH
2320     INPUT "Miles driven per year";MILES
2330     INPUT "Marginal utility of a $ of increased cost (-)";UO
2340     INPUT "Price expectation (S=static L=linear D=declining rate)";PEF$
2399 PRINT:PRINT:PRINT"                    END OF KEYBOARD INPUT"
2400 '
```

```
2410 ' SAVE PARAMETERS
2420   INPUT "Do you wish to save these parameters in a file? (Y/N)";FSAV$
2430        IF FSAV$="N" OR FSAV$="n" GOTO 2600   'DIMENSION VARS
2440   INPUT "Enter complete filename (.DAT will be added) for parameters.";C$
2450 ' WRITE FILE TO DISK
2460     OPEN C$+".DAT" FOR OUTPUT AS #1
2470   WRITE #1,IYR,NY,ITER,PPROB,PSIZE,FP$,NM,NL,BYS$,FPROB,APROB,NT,NP,TC$,DR,
NCTH,MILES,UO,PEF$
2480     CLOSE #1
2490 PRINT: PRINT "Parameters have been written to ";C$;".DAT": PRINT:PRINT:
2499 '
2600 'DIMENSIONING OF SUBROUTINE VARIABLES
2610  DIM EP(20),EPO(20),PRICE(50),MPGN(50),DU(50),SHRN(50),DIS(20)
2620  DIM SH(50),MPG(50),FP(22),NCYRS(50),NCYRF(50),MFG$(50),CAR$(50) 'PARAMS
2630  DIM NTYRS(2,50,10),NTYRF(2,50,10),DMPG(2,50,10),COST(2,50,10)  'TECHDATA S
UB
2640  DIM SUM(50,20),SSQ(50,20),MSUM(5,20),MSSQ(5,20),EFFSUM(5,20),EFFSSQ(5,20)
'MEANS AND VARIANCES SUB
2650  DIM SFP(22)                                    'PRICE SHOCKS SUB
2660  DIM MEAN(50,20),STD(50,20),MMEAN(5,20),MSTD(5,20),EFFMEAN(5,20),EFFSTD(5,2
0)  'MEAN & STD DEV SUB
2670  DIM IFOLLOW(50)                        'MANUFACTURER BEHAVIOR
2699 '
2700 'DIRECT OUTPUT TO DEVICE
2710    PRINT:PRINT:PRINT:
2720    INPUT "Do you want the output printed on the SCREEN (S) or PRINTER (P)";
OP$
2730 PRINT:PRINT:PRINT"              CALCULATING....":PRINT:PRINT
2799 '
2800 'INITIALIZE MEAN AND STANDARD DEVIATION MATRICES
2810    FOR I=1 TO NM*NL
2820       FOR J=1 TO NY
2830          SUM(I,J)=0:SSQ(I,J)=0:MEAN(I,J)=0:STD(I,J)=0
2840       NEXT J
2850    NEXT I
2855    FOR I=1 TO NM
2860       FOR J=1 TO NY
2865          MSUM(I,J)=0: MSSQ(I,J)=0: MMEAN(I,J)=0: MSTD(I,J)=0
2870       NEXT J
2875    NEXT I
2899 '
2990 RETURN   'END OF SETUP
2994 '
2995 '*****************************************************************
2999 '
```

```
3000 '********************  SUBROUTINE PARAMETERS  ********************
3001 '
3010     IF A$="K" OR A$="k" GOTO 3100
3020      OPEN B$+".DAT" FOR INPUT AS #1
3030      INPUT #1,IYR,NY,ITER,PPROB,PSIZE,FP$,NM,NL,BYS$,FPROB,APROB,NT,NP,TC$,D
R,NCTH,MILES,UO,PEF$
3040      CLOSE #1
3050 '
3100 'READ CARLINE INTRO YEAR, DISC YEAR, BASE YEAR SHARES, AND MPG
3120     OPEN BYS$+".DAT" FOR INPUT AS #1
3125      TOT=0            'INITIALIZE SUM OF SHARES
3130     FOR I=1 TO NM*NL
3150         INPUT #1,SH(I),NCYRS(I),NCYRF(I),MPG(I),MFG$(I),CAR$(I)
3160         TOT=TOT+SH(I)
3170     NEXT I
3180     CLOSE #1
3182     FOR I=1 TO NM*NL
3184       SH(I)=SH(I)/TOT
3186     NEXT I
3190 '
3200 'READ FUEL PRICE DATA
3220     OPEN FP$+".DAT" FOR INPUT AS #1
3230     FOR I=1 TO NY+2
3240       INPUT #1,FP(I)
3245       SFP(I)=FP(I)
3250     NEXT I
3260     CLOSE #1
3300 GOSUB 5000    'INITIAL EXPECTED PRICE
3310  FOR I=1 TO NY+2
3320     EPO(I)=EP(I)
3330  NEXT I
3400 '
3410 ' COMPUTE DISCOUNTED ANNUAL MILES
3420     FOR I=1 TO NCTH
3430       DIS(I)=MILES/((1+DR)^(I-1))
3440     NEXT I
3980 '
3990 RETURN
3994 '*****************************************************************
3999 '
4000 '*********************  SUBROUTINE TECHDATA  *********************
4001 '
4010  IF NP<2 THEN APROB=0     'CAN'T TAKE ALTERNATIVE PATH IF DOESN'T EXIST
4020 ' OPEN TECHNOLOGY DATA FILE
4030      OPEN TC$+".DAT" FOR INPUT AS #1
4100 ' READ COST, MPG IMPROVEMENT, YEARS OF AVAILABILITY BY CARLINE BY TECH
4105  FOR IP=1 TO NP
4110   FOR I=1 TO NM*NL
4120     FOR J=1 TO NT
4130       INPUT #1,COST(IP,I,J),DMPG(IP,I,J),NTYRS(IP,I,J),NTYRF(IP,I,J)
4140     NEXT J
4160   NEXT I
4165  NEXT IP
4170 CLOSE #1
4190 RETURN
4195 '*****************************************************************
```

```
4199 '
4200 '**************  SUBROUTINE MANUFACTURER BEHAVIOR  **************
4201 '
4210   FOR I=1 TO NL                    'MFGR #1 WILL IMPLEMENT TECHNOLOGY
4220     IFOLLOW(I)=1
4230   NEXT I
4240 ' FOR I=NL+1 TO NM*NL              'WILL OTHER MFGRS?
4250 '   IF RND<FPROB THEN IFOLLOW(I)=1 ELSE IFOLLOW(I)=0
4260 ' NEXT I
4300  FOR I=1 TO NM-1
4305   RTEST=RND
4310    IF RTEST<FPROB+APROB THEN IFP=1 ELSE IFP=0
4315   IF RTEST>FPROB AND RTEST<(FPROB+APROB) THEN IAP=2 ELSE IAP=1
4320       FOR J=(I*NL)+1 TO (I+1)*NL
4330           IFOLLOW(J)=IFP
4340       NEXT J
4350    NEXT I
4470 RETURN
4480 '*************************************************************
4490 '
4499 '
4500 '*****************  SUBROUTINE PRICE SHOCKS  *****************
4501 '
4505   SFP(1)=FP(1)
4510   FOR I=2 TO NY+2
4520     PSIND=0                      'SET PRICE SHOCK INDICATOR
4530     IF RND<PPROB THEN PSIND=1    'HAS PRICE SHOCK OCCURRED?
4540     SFP(I)=SFP(I-1)*(FP(I)/FP(I-1))*(1+PSIND*PSIZE*((RND*2)-1))
4545     ' SHOCKED PRICE = LAGGED VALUE * PREDICTED PRICE GROWTH * RANDOM SHOCK
4550   NEXT I
4560 RETURN
4570 '*************************************************************
4999 '
5000 '****************  SUBROUTINE EXPECTED PRICE  ****************
5001 '
5010   IF PEF$="L" OR PEF$="l" GOTO 5200      'JUMP TO LINEAR PRICE EXPECTATION F
UNCTION
5020   IF PEF$="D" OR PEF$="d" GOTO 5300      'JUMP TO DECLINING EXPONENTIAL
5100 'STATIC EXPECTATIONS
5110    FOR I=1 TO NCTH
5120      EP(I)=SFP(NOW+2)
5130    NEXT I
5199 GOTO 5990
5200 'LINEAR EXPECTATIONS
5210    FOR I=1 TO NCTH
5220   EP(I)=I*((SFP(2+NOW)-SFP(NOW))/2)+SFP(1+NOW)
5230    NEXT I
5240 GOTO 5990
5300 'DECLINING EXPONENTIAL EXPECTATIONS
5310    GRAD=((SFP(2+NOW)-SFP(NOW))/2)/SFP(1+NOW)
5315    EP(1)=SFP(2+NOW)
5320      FOR I=2 TO NCTH
5330        EP(I)=(1+(GRAD/I))*EP(I-1)
5340      NEXT I
5990 RETURN
5994 '
5995 '*************************************************************
```

```
5999 '
7000 '*********************  SUBROUTINE CHANGE  *********************
7001 '
7100  FOR I=1 TO NM*NL            'OVER CARLINES
7110 PRICE(I)=0
7112 IF MPG(I)=0 THEN MPG(I)=100
7114 MPGN(I)=MPG(I)
7120    FOR J=1 TO NT             'OVER TECHNOLOGIES
7122      TEX=1      'INITIALIZE TECHNOLOGY APPLICABILITY INDICATOR
7124      IF NTYRS(IAP,I,J)>(NOW-1+IYR) THEN TEX=0      'TOO SOON
7126      IF NTYRF(IAP,I,J)<(NOW-1+IYR) THEN TEX=0      'TOO LATE
7130      PRICE(I)=PRICE(I)+COST(IAP,I,J)*TEX*IFOLLOW(I)
7135        IF DMPG(IAP,I,J)=0 THEN DMPG(IAP,I,J)=1   'CORRECT 0 DMPG
7140      MPGN(I)=MPGN(I)*(1+(DMPG(IAP,I,J)-1)*TEX*IFOLLOW(I))
7150    NEXT J
7160  NEXT I
7990 RETURN
7994 '
7995 '*****************************************************************
7999 '
8000 '*****************  SUBROUTINE UTILITY CHANGE  *****************
8001 '
8020  FOR I=1 TO NM*NL
8030  PVS=0            'INITIALIZE
8040    FOR J=1 TO NCTH
8050     PVS=PVS+(DIS(J)*((EP0(J)/MPG(I))-(EP(J)/MPGN(I))))
8060    NEXT J
8070   DU(I)=U0*(PRICE(I)-PVS)
8080  NEXT I
8990 RETURN
8994 '
8995 '*****************************************************************
8999 '
9000 '*********************  SUBROUTINE SHARES  *********************
9010  DEN=0
9100 'EXIST TELLS WHETHER CARLINE IS MARKETED
9200  FOR I=1 TO NM*NL
9202  EXIST=1
9204   IF NCYRS(I)>(NOW-1+IYR) THEN EXIST=0      'TOO SOON
9206   IF NCYRF(I)<(NOW-1+IYR) THEN EXIST=0      'TOO LATE
9210    DEN=DEN+(SH(I)*EXIST)*EXP(DU(I))
9220  NEXT I
9300  FOR I=1 TO NM*NL
9310   EXIST=1         'INITIALIZE CARLINE EXISTENCE
9320   IF NCYRS(I)>(NOW-1+IYR) THEN EXIST=0     'TOO SOON
9330   IF NCYRF(I)<(NOW-1+IYR) THEN EXIST=0     'TOO LATE
9340    SHRN(I)=((SH(I)*EXIST)*EXP(DU(I)))/DEN
9350  NEXT I
9990 RETURN
9994 '
9995 '*******************************************************************
```

```
9999 '
10000 '********************  SUBROUTINE STATISTICS  ********************
10001 '
10010 'ACCUMULATE SUM AND SQUARED SHARES
10020 '   LOOP OVER CARLINES
10030     FOR I=1 TO NM*NL
10040        SUM(I,NOW)=SUM(I,NOW)+SHRN(I)
10050        SSQ(I,NOW)=SSQ(I,NOW)+(SHRN(I)^2)
10060     NEXT I           'END LOOP OVER CARLINES
10090 'SUM AND SQUARED SHARES BY MANUFACTURER
10100    FOR I=1 TO NM
10105       XSUM=0
10106       ESUM=0
10110       FOR J=((I-1)*NL)+1 TO I*NL
10120          XSUM=XSUM+SHRN(J)
10125          ESUM=ESUM+(SHRN(J)/MPGN(J))
10130       NEXT J
10140       MSUM(I,NOW)=MSUM(I,NOW)+XSUM
10150       MSSQ(I,NOW)=MSSQ(I,NOW)+(XSUM^2)
10152       EFFSUM(I,NOW)=EFFSUM(I,NOW)+(ESUM/XSUM)    'GALS/MI
10154       EFFSSQ(I,NOW)=EFFSSQ(I,NOW)+((ESUM/XSUM)^2)
10160    NEXT I
10899 'INCREMENT YEAR COUNTER
10900 NOW=NOW+1      'INCREMENT TIME COUNTER
10990 RETURN
10994 '
10995 '*****************************************************************
10999 '
11000 '***********  SUBROUTINE MEANS AND STANDARD DEVIATIONS  ***********
11001 '
11100    'COMPUTE BY CARLINE
11110       FOR I=1 TO NM*NL
11120          FOR J=1 TO NY
11130             MEAN(I,J)=SUM(I,J)/ITER
11140             STD(I,J)=SQR(ABS((SSQ(I,J)-((SUM(I,J)^2)/ITER)))/(ITER-1))
11150          NEXT J
11160       NEXT I
11200   'COMPUTE BY MANUFACTURER
11210      FOR I=1 TO NM
11220         FOR J=1 TO NY
11230            MMEAN(I,J)=MSUM(I,J)/ITER
11240            MSTD(I,J)=SQR(ABS((MSSQ(I,J)-((MSUM(I,J)^2)/ITER)))/(ITER-1))
11242            EFFMEAN(I,J)=ITER/EFFSUM(I,J)       'AVERAGE MPG
11244    EFFSTD(I,J)=SQR(ABS((EFFSSQ(I,J)-((EFFSUM(I,J)^2)/ITER)))/(ITER-1))
11250         NEXT J
11260      NEXT I
11990 RETURN
11994 '
11995 '*****************************************************************
11999 '
```

```
12000 '*********************  SUBROUTINE SIGNOFF  *********************
12001 '
12010 'PRINT SHARES TO SCREEN OR PRINTER
12020   FOR J=1 TO NY        'LOOP OVER YEARS
12030 IF OP$="P" OR OP$="p" THEN LPRINT"   MARKET SHARES ";J+IYR ELSE PRINT"   M
ARKET SHARES ";J+IYR
12040 IF OP$="P" OR OP$="p" THEN LPRINT" MFGR      CARLINE                MEAN
    STD. DEV." ELSE PRINT" MFGR     CARLINE                MEAN     STD. DEV."
12050      FOR I=1 TO NM*NL        'LOOP OVER CARLINES
12055 IF OP$="P" OR OP$="p" THEN LPRINT MFG$(I),CAR$(I), ELSE PRINT MFG$(I),CAR$
(I),
12060 IF OP$="P" OR OP$="p" THEN LPRINT USING "  #.####^^^^";MEAN(I,J),STD(I,J)
ELSE PRINT USING "  #.####^^^^";MEAN(I,J),STD(I,J)
12070      NEXT I
12080 IF OP$="P" OR OP$="p" THEN LPRINT ELSE PRINT
12090 IF OP$="P" OR OP$="p" THEN LPRINT"                    SHARE     STD DEV
  MPG       STD DEV GPM" ELSE PRINT"                    SHARE     STD DEV      MP
G       STD DEV GPM"
12100      FOR I=1 TO NM        'PRINT MFGR AVERAGES
12110 IF OP$="P" OR OP$="p" THEN LPRINT MFG$(I*NL), ELSE PRINT MFG$(I*NL),
12120 IF OP$="P" OR OP$="p" THEN LPRINT USING "  #.####^^^^";MMEAN(I,J),MSTD(I,J
),EFFMEAN(I,J),EFFSTD(I,J) ELSE PRINT USING "  #.####^^^^";MMEAN(I,J),MSTD(I,J),
EFFMEAN(I,J),EFFSTD(I,J)
12130      NEXT I
12140 IF OP$="P" OR OP$="p" THEN LPRINT ELSE PRINT
12190   NEXT J
12200 'OUTPUT TO SCREEN
12210  PRINT:PRINT"                    CALCULATIONS COMPLETED.":PRINT:
12220  PRINT"                           GOOD BYE!"
12230 '
12990 RETURN
12994 '
12995 '*****************************************************************
12996 '
13000 '*********************  SUBROUTINE DISKOUT  *********************
13001 '
13010 PRINT: PRINT: '   SEND OUTPUT TO A DISK FILE
13020     INPUT "Do you want output sent to a disk file? (Y/N)";DF$
13030     IF DF$="Y" OR DF$="y" THEN INPUT "Enter complete filename including ex
tension:";DOFN$ ELSE GOTO 13190
13032   PRINT: PRINT "Make sure disk drive is ready."
13034   PRINT: PRINT "Press any key to continue."
13036          AA$=INKEY$: IF AA$="" THEN 13036
13040 OPEN DOFN$ FOR OUTPUT AS #1
13050     FOR J=1 TO NY
13060        FOR I=1 TO NM*NL
13070     PRINT #1,MFG$(I),CAR$(I),J+IYR,
13080     PRINT #1,USING"  #.####^^^^";MEAN(I,J),STD(I,J)
13090        NEXT I
13100     NEXT J
13110 CLOSE #1
13190 RETURN
13194 '
13195 '*****************************************************************
```

APPENDIX C. SHRSIM INPUT DATA FILES

```
C:\BAS>type shares.dat
 571 1985 9999 23.0  GM,     C
 222 1985 9999 21.6  GM,     KE
 725 1985 9999 22.5  GM,     B
  41 1985 9999 21.4  GM,     Y
1113 1985 9999 26.5  GM,     A
 600 1985 9999 23.6  GM,     GG
 291 1985 9999 22.9  GM,     F
 433 1985 9999 28.8  GM,     GM20
 599 1985 9999 29.2  GM,     J
  84 1985 9999 27.2  GM,     P
 125 1985 9999 32.8  GM,     TGM
 157 1985 9999 21.3  CHRYS,  MC
 148 1985 9999 26.2  CHRYS,  EC
 131 1985 9999 26.8  CHRYS,  H
 131 1985 9999 26.9  CHRYS,  KCVJ
 312 1985 9999 29.3  CHRYS,  K
 102 1985 9999 27.7  CHRYS,  G
 187 1987 9999 29.6  CHRYS,  P
 264 1985 9999 31.0  CHRYS,  L
   0    0    0  0.0  CHRYS,  XXX
   0    0    0  0.0  CHRYS,  XXX
   0    0    0  0.0  CHRYS,  XXX
  45 1985 9999 20.5  FORD,   FOX
 454 1985 9999 20.3  FORD,   PANTHER
 284 1985 9999 23.4  FORD,   LTD
 255 1985 9999 22.7  FORD,   TBIRD
 158 1985 9999 25.0  FORD,   MUSTANG
 368 1985 9999 30.2  FORD,   TEMPO
 541 1985 9999 34.0  FORD,   ESCORT
   0    0    0  0.0  FORD,  XXX
   0    0    0  0.0  FORD,  XXX
   0    0    0  0.0  FORD,  XXX
   0    0    0  0.0  FORD,  XXX
```

```
C:\BAS>type fuel.dat
1.24733
1.20200
1.05415
0.97825
1.03009
1.09499
1.16726
1.37270
1.46879
1.56426
1.69253
1.86009
2.05354
2.29175
2.56676
2.88504
3.25432
3.56674
3.95194
4.29577
4.63943
5.06626
5.49688
5.95312
6.43533
6.91798
7.36765
7.85392
```

```
type hltech.dat
165 1.090 1987 9999
 30 1.020 1989 9999
315 1.110 1992 9999
  0     0    0    0
  0     0    0    0
365 1.200 1986 9999
 30 1.020 1989 9999
310 1.110 1992 9999
  0     0    0    0
  0     0    0    0
300 1.220 1986 9999
 55 1.050 1989 9999
300 1.110 1992 9999
  0     0    0    0
  0     0    0    0
 40 1.040 1986 9999
485 1.220 1992 9999
  0     0    0    0
  0     0    0    0
  0     0    0    0
 70 1.049 1987 9999
185 1.110 1989 9999
190 1.110 1994 9999
  0     0    0    0
  0     0    0    0
390 1.289 1988 9999
117 1.069 1990 9999
200 1.110 1993 9999
  0     0    0    0
  0     0    0    0
 24 1.020 1986 9999
 40 1.028 1988 9999
300 1.226 1990 9999
 25 1.030 1992 9999
230 1.095 1995 9999
 65 1.048 1987 9999
 35 1.040 1989 9999
135 1.100 1991 9999
170 1.070 1995 9999
  0     0    0    0
 30 1.024 1988 9999
375 1.250 1990 9999
 25 1.030 1993 9999
200 1.103 1995 9999
  0     0    0    0
 75 1.055 1988 9999
200 1.132 1991 9999
 38 1.045 1993 9999
  0     0    0    0
  0     0    0    0
255 1.160 1986 9999
160 1.130 1989 9999
260 1.170 1993 9999
  0     0    0    0
  0     0    0    0
450 1.270 1988 9999
180 1.095 1990 9999
110 1.080 1993 9999
 40 1.020 1995 9999
  0     0    0    0
```

60	1.050	1986	9999
160	1.010	1988	9999
180	1.095	1990	9999
110	1.080	1993	9999
40	1.020	1995	9999
65	1.050	1986	9999
110	1.080	1989	9999
180	1.105	1991	9999
245	1.110	1994	9999
0	0	0	0
40	1.030	1986	9999
105	1.102	1987	9999
340	1.145	1991	9999
50	1.050	1993	9999
220	1.080	1995	9999
68	1.058	1986	9999
140	1.005	1989	9999
345	1.165	1993	9999
40	1.020	1995	9999
0	0	0	0
40	1.030	1986	9999
45	1.040	1988	9999
190	1.120	1990	9999
50	1.050	1993	9999
40	1.020	1995	9999
45	1.040	1988	9999
190	1.115	1991	9999
50	1.050	1993	9999
200	1.080	1995	9999
0	0	0	0
68	1.058	1987	9999
265	1.198	1989	9999
255	1.160	1993	9999
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

165	1.120	1986	9999
285	1.220	1988	9999
55	1.050	1991	9999
155	1.080	1994	9999
0	0	0	0
160	1.110	1986	9999
25	1.027	1987	9999
380	1.240	1991	9999
105	1.070	1993	9999
0	0	0	0
405	1.184	1986	9999
480	1.028	1989	9999
115	1.080	1991	9999
160	1.060	1994	9999
0	0	0	0
80	1.060	1987	9999
270	1.085	1989	9999
305	1.224	1993	9999
40	1.020	1994	9999
0	0	0	0
80	1.045	1986	9999
330	1.250	1989	9999
65	1.070	1992	9999
190	1.110	1994	9999
0	0	0	0
100	1.080	1988	9999
150	1.100	1991	9999
45	1.050	1992	9999
230	1.140	1995	9999
0	0	0	0
175	1.117	1987	9999
255	1.190	1991	9999
25	1.030	1993	9999
180	1.080	1995	9999
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

80	1.057	1987	9999
30	1.020	1990	9999
65	1.047	1993	9999
0	0	0	0
0	0	0	0
80	1.057	1986	9999
30	1.020	1989	9999
65	1.047	1992	9999
0	0	0	0
0	0	0	0
70	1.057	1987	9999
55	1.050	1989	9999
45	1.047	1992	9999
0	0	0	0
0	0	0	0
40	1.040	1986	9999
65	1.100	1992	9999
0	0	0	0
0	0	0	0
0	0	0	0
40	1.038	1987	9999
50	1.037	1989	9999
75	1.057	1994	9999
0	0	0	0
0	0	0	0
110	1.092	1988	9999
30	1.020	1990	9999
75	1.057	1993	9999
0	0	0	0
0	0	0	0
24	1.020	1986	9999
20	1.020	1988	9999
80	1.053	1990	9999
25	1.030	1992	9999
28	1.016	1995	9999
35	1.027	1987	9999
35	1.040	1989	9999
45	1.047	1991	9999
40	1.020	1995	9999
0	0	0	0
18	1.020	1988	9999
95	1.084	1990	9999
25	1.030	1993	9999
40	1.030	1995	9999
0	0	0	0
41	1.036	1988	9999
110	1.070	1991	9999
25	1.030	1993	9999
0	0	0	0
0	0	0	0
255	1.160	1986	9999
115	1.097	1989	9999
85	1.070	1994	9999
0	0	0	0
0	0	0	0
450	1.270	1988	9999
30	1.020	1990	9999
45	1.047	1993	9999
0	0	0	0
0	0	0	0

60	1.050	1986	9999
160	1.010	1988	9999
30	1.020	1990	9999
45	1.047	1993	9999
0	0	0	0
65	1.050	1986	9999
50	1.047	1989	9999
50	1.040	1991	9999
25	1.030	1996	9999
0	0	0	0
40	1.030	1986	9999
105	1.020	1987	9999
50	1.037	1991	9999
25	1.030	1993	9999
60	1.030	1995	9999
68	1.058	1986	9999
80	0.970	1988	9999
70	1.063	1993	9999
0	0	0	0
0	0	0	0
40	1.030	1986	9999
45	1.040	1988	9999
55	1.052	1990	9999
50	1.050	1993	9999
0	0	0	0
45	1.040	1988	9999
40	1.038	1991	9999
50	1.050	1993	9999
60	1.030	1995	9999
0	0	0	0
68	1.058	1987	9999
93	1.082	1989	9999
115	1.110	1993	9999
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
165	1.120	1986	9999
70	1.037	1989	9999
25	1.030	1992	9999
85	1.047	1994	9999
0	0	0	0

160	1.110	1986	9999
25	1.027	1987	9999
70	1.037	1991	9999
25	1.030	1993	9999
0	0	0	0
405	1.184	1986	9999
30	1.020	1989	9999
65	1.047	1992	9999
60	1.027	1995	9999
0	0	0	0
80	1.060	1987	9999
50	1.037	1989	9999
95	1.071	1993	9999
0	0	0	0
0	0	0	0
80	1.045	1986	9999
210	1.167	1989	9999
65	1.070	1992	9999
100	1.077	1994	9999
0	0	0	0
100	1.080	1988	9999
75	1.067	1991	9999
45	1.050	1992	9999
90	1.040	1995	9999
0	0	0	0
175	1.117	1987	9999
110	1.084	1991	9999
25	1.030	1993	9999
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

APPENDIX D. SAMPLE SHRSIM MODEL RUN

```
C:\BAS>RUN

                    AUTOMOBILE MARKET SHARES MODEL

                              VERSION 1

Do you wish to input data from the keyboard or file (K/F)? k

REQUIRED DATA ARE:

  FORECAST PARAMETERS
     1. # of years in forecast
     2. # of Monte Carlo iterations
     3. Probability of at least 1 price shock during forecast period
     4. Maximum size of a price shock
     5. Name of fuel price data file

  MANUFACTURER & TECHNOLOGY DATA
     1. # of manufacturers
     2. # of carlines per manufacturer
     3. Name of base year sales data file
     4. Probability other manufacuters will follow leader
     5. Number of technology paths
     6. Probability others will choose alternative path
     7. # of technologies
     8. Name of Technology data file

  CONSUMER DATA
     1. Discount rate (decimal)
     2. Consumer time horizon (years)
     3. Average miles driven per year
     4. Marginal utility of a $ of increased cost (-)
     4. Choice of price expectation function

Starting or base year for this analysis? 1985
Number of years in forecast? 10
Number of Monte Carlo iterations?    100
Probability of at least 1 price shock (decimal)? .8
Maximum size of a price shock (percent)? 50
Name of fuel price data file? fuel
Number of manufacturers? 3
Number of carlines per manufacturer? 11
Name of base year sales data file? shares
Probability other manufacturers will follow leader (decimal)? .333
Number of technology paths (1 or 2)? 2
Probability others will adopt alternative path (decimal)? .333
Number of technologies? 5
Name of technology data file? hltech
Consumers' annual discount rate (decimal)? .3
Consumer time horizon (years)? 10
Miles driven per year? 15000
Marginal utility of a $ of increased cost (-)? -0.0015
Price expectation (S=static L=linear D=declining rate)? s


                 END OF KEYBOARD INPUT
Do you wish to save these parameters in a file? (Y/N)? y
Enter complete filename (.DAT will be added) for parameters.? params

Parameters have been written to params.DAT
```

Do you want the output printed on the SCREEN (S) or PRINTER (P)? p

CALCULATING....

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42		
43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62		
63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82		
83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100				

Do you want output sent to a disk file? (Y/N)?

MARKET SHARES 1986

MFGR	CARLINE	MEAN	STD. DEV.
GM	C	0.6977E-01	0.3821E-02
GM	KE	0.2715E-01	0.2435E-02
GM	B	0.8860E-01	0.5910E-02
GM	Y	0.5015E-02	0.4769E-03
GM	A	0.1363E+00	0.2505E-02
GM	GG	0.7332E-01	0.3017E-02
GM	F	0.3556E-01	0.2031E-02
GM	GM20	0.5321E-01	0.3003E-02
GM	J	0.7365E-01	0.4612E-02
GM	P	0.1030E-01	0.3123E-03
GM	TGM	0.1547E-01	0.1751E-02
CHRYS	MC	0.1921E-01	0.1879E-02
CHRYS	EC	0.1812E-01	0.2425E-03
CHRYS	H	0.1605E-01	0.3781E-03
CHRYS	KCVJ	0.1605E-01	0.4056E-03
CHRYS	K	0.3837E-01	0.2463E-02
CHRYS	G	0.1251E-01	0.4840E-03
CHRYS	P	0.0000E+00	0.0000E+00
CHRYS	L	0.3257E-01	0.2899E-02
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
FORD	FOX	0.5512E-02	0.6667E-03
FORD	PANTHER	0.5564E-01	0.7069E-02
FORD	LTD	0.3470E-01	0.1582E-02
FORD	TBIRD	0.3116E-01	0.1928E-02
FORD	MUSTANG	0.1932E-01	0.2457E-03
FORD	TEMPO	0.4533E-01	0.3517E-02
FORD	ESCORT	0.6712E-01	0.8607E-02
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00

	SHARE	STD DEV	MPG	STD DEV GPM
GM	0.5883E+00	0.5843E-02	0.2505E+02	0.2354E-03
CHRYS	0.1529E+00	0.4944E-02	0.2729E+02	0.2441E-03
FORD	0.2588E+00	0.1605E-02	0.2559E+02	0.7518E-03

MARKET SHARES 1987

MFGR	CARLINE	MEAN	STD. DEV.
GM	C	0.6961E-01	0.5509E-02
GM	KE	0.3107E-01	0.1364E-02
GM	B	0.1050E+00	0.1281E-01
GM	Y	0.5654E-02	0.5722E-03
GM	A	0.1300E+00	0.1982E-02
GM	GG	0.7251E-01	0.4545E-02
GM	F	0.3693E-01	0.2555E-02
GM	GM20	0.4960E-01	0.2643E-02
GM	J	0.6842E-01	0.4107E-02
GM	P	0.9748E-02	0.2482E-03
GM	TGM	0.1395E-01	0.2482E-02
CHRYS	MC	0.1971E-01	0.2614E-02
CHRYS	EC	0.1822E-01	0.7628E-03
CHRYS	H	0.1591E-01	0.7114E-03
CHRYS	KCVJ	0.1563E-01	0.5353E-03
CHRYS	K	0.3726E-01	0.3106E-02
CHRYS	G	0.1206E-01	0.5552E-03
CHRYS	P	0.0000E+00	0.0000E+00
CHRYS	L	0.2981E-01	0.2644E-02
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
FORD	FOX	0.6631E-02	0.9217E-03
FORD	PANTHER	0.6609E-01	0.9331E-02
FORD	LTD	0.3389E-01	0.1577E-02
FORD	TBIRD	0.3123E-01	0.2742E-02
FORD	MUSTANG	0.1917E-01	0.4618E-03
FORD	TEMPO	0.4175E-01	0.3187E-02
FORD	ESCORT	0.6016E-01	0.7857E-02
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00

	SHARE	STD DEV	MPG	STD DEV GPM
GM	0.5925E+00	0.1068E-01	0.2578E+02	0.7952E-03
CHRYS	0.1486E+00	0.5618E-02	0.2778E+02	0.5599E-03
FORD	0.2589E+00	0.7703E-02	0.2617E+02	0.1107E-02

MARKET SHARES 1988

MFGR	CARLINE	MEAN	STD. DEV.
GM	C	0.7070E-01	0.4359E-02
GM	KE	0.2933E-01	0.2215E-02
GM	B	0.1034E+00	0.9512E-02
GM	Y	0.5272E-02	0.7976E-03
GM	A	0.1315E+00	0.3504E-02
GM	GG	0.6803E-01	0.6847E-02
GM	F	0.3462E-01	0.3780E-02
GM	GM20	0.4985E-01	0.3692E-02
GM	J	0.6593E-01	0.3809E-02
GM	P	0.9307E-02	0.1615E-03
GM	TGM	0.1393E-01	0.2887E-02
CHRYS	MC	0.1830E-01	0.3523E-02
CHRYS	EC	0.1741E-01	0.6695E-03
CHRYS	H	0.1525E-01	0.6069E-03
CHRYS	KCVJ	0.1547E-01	0.1828E-02
CHRYS	K	0.3616E-01	0.3217E-02
CHRYS	G	0.1158E-01	0.4675E-03
CHRYS	P	0.2056E-01	0.1361E-02
CHRYS	L	0.3030E-01	0.3621E-02
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
FORD	FOX	0.6171E-02	0.1103E-02
FORD	PANTHER	0.6444E-01	0.1205E-01
FORD	LTD	0.3216E-01	0.1699E-02
FORD	TBIRD	0.3133E-01	0.3353E-02
FORD	MUSTANG	0.1816E-01	0.6279E-03
FORD	TEMPO	0.4041E-01	0.3173E-02
FORD	ESCORT	0.6045E-01	0.1177E-01
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00

	SHARE	STD DEV	MPG	STD DEV GPM
GM	0.5818E+00	0.1301E-01	0.2647E+02	0.7665E-03
CHRYS	0.1650E+00	0.7156E-02	0.2837E+02	0.7894E-03
FORD	0.2531E+00	0.1145E-01	0.2685E+02	0.1651E-02

MARKET SHARES 1989

MFGR	CARLINE	MEAN	STD. DEV.
GM	C	0.6779E-01	0.6635E-02
GM	KE	0.2812E-01	0.3069E-02
GM	B	0.9982E-01	0.1040E-01
GM	Y	0.4987E-02	0.1018E-02
GM	A	0.1281E+00	0.3358E-02
GM	GG	0.8473E-01	0.7649E-02
GM	F	0.3457E-01	0.4496E-02
GM	GM20	0.4912E-01	0.3324E-02
GM	J	0.6705E-01	0.4520E-02
GM	P	0.9682E-02	0.3219E-03
GM	TGM	0.1424E-01	0.3313E-02
CHRYS	MC	0.2070E-01	0.3474E-02
CHRYS	EC	0.1458E-01	0.9630E-03
CHRYS	H	0.1484E-01	0.6737E-03
CHRYS	KCVJ	0.1511E-01	0.1729E-02
CHRYS	K	0.3334E-01	0.3398E-02
CHRYS	G	0.1183E-01	0.8169E-03
CHRYS	P	0.2109E-01	0.1731E-02
CHRYS	L	0.3017E-01	0.3687E-02
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
FORD	FOX	0.6523E-02	0.1623E-02
FORD	PANTHER	0.6103E-01	0.1411E-01
FORD	LTD	0.3115E-01	0.2253E-02
FORD	TBIRD	0.2987E-01	0.4409E-02
FORD	MUSTANG	0.1752E-01	0.1130E-02
FORD	TEMPO	0.4252E-01	0.5428E-02
FORD	ESCORT	0.6156E-01	0.1360E-01
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00

	SHARE	STD DEV	MPG	STD DEV GPM
GM	0.5882E+00	0.1699E-01	0.2729E+02	0.1142E-02
CHRYS	0.1617E+00	0.9319E-02	0.2915E+02	0.1239E-02
FORD	0.2502E+00	0.1624E-01	0.2727E+02	0.1991E-02

MARKET SHARES 1990

MFGR	CARLINE	MEAN	STD. DEV.
GM	C	0.6526E-01	0.8127E-02
GM	KE	0.2751E-01	0.3605E-02
GM	B	0.1062E+00	0.1109E-01
GM	Y	0.4562E-02	0.1189E-02
GM	A	0.1348E+00	0.6790E-02
GM	GG	0.8317E-01	0.8306E-02
GM	F	0.3224E-01	0.5634E-02
GM	GM20	0.5271E-01	0.4154E-02
GM	J	0.6612E-01	0.3266E-02
GM	P	0.9444E-02	0.2277E-03
GM	TGM	0.1626E-01	0.4793E-02
CHRYS	MC	0.1965E-01	0.3963E-02
CHRYS	EC	0.1406E-01	0.1050E-02
CHRYS	H	0.1547E-01	0.1475E-02
CHRYS	KCVJ	0.1482E-01	0.1912E-02
CHRYS	K	0.3052E-01	0.2480E-02
CHRYS	G	0.1160E-01	0.7817E-03
CHRYS	P	0.2090E-01	0.1415E-02
CHRYS	L	0.3325E-01	0.6649E-02
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
FORD	FOX	0.6182E-02	0.1810E-02
FORD	PANTHER	0.5571E-01	0.1638E-01
FORD	LTD	0.2561E-01	0.7075E-02
FORD	TBIRD	0.2781E-01	0.4778E-02
FORD	MUSTANG	0.2020E-01	0.3534E-02
FORD	TEMPO	0.4248E-01	0.4882E-02
FORD	ESCORT	0.6347E-01	0.1344E-01
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00

	SHARE	STD DEV	MPG	STD DEV GPM
GM	0.5983E+00	0.2344E-01	0.2828E+02	0.1435E-02
CHRYS	0.1603E+00	0.1137E-01	0.2987E+02	0.1741E-02
FORD	0.2415E+00	0.2175E-01	0.2801E+02	0.2250E-02

MARKET SHARES 1991

MFGR	CARLINE	MEAN	STD. DEV.
GM	C	0.5889E-01	0.1180E-01
GM	KE	0.2451E-01	0.5019E-02
GM	B	0.9901E-01	0.1418E-01
GM	Y	0.3800E-02	0.1469E-02
GM	A	0.1320E+00	0.5152E-02
GM	GG	0.8592E-01	0.1284E-01
GM	F	0.3914E-01	0.5936E-02
GM	GM20	0.5268E-01	0.3632E-02
GM	J	0.8273E-01	0.1655E-01
GM	P	0.8982E-02	0.6246E-03
GM	TGM	0.1929E-01	0.7138E-02
CHRYS	MC	0.1877E-01	0.5156E-02
CHRYS	EC	0.1374E-01	0.1213E-02
CHRYS	H	0.1489E-01	0.1948E-02
CHRYS	KCVJ	0.1417E-01	0.2124E-02
CHRYS	K	0.2998E-01	0.2140E-02
CHRYS	G	0.1241E-01	0.1983E-02
CHRYS	P	0.2061E-01	0.1585E-02
CHRYS	L	0.3595E-01	0.9293E-02
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
FORD	FOX	0.5417E-02	0.2008E-02
FORD	PANTHER	0.4650E-01	0.1942E-01
FORD	LTD	0.2357E-01	0.7360E-02
FORD	TBIRD	0.2446E-01	0.6283E-02
FORD	MUSTANG	0.1977E-01	0.4417E-02
FORD	TEMPO	0.4307E-01	0.5567E-02
FORD	ESCORT	0.6974E-01	0.1808E-01
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00

	SHARE	STD DEV	MPG	STD DEV GPM
GM	0.6070E+00	0.3449E-01	0.2951E+02	0.1899E-02
CHRYS	0.1605E+00	0.1753E-01	0.3045E+02	0.2052E-02
FORD	0.2325E+00	0.3039E-01	0.2862E+02	0.2360E-02

MARKET SHARES 1992

MFGR	CARLINE	MEAN	STD. DEV.
GM	C	0.5453E-01	0.1391E-01
GM	KE	0.2268E-01	0.5775E-02
GM	B	0.9341E-01	0.1670E-01
GM	Y	0.3422E-02	0.1569E-02
GM	A	0.1272E+00	0.8579E-02
GM	GG	0.8311E-01	0.1366E-01
GM	F	0.3707E-01	0.6734E-02
GM	GM20	0.6034E-01	0.7810E-02
GM	J	0.8308E-01	0.1628E-01
GM	P	0.1039E-01	0.8212E-03
GM	TGM	0.2018E-01	0.7611E-02
CHRYS	MC	0.1767E-01	0.5586E-02
CHRYS	EC	0.1306E-01	0.1663E-02
CHRYS	H	0.1560E-01	0.3095E-02
CHRYS	KCVJ	0.1410E-01	0.2724E-02
CHRYS	K	0.2890E-01	0.2506E-02
CHRYS	G	0.1205E-01	0.2107E-02
CHRYS	P	0.2188E-01	0.3123E-02
CHRYS	L	0.3610E-01	0.9802E-02
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
FORD	FOX	0.5247E-02	0.2335E-02
FORD	PANTHER	0.5047E-01	0.2063E-01
FORD	LTD	0.2276E-01	0.6954E-02
FORD	TBIRD	0.2247E-01	0.7165E-02
FORD	MUSTANG	0.1879E-01	0.4542E-02
FORD	TEMPO	0.4649E-01	0.9634E-02
FORD	ESCORT	0.7900E-01	0.3106E-01
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00

	SHARE	STD DEV	MPG	STD DEV GPM
GM	0.5954E+00	0.4712E-01	0.2990E+02	0.1992E-02
CHRYS	0.1594E+00	0.2326E-01	0.3105E+02	0.2473E-02
FORD	0.2452E+00	0.4740E-01	0.3035E+02	0.3429E-02

MARKET SHARES 1994

MFGR	CARLINE	MEAN	STD. DEV.
GM	C	0.4978E-01	0.1359E-01
GM	KE	0.2062E-01	0.5611E-02
GM	B	0.8780E-01	0.1603E-01
GM	Y	0.3902E-02	0.1382E-02
GM	A	0.1141E+00	0.1726E-01
GM	GG	0.8854E-01	0.2125E-01
GM	F	0.3590E-01	0.9233E-02
GM	GM20	0.5710E-01	0.6631E-02
GM	J	0.8832E-01	0.1963E-01
GM	P	0.1085E-01	0.1275E-02
GM	TGM	0.2489E-01	0.1505E-01
CHRYS	MC	0.1772E-01	0.6876E-02
CHRYS	EC	0.1302E-01	0.2703E-02
CHRYS	H	0.1419E-01	0.3378E-02
CHRYS	KCVJ	0.1407E-01	0.3983E-02
CHRYS	K	0.2921E-01	0.4329E-02
CHRYS	G	0.1232E-01	0.3143E-02
CHRYS	P	0.2257E-01	0.4871E-02
CHRYS	L	0.4201E-01	0.1899E-01
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
FORD	FOX	0.4611E-02	0.2486E-02
FORD	PANTHER	0.4738E-01	0.2418E-01
FORD	LTD	0.2107E-01	0.8698E-02
FORD	TBIRD	0.2409E-01	0.8658E-02
FORD	MUSTANG	0.1994E-01	0.6765E-02
FORD	TEMPO	0.4912E-01	0.1383E-01
FORD	ESCORT	0.8691E-01	0.4004E-01
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00

	SHARE	STD DEV	MPG	STD DEV GPM
GM	0.5818E+00	0.7080E-01	0.3156E+02	0.2471E-02
CHRYS	0.1651E+00	0.4042E-01	0.3282E+02	0.3466E-02
FORD	0.2531E+00	0.6841E-01	0.3183E+02	0.3973E-02

MARKET SHARES 1993

MFGR	CARLINE	MEAN	STD. DEV.
GM	C	0.5206E-01	0.1135E-01
GM	KE	0.2269E-01	0.4647E-02
GM	B	0.9494E-01	0.1253E-01
GM	Y	0.4333E-02	0.1231E-02
GM	A	0.1232E+00	0.1142E-01
GM	GG	0.8059E-01	0.1551E-01
GM	F	0.3910E-01	0.7795E-02
GM	GM20	0.6002E-01	0.7303E-02
GM	J	0.8354E-01	0.1611E-01
GM	P	0.1018E-01	0.8362E-03
GM	TGM	0.2124E-01	0.8160E-02
CHRYS	MC	0.1680E-01	0.5839E-02
CHRYS	EC	0.1253E-01	0.2001E-02
CHRYS	H	0.1524E-01	0.3245E-02
CHRYS	KCVJ	0.1377E-01	0.2967E-02
CHRYS	K	0.2809E-01	0.2898E-02
CHRYS	G	0.1180E-01	0.2207E-02
CHRYS	P	0.2159E-01	0.3209E-02
CHRYS	L	0.3656E-01	0.1041E-01
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
FORD	FOX	0.5152E-02	0.2438E-02
FORD	PANTHER	0.4744E-01	0.2203E-01
FORD	LTD	0.2304E-01	0.8517E-02
FORD	TBIRD	0.2104E-01	0.8002E-02
FORD	MUSTANG	0.2134E-01	0.6936E-02
FORD	TEMPO	0.5125E-01	0.1458E-01
FORD	ESCORT	0.8246E-01	0.3342E-01
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00

	SHARE	STD DEV	MPG	STD DEV GPM
GM	0.5919E+00	0.5522E-01	0.3072E+02	0.2274E-02
CHRYS	0.1564E+00	0.2471E-01	0.3112E+02	0.2464E-02
FORD	0.2517E+00	0.5700E-01	0.3100E+02	0.3704E-02

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MFGR	CARLINE	MEAN	STD. DEV.
GM	C	0.4544E-01	0.1511E-01
GM	KE	0.1880E-01	0.6210E-02
GM	B	0.8218E-01	0.1869E-01
GM	Y	0.3510E-02	0.1479E-02
GM	A	0.1318E+00	0.1677E-01
GM	GG	0.8605E-01	0.2282E-01
GM	F	0.3320E-01	0.1013E-01
GM	GM20	0.5570E-01	0.6620E-02
GM	J	0.8878E-01	0.1967E-01
GM	P	0.1049E-01	0.1349E-02
GM	TGM	0.2893E-01	0.1811E-01
CHRYS	MC	0.1659E-01	0.7250E-02
CHRYS	EC	0.1225E-01	0.3104E-02
CHRYS	H	0.1420E-01	0.4325E-02
CHRYS	KCVJ	0.1356E-01	0.4332E-02
CHRYS	K	0.2827E-01	0.4728E-02
CHRYS	G	0.1192E-01	0.3359E-02
CHRYS	P	0.2206E-01	0.5212E-02
CHRYS	L	0.4387E-01	0.2146E-01
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
CHRYS	XXX	0.0000E+00	0.0000E+00
FORD	FOX	0.4651E-02	0.2670E-02
FORD	PANTHER	0.4295E-01	0.2536E-01
FORD	LTD	0.1962E-01	0.9011E-02
FORD	TBIRD	0.2235E-01	0.9542E-02
FORD	MUSTANG	0.2265E-01	0.1023E-01
FORD	TEMPO	0.4874E-01	0.1510E-01
FORD	ESCORT	0.9148E-01	0.4571E-01
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00
FORD	XXX	0.0000E+00	0.0000E+00

	SHARE	STD DEV	MPG	STD DEV GPM
GM	0.5848E+00	0.8182E-01	0.3234E+02	0.2481E-02
CHRYS	0.1627E+00	0.4498E-01	0.3308E+02	0.3573E-02
FORD	0.2524E+00	0.7943E-01	0.3249E+02	0.4036E-02

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type params.dat
1985,10,100,.1486601,.5,"fuel",3,11,"shares",.333,.333,5,2,"hltech",.3,10,15000,
-.0015,"s"
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