UNIVERSITY OF MICHIGAN DELPHI FORECAST AND ANALYSIS OF THE U.S. AUTOMOTIVE INDUSTRY THROUGH 1992

DELPHI III

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HOW TO USE THIS REPORT

This Delphi Forecast should be considered as analogous to the Standard Volume figures used for planning purposes by the major automotive vehicle manufacturers.

No matter how uncertain it is, the automotive future must be anticipated. With lead times up to five years for vehicles and longer for some facilities, manufacturers had to start taking action years ago in order to produce vehicles today. They must start actions today in order to produce years from now.

These actions must be based on the best available demand forecast. Not conservatively low or optimistically high but objective.

A conspicuous reality of the automotive business is that it is unpredictably cyclical. As cycle times cannot be predicted, no attempt is made to do so in the development of Standard Volumes.

Standard Volume is the best forecast possible of the trend in total unit sales over the next few years. All concerned with the Standard Volume concept know that it will probably never predict the "correct" figure--that sales will almost invariably be higher or lower than Standard Volume in any given year. But for planning purposes it is the bedrock on which all plans are built. The only weakness of the Standard Volume concept is that each company develops its own for internal use and this estimate is subject to whatever biases may be characteristic of the company.

The U-M Delphi forecasts are much broader than Standard Volumes. Unit sales of cars and trucks are forecast in detail, but dozens of other trends are covered including fuel prices, fuel economy, engine configuration, vehicle material content and weight, market shares, vehicle quality, supplier location, offshore sourcing, etc.

The U-M Delphi forecasts are similar to Standard Volumes in that extremes of opinion are excluded. They are better than Standard Volumes because they reflect the combined opinion of leading experts and executives from all the major companies and do not reflect individual corporate biases. The Delphi forecasts share with Standard Volumes the characteristic that they rarely "come true." They are planning trends about which developments will cycle and almost surely be higher or lower at any point in time.

The heart of a Delphi survey is the careful selection of expert respondents. Neither Delphi nor any other research method will result in meaningful predictions unless contributors are truly expert. The selection of such experts for the Delphi survey is made possible by close ties of long standing between University of Michigan faculty and staff and representatives of the automotive industry.

In the course of their planning activities, industry executives make extensive use of quantitative analyses and forecasts. But, because of major unknowns in the future environment of the industry, those executives also rely heavily on judgment. The Delphi procedures measure the results both of numeric analyses and judgmental factors being exercised by the experts.

How good are the Delphi forecasts? A factor to consider is that the experts whose opinions constitute the forecasts are in positions within the automotive industry where they have the responsibility, authority, and resources to make at least some of their predictions come true.

The U-M Delphi forecasts for the U.S. auto industry assemble information held by relatively few persons--experts who occupy high-level positions in major automotive companies. A series of frank, in-depth discussions with even a half-dozen such individuals would provide significant views on industry trends. The U-M Delphi study presents the combined opinions of more than 200 such well-placed authorities.

For suppliers and others interested in the automotive industry, these Delphi forecasts establish the best planning base we know. They provide lead time to move with trends or to attempt to alter events and change trend directions that are undesirable.

Note: The best method to locate individual items of interest in this report is to start on page xv with "Questions Listed Under Topic Headings."

FOREWORD

This report is a detailed presentation and analysis of data provided by three separate panels of automotive executives, managers, and engineers who are expert in Technology, Materials, and Marketing.

Part of the information included here was published in the UMTRI Research Review of the University of Michigan Transportation Research Institute, November-December, 1983.

Delphi III is the third in a series of in-depth studies of long-range automotive trends that started with Delphi I in 1979 and continued with Delphi II in 1981.

Panel Members

Three lists of prospective panel experts were developed--one each for Technology, Marketing, and Materials. Each prospect was evaluated by a committee of persons with long experience and wide contacts in the automotive industry. Many of the panel members are known personally by one or more members of the committee. Panel members were selected who occupy an automotive industry position dealing with the topic being surveyed and are known to be deeply knowledgeable and broadly experienced in the subject matter.

As discussed later, panel members and their replies are kept anonymous. However, panelists were asked to mail in a business card to enable us to send them follow-up questionnaires. These cards were used to determine the following panel characteristics.

Panel Characteristics

Approximately 18% of the Technology panelists were general managers or vice presidents; 40% were directors and chief or executive engineers; 35% were managers and assistant chief or staff engineers. The others were technical specialists. About 42% were employed by vehicle manufacturers, 45% by component and parts suppliers, and 13% by materials suppliers.

The Marketing panel was made up of 37% presidents, chairmen, CEO's, general managers, and vice presidents, 14% directors, and 43% managers. The remainder were marketing and planning specialists. Twenty percent were employed by vehicle manufacturers, 61% by component and parts suppliers, and 19% by materials suppliers.

Among Materials panelists, 18% were general managers and vice presidents, 23% directors and chief engineers, 48% managers and staff engineers, and the others consisted of technical, marketing, and planning specialists. Employment was 31% by vehicle manufacturers, 25% component and part supplers, and 44% materials suppliers.

new information submitted by other panelists. All participants are encouraged to comment on their own forecast and on group results, and that information is furnished the participants in the next round. The procedures reduce the effects of personal objectives (such as the desire to win an argument) and help the panelists to remain focused on the question, positions, and comments at hand.

Numerical results are shown as medians, a measure of central tendency that mathematically summarizes an array of judgmental opinions while discounting extremely high or low estimates.

When the question asked panelists calls for a response in the form of a number, the group response is reported in terms of the median value and the interquartile range, or IQR. The median value is the middle response, and the IQR is the range bounded at the low end by the 25th-percentile value and, at the high end, by the 75th-percentile value. For example, in a question calling for a percentage forecast, the median answer might be 40% and the IQR 35-45%. This means that one-quarter of the respondents answered 35% or less, another quarter chose 45% or more, and the middle half of all responses ranged between 35% and 45%. That narrow interquartile range would indicate a fairly close consensus among the respondents.

In contrast, the percentage forecasts for a different question might show a median of 40% (the same as in the preceding example) but an interquartile range of 20-70%, indicating little consensus among the respondents. This would be a warning that the median forecast of 40% does not have a high predictive value - which is in itself valuable information.

Uncovering differences of opinion is one of the major strengths of the Delphi method. Unlike some survey methods, where differences of opinion among experts are buried in averages, Delphi exposes such differences. A lack of consensus so demonstrated is little comfort to an individual or firm looking for planning guidance, but it is better to know the truth than to be misled.

The interquartile ranges (IQR) are a key to maximizing benefits from a Delphi study. A broad IQR suggests that a high priority be placed on closely following the subject under consideration in order to keep alert to significant developments. In addition, responses from representatives of vehicle manufacturers are frequently compared to replies from parts or material suppliers. Differences between these groups should be noted.

Respondent Comments

In a Delphi survey, respondents are encouraged to write in comments--to explain their forecast and to convince other respondents to change their positions. A number of these comments are shown in this report. Duplicate comments are excluded. A single comment can be a lead of high value. However, readers should be careful not to overrate the comments. It is possible for a well-stated contrary opinion to mislead the reader into ignoring an important majority opinion that is represented by numerical data. Of course, one point in collecting and displaying comments is that--perhaps--one or more of them should lead to contrary action. In the final analysis, it is up to the reader to decide.

Sample Size

Delphi surveys are undertaken with sample sizes that appear small when compared to the relatively large numbers needed to provide accurate results in a probability sampling of an extensive universe. Delphi is by design not a random technique, however, and should not be assessed with the measures used to evaluate probability surveys. Delphi respondents are carefully selected, not chosen at random.

Numerical Anomalies

Medians of ranked positions often duplicate each other and may skip certain ranked positions. A simplified example of the mechanism leading to such results is shown in the following example. Assume that three respondents (#1, #2, and #3) rank three factors (A, B, and C) as follows:

	#1	#2	#3	Median
A	1	3	2	2
B	2	1	3	2
C	3	2	1	2

All the factors rank the same (median of 2) and the first and third ranks do not appear as medians. The useful conclusion is that the aggregate group of respondents does not, as a group, differentiate between the factors.

INTRODUCTION TO THE STUDY RESULTS

Two hundred experts in the automotive industry made the Delphi III forecasts. We have performed the functions of data collection, data reduction, editing, and reporting, and analyzed the results. However, we wish to emphasize that the forecasts are not ours, but theirs--and many of the experts are in positions where they can make their forecasts come true.

Keep in mind in using any one of these forecasts that if it reflects a high degree of consensus it is a path the industry is following. Knowing this provides you with planning lead time; time that could be used either to plan to mesh with the forecast or to attempt to change the factors that are the basis for the forecast. In many cases it may be possible for you to change the future before it arrives.

In contrast, many individual forecasts do not reflect a high degree of consensus. Such uncertainty is displayed in the interquartile range and warns that the forecast should be viewed with less confidence and followed closely to avoid unpleasant surprises. And it should always be remembered that even the best forecasts are trend predictions about which cyclical variations are almost a certainty.

Delphi forecasts are primarily strategic planning instruments; not the only ones, but part of a collection that should be used in the planning process. The value of a Delphi forecast is measured by how well it helps you and your organization to succeed in the years ahead.

Delphi panelists are asked to provide comments and suggestions. These replies may be important clues to future events or trend changes that are not apparent in the numerical data. An individual panelist may know something unique and special that planners should carefully consider.

The many forecasts assembled in Delphi III may not always appear to be related to each other, but generally they are. Readers should realize that the automotive industry and its products represent a unified system. It is, of course, greatly complex, but an understanding of the interrelations between parts will lead to the most effective long-range planning.

We take pride in our efforts to report Delphi III forecasts, but no credit. The honor goes to the executives, managers, and engineers who provided them. Because of their source, we consider these to be the most authoritative and dependable automotive forecasts available.

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I. TECHNOLOGY

II. MARKETING

III. MATERIALS

QUESTIONS LISTED UNDER TOPIC HEADINGS

The 75 Technology questions, 61 Marketing questions, and 16 Materials questions are listed below under topic headings arranged in order by their first question number.

Technology Topics

Technology Questions

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Fuel Economy

Weight and Materials

Government Impact | Page

Transmissions and Drivetrains

Electronics

Chassis, Suspension, Brakes

Spare Tire

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I. TECHNOLOGY PANEL RESULTS AND ANALYSIS

T-1. What is your estimate of retail fuel prices per gallon in the U.S. in 1987? 1990? 1992? (In constant dollars; that is, without adding anything for inflation.)

	Retail Price per Gallon Median Response		
	1987	1990	1992
Unleaded Gasoline	$1.50	$1.60	$1.90
Diesel Fuel	1.40	1.60	1.75

	Interquartile Range		
	1987	1990	1992
Unleaded Gasoline	$1.45/1.50	$1.60/1.75	$1.80/2.00
Diesel Fuel	1.40/1.50	1.50/1.70	1.70/1.90

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS FOR 1990 RETAIL FUEL PRICES

	Forecast for 1990 in Current Dollars at the Time of the Survey		
	1979 Delphi I	1981 Delphi II	1983 Delphi III
Gasoline	$2.50	$3.00	$1.60
Diesel Fuel	2.40	3.00	1.60

	Forecast for 1990 Indexed to 1983 Dollars*		
	1979 Delphi I	1981 Delphi II	1983 Delphi III
Gasoline	$3.45	$3.30	$1.60
Diesel Fuel	3.31	3.30	1.60

*Based on Consumer Price Index.

Selected Comments from Panelists

With competitive sources for crude, we don't expect the wellhead cost to have the abrupt and great changes we have seen. Increases will be the result of taxation (major), inflation, and profit.

Downward pressure on demand should continue to offset inflation effect on production costs.

U.S. policy should keep cost of fuel high enough to motivate conservation, exploration, and alternate fuel technology. Tax burden should be less on diesel.

(T-1 continued)

Depends on:
1. Tax policy.
2. OPEC and world politics.

Limited volume of diesel fuel sold increases distribution costs and reduces competitive pressure, thus supporting higher price at pump and higher differential between refinery and motorist.

Believe diesel will rise to be same price/btu as unleaded by 1992.

U.S. policy will keep pressure and incentives on conservation, but the improving economy will increase usage which in turn will move prices up.

Non-OPEC oil-producing nations plus Russia bring more competition to the marketplace. I see another 10-15 cents/gallon federal tax by 1992.

I don't believe that the tax burden will be less on diesel.

Diesel fuel will become more "sophisticated," that is, more refining, more additives, etc. to meet future vehicle emission standards (vs. gasoline).

Diesel per gallon will eventually cost more than gasoline.

Price may increase to get revenues for rebuild of road system since general revenues are down.

Price separation between gas and diesel will widen due to continued operating cost ineffectiveness of diesel vehicles (in the U.S.) and some market revulsion due to decreased novelty and pleasability (at high mileage).

T-1 Discussion

Vehicle fuel prices are a key factor influencing practically all automotive product and marketing decisions. The fuel price question was asked first to establish a base of reference for most subsequent questions.

Unleaded gasoline prices are forecast at $1.50 per gallon in 1987, $1.60 in 1990, and $1.90 in 1992. As indicated by the interquartile ranges for these median responses, there is a good degree of consensus. The table shows that 50% or more of the respondents predict a 1987 price in the narrow range of $1.45 to $1.50 per gallon. Similarly, for the 1990 estimate, the interquartile range shows 50% or more of the respondents choosing an estimate between $1.60 per gallon and $1.75. The interquartile range for the 1992 estimate is not as tight, but at $1.80-$2.00 per gallon, is a good consensus on the median 10-year-away estimate of $1.90.

The median forecast for diesel fuel in 1987 is $1.40 per gallon, 10 cents less per gallon than gasoline; $1.60 per gallon in 1990, the same as unleaded gasoline; and $1.75 per gallon in 1992 or 15 cents per gallon less than the gasoline estimate. The interquartile ranges for diesel fuel are close and show good consensus. For 1987, the interquartile range indicates that at least half of the respondents forecast a price between $1.40 and $1.50 per gallon, and in both 1990 and 1992 the interquartile ranges are

(T-1 continued)

near the median response.

A close consensus, as indicated by a tight interquartile range, is encouraging in the sense that it indicates agreement among experts. Such a consensus does not "prove" the forecast is necessarily going to come true; a sudden change in the political front (see comments below) could lead all of our respondents to agree on prices that differ widely from the ones shown here. What these data do indicate, however, considering the expert knowledge and high position of the respondents, is that anyone whose interests are tied to the future of the U.S. automotive industry can make plans based on the knowledge that, until new factors prevail, industry plans and actions at all levels in vehicle manufacturer and major supplier companies will probably reflect the fuel cost assumptions shown here.

Discussion of Panelists' Comments

A number of edited comments are shown following the tables. Duplicate mentions are excluded. A single comment can provide an insight of high value to a particular individual, firm, or organization associated with the industry. However, readers should be careful not to overrate the comments. It is possible for a well-stated contrary opinion to mislead the reader into ignoring an important majority opinion that is represented by numerical data. Of course, one point in collecting and displaying comments is that--perhaps--one or more of them should lead to contrary action. In the final analysis, it is up to the reader to decide.

Comparison of Vehicle Manufacturer and Supplier Panelists

Panels include some respondents employed with motor vehicle manufacturers and others working for their suppliers of components, parts, and materials. It is common within the industry and convenient here to refer simply to "manufacturers" and "suppliers."

For competitive reasons the manufacturers try to maintain secrecy regarding their forward plans, and it might be thought that their representatives know more than others about the automotive future. Offseting this, the manufacturers source half or more of each finished product with suppliers and, ideally, they should work together closely with few secrets between them. However, the size (thousands of suppliers) and complexity of the information network prevent optimum information transfer.

Therefore, our analysis includes a comparison of answers from manufacturer and supplier respondents to determine if there are significant differences of opinion. On fuel prices, both groups gave identical median forecasts for gasoline and diesel fuel in 1987 and 1990. For 1992 the manufacturer respondents forecast gasoline at $1.90 per gallon compared to a supplier prediction of $1.80, and a diesel fuel price of $1.80 compared to $1.70 from

(T-1 continued)

the suppliers. Outstanding agreement by any standard.

Close forecast results between subgroups cannot guarantee the future but do indicate that diverse expert judgment applied to currently available data results in a common viewpoint and a reliable planning base.

Comparison of Replies to T-1, Mkt-1, and Mat-1

The three groups of panelists (Technology, Marketing, and Materials) contacted for this study were asked questions that focused on their area of expertise. Some questions, such as this one regarding fuel prices, were considered so basic they were asked of all panelists.

The Marketing panelists' median forecast of 1987 fuel prices are almost identical to those of the Technical panelists. For 1990 and 1992, Marketing panelists' estimates are 5-15 cents higher per gallon but still in line with the Technical forecasts. The Materials panelists are even closer, their median estimates never being more than 10 cents per gallon different from Technology replies. This commonality of viewpoint provides a strong planning basis for suppliers or others dependent on the U.S. automotive industry.

Trend from Three Delphi Surveys

The second table shows median responses from three Delphi surveys for 1990 fuel prices. In 1979, at the time of Delphi I, respondents forecast that gasoline would be $2.50 per gallon in 1990. In the 1981 Delphi II survey, the median forecast was $3.00 per gallon for unleaded gasoline. In the most recent survey, Delphi III, this projection has dropped to $1.60 per gallon. Each of these numbers is in current dollars at the time it was forecast and does not reflect an allowance for inflation--which has, of course, occurred since the earlier survey dates. When earlier data are adjusted to 1983 prices, the 1990 forecasts for gasoline were $3.45 per gallon in 1979, and $3.30 in 1981, as compared to the $1.60 per gallon median response in the 1983 Delphi III survey. The forecast trend for diesel fuel is almost identical to that of gasoline. These trends are shown graphically in Figure T-1 on page 7.

Strategic Considerations

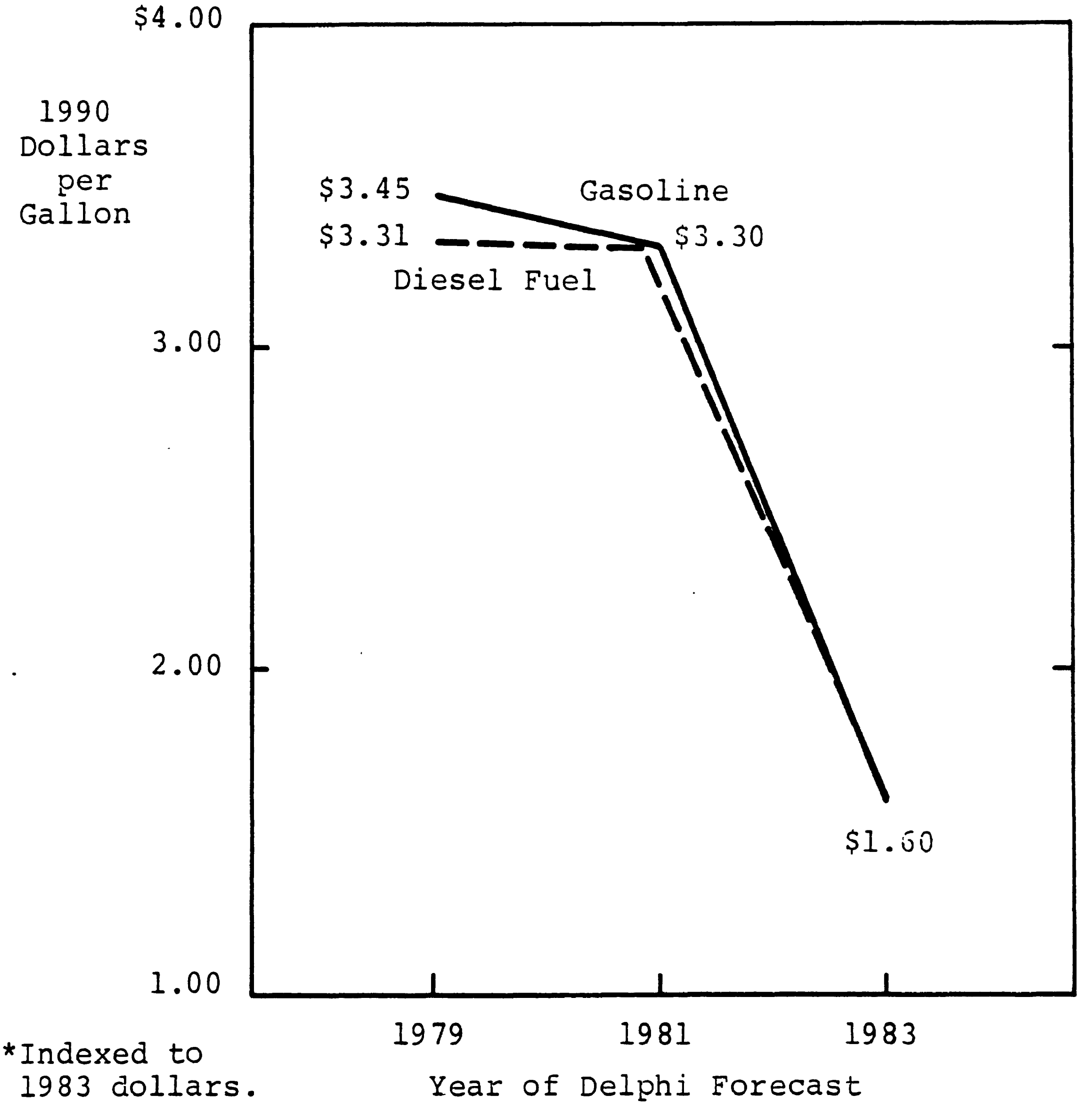
The sharp decline in 1990 fuel price forecasts to levels half those in previous surveys is not an indictment of our earlier panelists (many of whom are panelists in Delphi III), but a warning that even experts cannot be certain of a future which is, as in this case, determined by politics rather than free markets. Of course, the lower forecast reflects a return to free markets for fuel pricing in the U.S. (and, as a consequence, the world),

(T-1 continued)

but the occurrence and timing of domestic political changes that enabled that return could not have been judiciously forecast.

It may appear that panelists are now predicting no recurrence of domestic or foreign government interference in energy markets before 1992--a forecast that would seem highly unlikely with three presidential elections during the period and continued Middle East instability. Ten years is a long time to expect stable supplies and prices for energy, and our panelists are keenly aware of the fact. But they lack a methodology to predict when the political or military urge will prevail and the extent of the damage that will take place.

Figure T-1. Retail Fuel Prices* in 1990 as Forecast in 1979, 1981, and 1983.



*Indexed to 1983 dollars.

T-2. Assuming that the maximum CAFE fuel economy level of 27.5 miles per gallon is not changed, what is your fuel economy forecast (EPA urban cycle) for U.S. and Japanese-made passenger cars sold in the U.S. market in the following years?

	Median Response		
	1987	1990	1992
U.S. Passenger Cars	28 mpg	30 mpg	31 mpg
Japanese Passenger Cars	31	32	34

	Interquartile Range		
	1987	1990	1992
U.S. Passenger Cars	27/29 mpg	28/32 mpg	30/34 mpg
Japanese Passenger Cars	30/33	30/35	32/37

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
FOR 1990 FUEL ECONOMY (MPG)

	Forecast for 1990 at the Time of the Survey		
Country of Origin	1979 Delphi I	1981 Delphi II	1983 Delphi III
United States	30 mpg*	35 mpg	30 mpg
Japan	N.A.	36-39*	32

*Estimate based on related questions.

Selected Comments from Panelists

Government pressure and regulations will be dominant--remove this and values change significantly.

U.S. demand for larger cars will make it tougher for U.S. manufacturers to maintain a CAFE of 27.5.

Until fuel prices are stablized (upward), the consumer will resist buying fuel-efficient autos.

I assume U.S. companies will be required to maintain large cars whereas Japanese manufacturer will not penetrate into this market segment. Therefore, U.S. cars average fuel consumption will be higher.

1992 - expect Japanese cars to get larger and heavier.

This assumes that U.S. cars, on average, will be larger than Japanese cars.

Japanese rise limited by import restrictions causing richer import mix.

(T-2 continued)

Believe we have reached the end. No incentive from "Feds." or prices. Now we can go back to performance improvements, so lacking in the past "CAFE" years.

Assume Japanese will sell only fuel efficient cars versus U.S. full line. On a competitive model basis U.S. will close the gap in fuel economy both in real terms and in terms of perception by car buyers.

Looking at the subject rationally, our inducement to trade off size, packaging, performance, or cost to gain fuel economy diminishes rapidly as we go down the consumption curve, i.e., at 33 mpg (3 gal/100 miles), our inducement to go to 50 mpg (2 gal/100 miles) would not support much trade-off.

T-2 Discussion

Panelists forecast that by 1987 the average fuel economy for U.S.-produced passenger cars will be 28 mpg as measured by the EPA urban cycle. This increase is expected even if the CAFE fuel economy requirement remains at 27.5 mpg. Japanese passenger cars imported into the U.S. are expected to have an average fuel economy of 31 mpg in 1987.

By 1990, the average for U.S. cars is forecast to be 30 mpg and for Japanese cars sent to the U.S., 32 mpg. These levels continue to rise to 31 mpg and 34 mpg for U.S. and Japanese cars, respectively, in 1992.

As shown in the second part of the table, interquartile ranges are reasonably close and show good consensus on the median forecasts.

Discussion of Panelists' Comments

As indicated by the first two comments, government regulations and consumer demand in the U.S. are beginning to move in different directions. We have not attempted in this survey to predict the resolution of this conflict. The last comment regarding the trade-off of fuel economy versus size and other factors raises an important issue that we discuss subsequently in this analysis under the heading "Strategic Considerations".

Comparison of Vehicle Manufacturer and Supplier Panelists

For the 1987 and 1990 forecasts, the manufacturer and supplier respondents gave identical median answers of 28 mpg and 30 mpg for U.S. passenger cars. For U.S. cars in 1992 and for Japanese cars in all years, the supplier forecasts were a mile or two less per gallon than those made by vehicle manufacturer representatives. These differences are not great and probably not significant within the limitations of our survey technique. But, in view of large-car sales trends throughout 1983, it seems reasonable that the slightly lower estimates may prove to be closer to the average fuel economy levels actually achieved.

(T-2 continued)

Trend From Three Delphi Surveys

Earlier Delphi surveys did not ask this question with precisely the same wording, but it is possible to infer from similar questions a forecast for 1990 fuel economy at the time of the 1979 Delphi I and 1981 Delphi II surveys. This information is shown in the second table. In the 1979 survey, respondents forecast U.S.-produced passenger car average fuel economy at 30 mpg. in 1990. In the 1981 survey the forecast for 1990 had increased to 35 mpg. But, in the 1983 Delphi III survey, the prediction has dropped back to 30 mpg. These changes are as would be expected from the decline both in the level and trend of fuel prices since government controls were dropped and the free market allowed to prevail.

We had no forecast of Japanese-made car fuel economy in the 1979 survey. In 1981 it was forecast that, for 1990, Japanese cars would average in the area of 36 to 39 mpg. In the most recent survey this prediction has dropped to 32 mpg. This decline reflects lower fuel prices in effect and expected, but also shows the effect of larger Japanese cars being imported to meet changing consumer demands.

The Japanese are encouraged to import larger cars. Under an allocation system that restricts the number of units sold, it is pragmatic to sell the largest, highest-profit-per-unit models available. Also, Japanese and other importers are not threatened by U.S. CAFE laws, which are aimed primarily at domestic manufacturers.

Strategic Considerations

The most dramatic change in American cars in recent years has been in fuel efficiency. General Motors, for example, improved the average fuel economy of its cars from 12 mpg in 1974 to twice that level in 1982. Other American vehicle manufacturers have done as well or better, and all plan further advances. But economy improvements are approaching the point of rapidly diminishing returns.

There is a limit to the dollar value of fuel economy, particularly if the effort to achieve it produces a much more costly car or an impractically small vehicle. Some motorcycles get 125 mpg, but they would lack utility for a family of four with a dog and a boat trailer.

Figure T-2 shows the relationship between car efficiency and annual fuel costs. For example, at $1.50 per gallon, a gain or annual savings of $125 is achieved by moving from a 30 mpg car to one that gets 40 mpg. See page 11.

The objective here is to put fuel economy into perspective. It is important, but so are other vehicle characteristics. The

(T-2 continued)

vehicle's designers and its buyers must consider an array of consumer value factors including package size, performance, comfort, durability, and safety. The key word in evaluating fuel economy, or any other vehicle characteristic, is "optimum": enough, but not too much. Manufacturers must strive to offer products that meet consumers' trade-off analyses. This is by no measure a trivial task.

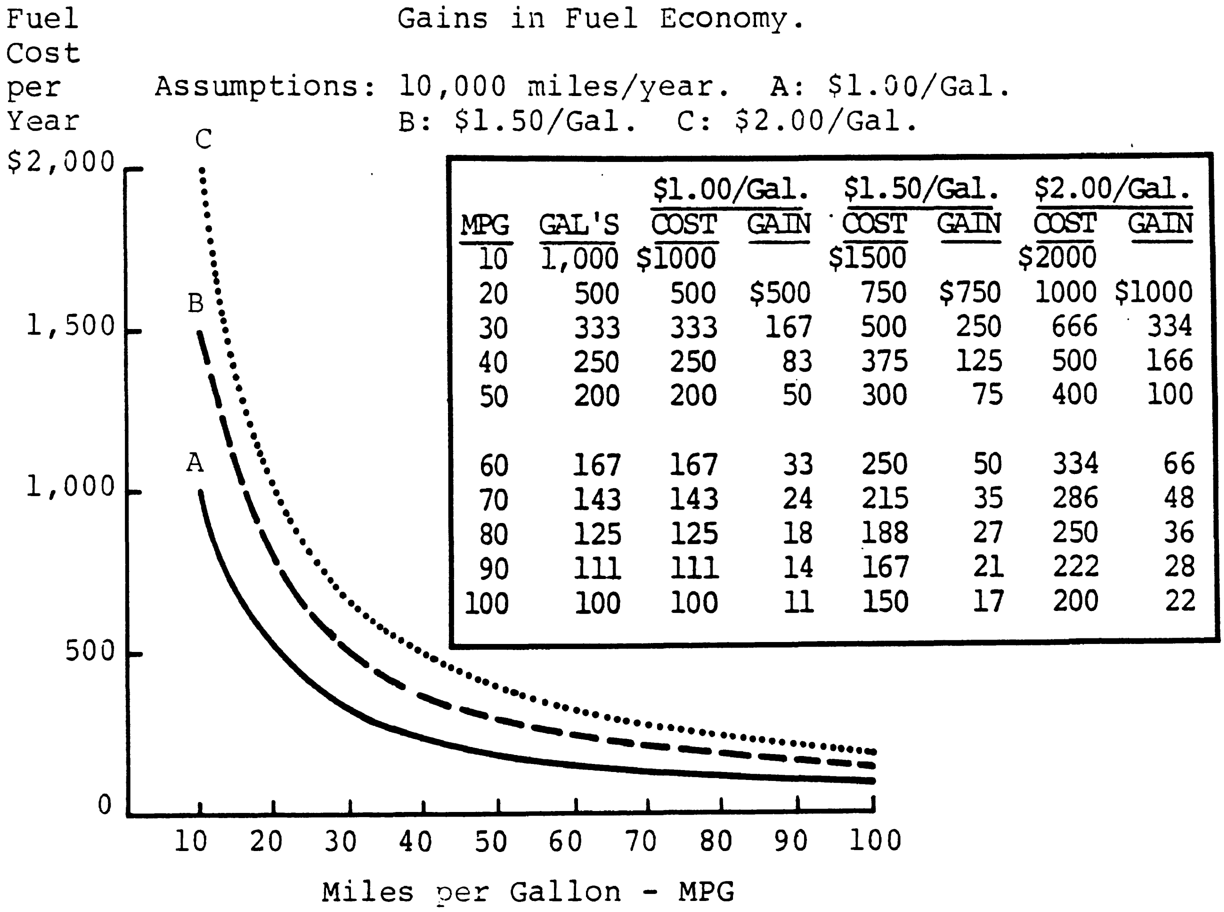
If you own a subcompact, two-adults plus two-children car that achieves 40 mpg, would it be worth an extra $125 per year in fuel cost to drive a 30 mpg model that has room inside for five adults plus their luggage? This is the kind of question that Americans --including those responsible for designing the American car--are asking themselves. Recently, car buyers in the U.S. have been answering by buying larger cars. After all, gasoline is well below $1.50 per gallon.

However, the answer cannot be based solely on financial considerations. The world is too unsettled to sustain rational belief in the permanence of free-market energy availability.

Vehicle buyers and designers must keep in mind the question of fuel availability as well as price.

Figure T-2. The Declining Value of Incremental Gains in Fuel Economy.

Assumptions: 10,000 miles/year. A: $1.00/Gal. B: $1.50/Gal. C: $2.00/Gal.



		$1.00/Gal.		$1.50/Gal.		$2.00/Gal.	
MPG	GAL'S	COST	GAIN	COST	GAIN	COST	GAIN
10	1,000	$1000		$1500		$2000	
20	500	500	$500	750	$750	1000	$1000
30	333	333	167	500	250	666	334
40	250	250	83	375	125	500	166
50	200	200	50	300	75	400	100
60	167	167	33	250	50	334	66
70	143	143	24	215	35	286	48
80	125	125	18	188	27	250	36
90	111	111	14	167	21	222	28
100	100	100	11	150	17	200	22

T-3. Of the passenger car fuel economy improvement scheduled for 1987, 1990, and 1992, what percentage of the improvement will come from the following factors?

Improvement Factors	Percent of Total MPG Improvement Median Response		
	1987	1990	1992
Reduced performance (lower power/wt. ratio)	6%	5%	3%
Improved aerodynamics	12	12	12
Reduced tire rolling resistance	6	6	7
Improved engine efficiency	22	23	24
Improved drivetrain efficiency, including transmission improvements	18	23	24
Downsizing	18	14	12
Weight (but not size) reduction through increased use of light-weight materials	18	17	18
Other	0	0	0
	100%	100%	100%

	Interquartile Range		
	1987	1990	1992
Reduced performance (lower power/wt. ratio)	0/ 6%	0/ 6%	0/ 7%
Improved aerodynamics	12/18	12/17	12/18
Reduced tire rolling resistance	6/ 6	6/ 6	7/ 7
Improved engine efficiency	22/29	23/29	18/30
Improved drivetrain efficiency, including transmission improvements	18/24	17/27	24/30
Downsizing	12/24	12/23	12/13
Weight (but not size) reduction through increased use of lightweight materials	18/24	17/23	18/27
Other	0/12	0/12	0/12

MEDIAN FORECASTS FROM TWO DELPHI SURVEYS
FUEL ECONOMY IMPROVEMENT FACTORS

Improvement Factors	Forecast for 1990 at the Time of the Survey: 1981 Delphi II	1983 Delphi III	Percentage Points Delphi III Over (Under) Delphi II
Aerodynamics	10%	12%	2 Pts.
Tire Resistance	5	6	1
Engine	15	23	8
Drivetrain	10	23	13
Downsizing	30	14	(16)
Weight	20	17	(3)
Other	10	5	(5)
Total	100%	100%	0 Pts.

(T-3 continued)

Selected Comments from Panelists

No MPG improvements.
My reply is percent improvement over current level.
Some fleet average improvement from change in mix of cars. Some special vehicles for special applications with special engine modification. Short-term energy storage could save 10% from braking in start-stop operation. Engine modification could save 10% in high idle operations.
OEM's will adopt turbos, technology, and materials to enlarge vehicles and maintain efficiency.
We don't separate downsizing and weight reduction.
Improved engines (fast burn/low friction) and CVT transmissions will provide the majority of future improvements.

T-3 Discussion

Improvements in fuel economy can be achieved by several methods. One of the easiest is to reduce the ratio of power to weight; for example, maintain the weight of a vehicle while decreasing the size of its engine or reducing its axle ratio. But there are limitations on these actions. For example, a lawnmower engine would not be adequate to power a six-passenger car. And long before this limit is reached there arise problems of inadequate performance. The vehicle is unable to climb hills, is unsafe when passing, etc.

Another relatively easy method (cost of redesign and tooling aside) of improving fuel economy is to reduce vehicle size. A motorcycle, for example, gets much better gas mileage than a passenger car. There are obvious limits here, too, because if the vehicle becomes too small it is not practical for most consumers.

The more challenging techniques to improve fuel economy are through improved aerodynamics, reduced tire rolling resistance, improved engine efficiency, improved drivetrain and transmission efficiency, and weight (but not size) reduction through the increased use of lightweight materials and improved design efficiency.

Question T-3 provides forecasts of the mix of these methods that will be used to improve fuel economy through the next ten years. The expected improvement from performance reduction is at the relatively low level of 6% in 1987 and declines to 5% in 1990 and 3% in 1992. In parallel, downsizing is expected to provide 18% of the mileage improvement in 1987, 14% in 1990, and only 12% in 1992. The other techniques account for the bulk of the MPG improvement.

It is important to note that these percentages refer to the mix of improvement methods and are not estimates of the improvements in each method. For example, improved engine efficiency is shown

(T-3 continued)

accounting for 22% of the total mpg improvement in 1987. This does not mean that engines are going to improve 22% in their internal efficiency. Rather, it is a forecast (for example) that engines will account for 2.2 percentage points if the overall vehicle economy improvement is 10%.

The interquartile ranges show a fair degree of consensus but vary from item to item. Reduced tire rolling resistance shows a tight range indicating a high degree of agreement among the respondents. In contrast, the downsizing factor has interquartile ranges with the higher quartile about twice the lower in both 1987 and 1990. Too much significance should not be read into these differences, however. The primary message to be gathered from these data is that the automotive industry has made most of the straightforward changes to improve economy and must now concentrate on the harder path of improved engineering and design in several areas. Note particularly the expected growth in efficiency contribution from the drivetrain including the transmission.

Discussion of Panelists' Comments

As indicated, some panelists do not believe there will be any further economy improvements, but most do. Several comments suggest specific techniques that will improve economy. The phrase "OEM," frequently used in the automotive industry, refers to the vehicle manufacturers.

Comparison of Vehicle Manufacturer and Supplier Panelists

The few differences in median forecasts between the two groups of respondents are not large. Vehicle manufacturers expect a little less improvement from aerodynamics and more from the improved drivetrain than do suppliers.

Trend from Two Delphi Surveys

Delphi III results, when compared to those of Delphi II, show the impact of readily available and relatively inexpensive motor fuel The improvement expected from downsizing declined from 30% in Delphi II to 14% in Delphi III, and the share expected from weight reduction was reduced from 20% to 17%. In contrast, improvement expectations from the drivetrain have more than doubled from 10% to 23% and substantial increases are also expected from improved aerodynamics and engine efficiency.

Strategic Considerations

Changing emphasis among economy improvement factors is in line with other evidence throughout the study that the move to smaller, lighter passenger cars is slowing. The trend is expected to continue, but at a lower level. Growing in importance are engineering improvements in major component systems, suggesting that advanced technology will be a major future thrust.

T-4. In the 1981 Delphi Forecast, the average U.S.-produced 1990 passenger car was projected to weigh 2,250 lbs. (curb weight). Considering the changes that have occurred since 1981, what is your present forecast for the average weight of a U.S.-produced passenger car in the following years:

	Dry Curb Weight Median Response		
	1987	1990	1992
Weight in Pounds	2500 lbs.	2400 lbs.	2250 lbs.

	Interquartile Range		
	1987	1990	1992
Weight in Pounds	2300/2700 lbs.	2250/2500 lbs.	2150/2500 lbs.

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
AVERAGE WEIGHT U.S.-PRODUCED CARS

	Forecast for 1990 at the Time of the Survey		
	1979 Delphi I	1981 Delphi II	1983 Delphi III
Weight in Pounds	2250	2250	2400

Selected Comments From Panelists

Vehicle size, plushness will increase offset by more subcompacts for net balance.

Further mass reduction of major significance can only be achieved through totally new and efficient structural design techniques using conventional material; other more radical approaches are too costly (exotic materials and processes in large doses), and downsizing has just about reached its marketable limit.

Throughout, the assumption is that government policy will dictate maintaining (short term) and increasing (long term) the cost of fuel.

T-4 Discussion

Prior Delphi surveys included this question and it was included in Delphi III to continue a trend analysis. Respondents are forecasting that the average U.S.-produced passenger car will have a dry curb weight of 2500 pounds in 1987, 2400 pounds in 1990, and 2250 pounds in 1992. The interquartile range consensus is fair although it is unusual that the widest spread is for the nearest year, 1987, where the range is 2300 to 2700 pounds.

In question T-6 in this report we ask for details showing individual weights for materials used in the vehicle. In reply to that

(T-4 continued)

question, total weight forecasts are 100 pounds or more higher for the 1987 and 1992 model years than shown here. We do not think these differences are significant, however.

Discussion of Panelists` Comments

Comment No. 2 regarding the difficulties of further downsizing and down-weighting suggests some of the limitations on these trends. The third comment, which, is of course volunteered by one of the respondents, reflects the point we made earlier that the price of fuel impacts heavily on almost every automotive consideration.

Comparison of Vehicle Manufacturer and Supplier Panelists

There were some fairly significant differences between the two groups, with the vehicle manufacturers forecasting 100-150 lbs. more weight per vehicle in each year than did the supplier respondents. In view of the manufacturers' special expertise in this subject and the above-mentioned differences between the total-vehicle weight forecast in question T-6 as compared to T-4, it is our judgment that the slightly higher estimates are probably the more likely.

Trend from Three Delphi Surveys

In 1979 and 1981, at the time of the Delphi I and Delphi II surveys, panelists forecast that the average U.S.-produced passenger car in 1990 would weigh 2250 lbs. In this most recent survey the 1990 forecast has been increased to 2400. Though higher than previously predicted, this is a not a trend reversal but a moderation in its downward slope.

T-5. What will the average weight in pounds (dry curb weight) be for U.S.-produced cars in the following size classes in the listed years?

	Dry Curb Weight (lbs.) Median Response		
Class Size	1987	1990	1992
Fullsized	3100 lbs.	3000 lbs.	2900 lbs.
Intermediate	2680	2550	2500
Compact	2400	2250	2200
Subcompact	2100	2000	1900
Mini	1750	1700	1700

	Interquartile Range		
Class Size	1987	1990	1992
Fullsized	2950/3400 lbs.	2800/3200 lbs.	2700/3000 lbs.
Intermediate	2550/2850	2500/2750	2400/2600
Compact	2300/2500	2200/2387	2100/2322
Subcompact	2000/2250	2900/2100	1800/2000
Mini	1700/1850	1600/1800	1600/1800

T-5 Discussion

The class designations we have used: Fullsized, Intermediate, Compact, Subcompact, and Mini are commonly used within the U.S. automotive industry. When we weight the estimates shown here with the market class shares shown subsequently in Marketing question Mkt-4, the derived average vehicle weights are each within less than 100 pounds of the corresponding averages shown in the preceding question, T-4. Accompanying question Mkt-4 are examples of cars in each size class. Note in Mkt-4 that we have further divided the fullsized class into luxury and standard models.

The main point of interest in T-5 is the indication that all of the size classes except the minis are going to lose approximately 200 pounds by 1992. These expectations suggest that a combination of improved design efficiency together with the use of lightweight materials will permit weight reduction without an equivalent change in interior volume. The interquartile ranges show good consensus on these forecasts and trends.

Comparison of Vehicle Manufacturer and Supplier Panelists

Agreement between the manufacturers and the suppliers was very good, with most of the differences being on the order of 50 lbs. An exception was the forecast for the 1987 fullsized class. Suppliers estimated 3200 lbs., compared to 3000 lbs. for the manufacturers. In general, however, the consensus between the two groups was close.

T-6. Forecast the material content, in pounds, and the total curb weight (dry, unloaded) for the average U.S.produced passenger car for model years 1987, 1990, and 1992.

	Pounds of Material Median Response		
	1987	1990	1992
Carbon Steel	1300 lbs.	1100 lbs.	1054 lbs.
HSLA Steel	300	300	320
Total Steel	1600	1400	1374
Aluminum Castings	102	103	102
Wrought Aluminum	35	34	33
Total Aluminum	137	137	135
Plastics			
Nonreinforced	90	105	100
Reinforced	110	120	150
Total Plastic	200	225	250
Cast Iron	350	270	250
Copper	22	22	22
Zinc (incl. coatings)	15	15	15
Magnesium	2	3	3
Glass	80	75	75
Rubber (incl. tires)	110	110	110
All Other	118	162	118
TOTAL VEHICLE	2634 lbs.	2419 lbs.	2352 lbs.

	Interquartile Range		
	1987	1990	1992
Carbon Steel	1296/1300 lbs.	1080/1179 lbs.	1050/1054 lbs.
HSLA Steel	300/ 300	300/ 305	300/ 320
Total Steel	1596/1600	1379/1450	1370/1400
Aluminum Castings	100/102	100/103	100/110
Wrought Aluminum	35/ 40	34/ 38	33/ 50
Total Aluminum	135/142	135/147	135/148
Plastics			
Nonreinforced	90/100	100/110	100/110
Reinforced	110/110	115/135	150/160
Total Plastic	200/220	225/250	250/260
Cast Iron	325/360	270/285	225/270
Copper	22/ 22	21/ 23	20/ 22
Zinc (incl. coatings)	15/ 15	15/ 15	15/ 15
Magnesium	2/ 2	2/ 3	3/ 4
Glass	80/ 80	75/ 75	75/ 75
Rubber (incl. tires)	103/111	100/110	100/110
All Other	108/118	148/162	104/118
TOTAL VEHICLE	2605/2650 lbs.	2362/2472 lbs.	2349/2400 lbs.

(T-6 continued)

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
FOR POUNDS OF MATERIALS IN 1990
MODEL U.S.-PRODUCED PASSENGER CAR

Material	Forecast For 1990 at the Time of the Survey		
	1979 Delphi I	1981 Delphi II	1983 Dephi III
Steel	1400	1300	1400
Aluminum	200	200	137
Plastics	300	300	225
Cast Iron	250	250	270
Other	365	200	387
Total	2515	2250	2419

Note: All data from Technical panels except figures for Delphi II individual materials are from Materials panelists.

Selected Comments from Panelists

Think cast iron use will be higher in 1992.
Cars will get progressively lighter at some cost increase for materials.
Cost pressures on small cars will restrict aluminum usage in engines and reduced engine size/wt will make aluminum weight reduction of lesser impact.
Recent changes by Detroit indicate less downsizing is likely, leading to a larger vehicle mix. These factors force addition of about 175 pounds to the expected steel content.
Magnesium will gain at the expense of aluminum based on mass efficiency, material availability, and cost.

T-6 Discussion

Not many years ago, the average U.S.-produced passenger car contained over 2,000 lbs. of steel. As cars have been down-sized and un-weighted, this usage has dropped and is forecast to decline to 1600 lbs. in 1987, 1400 lbs. in 1990, and only 1374 lbs. in 1992. All of this decline is taking place in carbon steel as the use of HSLA (high speed low alloy) steel is expected to increase to 300 lbs. per vehicle in 1987 and 1990 and 320 lbs.in 1992. Note the very tight interquartile range on the steel forecast for 1992. Three quarters or more of the panelists expect 1,054 pounds or less of carbon steel in that year.

Aluminum usage has grown substantially in recent years but these forecasts indicate the growth period has reached an end. The median estimate of total aluminum in the average U.S.-produced car is for 137 lbs. in 1987 and 1990, but only 135 lbs. in 1992. Even the high end of the interquartile range for 1992 shows only 154 lbs. of aluminum. As shown in the second table above and

(T-6 continued)

discussed below in more detail, the upper quartile forecast for aluminum is substantially below the median forecast made only two years ago.

Growth prospects for plastics show an increase from 200 lbs. per car in 1987 to 225 in 1990 and 250 in 1992. Most of this growth is expected to take place in reinforced plastic. Nonreinforced plastic use is expected to hold at about 100 lbs.

Use of cast iron continues to decline and is forecast at 350 lbs. in 1987, dropping to 250 lbs. by 1992. Copper and zinc usage are forecast as unchanged at 22 lbs. and 15 lbs., respectively. Magnesium use may grow slightly to 3 lbs. per vehicle, and glass is expected to hold at about 80 to 75 lbs.

Rubber, including tires, is estimated at 110 lbs. (We believe this forecast to be on the low side in view of the known weight of existing tires. At the present time, 4 tires alone would weigh 110-20 lbs. on the average car, and there are other uses of rubber in the vehicle. The vehicle manufacturers are working with tire suppliers to reduce the size of tires, but we do not expect such rapid progress).

Considering the detail and depth of the materials analysis, we believe the interquartile ranges are unusually tight. The indicated consensus is high.

Discussion of Panelists' Comments

Comments suggest one reason for the decline in forecast use of both aluminum and plastic. To the degree that U.S.-produced cars decrease in size they will be able to meet economy requirements using standard materials such as steel and cast iron and will not require as high a proportion of aluminum and plastics as previously believed. Also, expected improvements in engine and drivetrain efficiency will at least partially reduce the need for lightweight materials. These improvements should enable all domestic U.S. manufacturers to meet or surpass 27.5 mpg (CAFE for 1985+) in 1986 or 1987.

Comparison of Vehicle Manufacturer and Supplier Panelists

In previous years we often found significant differences between manufacturer and supplier respondents on questions of material usage, particularly aluminum. Aluminum suppliers have been more optimistic than others regarding the use of aluminum in U.S.-produced cars and trucks. In this survey, the forecasts for aluminum usage were essentially identical between the manufacturers and the suppliers. Even on the metals used in lower quantities--copper, zinc, and magnesium--there are no significant differences in the forecast between manufacturer and supplier panelists.

(T-6 continued)

Comparison of Replies to T-6 and Mat-2

This question was also asked of the Materials panelists. There were a few differences of opinion, although none that is outstanding. Materials panelists forecast the use of 5% less aluminum. The two groups agreed on total plastic use, but Materials panelists foresee a more even split between nonreinforced and reinforced plastic. In the 1987 forecast the Materials panelists estimate 50 lbs., or 14%, less cast iron, but their forecasts for the more distant years are about the same. Materials panelists also forecast about 5 lbs. less zinc usage each period. In general, however, the results are similar.

Trend From Three Delphi Surveys

When comparing forecasts for 1990, significant developments appear. The total weight of the average vehicle as forecast for 1990 declined from 2515 lbs. in the Delphi I Survey to 2250 lbs. in the Delphi II Survey, but has now reversed direction and increased to 2419 lbs. in the most recent study. These changes have occurred, as shown in the table, because of an expected increased use of steel and decreased use of aluminum and plastics. Surprisingly, the 1990 forecast for cast iron increased from 250 lbs. to 270 lbs. between 1981 and 1983. See Figure T-6, page 22.

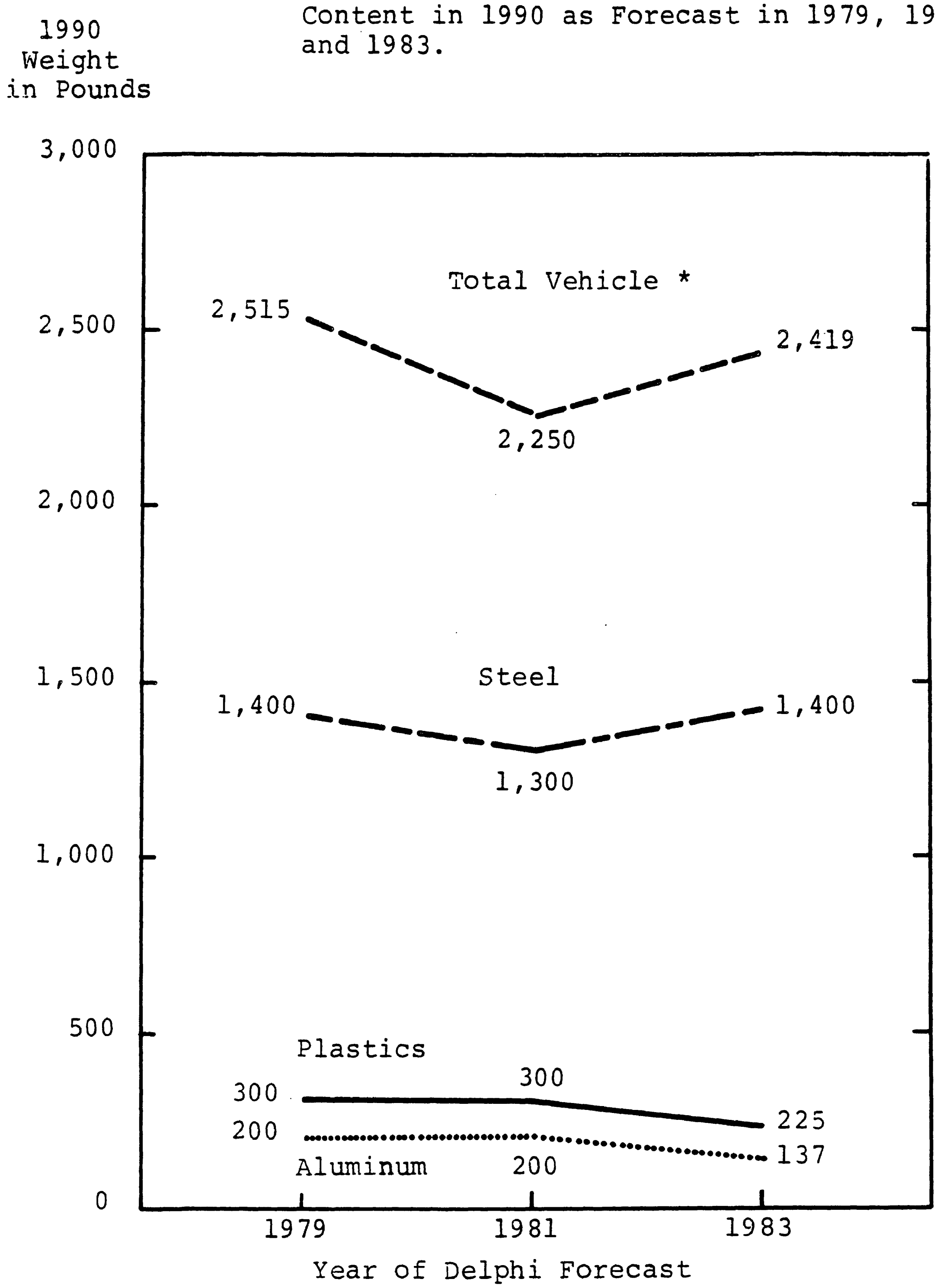
Strategic Considerations

What is most remarkable about the forecasts of materials usage is how little they have changed. Recent motor fuel prices, adjusted for inflation, are not a great deal higher than they were in the late 60's during the heyday of very large American-made passenger cars. If markets and producers were free of government controls, we might expect plans to move back to larger vehicles.

There are at least three reasons why this trend is not taking place. First and foremost, U.S. manufacturers and their suppliers no longer have the facilities to make the larger vehicles. And if they wanted to return to the larger cars, they do not have the capital to completely reverse their manufacturing structures, again, in order to do so. The second factor is the imponderable of fuel availability. As discussed earlier, under the Strategic Considerations section accompanying question T-2, manufacturers and consumers must consider not only the price of fuel but the possibility that supplies can be arbitrarily disrupted at any given moment. Finally, of course, consumers and producers are not free of government controls such as CAFE standards which are a barrier to larger cars.

(T-6. continued)

Figure T-6. Weight of Average U.S.-Produced Passenger Car and Its Steel, Plastic, and Aluminum Content in 1990 as Forecast in 1979, 1981, and 1983.



* Curb weight (dry, unloaded).

T-7. In general (excluding inertia-weight-class crises), what is the value (in current dollars) per pound of weight saved to a vehicle manufacturer? What will it be in 1987, 1990, and 1992? (In constant dollars; that is, without adding anything for inflation.)

	Value per Pound Saved	
	Median Response	Interquartile Range
Today	$1.00	$1.00/1.00
1987	1.25	1.00/1.25
1990	1.25	1.10/1.40
1992	1.50	1.25/1.50

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
VALUE TO VEHICLE MANUFACTURER OF WEIGHT SAVINGS

	Forecast for 1990 at the Time of the Survey		
Value Per Pound Saved	1979 Delphi I	1981 Delphi II	1983 Delphi III
Original Reply	$1.25	$2.00	$1.25
Indexed to 1983 Dollars	1.72	2.20	1.25

Selected Comments from Panelists

Companies not willing to pay much for weight reduction unless it affects inertia weight class. Big incentive is to reduce cost of parts through better material utilization.
Assuming constant CAFE.
May be impacted by gas guzzler tax impact.
Cost of mass still not recognized as an important tool for design evaluation.
Very short-range, short-sighted approach to weight reduction. This approach causes short-term payment of $5.00 to $10.00 per lb.
Companies will be willing to pay a little more for weight reduction to maintain inertia weight class, to meet CAFE, and to pay for added feature content.
All values seem too high. Would a manufacturer willingly add $100 to the cost of a vehicle to save 100 lbs.? Couldn't that $100 be better spent elsewhere to make the vehicle more competitive in a world market?
Very car-line-sensitive, e.g., Escort, Chevette are price-sensitive. Big cars, Continental etc., can price to recover - but need to avoid gas guzzler tax.
I think performance and fuel economy gains from weight reduction are not thoroughly understood by major decision makers (those who reject higher-cost material for weight savings).

(T-7 continued)

I expect more and more actual components to become available with time, such as aluminum rear axle housings on Corvettes, aluminum blocks on Cadillacs, aluminum heads on most foreign cars; managers will start to see the overall design effects this can have and start pushing their use. Paper studies do not have as much impact as real pieces.

Perceived value to vehicle manufacturer vs. what he is really willing to pay are often two quite different things.

The actual events don't support weight as a forcing function for fuel economy.

T-7 Discussion

Panelists estimate that the value per pound of weight saved to a vehicle manufacturer is $1.00 today and forecast an increase to $1.25 in 1987 and 1990 and $1.50 in 1992. The interquartile ranges show good agreement.

Discussion of Panelists' Comments

The question of the value to the manufacturer of reducing vehicle weight evokes a wide spectrum of opinion as indicated by the breadth of comment and discussion. We believe all these remarks deserve careful attention.

Comparison of Vehicle Manufacturer and Supplier Panelists

The median responses for both groups were essentially identical, the only difference being a five cent variation in the forecast for 1987.

Comparison of Replies to T-7 and Mat-9

As can be seen subsequently in this report, the Materials panelists gave forecasts of the value of weight saved at less than half the levels shown here in reply to question T-7.

Materials panelists may be closer to the buying decision - but Technical panelists may have a better grasp of secondary benefits from weight savings. Whoever is correct, this difference is important because of the uncertainty it discloses.

Trend from Three Delphi Surveys

In 1979, the median forecast for 1990 was $1.25. The 1990 prediction increased to $2.00 in 1981, but declined to $1.25 in the current survey. When adjusted for inflation, the 1979 forecast (for 1990) at 1983 prices was $1.72; this increased to $2.20 in 1981 but now has dropped substantially to the actual current level of $1.25. Whichever panelists (Technology or Materials) are more nearly correct in the current assessment, it is clear that the value of a pound of weight saved has dropped in the last two years to 63% of its former value.

(T-7 continued)

Strategic Considerations

If the value of a pound of weight saved is (or becomes) too low to be significant, the impact on the use of substitute materials will be very large. The value trend appears to correlate with moderating expectations for use of light materials.

T-8. Quality has become a very important issue, particularly in comparing U.S.-produced vehicles to some foreign-produced vehicles. Rank-order (most important = 1) the quality factors you believe are most valuable to the U.S. consumer. Also rank them in the order that you think the consumer (rightly or wrongly) judges them.

	Median Response	
	Your Ranking	Consumer's Ranking
Fit and finish	7	3
Basic structural integrity of body and chassis	4	9
Engine and drivetrain integrity and durability	2	6
Maintenance requirements	8	8
Corrosion resistance	8	8
Ride and comfort	7	6
Styling	8	3
Handling	9	8
Safety	9	11
Total car reliability	1	3
Fuel economy	8	5
Driveability	7	7
Emission level	13	13

	Interquartile Range	
	Your Ranking	Consumer's Ranking
Fit and finish	4/10	1/ 5
Basic structural integrity of body and chassis	3/ 7	6/11
Engine and drivetrain integrity and durability	2/ 3	3/ 9
Maintenance requirements	6/10	5/10
Corrosion resistance	5/10	6/10
Ride and comfort	4/ 9	4/ 8
Styling	5/11	2/ 6
Handling	7/11	7/10
Safety	5/12	9/12
Total car reliability	1/ 4	1/ 6
Fuel economy	6/10	3/ 7
Driveability	4/ 9	5/ 9
Emission level	13/13	13/13

(T-8 continued)

Selected Comments from Panelists

All factors must be tempered by price (cost to consumers).
Assuming that safety and driveability are "given"; i.e., exclusive of size and weight, consumers in the main do not seek out cars that are "safer than others" and expect cars to drive without annoying problems.

T-8 Discussion

As discussed in the introductory pages, medians of rankings tend to produce tie ratings and skip some of the ranks. These characteristics are apparent in the summary of replies to this question.

T-8 is particularly interesting because the experts' opinion of the relative value of quality factors is compared to their judgment on how consumers rank the same factors. Before considering the differences between the two series of rankings, it is worth noting that most of the interquartile ranges are quite wide.

For example, the experts rank fit and finish in seventh place but indicate that, in their opinion, consumers rank fit and finish third. However, the interquartile ranges show 25% of the experts ranking fit and finish fourth or better, from the expert point of view, while 25% believe consumers rank the item fifth or worse. The results overlap.

In contrast, the experts' ranking of their first and second choices, total car reliability and engine and drivetrain integrity and durability, show good consensus. But most median rankings in both columns are accompanied by relatively wide interquartile ranges.

In estimating consumers' rankings, the experts believe consumers would put fit and finish and styling at the head of the list. The experts also believe, however, that consumers would give a high ranking to total car reliability. The one item on which the experts all agree regarding their own and the consumers' ranking is emission level. This is ranked last and the interquartile range is zero. That is, less than 25% of the panelists believe it ranks higher than last place on either list.

Discussion of Panelists' Comments

It is useful to be reminded that benefits should be related to their costs. The second comment touches on a matter that must always be kept in mind when evaluating any product which has been successful for a long period and is now "taken for granted." For example, we do not include in our list of factors the item of "self-starting." If only a few cars had this feature it would probably rank first. As another example, "safety" (which is ranked in this question), probably is not rated highly because

(T-8 continued)

despite measurable differences all modern cars are safe to drive.

Comparison of Vehicle Manufacturer and Supplier Panelists

On many of these factors the manufacturers and other respondents show identical median rankings and in no case are their differences, if any, significant.

Trend From Two Delphi Surveys

Essentially this same question was asked two years ago in the 1981 Dephi II Survey. In that earlier survey, the Technical panel ranked total car reliability in fourth place compared to its lead position in this study. In estimating the consumers' rankings, the panel put fuel economy in second place two years ago compared to the present fifth-place rank. Most of the items rank about the same in the two surveys.

T-9. Check your estimate of how U.S. vehicles compare today and will compare in 1987, 1990, and 1992 with Japanese vehicles.

	U.S. Cars Compared to Japanese				
	Quality	Today	1987	1990	1992
Fit and Finish	Higher	1%	3%	15%	19%
	Same	5	75	81	78
	Lower	94	22	4	3
Basic Structural Integrity of Body and Chassis	Higher	58	55	47	48
	Same	33	45	53	52
	Lower	9	0	0	0
Engine & Drive-train Integrity and Durability	Higher	36	25	25	31
	Same	36	61	73	67
	Lower	28	14	2	2
Maintenance Requirements	Higher	24	13	25	28
	Same	45	79	73	70
	Lower	31	8	2	2
Corrosion Resistance	Higher	64	57	52	50
	Same	27	42	48	48
	Lower	9	1	0	2
Ride and Comfort	Higher	69	61	55	52
	Same	24	39	45	48
	Lower	7	0	0	0
Styling	Higher	39	41	47	45
	Same	38	55	51	53
	Lower	23	4	2	2
Handling	Higher	22	20	24	29
	Same	42	67	64	68
	Lower	36	13	2	3
Safety	Higher	91	84	63	58
	Same	9	16	37	42
	Lower	0	0	0	0
Total Car Reliability	Higher	6	13	21	27
	Same	36	58	75	70
	Lower	58	29	4	3
Fuel Economy	Higher	0	1	4	9
	Same	10	36	63	63
	Lower	90	63	33	28
Driveability	Higher	12	14	17	23
	Same	38	73	80	74
	Lower	50	13	3	3
Emission Level	Higher	20	10	11	11
	Same	68	88	89	89
	Lower	12	2	0	0

(T-9 continued)

Selected Comments from Panelists

Emission Level: No incentive to beat government regulations.
Fuel Economy: Overall, U.S. can't beat Japanese because size range is greater.

T-9 Discussion

We believe a mistake is made by many consumers, and some media and government analysts, when they define quality narrowly to include only fit and finish and similar highly visible characteristics of passenger cars. A broader view of consumer value items leads to the conclusion that there are many other quality factors such as safety, corrosion resistance, handling, etc.

In question T-9, American cars are compared to Japanese and judged to be either of higher quality, about the same, or of lower quality on 13 separate quality factors. The question asks for present opinion, and forecasts for the years 1987, 1990, and 1992.

Currently, American cars are rated higher than the Japanese on basic structural integrity of body and chassis, engine and drivetrain integrity and durability, corrosion resistance, ride and comfort, styling, safety, and emission level. Japanese cars were rated higher on fit and finish, maintenance requirements, handling, total car reliability, fuel economy, and driveability.

For 1992, the panel forecasts that--with the exception of fuel economy--American car quality will be the same or higher than Japanese on all factors, including fit and finish. The intervening forecasts for 1987 and 1990 show the trend from today's level to the 1992 predictions.

Discussion of Panelists' Comments

The comment to the effect that the U.S. cannot do better than the Japanese on fuel economy (because of the size range of U.S. products) is worth considering. As long as American manufacturers continue to supply the demand for larger cars than are imported from Japan, it seems reasonable that the average U.S. fuel economy will be somewhat less. We interpret the competitive evaluations of fuel economy, as shown in this question, to mean that car for car and product for product, on a comparable basis, Japanese cars are now better on fuel economy than U.S. cars. Actually, independent studies based on engineering criteria show that this is not true and that American cars, when matched for size, weight, and volume, closely match the Japanese cars on fuel economy. The Delphi survey is measuring here a perception that is important and should be addressed by American manufacturers to be sure that consumers are aware of the facts.

(T-9 continued)

Comparison of Replies to T-9 and Mkt-26

With minor exceptions, the Technical and Marketing panels agreed on the relative higher and lower quality aspects of American and Japanese cars and ranked these items almost precisely the same.

Trend From Two Delphi Surveys

Several of these quality factors were also rated in 1981. In both surveys, the relative rankings of quality items were about the same, and the trend toward American superiority in 1990 is also apparent in both.

Strategic Considerations

It might be thought that the forecasts for 1992 are wishful thinking on the part of our Technical panelists, most of whom represent the U.S. automotive industry. However, Japanese automotive experts agree with this forecast. One of their great concerns is that the U.S. industry has the capability of meeting any customer demand. They believe the U.S. automotive industry can, in time, match the Japanese on any and all factors.

If, as forecast, U.S. and Japanese cars reach parity on quality items they will become less significant in product differentiation. Other factors, such as technology, will increase in competitive importance.

T-10. In view of changing passenger car configurations, down-sizing, and material changes, what impact do you see on accident repair costs over the next decade?

Repair Cost Trend		Percent Cost Change by 1992: Median Response	Percent Cost Change by 1992: Interquartile Range
Increase	76%	+15%	0/25%
Same	17	-	-
Decrease	7	-10	-3/-25
TOTAL	100%		

Selected Comments from Panelists

Front-end collisions on unitized front wheel drive cars are more expensive to repair.
U.S. industry and insurance industry did not take advantage of experience from abroad when the unitized body was introduced. In the meantime they had to learn the hard way that repair costs increased drastically on these cars.
FWD - more vulnerable components, lack of wheel alignment adjustment, and use of HSLA steel all increase repair cost.
With less crush space, more components will be damaged.
Electronics repair/replace could be higher.
FWD damage costs more to fix.

T-10 Discussion

Three-quarters of our respondents expect repair costs to increase over the next decade. Among those forecasting an increase, the median expectation is 15%. A smaller proportion of respondents, 7%, expect a 10% decrease in repair costs.

Discussion of Panelists' Comments

Comments indicate clearly why 76% of the respondents expect repair costs to increase.

Comparison of Vehicle Manufacturer and Supplier Panelists

The ratio of increase to decrease responses was essentially the same for both groups.

T-11. List four factors that you believe will be the most important in influencing future light-duty vehicle design in the next ten years. For example, labor cost, foreign competition, fuel economy, quality, ...

Factors	Percentage of Total Responses
Quality	18%
Foreign competition	13
Fuel economy	12
Labor costs	9
Cost of manufacture	7
Functional styling (aerodynamics)	6
Reliability/durability	4
Efficient/economical manufacture & assembly, robotics	3
Lighter, more efficient powertrain controls	3
Cost of fuel	3
Safety	2
Performance	2
Reliability	2
Comfort	2
Development & availability of new materials	2
Market demand	1
EPA/government actions	1
Weight	1
CAD/CAM	1
Others (see below)	8
	100%

Single Suggestions:

Dollar exchange rate/Freedom from maintenance and service/Fun/ Simplicity: Our designs are too complex and costly and reliability suffers as a result./Worldwide sourcing and assembly/Cost reduction by OEM/Management approach to employees/Engine combustion/Fuel metering/Ability to invest in optimized designs/Availability of engineering talent/Integrated systems; e.g., wiring harnesses part of instrument panel/Emissions/Powertrain cost/ computerized transmission/Corrosion resistance/Customer satisfaction/Customer acceptance of small car, e.g., ride qualities/ Powertrain efficiency with electronic controls.

T-11 Discussion

Replies to this question on important design factors include a number of significant surprises. As expected, quality is near

(T-11 continued)

the top of the list, but fuel cost is well down the list with only 3% of the responses. Considered in conjunction with the relatively high ranking for fuel economy (third place), we interpret these relationships to indicate that designers plan such fuel-efficient cars in the future that fuel cost will not be of great importance.

Another surprisingly low-rated item is the EPA/government actions factor, mentioned in only 1% of the responses. Finally, important items such as safety, performance, and reliability rate relatively low because they are so fundamentally important (like round wheels) that panelists consider them of known value.

T-12 What percentage of passenger cars manufactured in the U.S. in 1987, 1990, and 1992, and using a reciprocating internal-combustion engine, will be equipped with engines of 2, 3, 4, 5, 6, and 8 cylinders?

	Percentage Distribution			
		Median Response		
	Est. 1981	1987	1990	1992
2 Cylinders	0%	0%	0%	0%
3 Cylinders	0	0	2	5
4 Cylinders	40	50	53	58
5 Cylinders	0	0	0	0
6 Cylinders (V-6)	33	35	35	32
8 Cylinders (V-8)	27	15	10	5
	100%	100%	100%	100%

	Interquartile Range		
	1987	1990	1992
2 Cylinders	0/0%	0/0%	0/1%
3 Cylinders	0/1	0/5	0/6
4 Cylinders	44/50	46/60	53/63
5 Cylinders	0/0	0/1	0/2
6 Cylinders (V-6)	30/40	25/40	27/40
8 Cylinders (V-8)	10/20	5/15	2/10

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
FOR NUMBER OF CYLINDERS IN CARS
PRODUCED IN U.S. IN 1990 MODEL YEAR

	Forecast For 1990 at the Time of The Survey		
Number of Cylinders	1979 Delphi I	1981 Delphi II	1983 Delphi III
2	-%	2%	0%
3	-	10	2
4	70	60	53
5	-	5	0
6	25	20	35
8	5	3	10
	100%	100%	100%

Selected Comments from Panelists

Turbocharged and fuel-injected 4-cyl. engines in lightweight cars will increase in popularity.

Flexibility and smoothness of multicylinder configurations may prevail more.

(T-12 continued)

T-12 Discussion

The general shift to smaller engines with fewer cylinders is predicted to continue, although at a slower rate than previously forecast. Continued reduction in V-8 engines is predicted. In-line 4-cylinder engines and V-6 engines will predominate. In addition, engines with only three cylinders are forecast beginning in 1990 and 1992. Panelists predict that by 1992, 58% of all engines used in passenger cars manufactured in the U.S. will be 4-cylinder.

Discussion of Panelists' Comments

Comments refer to engine refinements which are evaluated (with others) in question T-27.

Comparison of Vehicle Manufacturer and Supplier Panelists

The manufacturers and suppliers were in reasonably close agreement on all of their forecasts except for V-8 engines in 1987. The median estimate of their combined results, shown in the above table, is for 15% V-8 engines; but manufacturers forecast only 10% V-8 while suppliers are expecting 20%. The two-to-one relationship is relatively large, but even if the higher estimate proves to be correct, domestic engine capacity will probably be adequate to meet it.

Trend From Three Delphi Surveys

As shown in the second table, there have been some fairly substantial changes in the forecast of engine mixes for the year 1990. In the 1979 forecast it was expected that 4-cylinder engines would be used in 70% of U.S.-produced cars by 1990; this estimate dropped to 60% in the 1981 survey and to 53% in our most recent study. Most of the decline in the 4-cylinder estimate between the 1979 and 1981 forecasts reflected the expected addition of 2- and 3-cylinder configurations. These smaller engines were forecast to represent 12% of U.S. cars in the 1981 survey. In the latest survey, their share has dropped to 2%, and the percentage of V-6's and V-8's has increased to 45%, or almost half the market. See Figure T-12, page 37.

Strategic Considerations

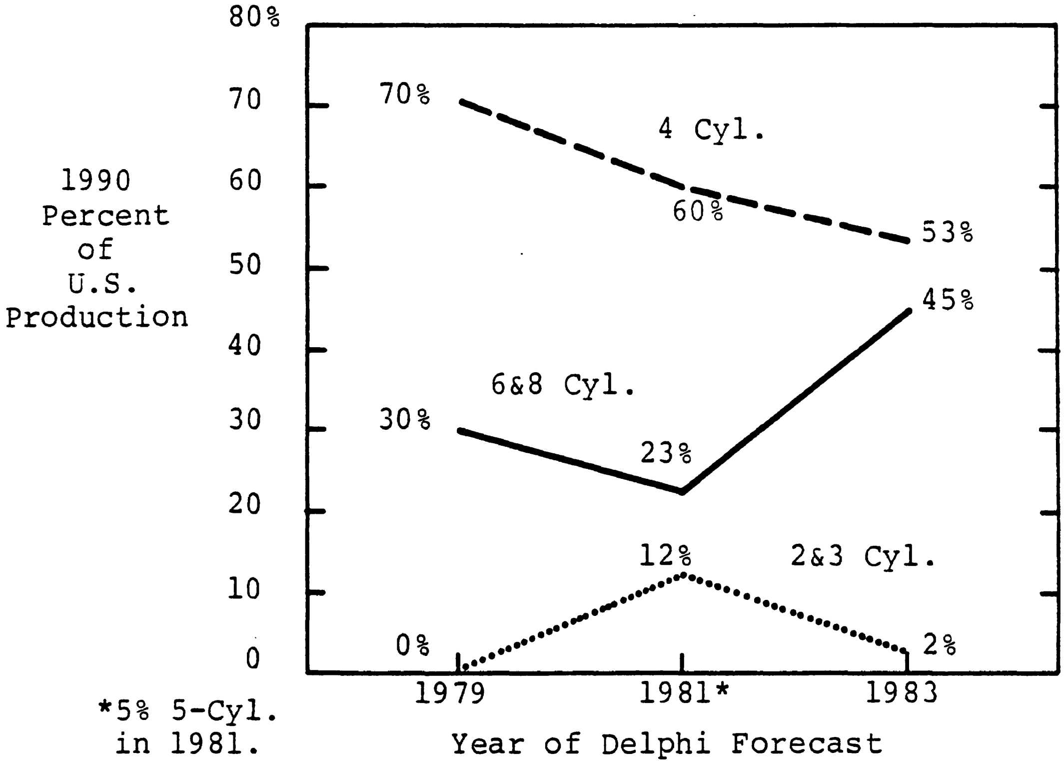
In early 1984, domestic manufacturers were straining to meet demand for larger engines because, as indicated in the earlier surveys discussed above, they were expecting substantially less call for V-8's than the market required. Domestic production was substantially higher than a year earlier but well below capacity on a total basis, and at or near full capacity for the larger cars and engines.

(T-12 continued)

The U.S. automotive industry faces the dilemma that it cannot afford facilities to match two widely different market demands. If the normal market for domestically produced cars is (for example) on the order of 10 million units per year, vehicle manufacturers and their suppliers cannot maintain plants and equipment to make either 10 million 4-cylinder cars or 10 million V-8 cars. Rather, the manufacturers must decide (many years beforehand) the mix of large and small cars they will be able to produce in a given year.

Under free market conditions, all forecasts, including automotive, are almost always wrong to some degree. However, production and marketing systems are designed with sufficient flexibility to meet most normal demand fluctuations. But when non-market factors prevail, domestic producers may lack facilities to match a rapid demand change. This problem is greatly magnified in an unexpected fuel shortage because sales are lost to imports produced on overtime in Japanese factories whose home market and basic production volume are culturally protected. When the reverse situation occurs, and fuel is abundant and relatively inexpensive, CAFE requirements prevent the manufacturers (and their laid-off employees) from realizing the potential benefit.

Figure T-12. Number of Cylinders in 1990 Car Engines as Forecast in 1979, 1981, and 1983.



*5% 5-Cyl. in 1981.

T-13. On a percentage basis, indicate the mix of spark-ignited and diesel engine displacements you expect in U.S.-produced cars made in 1987, 1990, and 1992?

	Engine Mix Median Response		
Spark-Ignited Engine Displacement in Liters	1987	1990	1992
5.0+	5%	5%	2%
3.0+ - 5.0	37	30	30
1.5 - 3.0	53	55	58
Below 1.5	5	10	10
	100%	100%	100%
Diesel Engine Displacement in Liters			
5.0+	11%	9%	6%
3.0+ - 5.0	56	54	50
1.5 - 3.0	33	37	44
Below 1.5	0	0	0
	100%	100%	100%

	Interquartile Range		
Spark-Ignited Engine Displacement in Liters	1987	1990	1992
5.0+	5/10%	5/ 5%	1/ 5%
3.0+ - 5.0	37/42	25/35	26/31
1.5 - 3.0	53/58	50/60	57/62
Below 1.5	5/ 9	5/10	10/16
Diesel Engine Displacement in Liters			
5.0+	11/22%	5/16%	2/14%
3.0+ - 5.0	44/61	43/59	44/56
1.5 - 3.0	28/50	33/48	39/56
Below 1.5	0/ 0	0/ 5	0/ 6

MEDIAN FORECASTS FROM TWO DELPHI SURVEYS
ENGINE DISPLACEMENTS IN 1990

Displacement in Liters: Spark-Ignited Engines	Forecast for 1990 at the Time of the Survey: 1981 Delphi II	Forecast for 1990 at the Time of the Survey: 1983 Delphi III	Percentage Points Delphi III Over (Under) Delphi II
5.0+	0%	5%	5 Pts.
3.0+-5.0	15	30	15
1.5-3.0	66	55	(11)
Below 1.5	19	10	(9)
	100%	100%	

(T-13 continued)

Diesel Engines	Delphi II	Delphi III	Inc.(Dec.)
5.0+	1%	9%	8 Pts.
3.0+-5.0	35	54	19
1.5-3.0	54	37	(17)
Below 1.5	10	0	(10)
	100%	100%	

Selected Comments from Panelists

Dependent on fuel cost and the cost difference between gasoline and diesel fuel.

The 1.5 to 3.0 class is perhaps too broad. Supercharging or turbocharging is likely to be used more instead of increased displacement to save fuel and maintain performance.

Diesel performance (acceleration time and durability) must improve.

Depends also on continuing demand for large cars. This could cause all large cars to become diesel.

There will be some 5.0-liter engines in cars essentially forever.

Diesel engines still have cold weather problems.

Depends on degree of turbocharging - especially diesel.

Assumes cotrol of particulates and noise/reliability improvement, plus development of direct injection diesel engines.

Manufacturing cost difference between gasoline and diesel fuel only 2-4 cents per gallon.

As consumption rates decrease, the trade-offs of a diesel engine become too great to accept.

T-13 Discussion

Engine size as measured by displacement is forecast to continue to decline but at a gradual rate. Panelists estimate 68% of spark-ignition engines will be in the 1.5 to 3.0 liter displacement range by 1992. Diesel engines are predicted to be slightly larger, with 56% in the 3.0 to 5.0 liter range.

Interquartile range consensus for spark ignition engines is good but quite wide on diesels, particularly in the 1987 forecast where the percentage of 1.5 to 3.0 liter diesel engines is shown in the range of 28% to 50%. The wider range of forecasts for diesel engines is not surprising in view of the difficulties they are experiencing as fuel prices decline and show little tendency to reverse this trend. Also, the concept of using diesels in passenger cars is unusual in that it creates emotional reactions - both pro and con - among some usually objective industry representatives.

Discussion of Panelists' Comments

Many of the comments address the competitive position of the diesel engine in the U.S. market place and are of interest in

(T-13 continued)

themselves even though they do not directly relate to question T-13.

Comparison of Vehicle Manufacturer and Supplier Panelists

The manufacturers' and suppliers' replies show a number of differences that are small, but all point in the same direction: the manufacturers forecast more engines below 3 liters and the suppliers predicted more engines above. None of these differences is large.

Trend From Two Delphi Surveys

Compared to two years ago, Delphi III panelists are now forecasting 20% more spark-ignition engines and 27% more diesel engines above 3 liters, with the differences being made up by correspondingly lower forecasts for smaller engines.

Strategic Considerations

It is important to note not only the changing level of forecasts for engines of various sizes but also the absolute level. For example, the change from a prediction of 66% spark-ignition engines in the 1.5 to 3.0 liter class to 55% may not be considered substantial because the 11 percentage point difference is not large compared to the base estimate. In contrast, much greater significance is attributable to the decline in the forecast of diesel engines of 1.5 liters and less from 10% of the total to 0%; and to the forecast of over 5-liter engines changing from 0% to 5% for gasoline engines and 1% to 9% for diesel engines. These relatively large percentage changes can be of major significance to manufacturers and suppliers. Increases in displacement forecasts (over the Delphi II level) support expectations that larger cars and engines are increasingly important in the marketplace.

T-14. What percent of U.S.-produced gasoline and diesel engines for light-duty vehicles will be either supercharged or turbocharged in model years 1987, 1990, and 1992?

Percent of Gasoline Engines

	Median Response			Interquartile Range		
	1987	1990	1992	1987	1990	1992
Supercharged	0%	2%	2%	0/1%	0/ 2%	2/ 5%
Turbocharged	5	10	15	5/6	8/12	10/15

Percent of Diesel Engines

	Median Response			Interquartile Range		
	1987	1990	1992	1987	1990	1992
Supercharged	0%	0%	0%	0/ 0%	0/ 2%	0/ 2%
Turbocharged	10	20	20	10/10	15/20	20/25

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
TURBOCHARGING AND SUPERCHARGING IN 1990

Percent of:	Forecast for 1990 at the Time of the Survey		
Gasoline Engines	1979 Delphi I	1981 Delphi II	1983 Delphi III
Supercharged	N.A.%	5%	2%
Turbocharged	25	10	10
Diesel Engines			
Supercharged	N.A.%	5%	0%
Turbocharged	28	20	20

Selected Comments from Panelists

Limited to high performance/specialty market.
Fewer super/turbochargers in future for gasoline engines.
Some type of air boost will become common in both engine types.
Turbocharger response on passenger car diesels will be critical and difficult because of less exhaust energy. Heat barrier components make turbocharger more attractive.
Air boost helps small engines (diesel and gas) exist in U.S. market.
Limited to specialty market.
Cost/complexity/durability/fuel economy limit application to low-volume performance/specialty applications.
Turbocharging is successful and is here to stay--cost reduction is needed. Supercharging is really not feasible at this time.

(T-14 continued)

Smaller engine displacement plus supercharging will give same effect as larger displacement, and therefore an engine family will have broader utilization (economics). Supercharging will give enhanced driveability, fun-to-drive.

Electronics makes forced induction more manageable. Supercharger driven through a continuously variable transmission will eliminate "turbo-lag."

T-14 Discussion

For gasoline engines used in light-duty vehicles, supercharging is forecast to have a modest future, reaching 2% in the next decade. Turbocharging is forecast to reach 5% in 1987, 10% in 1990, and 15% in 1992. For diesel engines, no supercharging is expected but turbocharging is forecast at 20% of the engines starting in 1990. The interquartile ranges for both the gasoline and diesel engine predictions show a good degree of consensus.

Discussion of Panelists' Comments

Comments cover a wide range of opinion. Note the contrast between the numerical data shown in the table and the third comment.

Comparison of Vehicle Manufacturer and Supplier Panelists

Both groups gave identical median responses in all twelve of the forecasts.

Trend From Three Delphi Surveys

A question on supercharging was not included in Delphi I but was part of Delphi II. A significant decline is forecast from the 1981 forecast of 5% supercharging in both gasoline and diesel engines in 1990 to the current forecast of 2% and 0%, respectively. The turbocharging estimate for gasoline engines declined very substantially between 1979 and 1981, from 25% to 10%, but has held at this level in the 1983 survey. The diesel engine turbocharging forecast for 1990 declined from 28% in the 1979 survey to 20% in Delphi II and the current Delphi III. See Figure T-14, page 43.

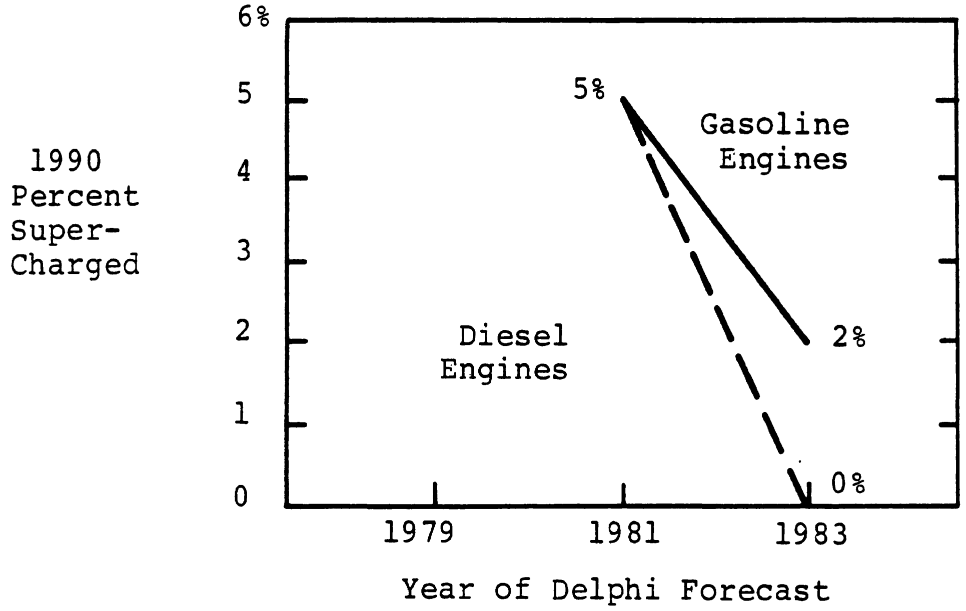
Strategic Considerations

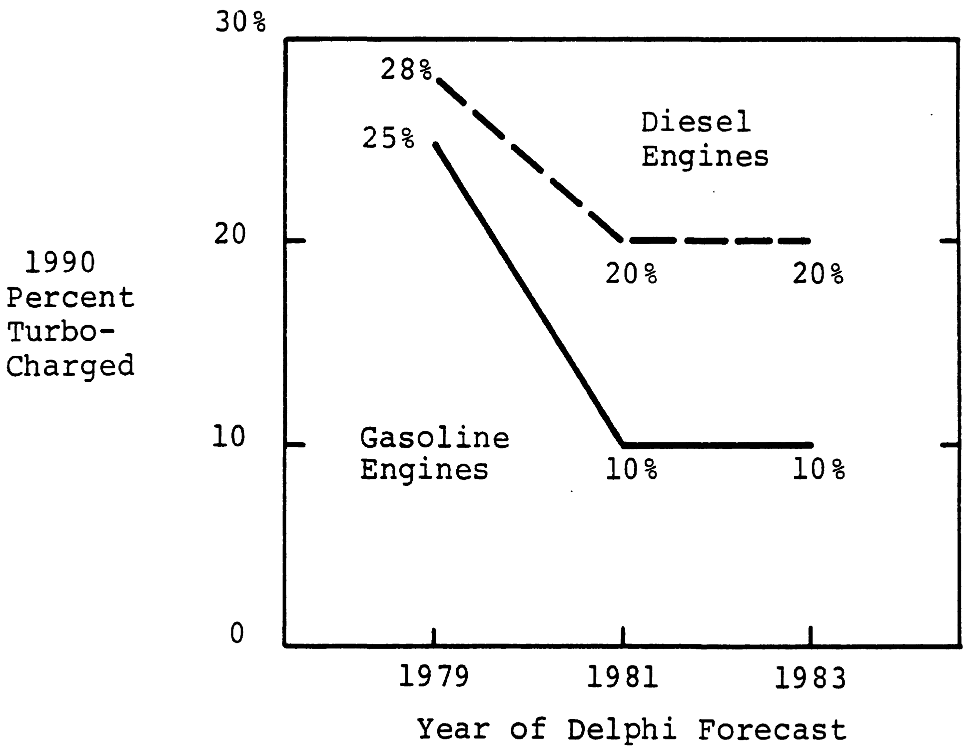
Both supercharging and turbocharging are more common on smaller engines. It is significant, therefore, that turbocharging held its forecast position between this survey and the previous one even though, as shown in Question T-13, the engine mix is expected to move in the direction of larger displacements. There is a suggestion here that turbocharging may be becoming uncoupled from engine size.

Turbo/supercharging can provide a greater effective displacement/power range for a given engine. One engine, with and without boost, might replace two different engines.

(T-14. continued)

Figure T-14. Turbocharging and Supercharging in 1990 Light-Duty Engines Produced in U.S. as Forecast in 1979, 1981, and 1983.





T-15. What percentage of U.S.-produced vehicles with spark-ignited engines will be produced with the following types of fuel management systems in the listed years?

	Fuel System Mix Median Response		
	1987	1990	1992
Port Fuel Injection	15%	25%	30%
Throttle Body or Manifold Fuel Injection	50	50	50
Carburetion	35	25	20
Other (please specify)	0	0	0
	100%	100%	100%

	Interquartile Range		
	1987	1990	1992
Port Fuel Injection	15/20%	20/30%	25/35/%
Throttle Body or Manifold Fuel Injection	45/50	50/60	50/60
Carburetion	30/40	20/30	10/25
Other (please specify)	0/ 0	0/ 0	0/ 0

Selected Comments from Panelists

Added cost of port injection limits application.
Marked success of TBI in 4-cyl. engines will increase usage.
High cost of feedback carburetors reduces TBI cost penalty.
Expect major reduction in cost of EFI/CFI and customer demand for enhanced driveability.
Most spark-ignition light trucks will have carburetors.

T-15 Discussion

Throttle body or manifold fuel injection is forecast to hold at 50% on all U.S.-produced vehicles with spark-ignited engines. Port fuel injection is forecast to show a steady growth to 15% in 1987, 25% in 1990, and 30% in 1992. Carburetion, in contrast, is expected to decline to only 20% in 1992.

The interquartile ranges show fair agreement. Note, however, that 25% of the respondents are forecasting that by 1992 only 10% of the engines will use carburetion.

Discussion of Panelists' Comments

The comments support the numerical findings.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median replies were identical on nine of the twelve forecasts and not significantly different on the other three.

(T-15 continued)

Strategic Considerations

Fuel management is undergoing a major shift in the direction of electronic fuel injection (EFI). This suggests that EFI costs are being reduced significantly and that performance/driveability characteristics are increasingly important consumer value considerations. Severe dislocations could occur among carburetor component/system suppliers.

T-16. What percentage of the vehicles manufactured in the U.S. in the listed years will be equipped with diesel engines?

	Percent with Diesel Engines Median Response		
	1987	1990	1992
Passenger Cars	6%	10%	10%
Light Trucks (1-14,000 GVW)	20	20	25
Medium Trucks (14,000-26,000)	40	50	50

	Interquartile Range		
	1987	1990	1992
Passenger Cars	5/8%	7/10%	8/12%
Light Trucks (1-14,000 GVW)	15/20	20/25	20/30
Medium Trucks (14,000-26,000)	40/50	50/55	50/65

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
DIESEL ENGINES IN PASSENGER CARS IN 1990

	Forecast for 1990 at the Time of the Survey		
	1979 Delphi I	1981 Delphi II	1983 Delphi III
Percent of Cars Made In U.S. With Diesel Engines	25%	20%	10%

Selected Comments from Panelists

Emission controls could change this sharply.

Obviously, dependent on fuel cost - my forecast is based on today's cost.

Small, unless turbo diesels are available. U.S. customer won't put up with poor-performing vehicles - maybe one time but never again.

Diesel engines will not be competitive with gasoline engines as long as diesel fuel costs equal gasoline.

Particulate standards will have a major determining effect.

Added efficiency of Direct Injection Diesel will be attractive if developed to acceptable state; noise less important in trucks.

Even with some fuel cost advantage, the diesel is not cost-effective in most passenger car applications and (at least in current state of development) has a host of disadvantages (smoke, odor, noise, performance, maintenance).

Gasoline engines are improving dramatically and high EGR rates and CVT transmissions will reduce pumping losses and significantly improve fuel economy.

(T-16 continued)

T-16 Discussion

Diesel engine use in passenger cars is expected to grow from current relatively low levels to 6% in 1987 and 10% in 1990 and 1992. Diesel usage is forecast at 20% to 25% in light trucks and 40% to 50% in medium trucks. Replies show good consensus as indicated by relatively narrow interquartile ranges.

Discussion of Panelists' Comments

Comments adequately cover the many factors determining the relative use of diesel and gasoline engines. The final comment relates the technology discussed to major improvements in fuel economy.

Comparison of Vehicle Manufacturer and Supplier Panelists

Most of the median responses were identical and there were no significant differences.

Trend from Three Delphi Surveys

Forecasts from three Delphi surveys show clearly the declining expectations for diesels in passenger cars. A similar trend is not evident for trucks, where the diesel is expected to play a prominent role.

Strategic Considerations

When demand for a major component varies from year to year, manufacturers and suppliers can usually accommodate the variation unless total use is relatively small, as is the case with the 1990 forecast for diesel engines. If the passenger car market for diesel engines is going to be 10% (or less, considering the trend), engine manufacturers must consider whether they should be in the market at all. Although 10% is by no means insignificant, the question arises: is it worth the investment risk if diesel demands may be only 5%? 1%? Or 0% by government decree?

In contrast, truck market prospects look bright.

T-17. Indicate the three most significant problems hindering development of a commercial light-duty electric-powered vehicle.

	Percent of Total Responses
Limited range	16%
Battery life/durability	16
Battery weight	12
High cost of battery replacement	9
Battery storage capacity (amp/hr)	8
Battery technology	8
High initial purchase price	7
Heating/AC	3
Decrease in price and availability of gasoline	3
Performance	3
Cost of operation/mile	2
High cost of electricity	2
Lack of proper maintenance facilities (servicing)	1
Safety	1
Customer acceptance	1
Others (see below)	8

Single Responses and Comments:

1. Same problems that existed 80 years ago still exist today.
2. Gasoline price drops hurt economics of buyers who would purchase an electric vehicle.
3. Lack of incentive to invest in development.
4. Recharge more cumbersome than fueling.
5. High production cost for low volume.
6. Crash integrity.
7. Vehicle weight.
8. Efficiency of electric motor.
9. Internal combustion engine momentum is substantial.
10. Economy of scale not available.
11. Infrastructure.
12. Expensive semiconductors.
13. Poor economic payback.
14. High risk relative to unstable petroleum prices.

T-17 Discussion

Perceptions of the problems slowing development of a commercial light-duty electric-powered vehicle do not change much over time. The limited range of the vehicle, its problems with

(T-17 continued)

battery life durability, and the weight of the batteries continue to be major factors preventing wide use of electric cars and trucks.

Strategic Considerations

One definition of an electric car is "a warm-weather vehicle designed to carry heavy batteries inefficiently and slowly from one point to another at great cost and inconvenience while providing limited space for the operator and passengers."

T-18. When will electric car, van, and truck production get firmly started in the U.S.?

	Median Response	Interquartile Range
Cars (year production reaches 10,000 units)	1992	1990/1995
Trucks and Vans (5,000 annual output)	1990	1990/1995

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
ELECTRIC VEHICLE PRODUCTION IN U.S. IN 1990

Electric Vehicle Units Produced In U.S.	Forecast for 1990 at the Time of the Survey		
	1979 Delphi I	1981 Delphi II	1983 Delphi III
Passenger Cars	600,000*	300,000	Under 10,000
Vans and Light Trucks	N.A.	45,000	5,000

* Estimated from related questions.

Selected Comments from Panelists

Both linked to technology.
Maybe never.
Not until an efficient battery can be developed that is competitive with gasoline and diesel engines.
Can't predict an invention.
Can be accelerated if fuel shortages become common.
Never - it is an absurd idea. Five minutes of rational thought will reveal that the basics make an electric vehicle a failure.
My answer assumes gasoline prices remain stable or rise slightly; sooner if gas prices escalate; later if battery technology is delayed.
When gas reaches $3.00/gallon for several years.

T-18 Discussion

Significant electric vehicle production is not expected in the 1980's. Median forecasts call for 10,000 cars per year by 1992 and 5,000 units of trucks and vans by 1990. The interquartile range on each median is five years and indicates little consensus because it is about equal to the lead time for planning production of such a vehicle.

Discussion of Panelists' Comments

Comments range from self-assurance (based on $3.00 per gallon gasoline) to complete negativism.

(T-18 continued)

Comparison of Vehicle Manufacturer and Supplier Panelists.

The manufacturers' panelists were two to three years less optimistic than the suppliers concerning the possible date of introduction.

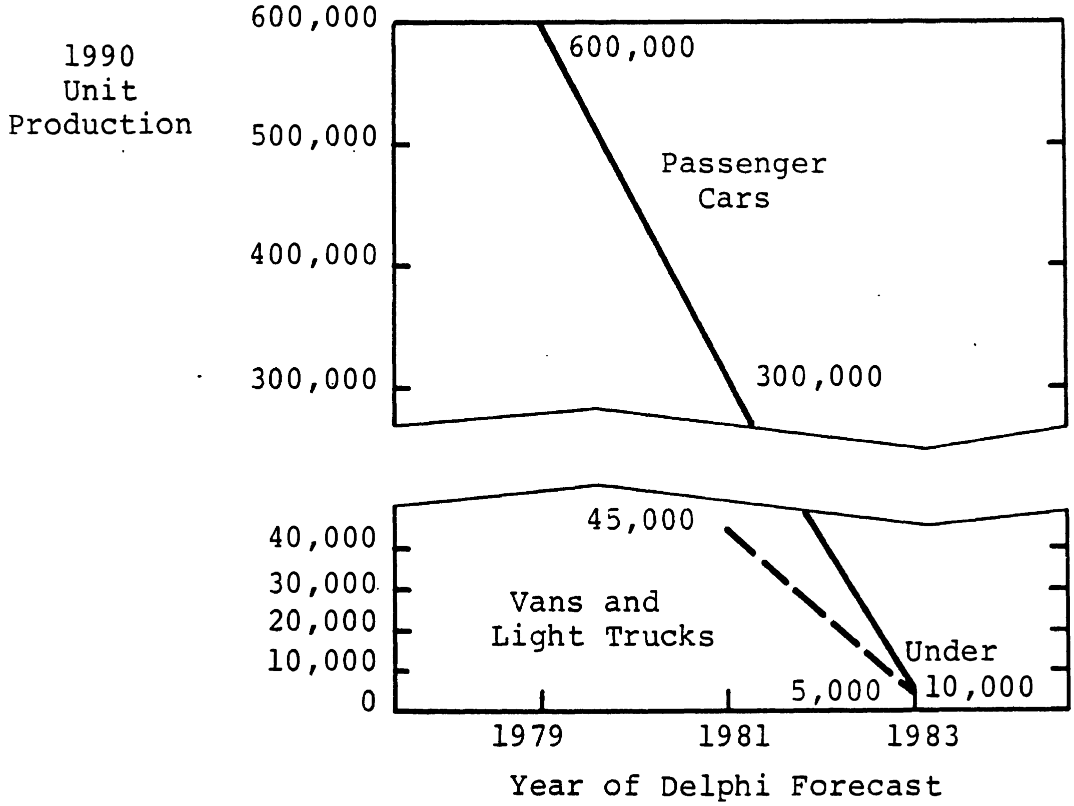
Trend From Three Delphi Surveys

Forecasts of electrical vehicle production have declined dramatically from the approximately 600,000 units forecast for 1990 at the time of the 1979 Delphi I Survey to the present level of less than 10,000 passenger cars and about 5,000 vans and light trucks. See Figure T-18, below.

Strategic Considerations

Like the diesel, but to a much greater extent, the success of electric vehicles is highly dependent on the cost and availability of gasoline and diesel fuel. And, as noted earlier, battery technology must be improved before significant production will occur.

Figure T-18. Electric Vehicle Production in the U.S. in 1990 as Forecast in 1979, 1981, and 1983.



T-19. What percentage of the light-duty vehicle engines produced in the U.S. in 1987, 1990, and 1992 will utilize aluminum cylinder heads and/or blocks?

	Percent with Aluminum					
	Median Response			Interquartile Range		
	1987	1990	1992	1987	1990	1992
Heads	20%	30%	40%	20/20%	25/35%	35/50%
Blocks	5	10	15	5/ 5	8/10	10/20

MEDIAN FORECASTS FROM TWO DELPHI SURVEYS
ALUMINUM HEADS AND BLOCKS IN 1990

U.S.-Produced Light Duty Vehicle Engines	Forecast for 1990 at the Time of the Survey: 1981 Delphi II	1983 Delphi III	Percentage Points Delphi III Over (Under) Delphi II
Aluminum Heads	50%	30%	(20) Pts.
Aluminum Blocks	15	10	(5)

Selected Comments from Panelists

Also influenced by heat barrier inclusion in the engine design.
Other materials may become important in engines.
Aluminum components are not cost-effective per amount weight saved now. Aluminum industry owes the auto industry cost reduction technology, not ads in the paper.
Smaller lightweight 4-cyl cast iron engines are narrowing the differences in weight and little secondary benefits are available if optional V-6 and/or diesel engines are offered.
Durability image of trucks will preclude wide use of aluminum in these engines.

T-19 Discussion

Median reponses indicate steady growth in the use of aluminum cylinder heads and blocks in light-duty vehicle engines produced in the U.S. The forecast is for 20% aluminum heads in 1987 growing to 30% in 1990 and 40% in 1992. Paralleling this growth, aluminum blocks are predicted in 5% of the engines in 1987, 10% in 1990, and 15% in 1992. The 1987 forecast shows a very tight interquartile range for both the head and block forecasts. These ranges widen into 1990 and 1992. However, by 1992, even the lower quartiles, representing 25% of the respondents at the bottom end of the forecast range, show 35% expecting aluminum heads and 10% expecting aluminum blocks.

(T-19 continued)

Discussion of Panelists' Comments

Despite optimism evident in the table, comments suggest reasons for caution that reflect materials content forecasts shown earlier in T-6.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median forecasts were identical except for blocks in 1992; manufacturers forecast 10% and the suppliers 20%.

Trend From Two Delphi Surveys

During the last two years, the 1990 forecasts for aluminum heads and blocks have declined substantially.

Strategic Considerations

Although predictions for growth have moderated, the forecasts continue to represent a significant increase in overall use of aluminum. Aluminum engines could lead to significant changes in structural components because of lower engine weight.

T-20. When will ceramic engine components be used commercially (not just experimentally) and what three parts will be produced first?

Engine Components	Percent of Total Responses	Year Used Commercially: Median Response	Year Used Commercially: Interquartile Range
Piston	25%	1990	1985/1992
Cylinder head component	21	1990	1987/1992
Combustion chamber coating	12	1990	1988/1990
Valves	8	1987	1987/1990
Exhaust manifold components	7	1987	1987/1989
Turbocharger	4	1987	1986/1994
Valve seat	Two responses	1988,1994	-
Cylinder	Two responses	1990,1995	-
Valve guides	Single response (SR)	1988	-
Bearings	SR	1985	-
Piston pin	SR	1990	-
Piston ring groove	SR	1983	-
Fuel injection components	SR	1985	-
Piston ring coating	SR	1986	-
Sliding surfaces on all bearings	SR	1989	-
Gas turbine parts	SR	1990	-
Gas turbine regenerators	SR	1995	-
Gas turbine rotors	SR	1995	-
Gas turbine combuster	SR	1995	-
Turbocharger bearings	SR	2000	-
Coatings-passage from exhaust valve to turbocharger	SR	1988	-
	100%		

T-20 Discussion

Ceramic engine components are expected in the near future. By 1990, 25% of the responses forecast ceramic pistons or piston parts, 21% ceramic cylinder head components, and 12% ceramic combustion chamber coatings. By 1987, responses indicate expectation of ceramic valves, exhaust manifold components, and turbocharger elements.

However, the interquartile range on most of these estimates is quite wide; seven years for piston components, five years for cylinder heads, and eight years for the turbocharger. Individual responses are shown that may be of interest and significance to suppliers.

(T-20 continued)

Clearly, this is an interesting emerging technology that should be closely watched. There is substantial international activity in the area. Other than turbocharger components for spark-ignition engines, most of the applications envisioned are applied to diesel or gas turbine engines.

T-21. Polymer-based materials have been suggested for engine components. Indicate the three engine components most likely to be built from these materials and their year of commercial introduction.

Engine Components	Percent of Total Response	Year of Commercial Introduction: Median Response	Year of Commercial Introduction: Interquartile Range
Oil pan	16%	1985	1983/1986
Valve covers	14	1985	1983/1987
Intake manifold	13	1989	1987/1990
Connecting rods	11	1990	1990/1990
Piston components	7	1990	1986/1995
Piston wrist pins	6	1989	1988/1990
Timing chain cover	5	1984	1983/1987
Valve push rods	4	1987	1987/1988
Water pump	4	1990	1987/1992
Carburetor	4	1990	1983/1990
Cylinder block	Two Responses	1990,1995	-
Air cleaner	Two Responses	1990,1995	-
Balance shafts	Single Response (SR)	1990	-
Valve spring retainer	SR	1986	-
Piston rings	SR	1986	-
Oil pump	SR	1988	-
Throttle body	SR	1990	-
Misc. brackets	SR	1990	-
	100%		

T-21 Discussion

By 1985, polymer-based materials are expected in engine oil pans and valve covers. By 1990, or earlier, this material may appear in internal parts such as connecting rods, piston wrist pins, other piston related components, and valve push rods. For most of these forecasts the interquartile ranges are reasonably narrow at three to four years or less. As with ceramics, this is an emerging technology that should be watched closely. One clear observation related to polymers in general is that it is imperative not to underestimate their potential. Development is rapid and the range of properties attainable is broad.

T-22. Fastburn combustion chambers are being used increasingly in spark-ignition engines. What is your expectation for:

a. Percentage fuel economy improvement (over present engines) to be achieved with this technology in the next 10 years?

Median response: 10% Interquartile range: 10/10%

b. Percentage of spark ignition engines produced in the U.S. that will use this technology in the following years?

	1987	1980	1992
Median Response	30%	50%	60%
Interquartile Response	20/40	40/60	60/80

Selected Comments from Panelists

We used it before - dropped it for non-catalyst hydrocarbon control - now returning to fast burn.
Existing engines can easily be converted.
Thermodynamic improvements over existing designs are minimal. Biggest improvements will be obtained in fuel management (deceleration shut-off, idle shut-off) and friction.
Anything we do to get the compression ratio back to where it used to be with leaded fuels will be an improvement.
Fastburn concept causes some loss in power which will control the Air/Fuel ratio used.
Easy conversion, better use of fuel octane permits somewhat higher compression ratio, more tolerant of EGR.
Use of fastburn will be mandatory for competitive fuel economy and performance.
Will become fashionable. Easy conversion will allow high penetration in short time span.

T-22 Discussion

Fastburn combustion chambers are expected to dominate U.S.-produced spark-ignition engines by 1992. A 10% fuel economy improvement over present engines is forecast with this feature. Usage is forecast at 30% in 1987, 50% in 1990, and 60% in 1992. For 1992 the interquartile range low is 60%. This means that over three-fourths of all respondents forecast 60% or more.

Discussion of Panelists' Comments

As might be expected from the dramatic increases forecast by the numerical medians, comments are highly supportive of fastburn combustion and suggest that one of the reasons for the predicted rapid employment of this feature is the relative ease of converting engines to its use.

(T-22 continued)

Comparison of Vehicle Manufacturer and Supplier Panelists

Manufacturers are even more optimistic than suppliers and forecast 80% use by 1992.

Trend From Two Delphi Surveys

In the Delphi II Survey, in 1981, panelists were asked to list in order of importance the technological factors likely to bring about new improvements by 1985 and 1990. At that time, two years ago, the fastburn combustion feature accounted for only 5% of the responses.

Strategic Considerations

In the automotive industry, technical innovations can develop very rapidly. As noted in the comments, fastburn implementation does not require major investment and can be accomplished quickly. The cost to obtain a significant MPG improvement is reasonably low when compared to other techniques.

T-23. With expected changes in engine technology and fuel characteristics, what average compression ratio and octane requirements do you expect for light-duty vehicle, spark-ignition engines in the listed years?

	Median Responses		
	1987	1990	1992
Octane Requirement $\frac{(M+R)}{2}$	88	88	89
Compression Ratio	9.0	9.2	9.5

	Interquartile Range		
	1987	1990	1992
Octane Requirement $\frac{(M+R)}{2}$	87/90	87/91	87/91
Compression Ratio	8.8/9.0	9.0/9.8	9.2/10.0

Selected Comments from Panelists

Knock sensors will be widely used. The answers above assume knock sensors widely used (over 50% by `92) and public appreciation of enhanced performance with knock sensors and higher octane fuel.

With improved combustion the compression ratio can be increased to take advantage of the better efficiency associated with a higher ratio.

Octane change due to technology. Some optional performance engines will use existing higher octane fuels. Hence, on a composite basis, the compressing ratio and octane number will increase. Compression ratio for a given octane will go up.

Manufacturers will use knock control systems and fast-burn to increase compression ratio without increasing octane requirements. However, more car makes may design for use of premium gasoline, thus raising the overall gasoline pool octane level.

My reply ignores the small fraction of engines requiring premium fuel (91 octane number or higher).

T-23 Discussion

Octane requirements and compression ratios are forecast to rise moderately to 89 and 9.5, respectively, in 1992. Interquartile range agreement is fairly tight on the predictions. However, for each forecast year, the lower quartile prediction for octane requirements is 87.

Discussion of Panelists' Comments

Comments touch on some of the technological factors underlying octane and compression ratio requirements.

(T-23 continued)

Comparison of Vehicle Manufacturer and Supplier Panelists

Median forecasts were identical for 1987. In 1990 and 1992 the manufacturers forecast a slighly higher octane requirement and, for 1990, a slightly higher compression ratio. The differences are not large, however.

Stategic Considerations

Modest fuel economy gains (1%-2%) will be achieved with the compression ratio increases forecast. Modest power gains are also likely.

T-24. What percentage of light-duty diesel engines produced worldwide will use an open chamber (direct injection) design in the following years?

	Percent Open-Chamber (Direct Injection)*					
	Median Response			Interquartile Response		
	1987	1990	1992	1987	1990	1992
U.S.-Produced for:						
Cars	1%	10%	15%	0/1%	5/10%	10/15%
Light Trucks (0-14,000 GVW)	5	15	20	5/5	10/15	18/25
Foreign-Produced for:						
Cars	5	14	35	5/ 5	12/15	20/35
Light Trucks (0-14,000 GVW)	10	20	30	10/10	15/22	30/40

* All other light-duty diesel engines would be pre-chamber (indirect injection) design.

Selected Comments from Panelists

U.S. application will depend on emission regulations in effect.

Probably all non-U.S. diesel engines will have direct injection by '87. U.S. usage requires new technology or relaxation in emission/particulate standards.

Acceptability of diesels and price of diesel fuel will contribute to implementation.

Figures could be skewed if U.S. manufacturers buy their diesels from overseas because of cost and volume uncertainty.

Direct Injection will eventually be required to keep diesel fuel economy competitive with spark ignition engines.

T-24 Discussion

As a percentage of diesels used, the open chamber or direct injection design for light-duty engines produced worldwide is expected to increase to 15% in U.S.-produced cars by 1992, 20% in U.S. trucks, 35% in foreign-produced cars, and 30% in foreign-produced trucks. Interquartile range agreement on these median forecasts is fairly good.

Discussion of Panelists' Comments

Comments emphasize the regulatory impact on the use of direct injection in diesels.

Comparison of Vehicle and Supplier Panelists

Median responses for the two groups were essentially the same.

(T-24 continued)

Trend From Two Delphi Surveys

The data shown here suggest a rapid trend toward the use of direct injection light-duty diesel engines, but the pace has slowed from previous forecasts. Two years ago, in the 1981 Delphi II Forecast for 1990, it was predicated that 30% of all light-duty diesel engines (for both cars and light trucks) would use direct injection. This earlier figure compares to 10% for cars and 15% for light trucks in this survey's 1990 forecast.

Strategic Considerations

In the automotive industry, enthusiasm for technical innovations can decline rapidly when the pressures for change are removed or reduced.

T-25. Will the addition of electronic controls be necessary to improve consumer acceptance of diesel-powered vehicles in North America?

Yes	60%
No	40%

Selected Comments from Panelists

Electronics will help but other design-related parameters of the diesel determine the acceptance. Noise, smoke, sluggishness, smell of diesel fuel, price of fuel.

Consumer acceptance is tied to reliability. Electronics only used for emission control.

Initial fuel price needs to be lower. Fuel price needs to be less than gasoline for the diesel to be acceptable.

T-25 Discussion

Sixty percent of the respondents predict that the addition of electronic controls will be necessary to improve consumer acceptance of diesel-powered vehicles in North America.

Discussion of Panelists' Comments

Comments indicate that although electronic controls may be necessary to improve consumer acceptance of diesel-powered vehicles in North America, this feature alone may not assure acceptance.

Comparison of Vehicle Manufacturer and Supplier Panelists

Responses from both groups were divided identically with 60% Yes and 40% No.

T-26. In which year do you expect electronically controlled diesel fuel injection systems will become commercial (25,000 units for passenger cars or 10,000 unit for trucks, worldwide)?

Median Response	1986
Interquartile Range	1985/1988

Selected Comments from Panelists

Japanese car manufacturers will most likely be first, although European companies showed the vehicles first.

Whenever emission standards dictate.

Regulations concerning diesel emissions play a major role.

T-26 Discussion

By 1986 it is predicted that electronically controlled diesel fuel injection systems will become commercial for cars and trucks, worldwide. The interquartile range indicates that three-fourths of the respondents expect this feature by 1988.

Discussion of Panelists' Comments

Comments reflect the tie-in between government regulations and technological change.

Comparison of Vehicle Manufacturer and Supplier Panelists

Both groups forecast 1986 as their median response.

T-27. What percentage of the engines produced in the U.S in 1992 will employ:

	Median Response	Interquartile Range
1. Stop/start devices	5%	2/5%
2. Balance shaft in 4-cyl. engines	15	10/15
3. Knock-limiting devices	50	50/70
4. Lighter-weight rotating parts	30	25/50
5. Methanol fueling (special design)	10	5/10
6. Turbocharging	15	10/20
7. Variable inlet valve timing	5	5/10
8. More than 2 valves/cylinders	10	5/15
9. Ultra-low friction designs	20	20/30
10. Electronic valve actuation	5	0/15
11. Tube type (hollow) camshaft	20	10/20
12. Powder metal cam and gears	20	10/25
13. Accessory load cut-out when not in use	20	15/35
14. Direct-fire (distributorless) ignition	20	20/30
15. Electronic spark control	65	50/80
16. On-board diagnostic systems	50	30/90
17. Multifuel capability	5	5/10
18. Variable number of cylinders operating	5	0/10

T-27 Discussion

Replies to this question list expectations for new features on engines produced in the United States in 1992. Half of the engines are expected to have knock-limiting devices and 65% to have electronic spark control. Also, 50% are expected to have on-board diagnostics systems. In total, 18 items are evaluated. The interquartile ranges vary from absolutely narrow, as in the 2% to 5% range for stop/start devices, to the 30/90% range on diagnostic systems.

Comparison of Vehicle Manufacturer and Supplier Panelists

There were significant variations in the median responses of the two groups. Only 2% of the manufacturers' responses call for stop/start devices in 1992 and only 10% looked for the balance shaft in that year. Manufacturers are also lower than the suppliers in their predictions for turbocharging, variable inlet valve timing, electronic valve actuation, and multi-fuel capability. Manufacturers' median responses were higher than those of the suppliers on lighter-weight rotating parts, direct-fire ignition, electronic spark control, and on-board diagnostic systems.

Strategic Considerations

The differences between manufacturer and supplier forecasts should probably not be taken too seriously; nor should the combined

(T-27 continued)

medians themselves as shown in the table be considered hard forecasts. These data are primarily useful as indicators of the relative prospects for the items evaluated.

T-28. Advanced engine types have been considered for many years in U.S. light-duty vehicles. When do you expect the following engines will attain commercial production quantities (25,000 units) in the U.S.?

	Start-up year	
	Median Response	Interquartile Range
Gas Turbine	*	*/*
Stirling	*	*/*
Open Chamber (D.I.) Diesel	1988	1987/*
Direct Injection Stratified Charge (spark-ignited)	1990	1990/*
Diesel/Gasoline Hybrid (spark-ignited diesel)	*	1990/*
Rotary Combustion or Wankel	*	*/*

* Unlikely in next 20 years.

T-28 Discussion

Expectations are not high for alternative engine production in the U.S. The open chamber diesel is predicted by 1988 and the direct injection stratified charged spark engine by 1990, but the gas turbine, Stirling, diesel-gasoline hybrid, and Wankel are not expected to be produced in the U.S. in the next 20 years. The interquartile ranges indicate that 25% or more of these respondents believe that none of these engines is likely within the next 20 years.

Comparison of Vehicle Manufacturer and Supplier Panelists

The only significant difference is that the vehicle manufacturers' median forecast was 1995 for the diesel/gasoline hybrid.

Strategic Considerations

From time to time the nontechnical media and other sources outside the automotive industry express enthusiasm for exotic engines that are expected to be revolutionary. (Gas turbines and Stirling engines are particularly popular). Expectations for these advanced engine types are much lower within the industry and for good reasons. Millions of dollars and hundreds of man-years have been invested in the evaluation of these and other advanced concepts, but they remain experimental because they have not yet proved to be practical for high-volume production and marketing in the U.S. market. Major technical and commercial barriers remain for most alternative power plants.

T-29. With increasing emphasis on vehicle aerodynamics, tighter underhood packaging requirements, higher engine load factors, and other changes, how much will underhood temperatures increase beyond those of today?

	Increase in Underhood Temperature (°F)		
	1987	1990	1992
Median Response	10	10	10
Interquartile Range	5/10	5/10	2/10

Selected Comments from Panelists

In order to avoid the penalties of higher underhood temperatures, auto engineers will work out improved cooling means.
Some vehicles are now on the limit. Better ventilation will be required.
Various methods of control will be used; e.g., insulated exhaust to improve catalyst light off.
Don't see any big change - cooling will be adjusted to suit. Turbocharging may cause some problem.
None. Design must maintain current levels or plastic usage will be impaired.
Catalytic converter technology should not add heat to engine compartment compared to thermal reactors.
These increases are average estimates. Obviously, selected applications (e.g., turbochargers) will see much higher peak values.
No change over the range that exists today. As engines become smaller and more efficient, there will be less total heat rejection.
Hi-temp electronics will be required.
Air flow will be reduced to cut drag.
Smaller engines must operate at higher load factors with less space for ventilation.
Caused by turbo installations and improved aerodynamics. Cooling can be handled.
Limiting condition may be the soak after a hard run when normal ventilation ceases. Increased usage of fuel injection, fuel recirculation systems, and electric fuel pumps in or near fuel tank will alleviate this problem; also applies to hot idling.
Reduced temperature would allow reduced cost elastomers, seals, mounts, wires.
Underhood air flow management can be expected to control underhood temperatures.

T-29 Discussion

Underhood temperatures are expected to increase by 10 degrees in the near future and remain at that higher level through 1992. However, the interquartile ranges indicate that many respondents expect a lower increase in temperature.

(T-29 continued)

Discussion of Panelists' Comments

The wide-ranging comments suggest that many respondents believe steps will be taken to prevent any temperature rise or that substantial changes will be needed to contain the increase in underhood temperature.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median responses were identical for both groups.

Strategic Considerations

In the past few years underhood temperatures have increased substantially. A further increase could stress already marginal components to the point where more expensive designs might be necessary.

T-30. U.S. sales declined in 1982 for passenger cars and light trucks equipped with diesel engines. List the three leading factors that contributed to this decrease.

	Percent of Total Response	
	Cars	Trucks
Ratio of gasoline/diesel fuel price decrease in the price of gasoline	25%	27%
High initial sales price (premium cost of engine)	17	23
Noise/odor	12	4
Reliability/durability	11	11
Performance problems	7	6
Quality of engine	5	5
Cold weather starting/stalling problems	5	4
Poor image/experiences (consumer dissatisfaction)	3	2
Maintenance difficulties	3	6
No real $ savings/cost recovery	2	2
Novelty gone (experimenters, fad buyers)	2	1
Cost of maintenance	2	3
Improved fuel economy of gasoline engine	2	2
Availability of diesel fuel	2	3
Inconvenience	1	-
Service availability	1	1
Forced Regular Production Options (RPO)	*	*
Fuel Contamination	*	*
	100%	100%

* Indicates single response

T-30 Discussion

Respondents believe the leading factor in the decline of diesel sales in the U.S. is the price ratio of gasoline to diesel fuels plus the relatively low cost of gasoline. A variety of other reasons is presented.

Comparison of Replies to T-30 and Mkt-40

Marketing panelists gave essentially the same priority to these reasons.

Strategic Considerations

It grows increasingly doubtful that the diesel engine will become a major competitor with the gasoline engine in the U.S. passenger car market unless there is a fuel-price ratio substantially in favor of the diesel or a renewed energy crisis.

T-31. Do you expect that the light-duty diesel engine will be able to meet regulated particulate levels and remain cost-effective in 1985? In 1987? In 1990? In 1992?

	1985	1987	1990	1992
Will be able to meet standards	47%	52%	73%	75%
Will not be able to meet standards	53	48	27	25
	100%	100%	100%	100%

Selected Comments from Panelists

If standards are reasonable.
Can't comment since it is presently not clear what the standards will be.
I think particulate standards were set to eliminate the diesel after government initial push for fuel economy.
If standards are set in `87 so as to require particulate traps, then the diesel cannot remain cost-effective.
Assume current standards.
Depends on size of car/engine.
If particulate traps are required, it will be very tough. Regulatory requirements vary so much that most people won't know how to answer this question.
Assumes 0.2 g/m is enforced.
Not cost-effective today.
Standards will probably be modified to accommodate any shortfall.
Standards will be adjusted to what manufacturers can achieve.
Is the light-duty diesel cost-effective in most applications today?
Will meet standards but doubt cost efficiency.
Regenerative externally-fueled particulate traps will be too costly/complex for light-duty use.
Will not be cost-effective.
Provided standards are stabilized at present levels.
EPA regulations are indeterminate for `87 and later.
Cost-effective is the key.
If regulated levels stay as presently set.

T-31 Discussion

A sizable proportion of the respondents forecast that the light-duty diesel engine will be unable to meet regulated particulate levels and remain cost-effective in the future. Over half of the respondents (53%) say that diesels will be unable to meet standards in 1985 but after that the majority believe standards will be met with 52% agreeing this will occur in 1987, 73% in 1990, and 75% in 1992.

Discussion of Panelists' Comments

Comments emphasize the role of government regulations in the use of the diesel in America.

(T-31 continued)

Strategic Considerations

The future of the diesel engine in U.S. passenger cars and light trucks appears to be highly dependent on government action (or inaction) but the real key continues to rest with consumers and their perception of the energy situation.

T-32. Considering the climate of accommodation between government and industry, what standard do you expect for light-duty diesel engine particulate emissions in 1985? 1987? 1990? 1992?

	1983	1985	1987	1990	1992
Current proposed particluate standards, g/mi	.6	.2			

	Future Standards Forecast, g/mi.			
	1985	1987	1990	1992
Median Reponse	.6	.4	.2	.2
Interquartile Range	.4/.6	.2/.6	.2/.4	.2/.4

Selected Comments from Panelists

I question the statement that a climate of accommodation exists between government and industry; particularly as related to EPA.

T-32 Discussion

Particulate standards, measured in grams per mile, are expected to decline from .6 in 1985 (much higher than currently proposed standards) to .4 in 1987 and .2 in 1990 and 1992. Even the high end of the interquartile range shows the particulate standard forecast at .4 in 1990 and 1992 - less stringent than now proposed for 1985.

Discussion of Panelists' Comments

Government-industry relations may have improved but the question raised is a good one.

Comparison of Vehicle Manufacturer and Supplier Panelists

The supplier respondents forecast a more stringent particulate standard (0.4 g/mi) in 1985 but thereafter were more optimistic than the vehicle manufacturers and in each year, 1987, 1990, and 1992, predicted a more relaxed standard.

Trend From Two Delphi Surveys

Two years ago, in 1981, respondents to the Delphi II Survey forecast that the 1990 particulate standard would be 0.4 g/mi. As shown above, expectations now have been lowered to 0.2 g/mi.

T-33. Do you expect a trend toward more or less government regulation of the automobile industry in the following areas during the 1980's?

	More	Same	Less	Total
Diesel engine emissions?	26%	43%	31%	100%
Gasoline engine emissions?	9	62	29	100
Safety?	27	52	21	100
Fuel economy?	19	49	32	100
Corrosion?	36	54	10	100

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
1980'S TREND IN GOVERNMENT REGULATIONS

Do you expect less regulation in the following areas:	Percent of Responses Predictions For The 1980's at the Time of the Survey		
	1979 Delphi I	1981 Delphi II	1983 Delphi III
Diesel Emissions	57%	42%	31%
Fuel Economy	0	37	32
Safety	5	39	21
Gasoline Emissions	25	41	29

Selected Comments from Panelists

Election in 1984 is critical.
More consumer-consciousness will be evident, more remedies for "lemons", etc.
Crashworthiness rather than crash avoidance.

T-33 Discussion

Respondents are not optimistic about possibilities for a decline in government regulation during the 1980's. Approximately 70% to 90% of the replies indicate expectations for the same or more regulation in the areas evaluated.

Trend From Three Delphi Surveys

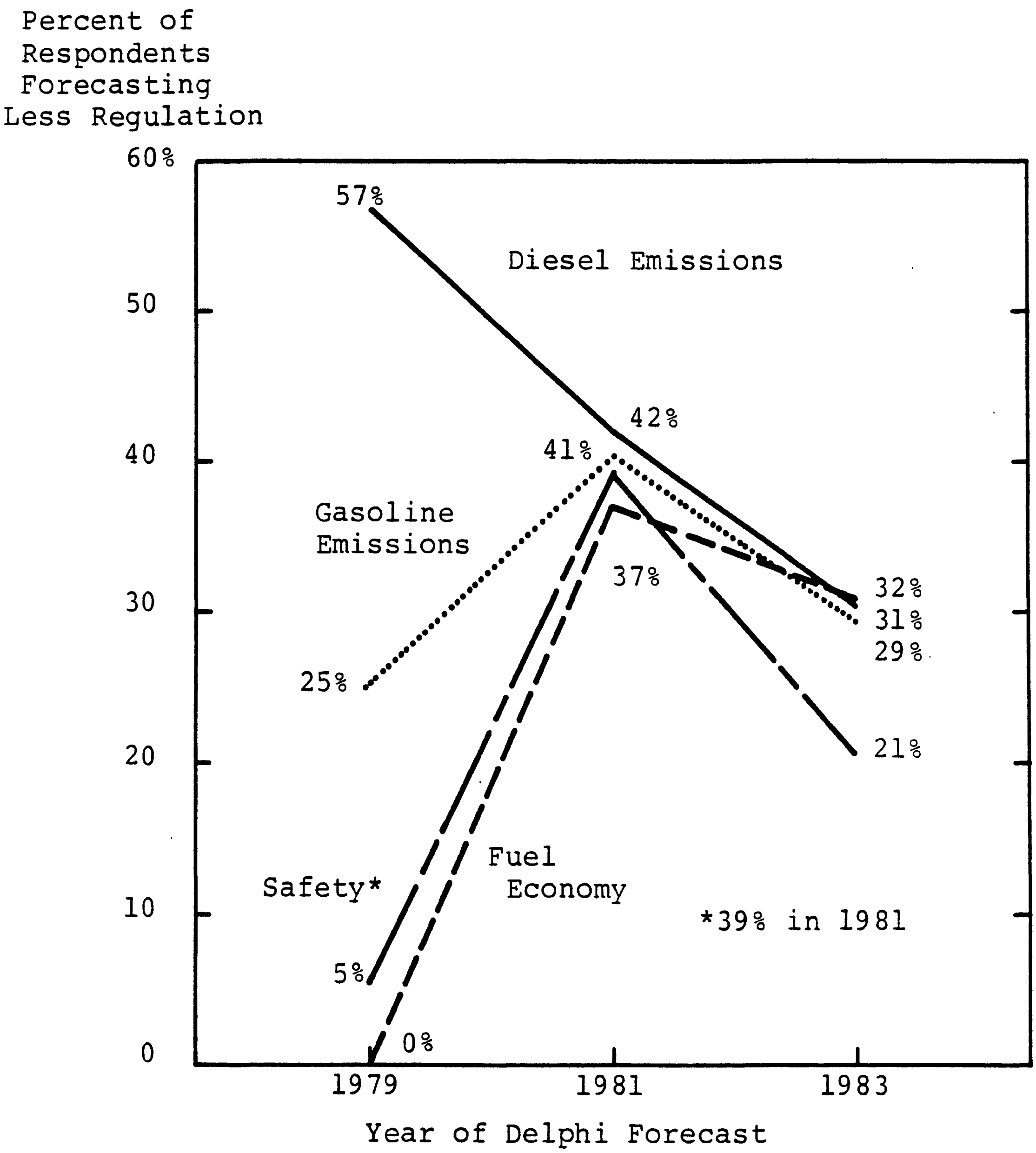
Expectations for less stringent regulations of diesel emissions have declined steadily over the years from 57% in 1979 to the current 31%. Between 1979 and 1981, forecasts called for less regulation on fuel economy, safety, and gasoline emissions. In the current survey, however, such expectations have declined. See Figure T-33, page 75.

(T-33 continued)

Strategic Considerations

Government regulation of the U.S. automotive industry appears to be following an up-trend that is independent of elections. Good planning practice dictates recognition of this fact.

Figure T-33. Less Government Regulation in 1990 as Forecast in 1979, 1981, and 1983.



T-34. Regulation of the automotive industry has recently stabilized, but new activity is always possible. In the following areas, indicate your expectation for possible future regulatory activity. These could be new regulations in previously unregulated areas or added regulations in an area now regulated.

	Percent Responding			
	More	Same	Less	Total
Emissions	31%	44%	25%	100%
Safety	67	21	12	100
Damageability	21	63	16	100
Noise	29	71	0	100
Product Liability	47	40	13	100

Selected comments and discussion on type or direction of foreseen regulations:

1. I think that regulatory activity will be concerned with refinements of existing regulations and that no significant changes will be introduced.
2. Attention should be given to harmonization with international standards.

Emissions:
1. Revisions of Clean Air Act will not provide direct relief but more sensible methods of certification.
2. Emission standards for propane-fueled vehicles are possible.
3. More activity on commercial vehicles.
4. Tighter light-duty standards for hydrocarbons, CO & NOx may occur.
5. Lapse of 1.5g NOx waivers after 1984 model year is important.
6. Gasoline engines: possible relaxation of CO.
7. Tighter evaporative emission regulation possible.

Of the total number of responses, 20% foresaw more regulation with respect to long-term in-use inspection, conformance assurance and certification; 11% an emphasis on monitoring field performance; 11% tighter particulate controls; 6% lowered NOx standards, and 6% a tightening of high altitude emission controls.

Safety:
1. More emphasis on surviving crash than on safety-related functions.
2. Encourage 35+ MPH crash testing.
3. Possible reactivation of antilock braking standards.
4. More recalls on defects.
5. Truck antiskid may come back.
6. Anti-skid on busses.

(T-34 continued)

Of the total number of responses, 31% foresaw increased regulation for occupant protection through passive restraints or a mandatory seat belt law while 3% predicted the elimination of air bags and passive restraints; 7% expected increased regulation regarding crashworthiness of small cars.

Damageability:
1. Insurance company reports will force changes ahead of regulations.
2. More regulation--especially tires.
3. Bumper standard possible.
4. 5 mph bumpers not cost effective

10% of the total responses indicated reduced repair cost requirements.

Noise:
1. Trucks and motorcycles increased regulation.
2. No change except for diesels.
3. More activity on commercial vehicles.
4. More regulation to reduce truck tire noise.
5. More regulation to reduce external noise.
6. Lower internal noise levels may be mandated.

Product Liability:
1. Capped cost for non-criminal negligence.
2. Too many recalls!
3. Stricter warranty.
4. More uniform laws state to state.
5. More accountability of OEM's.
6. Limit manufacturer's liability.
7. Preemptive federal law.

14% of the total responses indicated more "lemon laws" are likely.

Others:
1. Chlorofluorocarbons - limit emission to atmosphere.
2. Warranty - more liberal terms.
3. Fuel economy - standards beyond 27.5 mpg.

T-34 Discussion

A substantial proportion of the respondents expects more regulation in all areas of emissions, safety, damageability, noise, and product liability. 25% or less of the respondents expect reduced regulatory activity.

T-35. In the 1979 Delphi Study, panelists projected that engine oil change intervals for the average U.S.-produced passenger car would be extended to 15,000 miles by 1990. What is your current expectation for oil change intervals by 1992? Also, what will the average oil sump capacity be for U.S.-produced passenger cars in 1992?

1992 Forecast	Median Response	Interquartile Range
Oil Change Interval	12,000 miles	10,000/15,000 miles
Sump Capacity	4 quarts	4/5 quarts

Selected Comments from Panelists

Actual practice is much below manufacturers' recommendation of 7500 miles--it is about 4600-4900 miles on average.
Less capactiy due to ground clearance requirements for aerodynamics.
Or every six months.

T-35 Discussion

By 1992 the oil change interval is predicted to be 12,000 miles and sump capacity four quarts for the average U.S.-produced passenger car.

Discussion of Panelists' Comments

To the extent that it is representative of consumers in general, the first comment indicates they are not taking full advantage of the manufacturers' efforts to increase the oil change interval. The suggestion that sump capacity will be less in order to improve aerodynamics is an interesting example of the tight relationship between most vehicle parameters.

Comparison of Vehicle Manufacturer and Supplier Panelists

The median forecast of 12,000 miles for the oil change interval, as shown above, is made up of two parts. The vehicle manufacturers' median estimate was 10,000 miles, while the suppliers' estimate was 15,000. These are significant differences in such an important factor and trends in future oil change intervals should be watched closely by all concerned.

Trend From Two Delphi Surveys

As indicated in the question, the Delphi panelists in 1979 forecast that the engine oil change interval for the average U.S.-produced passenger car would be 15,000 miles by 1990. The current forecast is that by 1992 the oil change interval will be 12,000 miles. However, the upper quartile, the top 25% estimate, is at 15,000 miles or more.

(T-35 continued)

Strategic Considerations

The change in the 10-year forecast from 15,000 miles to 12,000 miles is not of major significance per se, but it is important that the recent strong upward trend toward increased service intervals may be peaking.

T-36. A major effort is being devoted to engine friction reduction. What percentage fuel economy gains will be achievable over present engines with advanced lubricant and engine technology? In addition, what minimum viscosity will be practical for advanced engines?

	Median Response	Interquartile Range
Economy gain from friction reduction	6%	5/10%
Minimum oil viscosity	5w	5w/10w

Selected Comments from Panelists

Some gain from gear lubes, wheel bearings, etc.
Single-ring pistons look good for reduced friction.
Most improvements in the engine, not lubricant.
Minimum of 5W if with 40 rating: 5W40.
6% friction reduction translates to 3% fuel economy gain.
Fuel economy gain = 2.5%.
Cold climates may use 5w.

T-36 Discussion

Fuel economy gains of 6% are expected from friction reduction efforts, including engine design and improved lubricants. The mimimum viscosity that is practical for advanced engines is forecast at 5w.

Discussion of Panelists' Comments

The panelists' comments suggest some of the benefits to be gained from a friction reduction.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median responses for the two groups are essentially the same.

Strategic Considerations

The automotive industry, not only in the U.S. but internationally, constantly strives to improve the efficiency of engines. It should be recognized, however, that internal combustion engines are now so well developed that the total remaining potential for improved efficiency is not large without unforeseen major breakthroughs in design and materials. Some experts believe that even with the use of advanced materials and known commercial design techniques, the top additional improvement is only on the order of 15%. This relatively modest potential does not reflect engineering deficiencies in present engines but rather that over the years research and development have led to a highly refined product. Also, the possible gains are by no means unimportant. For example, in a 30 mpg vehicle a 5% improvement yields an mpg gain of 1.5 mpg. Furthermore, mpg increases due to friction reduction are likely to be very cost-effective and should result in power and emission reductions as well.

T-37. Indicate probable changes in engines where you expect design modifications to be made in order to reduce engine friction or other losses.

Probable Design Changes

I. Rings/Piston/Cylinder	Percent Of Total Responses
Lower tension rings	26%
Reduced piston height and surface area	14
Narrower ring faces	11
Less bore distortion	9
Cylinder wall/bore finish improvements	7
Ring improvements	5
Fewer rings/single-ring pistons	5
Improved fit of piston in bores	5
Lighter-weight components	4
Lower friction coatings	*
Reduced piston travel	*
Means to achieve oil and blow-by control	*
Low mass, flexible skirt pistons	*
Material changes	*
Ceramics	*
Pressure balance techniques to permit fewer rings	*
Effort to use dry sump engine	*
	100%

II. Valve Train	% Total Responses
Roller cam followers	24%
Roller tappets/lifters	24
Spring tension reduction	12
Improved bearings/rolling elements	12
Lighter parts	5
Cardonic rockers	*
Pressure dynamic balance	*
Less wear/friction contact area	*
Finger followers/rollers	*
Revised rockers	*
Smaller tappets/lash adjusters	*
Overhead cam V6 engines	*
More rolling rather than sliding friction	*
Hollow camshafts	*
Ceramics	*
	100%

* Single responses

(T-37 continued)

Probable Design Changes

III. Crank/Connecting Rod/Bearings	% Total Responses
Improved smaller-diameter bearings	41%
Lighter-weight parts	23
Ceramics	*
Better finishes	*
Improved hydrodynamic design	*
Computer-optimized design	*
Precision rod dimensions	*
	100%

IV. Other	% Total Responses
Oil pump: lower power requirement, higher efficiency/lower flow	32%
Accessories: A/C, etc.	16
Water pump	11
Smaller alternator	11
Improved seals	11
Electronic accessory and component actuation to eliminate vacuum pumps	*
Manufacturing - more precision	*
Operating strategy (1) low RPM/higher load; (2) lower idle speed	*
Modified lubricants are best	*
	100%

T-37 Discussion

Many suggestions were made about probable changes in the engine to reduce engine friction. These are listed under four major engine areas: rings, pistons, cylinders; valve train; crank and connecting rod bearings; and others.

Efforts to reduce friction are only part of the ongoing attempt to improve engine efficiency, but the great variety of choices listed here indicates the extent of the industry's efforts and emerging new technology. Important opportunities as well as threats are suggested. Engine component manufacturers should pay careful attention, even to points that were mentioned in only a few responses.

T-38. In light of expected technological changes in engines and transmissions, and problems with current designs, indicate three fuel and three lubricant additives (based on type of problem) that you would like to see developed.

Engine Problem or Change	Percent of Total Responses	Fuel Additive
Spark knock/detonation	27%	Octane enhancers, anti-knock additives
Diesel soot emissions	18	Glow point reducers, particulates reduction additives
Fuel wax formation (diesel)	12	Flow improvers
Sophisticated fuel control systems	8	Detergent/dispersant/ rust inhibitors
Octane requirement increases	6	Octane requirement reducers
Water in fuel (diesel)	6	Dryers
Starting assistance	*	Alcohol fuel additive
Driveability	*	Volatility improver
Friction	*	Upper-cylinder lubrication
Catalyst poisoning	*	Additive to reduce phosphorus & sulfur effects.
Intake valve deposits	*	Detergent
Improve spark plug life/to 100,000 miles	*	Whatever it takes
Valve tulip deposits	*	Dispersants
Diesel delay period	*	Cetane improver
	100%	

* Single Responses

Engine Problem or Change	Percent Of Total Responses	Lubricant Additive
Engine friction	31%	Surface friction modifiers
Diesel oil deposits in ring belt	7	Low-ash, high-performance additive system, eliminate deposits
Loss of diesel lubricant anti-wear properties due to soot in crankcase	7	Whatever it takes
Constant viscosity at all temperatures	*	Use of synthetic materials with naturally high viscosity index
Wear with low viscosity oils	*	Anti-wear agent
Boundary lubrication of rings	*	Friction modifiers

(T-38 continued)

Low temperature pumpability	*	Flow improvers
Catalyst deterioration	*	Non-phosphorus anti-wear agent
Transmission fluid with less viscosity at cold temperatures	*	-
Corrosion	*	Anti-corrosion
Roller lifter axle shaft wear	*	-
Lower friction oils	*	-
Eliminate oil drain	*	-
Increasing sludge-related problems	*	Dispersants
Improved high temp./low shear performance	*	Viscosity-index (VI) improvers
Improved diesel performance (passenger car oils)	*	Detergents and VI improvers
Component wear	*	Lubricity and penetration to small areas that are loaded & unloaded quickly
Oil oxidation (turbocharger)	*	Anti-oxidants
	100%	

* Single response

T-38 Discussion

Several fuel and lubricant additives have been suggested to match expected technological changes and meet current problems. The leading items mentioned are octane enhancers and anti-knock compounds to meet the problem of spark detonation, and surface friction modifiers to reduce engine friction. Many others are also mentioned. Suggestions highlight fuel and lubricant problems and provide clues to possible solution. An entire in-depth survey could be conducted on factors related to this question alone.

T-39. If there is a major and continuing interruption in international petroleum supplies, rank order the following list of possible motor vehicle fuel alternatives in terms of likelihood of production in significant quantities.

Rank Order (1= Most Likely)

Median Response		Interquartile Range
2	Methanol from coal or natural gas	1/3
2	Petroleum-like fuels derived from coal liquids	1/3
4	Natural gas	3/5
3	Liquid petroleum gas	2/4
4	Ethanol or methanol from biomass	3/5

Selected Comments from Panelists

Time scale? It would take 20 yrs. to turn on synfuel production.
Assume you are talking about USA. Rank varies by country.
LPG is supply-limited.

T-39 Discussion

Respondents were asked to rank possible motor vehicle fuel alternatives in terms of their likelihood of production in significant quantities in case of major and continuing interruption in international petroleum supplies. The most likely prospects were considered methanol from coal or natural gas and petroleum-like fuels derived from coal liquids. Surprisingly, both of these were ranked higher than liquid petroleum gas which is already in use in many vehicles. Natural gas and ethanol or methanol from biomass were rated last. There was a fair degree of consensus on these rankings.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median responses were identical or essentially equal on all ranks shown.

Strategic Considersations

The comment concerning time for implementation is important. The enormous supply requirements to fill a significant share of our transportation fuel demand suggests that we face a major challenge with any alternative to petroleum.

T-40. Assuming no major international dislocations in petroleum supply and/or price, in what year do you expect synthetic or alternative fuels will be produced in significant quantity in the U.S. (1 million barrels per day)?

Year of Significant Production	
Median Response	Interquartile Range
*	1995/*

* 20 years or more away.

Selected Comments from Panelists

Just not cost-effective.
We must have technology on shelf.
Tax incentives required.
Crude-oil-based fuels must increase in price enough to make synthetic fuel profitable.

T-40 Discussion

Unless there are major international dislocations in petroleum supplies or price, respondents do not expect significant production levels of synthetic fuels within the next 20 years.

Comparison of Vehicle Manufacturer and Supplier Panelists

The manufacturers were a little more optimistic; their median forecast called for first-year production in 1995.

T-41. Project the mix of transmissions for passenger cars manufactured in the U.S. in 1987, 1990, 1992.

	Transmission Mix Projection Median Response		
	1987	1990	1992
Manual			
Three speed	0%	0%	0%
Four speed	15	15	10
Five speed *	10	15	16
Total Manual	25%	30%	26%
Automatic			
Three speed	36%	27%	19%
Four speed *	36	35	41
Continuous variable (CVT)	3	8	14
Other	0	0	0
Total Automatic	75%	70%	74%
Total All Transmissions	100%	100%	100%

* Includes Overdrive

	Interquartile Range		
	1987	1990	1992
Manual			
Three speed	0/0%	0/0%	0/0%
Four speed	10/15	10/20	6/15
Five speed *	10/14	10/15	20/20
Automatic			
Three speed	30/40%	20/35%	10/25%
Four speed	30/40	30/42	30/45
Continuous variable (CVT)	0/5	5/10	10/20
Other	0/0	0/0	0/0

MEDIAN FORECASTS FROM TWO DELPHI SURVEYS
1990 TRANSMISSION MIX, U.S.-PRODUCED CARS

	Forecast for 1990 at the Time of the Survey		Percentage Points Delphi III Over (Under) Delphi II
	1981 Delphi II	1983 Delphi II	
Manual			
Three speed	1%	0%	(1) Pts.
Four speed	18	15	(3)
Five speed	13	15	2
Total Manual	32%	30%	(2) Pts.
Automatic			
Three speed	16%	27%	11 Pts.
Four speed	42	35	(7)
CVT	10	8	(2)
Total Automatic	68%	70%	2 Pts.

(T-41 continued)

Selected Comments from Panelists

I think there will be 6-speed manuals too.
CVT will dominate in 1990's.
Next generation automatic transmission concepts that achieve fuel economy/performance parity to manual transmission will preclude dramatic mix shifts from A/T to M/T.
Considerable gains are being made in automatic transmission technology relative to pleasability and economy, while the manual is about unchanged.

T-41 Discussion

Overall, the transmission mix is expected to hold at about 25% manual and 75% automatic. Within the manual category, there are no 3-speed transmissions forecast and 4-speeds are expected to decline from 15% of all transmissions to 10%. Some growth is expected in 5-speed transmissions. Among automatic transmissions, the 3-speeds are also expected to decline while 4-speeds hold their own. Growth is expected in continuous variable transmissions.

Interquartile range consensus on these forecasts is fair for 1987 but widens for the later years.

Discussion of Panelists' Comments

The comments suggest reasons why the automatic transmission is predicted to hold its own in the face of (presumably) steady pressure for continued or improved fuel economy.

Comparison of Vehicle Manufacturer and Supplier Panelists

The one significant difference is that the vehicle manufacturers forecast a higher share of the market for the continous variable transmission. For 1987, the vehicle manufacturers predict 5% CVT compared to 2% for suppliers. For 1990, the vehicle manufacturers forecast 10% compared to the suppliers' 5%. For 1992, the ratio is vehicle manufacturers 15% to 10% for the suppliers.

Trend From Two Delphi Surveys

The major observation in the trend data is the increased forecast for 3-speed automatic transmissions and the offsetting decrease in 4-speed and CVT automatic transmission. This fairly significant reversal between the 1981 and 1983 surveys reflects the improved situation for fuel supplies and prices, the associated decline in the pressure for greater fuel economy, and technical advances that have increased acceptance of the 3-speed automatic.

(T-41 continued)

Strategic Considerations

The CVT represents one of the most important technological advances of the coming decade. It is projected initially to be a small car transmission, but the lightweight trend among most vehicles suggests potential CVT application to a large fraction of future production. As an emerging technology, CVT progress must be watched closely. The forecast rate of increase, particularly by the manufacturers from 1987 to 1997, is significant and a clue to a possible technological revolution that could sweep the industry.

T-42. Indicate your expectations for the percentage use of various passenger car transmission types in the vehicle classes listed below for 1987 and 1992.

Median Response

1987

Vehicle Class	Conventional Automatic	CVT*	Manual	Total
Full-sized	95%	0%	5%	100%
Intermediate/Compact	75	0	25	100
Subcompact/Mini	40	5	55	100

1992

Vehicle Class	Conventional Automatic	CVT*	Manual	Total
Full-sized	95%	0%	5%	100%
Intermediate/Compact	65	10	25	100
Subcompact/Mini	30	20	50	100

* Continuously Variable Transmission

Interquartile Range

1987

Vehicle Class	Conventional Automatic	CVT*	Manual
Full-sized	95/100%	0/2%	0/0%
Intermediate/Compact	70/75	0/0	20/30
Subcompact/Mini	30/45	5/10	50/60

1992

Vehicle Class	Conventional Automatic	CVT*	Manual
Full-sized	90/98%	0/2%	0/8%
Intermediate/Compact	60/70	2/10	20/30
Subcompact/Mini	20/35	10/25	40/55

T-42 Discussion

Within the full-sized car vehicle class, the conventional automatic transmission is expected in 95% of the vehicles in both 1987 and 1992, with the difference made up of manual transmissions. In both 1987 and 1992, manual transmissions are expected in 25% of the intermediate compact class. The difference will be conventional automatic transmissions in 1987, but by 1992 there is an expectation of 10% continuous variable transmissions in these intermediate-size cars. Manual transmissions are forecast in half or more of the subcompact and mini cars, and continuous

(T-42 continued)

variable transmissions are predicted in 5% of them in 1987 and 20% in 1992, largely at the expense of conventional automatic transmissions.

The interquartile range consensus on these forecasts varies from close to only fair.

Comparison of Vehicle Manufacturer and Supplier Panelists

There were no significant differences.

Strategic Considerations

The continuous variable transmission has yet to be introduced in volume in the United States but is forecast in 20% of all subcompact and mini class cars by 1992. It will be important for those with an interest in CVT to watch developments closely not only in the U.S. but also in Europe and Japan.

T-43. What percentage of U.S.-produced passenger cars will use the following drivetrain configurations in the listed years?

	Median Response		
	1987	1990	1992
Front engine, rear drive	25%	20%	15%
Front engine, front drive (FWD)	73	77	81
Mid engine, rear drive	2	3	4
Rear engine, rear drive	0	0	0
Total	100%	100%	100%

	Interquartile Range		
	1987	1990	1992
Front engine, rear drive	15/33%	10/26%	8/20%
Front engine, front drive (FWD)	60/80	70/85	72/89
Mid engine, rear drive	1/5	1/5	1/5
Rear engine, rear drive	0/1	0/1	0/1

Selected Comments from Panelists

FWD components are basically more expensive for both new cars and repair as used cars.

There may be a customer backlash when FWD cars 5 years old have poor resale value because of high cost of repair.

T-43 Discussion

The former standard arrangement of a front engine with rear-wheel drive is expected to continue its decline to 25% of U.S.-produced cars in 1987, 20% in 1990, and only 15% in 1992. The front-engine, front-drive (FWD) arrangement has become or is becoming standard and is forecast in 73% of U.S.-produced cars in 1987, 77% in 1990, and 81% in 1992. A few mid-engine, rear-drive cars are forecast but no rear-engine, rear-drive cars. The interquartile ranges are somewhat broad, particularly for the front-engine, rear-drive arrangement, which shows a ratio of upper to lower quartile in excess of 2:1 in each forecast year.

Discussion of Panelists' Comments

The second comment echoes the finding shown earlier (in reply to question T-10) regarding the higher cost of repair for front-wheel-drive vehicles.

Comparison of Vehicle Manufacturer and Supplier Panelists

Compared to their suppliers, the vehicle manufacturers see a slightly lower proportion of front-engine, rear-drive passenger cars and an offsetting higher proportion of front-engine, front-drive cars.

(T-43 continued)

Trend From Two Delphi Surveys

Panelists responding to the 1981 Delphi II survey forecast that in 1990, 85% of U.S.-produced cars would be front-engine, front-drive. This compares to the 77% prediction shown here. The difference is in accord with the improved fuel situation and the introduction of advanced rear-drive vehicles. Some of the marketing appeal of FWD of just two years ago is fading.

Strategic Considerations

There has been discussion in the media about a slowdown in the phasing out of front-engine, rear-drive cars because of revived consumer interest in these larger vehicles. Nevertheless, as shown here, predictions call for continued decline in the proportion of such vehicles and, as discussed above, vehicle manufacturer respondents are leading the way in such predictions. Sporty cars (high power/weight ratio) and vehicles intended to carry heavier loads are probably best configured with rear-wheel drive.

T-44. Name two major electronic automotive advances that you expect to reach commercialization by 1992.

	Percent of Total Responses
Transmission/controls	21%
Computerized instrument panel	11
On-board diagnostic capability/ driver information systems	11
Navigational systems	8
Anti-skid braking system	5
Voice-interactive electronics	4
Radar braking	4
Ride control	4
Fiber-optic wiring	3
Electronic fuel injection	3
Multiplex wiring/signal/power control	3
Actuators	3
Throttle optimization	*
In-vehicle entertainment system	*
Driver alcohol check	*
Communications (car to base)	*
Replacement of vacuum actuators	*
LSI--hybrid engine controls	*
Mass airflow engine management	*
Diesel engine control	*
Fuel metering	*
CRT displays	*
Vehicle suspension active controls	*
Adaptive control	*
Headway monitoring	*
Central microcomputer for engine systems, drivetrain, sound, etc.	*
Data-gathering system that allows for monitoring and diagnostics either through home computers or dealerships	*
Complete color LCD display, including maps	*
Distributorless ignition	*
Microprocessors for all controls	*
	100%

* Single response

(T-44 continued)

T-44 Discussion

Many new electronic automotive advances are expected to reach commercialization by 1992. Included are transmission controls, mentioned in 21% of the responses, a computerized instrument panel mentioned by 11%, and several others.

Strategic Considerations

The broad range of expected electronic advances--from vehicle controls to map displays--support the forecast (shown in reply to the next question, T-45) of a significant share of total vehicle costs represented by electronics. Readers are advised to give serious consideration to even single responses. In many instances they may be suggestive of "hot" new or emerging electronic technologies. Single responses may be from panelists who know something special.

T-45. What fraction of total vehicle cost will be represented by electronic componentry such as micro-processors, transducers, actuators, etc., in the following years?

	Electronic Component Percent of Total Vehicle Cost		
	1987	1990	1992
Median Response	10%	10%	12%
Interquartile Range	5/10	7/15	8/15

Selected Comments from Panelists

Electronics use will increase while vehicle cost decreases.
It is apparent that additional electronic componentry will be included in future vehicles. However, the percent of vehicle cost probably will not change because of improvements in "state of the art" concerning design and manufacture of electronic components.
Use will increase, offset by cost reductions.
Uplevel cars could approach 20%.
Rate of increase will be controlled by cost reduction in electronics, tending toward constant percentage.
Increasing then leveling as electronic costs continue to decrease.

T-45 Discussions

Electronics are playing a rapidly growing part in modern motor vehicles. The cost of electronics is forecast to represent 10% of the total vehicle cost in 1987 and 1990 and 12% by 1992. This is a remarkable growth prediction in view of the fact, well known to our respondents, that the cost of individual electronic units and components is declining rapidly. In other words, the actual physical use of electronics in vehicles will increase much faster than these cost estimates would indicate.

The 12% forecast for 1992 when multiplied by the forecast (see Marketing question Mkt-2) median car price in 1992 of $11,250 results in an electronic dollar cost of $1350. This compares to a recent public prediction by a representative of a leading U.S. vehicle manufacturer that the electronics in a 1992 passenger car will have a retail value of $1400.

Panelists' Comments

Comments parallel the discussion.

Comparison of Vehicle Manufacturer and Supplier Panelists

Manufacturer and supplier forecasts differ slightly for 1987, with the manufacturer panelists indicating a little less use, but the median responses for both the manufacturers and suppliers were the same for the 1990 and 1992 forecasts.

(T-45 continued)

The relationship between volume use on one hand and unit cost on the other, when both are moving rapidly in opposite directions, is not easy to predict. The interquartile ranges are significantly wide here. The range from the lower to the higher quartile aversages 2 to 1 for the three forecasts. Those interested in these trends are forewarned by this relatively broad range to watch developments closely.

Trend From Two Delphi Surveys.

We did not ask this question in Delphi II but did in Delphi I in 1979. At that time it was expected that electronics would represent 15% of the cost of the vehicle by 1990. The hazards of projecting a two-point trend do not need emphasizing, but the decrease in the 1990 forecast to 10% in this study could be interpreted to mean that cost may drop faster than use increases.

Strategic Considerations

A hidden revolution is taking place in passenger cars. Other than becoming smaller, they may not seem to have changed, but the functional components of today's car are radically changed and improved from those of ten years ago. Many of the improvements have been possible only because of advanced electronic componentry, which is encroaching on an increasing number of vehicle functions formerly managed mechanically. These developments can have a major effect on the competitive standing of component suppliers. For example: are former suppliers of mechanically driven carburetors able to produce their electronic replacements?

T-46. In U.S.-produced passenger cars and light trucks, what fraction of the cost of the following major vehicle systems will be represented by electronic components?

	Electronic Percent of System Cost Median Response		
	1987	1990	1992
Passenger Car Systems			
Engine/transmission	10%	15%	15%
Comfort & convenience	40	40	40
Safety	5	10	10
Light Truck Systems			
Engine/transmission	10%	15%	15%
Comfort & convenience	20	30	30
Safety	5	5	10

	Interquartile Range		
	1987	1990	1992
Passenger Car Systems			
Engine/transmission	10/13%	12/20%	15/20%
Comfort & convenience	35/40	35/40	35/45
Safety	5/5	10/10	10/13
Light Truck Systems			
Engine/transmission	10/10%	12/15%	15/15%
Comfort & convenience	20/30	20/30	25/35
Safety	5/5	5/10	5/10

Selected Comments from Panelists

Strongly affected by emission and fuel economy issues.
Diagnostics may be major motivator for electronics as it could reduce cost of warranty and lifetime costs.

T-46 Discussion

Over the next decade, electronics are expected to represent 10 to 15% of the cost of engine and transmission and safety systems in passenger cars. In passenger car comfort and convenience systems, electronics are expected to represent 40% of the cost. Similar growth in electronic costs are expected in light trucks although at a slightly lower level in the comfort and convenience area. The interquartile consensus is fairly good on these forecasts.

Comparison of Vehicle Manufacturer and Supplier Panelists

There are no major differences between the median replies of the two groups.

T-47. Entertainment systems represent an increasingly important fraction of vehicle cost. What percentage of U.S.-produced passenger cars will use electronically-controlled entertainment system components in 1987, 1990, and 1992?

	Percent With Electronic Control Median Response		
Component	1987	1990	1992
AM/FM Radios	70%	80%	90%
Tape Players	25	30	40
Equalizers	10	10	15

	Interquartile Range		
Component	1987	1990	1992
AM/FM Radios	70/80%	80/80%	90/95%
Tape Players	25/25	30/30	30/40
Equalizers	5/10	10/15	10/20

Selected Comments from Panelists

Equalizers may not be needed as systems are matched to acoustics of each vehicle and as better speakers are available.
Packaging requirements will dictate rate of growth.
Tapes may be used for continuing professional development as well as entertainment - e.g., learn Chinese while you commute.
The new radios are so good that equalizers are "overkill" gadgets.
Increased popularity of educational/entertainment tapes/rental tapes etc. will increase tape player usage.

T-47 Discussion

Entertainment systems represent an increasingly important and rapidly growing factor in vehicle cost. Among U.S.-produced passenger cars, panelists forecast that AM/FM radios will incorporate electronic controls in 90% of passenger cars by 1992. Electronic controls are also expected to increase on tape players and equalizers, but at a lower rate. The interquartile range shows good consensus on these forecasts.

Discussion of Panelists' Comments

Comments suggest some of the interesting crosscurrents in the highly competitive and rapidly changing field of vehicle entertainment systems.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median responses were essentially identical.

Strategic Considerations

A few years ago it would have been hard to believe a prediction that in 1983 consumers would be paying $800 or more for factory-installed high-fi systems in new cars. Sticker-shock is still a problem for many buyers, but others are voluntarily adding value to the vehicles they buy at a rate far in excess of inflation. It is not easy to analyze a market that shows such extremes, but precedents suggest that in time the entire market will follow those who are leading with their pocketbooks. The good old American custom of manufacturers offering and customers buying more-car-per-car appears to be alive and well.

T-48. In what year are we likely to see commercial applications by U.S. automotive manufacturers of the following electronic components or systems? (The definition of commercial application is 30,000 units of production or more.)

	Year Of Median Response
a. Liquid-crystal dashboard displays	1985
b. Cathode-ray tube dashboard displays	1987
c. Fiber-optic devices used for control functions	1987
d. Common buss wiring	1987
e. Comprehensive engine-transmission diagnostic system	1987
f. On-board map or other locational readout device	1990
g. Anti-skid braking or wheel-slide protection	1988

	Interquartile Range
a. Liquid-crystal dashboard displays	1984/1985
b. Cathode-ray tube dashboard displays	1986/1988
c. Fiber-optic devices used for control functions	1985/1990
d. Common buss wiring	1986/1990
e. Comprehensive engine-transmission diagnostic system	1986/1988
f. On-board map or other locational readout device	1987/1990
g. Anti-skid braking or wheel-slide protection	1987/1990

T-48 Discussion

Commercial application by U.S. automotive manufacturers of the major electronic components or systems listed here are expected by 1990 at the latest. Liquid-crystal dashboard displays are forecast for 1985, and several other major items for 1987. Even the upper ends of the interquartile ranges on these forecasts are 1990 or earlier.

Comparison of Vehicle Manufacturer and Supplier Panelists

For items a, b, f, and g the manufacturers' forecasts were one to two years earlier than those of the suppliers. On the other three items (c, d, e), both groups provided the same median figure of 1987.

Strategic Considerations

The industry is moving so fast we would not be surprised to see some of these dates improved upon. A key would appear to be the relatively near-term expectations represented by the lower quartile results, all of which are 1987 or earlier.

T-49. What percentage of U.S.-produced passenger cars will employ multiplexed, common-buss wiring (either on subsystem or total system basis) rather than the conventional loom-type harness design in these model years?

	Percent With Multiplexed Common-buss Wiring		
	1987	1990	1992
Median Response	2%	10%	20%
Interquartile Range	0/2	5/10	10/20

Selected Comments from Panelists

Multiplex depends on developing a low-cost reliable switching device.
Multiplexing more likely on subsystem basis.
Packaging and material costs will be major driving factors.
Switching at the component with a common buss can be done without multiplexing.
Organizational factors, more than technical ones will delay/slow introduction.
Cost will be driving factor.
Improvements in diagnostics and serviceability may offset material cost increase. Rate of growth will be controlled by availability of cost-effective, automotive-grade electronic components.

T-49 Discussion

Multiplexed, common-buss wiring is expected on U.S.-produced passenger cars starting in 1987 and is forecast to increase to 10% in 1990 and 20% in 1992. There is a fair degree of consensus on these forecasts.

Discussion of Panelists' Comments

The first comment is of major importance. The advent of multiplexing will be dependent on the availability of reliable, low-cost switching devices.

Comparison of Vehicle Manufacturer and Supplier Panelists

For the 1990 forecast, the manufacturers' prediction was somewhat less than that of the suppliers but by the 1992 forecast the two medians are approximately equal.

Strategic Considerations

Multiplexing is an another example of the hidden revolutions taking place in the modern automotive vehicle. Anyone who has attempted to repair the electrical system in a car or truck or has watched a service man struggling with the incredible complexity of wiring in modern vehicles has been made aware of the

(T-49 continued)

"wiring harness", which may in time be replaced by the much simpler multiplex system.

Two years ago, in the Delphi II Survey, there was only a single comment on multiplexing. We made the following observation at that time: "The comment on multiplexing is an important forewarning of future technology."

T-50A. What percentage of U.S.-produced passenger cars will be integral frame design in model years 1987, 1990, and 1992?

Passenger Car Frame Designs
Median Response

	Separate Body/Frame	Integral Body/Frame or Unibody	"Bird Cage"	Total Integral & "Bird Cage"	Grand Total
1987	10%	85%	5%	90%	100%
1990	5	90	5	95	100
1992	0	90	10	100	100

Interquartile Range

	Separate Body/Frame	Integral Body/Frame or Unibody	"Bird Cage"	Total Integral & "Bird Cage"
1987	10/15%	82/87%	5/5%	85/90%
1990	3/5	82/92	5/10	92/94
1992	0/4	80/92	5/14	95/100

Selected Comments from Panelists

See the Pontiac Fiero. Bird cage offers great opportunities for mass production cost reduction, durability, and value coupled to customization to suit individual tastes.

Body/frame represents U.S. luxury vehicle image.

Experience factor on bird cage not developed adequately. It could be great - who knows?

T-50A Discussion

The median forecasts indicate that separate body frame construction is on its way out. Only 10% of U.S.-produced passenger cars are expected to have the separate body frame in 1987. The forecast drops to 5% in 1990 and zero in 1992. Most cars will have the integral body frame or unibody. The bird cage design is forecast at 10% in 1992. The interquartile range consensus on these forecasts is very good.

Discussion of Panelists' Comments

The second comment raises an interesting point. Resurgent interest in larger, heavier, body frame passenger cars once typical of U.S. production may delay indefinitely the disappearance of such construction.

Comparison of Vehicle Manufacturer and Supplier Panelists

There were no significant differences between the median forecasts of these two groups.

(T-50A continued)

Trend From Two Delphi Surveys

The 1990 forecast of 95% integral and "bird cage" frame designs, shown here, is identical to the 1990 forecast made in Delphi II, two years ago, although the "bird cage" was not broken out then as a separate concept.

Strategic Considerations

As with the continuously variable transmission, the "bird cage" concept warrants careful inspection. It is a potential technology that is really not well understood as applied to mass-produced U.S. vehicles. The experience with the new Pontiac Fiero will in larger measure determine prospects during the 80's. If the Fiero proves to be successful, the "bird cage" design could have a far more sweeping impact than forecast here.

T-50B. What percentage of U.S.-produced vans will use integral frame design in model years 1987, 1990, and 1992?

Van Frame Designs
Median Response

	Separate Body/Frame	Integral Body/Frame or Unibody	Grand Total
1987	20%	80%	100%
1990	25	75	100
1992	25	75	100

Interquartile Range

	Separate Body/Frame	Integral Body/Frame or Unibody
1987	20/27%	73/80%
1990	20/25	75/80
1992	15/25	75/85

Selected Comments from Panelists

All new designs will be integral.

T-50B Discussion

About 20 to 25% of vans are expected to maintain separate body frames, with the remainder using the integral body frame or unibody.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median responses from both groups were identical.

Trend From Two Delphi Surveys

Two years ago, the Technical Panelists forecast that 60% of vans would have the integral frame design in 1990. The forecast has increased to 75% in this study.

T-50C. What percentage of U.S.-produced light trucks will use integral frame design in model years 1987, 1990, and 1992?

Light Truck Frame Designs
Median Response

	Separate Body/Frame	Integral Body/Frame or Unibody	Grand Total
1987	90%	10%	100%
1990	80	20	100
1992	70	30	100

Interquartile Range

	Separate Body/Frame	Integral Body/Frame or Unibody
1987	90/90%	10/10%
1990	60/85	15/40
1992	50/80	20/50

Selected Comments from Panelists

Need versatility of separate frame.

T-50C Discussion

Most light trucks will continue to use a separate body frame, but the percentage share is forecast to drop from 90% in 1987 to 70% in 1992. The difference will be made up by growth in the integral body frame, or unibody, from 10% in 1987 to 20% in 1990 and 30% in 1992. The interquartile ranges in the 1990 and 1992 integral body frame forecasts are quite wide.

Comparison of Vehicle Manufacturer and Supplier Panelists

The manufacturer panelists forecast a slightly higher share of separate body frames than the other panelists.

Trend From Two Delphi Surveys

Two years ago the Technical panelists forecast 45% integral frame design for light trucks by 1990. In contrast, the 1990 forecast in this survey is only 20%, a substantial and significant decrease.

T-51. Indicate two significant developments, in the chassis/suspension areas, that are likely to be introduced in commercial quantities by 1992. These could be such innovations as electrically controlled active suspension, modular brake-suspension subassemblies, lightweight structural components, etc.

	Percent of Total Responses
Electronically controlled interactive suspension systems	39%
Light-weight structural components - FRP/Aluminum	22
Driver-selected ride mode control	5
Radar controlled brakes	5
Variable speed shock absorbing and ride heights	5
More independent rear suspension	5
Rubber-isolated suspension systems	*
Parking brake off of service brake	*
Electric brakes	*
Electronically controlled variable center of gravity	*
CV transmissions	*
Automatic attitude controls	*
Anti-skid systems	*
	100%

*Single response

T-51 Discussion

Over a third of the responses, 37%, indicate that electronically controlled interactive suspensions systems are likely to be introduced in commercial quantity by or before 1992. A number of other possibilities are mentioned. Some of the developments suggested are subsets of item one.

Strategic Considerations

Electronically controlled interactive suspension systems and new structural materials are other examples of component changes that, because of major qualitative differences, could also lead to a change in the source of component supply and offer both a threat and opportunity. Trends must be closely watched here in the U.S. as well as overseas.

T-52. What percentage of U.S.-produced cars will have mini-spare tires, standard spares, or no spares in model year 1987? 1990? In 1992?

	Percent Usage: Median Response		
	1987	1990	1992
Cars with mini-spares	80%	80%	80%
Cars with standard spares	20	15	10
Cars with no spares	0	5	10
	100%	100%	100%

	Interquartile Range		
	1987	1990	1992
Cars with mini-spares	75/82%	75/83%	80/85%
Cars with standard spares	10/25	10/20	0/15
Cars with no spares	0/ 2	0/ 5	3/10

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
CARS WITH AND WITHOUT SPARE TIRES

	Forecast for 1990 at the Time of the Survey		
U.S.-Produced cars with:	1979 Delphi I	1981 Delphi II	1983 Delphi III
Mini-spares	50%	63%	80%
Standard spares	0	11	15
No spares	50	26	5
	100%	100%	100%

Selected Comments from Panelists

I hope very few cars will be equipped with mini-spares or will have no spares. The nuisance just does not justify the saving in weight and space.

I do not know of anyone who with his own money would spend the equivalent of an OEM-cost road wheel and tire just to carry around a spare and suffer the age deterioration, theft probability, vehicle weight penalty, and space loss in addition.

Cars will have spare tires of some sort - except for a very few leading edge experiments through 1992.

Also, new ways of stowing spares could become popular - see Chrysler Minivan for '84.

I assume you mean new cars. Many owners discard mini-spares when they buy tires and save a worn tire for the spare. Some mini-spares are on standard wheels (Ford) and some are not (GM).

Smaller cars and reduced trunk space will push no-spare acceptance.

Temporary nonstandard spares may be used--e.g., inflatable.

(T-52 continued)

T-52 Discussion

Mini-spares are expected in 80% of U.S.-produced cars through the 80's and into 1992. Standard-size spares are expected to decline from 20% in 1987 to 10% in 1992, with the difference made up by no spare. Interquartile range consensus is good on these forecasts.

Discussion of Panelists' Comments

The contrast between the first two comments displays clearly the wide range of opinion on the question of spare tires.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median replies were essentially the same for both groups.

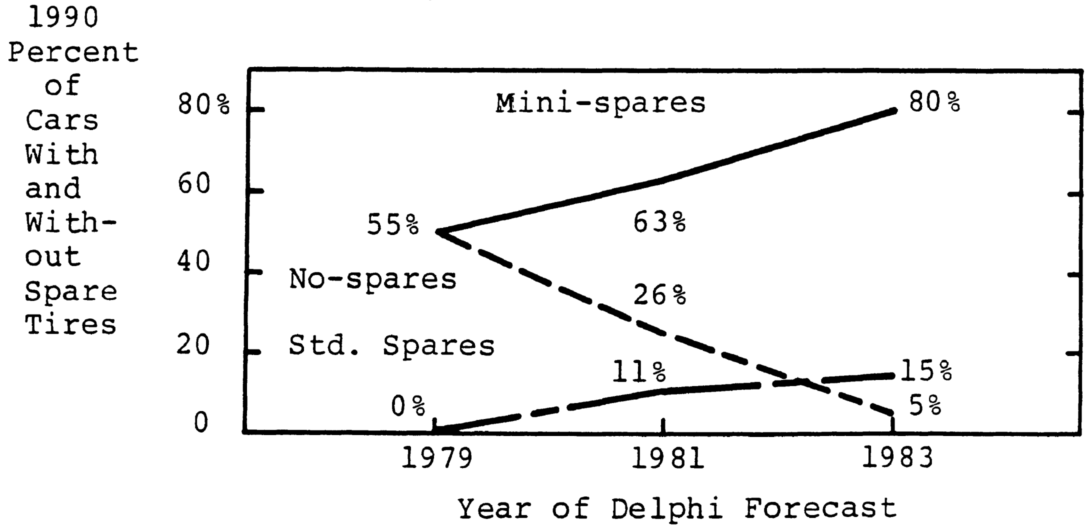
Trend From Three Delphi Surveys

As shown in the second table, the forecasts for 1990 have changed substantially over the years. The predicted use of the mini-spare has grown from 50% at the time of the 1979 survey to 80% currently. An even greater change is a decline in the forecast of no-spare from 50% to only 5%. See Figure T-52, below.

Strategic Considerations

The no-spare concept is a good example of the concept that "sometimes it is easier to sell the sizzle than the steak". Four years ago enthusiasm for the no-spare concept was overwhelming but has faded as the technology became better known. One must always be cautious about getting caught on a wave of enthusiasm. In the automotive business this can lead to very expensive mistakes. However, it can be even more costly to ignore a bona fide trend.

Figure T-52. Mini-spares, No-spares, and Standard Spares in 1990 as Forecast in 1979, 1981, and 1983.



T-53. Of the U.S.-produced passenger cars (if any) sold without spare tires, what percent will incorporate the following features?

	Percent Usage	
	Median Response	Interquartile Range
Runflat Design*	40%	30/50%
Self-Sealing	45	40/50
Low-Pressure Warning Devices	10	10/20

*Includes mechanical support

Selected Comments from Panelists

I don't think it will happen.
If it does happen, the tires on the car will have to have some premium feature; runflat would seem to be mandatory.
I believe that essentially all cars will have spare tires.
I hope it doesn't happen.
No appeal to the consumer.
Self-sealing is used today with spares.
Runflat, self-sealing, and LPWD are not mutually exclusive.
Demand for security, "don't get stranded" will sell runflat and self-sealing tires.

T-53 Discussion

Among U.S.-produced cars (if any) sold without spare tires, it is believed that 40 to 45% will use the runflat design or a self-sealing feature, and 10% will have low-pressure warning devices. An individual vehicle could have more than one of these features. The interquartile ranges are fairly close on these predictions.

Discussion of Panelists' Comments

The first comment would appear to be supported by the trend data shown in the previous question, T-52.

Comparison of Vehicle Manufacturer and Supplier Panelists

Replies of the two groups were essentially the same.

T-54. As part of the passenger car redesign process, new brake designs may be considered which could include increased or decreased use of both disc or drum brakes. What percentage of U.S.-produced cars will use front-disc, front-drum, rear-disc, and rear-drum brakes in 1987? In 1990? In 1992?

	Percent Usage					
	Median Response			Interquartile Range		
Front:	1987	1990	1992	1987	1990	1992
Drum	5%	2%	0%	0/5%	0/5%	0/5%
Disc	95	98	100	95/100	95/100	95/100
	100%	100%	100%			
Rear:						
Drum	80%	70%	60%	80/80%	60/80%	50/80%
Disc	20	30	40	20/20	20/40	20/50
	100%	100%	100%			

Selected Comments from Panelists

Possibility of a very small number of front-drum brakes on city-type cars but not likely.

Adaptive rear proportioning will be necessary for front-heavy, front-drive cars, and rear discs will be used due to linear response.

Electronic brakes in 1992.

T-54 Discussion

In brake design, the drum brake is forecast to continue to decline in use. By 1992, no drum brakes are expected on the front wheels of passenger cars and on only 60% of the rear wheels. The difference is made up, of course, by disc brakes. The drum vs. disc forecasts show wide variability in the interquartile ranges for 1990 and 1992.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median results were essentially the same.

Trend From Two Delphi Surveys

This question was asked two years ago in the 1981 Delphi II Survey. The 1990 median forecasts for rear-brake usage were identical in that survey and this one. In the earlier survey it was thought that by 1990 the drum brake would still be on the front wheels of 5% of U.S.-produced cars. The forecast for 1990 has now declined to 2%.

T-55. Considering projected vehicle sizes and configurations, and engine types and sizes, what do you think the impact will be on the market penetration of the following accessories?

PERCENT OF RESPONSES
Market Penetration

Accessories	1987 Compared to 1982			
	Increase	Same	Decrease	Total
Air Conditioning	43%	45%	2%	100%
Power Brakes	33	35	32	100
Power Steering	40	28	32	100
Power Windows	37	38	25	100
Power Seats	38	40	22	100
Power Door Locks	63	28	9	100
Speed Control	78	20	2	100
	1990 Compared to 1982			
	Increase	Same	Decrease	Total
Air Conditioning	43%	45%	2%	100%
Power Brakes	39	24	37	100
Power Steering	42	16	42	100
Power Windows	37	37	26	100
Power Seats	39	34	27	100
Power Door Locks	64	22	14	100
Speed Control	73	20	7	100
	1992 Compared to 1982			
	Increase	Same	Decrease	Total
Air Conditioning	47%	38%	15%	100%
Power Brakes	37	22	41	100
Power Steering	42	13	47	100
Power Windows	37	36	37	100
Power Seats	37	32	31	100
Power Door Locks	63	22	15	100
Speed Control	70	22	8	100

T-55 Discussion

As vehicle sizes and designs change, it may become more or less difficult or more or less costly to install a particular accessory. Also, there may be less need for some accessories as, for example, power brakes when the car is smaller and lighter. With these considerations in mind we asked our Technical panelists to consider the impact on major accessories of changing vehicle sizes and configurations. Their responses are shown here. The question was phrased to compare future years to 1982 in each case.

(T-55 continued)

A major finding is the absence of trend between the forecast years of 1987, 1990, and 1992. That is, most of the forecasts do not vary significantly from year to year. In all years forecast, the total of the responses calling for the same or increased market penetration exceeds the responses predicting a decrease.

The greatest increases are expected for speed controls and power door locks.

T-56. What is your estimate of the yearly growth rate, the percent change (+ or -), in size of the future U.S. aftermarket for these parts?

	Median Response Percent (+ or -) Yearly Growth			
	1985	1987	1990	1992
a. Spark Plugs	-5%	-5%	-5%	-5%
b. Exhaust Systems	-2	-2	+3	+2
c. Tires	-2	-1	0	0
d. Batteries	0	-1	0	0
e. Shock Absorbers	0	0	+1	+1
f. Brakes & Related	+2	+2	+2	+2
g. Electronic-Electrical	+7	+8	+5	+6
h. Engine Tune-Up	-2	-2	-1	-1
Total Parts Market *	-3	-3	-3	-3

	Interquartile Range			
	1985	1987	1990	1992
a. Spark Plugs	-5/0%	-5/-2%	-9/0%	-10/0%
b. Exhaust Systems	-5/-3	-5/+5	-5/+5	-5/+5
c. Tires	-5/+2	-5/+2	-5/+3	-5/+3
d. Batteries	-5/+4	-2/+5	-1/+5	-5/+1
e. Shock Absorbers	-3/+3	0/+3	0/+4	0/+4
f. Brakes & Related	0/+5	0/+5	0/+5	0/+5
g. Electronic-Electrical	+5/+10	+5/+10	+5/+10	+5/+10
h. Engine Tune-Up	-5/0	-5/0	-5/+3	-5/+5
Total Parts Market *	-5/+4	-5/+5	-7/+4	-9/+5

* Note that individual %'s do not add to the total, which is a separate estimate; a judgment-weighted average of the increases or declines in the total of all individual parts, including those not listed.

Selected Comments From Panelists

Everyone expects a growth in electronics replacements, but after three or four years on the road for a given model, the availability of good used electronic components from junkyards exceeds the replacement demand in the remaining vehicles.

T-56 Discussion

The total aftermarket for parts in the U.S. is forecast to decline at an average rate of about 3% per year over the next decade. Spark plugs are expected to show the greatest annual decline at an annual rate of -5%. Growth is expected in brakes and related parts and electronic/electrical parts.

(T-56 continued)

The interquartile ranges are very wide on these predictions. Some items such as exhaust systems and engine tune-ups show a range from -5% to +5%. The total parts market itself shows interquartile forecasts ranging from an annual rate of -9% to an increase of +5%. These uncertainties appear to point in the direction of slow (or no) growth in the aftermarket for parts.

Comparison of Vehicle Manufacturer and Supplier Panelists

There were significant differences between the manufacturer and the other respondents on most of the median forecasts. In almost every case the manufacturers were less optimistic. For the total parts market the manufacturer panelists forecast a yearly growth rate of -5% for 1985, 1987, and 1990 and -9% for 1992.

Comparison of Results From Two Delphi Surveys

These Delphi III results are markedly different from those obtained in the Delphi II Survey in 1981. At that time the panelists forecast a 6% positive growth rate in 1985 and +10% for 1990.

Strategic Considerations

The spread of forecasts ranging from positive to negative growth expectations bears careful watching. Change in the traditional aftermarket seems likely because of a host of factors including the introduction of advanced electronic componentry which could provide diagnostic information to the car owner. This in turn is likely to change the aftermarket purchase from a partially emotional decision to one based on the specific needs of the vehicle.

The single comment may be of major significance.

T-57. With cars being downsized, will the use of trailers decrease, because of declining towing capacity, or increase, because of the need to transport more than the car will hold?

Percent of Respondents Choosing:		Percent Change: Median Response	Percent Change: Interquartile Range
Increase	62%	+10%	+5/15%
Decrease	38	-15	-20/-10
	100%		

Selected Comments from Panelists

Offsetting factors - probably not much change.
House trailers will likely decrease sharply.
Rooftop carries increase 25%.
Light-duty hauling will increase. Camping type will decrease. Can't quantify.
The number of trailers won't change appreciably but the size and purpose will.
Will hold about at today's very depressed level of activity - maybe a small increase.
Trailers will be towed by light trucks. Also trailers will be downsized or at least lightened to compensate somewhat.
Use of large trailers will decrease; use of small trailers will increase.
Biggest switch will be from passenger cars to light trucks which will have towing capacity.
Greater use of vans.

T-57 Discussion

Opinion is divided as to the use of trailers with cars that are being downsized. Over 60% of the respondents expect an increase of 10% in trailer use. On the other hand, 38% expect a decrease of 15%.

Discussion of Panelists' Comments

Comments reflect the divergence of opinion apparent in the numerical results. Obviously, there will be limits on the maximum size of trailer that can be hauled by smaller, lighter cars and particularly those with front-wheel drive.

Comparison of Replies to T-57 and Mkt-35

Marketing panelists' forecasts were about the same.

T-58. In the next 10 years, will the vehicle manufacturers decrease or increase their use of "off-line" subassemblies?

Percent Of Respondents Choosing:		Percent Change: Median Response	Percent Change: Interquartile Range
Increase	92%	20%	10/30%
Decrease	8	-15	-30/-5
	100%		

T-58 Discussion

Over 90% of the respondents expect the vehicle manufacturers to increase their use of "off-line" subassemblies. This relatively large majority expects a 20% increase in the use of such subassemblies.

Strategic Considerations

Embodied in this question are some of the fundamental changes likely to impact the production of future vehicles. It appears that increased automation of the assembly process will dictate major increases in "off-line" subassembly use. Trends here could have a profound impact on the supplier community, leading to substantial restructuring of many purchasing relationships. We would certainly urge all potentially impacted grops to explore creative and innovative approaches to vehicle subsystem design and manufacturing technology.

T-59. What percent (dollar value) of "off-line" vehicle subassemblies will be produced by the vehicle manufacturers and by suppliers?

	Off-Line Subassemblies Source Median Response		
	1987	1990	1992
% by Manufacturers	50%	50%	50%
% by Suppliers	50	50	50
Total	100%	100%	100%

	Interquartile Range		
	1987	1990	1992
% by Manufacturers	50/60%	50/55%	50/55%
% by Suppliers	45/50	45/50	45/50

T-59 Discussion

When asked what percentage of "off-line" vehicle subassemblies will be produced by the vehicle manufacturers or by suppliers, the respondents estimated that the ratio would hold at 50%. The interquartile ranges are very close on these estimates.

Strategic Considerations

As noted in the prior question, subassemblies have the potential of dramatically altering traditional methods of vehicle assembly, and purchasing relationships. Trends must be closely watched.

T-60. Estimate the percentage of off-line production in the U.S. for the following subassemblies.

	Percent Off-Line Production Median Response		
	1987	1990	1992
Electronic components, controls, sensors, etc.	50%	60%	80%
Wheel package or wheel-brake subassembly	55	60	70
Suspension modules	50	50	50
Heating-cooling units (radiators, fan, air conditioning, etc.)	40	60	60
Powertrain, transmission	70	70	65
Seats and seat systems	75	75	80
Dashboard, instrumentation	60	70	80
Electrical subassemblies	30	50	70
Subassemblies requiring capital-intensive manufacturing or special technology	30	50	55
Small subassemblies-water pump, steering gear, fuel pump, oil pump	50	70	60
Others (batteries, turbochargers, windshield wiper, door-locking systems)	70	70	65

	Interquartile Range		
	1987	1990	1992
Electronic components, controls, sensors, etc.	50/60%	60/70%	70/90%
Wheel package or wheel-brake subassembly	50/60	60/65	60/80
Suspension modules	40/50	40/50	40/50
Heating-cooling units (radiators, fans, air conditioning, etc.)	40/50	50/60	50/60
Powertrain, transmission	70/75	65/75	60/75
Seats and seat systems	50/75	60/80	60/80
Dashboard, instrumentation	60/60	60/75	70/80
Electrical subassemblies	30/50	40/50	45/70
Subassemblies requiring capital-intensive manufacturing or special technology	30/40	30/50	35/60
Small subassemblies-water pump, steering gear, fuel pump, oil pump	50/70	60/75	60/75
Others (batteries, turbochargers, windshield wiper, door-locking systems)	60/70	65/75	60/75

(T-60 continued)

Selected Comments from Panelists

Areas affecting MVSS certification and major product liability will probably stay within the manufacturers' control (i.e., suspensions affect trim heights).

T-60 Discussion

It is predicted that by 1992 over half of each of the listed subassemblies will be produced off-line. The interquartile ranges show good consensus on these forecasts.

Strategic Considerations

By 1992, half or more and as much as 80% of the listed subassemblies are forecast to be produced off-line in the U.S. The detailed forecasts shown in this question can assist suppliers in planning for possible substantial changes - as, for example, in electrical subassemblies where off-line growth is forecast to more than double from 30% in 1987 to 70% in 1992.

T-61. Forecasts of the past few years have projected an unprecedented demand for engineers. However, changing economic and market conditions have apparently moderated some expectations. What is your forecast of the demand for graduate engineers (B.S., M.S., Ph.D.) in your organization? Use 1980 as a base and express as a percentage change.

	Percent Change in Demand for Engineers: 1980 Base			
	1985	1987	1990	1992
Median Response	5%	5%	10%	10%
Interquartile Range	1/10	3/12	3/15	5/20

Selected Comments from Panelists

Look for more modular components, outsourcing and joint ventures to reduce costs, including the need for engineers.
Almost even demand for constant business picture.
Need E.E.'s with M.S. in computer science.
Business climate, not need, has dictated a lower demand at our company than would be desired for large quantity of engineering projects we have initiated.

T-61 Discussion

Compared to the 1980 base, the change in demand for engineers is expected to show an increase of 5 to 10% per year during the forecast years. These percentages apply to the organizations of the Delphi panelists and largely reflect automotive industry needs.

Discussion Of Panelists' Comments

As indicated in these comments, during the pre-1983 depressed period the auto companies were unable to hire as many engineers as they needed.

Furthermore, the increasing technical sophistication of the forecast products and manufacturing processes create an obvious need for qualified technical people. While contraction appears likely in many professional disciplines within the automotive industry this is not true of engineering when the industry as a whole is considered. Selected companies do appear to be reducing and consolidating technical staffs but the data presented here suggest this to be the exception.

T-62. Lead time continues to be an important consideration in the design process. Recent advances in CAD/CAM have apparently shortened the interval between the end of the product planning and the start of production of a major vehicle redesign. What are your estimates of this time interval in 1970, today, and 1992?

	Lead Time In Months		
	1970	1983	1992
Median Response	36 mo.	36 mo.	30 mo.
Interquartile Range	36/40	34/36	25/30

Selected Comments from Panelists

The time saved with CAD/CAM will be allocated to the validation of product and manufacturing capability and reliability.

The shortening is counteracted by manufacturing's demand for more time to "tune" processes for high quality and lower start-up costs.

New vehicles take just as long to design. Iterations in the design process are quicker; thought and decision processes of the designer take just as long.

Increase based on greater scope of change and increased technology.

Proving and customer acceptance tests still take time. Certification may be needed. Shape forming helped considerably.

In the computer industry the cycle has been cut from 36 months to 18 months in the last five years. The Japanese appliance and home electronics industry is reported to have a 6 month cycle.

The first three comments are logical, but pressure from Japan (they are fast!) will force the issue.

More modularity and worldwide engineering will reduce complexity and allow compression of timing by concentration of resources.

The lead-time economics of CAD/CAM will be re-allocated to design process development and validation.

CAD/CAM is effective to the tune of 1 man + 1 CRT = 3 designers without CRTs; however, the engineering community is using increased capacity to iterate the design to sweeten it rather than compress timing.

T-62 Discussion

The lead time between the end of product planning and the start of production is forecast at 36 months in 1983, the same as in 1970, but is expected to drop to 30 months in 1992. The interquartile range consensus is good on these median predictions.

(T-62 continued)

Discussion of Panelists' Comments

As indicated in the numerical results, the comments show that much of the available improvement in time from the CAD-CAM techniques is being utilized for better design rather than to shorten the design period.

T-63. Historically, major body changes were made every 3 to 4 years but are getting further apart. On the average, how long will U.S. passenger car model runs be on cars introduced in the following years?

	Length of Model Run for U.S. Cars Introduced in:		
	1987	1990	1992
Median Response	5 yrs.	6 yrs.	6 yrs.
Interquartile Range	5/6	5/7	5/8

Selected Comments from Panelists

As technology changes faster, cars will have to be updated more frequently but this does not mean body styles will have to change; e.g., CVT's may be put into an existing chassis or aluminum may replace steel in an application.

T-63 Discussion

Major body changes on U.S. passenger car models are expected to be made every five years in the 1987 period and then to increase to six years later in the decade and in 1992. The interquartile ranges indicate a good degree of consensus among the respondents on this topic.

Major U.S. vehicle manufacturers have announced objectives that include the concentration (or re-concentration) of suppliers in the Great Lakes region. What is your opinion, pro and con, of such plans? Please answer in three or four sentences.

	Percent of Responses	
	Technical Panel	Marketing Panel
Pro	39%	44%
Pro with conditions	24	33
Con	37	20
Other	-	3
	100%	100%

MEMO: This question was asked of both the Technical and Marketing panelists. As their replies were similar, it is efficient to consider them in a combined format.

Among Pro responses, comments cite the following advantages:

(a) Decrease in inventory costs and capital expense requirements.
(b) Decrease in costs of shipping.
(c) Increase in quality/control.
(d) Economic advantages of KANBAN (Just-in-Time).
(e) Availability of large pool of skilled labor.

Selected comments:

1. The Great Lakes region has excellent resources for such a plan: plant facilities, transportation, dedicated work force.
2. Concentration of supplier facilities, quality control, lower shipping costs, and reduces stock inventory requirements and thus will improve quality at lower costs.
3. ...providing quicker feedback to suppliers on quality problems.
4. ...moving nearer to their source of supply, especially steel, which is their major material.
5. Socially it will be good for absorbing displaced skilled workers.
6. Geographical proximity promotes better communication through plant visits and direct reviews of product development as well as fabrication development.
7. This plan is likely as the just-in-time inventory system usage grows. Shorter distances between user and producing plant are a natural evolution in management technique and are required to keep costs under control. The Great Lakes region is a natural, given the already high concentration of producing and supplying plants.
8. ...reduce the floor-space requirements at assembly plants. Will reduce the number of times a part must be handled prior to final assembly.

(T-64 plus Mkt-47)

9. Cost of labor will be solved.
10. ...reduction of supplier base will also result in this concentration.
11. Would result in improved teamwork.
12. That's step 1. We will then have a West Coast assembly area and East Coast assembly area.
13. The concentration will take place very slowly.

Among conditions attached to Pro comments:
(a) Need changes in labor legislation, decrease in restrictive union work rules, decrease in labor costs
(b) Address reluctance of suppliers to relocate without assurances of volume of business, price escalation agreements protection from low-cost foreign manufacturers (e.g., plans to have component plants in Mexico, etc.)

Selected comments:

1. Trend towards longer contracts (multi-year) with suppliers, rather than annual contracts. Just-in-time delivery will require closeness to where material or components are used. If use will be in Great Lakes region, supplier should be there. Freight costs are also important.
2. The area governments must provide attractive and competitive conditions if this is to take place.
3. Tend to grow in this manner until 1990, then go back to remote locations.
4. Good move, but will work only if suppliers are competitive with offshore competition.
5. May work for in-house suppliers. Lowest price and not nearest location will determine who gets the business.

Among Con, comments cite following disadvantages:

(a) Adverse labor climate in region, high labor costs
(b) High operating costs, taxes, energy, etc.
(c) Costs of relocation too great/inadequate return on investment.
(d) Market shifts/industry moving away from region.
(e) Reluctance of suppliers to move vs warehousing (U.S. version Just-in-Time, order entry systems).
(f) Weather.

Selected comments:

1. This is a short-term approach and Detroit will forget that strategy very quickly when the economy bounces back.
2. Too much concentration in expensive labor market. Need healthy state to meet competition.
3. All window dressing. Headquarters will continue with strong presence in Michigan. Manufacuturing plants will continue to move slowly from Michigan to South and West.
4. Labor rates, through concentration of union activity, become less flexible. Reality of this "reconcentration" is doubtful.

(T-64 plus Mkt-47 continued)

5. Think industry will gravitate towards world car concept with widely diversified geographical sources.
6. ...there will be some continued spreading of manufacturing more uniformly throughout the entire country.
7. ...suppliers will always be located where the most economical supply of labor is. This will not change. Cost will prevail.
8. Is Great Lakes optimum location? South and Southwest more logical -- cost, climate, market location. Is concentration logical -- sourcing of major components such as engines on world basis is cost-effective.
9. Very difficult to bring about. U.S. distribution and market too diverse.
10. OEMs are moving production away from the Great Lakes region, suppliers will follow.
11. Michigan is rated dead last for states that manufacturing corporations wish to locate in. We are located in Indiana and there is no pressure on us to locate within 60 miles of Flint. Shifting inventory to the 2nd and 3rd tier of production raises cost in that tier which will be passed on. Frequent delivery along with high quality (statistical quality controls) can reduce inventories at all levels and reduces costs and, let's face it, leave some more profit for everyone while the consumer can purchase the end product for less money.

Others:

1. The objective is to shorten the delivery pipeline and reduce on-hand inventory; a supplier need not be in the Great Lakes area if he can guarantee just-in-time delivery at the assembly plant (which may require him to set up a warehouse at his expense and carry all inventory between his plant and ours).
2. Good in peacetme; bad in wartime.
3. The idea is probably short-range.
4. Given a return of higher volumes, production and assembly will again spread out...
5. ...buying decisions will still come down to delivered cost and service.

<u>T-64 and Mkt-47 Discussion</u>

This is a question that does not lend itself to easy summarization, as is obvious from the extensive "summary" of replies shown above. There is little we can add to the discussion as shown.

<u>Strategic Considerations</u>

Obviously, if re-concentration does take place, the impact on individual suppliers could be immense.

T-65. Worldwide, the automotive industry has been constructing very large-scale facilities to produce "world car" components such as engines and transmissions. Except in Japan, where automotive production is concentrated geographically, the relatively small number of such facilities is in conflict with developing efforts to use "just-in-time" inventory systems that require short "pipelines." How do you see this conflict being resolved? Please answer in three or four sentences.

It is difficult to classify the many thoughtful comments provided by the panelists; however, several general categories have been established to summarize the diverse replies to the question.

Summary Categories	Percent Of Total Responses
Suppliers will relocate closer to OE assembly plants.	21%
The "world car" concept is economically advantageous.	18
Just-in-time (JIT) will be utilized in some degree.	14
JIT will not be utilized in the U.S.	7
The JIT philospphy will be adopted but will not resemble the KANBAN system in Japan.	7
Reduce product complexity/increase commonality.	7
Increased warehousing with sophisticated scheduling.	9
World sourcing of component parts will increase.	9
Others.	8
	100%

Selected, edited comments:

A. Suppliers will relocate closer to OE assembly plants

1. Staging areas or warehouses close to assembly plant. Vendors pressured to consign goods to this area and invoice when goods are moved to assembly plant.
2. Facilities will be smaller and there will be more of them. Suppliers will relocate closer to these facilities.
3. Suppliers of critical components may build satellite facilities. Additionally, dedicated transporation means will be used.
4. Cost-effective forward planning of plant viability or relocation relative to final assembly plants.

B. The "world car" concept is economically advantageous

1. By using the same engines and transmissions across several car/light truck lines, it is possible to have both worlds - large component plants and just-in-time inventory to some of the assembly plants where they are concentrated.
2. The economies of building the vehicle where required (country) must be the eventual way to keep world car production a viability.
3. "World car" concepts would yield large savings in the design phase. More automation would allow for smaller production facilities in more locations.

(T-65 continued)

B. (Cont'd) The "world car" concept is economically advantageous

4. Continued "world use" increase of "high capital" major components.

C. Just-in-time will be utilized in some degree

1. Just-in-time assembly can still be used with greater distances. The computer must be used to help solve the logistics problem.
2. Major components will be supplied worldwide with long-term and exclusive contracts. Minor components will be sourced on a Just-in-time basis.
3. Just-in-time assembly is the key. That does not mean that all items must be built next to the assembly line. Economics of scale will be more important for some items. The present facilities will change, but not too much.

D. Just-in-time will not be utilized in the U.S.

1. Just-in-time will lose.
2. Benefits of JIT may not be sufficient to justify major changes.
3. (The conflict) won't get completely resolved and will not reach a Japanese-style solution.

E. The JIT philosophy will be adopted but will not resemble the KANBAN system in Japan

1. In the U.S. things will not change that much except more & smaller specialized plants in low labor areas will be established. Just-in-time activity will have to accommodate whatever the system presents.
2. Most importantly, just-in-time will not be the same as in Japan.
3. Just-in-time will be secondary to economics of supply location.

F. World sourcing of component parts will increase

1. World sourcing of major components will increase and be made compatible with geographical concentrations for the remainder of the vehicle.
2. If OE production moves offshore, local suppliers will have to follow or be replaced by locally domestic suppliers.
3. To the extent necessary to serve world markets, plants will become more global in scope. Manufacturers will try to reduce average costs through global sourcing. The result may be a more global replacement parts market weighing against a less global OEM market. The conflict will not be easily resolved.
4. I believe that world sourcing will rise and then subside because of high freight costs and inventory costs.

(T-65 continued)

5. Due to competition, components will be sourced on a more worldwide scale. Toyota City experience for suppliers was to locate nearby or lose business. The supplier took the brunt of it.

G. Increased warehousing with sophisticated scheduling and shipping controls

1. Proper scheduling can resolve this conflict. Fixed schedules can assist the supplier in helping the manufacturer control inventory.
2. Tremendous improvement in audio and visual communication equipment with computer-controlled system will permit accurate and reliable inventory control.
3. Scheduled manufacturing and close shipping control ... but not a great increase of total manufacturing and assembly complexes.

H. Reduce product complexity/increase commonality

1. The real solution is in reducing product complexity. Flexibility in customizing basic designs with minimal cost (is a) must.
2. Components will be designed with more commonality.

I. Others

1. Japan doesn't have a UAW that strikes periodically.
2. Slow, over a long period of time.
3. World cars are difficult to obtain because each country and continent has different demands.
4. It is an issue of capital-intensive facilities paying for freight costs and interchangeability.
5. Just-in-time delivery is just one of many components that represent the Japanese advantage.

T-65 Discussion

As indicated in the lengthy question, the "world car" concept could be in conflict with efforts to reduce inventory levels. We received a great wealth of comments from our respondents on this question and they have been summarized as shown. The greatest expectation is that suppliers will relocate closer to the vehicle manufacturers' assembly plants in order to resolve this conflict. Many other suggestions were shown and, in addition, selected edited comments have been included.

T-66. What percentage of total sales revenue should a prudent automotive manufacturer or supplier apply to capital investment and R&D under normal conditions over the long run?

	Recommended Capital Investment and R&D Percent of Sales for:	
Capital Investment	Vehicle Manufacturer	Supplier
Median Response	10%	10%
Interquartile Range	10/12	6/10
R&D Expenditure		
Median Response	5%	5%
Interquartile Range	5/5	5/5

Selected Comments from Panelists

Must plan for survival as well as profits.

Long-range product devlopment and improved manufacturing processes are essential to survival in the world market.

Quality/competitive pressures will require more R&D and capital change and/or more joint ventures.

"R&D" definition broadly interpreted. 3% is good figure for total product engineering, of which 1/4 to 1/2 is new product R&D. Also R&D content varies considerably by product line.

T-66 Discussion

Our technical respondents believe that both vehicle manufacturers and their suppliers should spend about 10% of their revenue on capital investment and 5% on R&D. Interquartile ranges are remarkably close on this question.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median replies were identical.

Strategic Considerations

Comments two and three touch on what we believe to be a factor of major importance to automotive industry suppliers. The vehicle manufacturers have made it clear that they are going to depend more on suppliers in the future for engineering and design assistance. This increased demand should be taken into account by those suppliers hoping to succeed in the automotive industry.

Issues related to rewarding suppliers by the manufacturers for R&D and capital investment are of critical importance and need attention. Improved communication, long-term relationships, and mutual understanding are necessary to motivate suppliers to increase their financial commitment to their customer.

T-67. If there is no local content law for the U.S., what percent of the parts purchased (dollar volume basis) by domestic U.S. vehicle manufacturers (including VWoA and Japanese) will be sourced outside the U.S. for 1987, 1990, and 1992?

	Vehicle Manufacturers' Parts Sourced Outside U.S. Median Response		
Outside Parts Source	1987	1990	1992
Canada	8%	8%	8%
Western Europe	3	4	5
Japan	6	9	10
Other Asia	2	3	4
Mexico and South America	5	6	7
Other	0	0	0
Total (sum of above)	24%	30%	34%

	Interquartile Range		
Outside Parts Source	1987	1990	1992
Canada	8/8%	7/8%	7/8%
Western Europe	2/4	3/5	3/5
Japan	5/8	7/10	8/12
Other Asia	1/3	2/5	3/6
Mexico and South America	5/8	5/10	6/10
Other	0/0	0/0	0/0
Total (sum of above)	23/30%	30/33%	33/39%

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
1990 PARTS SOURCING OUTSIDE U.S.
BY U.S. VEHICLE MANUFACTURERS

	Forecast For 1990 at the Time of the Survey		
Outside Parts Source	1979 Delphi I	1981 Delphi II	1983 Delphi III
Canada	N.A.	9%	8
Western Europe	N.A.	4	4
Japan	N.A.	8	9
Other Asia	N.A.	4	3
Latin America	N.A.	8	6
Other	N.A	4	0
Total	15%	37%	30%

(T-67 continued)

Selected Comments from Panelists

Robotics will affect "other Asia" and Mexico imports as they primarily affect lower labor rates. Japan and Europe offer technology improvements.
This depends on attitudes about rights, costs, patriotism, competing with productivity.
Many Asian and Latin American countries are highly unstable.

T-67 Discussion

Panelists expect the proportion of parts bought outside the U.S. for use in manufacturing vehicles in the U.S. by all manufacturers, including the domestic manufacturers, to increase substantially to 24% in 1987, 30% in 1990, and 34% in 1992.

Comparison of Vehicle Manufacturer and Supplier Panelists

Supplier panelists, whose business would be most hurt by such a trend, were a little more optimistic than the manufacturers. For example, they forecast that in 1992 "only" 29% of the manufacturers' parts would be sourced outside the U.S. This remains a substantial share.

Trend from Three Delphi Surveys

As shown in the second table above, previous forecasts of parts imports were even more pessimistic from the point of view of the U.S. supplier industry. Forecasts made for the year 1990 at the time of the 1979 Delphi I survey showed 15% imported. By the 1981 survey, this estimate had grown to 37% and has now declined to 30%. We do not know whether this decline is realistic or simply represents an inability on the part of our respondents to believe there will not be a local content law for the U.S.

Comparison of Replies to T-67 and Mkt 29

Marketing panelists also predict a strong trend toward importing parts but not to the same degree as the Techonology panelists. For the three years 1987, 1990, and 1992 the Marketing forecasts for total parts imports were 22%, 26%, and 27%, respectively. Nevertheless, these are high levels of imports.

Strategic Considerations

The significance of these data to the U.S. automotive industry cannot be overemphasized. With respect to final assembly of automobiles, the U.S., Japanese, and other modern automotive industries, are at the end of a revolution, not the beginning. Robots have had much publicity but even before robots the final assembly of automobiles and their components had been highly automated and required relatively few labor hours.

(T-67 continued)

Therefore, parts production utilizes a substantial proportion of automotive labor. Parts imports directly reduce domestic labor content. However, in comparison to Japanese practice, U.S. automotive labor hours are high and a key competitive factor that cannot be ignored.

It is important to recognize that the import trend is not the result of arbitrary company policies but the direct result of competitive and political factors beyond industry control. Not just labor hours and hourly cost, but prior investments, experience, advanced technology, materials and parts costs, quality, and lead time considerations are all factors that can result in off-shore sourcing. In addition, local content laws in other countries may require a firm to export from those countries in order to participate in their internal markets.

In any event, this issue will remain volatile amd emotionally charged. The only way to control off-shore sourcing is to address every factor that stimulates the practice.

T-68. If there is no local content law for the U.S., what percent of the parts and materials sold (dollar volume basis) in the U.S. by suppliers (including foreign-owned) will be sourced outside the U.S. for 1987, 1990, and 1992?

	Suppliers' Parts Sourced Outside U.S. Median Response		
Outside Parts' Source	1987	1990	1992
Canada	5%	5%	5%
Western Europe	4	5	5
Japan	8	8	8
Other Asia	2	2	3
Mexico and South America	5	5	5
Other	0	0	0
Total (sum of above)	24%	25%	26%

	Interquartile Range		
Outside Parts' Source	1987	1990	1992
Canada	5/5%	5/6%	5/7%
Western Europe	3/4	3/5	4/5
Japan	8/8	7/8	7/8
Other Asia	1/2	2/4	3/4
Mexico and South America	5/5	5/6	5/7
Other	0/0	0/0	0/0
Total (sum of above)	23/25%	24/28%	26/32%

Selected Comments from Panelists

Change in exchange rates - particularly yen to dollar, and U.S. government tax policies could revise results substantially.

T-68 Discussion

Parallel to the vehicle manufacturers, the suppliers are forecast to source a significant proportion of their parts and materials outside the U.S. The total estimated for 1987 is 24%, with slight growth through 1990 and 1992. Most of these parts are expected to be imported from Japan. Little change is predicted in the mix of sources over the forecast period. The interquartile ranges show good consensus on these median estimates.
Comparison of Vehicle Manufacturer and Supplier Panelists

With the exceptions of three minor difference that were not significant, all the median replies were identical.

(T-68 continued)

Comparison of Replies to T-68 and Mkt-30

Marketing panelists' median forecasts for total imports were about 5 percentage points lower in each of the three years.

Strategic Considerations

Many of the points raised in T-67's Strategic Considerations are pertinent here. Obviously, the internationalization of the world's automotive industries is increasing the opportunities for both success and failure.

T-69. What percentage of U.S.-produced passenger cars will be made with diesel or gasoline engines manufactured outside the U.S.?

Source of Imports	Percentage of Engines Imported Median Reponse		
	1987	1990	1992
Gasoline Engine Cars:			
Canada	10%	10%	10%
Mexico & S. America	7	9	8
Europe	4	3	3
Far East	9	11	12
Total (sum of above)	30%	33%	33%
Diesel Engine Cars:			
Canada	0%	0%	0%
Mexico & S. America	0	0	0
Europe	5	8	8
Far East	5	8	8
Total (sum of above)	10%	16%	16%

Source of Imports	Interquartile Range		
	1987	1990	1992
Gasoline Engine Cars:			
Canada	6/10%	6/10%	8/10%
Mexico & S. America	5/12	6/12	8/12
Europe	2/4	2/4	3/4
Far East	4/12	5/12	6/12
Diesel Engine Cars:			
Canada	0/0%	0/2%	0/2%
Mexico & S. America	0/0	0/1	0/1
Europe	3/6	3/9	4/8
Far East	3/11	5/9	6/9

T-69 Discussion

Large numbers of U.S.-produced cars are expected to use diesel or gasoline engines manufactured outside the U.S. In 1987, it is forecast that 30% of gasoline engines and 10% of diesels will be produced outside the U.S. These import shares are expected to increase to 33% and 16% in 1992. The interquartile ranges are quite wide on some of these estimates, indicating no great degree of consensus, but with the exception of imports of diesel engines from Canada and Mexico-South America, none of the interquartile forecasts is zero.

(T-69 continued)

Comparison of Replies to T-69 and Mkt-39

Compared to the diesel import total percentages of 10%, 16%, and 16% shown above for 1987, 1990, and 1992, respectively, the Marketing panelists for these three years are predicting diesel imports of 20%, 25%, and 25%.

T-70. Do you expect more or less do-it-yourself maintenance on passenger cars and light trucks in the future?

More	30%
Same	18
Less	52
	100%

Selected Comments from Panelists

Design complexity of electronics, servos, electro-mechanical systems, etc. scares off the do-it-yourselfer, and many parts are only available over a dealer's counter--not from the open-all-weekend auto parts store.

What is there to maintain? Oil changes and spark plugs.

Complexity and equipment requirements will force less do-it-yourself.

The DIY will do a greater percentage of routine maintenance but there will be less routine maintenance to do.

Electronics scare people. Maintenance intervals increased.

The vehicles are becoming next to impossible for do-it-yourself on engines.

Electronic-controlled engines, pollution hardware, McPherson struts, etc. make it more difficult for the DIY.

Trend to more but increased complexity and electronic controls discourage DIY.

Maintenance becomes more simplified with use of electronics (black boxes). The strong trend to more DIY now will improve.

Expect fewer total maintenance items; more "lifetime" components.

More on easy items, such as spark plugs and oil changes; less on mechanical, and especially less on electronics.

Total maintenance will be less, but that still required will be designed so that the owner can do it.

T-70 Discussion

Do-it-yourself maintenance on passenger cars and light trucks is expected to decrease. 52% of the respondents forecast there will be less such maintenance, 18% forecast the same as current levels, and 30% look for more.

Discussion of Panelists' Comments

Comments indicate crosscurrents affecting the level of do-it-yourself maintenance. Less do-it-yourself maintenance is expected on newer, complex electronics and related systems, but more is forecast for relatively simple operations such as changing the oil and spark plugs. The net effect of all the comments appears to be support for the numerical results; that is less owner/operator maintenance.

(T-70 continued)

Strategic Considerations

Presently, vehicle electronics are increasing the apprehension of would-be mechanics but in time may increase do-it-yourself operations by providing diagnostic information that identifies the real problem the first time. And, whether repaired at home or in the professional shop, the electronic components themselves will probably be "fixed" on a remove/replace basis.

T-71. Which components or subsystems do you expect to become more important for do-it-yourself service, and which ones less important?

More Important	Percent Of Total Responses
Filters: oil, air, fuel	17%
Engine/engine service, components: spark plugs, PCV valves, etc.	16
Electrical/electronics (on-board, sensor, self-diagnostic electronic assemblies; actuators, electronic fuel/spark system, etc.)	16
Oil changes	13
Brake system	9
Chassis lubrication	6
Transmission/powertrain components & controls	4
Air conditioning/heater systems	3
Cooling system	3
Body/body panels	3
Belts and hoses	2
Lighting systems	3
Ignition system	2
Accessories	2
Shocks	*
Exhaust systems	*
Oil & water level indicators	*
	100%

Less Important	Percent Of Total Responses
Ignition system/components: spark plugs, point sets, distributors	18%
Electrical/electronics (fuses, switches, electrical buss, etc.)	13
Carburetion/fuel systems (injectors & controls)	13
Chassis components	9
Transmission	6
Tune-Ups	6
Basic engine	5
Brakes	5
Exhaust systems	3
Tires	3
Suspension systems	3
Chassis lubrication	3
Battery (sealed)	3
Belts	2
Aftermarket sound systems/entertainment	2

(T-71 continued)

Less Important (Cont'd)	Percent Of Total Response
Tappets	*
CV joints	*
Clutch	*
Interior elements	*
	100%

Selected Comments from Panelists

More computerized test and diagnosis and owner replacement of parts.
Do-it-yourselfers must become familiar with the new electronic fuel systems.
There will be exchange on electrical systems after self-test.
Better diagnostics will allow pinpointing components specifically.
Exchange program for electronics will be vital - rebuilt.
By all means, maintain self-diagnosing capability of electronic systems!
Systems are too complex for do-it-yourself.
High technology required to meet fuel and EPA requirements precludes "shade-tree" tune-ups etc.

T-71 Discussion

Despite the expectation of decreased do-it-yourself maintenance (as indicated in the previous question), there are projections here for increased self-service on a number of items including filters, spark plugs, oil changes, and some electrical components as shown. However, another 18% of the responses indicate less self-service on spark plugs and 13% less on electrical components. The leading net gainers are filters and oil changes.

Strategic Considerations

Mixed and contradictory opinions indicate the issue is unresolved and should be followed closely by automotive service and related businesses.

T-72. Excluding oil changes, what trend do you foresee in the manufacturer's scheduled maintenance for passenger cars? (Compared to 1983 model schedules).

Shorter Intervals	2%
Same	21
Longer Intervals	77
	100%

Selected Comments from Panelists

Implies better fluids and filters and belts/blades.

We have just about reached the limits of "zero-maintenance"; we've pushed it so hard that most people don't have any maintenance done any more (either because dealers have to do it at $38.00/hr. or because they can't see spending any money on maintenance); then they scream bloody murder when one of the 15,000 parts in their "zero-maintenance" car fails. We still have many parts and systems on the car that have a shorter design life than the customer believes he should get without repairs.

Expect new materials and better designs to lead to less and less routine maintenance.

More stable fluids - more "fill for life" and better quality "rubber" materials.

Most people don't want to do maintenance, but a trip to the dealer is viewed as a license to steal.

Smaller, harder working engines need more frequent maintenance.

Addition of adaptive electronic controls will adjust for normal mechanical wear.

Fewer items will require scheduled maintenance and those that do will be further apart.

Goal is to eliminate as many dealer visits as possible.

T-72 Discussion

More than three-fourths of the respondents forecast a continuing trend toward longer service intervals.

Discussion of Panelists' Comments

Comments indicate some of the technical support factors required to have longer service intervals and also discuss limiting factors on extended service.

Comparison of Vehicle Manufacturer and Supplier Panelists

The vehicle manufacturer and supplier panels showed fairly close agreement on this forecast.

Strategic Considerations

The post-war trend to increased maintenance intervals is predicted to continue. This suggests not only reduced parts and labor needs but fewer contacts between customers and service outlets and decreased opportunities for sales of parts and accessories.

T-73. On a dollar value basis, what will be the vehicle manufacturer's make-buy ratios for electronic hardware (including sensors and actuators)?

Electronics Make/Buy Ratios
Median Response

	1987		1992	
	Make	Buy	Make	Buy
G.M.	70%	30%	70%	30%
Ford	50	50	50	50
Chrysler	50	50	50	50
AMC-Renault	10	90	10	90
VW of America	10	90	10	90

Interquartile Range

	1987		1992	
	Make	Buy	Make	Buy
G.M.	50/80%	20/50%	60/80%	20/40%
Ford	40/60	40/60	50/60	25/50
Chrysler	25/60	40/75	25/55	45/75
AMC-Renault	5/30	70/95	5/40	50/95
VW of America	5/20	70/95	5/50	50/95

T-73 Discussion

As the use of electronics in vehicles expands a subject of major interest is whether the vehicle manufacturers will produce in-house their own electronic components. Responses to this question indicate no apparent trend between 1987 and 1992, but it is forecast that General Motors will make 70% of its own electronic hardware, Ford and Chrysler will produce 50%, and AMC-Renault and VW of America, 10% each. The interquartile ranges on these median predictions are wide, indicating a relatively low degree of consensus.

Comparison of Vehicle Manufacturer and Supplier Panelists

The vehicle manufacturers' panelists forecast that, by 1992, General Motors would be making 75% of its electronic components and Ford, 60%. They forecast in both 1987 and 1992 that Chrysler would produce only 40% of its own electronics.

T-74. Is your company or division allowing for statistical quality control (SQC) procedures in the product engineering function?

Yes 97%

No 3% (If no) Plan to add in: 1983/1985.

Selected Comments from Panelists

Must consider to meet program objectives.
Engineers are being trained on both manufacturing engineering and product engineering areas.
More an awareness than specific plan.
Systems are just being devised and applied.

T-74 Discussion

Almost 100% of the respondents replied that their company or division is allowing for statistical quality procedures in the product engineering function. The remainder are planning to do so by 1983 or 1985.

T-75. Is your company or division now implementing statistical quality control (SQC) procedures in manufacturing?

Yes	98.5%	
No	1.5%	(If no) Plan to add in 1984.

Selected Comments from Panelists

Isn't everyone?

Very important to improving both quality and productivity.

We have a lot of catch-up to do in this area, and a lot of attitudinal modification as well for managers who have been judged for years on making schedule rather than specifications. This commitment must come from the very top; if not, forget it.

Heavy commitment to statistics in design and test also.

T-75 Discussion

All the companies represented in this study are either using statistical quality control procedures in manufacturing or plan to be doing so by next year.

Discussion of Panelists' Comments

Comment number three is particularly significant.

II. MARKETING PANEL RESULTS AND ANALYSIS

Mkt-1. What is your estimate of retail fuel prices per gallon in the U.S. in 1987? 1990? 1992? (In constant dollars; that is, without adding anything for inflation.)

	Retail Price per Gallon Median Response		
	1987	1990	1992
Unleaded Gasoline	$1.50	$1.75	$2.00
Diesel Fuel	1.42	1.65	1.90

	Interquartile Range		
	1987	1990	1992
Unleaded Gasoline	$1.50/1.50	$1.70/1.85	$1.85/2.00
Diesel Fuel	1.40/1.50	1.58/1.75	1.70/1.90

Selected Comments from Panelists

Primarily due to taxes, leaded gas to be eliminated.
Assumes a substantial tax increase in future years to cover cost of infrastructure repair. Diesel fuel will reflect cost of increased energy content plus environmental hazard.
Extremely unpredictable.
Discovery of additional supplies plus improved engine efficiency may keep price at $1.50 level.
Convinced now that burden of added taxes will cause prices to escalate over earlier forecasts.
Assume that supply and demand will be kept in better balance than recently.
Leaded gas will be eliminated completely by Dec. 1984.
Diesel fuel will be taxed unfairly to repair damage that is thought to be caused by heavier trucks. The demand for diesel fuel will continue to increase as the efficient diesel engine is introduced in the automotive market with better designs and engineering.
Large truck users will fight tax increases for diesel fuel.
State governments will try to raise revenues via a gas tax.
The increase will come more from tax increase than oil base price due to needs for road and bridge repair.
Very tentative - critical variables are unpredictable.
Taxes will increase in the short term to build up the highway infrastructure - 1987. 1990 - Mideast crisis.
Assume significant tax increases.
Sufficient crude oil productive capacity in world through 1992 to prevent a high price run-up.

(Mkt-1 continued)

Mkt-1 Discussion

Marketing panelists forecast that unleaded gasoline prices will rise to an average of $1.50 per gallon in 1987, $1.75 in 1990, and $2.00 in 1992. They forecast that diesel fuel will parallel this rise but at ten cents less per gallon. The consensus on these median forecasts is quite good. For example, for unleaded gasoline in 1987, half or more of the respondents picked the figure of $1.50 per gallon. As usual, the interquartile ranges broaden with the length of the forecast period. The interquartile range on diesel fuel is 10 cents in 1987, 17 cents in 1990, and 20 cents in 1992. Nevertheless, these represent good agreement among the panelists.

Discussion of Panelists' Comments

Comments indicate that much of the predicted increase in fuel prices may come from taxes. Mention is also made of difficulties in forecasting fuel prices owing to unpredictable variables.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median responses were identical except for diesel fuel in 1992 where there was a 10-cent difference between the two groups.

Comparison of Replies to Mkt-1, T-1, and Mat-1

See Discussion under T-1.

Trend From Three Delphi Surveys

See Discussion under T-1.

Mkt-2. What is your estimate of the average retail sales price (in constant dollars) of cars sold in the U.S.?

	Average Retail Sales Price	
	Median Response	Interquartile Range
1981 Estimate	$8,850	-
Forecast:		
1987	10,000	$9,000/10,500
1990	10,900	9,450/11,600
1992	11,250	9,600/12,100

Selected Comments from Panelists

Approximately 4-5% increase in price over 11-year period.
Assumes projected net increase of $1000 for vehicle upgrades, model deproliferation, economies of scale, and smaller vehicles due to fuel price rises.
Manufacturers continue to amortize costs over lower volumes.
Using constant dollars, estimate 1% per year compounded for technology improvements.
Reflects increase in luxury over next couple of years.
Increases likely to be caused by content improvements, technological advances, and some safety equipment.
Continuing reduction in avg. size and labor hour content.

Mkt-2 Discussion

The average retail sales price, in constant dollars, of cars sold in the U.S. is expected to rise from an estimated $8,850 in 1981 to $10,000 in 1987, $10,900 in 1990, and $11,250 in 1992. The consensus on these forecasts, indicated by the interquartile range, is only fair in the later years. In 1992 the interquartile range covers an expanse of $2,500 between the lower range of $9,600 and the upper limit of $12,100. The compound year-to-year price increase from 1981 through 1992 is 2.2%.

Discussion of Panelists' Comments

Comments suggest some of the reasons for the projected price increases.

Comparison of Vehicle Manufacturer and Supplier Panelists

The vehicle manufacturer panelists' median forecasts were significantly lower than those of the other panelists. For 1992, the manufacturers' estimate is $10,000 compared to $11,600 for suppliers.

(Mkt-2 continued)

Trend From Two Delphi Surveys

Two years ago, at the time of Delphi II, the 1990 forecast by Marketing panelists for the average price for cars sold in the United States was $13,000 in constant 1980 dollars. Adjusted for inflation to date, this figure would be even higher; so it is apparent that panelists now foresee substantialy lower prices than previously.

Strategic Considerations

Replies here, considered in context with known improvements in product quality and manufacturing productivity, suggest growing stability in the U.S. automotive business.

Mkt-3. In 1982 the Japanese yen/U.S. dollar exchange ratio reached a high of over 270 Y/$. At what ration do you believe domestically-produced cars would be price-competitive with Japanese-produced cars in the U.S. market?

	Competitive Ratio
Median Response	200 Y/$
Interquartile Range	180/220

Selected Comments from Panelists

Cannot say because price is only one factor. Quality is far more important and U.S. producers are nowhere near the Japanese.
Good comparison is Mazda 626 and Buick Century, equal cars with a significant price differential.
Yen/$ is a political football covering up both Japanese currency manipulations and inefficient U.S. labor practices.
Price not primary factor.

Mkt-3 Discussion

A yen dollar exchange ratio that would allow domestically produced cars to be competitive with Japanese-produced cars in the U.S. market is estimated at 200 yen/dollar. The interquartile range for this estimate is 180/220 yen per dollar. The median and range are precisely in accord with independent estimates that have been published by a number of government, labor, business, and academic experts.

Discussion of Panelists' Comments

Remarks from the panelists indicate some question as to whether an improvement in the yen/dollar ratio would be enough to offset other Japanese automotive advantages.

Strategic Considerations

Exhaustive studies of great depth and breadth have been undertaken by government, industry, and academic experts to determine how much, if any, the yen is undervalued relative to the dollar and, if so, the underlying causes. These many efforts have failed to result in widely accepted conclusions. It would be wrong to assume that the exchange rate will never drop to lower levels considered desirable in the U.S., but there appear to be few practical reasons to expect a sudden decline based on a solution to the "mystery" followed by instantly effective government action.

Mkt-4. Indicate your projections for U.S. market-share percentages for passenger car classes in 1987, 1990, and 1992, including mini-subcompact and commuter sizes.

		Passenger Car Class Mix Median Response		
Classes	Est. 1981	1987	1990	1992
Luxury	5%	5%	5%	5%
Standard	10	10	10	10
Intermediate	20	22	21	20
Compact	20	22	23	25
Subcompact	45	39	37	34
Mini-subcompact	0	2	3	4
Commuter	0	0	1	2
TOTALS	100%	100%	100%	100%

	Interquartile Range		
Classes	1987	1990	1992
Luxury	5/6%	5/6%	5/5%
Standard	10/11	10/10	9/10
Intermediate	20/25	20/25	20/25
Compact	20/25	21/25	20/25
Subcompact	32/41	30/39	30/35
Mini-subcompact	2/3	3/4	3/5
Commuter	0/0	1/2	1/2

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
FOR 1990 PASSENGER CAR MARKET SHARES
IN U.S. BY SIZE CLASS

	Forecast for 1990 at The Time of the Survey		
Classes	1979 Delphi I	1981 Delphi II	1983 Delphi III
Full Size*	10%	9%	15%
Intermediate	20	15	21
Subtotal	30%	24%	36%
Compact	35	25	23
Subcompact	35	36	37
Mini-Subcompact	-	10	3
Commuter		5	1
Subtotal	70%	76%	64%
Total	100%	100%	100%

*Includes Luxury and Standard

(Mkt-4 continued)

MEMO: Class Size Examples:

Luxury: Cadillac, Continental, Corvette
Standard: Ford Crown Victoria, Chevrolet Caprice
Intermediate: Buick Century, Ford Thunderbird

Compact: Ford Tempo, Chevrolet Citation
Subcompact: Rabbit, Escort, Chevette
Mini-subcompact: Toyota Starlet
Commuter: Honda Civic CRX

Selected Comments from Panelists

Growth in mini-commuter base imports will be restricted. Homegrown U.S. industry a factor, perhaps independent or Japanese-owned.
Which classification is meant for sports (and sporty) cars like RX7, Fiero, EXP, Corvette, etc.?
Assumes there will be a redefinition of classes over next 10 years--as occurred during last 10--i.e.--lighter-weight cars in all classes.
U.S. probably will not "compete" in low end.
No big change.
Some trend towards larger, luxury cars.
Cars will be lighter than today's models.
Standard car, by `83 definition, will have to be redefined by `90.
American demand for larger cars has been underestimated by U.S. car companies.
Larger cars will continue to be popular until gas reaches $2.00/gallon.
Commuter vehicles will be imports (low sales potential, high development costs etc.).
Mini-subcompacts will grow more because of price instead of fuel economy.
Subcompact and smaller numbers assumes additional U.S.-based production by foreign-owned firms.
American public fed up with unsafe small cars.
Subcompact increased popularity relative to compact size: better first cost, handling, and fuel economy.

Mkt-4 Discussion

The most interesting thing about class size forecasts for 1987, 1990, and 1992 is the lack of trend. There are a few changes, with compacts expected to increase slightly to 25% of total in 1992 while subcompacts decrease slightly to 34% as the mini-subcompacts and commuters carve a small notch in the market, but the general picture and pattern is one of little change.

(Mkt-4 continued)

Panelists' Comments

The comments reflect a variety of views but are largely supportive of the numerical results shown in the table. The third comment is significant; it points out that while class shares may remain relatively constant, the actual vehicles included in each class could be lighter in weight if not smaller in size.

Comparison of Vehicle Manufacturer and Supplier Panelists

There were no significant differences in the medians as forecast by the manufacturers and suppliers.

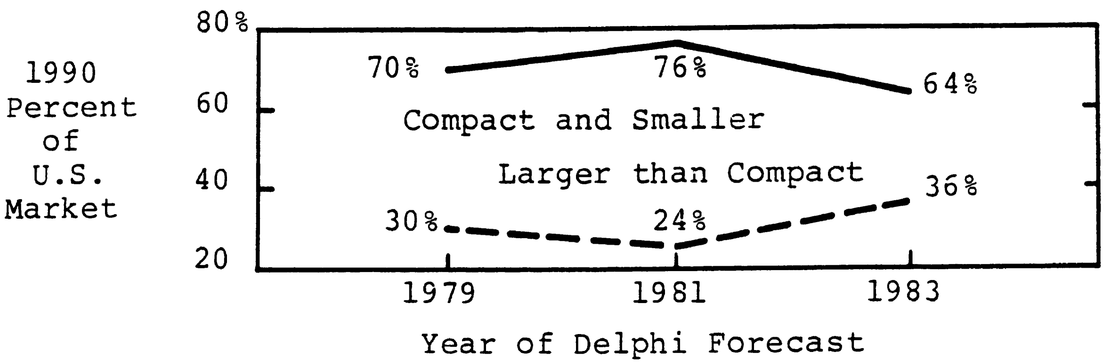
Trend From Three Delphi Surveys

Between 1979 and 1981 there was a general movement of predictions to the effect that by 1990 the mix of cars would be relatively smaller. In the 1983 survey, on the other hand, this trend is reversed and panelists are predicting that over one-third, 36%, of cars sold in the United States will be full-size or intermediate. Note the sharp drop in the estimate of mini-subcompact and commuter car sales in 1990 as forecast in the 1983 Delphi III study compared to the 1981 Delphi II report. The memo following the table gives some examples of cars in the class sizes under discussion. See Figure Mkt-4, below.

Strategic Considerations

In 1974, the year after the OPEC embargo, more than 50% of all cars sold in the U.S. were full size or intermediate. Their share declined to a low of 36% in 1981 but increased to 45% in 1983. However, the forecast for the three classes combined (luxury, standard, intermediate) is 37% in 1987 and drops to 35% in 1992. This is strategically significant. Despite developments that have led to increased sales of larger cars, the industry forecasts a substantially leaner mix in the future, with emphasis on smaller, lighter, more fuel-efficient vehicles. Low expectations for mini-subcompacts and commuters reflect in part the trend toward a richer mix of Japanese imports.

Figure Mkt-4. Larger and Smaller Car Market Shares in 1990 as Forecast in 1979, 1981, and 1983



Mkt-5. What is your forecast of U.S. passenger car market shares by body type?

	Passenger Car Body Mix Median Response		
	1987	1990	1992
4-Door Sedan	33%	32%	31%
4-Door Hatchback	13	14	15
4-Door Station Wagon	9	9	9
Subtotal 4-Door	55%	55%	55%
2-Door Coupe	21	21	21
2-Door Hatchback	18	18	18
2-Door Station Wagon	3	3	3
Subtotal 2-Door	42%	42%	42%
Convertibles	3	3	3
Grand Total	100%	100%	100%

	Interquartile Range		
	1987	1990	1992
4-Door Sedan	32/33%	30/32%	30/33%
4-Door Hatchback	10/15	11/15	10/15
4-Door Station Wagon	9/10	9/10	9/10
Subtotal 4-Door			
2-Door Coupe	20/22	20/22	20/21
2-Door Hatchback	18/20	18/20	18/20
2-Door Station Wagon	3/5	3/5	3/5
Subtotal 2-Door			
Convertibles	2/3	2/3	2/4

Selected Comments from Panelists

As cars get smaller, the two-door back seat will be harder to get into.

1987 figures based on some guesswork--assumes demographic changes (older population) and greater number of 4-dr sedans with characteristics similar to more sporty vehicles.

As cars get smaller, the 4-door and hatchback will become more popular.

What the American public wants or says they want and what they buy are two different things. Everybody says they want leg room in the back seat, but has anyone in Detroit bothered to notice the number of 280Z's and RX7's on the road with no back seat at all?

2-seater commuter car, if it comes, will have an effect on % distribution.

Minivans will take some sales away from station wagons.

(Mkt-5 continued)

More wagon owners will switch to hatchbacks.
The four-door trend goes with the demand trend for larger cars.
Hatchback (4-door/2-door) will gain over sedan/coupe versions as people opt for convenience. Two-door station wagon will be a thing of the past in 10 years.
Demographic changes will cause 2-Dr. & 4-Dr. hatchbacks to increase share. The chief factor being the desire to have maximum use of interior space available.

Mkt-5 Discussion

Forecasts of body type mix in the U.S. passenger car market show a remarkable uniformity over the years 1987 through 1992. The only noticeable change is a small tradeoff between the four-door sedan and the four-door hatchback, with the latter growing from 13 to 15%, while the former declines from 33% to 31%. The interquartile ranges display a high degree of consensus on these forecasts for all years under consideration.

What these data do not show is the possible impact of the minivan on the passenger car body mix. If the minivan proves to be as successful as its proponents are predicting, there may be a significant impact, with the minivan benefiting at the expense of regular passenger cars. Looked at another way, if the mini-van is classified as a passenger car and is successful, it will reduce the market shares of the traditional body types shown here.

Discussion of Panelists' Comments

Several of the comments suggest reasons why the numerical forecasts may not hold as shown.

Comparison of Vehicle Manufacturer and Supplier Panelists

Differences between the two groups were not of major significance. A noticeable but not large difference is that the vehicle manufacturer panelists forecast a slightly richer mix of 4-door sedans and a slightly leaner mix of 4-door hatchbacks than do the supplier respondents.

Mkt-6. What percentage of passenger car sales (including vans) in the U.S. will have the following seating capacities?

Seating Capacity	Passenger Car and Van Seating Capacities Median Response 1987	1990	1992
2	5%	5%	5%
4	39	39	39
5	35	35	35
6	16	15	16
7	2	3	2
8	2	2	2
9 or more	1	1	1
Total	100%	100%	100%

Seating Capacity	Interquartile Range 1987	1990	1992
2	3/6%	4/6%	5/6%
4	35/41	36/41	35/42
5	34/40	32/40	31/40
6	15/17	14/17	12/18
7	1/3	1/4	1/3
8	2/3	2/3	1/2
9 or more	1/2	1/2	1/2

Selected Comments from Panelists

Seating capacity as advertised and practical seating are two different things.
Seating capacity will trend down. Rent bigger vehicles when needed.
Four- and 5-seat configuration will increase with corresponding decreases in 6- to 9-seat configurations.
Minivans (domestic & import) could be successful in taking current 4-door sedan and 4-door station wagon sales--thereby increasing the 6-to 7-seat figures over time.
Higher passenger counts will be demanded in intermediates for utilitarian reasons.

Mkt-6 Discussion

Little change is forecast in the seating capacity of passenger cars and vans sold in the U.S. Four-passenger cars are expected to dominate with five-passenger models a close second. Interquartile ranges are fairly close.

We do not believe these forecasts truly reflect the potential of the minivan.

(Mkt-6 continued)

Discussion of Panelists' Comments

The fourth comment regarding the possible inroads of minivans, if true, is not reflected in the numerical forecasts.

Comparison of Vehicle Manufacturer and Supplier Panelists

The individual median replies of the vehicle manufacturer and supplier groups were either identical or close. This is surprising because we expected to see, among manufacturer representatives, higher forecasts for larger seating capacity vehicles to reflect manufacturer enthusiasm for the minivans.

Mkt-7. MEMO — In questions 8 through 16, "domestic" includes all vehicles assembled in the U.S. without regard to domestic or foreign ownership of facilities.

Mkt-7 Discussion

In subsequent questions Mkt-8 through Mkt-16, sales are predicted for passenger car models and truck size classes. In each case, the designation, "domestic" production, includes all vehicles assembled in the U.S. without regard to domestic or foreign ownership of facilities.

Mkt-8. How many domestic- and foreign-produced passenger cars and trucks do you forecast will be sold in the U.S. during the following years?

Median Response: Millions of Units

	Passenger Cars			Trucks			MEMO:
	Domestic-Produced	Foreign-Produced*	Total	Domestic-Produced	Foreign-Produced*	Total	Cars & Trucks
Est.1981	6.2	2.3	8.5	1.8	0.4	2.2	10.7
1984	7.2	2.5	9.7	2.5	0.5	3.0	12.7
1985	7.5	2.5	10.0	2.6	0.5	3.1	13.1
1987	7.7	2.6	10.3	2.6	0.5	3.1	13.4
1990	8.0	2.7	10.7	2.9	0.6	3.5	14.2
1992	8.0	2.7	10.9	2.9	0.6	3.5	14.2

Interquartile Range

1984	6.8/7.5	2.3/2.7	9.1/10.1	2.2/2.6	0.4/0.6	2.6/3.1
1985	7.3/7.8	2.4/2.8	9.7/10/6	2.2/2.9	0.4/0.7	2.7/3.4
1987	7.0/8.0	2.3/3.0	9.6/11.0	2.1/3.0	0.4/0.6	2.7/3.5
1990	7.5/8.3	2.4/3.0	10.0/11.3	2.3/3.3	0.4/0.7	2.9/3.7
1992	7.5/8.6	2.4/3.0	10.3/11.4	2.3/3.3	0.4/0.7	3.0/3.9

* Includes captive imports sold by domestic manufacturers.

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS FOR 1990 PASSENGER CAR SALES IN THE U.S.

	Forecast for 1990 at the Time of the Survey Millions of Units		
Passenger Cars	1979 Delphi I	1981 Delphi II	1983 Delphi III
Domestic	-	10.0	8.0
Foreign	-	2.1	2.7
Total	12.5-13.00	12.1	10.7

Mkt-8 Discussion

Passenger car sales in the U.S. are forecast to increase from the estimated actual 1981 level of 8.5 million to 10.9 million in 1992, amd truck sales from 2.2 million in 1981 to 3.5 million in 1990 and 1992. The total U.S. market for cars and trucks is predicted to be over 14 million vehicles by 1990. These forecasts represent compound average annual growth rates, between 1981 and 1990, of 2.6% for cars and 5.3% for trucks; a two-to-one ratio. Interquartile range consensus was fair considering the difficulty of forecasting unit sales several years ahead.

(Mkt-8 continued)

Comparison of Vehicle Manufacturer and Supplier Panelists

The two groups were in fair agreement on their total forecast, but vehicle manufacturer panelists tended to predict slightly more domestic production and slighly less foreign-produced sales than the supplier group.

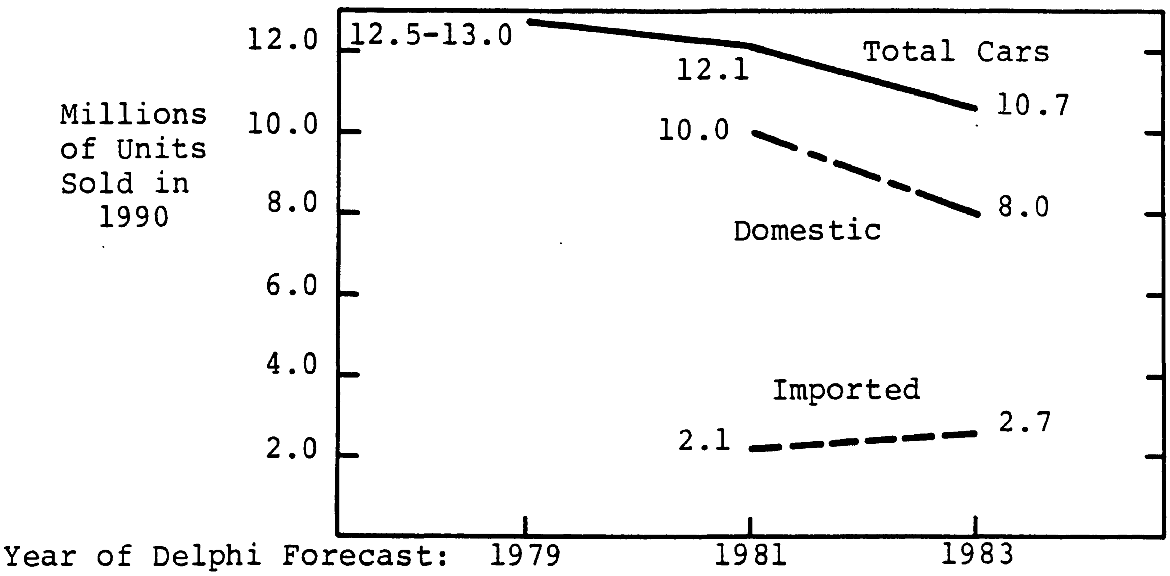
Trend From Three Delphi Surveys

The forecasts for 1990 passenger car and truck sales in this survey are below the levels predicted in the 1981 and earlier 1979 Delphi surveys. The second table compares car sales forecasts for 1990 from three surveys. See Figure Mkt-8, below. (Light truck sales forecast comparisons are shown in Mkt-11.) Total car sales are now predicted at 10.7 million units in 1990; down from 1990 forecasts of 12.1 million made in 1981 and 12.5-13.0 million in 1979. Between 1981 and 1983 the forecast for 1990 sales of foreign-produced cars actually increased from 2.1 million to 2.7 million, while the forecast for domestic sales declined from 10.0 to 8.0 million.

Strategic Considerations

Panelists are forecasting that U.S. automotive unit sales will remain below previous record high levels during the next 10 years. Such a forecast is evidence that experts believe the industry is mature. However, as explained in the introductory section on "How to Use This Report," predictions such as these reflect long-range trend expectations. Individuals familiar with the industry will not be surprised if a new sales peak does occur during a normal cycle above the trend line.

Figure Mkt-8. Passenger Car Sales in U.S. in 1990 as Forecast in 1979, 1981, and 1983.



Mkt-9. How many domestic- and foreign-produced two-passenger urban-type vehicles* will be sold in the U.S. during the following years?

Two-Passenger Urban Type Sales in Thousands of Units

	Domestic-Produced	Foreign-Produced*	Total
Median Response			
Est. 1981	0	0	0
1985	0	1	1
1987	3	20	23
1990	40	60	100
1992	80	100	180
Interquartile Range			
1985	0/0	0/5	0/10
1987	0/15	3/30	5/50
1990	4/60	20/75	25/175
1992	12/100	30/100	75/200

*Excluding sporty cars such as Corvette, Pontiac Fiero, etc.

Selected Comments from Panelists

I do not see explosive growth unless new companies come into the field perhaps using motorcycle platforms.
A trend to two-passenger cars--but not a big factor.
Don't believe there will be a market for this type of vehicle unless gas goes to $5.00/gal (1982 $'s).
Gas prices will just have to skyrocket, and I don't believe they will. Improved MPG's of all cars will be enough to offset forecast increases in fuel costs.
Predicated on removal of the quota on Japanese vehicles in 1985 and uncertainty in the oil market thereafter.
Urban-type vehicles will be classified as motorcycles.
Some growth if initial price is substantially below that of 4-passenger car.
Regional markets other than Midwest will determine the success of two-passenger urban-type vehicles.
No market in America for this vehicle.
We believe that most consumers who are interested in micro-minis want a four-passenger configuration.
Not enough utility - does not match our road types.

Mkt-9 Discussion

Two-passenger, urban-type, commuter vehicle sales are not expected to become a large part of the U.S. market. By 1992, annual sales of these vehicles are forecast to be only 180,000 units. The interquartile range is quite wide on this estimate

(Mkt-9 continued)

because many of the respondents expect sales to be far below the median level. The upper quartile estimate for 1992 sales is 200,000 units, while the lower quartile is at 75,000 units.

Discussion of Panelists' Comments

Comments suggest several reasons for doubts about the future of the two-passenger urban-type vehicle in the U.S. market.

Comparison of Vehicle Manufacturer and Supplier Panelists

There is good agreement between the two groups.

Trend From Two Delphi Surveys

Two years ago, in the 1981 Delphi II Survey, panelists forecast sales of these vehicles in 1990 at 400,000 units, or four times the current prediction of 100,000.

Mkt-10. How many domestic- and foreign-produced two-passenger sporty cars, such as the Corvette, Pontiac P car, Mazda RX-7, will be sold in the U.S. during the following years.

Two-Passenger Sporty Car Sales
in Thousands of Units
Median Response

	Domestic-Produced	Foreign-Produced	Total
Est. 1981	30	135	165
1985	100	150	250
1987	110	150	260
1990	135	150	285
1992	145	155	300

Interquartile Range

1985	75/140	145/150	225/300
1987	85/155	145/150	240/325
1990	125/200	150/165	275/350
1992	120/200	150/170	285/345

Selected Comments from Panelists

Growing levels of congestion in urban areas will discourage this type of vehicle--as will older population.

Most of the two-seaters I see are driven by older people. Price and the lack of American two-seaters to choose from has kept sales at a low level.

Give me a two-seater Cadillac, Olds, Mercury, Chrysler; I'll sell a lot of them to older people.

Give me a two-seater Pontiac, Ford, Dodge; I'll sell a lot of them to younger people.

Too expensive for significant growth.

Older population will find this type of vehicle inconvenient to use, thus discouraging or limiting size of niche.

Economy must be good and gas prices under $2.00 per gallon. The "fun" of driving a sporty car will be very strong.

Includes EXP & LN-7. Assuming Fiero (or similar model) is extended to other G.M. lines. Also assumes 2-seat sporty entries from Honda & Toyota.

Specialty performance cars to play a larger role in U.S. market. Demand is there if U.S. manufacturers can develop a car with good fuel economy and performance.

Mkt-10 Discussion

Sales of two-passenger sporty cars are expected to continue to increase and reach a level of 300,000 units in 1992; about evenly divided between domestic- and foreign-produced models. For such a distant forecast, the interquartile range shows a fair degree of consensus.

(Mkt-10 continued)

Discussion of Panelists' Comments

The comments offer a fair spectrum of reasons why sporty car sales may or may not increase.

Comparison of Vehicle Manufacturer and Supplier Panelists

The two groups provided almost identical forecasts on the foreign-produced forecasts, but on the domestic-produced side, the vehicle manufacturers were significantly more optimistic than the suppliers.

Mkt-11. How many domestic- and foreign-produced light trucks (0-14,000lbs. GVW) do you forecast will be sold in the U.S. during the following years (including compact trucks)?

	Light Truck Sales in Millions of Units Median Response		
	Domestic-Produced	Foreign-Produced*	Total
Est. 1981	1.6	0.4	2.0
1985	2.2	0.4	2.6
1987	2.3	0.4	2.7
1990	2.5	0.4	2.9
1992	2.6	0.4	3.0
	Interquartile Range		
1985	2.2/2.3	0.4/0.5	2.6/2.8
1987	2.2/2.5	0.4/0.5	2.7/2.9
1990	2.4/2.6	0.4/0.5	2.9/3.1
1992	2.4/2.7	0.4/0.5	2.9/3.2

* Includes imports sold by domestic manufacturers.

MEDIAN FORECASTS FROM THREE DELPHI SURVEYS
FOR 1990 LIGHT TRUCK SALES
IN THE U.S.

	Forecast For 1990 at the Time of the Survey Millions of Units		
Light Trucks	1979 Delphi I	1981 Delphi II	1983 Delphi III
Domestic	-	3.3	2.5
Foreign	-	0.4	0.4
Total	4.0-4.1	3.7	2.9

Selected Comments from Panelists

U.S. will take over.
Light trucks in consumer market a factor.
Foreign manufacturers will begin strong emphasis on trucks during the next ten years.
If anything, my domestic-produced forecast is understated as replacement demand and diversions from passenger cars to new truck and van products could be higher than currently anticipated.
Better U.S. design will provide substitution incentive for small cars.
Assumes 100% of Nissan trucks are built domestically from 1985.

(Mkt-11 continued)

Mkt-11 Discussion

Sales of light trucks, defined as 14,000 lbs. GVW and less, are predicted to rise steadily to a level of 3,000,000 units per year in 1992. No growth is seen in sales of foreign-produced light trucks. Interquartile ranges are very close on these forecasts.

Discussion of Panelists' Comments

The first comment is well-supported by the numerical forecast that shows no growth in sales of imported light trucks.

Comparison of Vehicle Manufacturer and Supplier Panelists

The manufacturer panelists' forecast for domestic-produced and total light truck sales were slightly higher than those of the other panelists, but the differences are not large.

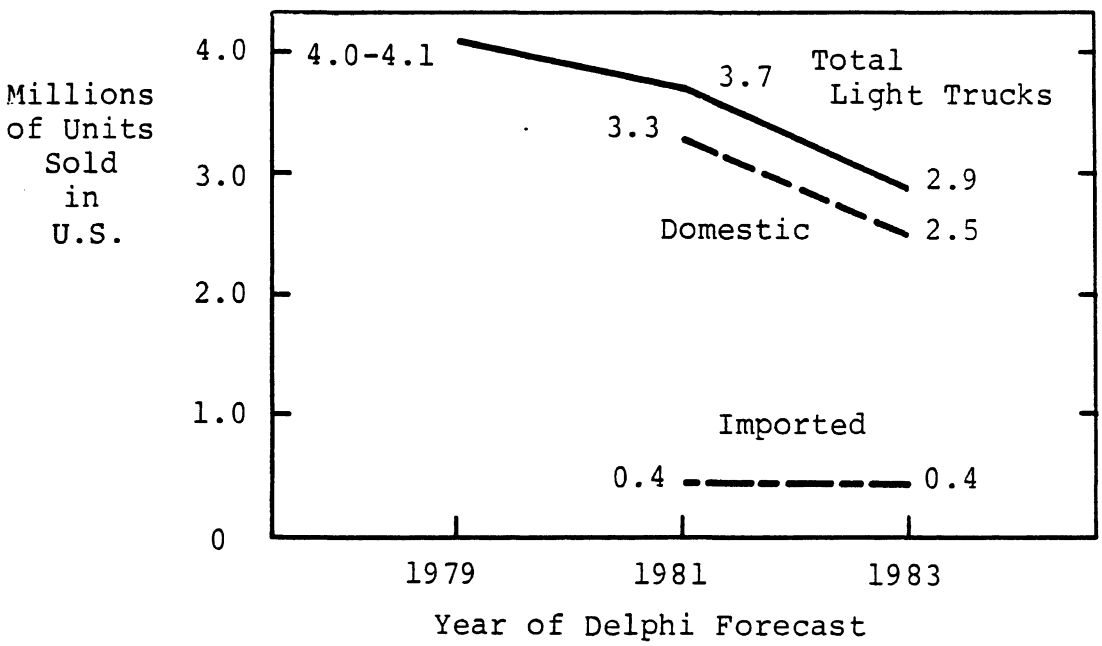
Trend From Three Delphi Surveys

The 1990 forecast of 2.9 million light truck sales compares to the forecast made two years ago of 3.7 million and the 1979 forecast of 4.0-4.1 million. See Figure Mkt-11, below.

Strategic Considerations

Predictions call for a recovery but no new growth in the light truck market. However, normal cyclical departures both over and under trend should be expected.

Figure Mkt-11. Light Truck Sales in U.S. in 1990 as Forecast in 1979, 1981, and 1983.



Mkt-12. How many domestic- and foreign-produced medium-duty trucks (14-26,000 lbs. GVW) do you forecast will be sold in the U.S. during the following years?

Medium-Duty Truck Sales in Thousands of Units
Median Response

	Domestic-Produced	Foreign-Produced	Total
Est. 1981	50	5	55
1985	60	6	66
1987	61	8	69
1990	67	9	76
1992	70	10	80
	Interquartile Range		
1985	56/60	6/7	64/70
1987	60/65	8/10	68/73
1990	65/70	9/11	72/80
1992	65/70	10/13	75/85

Selected Comments from Panelists

Should be parallel growth in population in urbanized areas.

Mkt-12 Discussion

Medium-duty truck sales are expected to increase modestly to 80,000 units in 1992. Of these, 70,000 are forecast to be domestically produced. Foreign-produced sales are expected to increase steadily from an estimated 5,000 units in 1981 to 10,000 units in 1992. Although not absolutely large, this steady increase would represent a significant penetration into the U.S. maket. Interquartile ranges show a high degree of consensus.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median forecasts were fairly close, although the manufacturer panelists tended to be a little more optimistic about sales starting in 1987.

Mkt-13. How many domestic- and foreign-produced heavy-duty trucks (26-33,000 lbs. GVW) do you forecast will be sold in the U.S. during the following years?

	Heavy-Duty Truck Sales in Thousands of Units Median Response		
	Domestic-Produced	Foreign-Produced	Total
Est. 1981	65	1	66
1985	70	2	72
1987	72	2	74
1990	74	2	76
1992	78	2	80
	Interquartile Range		
1985	65/80	1/2	61/71
1987	67/95	1/3	70/100
1990	68/96	1/4	70/100
1992	70/100	1/4	71/102

Mkt-13 Discussion

Heavy-duty truck sales are forecast to expand to 80,000 units by 1992 with all but 2,000 of these being domestically manufactured. Interquartile ranges are fairly close with some leaning in the direction of higher sales.

Comparison of Vehicle Manufacturer and Supplier Panelists

The manufacturers were a little more optimistic than the suppliers, but the differences in their forecasts are not large.

Trend From Three Delphi Surveys

In both the 1979 Delphi I and the 1981 Delphi II surveys, the forecast for heavy-duty truck sales in 1990 was 400,000 units. The current forecast is almost twice that level.

Mkt-14. How many domestic- and foreign-produced extra-heavy-duty trucks (33,000 lbs. GVW, and over) do you forecast will be sold in the U.S. during the following years?

Extra-Heavy Duty Truck Sales in Thousands of Units
Median Response

	Domestic-Produced	Foreign-Produced	Total
Est. 1981	95	1	96
1985	105	1	106
1987	106	1	107
1990	107	2	109
1992	111	2	113
	Interquartile Range		
1985	95/120	1/2	97/123
1987	100/140	1/2	100/141
1990	96/134	1/3	100/135
1992	100/150	1/3	100/152

Mkt-14 Discussion

Extra-heavy-duty truck sales are predicted to increase slightly from current levels of 96,000 units annually to 113,000 by 1992. All but 2,000 of these would be domestic. Interquartile ranges are not close and suggest the possibility of slightly higher sales than indicated by the median.

Comparison of Vehicle Manufacturer and Supplier Panelists

Both groups agreed that the sales of foreign-produced extra-heavy-duty trucks would be at low levels, but the manufacturer respondents were significantly more optimistic than the suppliers on estimates for domestically produced sales.

Mkt-15. How many vans do you forecast will be sold in the U.S. during the following years?

Van Sales in Thousands of Units
Median Response

	Domestic-Produced	Foreign-Produced	Total
Est. 1981	240	10	250
1985	300	12	312
1987	300	20	320
1990	320	20	340
1992	320	20	340

Interquartile Range

	Domestic-Produced	Foreign-Produced	Total
1983	250/280	10/10	265/290
1985	290/315	10/18	300/350
1987	300/330	14/25	314/360
1990	305/390	15/30	325/390
1992	320/390	15/30	335/410

Selected Comments from Panelists

Vans are the future "standard" cars; i.e., will seat 6 passengers.

Small trend to mini-vans but will not be a significant factor.

Large station wagons will go away during 1985, resulting in switch to vans.

Possibility of increased foreign-produced, as vans are not part of import quotas.

Total volume will remain basically flat after the initial demand is satisfied.

Flat sales--probably less a factor in market. Replaced by new van-wagon.

I believe foreign-produced vans could reach the same share as autos if there are no import or tax restrictions.

I don't think imports have a chance in vans.

I have just purchased a van to replace my station wagon. What do you do when you have 3 children all over 6 ft. tall?

Will mini-vans be considered vans or station wagons?

Given the difference in outlook I wonder if we're looking at the same market. Sales in 1983 are limited by plant capacity. New van concepts coming in future years will expand market further.

Includes panel vans, passenger vans, and VW Vanagon in 1983. Mini-vans enter picture in 1984 and become dominant by 1987. Assumes minis from GM & Ford as well as Chrysler's T-115. Also assumes minis from Toyota, Mitsubishi, Nissan, Toyo Kogyo, and Isuzu.

Except for possible trade restrictions, why should foreign manufacturer lose out in the van market?

(Mkt-15 continued)

Mkt-15 Discussion

Sales of vans are forecast to increase from the estimated 1981 level of 250,000 units to 1992 deliveries of 340,000 units, all but 20,000 of which would be domestically produced. Interquartile ranges are fairly tight at the lower end but show more optimism in the upper quartile.

Van sales shown here were included earlier as part of light truck sales in Mkt-11.

Discussion of Panelists' Comments

The variety of comments reflects the turbulence expected in the van market because of the advent of the minivan and foreign competition.

Comparison of Vehicle Manufacturer and Supplier Panelists

In the replies to this question we found one of the greatest differences between the forecasts of manufacturer and supplier panelists. For the early 1990's, the manufacturer panelists' median annual forecasts are on the order of 200,000 to 300,000 units higher than those of the supplier panelists.

Mkt-16. How many domestic- and foreign-produced compact* trucks do you forecast will be sold in the U.S. during the following years?

Compact Truck Sales in Thousands of Units
Median Response

	Sold By Domestic Manufacturers: Domestic-Produced	Sold By Domestic Manufacturers: Captive Imports	Other Imports	Total
Est. 1981	59	160	284	503
1985	300	130	250	680
1987	350	160	250	760
1990	410	150	250	810
1992	480	160	260	900
	Interquartile Range			
1985	280/400	100/140	200/270	600/770
1987	350/450	120/160	200/250	680/780
1990	380/500	100/150	200/260	700/850
1992	400/500	100/170	200/275	750/945

* Examples: Chevrolet S-10, Ford Ranger, Datsun, Toyota

Selected Comments from Panelists

Datsun is considered a domestic unit, starting in 1984.

Japanese may expand compact truck production by using passenger car platforms, as compact trucks do not fall in passenger car quotas.

Sports vehicles rather than "trucks" have little usable room. See moderate growth but nothing big unless innovation sets in.

1983 through 1987 estimates assume only Nissan as a foreign-produced domestic manufacturer. This segment will become the largest truck growth category.

I see higher compact truck sales (total) throughout the time period. Most come from U.S. domestic plants, with only a few from domestic manufacturers' overseas plants.

Mkt-16 Discussion

Compact truck sales are forecast to continue strong and increase from slightly over 500,000 units in 1981 to 900,000 units in 1992. A substantial proportion of these are expected to be imported; 160,000 imports to be sold by domestic manufacturer dealers and 260,000 additional imports sold through import dealerships. Interquartile ranges are reasonably close.

Data shown here are also included in total light truck sales discussed earlier in question Mkt-11.

(Mkt-16 continued)

Discussion of Panelists' Comments

Although few in number, the comments quoted show diverse viewpoints on the subject of compact trucks.

Comparison of Vehicle Manufacturer and Supplier Panelists

Manufacturer forecasts were significantly higher than those of the supplier group with the exception of foreign-produced compact trucks sold by domestic manufacturers; here the manufacturer and suppliers were in agreement.

Mkt-17. How many conventional* pickup trucks do you forecast will be sold in the U.S. during the following year?

	Millions of Units	
	Median Response	Interquartile Range
Est. 1981	1.0	-
Forecast		
1985	1.2	1.0/1.4
1987	1.2	1.0/1.5
1990	1.2	1.0/1.5
1992	1.3	1.0/1.6

*Includes extended and crew cabs; excludes compacts.

Mkt-17 Discussion

Pickup truck sales are forecast to increase from the current level of approximately 1.0 million units a year to 1.3 million in 1992. Interquartile ranges are fairly close.

These data are also included in Mkt-11 which covered total light truck sales.

Comparison of Vehicle Manufacturer and Supplier Panelists

Replies were essentially the same.

Mkt-18. How many 4-wheel-drive light-duty vehicles* do you forecast will be sold in the U.S. during the following years?

	Thousands of Units	
	Median Response	Interquartile Range
Est. 1981	400	-
Forecast		
1985	500	420/545
1987	465	420/550
1990	500	420/600
1992	500	450/600

*Includes light trucks, Jeep, Blazer, Eagle, Subaru, Toyota Land Cruiser, captive imports, etc.

Mkt-18 Discussion

Sales of light-duty vehicles with 4-wheel drive are expected to increase from the 400,000 level estimated for 1981 to 500,000 units in 1992. Interquartile ranges are reasonably close.

Comparison of Vehicle Manufacturer and Supplier Panelists

The vehicle manufacturers' forecasts were about 20% higher than those of the supplier panelists.

Mkt-19. What is your estimate of the import share of the U.S. passenger car market in these years?

Country of Origin	Est. 1981	Percent of U.S. Market Median Response 1987	1990	1992	1997
Japan	23%	22%	22%	20%	20%
Other Asia	0	0	0	0	0
Western Europe	6	5	5	5	5
Latin America	0	0	0	0	0
Other	0	0	0	0	0
Total	29%	27%	27%	25%	25%

	Interquartile Range 1987	1990	1992	1987
Japan	20/25%	18/26%	18/25%	16/25%
Other Asia	0/0	0/1	0/1	0/2
Western Europe	5/6	4/6	4/6	4/6
Latin America	0/0	0/0	0/0	0/0
Other	0/0	0/0	0/0	0/0

MEDIAN FORECASTS FROM TWO DELPHI SURVEYS
PASSENGER CAR IMPORT* SHARES OF U.S. MARKET IN 1990

Import Source	Forecast for 1990 at the Time of the Survey: 1981 Delphi II	1983 Delphi III	Percentage Points Delphi III Over/Under Delphi II
Japan	11.0%	22%	11.0 Pts.
Western Europe	3.8	5	1.2
Other	1.0	0	(1.0)
TOTAL	15.8%	27%	11.2 Pts.

* Figures exclude captive imports, Japanese production (independent or joint) in U.S., VWoA and AMC/Renault production in U.S., and imports from Canada.

Selected Comments from Panelists

Mexico will import cars into southwest U.S. as West Coast plants of U.S. OEM's close.
Korea & Brazil will be significant factors.

(Mkt-19 continued)

Mkt-19 Discussion

In 1981, imported passenger cars reached a new peak of 29% of the U.S. market. Most of these vehicles were of Japanese origin. Forecasts as far out as 1997 show little change in this pattern, although a slight decline in Japanese penetration from 23% of the total U.S. market to 20% is predicted.

Discussion of Panelists' Comments

Comments are not in accordance with numerical forecasts which show no imports from Latin America and Other Asia. However, see the discussion under "Strategic Considerations", below.

Comparison of Vehicle Manufacturer and Supplier Panelists

The median responses for the two groups were essentially the same.

Trend from Two Delphi Surveys

The forecast of the Japanese 1990 share of the U.S. market doubled from 11% in the 1981 survey to 22% in the current study. The Western Europe share is now predicted at 5% in 1990 compared to the earlier estimate of 3.8%.

Strategic Considerations

As shown above, zero imports are forecast from Latin America or Other Asia. However, in the relatively short time since the questionnaires for our survey were completed, Ford and GM have announced plans to import cars from Mexico and South Korea, respectively. Of course, implementation of these plans may be subject to collective bargaining or political modification.

Even without such possible new entries, respondents are conceding 25% or more of the U.S. market to imports.

Mkt-20. What share of the U.S. passenger car and light truck markets do you predict will be supplied by U.S. and foreign vehicle manufacturers?

Passenger Car Source	Percent of U.S. Passenger Car Market Median Response 1987	1990	1992
GM*	45%	45%	45%
Ford*	16	16	16
Chrysler*	10	10	10
AMC/Renault*	2	2	2
VW of America*	1	2	2
Japanese Mfd. in U.S.	2	2	2
Japanese Imports**	21	20	20
Other Foreign Mfr. & Joint Ventures in U.S. ***	1	1	1
Other Imports	2	2	2
	100%	100%	100%

	Interquartile Range 1987	1990	1992
GM*	44/46%	44/46%	44/46%
Ford*	15/16	15/16	15/17
Chrysler*	10/11	9/11	10/11
AMC/Renault*	2/3	2/3	2/3
VW of America*	1/2	1/2	1/2
Japanese - Mfd. in U.S.	1/2	2/3	2/3
Japanese Imports**	20/22	19/22	18/22
Other Foreign Mfr. & Joint Ventures In U.S. ***	1/1	1/2	1/2
Other Imports	2/2	2/3	2/3

Light Truck Source	Percent of U.S. Light Truck Market Median Response 1987	1990	1992
GM*	38%	38%	38%
Ford*	33	33	34
Chrysler*	9	9	10
AMC/Renault*	3	3	3
VW of America*	1	1	1
Japanese - Mfd. in U.S.	2	3	3
Japanese Imports**	14	13	11
Other Foreign Mfr. & Joint Ventures In U.S. ***	0	0	0
Other Imports	0	0	0
	100%	100%	100%

Footnotes: See end of table, p. 184.

(Mkt-20 continued)

Light Truck (Cont'd)	Interquartile Range 1987	1990	1992
GM*	38/39%	38/40%	38/40%
Ford*	33/33	33/33	33/35
Chrysler*	9/9	9/10	9/10
AMC/Renault*	3/3	3/3	3/3
VW of America*	1/1	1/1	1/1
Japanese - Mfd. in U.S.	1/2	3/3	3/3
Japanese Imports**	12/14	11/13	10/12
Other Foreign Mfr. & Joint Venture In U.S. ***	0/0	0/0	0/0
Other Imports	0/0	0/0	0/0

*Includes captive imports.
**Excludes captive imports.
***Foreign plus U.S. manufacturers.

MEDIAN FORECASTS FROM TWO DELPHI SURVEYS
SHARES OF U.S. PASSENGER CAR AND LIGHT TRUCK MARKETS

Forecast for 1990 at the Time of the Survey

Source	Passenger Cars 1981 Delphi II	1983 Delphi III	Percentage Points Delphi II Over (Under) Delphi II
GM	50.0%	45%	(5.0) Pts.
Ford	18.5	16	(2.5)
Chrysler	7.0	10	3.0
AMC/Renault	1.5	2	0.5
VWoA	3.0	2	(1.0)
Imports Plus Other Foreign Mfr. in U.S.	20.0*	25**	5.0
	100.0%	100%	

Source	Light Trucks		
GM	46.0%	38%	(8.0) Pts.
Ford	34.0	33	(1.0)
Chyrsler	6.5	9	2.5
AMC/Renault	3.5	3	(0.5)
VWoA	0.1	1	0.9
Imports Plus Other Foreign Mfr. in U.S.	9.9*	16**	6.1
	100.0%	100%	

* Includes captive imports.
** Excludes captive imports.

(Mkt-20 continued)

Selected Comments from Panelists

Other than Honda, Japan will never really get going in U.S.

I believe U.S. quality will constantly improve and the yen will increase in value.

Nissan-U.S. will make the only foreign trucks produced in the U.S. U.S. understands its own truck market (unfortunately does not extend to cars.)

At least one other Japanese manufacturer will assemble cars in the U.S. Probably Nissan.

Japanese manufacturers will be pressured into building U.S. manufacturing facilities.

The Japanese imports are here to stay and will be attacking all market segments fiercely.

By 1990 it is assumed that Nissan will be joined by another Japanese manufacturer of trucks in the U.S. We also assume that three Japanese companies will be involved in U.S. passenger car assembly in 1987, increasing to four by 1992.

Low-cost imports from Korea and Taiwan will fill a mini-car need.

New mini-van will spur 1984-1987 Chrysler truck sales.

Mkt-20 Discussion

Panelists were asked to forecast the shares of the U.S. passenger car and light truck markets that would be taken by the major domestic manufacturers, (including captive imports), Japanese imports, other imports, and joint ventures in the U.S. In the original questionnaire as presented to our respondents we included the actual market shares for 1981. These figures were similar to the ones shown here in the forecasts for 1987, 1990, and 1992. Essentially, the respondents predict little change in market shares, the only exceptions being a decline in Japanese passenger car imports to "only" 20% of the U.S. market and a more significant decline in light truck penetration to 11%. However, both estimates exclude captive imports.

Comparison of Vehicle Manufacturer and Supplier Panelists

The vehicle manufacturers are slightly less optimistic about the future for the major American manufacturers and foresee a higher share of the market going to Japanese products manufactured in the U.S. These differences are not large, however.

Trend From Two Delphi Surveys

During the last two years, industry experts have become less hopeful about the possibilty of reducing Japanese imports, which are now expected to continue at the relatively high level of 20% of the U.S. car market in 1990 and 11% of truck sales, with both figures excluding captive imports.

(Mkt-20 continued)

Forecasts of market shares for domestic manufacturers show substantial changes. Chyrsler is expected to improve over prior estimates while GM and Ford penetration levels are predicted at significantly lower levels. These declines are even larger than indicated because in the earlier survey data shown, domestic share forecasts exclude captive imports while the 1983 predictions include captive imports in the domestic-source estimates.

Mkt-21A. What share of the U.S. market for imported (noncaptive) passenger cars will be supplied by these manufacturers?

		Percent Share of Import Sales In U.S. Median Response		
	Est. 1981	1987	1990	1992
Passenger Cars				
Toyota	28.7%	28%	27%	27%
Nissan	23.2%	23	23	22
Honda	18.5%	19	20	20
Mazda	8.3%	9	9	10
Subaru	7.6%	7	7	7
Volvo	3.2%	3	3	3
Mercedes	3.1%	3	3	3
BMW	2.1%	2	2	2
Fiat	1.6%	0	0	0
Other	3.7%	6	6	6
Total	100%	100%	100%	100%

	Interquartile Range		
	1987	1990	1992
Toyota	25/30%	24/30%	24/29%
Nissan	22/24	21/24	21/24
Honda	19/21	18/21	18/22
Mazda	8/10	8/10	8/11
Subaru	7/8	7/8	7/8
Volvo	3/3	3/3	3/3
Mercedes	3/4	3/4	3/4
BMW	2/3	2/3	2/3
Fiat	0/0	0/0	0/0
Other	5/7	5/7	5/7

Selected Comments From Panelists

Honda's new plant in Ohio may help their share. GM marketing Toyota subcompact cars may help Toyota some.

Mkt-21A Discussion

Except for the disappearance of Fiat from the U.S. market, manufacturers' shares of import sales are expected to change very little between estimated 1981 levels and the 1992 forecast.

Comparison of Vehicle Manufacturer and Supplier Panelists

Manufacturer panelists' forecasts of Toyota penetration are about three percentage points less than those of other panelists.

Mkt-21B. What share of the U.S. market for imported (noncaptive) trucks will be supplied by these manufacturers?

		Percent Share of Import Sales In U.S. Median Response		
	10 Mo. 1982	1987	1990	1992
Total Trucks				
Toyota	49%	47%	46%	45%
Nissan	34	35	34	35
Mazda	12	12	12	12
Isuzu	2	2	2	2
Mitsubishi	1	2	2	2
Other	2	2	4	4
Total	100%	100%	100%	100%

	Interquartile Range		
	1987	1990	1992
Total Trucks			
Toyota	41/48%	42/49%	39/48%
Nissan	32/36	32/36	31/37
Mazda	12/14	12/15	12/15
Isuzu	2/3	2/3	2/3
Mitsubishi	1/3	1/4	1/4
Other	1/2	3/5	3/5

Mkt-21B Discussion

Shares of import truck sales in the U.S. are predicted to change very little in the next 10 years, although Toyota is expected to give up some slight proportion of its leadership to small increases in the shares achieved by Nissan, Mitsubishi, and others.

Comparison of Vehicle Manufacturer and Supplier Panelists

Most of the median responses were identical. Where they were not, the only significant differences were that supplier panelists forecast 2 to 4 percentage points greater market share for Toyota than did the manufacturer panelists.

Mkt-22. What is your forecast of the volume of cars and light trucks produced in U.S. facilities by all foreign vehicle manufacturers in 1985, 1987, 1990, and 1992?

		Thousands of Units	
		Median Response	Interquartile Range
Cars	1985	300	275/300
	1987	400	400/475
	1990	500	500/500
	1992	600	550/600
Trucks	1985	100	100/100
	1987	175	150/175
	1990	250	200/300
	1992	200	200/300

Selected Comments from Panelists

Cars - Honda. Light Trucks - Nissan.
I don't forecast much more domestic production by foreign companies. Look for joint-venture on low-line items.
When they come face to face with the UAW they'll return to Japan and save money.
Other "foreign" items will be domestic joint ventures between U.S. and foreign companies (i.e., GM and Toyota).

Mkt-22 Discussion

This question asks for predictions of car and light truck production in the U.S. in foreign-owned facilities. Although not stated in the question itself, we believe these predictions assume no local content legislation in the United States. Relatively modest levels of production are forecast, with a peak of 600,000 for cars and 200,000 for trucks in 1992. Interquartile ranges are fairly close on these median estimates.

Comparison of Vehicle Manufacturer and Supplier Panelists

Manufacturer forecasts tended to be moderately higher than those of the supplier panelists.

Trend From Three Delphi Surveys

This question was asked in the Delphi surveys of 1979 and 1981. The 1990 forecasts for cars and trucks made in U.S. facilities by foreign vehicle manufacturers were the same in the current survey and the previous, 1981 study. In the 1979 survey, truck production in U.S. facilities by foreign vehicle manufacturers was not forecast but panelists did predict that by 1990 Japanese manufacturers would be producing about 600,000 passenger cars in the U.S.; 100,000 units more than the 1990 forecast in the most recent survey but identical to the 1992 prediction.

Mkt-23. How many Japanese companies will have U.S. passenger car assembly facilities? How many cars will they assemble in the U.S. in these years? (Include joint ventures with U.S. manufacturers.)

	Median Response	
	Number of Companies	Thousands of Units
1987	2	400
1990	3	500
1992	3	600
	Interquartile Range	
1987	2/3	400/400
1990	3/3	500/550
1992	3/4	550/650

Selected Comments from Panelists

Honda, Nissan, Toyota.
Nissan will be into passenger car assembly by 1987.
Honda, Nissan, Mitsubishi (perhaps Toyota).
I look for either Isuzu or Daihatsu to come in by 1990.
Honda, GM-Toyota, Nissan (Perhaps Chrysler-Mitsubishi or Ford Toyo-Kogyo).

Mkt-23 Discussion

It is forecast that by 1992 there will be three Japanese companies with assembly facilities in the United States, producing 600,000 passenger cars. Interquartile ranges here are close.

Discussion of Panelists' Comments

Panelists' comments suggest additional Japanese companies that may be manufacturing passenger cars in the U.S.

Comparison of Vehicle Manufacturer and Supplier Panelists

Replies from the two groups were essentially the same.

Trend From Two Delphi Surveys

The forecast of three Japanese companies with passenger car facilities in the United States in 1990 is identical to the 1990 forecast made two years ago in Delphi II.

Strategic Considerations

The estimate of Japanese production in the United States is equal to the total production forecast for all foreign vehicle manufacturers of passenger cars in the United States as shown previously in question Mkt-22.

Mkt-24. How many Japanese companies will have U.S. truck assembly facilities? How many trucks will they assemble in the U.S. in these years? (Include joint ventures with U.S. manufacturers.)

	Median Response	
	Number of Companies	Thousands of Units
1987	1	175
1990	2	200
1992	2	240
	Interquartile Range	
1987	1/1	150/185
1990	1/2	200/200
1992	2/2	200/250

Selected Comments from Panelists

High U.S. production cost will discourage high production here.
Nissan followed by Honda.
Honda will be into trucks by 1987 or Toyota will build them on west coast by 1987.
Possibly Hino trucks.
No joint ventures with U.S. manufacturers.

Mkt-24 Discussion

By 1992, panelists expect two Japanese companies to be producing 240,000 units per year. Interquartile ranges show good consensus on these predictions.

Discussion of Panelists' Comments

Panelists' comments suggest additional Japanese companies that may be manufacturing trucks in the U.S.

Comparison of Vehicle Manufacturer and Supplier Panelists

Replies from the two groups were essentially the same.

Trend From Two Delphi Surveys

The forecast shown here of two Japanese companies producing trucks in the United States in 1990 is unchanged from the 1981 Delphi II survey prediction.

Strategic Considerations

The forecast of 240,000 Japanese truck units produced annually in the United States is only 10,000 units less than the forecast of 250,000 foreign trucks manufactured in total in the United States as shown in question Mkt-22.

Mkt-25. Quality has become a very important issue, particularly in comparing U.S.-produced vehicles to some foreign-produced vehicles. Rank-order (most important = 1) the quality factors you believe are most valuable to the U.S. consumer. Also rank them in the order that you think the consumer (rightly or wrongly) judges them.

	Median Response	
	Your Ranking	Consumer's Ranking
Fits and finishes	5	2
Basic structural integrity of body and chassis	5	9
Engine and drivetrain integrity and durability	3	7
Maintenance requirements	10	8
Corrosion resistance	8	9
Ride and comfort	6	5
Styling	7	2
Handling	7	8
Safety	9	10
Total car reliability	2	4
Fuel economy	7	4
Driveability	8	8
Emission level	13	13

	Interquartile Range	
Fits and finishes	2/8	1/4
Basic structural integrity of body and chassis	3/8	6/11
Engine and drivetrain integrity and durability	2/6	5/10
Maintenance requirements	6/11	6/11
Corrosion resistance	6/11	7/11
Ride and comfort	4/9	3/7
Styling	3/9	1/4
Handling	5/10	6/10
Safety	6/12	7/12
Total car reliability	1/5	2/7
Fuel economy	4/9	3/6
Driveability	6/10	6/9
Emission level	13/13	13/13

Selected Comments from Panelists

Fuel economy is overrated by consumer as it is not that different costwise between similar sized vehicles.
Ranking reflects average car; ranking would be different by segment.
Believe consumers are less technically oriented.
All factors tempered by price.

(Mkt-25 continued)

My ranked items are subjective except fits and finishes - which is objective. Usually the decision to purchase is based on objective items. Purchaser disappointment is usually based on subjective expectations.

Mkt-25 Discussion

Marketing panelists ranked 13 quality factors in the order in which they consider them to be of importance to the consumer and also in the order that they, the panelists, believe consumers themselves would rank them. Panelists place total car reliability as, in their view, most valuable to consumers but expect that consumers put both fits and finishes and styling ahead of reliability. The second most important item to the panelists is engine and drivetrain integrity and durability. They believe consumers would rank this item in 7th place. The experts rank fuel economy as tied at 7th place with styling and handling. In comparison, they expect consumers would rank fuel economy in a tie for fourth place with total car reliability.

Discussion of Panelists' Comments

The first comment is significant and treated at length in the analysis of question T-1. The fourth comment is fundamentally important. A car perfect in every respect would be unaffordable.

Comparison of Vehicle Manufacturer and Supplier Panelists

In the only major difference, vehicle manufacturer panelists rated safety significantly higher in the "Your Ranking" column than did supplier panelists.

Mkt-26. Check your estimate of how U.S. vehicles compare today and will compare in 1987, 1990, and 1992 with Japanese vehicles.

	American Cars Compared to Japanese				
	Quality	Today	1987	1990	1992
Fits and Finishes	Higher	0%	10%	17%	23%
	Same	15	75	75	69
	Lower	85	15	8	8
Basic Structural Integrity of Body and Chassis	Higher	53	58	49	54
	Same	28	32	51	46
	Lower	19	10	0	0
Engine & Drive-train Integrity and Durability	Higher	34	36	37	41
	Same	42	49	58	57
	Lower	24	15	5	2
Maintenance Requirements	Higher	19	27	35	39
	Same	44	68	60	55
	Lower	37	11	5	6
Corrosion Resistance	Higher	58	47	40	40
	Same	36	53	60	60
	Lower	6	0	0	0
Ride and Comfort	Higher	69	63	50	49
	Same	31	37	50	0
	Lower	0	0	0	0
Styling	Higher	21	28	36	35
	Same	51	68	60	62
	Lower	28	4	4	3
Handling	Higher	13	17	21	19
	Same	47	66	72	75
	Lower	40	17	7	6
Safety	Higher	79	73	62	58
	Same	21	27	38	37
	Lower	0	0	0	0
Total Car Reliability	Higher	15	15	25	35
	Same	23	51	60	54
	Lower	62	34	15	11
Fuel Economy	Higher	0	2	6	6
	Same	21	44	73	80
	Lower	79	54	21	14
Driveability	Higher	8	11	11	14
	Same	52	78	83	84
	Lower	40	11	6	2

(Mkt-26 continued)

	American Cars Compared to Japanese				
	Quality	Today	1987	1990	1992
Emission Level	Higher	18	14	12	15
	Same	67	76	82	79
	Lower	15	10	6	6

Selected Comments from Panelists

If you compared luxury to compact classes, you would get a different set of answers. I tried to average.
Depends on particular car and model.

Mkt-26 Discussion

Respondents were asked to apply the 13 quality factors ranked in the preceding questions to an estimate of how U.S. vehicles compare today and will compare in 1987, 1990, and 1992 with Japanese vehicles. Each quality rating merits individual inspection, but the general pattern is one of U.S. cars improving, either by increasing their higher quality margin or decreasing the Japanese advantage. By 1992, American cars are predicted to be of the same or higher quality on every factor except fuel economy.

Additional discussion is presented with question T-9.

Mkt-27. What is your estimate of the yearly growth rate, the percent change (+ or -), in size of the future U.S. aftermarket for these parts?

	Percent (+ or -) Yearly Growth Median Response			
	1985	1987	1990	1992
a. Spark Plugs	-1%	-1%	0%	0%
b. Exhaust Systems	1	1	1	0
c. Tires	2	2	2	2
d. Batteries	2	2	2	2
e. Shock Absorbers	1	1	1	2
f. Brakes & Related	2	2	2	2
g. Electronic-Electrical	5	5	5	6
h. Engine Tune-Up	1	1	2	1
Total* Parts Market	3	3	3	2

	Interquartile Range			
	1985	1987	1990	1992
a. Spark Plugs	-3/2%	-5/2%	-4/2%	-3/2%
b. Exhaust Systems	-1/3	0/3	0/3	-3/3
c. Tires	0/5	-1/3	0/2	0/3
d. Batteries	0/3	0/3	0/3	0/3
e. Shock Absorbers	0/4	0/5	0/4	0/5
f. Brakes & Related	0/4	0/3	0/4	0/6
g. Electronic-Electrical	1/8	2/8	2/7	1/10
h. Engine Tune-Up	-2/3	-3/3	0/3	0/3
Total* Parts Market	3/5	2/4	2/4	1/4

*Note that individual percentages do not add to the total, which is a separate estimate; a judgment-weighted average of the increases or declines in the total of all individual parts, including those not listed.

Selected Comments from Panelists

More vehicle maintenance will occur as average automobile life cycle will continue to increase.
Electronic ignition should reduce tune-ups.
I expect more stainless exhaust systems.

Mkt-27 Discussion

With the exception of spark plug and exhaust system sales in 1992, panelists forecast growth of between 1% and 6% per year aftermarket sales for the parts listed here. However, the interquartile ranges associated with these median estimates are relatively wide. Except for electronic-electrical parts and the total parts market, the respondents' lower quartile estimate is zero or negative in all years. However interpreted, these data indicate that

(Mkt-27 continued)

respondents do not expect substantial growth in the aftermarket for parts during the next 10 years.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median replies from the two groups were either identical or very close.

Comparison of Replies to Mkt-27 and T-56

For a comparative analysis of the replies to this question, which was also asked of Technical panelists, see the discussion under T-56. Marketing panelists are more optimistic about aftermarket growth than are Technical panelists.

Trend From Three Delphi Surveys

The 3% anual growth rate (2% in 1992) forecast for total parts is higher than the growth rates indicated two years ago in Delphi II but lower than the 5% forecast in the 1979 Delphi I survey.

Mkt-28. What percent of the U.S. automotive supplier industry's output* will be sold to the following markets?

A. MEDIAN RESPONSE

	Sold To Vehicle Manufacturers					
		Within U.S.				
	Outside U.S.	U.S.-Owned	Foreign-Owned	Sub-Total	Sold To After-Market	Grand Total
Actual 1980**	5%	60%	5%	65%	30%	100%
1985	5	60	5	65	30	100
1987	5	60	5	65	30	100
1990	5	58	7	65	30	100
1992	5	58	7	65	30	100

B. INTER-QUARTILE RANGE

	Sold To Vehicle Manufacturer				
		Within U.S.			
	Outside U.S.	U.S.-Owned	Foreign-Owned	Sub-Total	Sold To After-Market
Actual 1980**	3/5%	44/76%	2/5%	52/80%	20/40%
1985	2/7	41/74	4/7	51/80	17/40
1987	3/8	38/74	4/10	50/79	16/45
1990	3/10	35/74	5/10	50/78	18/45
1992	3/10	55/73	5/10	50/76	20/45

* On a dollar-volume basis, including parts, materials, etc.
** Panelists' estimate.

Selected Comments from Panelists

Primarily Canada outside U.S.
See very little U.S. supplier sales to outside U.S. market unless joint venture--especially in Japan.
Assume you mean U.S. suppliers' U.S. output.

Mkt-28 Discussion

This table is most conveniently analyzed from right to left. For all years under consideration, including the actual year of 1980 and the forecast years of 1985 through 1992, panelists estimate that U.S. automotive suppliers sell 30% of their output to the aftermarket, 65% within the U.S., and 5% outside the U.S. Sales within the U.S. are approximately 60% to U.S.-owned companies and the remainder to foreign-owned facilties.

Although median forecasts change little from year to year for any one of these categories, it is apparent from the interquartile ranges, which are moderatly wide, that there are several opinions about the market breakdown of sales by U.S. automotive suppliers.

(Mkt-28 continued)

Comparison of Vehicle Manufacturer and Supplier Panelists

Both groups made identical median forecasts of 5% for parts sold to Vehicle Manufacturers outside the U.S. in each of the forecast years. There were significant differences between the two groups in their forecast of the percentage of parts to be sold to Vehicle Manufacturers within the U.S. The manufacturer panelists' forecast of parts sold to vehicle manufacturers within the U.S. which are U.S.-owned is one-third less than the supplier panelists' prediction. In contrast, the manufacturers see about twice the share of business from U.S. supplier output going to foreign-owned manufacturers in the U.S., as do the supplier panelists. Also, the manufacturers see a significantly larger share of the U.S. suppliers' business going to the aftermarket. The fairly wide differences of opinion between the two groups tend to parallel and help to explain the rather broad interquartile ranges shown in the table.

Strategic Considerations

The U.S. vehicle manufacturers and their suppliers have significantly different expectations regarding the structure of the market for the output of suppliers located in the U.S.

Mkt-29. If there is no local content law for the U.S., what percent of the parts purchased (dollar volume basis) by domestic U.S. vehicle manufacturers (including VW and Japanese) will be sourced outside the U.S. for 1987, 1990, and 1992?

	Percent of Parts Sourced Outside U.S. Median Response		
Outside Parts Source	1987	1990	1992
Canada	8%	8%	7%
Western Europe	3	3	2
Japan	6	8	9
Other Asia	1	2	2
Mexico & South America	5	6	8
Other	0	0	0
Total	23%	27%	28%

	Interquartile Range		
Outside Parts Source	1987	1990	1992
Canada	7/8%	7/8%	7/9%
Western Europe	3/3	3/3	2/3
Japan	6/9	8/10	9/11
Other Asia	0/1	2/2	2/4
Mexico & South America	5/5	6/7	7/8
Other	0/0	0/0	0/0

Selected Comments from Panelists

American suppliers will improve their quality constantly and some purchases will be political.
Includes own in-house production.
Increases due to cost advantages.
If 2 million engines are imported from Mexico, their percentage could increase greatly.
25% of engines will come from outside U.S. by 1985.
Percent will continue to increase until U.S. manufacturers get cost under control.
Depends on currency values, export subsidies, rebates, and import credits.
U.S. manufacturers will be looking for low-cost offshore operations.
Suppliers will be forced to supply OEM's from low-cost labor areas.

Mkt-29 Discussion

Parts purchases outside the U.S. by domestic U.S. vehicle manufacturers are forecast to expand to 23% in 1987, 27% in 1990, and 28% in 1992. The Canadian share is expected to hold at 7% to 8%, while the Japanese share increases from 6% to 9%. The Mexican-South American share is predicted to grow from 5%

(Mkt-29 continued)

in 1987 to 8% in 1992. The interquartile forecast ranges are fairly tight around most of the median predictions.

Discussion of Panelists' Comments

The comments mention reasons for sourcing out of the U.S., but also touch on factors that may modify these pressures.

Comparison of Vehicle Manufacturer and Supplier Panelists

All median replies were essentially the same.

Comparison of Replies to Mkt-29 and T-67

For a comparative discussion of this question, asked of both the Marketing and Technical panelists, see T-67.

Trend From Two Delphi Surveys

In the 1979 Delphi I survey the Marketing panelists forecast 15% of parts purchased by the U.S. vehicle manufacturers would be from outside the U.S. In 1981, at the time of the Delphi II Survey, Marketing panelists forecast that 14% of the U.S. vehicle manufacturers' parts purchases would be imported by 1990. Now the forecast is for 27%, a significant and substantial increase. Within the last two years, the Marketing panelists' viewpoint has fallen into line with that held by the Technical panelists.

Strategic Considerations

There is a growing consensus among automotive experts that U.S. vehicle manufacturers' parts purchases outside the U.S. will increase substantially over the next decade unless, of course, important changes occur in U.S. productivity, local content legislation is passed, etc.

Mkt-30. If there is no local content law for the U.S., what percent of the parts and materials sold (dollar volume basis) by domestic U.S. suppliers (including foreign-owned) will be sourced outside the U.S. for 1987, 1990, and 1992?

	Percent of Parts Sourced Outside U.S. Median Response		
Outside Parts Source	1987	1990	1992
Canada	6%	6%	6%
Western Europe	2	2	2
Japan	5	5	5
Other Asia	1	2	2
Mexico & South America	5	5	5
Other	0	0	0
Total	19%	20%	20%

	Interquartile Range		
Outside Parts Source	1987	1990	1992
Canada	6/6%	6/6%	6/7%
Western Europe	2/3	2/3	2/3
Japan	5/6	5/8	5/10
Other Asia	1/1	2/3	2/3
Mexico & South America	5/5	5/7	5/8
Other	0/0	0/0	0/0

Selected Comments from Panelists

Local content laws will not help.
Depends on trade laws, subsidies, rebates, export bonuses, etc.

Mkt-30 Discussion

U.S.-based suppliers of parts and materials will parallel vehicle manufacturers in their purchase of parts outside the U.S. Supplier imports are expected to increase from 19% in 1987 to 20% in 1990 and 1992. In most cases, the interquartile range forecasts are close, indicating a tight consensus.

Comparison of Vehicle Manufacturer and Supplier Panelists

Each of the median forecasts by the supplier panelists was identical to its counterpart made by the vehicle manufacturer panelists.

Comparison of Replies to Mkt-30 and T-68

See Technical panel question T-68 for a comparative analysis of replies to this question from both the Marketing and Technical panelists.

Mkt-31. What percentage of U.S.-produced automotive parts and materials will be sold to foreign vehicle manufacturers in the future? (On a dollar volume basis).

	Percent of Sales to Foreign-Owned Vehicle Manufacturers	
Foreign-Located	Median Response	Interquartile Range
1985	2%	2/2%
1987	2	2/3
1990	4	3/4
1992	5	3/5
U.S.-Located		
1985	5%	5/5%
1987	5	5/6
1990	7	6/8
1992	10	7/10

Selected Comments from Panelists

Protectionism will not change.
No growth for U.S. companies due to protectionism.

Mkt-31 Discussion

Marketing panelists do not believe that foreign vehicle manufacturers represent a large market for U.S.-produced automotive parts and materials. By 1992, they foresee only 5% of U.S.-produced parts and materials being sold to foreign-located vehicle manufacturers and another 10% sold to foreign-owned vehicle manufacturers located in the U.S. The interquartile ranges show a good degree of consensus.

Comparison of Vehicle Manufacturer and Supplier Panelists

Replies were essentially the same.

Trend From Three Delphi Surveys

In the 1979 Delphi I survey it was forecast that sales to foreign-owned vehicle manufacturers might total about 3 or 4% of total U.S. auto parts production by 1990. This percentage estimate was raised to 8% in the 1981 Delphi II survey but in the present study has dropped back to 4% for the 1990 forecast.

Mkt-32. What percent of their components, parts, and materials (cost basis) will Japanese vehicle manufacturers buy in in the U.S.?

Median Response	Percentage For Vehicles Manufactured in: Japan	Percentage For Vehicles Manufactured in: U.S.	Percentage of U.S. Service Parts
1985	1%	10%	5%
1987	2	20	9
1990	3	24	10
1992	3	30	12
Interquartile Range			
1985	1/1%	10/10%	4/5%
1987	1/3	15/22	6/9
1990	2/3	20/25	7/10
1992	2/3	25/40	8/12

Selected Comments from Panelists

Token amount going into Japan.
U.S. quantities increase as credibility improves.
U.S. just can't meet Japanese costs and prices.
Believe Japanese will buy from Japanese vendors manufacturing in U.S.
Japan will continue to protect their home suppliers.
Nothing imported into Japan if available there.

Mkt-32 Discussion

Respondents are far more optimistic about the opportunity for selling components, parts, and materials to Japanese vehicle manufacturers with operations in the U.S. than in Japan. By 1992 it is expected that 30% of the purchases by such organizations will be sourced here. A smaller but significant 12% of service parts for Japanese vehicles are also expected to be sourced in the U.S. in 1992. Interquartile ranges are quite close on these estimates.

Discussion of Panelists' Comments

The comments support the low forecast of Japanese imports of parts from the U.S.

Comparison of Vehicle Manufacturer and Supplier Panelists

Replies were essentially the same.

(Mkt-32 continued)

Strategic Considerations

Panelists are doubtful that Japan will be a significant market for U.S.-produced parts, components, and materials. Also, note the fourth comment: Japanese vehicle manufacturers who produce vehicles in the U.S. may bring their suppliers with them. A Japanese plastics parts manufacturer, in its first U.S. venture, has already announced plans to build a plant to supply the Nissan truck operation in Tennessee.

Mkt-33. What will happen to the average life of new cars and the length of time new car buyers keep their cars?

	Est. 1981	Median Response 1987	1990	1992
Average Life of New Cars	11 yrs.	12 yrs.	12 yrs.	13 yrs.
Length of Ownership of New Car Buyers	3+	4.0	4.5	5.0

	Interquartile Range 1987	1990	1992
Average Life of New Cars	11/12 yrs.	12/13 yrs.	12/15 yrs.
Length of Ownership of New Car Buyers	4.0/4.5	4.0/5.0	4.0/6.0

Mkt-33 Discussion

The average life of new cars in the U.S. is expected to increase from the estimated 1981 level of 11 years to 12 years in 1987 and 1990 and then 13 years in 1992. New car buyers, who now keep their new car for a little over three years, are expected to retain ownership for up to five years by 1992. The interquartile ranges indicate fairly close agreement on these median estimates.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median results were essentially the same from both groups.

Trend From Two Delphi Surveys

This question was asked of the Marketing panelists in the 1981 Delphi II Survey. At that time the forecasts for 1990 were 14 years for the average life of new cars and 5 years' ownership by new car owners. The decline from 14 to 12 years does not suggest a reversal of the trend to longer car life but indicates that panelists now forecast the trend to be more moderate than previously believed.

Strategic Considersations

Car sales and car life are directly related. An increase in vehicle life of one year can be interpreted to mean that during the period in which the longevity increase took place there was a loss of sales approximately equal to an average year's sales during the period. At the extreme, in a year such as 1943 when essentially no cars were sold to civilians and few were scrapped, the average age increased one year during the year.

(Mkt-33 continued)

We believe the increases forecast are very significant and likely to require major strategic changes on the part of the manufacturers. Technological factors such as improved corrosion protection support the notion of longer expected life but may have little effect on the length of new car ownership.

Mkt-34. Historically, major body changeovers were made every 3 to 4 years but are getting farther apart. On the average, how long will U.S. passenger car model runs be on cars introduced in the following years?

	Length of Model Run	
Introduction Year	Median Response	Interquartile Range
1987	5 yrs.	4/5 yrs.
1990	5	5/6
1992	5	5/7

Selected Comments from Panelists

I believe we will work back roughly to the 4-year cycle of auto and truck production.

Too costly any more to change every 3-4 years.

Average car; frequency of changeover varies by segment.

New technology changes will become more rapid, keeping model-run lengths at about 5 years.

Re-skins will be more popular. Major body changes and expensive further downsizing will not be critical.

Mkt-34 Discussion

Model runs are expected to be five years, on the average, over the next decade. There is good consensus on these forecasts.

Comparison of Vehicle Manufacturer and Supplier Panelists

Replies were essentially the same on this question.

Comparison of Replies to Mkt-34 and T-63

In answer to question T-63, shown earlier, the Technical panelists forecast a six-year model run by 1990.

Trend From Two Delphi Surveys

Reflecting a return to more normal sales (and optimism) within the industry, the 1990 forecast of five years for the length of the model run in this survey contrasts with the eight-year forecast made two years ago at the time of the 1981 Delphi II Survey.

Strategic Considerations

The shorter the model run, the more opportunities there are for suppliers to gain or lose contracts. In addition, faster-paced model changes could restore some aspects of the more frequent model changes common in the 50's & 60's. However, at that time there were fewer models available. Certainly, short model runs suggest that automobiles are likely to be treated less like a "commodity" purchase than many believed a few years ago.

Mkt-35. With cars being downsized, will the use of trailers decrease, because of declining towing capacity, or increase, because of the need to transport more than the car will hold?

	Percent of Replies	Percent Change: Median Response	Percent Change: Interquartile Range
Increase	65%	+5%	0/10%
Decrease	35	-13	-20/-10
	100%		

Selected Comments from Panelists

This increase represents small, cargo-type trailers that may also serve as a crude camper (pup-tent type).
Families are also smaller; thus those who need or want trailers will not change.
Trailer towing accounts for an insignificant use (2%) of passenger cars.
Light trailer use will increase, offsetting decreasing use of heavier trailers (e.g., house trailers).
Those needing high trailer towing capability will have a light truck or used car for a second vehicle.

Mkt-35 Discussion

As indicated in the wording of this question, there are conflicting trends affecting the use of trailers with passenger cars in the U.S. market. 65% of the respondents expect a 5% increase in the use of trailers. On the other hand, 35% expect a 13% decrease in the use of trailers. Actual market direction will probably depend largely on the ingenuity of trailer manufacturers in providing trailers and attachments suitable for the smaller cars becoming prevalent in the U.S. Also, the vehicle manufacturers may provide more trailer-towing packages if the market demands them.

Comparison of Vehicle Manufacturer and Supplier Panelists

There were no significant differences in the percent choosing an increase or decrease in the use of trailers.

Comparison of Replies to Mkt-35 and T-57

The responses from the two groups were about the same.

Mkt-36. What specific applications are likely for electric vehicles in 1987? In 1990? In 1992?

	Percent of Total Responses		
	1987	1990	1995
Intracity Commercial (delivery/taxis)	27%	34%	30%
Government/Postal	11	10	8
Intercity Commercial (intermediate range)	11	10	11
Urban/Personal Commuter (limited range)	14	29	39
Specialty Vehicles *	10	10	8
No Application	13	5	3
Others **	14	2	1
	100%	100%	100%

* Baggage handling, golfcarts, specialty service vehicles, vans.

** Government-sponsored demos, experimental vehicles

Mkt-36 Discussion

In the relatively short term, through 1987, the primary application for electric vehicles in the U.S. is seen in intracity commercial uses such as delivery vans and taxis; 27% of the responses were in this category. The major change seen over the decade is a growth in the use of urban/personal commuter electric vehicles, from 14% of total electric vehicle use in 1987 to 39% in 1992.

Trend From Two Delphi Surveys

When this question was asked two years ago in the Delphi II Survey, the leading reply was commuting for all future years. In this most recent study, commuting is seen as a mid-range use in 1987 with 14% of the responses, but by 1995 it is the leading category with 39%.

Mkt-37. When will electric car, van, and truck production get firmly started in the U.S.?

	Median Response	Interquartile Range
Cars *	1990	1990/1995
Trucks and Vans **	1990	1988/1995

* Year production reaches 10,000 units
** 5,000 annual output.

Selected Comments from Panelists

Electric power market penetration will not happen unless dramatic breakthroughs occur in battery storage capacity and improved recharge time.

Mkt-37 Discussion

Electric vehicle production is expected to get firmly started in the United States in 1990, as defined by annual production of 10,000 passenger cars and 5,000 trucks and vans.

Comparison of Vehicle Manufacturer and Supplier Panelists

The manufacturer panelists are less optimistic than the suppliers regarding electric vehicles and provided median estimates that were from two to four years longer than those given by supplier panelists.

Comparison of Replies to Mkt-37 and T-18

The Marketing panel median estimate for cars, shown here as 1990, is two years ahead of the 1992 forecast given by the Technical panel. Both groups agree on the 1990 year for trucks and vans.

Strategic Considerations

The forecast years of significant but modest production of electric vehicles in the U.S. are so far away that even if they prove to be correct there will not necessarily be any near-term development work on such vehicles.

Mkt-38. If the retail prices of diesel fuel and unleaded gasoline are about the same, what price premium will consumers pay for diesel-engine-equipped vehicles?

	Price Premium Median Response		
	1987	1990	1992
Passenger Cars	$200	$200	$200
Light Trucks	300	400	400

	Interquartile Range		
	1987	1990	1992
Passenger Car	$50/200	$100/200	$100/200
Light Trucks	150/300	200/400	200/400

Selected Comments from Panelists

The whole premise of diesels is low-cost fuel. Without it, you have no market.
Diesels are developing a bad image due to initial problems and lack of fuel price differential. They are not cost-effective for the average driver.
Darn little if any.
Assuming improvements in USA-produced diesel engines.
They won't beyond 1986.
They're paying $500 now!

Mkt-38 Discussion

Over the next decade, consumers are expected to pay a premium of $200 for diesel-equipped passenger cars and $300 to $400 for light trucks. These forecasts assume that diesel fuel and unleaded gasoline will be priced about the same at the retail level. As indicated elsewhere in this report, however, predictions as to the number of diesel car buyers have declined sharply.

Comparison of Vehicle Manufacturer and Supplier Panelists

Price premium estimates were approximately the same for both groups.

Strategic Considerations

A key point to keep in mind is that the diesel is inherently a more expensive engine that the gasoline engine. Consequently, unless the market perceives sufficient added value to justify a price premium, the diesel faces difficult times.

Mkt-39. Among diesel-engine-equipped vehicles sold in the U.S. and Canada, what percentage will be imported from outside North America?

	Percent Imports Median Response		
	1987	1990	1992
Passenger Cars	20%	25%	25%
Light Trucks	10	10	10
Medium Trucks	10	10	10
Heavy & Extra-Heavy Trucks	5	5	5

	Interquartile Range		
	1987	1990	1992
Passenger Cars	20/20%	20/25%	20/30%
Light Trucks	10/10	10/10	10/10
Medium Trucks	10/10	10/11	10/10
Heavy & Extra-Heavy Trucks	3/5	5/5	5/5

Selected Comments from Panelists

Light truck estimates assume full-sized trucks will use U.S.-built V-8 diesels while compact trucks will use imported diesels.

Mkt-39 Discussion

Among diesel-equipped vehicles sold in the U.S. and Canada, panelists forecast that in 1992 engines will be imported for 25% of passenger cars, 10% of light and medium trucks, and 5% of heavy and extra-heavy trucks. The interquartile ranges in these forecasts are fairly tight.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median replies were very close.

Mkt-40. U.S. sales declined in 1982 for vehicles equipped with diesel engines. List the three leading factors that contributed to this decrease.

Passenger Cars	Percent Of Total Responses
High price of diesel fuel vs. gasoline (decrease in price of gasoline)	33%
High initial sale price (premium cost of engine)	12
Maintenance difficulties	8
Performance problems	8
Noise/odor	7
Reliability/durability	5
Poor image/experience	5
Problems associated with engine operation	4
Increased fuel supply/stability of price	3
Particulant emissions	2
Cost of maintenance	2
No real $ savings/cost recovery	2
Cold weather starting problems	2
Improved fuel economy of gas engine	2
Quality of engine	2
Fewer repeat buyers	2
Cold weather stalling	*
Recession	*
	100%

Light Trucks	Percent Of Total Responses
High price of diesel fuel vs. gasoline (decrease in price of gasoline)	33%
High initial sales price (premium cost of engine)	17
Maintenance difficulties	6
Performance problems	5
Noise/odor	6
Reliability/durability	5
Poor image/experience	6
Problems associated with engine (mechanical difficulties)	5
Increase in fuel supply/stability of price	4
Particulant emissions	2
Cost of maintenance	2
No real $ savings/cost recovery	4
Cold weather starting problems	2

(Mkt-40 continued)

Light Trucks	Percent Of Total Responses
Improved fuel economy of gas engine	*
Quality of engine	*
Fewer repeat buyers	*
Economy	*
Inadequate power from 4-cylinder units	*
	100%

* Indicates single response

Mkt-40 Discussion

Respondents were asked to list their opinion of the three leading factors that contributed to decreased diesel sales in 1982. For both cars and trucks the main factors were considered to be the high price of diesel fuel relative to gasoline and the declining absolute cost of gasoline. The problem is not only that diesel fuel and gasoline cost about the same, but that gasoline prices per se are lower and make the familiar gasoline engine more attractive compared to the relatively unknown diesel. Other factors listed include the high initial sales price of the diesel, maintenance difficulties, performance problems, etc.

Comparison of Replies to Mkt-40 and T-30

Replies to this question, asked of both the Technical and Marketing panels, show in each case a concentration on the price relationship of gasoline and diesel fuel as the main factor in declining diesel sales.

Mkt-41. Within the next 10 years, who (in addition to General Motors and I.H.C.) will produce diesel engines in the U.S. and Canada for passenger cars and light trucks?

	Percent of Total Responses
Ford	30%
Chrysler	20
Cummins	10
No One	10
Caterpillar	4
Perkins	4
AMC/Renault	4
VW	4
Toyota	*
Nissan	*
Consolidated Diesel	*
BMW	*
Volvo	*
Current manufacturers with product knowledge capabilities	*
GM may discontinue	*
	100%

* Single response

Mkt-41 Discussion

In addition to General Motors and IHC, it is expected that in the next 10 years Ford, Chrysler, Cummins, and possibly others will produce diesel engines in the U.S. for passenger cars and light trucks. Note, however, that 10% of the respondents forecast there will be no additional producers.

Mkt-42. It has been suggested that vehicle size will cease to be a primary distinguishing feature of U.S.-produced passenger cars in the years ahead. In your opinion, what other features will be used to distinguish vehicles from one another in order to obtain product differentiation between various vehicle makes and within classes of a given manufacturer's overall product line? Please rank (1 = most emphasis) the following seven nonsize features that might be used.

	Rank	
	Median Response	Interquartile Range
Design/styling (shape, form, paint, trim, image)	1	1/2
Comfort (plushness, ride, sound control, options)	4	2/5
Economics (price, mpg, financing, warranties)	3	2/4
Utility (vehicle function, range, safety, performance)	5	3/6
Engine/drivetrain (front/rear-wheel drive, engine size, fuel, turbo/supercharging)	4	3/6
Durability (reliability, corrosion resistance, serviceability)	5	4/7
Technical innovation (electronics, aerodynamics)	5	3/6

Selected Comments from Panelists

Don't agree that size will not be a factor. U.S. is unique in that niche and does not have severe tax penalties of others.

Mkt-42 Discussion

As large size becomes less characteristic of U.S.-produced passenger cars, it is expected that design and styling will become the number-one distinguishing feature within classes. Price is forecast to be next in importance, followed by comfort and the engine/drivetrain options. Note that technical innovations share last place with utility and durability.

Discussion of Panelists' Comments

The single comment merits consideration.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median response rankings were similar for both groups.

Trend From Two Delphi Surveys

The ranking of these distinguishing vehicle features has changed little since the 1981 Delphi II Survey.

Mkt-43. What new product concepts have the most growth potential? List in order of potential--highest first.

	Percent Of Total Responses For Each Choice		
Order of Potential:	1st	2nd	3rd
Electronics	33%	*%	16%
CVT (Continuously Variable Transmission	10	7	11
Mini-vans	7	*	*
Small pickups	5	-	-
Function monitoring	5	*	-
On-board computers	*	17	*
Aerodynamics	*	7	-
Alternative fuels	*	7	*
Mini-compacts	*	7	*
Turbocharging	-	15	*
Comfort items	*	*	*
Maintenance-free [reduced] vehicles	*	*	-
Turbine engines	*	-	-
Electronic ignition	*	-	-
Diesel particulate traps	*	-	-
Electronic satellite location maps	*	-	-
5-door vehicles (hatchbacks)	*	-	-
Ride management	*	-	-
"Statistical Process Control"	*	-	-
Multi-point fuel injection	*	-	-
Total product quality commitment	*	-	-
Plastics	-	7	-
"Sporty" cars	-	*	*
Four-wheel drive vehicles	-	*	-
Fiberglas reinforced springs	-	*	-
Composite materials	-	*	-
High-tech sound systems	-	*	-
Bird cage construction	-	*	-
Corrosion protection	-	-	11
Safety	-	-	11
Power storage flywheel	-	-	*
Convertibles	-	-	*
New tire technology	-	-	*
Technological enhancements	-	-	*
	100%	100%	100%

* Indicates single response

(Mkt-43 continued)

Mkt-43 Discussion

Respondents were asked to give three choices for new product concepts that have the most growth potential. Electronics were far and away the leader, garnering 33% of the first-choice votes. The CVT or continuously variable transmission was in second place among the first choices. Mini-vans took third. On-board computers and turbocharging were second-choice leaders. Among third choices, electronics again took first place.

Other than the obvious lead for electronics, the percentage differences between these various mentions are not highly significant. Of more importance, the entire list provides thought starters for those interested in new product concepts with growth potential.

Stategic Considerations

We have observed before that a suggestion with only one vote may be important because of the unique knowledge or vision of that respondent. He or she may know something. Moreover, any given suggestion may trigger the reader's mind to a potential opportunity.

Mkt-44 Check whether you believe there will be more, or less vertical integration among U.S. motor vehicle manufacturers in the future, compared to 1982.

Vehicle Manufacturers	Percent of Replies 1987	1990	1992
More vertical integration	21%	23%	20%
Less vertical integration	67	54	49
No change	12	23	31
	100%	100%	100%

Selected Comments from Panelists

Cost of capital will result in less "in-house."
Trend is toward less: short term.

Mkt-44 Discussion

Compared to the base of 1982, less vertical integration is expected among vehicle manufacturers in all three of the forecast years. However, the data suggest a softening in this trend as the decade progresses. These trends recognize that the vehicle manufacturers are now short of capital and more dependent on suppliers. As their profits improve and their financial picture becomes stronger, they may be able to reintegrate.

Comparison of Vehicle Manufacturer and Supplier Panelists

Significant differences appear between the two groups. It is largely supplier panelists who are expecting significantly less vertical integration among vehicle manufacturers in 1987. Among vehicle manufacturer panelists themselves there is a 50/50 tie regarding the question of more or less vertical integration in 1987. In subsequent years vehicle manufacturers forecast more integration. The forecast pattern among supplier panelists is just the opposite.

Trend From Three Delphi Surveys

Panelists in both of the two previous surveys, taken in 1979 and 1981, agreed there would be less vertical integration within vehicle manufacturers in 1990. There were no significant differences between manufacturer and supplier panelists on replies to this question and the percentage voting for less integration (approximately 50% to 60%) was about the same as shown for the totals here.

Strategic Considerations

Panelists representing the vehicle manufacturers are forecasting that the trend to less vertical integration among vehicle manufacturers is weaker than once predicted. Expectations of greater supplier participation in the design and development process should be reviewed frequently as actual trends develop.

Mkt-45. Check whether you believe there will be more, or less vertical integration among U.S. automotive parts supplier companies in the future, compared to 1982.

Automotive Suppliers	Percent of Replies 1987	1990	1992
More vertical integration	44%	48%	41%
Less vertical integration	20	26	22
No change	36	26	37
	100%	100%	100%

Selected Comments from Panelists

More suppliers will try to control distribution, especially by acquiring interest in groups, repair outlets.

Mkt-45 Discussion

Among automotive suppliers, more vertical integration or no change are the major expectations. Only 22% to 26% of the respondents think that there will be less vertical integration.

Comparison of Vehicle Manufacturer and Supplier Panelists

Replies were close and without significant differences.

Trend From Three Delphi Surveys

Forecasts made for 1990 in two earlier Delphi Surveys indicate that the present prediction of 48% greater vertical integration among suppliers is essentially the same as the forecast of two years ago but less than the 63% predicted for the period 1985-90 in Delphi I, taken in 1979.

Mkt-46. What are your estimates of the percent and future percentages (dollar volume basis) of parts, components, and materials that the following U.S. companies will produce in-house?

	Percent Produced In-House Median Response			
	Present	1987	1990	1992
AMC/Renault	40%	35%	30%	30%
Chrysler	40	35	30	30
Ford	50	45	40	40
GM	60	50	50	50
VW of America	45	40	35	35

	Interquartile Range			
	Present	1987	1990	1992
AMC/Renault	35/40%	30/35%	30/30%	30/30%
Chrysler	40/40	35/35	30/30	25/30
Ford	50/50	45/45	40/40	40/40
GM	60/60	50/55	50/50	50/50
VW of America	35/45	35/40	35/35	30/35

Selected Comments from Panelists

Slight increase because of pressures from the UAW.
Will trend away from basic commodity materials--but will trend more toward fabrication of components and assembling.
Outsourcing will increase in the next ten years.
They all will buy more and produce less to reduce capital spent and concentrate on what they do best, design and assemble cars.
Due to pricing pressures and need to be price-competitive with Japanese and other importers, would expect U.S. companies to look more and more for lowest cost producer.

Mkt-46 Discussion

The percent of in-house production by American manufacturers is expected to decline across the board. Changes shown here are in accord with forecasts in Mkt-44 that there will be no increase in vertical integration among U.S. motor vehicle manufacturers. Interquartile range forecasts for the median predictions shown here indicate close consensus.

Comparison of Vehicle Manufacturer and Supplier Panelists

Median replies for the two groups were identical or essentially the same for each forecast.

(Mkt-46 continued)

Trend From Two Delphi Surveys

This question was also asked in the 1981 Delphi II Survey. The 1990 forecasts, made at that time, were 38% for AMC/Renault, 25% for Chyrsler, 35% for Ford, and 45% for GM. We did not ask about VW of America. These replies show little change over the last two years.

Strategic Considerations

The "Comparison of Vehicle Manufacturer and Supplier Panelists" accompanying Mkt-44 discusses conflicting replies to that related question. Such uncertainty requires close future monitoring.

Mkt-47. Major U.S. vehicle manufacturers have announced objectives that include the concentration (or re-concentration) of suppliers in the Great Lakes region. What is your opinion pro and con, of such plans. Please answer in three or four sentences.

Distribution of Response

44%	=	Pro
33	=	Pro (with conditions)
20	=	Con
3	=	Other
100%		

Pro, comments cite following advantages:

(a) Decrease in inventory costs and capital expenses requirements.
(b) Decrease in costs and increased efficiency of inbound transportation.
(c) Economic advantages of KANBAN (Just-in-time).
(d) Availability of large pool of skilled labor.

Also mentioned: availability of underused manufacturing capabilities; increased stability of relationship between suppliers and manufacturers; address social problems in area.

Major conditions attached to Pro comments:

(a) Need changes in labor legislation, decrease restrictive union work rules, decrease in labor costs.
(b) Address reluctance of suppliers to relocate without assurances of volume of business, price escalation agreements protection from low-cost foreign manufacturers (e.g., plans to have component plants in Mexico, etc.).

Con, comments cite following disadvantages:

(a) Adverse labor climate in region, high labor costs.
(b) Market shifts/industry moving away from region.
(c) Reluctance of suppliers to move vs warehousing (U.S. version of Just-in-time), order-entry systems.
(d) Weather.

Also mentioned: size of country, population problems, concentration of targets in case of war.

Other opinions include: "The idea is probably short-range. Given a return of higher volumes, production and assembly will again spread out....."
"...buying decisions will still come down to delivered cost and service."

Mkt-47 Discussion

Although opinion appears to be generally favorable to reconcentration it probably will not take place to any great extent unless the major conditions (attached to Pro comments) are met.

Comment c under Con defines warehousing (near the vehicle manufacturer) as a form of just-in-time inventory. In the sense of timely and frequent delivery this is true, but the concept misses the point of keeping all inventories low to avoid mistakes piling up.

See question T-64 for additional comments and discussion.

Mkt-48. Check whether you believe there will be more or fewer U.S. automotive supplier* firms in the future.

Number of U.S. Suppliers	Percent of Replies 1987	1990	1992
More Firms	6%	8%	8%
Fewer firms	81	73	59
No change	13	19	33
	100%	100%	100%

*Including firms supplying parts, components, materials, etc.

Selected Comments from Panelists

Parts suppliers may become more and more specialized.
Foreign competition for U.S. market as a result of cheap labor and artificially stimulated exports into U.S. will drive many out of vehicle supply business.
More in-house manufacturing in future years.
Supplier shakeout will be severe in next five years.

Mkt-48 Discussion

At the most, 8% of the respondents forecast more supplier firms in the U.S. in the future. They expect 81% percent fewer firms in 1987. The estimates for 1990 and 1992 are a little less pessimistic, but, clearly, panelists foresee a decline in the number of U.S. automotive suppliers.

Comparison of Vehicle Manufacturer and Supplier Panelists

The two groups gave approximately the same replies although the vehicle manufacturers are slightly more optimistic than the suppliers about the number of future supplier firms.

Trend From Three Delphi Surveys

In this survey, for the 1990 forecast, 73% of the respondents predict fewer supplier firms. Two years ago in Delphi II, the percentage expecting fewer supplier firms was 68%, and in the 1979 Delphi I study it was 64%.

Mkt-49. What do you predict worldwide total motor vehicle production volume will be for these major vehicle manufacturers in the future?

Worldwide Motor Vehicle* Production in Millions of Units

	Est. 1981	Median Response 1985	1987	1990	1992
GM	6.8	7.3	7.6	7.9	8.0
Ford	4.4	4.8	5.0	5.2	5.3
Toyota	3.3	3.6	3.7	4.0	4.2
Nissan (Datsun)	2.8	3.0	3.0	3.3	3.3
VW	2.3	2.3	2.3	2.3	2.3
AMC-Renault	1.8	1.9	2.0	2.1	2.1
Peugeot-Citroen	1.6	1.6	1.6	1.6	1.6
Fiat	1.4	1.4	1.3	1.3	1.3
Toyo Kogyo (Mazda)	1.2	1.3	1.4	1.5	1.4
Chrysler	1.1	1.3	1.3	1.3	1.3
Honda	1.0	1.2	1.3	1.4	1.4
Mitsubishi	1.0	1.1	1.2	1.2	1.3
Daimler-Benz (Mercedes)	0.6	0.7	0.7	0.7	0.7
Subaru	0.6	0.6	0.6	0.7	0.7
British Leyland	0.5	0.5	0.4	0.4	0.4
Volvo	0.2	0.2	0.2	0.3	0.3

	Interquartile Range 1985	1987	1990	1992
GM	7.1/8.0	7.2/8.0	7.2/8.5	7.6/8.5
Ford	4.6/5.3	4.7/1.8	4.9/5.5	5.0/5.7
Toyota	3.4/3.9	3.5/4.1	3.5/4.4	3.6/4.5
Nissan (Datsun)	2.9/3.2	2.9/4.4	2.9/3.8	2.9/3.7
VW	2.2/2.5	2.1/2.6	2.2/2.6	2.2/2.7
AMC-Renault	1.9/2.1	1.9/3.3	1.8/2.4	1.8/2.4
Peugeot-Citroen	1.5/1.7	1.5/1.7	1.5/1.7	1.5/1.7
Fiat	1.2/1.5	1.2/1.5	1.2/1.5	1.2/1.6
Toyo Kogyo (Mazda)	1.2/1.5	1.3/1.6	1.3/1.7	1.1/1.7
Chrysler	1.1/1.5	1.1/1.5	1.2/1.6	1.3/1.7
Honda	1.1/1.3	1.2/1.5	1.2/1.6	1.2/1.6
Mitsubishi	1.1/1.3	1.1/1.3	1.1/1.4	1.0/1.5
Daimler-Benz (Mercedes)	0.6/0.7	0.7/0.9	0.6/0.9	0.6/0.9
Subaru	0.6/0.7	0.5/0.7	0.5/0.7	0.5/0.8
British Leyland	0.4/0.5	0.2/0.5	0.2/0.6	0.2/0.6
Volvo	0.2/0.3	0.2/0.3	0.2/0.3	0.2/0.4

* Includes passenger cars, trucks, and busses.

(Mkt-49 continued)

Selected Comments from Panelists

Total increasing 10% by `87, another 10% by `92. There's going to be a major shakeout by `87.

Mkt-49 Discussion

Among major free-world manufacturers, vehicle production in 1981 is estimated to have ranged from 6.8 million units for General Motors down to 200,000 units for Volvo. With the exceptions of Fiat and British Leyland, all manufacturers listed are forecast to maintain production or enjoy moderate growth through 1992. (Several lower-volume manufacturers such as Saab, BMW, and Porsche were not covered).

Comparison of Vehicle Manufacturer and Supplier Panelists

Most of the Supplier and Manufacturer Panelists' replies were identical and the exceptions were rarely more than 10% apart on these many forecasts.

Mkt-50. What do you predict worldwide passenger-car production volume will be for these major vehicle manufacturers in the future?

Worldwide Motor Passenger Car Production in Millions of Units

	Est. 1981	Median Response 1985	1987	1990	1992
GM	5.6	6.0	6.3	6.5	6.5
Ford	3.3	3.7	3.8	3.9	4.0
Toyota	2.2	2.4	2.5	2.7	2.8
Nissan (Datsun)	1.9	2.2	2.0	2.3	2.3
VW	2.0	2.0	2.0	2.0	2.0
AMC-Renault	1.5	1.6	1.7	1.8	1.8
Peugeot-Citroen	1.4	1.4	1.4	1.4	1.4
Fiat	1.2	1.2	1.1	1.1	1.1
Toyo Kogyo (Mazda)	0.8	0.9	1.0	1.1	1.0
Chrysler	0.9	1.1	1.2	1.3	1.1
Honda	0.9	1.1	1.2	1.3	1.3
Mitsubishi	0.7	0.8	0.9	0.9	1.0
Daimler-Benz (Mercedes)	0.4	0.5	0.5	0.5	0.5
Subaru	0.4	0.4	0.4	0.5	0.5
British Leyland	0.4	0.4	0.3	0.3	0.3
Volvo	0.2	0.2	0.2	0.3	0.3

Interquartile Range

	1985	1987	1990	1992
GM	5.9/6.6	6.0/6.5	6.2/6.8	6.3/6.8
Ford	3.5/4.0	3.6/4.0	3.7/4.0	3.8/4.2
Toyota	2.3/2.6	2.4/2.7	2.4/3.0	2.4/3.0
Nissan (Datsun)	2.0/2.2	2.0/2.3	2.0/2.7	2.0/2.6
VW	1.9/2.2	1.8/2.2	1.9/2.2	2.0/2.3
AMC-Renault	1.6/1.8	1.6/1.9	1.6/2.0	1.6/2.0
Peugeot-Citroen	1.3/1.5	1.3/1.5	1.3/1.5	1.3/1.6
Fiat	1.0/1.3	1.0/1.3	1.0/1.3	1.0/1.3
Toyo Kogyo (Mazda)	0.8/1.0	0.9/1.1	0.9/1.2	0.8/1.2
Chrysler	0.9/1.2	0.9/1.3	1.0/1.3	1.0/1.4
Honda	1.0/1.2	1.1/1.3	1.1/1.4	1.1/1.4
Mitsubishi	0.8/0.9	0.8/1.0	0.8/1.0	0.8/1.1
Daimler-Benz (Mercedes)	0.4/0.5	0.5/0.6	0.4/0.6	0.4/0.6
Subaru	0.4/0.5	0.4/0.5	0.4/0.5	0.4/0.6
British Leyland	0.3/0.4	0.2/0.4	0.2/0.5	0.3/0.5
Volvo	0.2/0.3	0.2/0.3	0.2/0.3	0.2/0.4

(Mkt-50 continued)

Mkt-50 Discussion

Among passenger car manufacturers, all companies except Fiat and British Leyland are forecast to maintain production or show some increase through 1992. On a percentage basis, the greatest growth is expected for Honda, Mitsubishi and Volvo.

Comparison of Vehicle Manufacturer and Supplier Panelists

Most of the Supplier and Manufacturer Panelists' replies were identical and the exceptions more rarely more than 10% apart on these many forecasts.

Mkt-51. What do you predict worldwide truck production volume will be for these major vehicle manufacturers in the future?

		Worldwide Truck* Production in Millions of Units Median Response			
	Est. 1981	1985	1987	1990	1992
GM	1.2	1.3	1.3	1.4	1.5
Ford	1.1	1.1	1.2	1.3	1.3
Toyota	1.1	1.2	1.2	1.3	1.4
Nissan (Datsun)	0.9	1.0	1.0	1.0	1.0
VW	0.3	0.3	0.3	0.3	0.3
AMC-Renault	0.3	0.3	0.3	0.3	0.3
Peugeot-Citroen	0.2	0.2	0.2	0.2	0.2
Fiat	0.2	0.2	0.2	0.2	0.2
Toyo Kogyo (Mazda)	0.4	0.4	0.4	0.4	0.4
Chrysler	0.2	0.2	0.2	0.2	0.2
Honda	0.1	0.1	0.1	0.1	0.1
Mitsubishi	0.3	0.3	0.3	0.3	0.3
Daimler-Benz (Mercedes)	0.2	0.2	0.2	0.2	0.2
Subaru	0.2	0.2	0.2	0.2	0.2
British Leyland	0.1	0.1	0.1	0.1	0.1
Volvo	**	0	0	0	0

	Interquartile Range			
	1985	1987	1990	1992
GM	1.2/1.4	1.2/1.5	1.2/1.7	1.3/1.7
Ford	1.1/1.3	1.1/1.4	1.2/1.5	1.2/1.5
Toyota	1.1/1.3	1.1/1.4	1.1/1.4	1.2/1.5
Nissan (Datsun)	0.9/1.0	0.9/1.1	0.9/1.1	0.9/1.1
VW	0.3/0.3	0.3/0.4	0.3/0.4	0.2/0.4
AMC-Renault	0.3/0.3	0.3/0.4	0.2/0.4	0.2/0.4
Peugeot-Citroen	0.2/0.2	0.2/0.2	0.2/0.2	0.2/0.2
Fiat	0.2/0.2	0.2/0.2	0.1/0.2	0.1/0.3
Toyo Kogyo (Mazda)	0.4/0.5	0.4/0.5	0.4/0.5	0.3/0.5
Chrysler	0.2/0.3	0.2/0.2	0.2/0.3	0.2/0.3
Honda	0.1/0.1	0.1/0.2	0.1/0.2	0.1/0.2
Mitsubishi	0.3/0.4	0.3/0.3	0.3/0.4	0.2/0.4
Daimler-Benz (Mercedes)	0.2/0.2	0.2/0.3	0.2/0.3	0.2/0.3
Subaru	0.2/0.2	0.1/0.2	0.1/0.2	0.1/0.2
British Leyland	0.1/0.1	0.1/0.1	0.0/0.1	0.0/0.1
Volvo	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0

* Includes trucks and busses.
** Less than 50,000.

(Mkt-51 continued)

Mkt-51 Discussion

With the exception of the four leaders - General Motors, Ford, Toyota, and Nissan - truck production is forecast unchanged over the next 10 years for all the major manufacturers listed.

Comparison of Vehicle Manufacturer and Supplier Panelists

Most of the Supplier and Manufacturer Panelists' replies were identical and the exceptions were rarely more than 10% apart on these many forecasts.

Mkt-52. In 1981, U.S. vehicle manufacturers exported over 50,000 passenger cars and produced approximately 3.7 million passenger cars in their foreign-located facilities. What is your forecast for the following years?

Passenger Car Exports From U.S.-Located Manufacturing Facilities	Est. 1981	In Thousands of Units Median Response 1985	1987	1990	1992
- To Canada	470	500	520	530	550
- To Other Countries	75	85	90	100	100

	Interquartile Range 1985	1987	1990	1992
- To Canada	470/520	470/520	480/620	485/650
- To Other Countries	75/100	80/125	82/140	84/150

Passenger Car Production In U.S.-Owned Facilities Located In Foreign Countries	Est. 1981	In Millions of Units Median Response 1985	1987	1990	1992
- In Canada	0.7	0.8	0.9	0.9	1.0
- In Other Countries	3.0	3.2	3.4	3.6	3.8

	Interquartile Range 1985	1987	1990	1992
- In Canada	0.7/0.9	0.8/1.0	0.8/1.2	0.9/1.3
- In Other Countries	3.0/3.5	3.3/3.6	3.4/4.0	3.5/4.0

Selected Comments from Panelists

Very little demand left for U.S.-style cars other than some luxury or Jeep types. Also, protection and lack of reciprocity make imports difficult. Canada is only market available in volume and they ship back similar value.

Mkt-52 Discussion

In 1981, U.S. manufacturers exported 75,000 units to countries other than Canada. These exports are forecast to increase to 100,000 by 1992. Production of vehicles by U.S.-based manufacturers in countries other than Canada are forecast to grow significantly from 3 million units in 1981 to 3.8 million units in 1992.

Mkt-53A. Smaller and financially weaker motor vehicle manufacturers may disapear or be absorbed by larger companies. By 1992, who will be the top car and truck companies, worldwide (free world only)? List in order of size-- use multiple names such as Renault/AMC, for example.

Passenger Car Manufacturers	Forecast 1992 Rank Median	High	Low	Estimated Actual 1981 Rank
General Motors	1	1	1	1
Ford	2	2	6	2
Toyota	3	2	4	3
Nissan	4	3	6	5
Renault/AMC	5	3	9	6
Volkswagen	6	4	9	4
Honda	7	4	10	9-10
Chrysler	8	5	10	9-10
Fiat	8	5	10	8
Toyo Kogyo	9	6	10	11
Mitsubishi	9	6	10	12
British Leyland	9	8	9	14
Daimler-Benz	10	10	10	14
Peugeot/Citroen	-	-	-	7
Subaru	-	-	-	14
Volvo	-	-	-	16
Chry.-Mit.-Peugeot	4*	-	-	
PSA	8*	-	-	
Nissan-Subaru	3*	-	-	
Toyota/Diahstra	4*	-	-	

* Single Response

Mkt-53A Discussion

The following discussion applies only to passenger car manufacturers.

The results for this question show median ranks, as with other similar questions throughout the survey, but we have replaced the interquartile range with the highest and lowest rank achieved by each firm or combination of companies. All of the respondents rank General Motors as number 1 in the forecast for 1992 and, therefore, both the high and low ranking for GM were also number 1. The median ranking for Ford Motor Company was number 2, but this was also its high; its low ranking was 6th place. Toyota, ranked number 3 overall in the 1992 forecast, is ranked as high as 2 and no lower than 4th.

(Mkt-53A continued)

The right-hand column shows estimated actual 1981 ranks for these companies based on the estimated actual data shown earlier with question Mkt-49. Among the changes indicated, both Nissan and the combination of Renault/AMC are expected to improve their rankings by one each. In contrast, Volkswagen is forecast to drop from 4th to 6th place. Honda and Chrysler are expected to improve from a tie for 9th and 10th place to 7th and 8th, respectively. All others ranked in 1992 are expected to improve their position over their estimated actual 1981 rank.

Peugeot/Citroen, ranked 7th in estimated actual 1981 vehicle production, is not even listed in the forecast. Subaru and Volvo, which ranked 14th and 16th, respectively, in the estimated actual 1981 standings, are unlisted in the forecast (although the combination of Nissan and Suburu is predicted to rank number 3 by one of the respondents), probably because respondents only ranked the top 10.

Mkt-53B. Smaller and financially weaker motor vehicle manufacturers may disappear or be absorbed by larger companies. By 1992, who will be the top car and truck companies, worldwide (free world only)? List in order of size-- use multiple names such as Renault/AMC, for example.

Truck Manufacturers	Forecast 1992 Rank Median	High	Low	Estimated Actual 1981 Rank
General Motors	1	1	3	1
Ford	2	1	4	2-3
Toyota	3	1	8	2-3
Nissan	4	2	8	4
Toyo Kogyo	6	5	10	5
Mitsubishi	6	5	10	7
Volkswagon	6	5	9	7
Renault/AMC	8	7	10	7
Chrysler	7	3	9	10
Daimler-Benz	9	1	10	10
Fiat	10	2	10	10
IVECO	7	3	10	
Volvo	8	6	9	
Subaru	9	9	10	10
IHC	3*	-	-	
Hino	7*	-	-	
Suzuki	5*	-	-	
Diahatsu	7*	-	-	
Chry.-Mit.-Peugot	5*	-	-	

* Single Response

Mkt-53B Discussion

Essentially all truck manufacturers are forecast to maintain or improve their rankings in 1992 over the estimated actual position they held in 1981. IVECO and Volvo are forecast to rank 7th and 8th, respectively, although their truck production was not sufficient to register in the top 10 during 1981.

Mkt-54. Worldwide, the automotive industry has been constructing very large-scale facilities to produce "world car" components such as engines and transmissions. Except in Japan, where automotive production is concentrated geographically, the relatively small number of such facilities is in conflict with developing efforts to use "just-in-time" inventory systems that require short "pipelines." How do you see this conflict being resolved? Please answer in three or four sentences.

The following are composites of comments on the conflicts queried in Mkt-54. They are grouped in general categories reflecting relationships among the individual responses.

Build assembly plants closer to OEM (38%)

Build assembly plants close to facilities manufacturing major components/clustering/establish small plants near OEM.

This concept would have to evolve over a period of time/years/ after present facilities are obsolete/as new facilities are built -- have satellite plants.

Manufacturers will have to induce suppliers to relocate by means of long-term contractual agreements/guarantee minimum purchases to reduce current volatility.

Benefits of concentration will exceed penalties.

Warehousing - "Just-in-Time" Inventory (21%)

Suppliers will warehouse, carry inventory, and ship as directed to intermediate storage points/warehousing parts to approach the "just-in-time" philosophy.

Economics (17%)

Economics will prevail/will see a mix of large-volume-produced components plus locally produced components;/major "world" components will be produced in low labor cost areas and assembled with JIT inventory control at chosen locations.

Assembly/"World Car" (10%)

The world car is a myth/will come to mean a vehicle that has multiple markets but is produced in a geographically centralized location. Economics will prevail over the need for a "world concept." Market segmentation will always exist across geographical and cultural boundaries.

No 'JIT' (8%)

Economics of scale will outweigh the advantages of "just-in-time" scheduling. Very large labor cost and efficiency-of-scale benefits of world car major components such as engines from

(Mkt-54 continued)

Brazil cannot be ignored, particularly where transportation costs are relatively low.

Others (6%)

Short pipelines are still possible. Streamline the supply pipeline using unconventional methods (dedicated highways, tracks, etc.)

Mkt-54 Discussion

The respondents' replies to this question are organized to be self-explanatory.

Strategic Considerations

In this question as with others, conflict of opinion is evident among panelists. Perhaps responses indicate the suppliers' widely different circumstances and their experience with customers and other suppliers. In this industry it is essentially impossible to characterize suppliers according to a formula. The sheer number of suppliers and the diversity of their internal structures suggest that there may be as many answers to the detailed implementation of JIT as there are suppliers.

Mkt-55. Strategic planning factors could include the following. Please check your forecast of the trend in each. All factors refer to the U.S. unless otherwise indicated.

Planning Factors	10-Year Trend Better	Same	Worse	Percentage Points "Better" Is Over (Under) "Worse"
World truck sales volume	75%	23%	2%	73 Pts.
World car sales volume	73	23	3	69
Unemployment	75	19	6	69
Intererst rates	65	31	4	61
Personal income	54	42	4	50
Savings	40	56	4	36
Government regulations	44	37	19	25
Energy availability	35	38	27	8
Highway/road conditions	34	33	33	1
U.S. political stability	15	70	15	0
Truck prices	31	31	38	(7)
Car prices	26	37	37	(11)
Energy prices	29	27	44	(15)
Cold war pressure	12	60	28	(16)
Japanese competition	21	41	38	(17)
Other foreign competition	13	54	33	(20)
World political stability	10	37	53	(43)
Taxes	8	42	50	(48)

Selected Comments from Panelists

Interest rates about the same as January 1983.
When quality improves maybe car and truck prices will not be as bad as indicated.
Quality will supply base cuts that may help car and truck prices as well.
Other nations will try to form cartels to exploit U.S. Unless U.S. modifies trade stands, U.S. will be the recipient of foreign production or power trains, components, etc. with no opportunity to offset by exports.

Mkt-55 Discussion

Respondents are bullish about the 10-year prospects for truck and car sales, and -- in the United States -- the trends in unemployment, interest rates, personal income, savings, government regulations, energy availability, and to a very slight extent, highway and road conditions. U.S. politcal stability is expected to remain at about the present level while prices of trucks, cars, cold war pressure and, within the U.S., Japanese competition and other foreign competition. Political instability throughout the world is forecast to continue to be a major negative factor and, as might be expected, taxes are predicted to be the worst of the lot.

Mkt-56A. While it is difficult to generalize about all vehicle manufacturers in a given country, there does appear to be some degree of consistency in performance. What are the major strengths and weaknesses of U.S., Japanese, German, French, English, Swedish, and Italian manufacturers?

Country of Manufacture	Distribution of Responses--Strengths and Weaknesses--Within Categories					Total Responses	
	Product	Organization	Labor	Government	Locality	%	No.
U.S.							
Strengths	29%	13%	0%	0%	8%	50%	101
Weaknesses	29	14	6	1	0	50	101
Net	0%	-1%	-6%	-1%	+8%	0%	202
Japan							
Strengths	48%	8%	9%	2%	0%	67%	118
Weaknesses	18	5	2	0	8	33	58
Net	+30%	+3%	+7%	+2%	-8%	+34%	176
Germany							
Strengths	56%	2%	1%	0%	1%	60%	80
Weaknesses	21	11	3	1	4	40	53
Net	+35%	- 9%	-2%	-1%	-3%	+20%	133
France							
Strengths	35%	2%	0%	5%	2%	44%	39
Weaknesses	32	9	6	8	1	56	49
Net	+ 3%	-7%	-6%	-3%	+1%	-12%	88
England							
Strengths	22%	0%	2%	1%	3%	28%	24
Weaknesses	36	17	13	3	3	72	61
Net	-14%	-17%	-11%	-2%	0%	-44%	85
Sweden							
Strengths	55%	3%	0%	0%	0%	58%	59
Weaknesses	32	5	3	1	1	42	42
Net	+23%	-2%	-3%	-1%	-1%	+16%	101
Italy							
Strengths	52%	0%	0%	0%	2%	54%	43
Weaknesses	33	6	4	3	0	46	36
Net	+19%	-6%	-4%	-3%	+1%	+ 8%	79

Mkt-56A Discussion

It is difficult to generalize about all vehicle manufacturers in a given country and their products, but everybody does it - particularly consumers - so the question has considerable practical interest.

(Mkt-56A continued)

Subsections to this question, numbered Mkt-56B through Mkt-56H, show in detail the responses underlining the summary shown in Mkt-56A. The detailed responses are largely self-explanatory. This discussion will concentrate on the summary distribution of responses.

The table is best understood by reading it from right to left. Starting with U.S. strengths and weaknesses, there is an even split between the number and percentage of total responses indicating strengths or weaknesses. Put another way, U.S. manufacturers have a net strengths/weaknesses rating of zero. This overall rating reflects zero net strengths on product together with minor negative factors related to organization, labor, and government. The strong point for the U.S. automotive industry is that it is located here.

Japanese strengths net out at 34% positive and show leadership among the seven countries evaluated. This strong showing is based largely on product but includes net gains in every other factor except locality, which Japanese manufacturers are taking preliminary steps to correct by producing in the U.S. However, this may adversely effect their other strong ratings.

German manufacturers enjoy the highest net strength on product but show varying degrees of weaknesses in every other category listed. Nevertheless, German manufacturers rank second to the Japanese.

French manufacturers show no major strengths or weaknesses and an overall negative rating of -12%. The English do not do well in any category and show the lowest overall net rating of all the manufacturers evaluated.

Swedish and Italian manufacturers show positive product ratings which, although offset by problems in other areas, lead to positive overall ratings.

Mkt-56B. U.S. Vehicle Manufacturers' Strength and Weaknesses.

% of Total Responses	Strengths	Weaknesses	% of Total Responses
	Product and Related		
6.5%	Engineering/technology	Quality/workmanship	12.0%
4.5	Safety/crashworthiness	High priced/expensive	5.0
2.5	Durability	Small-car design	3.0
2.5	Variety of models/options		
2.0	Comfort	Efficiency/performance	2.5
2.0	Design	Small-car styling	2.5
2.0	Improving quality	Reliability	1.0
1.5	Price	Large-car handling	*
1.5	Styling	Engines	*
1.5	Innovation	Engineering	*
1.0	Lower repair costs	Late to FWD	*
*	Corrosion protection	Catch-up required	*
*	Automatic transmission	Repair frequency	*
*	Large-car technology		
*	V-8 engines		
29.0%	Subtotal Product	Subtotal Product	29.0%
	Organization and Related		
3.0%	Service structure	Management style	3.0%
2.5	Parts availability	Dealer service	2.0
2.0	Marketing skills	Manufacturing costs	2.0
1.5	Distribution network	Response to customers	2.0
1.5	Economy of scale	Old manufacturing plants	2.0
*	Reindustrialization	Economics	1.5
*	Economic resources	Marketing	*
*	Self-financing	Productivity	*
*	Meet government dictates	Resistance to regulations	*
*	Vertical integration	Short-term supplier relationships	
13.0%	Subtotal Organization	Subtotal Organization	14.0%
	Labor and Related		
		High labor costs	3.0%
		UAW	2.0
		Poor work ethics	1.0
0%		Subtotal Labor	6.0%
	Government and Related		
0%		Government hostility	1.0%
	Locality and Related		
4.0%	In local, volume market		
1.5	Natural resources		
1.5	"Buy America"		
*	Supplier base		
*	Cheap energy		
8.0%	Subtotal Locality		0%

*Single response

Mkt-56C. Japanese Vehicle Manufacturers' Strengths and Weaknesses

% of Total Responses	Strengths	Weaknesses	% of Total Responses
	Product and Related		
20.1%	Quality image	Corrosion	3.0%
18.4	Low prices	Poor styling	2.3
4.0	High mpg	Safety	2.3
1.7	Design	Durability	1.6
1.7	Engineering/Technology	Model identity	1.6
1.7	Economical	Comfort	1.0
1.1	Durability/Reliability	Repair costs	1.0
1.1	Value/trade-in	Too many models	1.0
1.1	Innovation	Poor design	1.0
1.1	Styling	Small car image	1.0
*	Electronics	Automatic transmissions	*
*	4-cylinder engines	Rapid depreciation	*
*	Diversity of models		
*	Powertrain durability		
48.0%	Subtotal Product	Subtotal Product	18.0%
	Organization and Related		
4.5%	Mgf.tech/modern plants	Service/parts avail.	3.3%
1.1	Distribution/dealers	Long supply lines	1.0
*	Short lead time	Marketing	*
*	Responsive to customers		
*	Marketing		
*	Mfg. Flexibility		
8.0%	Subtotal Organization	Subtotal Organization	5.0%
	Labor and Related		
4.5%	Workers/work ethic	Human factor	1.0%
4.0	Labor cost	Lifetime employment	1.0
*	Culture		
9.0%	Subtotal Labor	Subtotal Labor	2.0%
	Government and Related		
2.0%	Healthy business environment/ government assistance		0%
	Locality and Related		
		Foreign product/anti-Japanese sentiment	4.6%
		Natural resources	1.7
		Geography/dependent on exports	1.7
0%		Subtotal Locality	8.0%

*Individual response

Mkt-56D. German Vehicle Manufacturers' Strengths and Weaknesses

% of Total Responses	Strengths	Weaknesses	% of Total Responses
	Product and Related		
18.6%	Quality	High price/cost	13.5%
9.6	Engineering	Styling	3.0
6.0	Product technology	Poor mileage	*
5.4	Design	Product value	*
3.0	Image/reputation	Cost structure	*
3.0	Handling/roadability		
2.4	Styling		
1.5	Workmanship		
1.5	Reliability/durability		
1.5	Powertrain		
*	Trade-in value		
*	Innovation		
*	Prestige		
56.0%	Subtotal Product	Subtotal Product	21.0%
	Organization and Related		
2.0%	U.S. support/service	Service cost (parts availability)	4.4%
		Resistance to change	3.6
		Inefficient plants	*
		Dealers	*
2.0%	Subtotal Organiz.	Subtotal Organization	11%
	Labor and Related		
1.0%	Good work	High labor costs	3.0%
	Government and Related		
0%		Currency	1.0%
	Locality and Related		
1.0%	Strong European base	High energy cost	*%
		Shrinking exports	*
		Small local markets	*
1.0%	Subtotal Locality	Subtotal Locality	4.0%

* Individual response.

Mkt-56E. French Vehicle Manufacturers' Strengths and Weaknesses

% of Total Responses	Strengths	Weaknesses	% of Total Responses
	Product and Related		
5.7%	Styling	Poor quality	8.0%
5.7	Low price	Styling/Design	6.8
4.5	Design	Design	5.7
3.4	Performance	Poor reputation	2.3
3.4	Quality	Price	*
2.3	Engineering	Frequency of repair	*
2.3	Innovation	Safety	*
2.3	Technology	Corrosion	*
*	Durability	Performance	*
*	Safety	Durability	*
*	Fuel economy	Crowded market segment	*
*	European reputation	Comfort	*
35.0%	Subtotal Product	Subtotal Product	32.0%
	Organization and Related		
2.0%	Distribution system	Service	3.4%
		Parts availability	3.4
		Dealer network	*
		Low profits	*
2.0%	Subtotal Organization	Subtotal Organization	9.0%
	Labor and Related		
		High labor costs	4.5%
		Workmanship	*
0%		Subtotal labor	6.0%
	Government and Related		
3.4%	Government support	Nat'l econom. politics	8.0%
*	Restricted Jap. imports		
5.0%	Subtotal Government	Subtotal Government	8.0%
	Locality and Related		
*%	Large home market	Shrinking exports	*%
*	Geography		
2.0%	Subtotal Locality	Subtotal Locality	1.0%

* Individual responses

Mkt-56F. English Vehicle Manufacturers' Strengths and Weaknesses

% of Total Responses	Strengths	Weaknesses	% of Total Responses
	Product and Related		
4.7%	Quality of luxury models	Poor quality	12.6%
4.7	Styling	Reliability/Durability	7.4
3.5	Design	Conservative styling	5.1
2.4	Image/Reputation	Price	3.8
2.4	Performance	Home market share	2.5
*	Engineering	Engineering/Technology	2.5
*	Workmanship	Corrosion	*
*	Reliability	Low volume	*
*	Product loyalty	Electrical systems	*
22.0%	Subtotal Product	Subtotal Product	36.5%
	Organization and Related		
		Limited, costly, service and repair	5.1%
		Parts availability	5.1
		Marketing	3.8
		Dealer network	2.5
0%		Subtotal Organization	16.5%
	Labor and Related		
2.0%	Low labor rates	Labor/productivity	13.0%
	Government and Related		
*%	Government assistance	Government economics	*%
		Currency	*
*%		Subtotal Government	3.0%
	Locality and Related		
*%	Geography	National Resources	*%
*%	Supplier base	Distance to markets	*
3.0%	Subtotal Locality	Subtotal Locality	3.0%

* Individual response

Mkt-56G. Swedish Vehicle Manufacturers' Strengths and Weaknesses

% of Total Responses	Strengths	Weaknesses	% of Total Responses
	Product and Related		
17.8%	Durability/Reliability	Price	9.9%
13.9	Quality	Styling	9.9
5.0	Image/Reputation	Quality	5.0
5.0	Engineering	Low volume	3.0
5.0	Safety	Lack of variety	*
3.0	Performance	Maintenance requirements	*
3.0	Design	Lack of innovation	*
2.0	Styling	Durability	*
*	Small car experience		
*	Innovation		
55.0%	Subtotal Product	Subtotal Product	32.0%
	Organization and Related		
3.0%	Marketing	Parts & service availability	2.0%
		Small dealer network	2.0
		Component sourcing	*
3.0%	Subtotal Organization	Subtotal Organization	5.0%
	Labor and Related		
0%		Labor cost	3.0%
	Government and Related		
0%		Government	1.0%
	Locality and Related		
0%		Resource availability	1.0%

* Individual response

Mkt-56H. Italian Vehicle Manufacturers' Strengths and Weaknesses

% of Total Responses	Strengths	Weaknesses	% of Total Responses
	Product and Related		
21.6%	Styling	Quality/Workmanship	11.4%
10.6	Design	Durability	6.3%
4.4	Quality	Corrosion	3.8
3.0	Image	Reliability/Repair frequency	3.8
3.0	Small car range	Image	1.3
3.0	Innovation	Engineering	1.3
3.0	Performance	Price	*
*	Price	Comfort	*
*	Handling	Handling	*
		Low volume	*
52.0%	Subtotal Product	Subtotal Product	33.0%
	Organization and Related		
		Parts availability	2.5%
		Service availability	2.5
		Export marketing	1.3
0%			6.0%
	Labor and Related		
0%		Labor/Productivity	4.0%
	Government and Related		
0%		Economics/Politics	3.0%
	Location and Related		
0%		Domestic market	2.0%

*Individual Response

Mkt-57. There is considerable uncertainty in the U.S. supplier community related to Kan-Ban, or just-in-time inventory practices, being initiated by the U.S. automotive manufacturers. What types of suppliers, based on components or material, are likely candidates for relocation near assembly or major component operations? Also, what suppliers are not likely to relocate near these operations?

Type of Supplier Likely to Relocate	% of Total Responses
Large, heavy, high-cost components & materials: (motor blocks, axles, wheels, body parts, crankshafts, heads, frames, steel items, heavy fabrications & stampings)	13%
Capital-unintensive operations	13
Small components supplier & assemblies: (gauges, machined parts, springs, ignition & door locks, radios, sealed beams, etc.)	11
Captive supplier with narrow customer base	8
Bulky components necessitating high shipping & warehousing costs: (foam seats, plastic gas tanks, fenders, cushions, etc.)	8
Trim & accessories producers	7
Labor-intensive operations: (fasteners, stampers, seat manufacturers, etc.)	6
Assemblers	5
Commodity/universal product producers: (nuts, bolts, hoses, belts, etc.)	5
Labor-unintensive operations	3
Electronic components producers	3
Plastics producers	3
Fabricators	2
Finished components for interior/exterior material assembly	2
New supplier anxious to enter market	2
Supplier of a finished product where single warehousing can be employed	2
Large company with long-term contract & financial capability	*

(Mkt-57 continued)

Type of Supplier Likely to Relocate	% of Total Responses
Low-technology operation	*
Highly price-competitive product supplier	*
Newer high-tech suppliers where margin would support relocation	*
Operations with no environmental problems	*

* Indicates single response.

Comments & selected responses (included in above tabulation):
1. Finished components for interior, trim, & parts having larger cubic volume or storage space requirements.
2. Those who serve only the auto industry & where raw material supply is not affected by such a move.
3. Supplier of a finished part or product that could be warehoused near assembly plant.
4. Low investment type, perhaps minor assembly, but not too labor-intensive because of proximity to larger "expensive" labor market. Probably proprietary design of material.
5. Assembly or sub-assembly of components, with low in-place capital investment (heavy manufacturing). Hoover's seat plant near Nissan is a good example.

Type of Supplier Not Likely to Relocate	% of Total Responses
Capital-intensive manufacturing	16%
Small, lightweight, component manufacturing with low freight costs	11
Raw materials suppliers; e.g., chemical, plastics aluminum, etc.	9
Steel producers	8
Commodity/universal product producers: (seat belts, tires, paints, interior fabrics)	8
Heavy manufacturing: (axle assemblies, engines, front ends, engine powertrains	7
High-technology/high-cost producers	6
Supplier with large customer base	6
Operations requiring skilled labor	5

(Mkt-57 continued)

Type of Supplier Not Likely to Relocate	% of Total Responses
Foundries	5
Glass plants	5
Low-volume, specialty components	3
Labor-intensive operations	3
Electronic/electrical suppliers	2
Rubber plants	2
Stamping plants	*
Industries with environmental problems	*
Smaller companies without financial resources and/or long-term contracts	*
Low-margin suppliers	*
Fastener manufacturers	*
Strong supplier with good distribution capability	*
Suppliers with low penetration, low utilization on passenger cars	*

* Indicates single response

Comments and selected representative responses (included in above tabulation):

1. Heavily capitalized, complex processing/assembly operations serving many OEM's.
2. Raw material suppliers will stay near feedstocks; e.g., plastics producers.
3. Raw material suppliers in steel & aluminum that have high in-place assets.
4. Suppliers whose businesses are only partially dependent upon the automotive or transportation industry.
5. Most suppliers, because of heavy investment of capital in existing plant.
6. Capital-intensive type of manufacturers who would find relocation very expensive; often involves fairly large percentage of highly skilled personnel.
7. Heavy manufacturers, with high capital costs, who need high volume to generate low costs. They can't have economically sized plants next to many different customers.
8. High-technology companies likely to be unwilling to move.

Mkt-57 Discussion

This question and its responses are fairly self-explanatory.

Mkt-58. At the present time there appears to be a trend to recentralization of the U.S. automotive industry in the Midwestern or North Central states. Do you believe this trend will continue? If your answer is yes, what states are likely to benefit most, based on current and expected future business climate considerations, labor market, etc.?

	Yes	No
Trend to Recentralization	78%	22%

States likely to benefit:

Percent of Total Responses

Michigan	24%	Wisconsin	5%
Ohio	22	Tennessee	3
Indiana	20	Pennsylvania	3
Illinois	13	Kentucky	3
Missouri	7		

Selected Comments from Panelists

Yes. Just means a smaller U.S. base, not more economic activity at remaining plants. Thus, no discernible benefit.

Michigan - If state gov`t doesn't continue to discourage through taxation.

Most likely - Indiana.

Least likely - Michigan.

This will require continued labor cost reductions.

Design & engineering functions will remain concentrated in Midwest and North Central states, but I see assembly operations widespread.

Not beyond current plans and utilization of plants or facilities which already exist.

I don't believe in the recentralizing issue. "Kanban" trends will force suppliers to be more responsive and probably abandon rail transportation. This will (affect) "West of the Rockies" suppliers but othewise labor cost/ cooperation will be more of a factor than location.

Movement to South will lose appeal as initially lower labor rates increase. Also, the job skills needed for quality fabrication of components and assembly are still concentrated in the traditional places (Midwestern or North Central states). We may well experience an unemployment shift (Midwestern/North Central states gaining while Southern and Western decline) in auto-related industries.

Entrenched unionization and life style in Midwestern or North Central regions mitigate against this trend.

Depends on state legislation in the area of labor practices and work rules.

Uncertainty makes supplier decisions difficult.

(Mkt-58 continued)

Mkt-58 Discussion

Almost 4 out of 5 respondents believe the trend to recentralization of the U.S. automotive industry will continue. Michigan is indicated as the state most likely to benefit from recentralization, but the percentages of responses naming Ohio and Indiana are higher, relative to Michigan's 24%, than the actual shares those states now enjoy relative to Michigan.

Discussion of Panelists' Comments

Comments cover the range of why such recentralization may or may not occur.

Mkt-59. In order of descending importance indicate what changes are needed for the U.S. automotive manufacturers to become more competitive with the Japanese. (Structural, organization and policy changes - not vehicle changes.)

	% of Total Responses
Decentralization of management, decrease in levels of organization, more autonomous operations	14%
Changes in attitude between UAW and management, labor relations	13
Changes in government/industry relationship	7
Increased worker involvement & responsibility for quality and output, increased worker motivation	7
Increased cooperation with suppliers	
Lowered labor content, automation/robotics	6
Fundamental changes in management philosophy; more outward-looking, innovative thinking.	6
Changes in governmental (state & federal) policy: restructuring of tax laws, tariff adjustments, equal trade agreements, lowered U.S. inflation rate.	5
Changes in labor practices, less UAW influence and power	5
Higher productivity	5
Reduced pay rates for both labor and management	3
Need for a customer-responsive product	3
Readjustment of value for Yen vs. Dollar	3
Profit-sharing incentive program	2
Reduction in the number of models and options available	2
Lower in-house inventories	*
More central purchasing function	*
Modernization of facilities	*
Very competitive financing	*
Fewer suppliers (without reducing outsource purchase dollars)	*
Kan-ban parts delivery, flexible production schedules	*
Increased statistical quality control	*
Reduction of "not invented here" philosophy	*
Reception & sponsorship of raw technology by manufacturers	*
Better (in-house) vehicle inspection resulting in fewer recalls	*
Joint ventures, a la Toyota-GM, to diminish "differences"	*
Become more cost-competitive in low end of market	*

(Mkt-59 continued)

	% of Total Responses
Greater respect for competition	*
Acceptance of international material standards	*
Increased outsourcing to low-cost sources	*
Improved dealer service	*
	100%

* Indicates single response.

Comments and selected representative responses (included in above tabulation):

1. Better understanding and cooperation between management and labor. Chrysler workers wanting an immediate contract adjustment is an example.
2. Clearly defined and understood values; i.e., service, quality, value.
3. Reliable supplier incentive system, including quality incentives.
4. Attitude of management regarding quality and productivity. Must adopt long-term outlook vs. current push for short-term results.
5. Better coordination among engineering, marketing, finance, and manufacturing departments so long-term plans have a chance of being efficiently implemented. This will require a change in both organization and philosophy.
6. Decrease the level of management. Give more responsibility to the worker and assembly operation.
7. More autonomous operations; less interference from central staffs.
8. Completely different approach by the UAW that will permit increased productivity and ultimately competitive pricing and better quality.
9. Only one - a change of attitude between union and management toward a unified team effort.
10. A better, more productive working relationship between government & industry. A clear industrial policy.
11. Government recognition and actions regarding Yen/Dollar imbalance and tax inequities.
12. A true worldwide value for the Yen.
13. An industry more anticipative of customer needs and wants; more customer orientation.
14. Commitment to quality through improved engineering.

Editor's Note: Although, in this question, we asked for structural, organizational, and policy changes, as opposed to vehicle changes, responses cited the following needed changes: Better vehicle quality, 15%; reduced costs/lower prices, 12%; improved engineering, 3%; improved styling, 2%; less vehicle maintenance requirements and improved design, 1% each.

(Mkt-59 continued)

Mkt-59 Discussion

Most of the responses to this question are in line with expectations based on the voluminous literature on the subject. However, the leading response, calling for decentralization of management etc., is surprising in view of the highly centralized managements of Japanese competitors.

Some of the categories shown are related and could be consolidated but we believe the narrower descriptions used are of interest.

Mkt-60. On an international scale what automotive companies do you believe will no longer be producing and selling motor vehicles in 1990?

Percent of Total Responses

AMC	19%	Fiat	5%	Suzuki	*
None	10	Vauxhall	3	BMW	*
SAAB	10	Isuzu	3	Mazda	*
BLMC	10	Citroen	3	Lancia	*
Alfa-Romeo	8	Peugeot	3	Volvo	*
Chrysler	6	Subaru	*		

* Single Response

Selected Comments from Panelists

American Motors unless it is converted to Renault.
The automotive portion of AMC will be absorbed by Renault, as will Mack.
White will disappear under Volvo ownership.
GMC will cease heavy-duty production concentraing on Class 1-7.
Iveco will absorb IHC.
Chrysler (bought by either Peugeot or Mitsubishi).
AMC (bought out completely by Renault).
They will all be here in 1990, but, perhaps, not operating independently.
Some names will drop out due to affiliations.
AMC will not be part of Renault.
Of the major manufacturers, I see some joint venture (GM-Toyota) but no withdrawal from the business. Of the smaller manufacturers, too many uncertainties with little impact.
Formation of major joint ventures.
- GM - Isuzu - Toyota
- Ford - Toyo Kogyo
- Nissan - Volkswagen
- Chrysler-Mitsubishi-Peugeot
- AMC-Renault-Volvo
- Fiat-Honda-Daimler-British Leyland-Benz

AMC to Renault
Isuzu to General Motors
Most will be producing; however, joint ventures will increase and mergers are a possibility.
Following companies may be merged into more successful companies: BL, Peugeot, Volvo.
Alfa Romeo. In addition, eight other companies will survive primarily by strengthening relationships with stronger companies as follows:
BL with Honda, Saab with Fiat, Isuzu with GM, Suzuki with GM & Isuzu
Daihatsu with Toyota, Fuji (Subaru) with the Nissan group,
Mitsubishi with Chrysler or other company, AMC with Renault.

(Mkt-60 continued)

Mkt-60 Discussion

The reasons for the changes tabulated here are discussed at some length in the panelists' comments.

Discussion of Panelists' Comments

Comments tend to justify the choices that individual panel members gave for their response to the question.

The rapidly evolving automotive industry environment may overwhelm the smaller vehicle producers. However, some of them are relatively strong financially and technically and could prosper as specialty manufacturers in an increasingly diverse market.

Strategic Considerations

We expect to see acceleration of creative joint ventures and other associations among the vehicle manufacturers, their suppliers, and between the two groups.

Mkt-61. It has been suggested that the mode of light-duty vehicle ownership is likely to change in the years ahead. For example, lease vs rent. What fraction of vehicles sold in the United States in 1987 and 1992 will be sold for private or corporate ownership, lease, or rental?

	Median Response		Interquartile Range	
	1987	1990	1987	1990
Outright Ownership (Individual, Company or Govt.)	80%	70%	65/85%	60/80%
Long-term Lease	15	20	10/20	12/25
Short-term Rental	5	10	5/10	5/10
Total	100%	100%		

Selected Comments from Panelists

Depends on price of fuel and tax implications. If fuel prices go up, then rental might increase for larger capacity vehicles. I expect no real change with conditions that exist now projected forward.

Very dependent on interest rates and tax structures.

Agree there will be a trend toward more car rentals, but it's difficult to quantify.

Impossible to determine - depends almost entirely on tax structure.

Mkt-61 Discussion

Outright vehicle ownership is predicted to continue to predominate but long- and short-term leases and rentals are forecast to increase to 30% of the total. Interquartile agreement is good.

Comparison of Vehicle Manufacturer and Supplier Panelists

There were no major differences in the replies of the two groups.

III. MATERIALS PANEL RESULTS AND ANALYSIS

Mat-1. What is your estimate of retail fuel prices per gallon in 1987? 1990? 1992? (In constant dollars, that is, without adding anything for inflation).

	Retail Price Per Gallon Median Response		
	1987	1990	1992
Unleaded Gasoline	$1.50	$1.70	$1.90
Diesel Fuel	1.45	1.60	1.80

	Interquartile Range		
	1987	1990	1992
Unleaded Gasoline	$1.40/1.70	$1.50/1.85	$1.57/2.25
Diesel Fuel	1.39/1.60	1.50/1.75	1.66/2.15

Selected Comments from Panelists

Crude oil prices will remain relatively stable. Anticipate retail price increases as a result of irrational taxation at federal and state levels.

Expect "real" prices of gasoline to stay level with major increases coming in form of taxation. Supply/demand will keep diesel fuel approximately same as gasoline.

Mat-1 Discussion

Gasoline and diesel fuel prices are expected to remain at relatively low levels, compared to previous forecasts. Of the three groups of panelists, the Materials respondents show the widest interquartile ranges or, put another way, the lowest consensus.

Comparison of Vehicle Manufacturer and Supplier Panelists

The median responses from the vehicle manufacturer panelists were 10 to 30 cents per gallon less than the medians of the supplier panelists' forecasts for gasoline prices. On diesel fuel, the manufacturer panelists were 5 cents to 15 cents per gallon less in their estimate than the supplier panelists. These differences are also apparent in the interquartile ranges, discussed above. In view of the generally good consensus among all three panels on fuel price forecasts and in light of the difficulty of predicting fuel prices 10 years ahead, we do not believe these differences are of major significance.

Comparison of Replies to Mat-1, T-1 and Mkt-1

Refer to the discussion under T-1.

Trend From Three Delphi Surveys

See analysis under T-1.

Mat-2. Forecast the material content, in pounds, and the total curb weight (dry, unloaded) for the average U.S.-produced passenger car for model years 1987, 1990, and 1992.

	Pounds of Material Median Response		
	1987	1990	1992
Low carbon steel	1250 lbs.	1100 lbs.	1050 lbs.
HSLA steel	250	300	325
Total steel	1500	1400	1375
Aluminum castings	100	100	100
Wrought aluminum	30	30	27
Total aluminum	130	130	127
Plastics			
Nonreinforced	120	125	125
Reinforced	80	90	125
Total plastic	200	215	250
Cast iron	300	270	260
Copper	25	22	20
Zinc (inc. coatings)	10	13	10
Magnesium	1	2	3
Glass	80	75	70
Rubber (excl. tires)	25	22	22
All other	234	288	213
TOTAL VEHICLE	2505 lbs.	2437 lbs.	2350 lbs.

	Interquartile Range		
	1987	1990	1992
Low carbon steel	1200/1262 lbs.	1100/1170 lbs.	1000/1090 lbs.
HSLA steel	200/280	250/350	300/350
Total steel	1432/1550	1360/1490	1350/1410
Aluminum castings	90/100	100/100	95/102
Wrought aluminum	30/30	30/30	25/30
Total aluminum	120/130	130/140	120/130
Plastics			
Nonreinforced	113/130	120/140	120/140
Reinforced	75/80	90/100	100/133
Total plastic	193/230	210/243	240/253
Cast iron	300/325	270/300	250/280
Copper	22/25	21/22	20/20
Zinc (inc. coatings)	10/10	10/13	10/13
Magnesium	1/1	2/2	3/4
Glass	80/80	75/75	70/70
Rubber (excl. tires)	25/25	22/24	20/23
All other	200/270	225/329	150/247

(Mat-2 continued)

Selected Comments from Panelists

Would expect plastics to fill loss of steel. Major growth in HSLA will be limited by availability of formable HSLA coated steels on outer body panels. Even then, growth potential has been overstated.

Expect some resurgence of high strength cast irons - possibly replacing forgings.

Plastics can reduce weight, cost, corrosion, and dents.

Higher wrought aluminum forecasts reflects aluminum-intensive vehicle developments, e.g., Volvo, British Leyland ECV3, Porsche, and Audi programs. These programs will influence North America in the 1990's.

The 1992 total is outside the Round 1 range because the need for lightweighting will continue into the 90's, not stop as indicated by the range in Round 1.

Mat-2 Discussion

The steel content of U.S.-produced passenger cars is predicted to continue declining to 1500 pounds in 1987, 1400 pounds in 1990, and 1375 pounds in 1992. Decreasing use of low carbon steel is the source of this decline. HSLA steel use is forecast to increase from 250 pounds in 1987 to 325 pounds in 1992.

Aluminum usage is forecast to stay fairly steady at about 100 pounds of aluminum casting and 30 pounds of wrought aluminum in each vehicle. Plastic use is expected to grow from 200 pounds in 1987 to 250 pounds in 1992 with most of the growth taking place in reinforced plastics.

The cast iron and copper content of U.S.-produced passenger cars are expected to continue to decline to 260 pounds and 20 pounds, respectively, in 1992. Other materials including zinc, glass, and rubber are forecast to experience slow declines. Magnesium use is forecast to grow from a pound per automobile in 1987 to 2 pounds in 1990 and 3 pounds in 1992.

Total vehicle weight is expected to be 2505 pounds in 1987, 2437 in 1990, and 2350 in 1992.

The interquartile ranges show good or excellent consensus on these forecasts for each material in every year under consideration.

Comparison of Vehicle Manufacturer and Supplier Panelists

There were few significant differences in the replies between the two groups. For the 1987 forecast, manufacturer panelists foresee about 7% more steel than forecast by the supplier panelists, 8% less aluminum, and 18% more plastic. For the 1990 forecast the steel and aluminum predictions are about the same, with the manufacturer panelists predicting a 16% greater use of plastic.

(Mat-2 continued)

By the 1992 forecast these differences have essentially disappeared.

Comparison of Replies to Mat-2 and T-6

See the discussion under T-6 for this comparison.

Trend from Three Delphi Surveys

See analysis under T-6.

Mat-3A. Consider the following representative list of automotive components and indicate the percentage of each likely to be made in 1987, 1990, and 1992 from the materials listed.

Median Response: Percentage Made From:

1987	Steel	HSLA Steel	Aluminum	Reinforced Plastics & Composites	Non-Reinforced Plastics
Hood-outer	90%	0%	3%	3%	0%
Hood-inner	90	0	3	3	0
Roof	99	0	0	0	0
Doors	95	1	0	2	0
Seat frame	80	12	0	5	0
Wheels	66	20	10	0	0
Gas tank	98	0	0	0	1
Bumper-fascia	25	20	5	15	30
Bumper-support	40	40	10	2	0
Fenders	95	0	0	2	0
Suspension springs	95	0	0	5	0
Suspension control arms	95	5	0	0	0
Radiator support	85	5	0	5	0
Floor pan	100	0	0	0	0
Cylinder head cover	90	0	5	5	0

Interquartile Range

1987	Steel	HSLA Steel	Aluminum	Reinforced Plastics & Composites	Non-Reinforced Plastics
Hood-outer	90/95	0/1	0/5	2/5	0/0
Hood-inner	90/94	0/5	2/5	1/5	0/0
Roof	98/100	0/0	0/0	0/2	0/0
Doors	90/99	0/5	0/0	0/3	0/0
Seat frame	80/85	10/15	0/0	3/8	0/0
Wheels	60/75	20/20	10/10	0/0	0/0
Gas tank	95/100	0/0	0/0	0/0	0/5
Bumper-fascia	20/40	15/25	0/20	10/20	20/35
Bumper-support	33/45	40/50	5/10	0/10	0/0
Fenders	90/96	0/1	0/0	1/5	0/1
Suspension springs	95/98	0/0	0/0	2/5	0/0
Suspension control arms	89/95	5/10	0/0	0/0	0/0
Radiator support	80/95	0/10	0/0	1/10	0/0
Floor pan	100/100	0/10	0/0	0/0	0/0
Cylinder head cover	80/95	0/0	3/8	0/10	0/0

Mat-3B. Consider the following representative list of automotive components and indicate the percentage of each likely to be made in 1987, 1990, and 1992 from the materials listed.

Median Response: Percentage Made From:

1990	Steel	HSLA Steel	Alum-inum	Reinforced Plastics & Composites	Non-Reinforced Plastics
Hood-outer	85%	0%	3%	9%	0%
Hood-inner	85	3	3	8	0
Roof	95	0	0	3	0
Doors	90	3	0	5	0
Seat frame	71	20	0	10	0
Wheels	60	30	10	0	0
Gas tank	95	0	0	0	3
Bumper-fascia	15	10	15	30	30
Bumper-support	30	45	10	10	0
Fenders	90	0	0	5	0
Suspension springs	95	0	0	5	0
Suspension control arms	90	10	0	0	0
Radiator support	80	10	0	10	0
Floor pan	100	0	0	0	0
Cylinder head cover	80	0	5	10	0

1990	Interquartile Range				
Hood-outer	80/90	0/2	0/5	5/15	0/0
Hood-inner	80/90	0/5	2/5	5/10	0/0
Roof	95/98	0/0	0/0	1/5	0/0
Doors	80/93	0/5	0/0	2/10	0/0
Seat frame	65/75	10/20	0/5	5/10	0/5
Wheels	55/65	20/30	10/15	0/0	0/0
Gas tank	90/98	0/0	0/0	0/2	0/5
Bumper-fascia	10/20	10/20	5/20	20/35	15/40
Bumper-support	25/40	40/55	5/15	5/15	0/0
Fenders	80/90	0/5	0/0	5/10	0/5
Suspension springs	90/95	0/0	0/0	5/10	0/0
Suspension control arms	84/95	3/15	0/0	0/0	0/0
Radiator support	75/85	0/15	0/0	5/20	0/0
Floor pan	95/100	0/0	0/0	0/2	0/0
Cylinder head cover	75/87	0/0	3/10	5/15	0/0

Mat-3C. Consider the following representative list of automotive components and indicate the percentage of each likely to be made in 1987, 1990, and 1992 from the materials listed.

Median Response: Percentage Made From:

1992	Steel	HSLA Steel	Aluminum	Reinforced Plastics & Composites	Non-Reinforced Plastics
Hood-outer	80%	0%	5%	15%	0%
Hood-inner	75	5	3	10	0
Roof	90	0	0	5	0
Doors	75	10	0	10	0
Seat frame	60	20	0	10	0
Wheels	50	30	10	0	0
Gas tank	90	0	0	0	2
Bumper-fascia	10	10	10	25	40
Bumper-support	30	45	10	20	0
Fenders	80	0	0	10	1
Suspension springs	90	0	0	10	0
Suspension control arms	80	10	0	0	0
Radiator support	80	5	0	10	0
Floor pan	95	0	0	0	0
Cylinder head cover	75	0	5	15	0

1992	Interquartile Range				
Hood-outer	75/88	0/3	0/5	6/20	0/0
Hood-inner	70/88	0/10	0/5	6/20	0/0
Roof	90/95	0/5	0/0	1/10	0/0
Doors	75/90	4/15	0/0	5/15	0/0
Seat frame	50/75	15/30	0/3	10/15	0/0
Wheels	47/55	20/40	10/15	0/5	0/0
Gas tank	85/95	0/0	0/0	0/10	0/5
Bumper-fascia	5/25	0/10	0/20	20/40	0/50
Bumper-support	20/30	30/60	0/10	10/30	0/0
Fenders	65/85	0/10	0/0	5/20	0/10
Suspension springs	85/90	0/0	0/10	10/15	0/0
Suspension control arms	70/90	5/20	0/0	0/5	0/0
Radiator support	50/85	0/15	0/0	5/20	0/0
Floor pan	90/100	0/3	0/0	0/5	0/0
Cylinder head cover	60/85	0/0	0/15	5/20	0/0

(Mat-3 continued)

Selected Comments from Panelists

There will be a major move to aluminum gas tanks due to corrosion problems with terne plate in the alternative fuel marketplace.

Rear springs are to be fiberglass composite.

It would appear two new forces are coming into play that may impact the future materials usage independent of the traditional cost/weight tradeoff:

1. A focus on the manufacturing process and its ability to achieve high productivity and quality, i.e. low cost. The uniformity and predictability of material properties are important contributors toward this, and steel will have a distinct advantage if this factor becomes predominant.
2. Interest at GM in expanding the Fiero design/manufacturing concept to achieve Divisional differentiation from a common body platform-driveable chassis. This factor would tend to favor plastics, as the volume/panel cost relationship become more competitive. It seems too early to determine the relative impact of these new forces.

Engineering reinforced plastics offer great savings in manufacturing costs, especially capital costs, floor space, material handling, design flexibility, high productivity, etc.

Plastic gas tanks (reinforced or not) will be developed that have high impact strength and a tolerance for massive deformation without fracture.

Non-reinforced plastics such as Nyrim and others may be combined with foam cores or, in fact, be formed in the tool to provide structure for horizontal applications such as hoods, fenders, and door outers. Paint temperature in 1990 time frame will be lowered in some manufacturing operations to 220-260 F.

Plastic gas tanks are well proven in European usage and are being introduced now in the U.S. European and Japanese experimental and production vehicles are showing increased use of plastics for bumpers, fenders, hoods, decks.

Iron castings will continue to be used extensively for brake, transmission, and engine components.

Styling considerations will continue to determine where aluminum wheels are used. Volume could increase substantially; however, fleet percent will likely be volatile.

Reinforced plastics/composites and ceramics will become significant materials in engine and body/frame design.

Plastics and elastomers will find additional usage/application due to environmental integrity and predictability.

Improved mechanical properties, processing capabilities, and uniformity of quality, along with the continued need for lightweight design, will help move plastics and aluminum into structural and nonstructural areas of the car in the early 1990's.

(Mat-3 continued)

Mat-3 Discussion

In question Mat-3, median responses do not always add across to 100%. This is not an error of reporting but a charateristic of medians when there is a wide range of replies.

For example, the first item, the hood-outer, shows for 1987 a forecast of 90% steel with 3% each aluminum and reinforced plastics and composites. These three medians add to only 96%. The significant forecast regarding hood-outers is that 90% are expected to be made out of steel with the remainder sourced equally from aluminum and reinforced plastics. Note in the interquartile range data that the consensus is close on this question, but 25% of the respondents forecast that 1% or more of the hood-outers in 1987 may be made out of HSLA steel.

It is apparent that steel is the material of choice for most of the components listed and, also, that the interquartile ranges on these steel forecasts are fairly close.

Over the forecast period, the use of steel is expected to decline. Between the 1987 and 1992 forecasts, each of the 15 components listed shows an expectation of decreased use of steel and, of course, added use of other materials. Even the bumper-fascia, only 25% of which are expected to be steel in 1987, shows a declining expectation to 10% in 1992.

As would be expected from the earlier question (Mat-2) on total usage by categories, the proportion of aluminum going into these components stays relatively flat over the period of the forecast shown here. The growing opportunities are in HSLA steel and plastics.

Discussion of Panelists' Comments

Panelists' comments here are particularly instructive and should be read carefully. The first part of the third comment, when contrasted with the bulk of the remaining comments, outlines the competitive area that will have to be watched closely to foresee trends in material substitutions.

Comparison of Vehicle Manufacturer and Supplier Panelists

Noticeable difference between the two groups are listed below by year.

1987

1. The manufacturer panelists did not foresee any use of aluminum in the hood; the 3% forecast shown represents supplier replies.
2. The use of reinforced plastic and composites in the hood, both the outer and inner, is forecast by 5% of the manufacturer panelists, but only 2% of the supplier respondents.

(Mat-3 continued)

3. Bumper-fascia forecasts by manufacturer panelists show slightly less use of steel and a greater use of reinforced plastics and composites.
4. On fenders, 5% of the manufacturer respondents forecast the use of reinforced plastics and composites compared to only 2% for the supplier panelists.
5. Radiator support and cylinder head cover forecasts of reinforced plastics and composites use show the manufacturer panelists' predictions as significantly higher than those of the supplier panelists.

1990

1. On the hood-outer and hood-inner the manufacturer panelists continue to forecast zero use of aluminum and the use of reinforced plastics and composites at a rate about 2 to 1 as compared to supplier respondents.
2. On seat frames, bumper-fascia, and bumper-support the manufacturer panelists forecast a slightly higher use of plastics (both reinforced and nonreinforced) than do the supplier panelists.

1992

1. The pattern of hood forecast differences continue.
2. Manufacturers forecast a significantly higher use of alumimum for wheels and of plastics for wheels, bumpers, and suspension springs. Manufacturers also foresee a higher use of reinforced plastics and composites in floor pans and cylinder head covers than do the supplier respondents.

The above differences, although measureable, are never large in view of the time frame of the forecast.

Trend From Two Delphi Surveys

Compared to the results from the 1981 Delphi II Survey, the current study shows very large and significant changes in the forecast use of materials in the listed components, as indicated in the following table.

As explained in the Introduction, survey results are summarized as medians to reduce the effect of unusually high or low replies, but medians can be disconcerting if they do not add to 100% where they would be expected to do so. This latter characteristic of medians was a particular problem with the summarized replies to this question in the 1981 Delphi II survey, so an exception was made and means (averages) were calculated. To facilitate comparison of replies, means were also determined for the present study and the two-survey results are compared starting on Page 273, with the 1981 forecast for each component and material listed first and the 1983 forecast shown second.

Mat-3. Continued

MEAN FORECASTS FROM TWO DELPHI SURVEYS
1990 FORECASTS OF MATERIALS USE BY COMPONENT
1981 SURVEY (FIRST) VS 1983 SURVEY (SECOND)

	Steel	HSLA Steel	Alum-inum	Reinforced Plastics or Composites	Non-Reinforced Plastics
Hood -	29%	22%	20%	28%	1%
Outer	82	1	3	14	*
% Pts. Diff.	+53	-21	-17	-14	-1
Hood -	26	23	17	29	5
Inner	83	4	3	10	*
% Pts. Diff.	+57	-19	-14	-19	-5
Roofs	49	28	7	15	1
	97	*	0	3	*
% Pts. Diff.	+48	-28	-7	-12	-1
Doors	36	26	11	26	1
	87	5	1	7	*
% Pts. Diff.	+51	-21	-10	-19	-1
Seat Frames	26	36	12	25	1
	67	18	2	13	0
% Pts. Diff.	+41	-18	-10	-12	-1
Wheels	25	33	25	17	0
	60	27	12	1	0
% Pts. Diff.	+35	-6	-13	-16	0
Gas Tank	46	12	3	19	20
	88	0	*	8	4
% Pts. Diff.	+42	-12	-3	-11	-16
Bumper -	10	20	19	17	34
Fascia	18	13	11	30	28
% Pts. Diff.	+8	-7	-8	+13	-6
Bumper -	15	45	22	17	1
Support	31	43	12	13	1
% Pts. Diff.	+16	-2	-10	-4	0
Fenders	38	17	6	31	8
	82	3	0	13	2
% Pts. Diff.	+44	-14	-6	-18	-6
Suspension	31	45	0	24	0
Springs	89	0	0	11	0
% Pts. Diff.	+58	-45	0	-13	0

(Mat-3 Continued)

	Steel	HSLA Steel	Alum-inum	Reinforced Plastics or Composites	Non-Reinforced Plastics
Radiator	27	31	7	35	0
Support	78	9	1	12	0
% Pts. Diff.	+51	-22	-6	-23	0
Floor Pan	50	24	5	21	0
	98	1	0	1	0
% Pts. Diff.	+48	-23	-5	-20	0
Cylinder Head	37	8	19	21	15
Cover	83	0	7	10	0
% Pts. Diff.	+46	-8	-12	-11	-15

* Less than 0.5%

The survey-to-survey changes, shown as percentage-point differences, portray a massive shift back to plain steel and away from lighter-weight materials. With one exception - the increased forecast for reinforced plastics or composites in bumper fascias - all 1990 forecasts for materials other than steel show declines.

Many of the changes are very large. In several instances the use of steel in 1990 is forecast to more than double from the previous prediction.

Relative declines in the predicted use of aluminum range from a "low" of 42% to several cases of 100%. Many substantially reduced forecasts are also apparent for HSLA steel and plastics.

Strategic Considerations

Automotive materials plans evolve rapidly under the impetus of volatile consumer demand, changes in expectations for fuel, both prices and supplies, and new technology (particularly processing technology). The spirited competition between automotive materials promises to continue and may intensify.

Mat-4. If you had to invest in one or more plastics suppliers, how would you divide your investment based on their sales prospects in automotive applications?

	Investment Percentage	
	Median Response	Interquartile Range
Sheet Molding Compound (SMC)	10%	7/28%
High-Glass SMC	11	3/14
Oriented-Glass Reinforced Plastics	14	7/28
Carbon-Fiber Composites	4	0/7
RIM Urethane	14	2/28
Reinforced RIM	23	7/35
Structural Foam	7	0/12
Compression-Formable (Stampable) Reinforced Plastics	14	4/14
Metal-Plastic Laminates	3	0/7
Other (please specify)	0	-
Total	100%	

MEDIAN FORECASTS FROM TWO DELPHI SURVEYS
AUTOMOTIVE PROSPECTS FOR PLASTICS

	Forecast at the Time of the Survey		Percentage Points Delphi III Over (Under) Delphi II
	1981 Delphi II	1983 Delphi III	
Reinforced RIM	-%	23%	
RIM Urethane	20	14	
Subtotal	20	37	17 Pts.
Compression-Formable (Stampable) Reinforced Plastics	10	14	4
Oriented Glass Reinforced Plastics	10	14	4
Sheet Molding Compound (SMC)	20	10	(10)
High-Glass (SMC)	10	11	1
Subtotal	30	21	(9)
Structural Foam	10	7	(3)
Carbon-Fiber Composites	5	4	(1)
Metal-Plastic Laminates	10	3	(7)
Other	5	-	(5)
	100%	100%	

Selected Comments from Panelists

Oriented reinforced plastics for all structural parts.

(Mat-4 continued)

Mat-4 Discussion

Replies to this question indicate that reinforced RIM (reaction injection molding) has the best potential for sales prospects in automotive applications. Almost 1/4, or 23% of the respondents, chose reinforced RIM (RRIM) as a leader. Oriented-glass reinforced plastics, RIM urethane, and stampable plastics each received 14% of the responses. Despite their great promise for engineering applications, carbon-fiber composites and metal/plastic laminates received only modest mention.

Interquartile ranges are quite wide. The leading choice, reinforced RIM, has a lower interquartile rating that indicates 25% of the respondents would put 7% or less of their investment into reinforced RIM. In comparison, carbon-fiber composites and metal/plastic laminates, which received the lowest median ratings, would receive 7% or more of the investment from 25% of the respondents. Clearly, there are no "sure things" in these projections of automotive potential for various types of plastics.

Comparison of Vehicle Manufacturer and Supplier Panelists

Manufacturer respondents are more favorably disposed then the suppliers toward sheet molding compound and stampable plastics.

Trend from Two Delphi Surveys

Since the Delphi II forecast made in 1981, the major change is the near doubling of the choice of RIM. Furthermore, to many knowledgeable users, RIM means "urethane" unless otherwise specified. Therefore, the RIM plus RRIM total of 37% can also be considered a vote for urethane.

Strategic Considerations

Automotive applications for plastics and polymers continue to increase. Many problems that hindered automotive applications have been solved although new challenges have appeared that need resolution. Significant progress has been made in process technology.

Within the framework of bright prospects for plastics in general, the future is uncertain for specific materials (and, of course, for metals) because of rapid technological changes. Materials planners, suppliers, and users all face an unstable future. But we continue to be impressed with the broad potential for automotive polymers.

Mat-5. What percent of copper and aluminum radiators will use plastic top and bottom tanks in U.S. cars and trucks produced in model years 1987, 1990, and 1992?

	Percentage With Plastic Tanks Median Response		
	1987	1990	1992
Copper with plastic	25%	40%	40%
Aluminum with plastic	30	40	50

	Interquartile Range		
	1987	1990	1992
Copper with plastic	25/40%	35/45%	40/50%
Aluminum with plastic	30/40	40/65	50/80

Selected Comments From Panelists

Assumption: Heat transfer effects on copper, plus independent fan blower, will have more of an impact than weight reduction on the compact vehicles.

The conversion will be from copper with metal tanks to aluminum with plastic tanks.

Except for possibly some foreign makes, all aluminum radiators; SOFICA, Ford, GM, use plastic tanks on cars and light trucks.

Again, plastics or reinforced and composites will become standard due to integrity and corrosion properties.

Mat-5. Discussion

The use of plastic top and bottom tanks with copper and aluminum radiators is forecast to continue to grow to levels of 25% and 30%, respectively, in 1987, and 40% and 50% in 1992. Interquartile ranges are fairly close but suggest the possibility of considerable variation in final usage compared to median estimates.

Discussion of Panelists' Comments

The comments suggest the possibility of trends not apparent in the numerical data.

Comparison of Vehicle Manufacturer and Supplier Panelists

Manufacturer panelists forecast a significantly higher use of aluminum radiators with plastic tanks than do the supplier panelists. For 1992, the median response from manufacturer panelists calls for 80% of aluminum radiators to have plastic tanks.

(Mat-5 continued)

Trend From Two Delphi Surveys

In the 1990 forecast made two years ago at the time of the Delphi II Survey, copper radiators with plastic tanks were forecast on 30% of U.S. cars and trucks compared to 40% this year, and aluminum radiators with plastic tanks were forecast at 70% compared to 40% this year. Note, however, in the above discussion that vehicle manufacturer panelists continue to forecast a high use of aluminum radiators with plastic tanks.

Mat-6. What percentage of U.S.-produced vehicles manufactured in model years 1987, 1990, and 1992 will use aluminum radiators?

	Percentage With Aluminum Radiators Median Response		
	1987	1990	1992
Passenger cars with aluminum radiators	20%	25%	35%
Light trucks with aluminum radiators	10	20	30

	Interquartile Range		
	1987	1990	1992
Passenger cars with aluminum radiators	20/30%	25/40%	35/50%
Light trucks with aluminum radiators	10/15	20/25	20/30

Selected Comments From Panelists

At present the only reason we are not 100% released with aluminum radiators and plastic caps is due to manufacturing constraints.

Light trucks will follow the passenger car on aluminum radiators.

Mat-6. Discussion

The use of aluminum radiators in U.S.-produced vehicles is predicted to increase to 35% of passenger cars and 30% of light trucks in 1992.

Discussion of Panelists' Comments

Both comments are very favorable to aluminum prospects.

Comparison of Vehicle Manufacturer and Supplier Panelists

There were no large differences, but in general the manufacturer panelists forecast a slightly higher use of aluminum radiators in both cars and trucks.

Mat-7. What percent of the windshields and side glass produced for U.S.-built vehicles in 1987, 1990, and 1992 will use hard surface plastic rather than conventional glass?

	Percentage With Plastic Median Response					
	Windshields			Side Windows		
	1987	1990	1992	1987	1990	1992
Passenger car	0%	0%	0%	0%	5%	10%
Light-duty trucks	0	0	0	0	5	10
Vans	0	0	0	0	10	20
Medium and heavy-duty trucks	0	0	0	0	0	5

	Interquartile Range					
	Windshields			Side Windows		
	1987	1990	1992	1987	1990	1992
Passenger cars	0/0%	0/0%	0/5%	0/0%	0/5%	8/10%
Light-duty trucks	0/0	0/0	0/5	0/0	0/5	5/10
Vans	0/0	0/0	0/5	0/5	5/10	10/20
Medium and heavy-duty trucks	0/0	0/0	0/0	0/0	0/2	0/5

Selected Comments from Panelists

There may be safety coating on the interior for safety. Windshields particularly require hardness on exterior which plastics do not offer.

Cannot forecast until legislation is revised. Obviously, testing as well as manufacturing capacity would be involved.

Emerging plastic technology and high strength, abrasion resistant, coating technology will enable engineering versatility to design with these materials.

The use of polymer materials on any but the back windows of trucks conflicts with the trend toward extended warranties.

Mat-7. Discussion

Based on median responses, the panelists do not expect that hard surface plastic will be used in place of conventional windshields on any U.S.-built vehicles through the year 1992. Starting in 1990, modest use of hard surface plastic is expected in side windows, particularly on vans, where the median forecast for usage reaches 20% in 1992. The interquartile ranges show fair consensus on these median forecasts.

(Mat-7 continued)

Discussion of Panelists' Comments

The comments suggest several reasons for slow growth.

Comparison of Vehicle Manufacturer and Supplier Panelists

Differences were not significant.

Trend From Two Delphi Surveys

Respondents are less optimistic now than two years ago on the use of hard surface plastic in place of conventional glass. The forecast for the use of plastic windshields dropped from 5% at that time to 0% in the current forecast and in side windows from 15% to 5%. Forecasts for other uses also declined about 5 percentage points each.

Mat-8. Estimate the number of years before panel penetration will occur due to corrosion in a severely corrosive environment (Detroit, Pittsburgh, etc.) for U.S.-manufactured passenger cars produced in 1987, 1990, and 1992.

	Number of Years Before Panel Penetration	
	Median Response	Interquartile Range
1987 Model Year Cars	5 yrs.	5/8 yrs.
1990 Model Year Cars	8	7/10
1992 Model Year Cars	10	8/10

Selected Comments from Panelists

Antirust coatings and application methods are improving.

Mat-8. Discussion

Rapid improvement is forecast in the ability of automotive vehicle panels to resist corrosion as measured by panel penetration. The number of years before panel penetration is expected to increase from five years in 1987 to ten years in 1992. Note in the interquartile range that fully three-quarters of the respondents expect the number of years before panel penetration to be eight years or more by 1992.

Comparison of Vehicle Manufacturer and Supplier Panelists

The two groups gave essentially the same response.

Trend From Two Delphi Surveys

The 1981 Delphi II Survey also forecast eight years before panel penetration on 1990 model year cars.

Strategic Considerations

Corrosion protection has been identified as a key factor in automotive quality. All manufacturers are making rapid and important progress and the forecast gains are impressive. Significantly improved corrosion resistance could have a major effect on vehicle life expectancy and may impact other areas such as service requirements, durability requirements for mechanical components and systems, and marketing strategy.

Mat-9. In general (excluding inertia-weight-class crises), what is the value (in current dollars) per pound of weight saved to a vehicle manufacturer? What will it be in 1987, 1990, and 1992? (In constant dollars: that is, without adding anything for inflation.)

	Value Per Pound Saved	
	Median Response	Interquartile Range
Today	$0.40	$0.25/0.50
1987	0.50	0.40/0.60
1990	0.60	0.45/0.65
1992	0.67	0.50/0.75

Selected Comments from Panelists

Value per pound of weight saved applies only to very specific cases (e.g., Corvette or front-wheel-drive overload conditions).

Parts governed by safety requirements are not as likely to be redesigned (due to testing time) as those which are used only for appearance.

Mat-9. Discussion

The value to vehicle manufacturers of weight saved is forecast at less than one dollar per pound today (40 cents) and is expected to increase to 50 cents in 1987, 60 cents in 1990, and 67 cents in 1992.

Comparison of Vehicle Manufacturer and Supplier Panelists

The two groups were in essential agreement.

Comparison of Replies to Mat-9 and T-7

See discussion under T-7.

Trend From Two Delphi Surveys

Four years ago, at the time of the 1979 Delphi I Survey, the value per pound saved was forecast in the range of a $1.13 to $1.50. The Materials panelists' median forecasts as shown above are lower than might be expected, and less than half the Technology panel estimates, but it is clear that the trend is down in the forecast value of weight saved.

Strategic Considerations

See T-7.

Mat-10. Rank-order (most important = 1) the following materials according to weight savings potential in automobiles in the following years.

Weight Savings Potential Rank

Median Response

	1985	1987	1990	1992
HSLA Steel	1	2	2	2
Aluminum	2	2	3	2
Plastic	2	2	1	1

Interquartile Range

	1985	1987	1990	1992
HSLA Steel	1/3	1/3	2/3	2/3
Aluminum	2/3	2/3	2/3	2/3
Plastic	1/2	1/2	1/2	1/2

Selected Comments from Panelists

This disregards cost. If cost-effectiveness is added, then the order would be reversed with plastics achieving a ranking of 1 on some applications.

I feel all three will increase--each has a particular usefulness.

Mat-10. Discussion

In 1985, the weight savings potential of HSLA steel in automobiles is expected to be superior to that of aluminum and plastic. In 1990 and 1992 it is expected that plastics will take the lead. In none of the forecast years is aluminum the first choice.

Comparison of Vehicle Manufacturer and Supplier Panelists

In all years, the manufacturers ranked HSLA steel higher and aluminum lower than did the supplier panelists.

Trend from Two Delphi Surveys

Two years ago, at the time of the Delphi II Survey, in the forecast for 1990 it was predicted that plastic would rank first in its weight savings potential, as in the current survey, but there was a reversal on the other two. Aluminum was forecast in second place and HSLA steel in third. Now, aluminum has dropped to third place.

Mat-11. In the next ten years, what are the two most likely breakthroughs in automotive materials technology?

	Percent of Total Responses
Development of economical, high-strength structural & engineering plastics	23%
Composite materials **	14
Corrosion protection	9
Easily formable, weldable HSLA steels	6
Coatings ***	6
Ceramics	6
Formable reinforced plastics (FRP)	6
Improved sheet molding compound (SMC)	6
Increased use of magnesium & aluminum	5
Adhesive bonding	*
Ductile iron suspension parts	*
Compact high-energy batteries for electric cars	*
Stainless steel manifolds vs cast iron	*
RIM nylon and polyesters	*
Shorter cycle time for plastics	*
Ability to use two-sided galvanized steel	*
Plastic body solder substitute	*
Injection-molded modular components	*
Blow-molded superplastic aluminum components	*
High-temperature plastics	*

* Single responses
** Laminated, carbon-fiber, glass-fiber, etc. reinforced composite materials
*** Other than for corrosion protection

Mat-11. Discussion

A number of breakthroughs in automotive materials technology are forecast during the next ten years, with the leader being the development of economical, high-strength, structural and engineering plastics. Polymer-based composite materials (which in themselves could be considered as engineering plastics) are the second choice. Several suggestions are listed, some of which could be considered as subsets of others. We avoided consolidation to preserve the identity of individual technologies.

Strategic Considerations

As a class, the plastics and polymers get the most mentions. This reflects in part the growing industry perception that related technology is entering a region of significant slope on the learning curve. Even a single comment can be revealing.

Mat-12. What new joining techniques do you foresee for body construction and panel attachment, such as gluing, new welding methods, etc.?

I. Body-Joining Techniques	Percent of Total Responses
Adhesives *	72%
Laser welding	19
Others **	9

* Epoxy and polyurethanes replacing spot welding.
High-strength glue which sets upon "command."
Gluing techniques such as used in buss assembly.
Anaerobic and ultra violet adhesive bonding.
Hot melt adhesives.

** Self-tapping screws, self-piercing rivets.
Structural joints to continue as automated spot welding using robotics.

II. Panel Attachment Techniques	Percent of Total Responses
Adhesives	50%
Mechanical joining ***	34
Laser welding	11
Utlization of ultrasonic & high-energy sources	S.R.
Welds in place of bolt-on or structural adhesives	S.R.

*** Includes plastics with molded inserts acting as attachment points (snap-on construction).

S.R. indicates single response.

Mat-12. Discussion

The primary new joining technique is expected to be improved adhesives including epoxy and polyurethane adhesives capable of replacing spot-welding. These new adhesives are listed in first place for both body-joining techniques and panel attachment techniques.

Strategic Considerations

A significant move to adhesives in assembly technology would profoundly affect labor requirements, vehicle design, equipment technology (and obsolescence), and capital investment.

Mat-13. What are the most important changes or factors that are leading to increased corrosion resistance as measured by:

A. Better surface resistance?

Response Categories	Percent of Total Responses
Improved paints/coatings (zinc, aluminum alloys)	30%
Zinc-coated steel	10
Replacement of steel in body exterior (increased use of plastics, nonferrous materials)	9
Improved electrocoat systems (E-coat primer, cationic electro deposition, ELPO)	9
Improved substrate surface preparations & processes	7
Increased customer value	7
Cleaner steel	5
Industry standards for corrosion testing/selection of materials with higher corrosion resistance	5
Increased use of galvanized steel	*
Improved techniques for prepainting zinc-rich materials that lend themselves to severe fabrication	*
Competition in extended warranties	*
Coil steel coatings	*
Marketing/PR advantage	*
Plastisol coatings	*
Improved undercoating	*
Stone chip-resistant coatings	*
Flush glass requirements for aerodynamics removed pockets around windshield that caught and held moisture and salt	*
Thermo-set top coats	*

Representative responses (included in above):

1. Durability is a major ingredient of marketplace push for quality.
2. The need for reduced cost of ownership through better re-sale or longer use by original owner.
3. Better control of ZnPH applications.
4. Consumer/regulatory pressure for improvement & availability of better zinc, zinc-alloy coatings.
5. New processes for coating (spraying, plating, one-side coating, arc spraying).
6. Thin zinc-iron alloy coatings on steel.
7. Thin free-zinc coatings on steel.
8. Clear-coat paint process.

* Indicates single response.

(Mat-13 continued)

B. Increased time before panel penetration?

Response Categories	Percent Of Total Responses
Zinc/alloy coatings on steel	27%
Improved paints/coatings (zinc, aluminum alloys)	20
Replacement of steel in body panels (increased use of plastics)	9
Increased customer value	9
Improved substrate surface preparation & processes	3
Cleaner steel	3
Cationic electro deposition	3
Coil steel coatings	3
Flush & dry rocker panels	3
Improved design	3
SMC and aluminum panels	3
Pigment systems	3
Use of plastic inner panels to protect high-exposure metal sections	3
Thermo-set top coats	3
Better control of ZnPH applications	2
Other	3

Representative responses:

1. Use of plastics in external body panels.
2. Availability of better zinc, zinc alloy coatings.
3. Increased use of and high quality zinc/aluminum coatings on steel sheets.
4. Increased usage of pre-coated steels.

Mat-13. Discussion

Many improvements and techniques are named to account for increased corrosion resistance as measured by better surface resistance and increased time before panel penetration. In each case the leading factor is improved paints and coatings, particularly those of zinc. Corrosion protection expectations (see Mat-8) places a high demand on zinc technology.

Mat-14. How important are initial tooling costs to decisions on materials choice?

Controlling	0%
Major	70
Minor	26
Not very important	4
	100%

Selected Comments from Panelists

There is a trend to more sand-cast aluminum for cylinder head covers (and also oil pans) for small, lower production engines. The big attraction is lower tooling costs. Stamping die sets for these parts are very expensive.
Piece price is still the main factor.
Tooling costs are very definitely a major factor; an additional factor (of almost equal importance) is tooling lead time.
Not very important for large volume production.
Longer model runs = better tooling R&D.
Major when considering change from ferrous to nonferrous.
Materials choice is sometimes dictated by process (casting vs. tubing) and vice versa. Therefore, the manufacturing process will have a major effect on the required tooling and the choice of material.
Piece cost is only half the cost story. One has to include a discounted cash flow analysis of tooling cost (over part life) to arrive at the total cost of material alternatives.
Pressure is to lower break-even volumes. High tooling (i.e., fixed or sunk) cost raises break-even volume. Materials permitting lower tooling costs should gain in use.
Major for lower volumes (less than 150,000/year)
Minor for higher volumes (more than 150,000/year)
Individual car manufacturers have markedly different philosophies about tooling costs, tooling funding, and relative weighting given to this factor in purchasing or engineering material decisions.

Mat-14. Discussion

In decisions on choice of materials, initial tooling costs are seen to be of major importance but are not the controlling factor.

Discussion of Panelists' Comments

The comments offer a rich selection of the complex factors that must be considered when evaluating tooling costs.

The last comment is particularly interesting in another context. Manufacturer-supplier relations are improving but suppliers must still learn to work with customers who differ significantly from each other. This is not a trivial problem.

Mat-15. How important is recyclability to material choices?

Important	7%
Of Interest	61
Unimportant	32
	100%

Selected Comments from Panelists

Should be important, but cost dictates decisions.

Recycling can improve a material's cost and supply. But many materials are selected which are less recycled than steel or copper.

Only important if economics of the vehicle are impacted.

This is a part of overall economic evaluation.

Life-cycle energy cost is strictly a marketing concept used by materials vendors.

Mat-15. Discussion

Recyclability is of interest but not of major importance in the determination of material choices.

Trend From Two Delphi Surveys

In 1981, at the time of the Delphi II Survey, 68% of the respondents forecast that by 1990 recylability would become a key design consideration. The current question does not duplicate the earlier one, but responses suggest that recylability is now considered of less importance.

Strategic Considerations

The recycling efficiencies of competing automotive materials have not been determined with enough precision to differentiate between them. High interest in recyclability a few years ago supported a number of studies but they did not clearly establish the automotive materials recycling leaders.

Note that question Mat-15 asks how important recyclability is to material choices. Automotive designers agree that recyclability is important to conservation efforts but cannot use it as a choice criterion unless recylcing differences between materials are known to be significant.

We believe several of the comments reflect confusion between the widely recognized importance of recyclability and the lack of information necessary to use it as an automotive design factor.

Mat-16. Are reduced vehicle volume forecasts influencing materials choices?

A. Yes 64% No 36%

B. (If "Yes"): How?

Moves the choice of manufacturing process towards low tooling cost processes and the corresponding materials.

Total cost which includes tooling cost (discounted over part life) will favor alternatives to steel such as plastic in body panels when nameplate volumes are lower.

Slow small-car sales, rising large-car sales require more lightweight materials to meet CAFE requirements and customer mpg expectations.

We try to hold down costs on low-volume cars. This precludes the use of premium materials.

Investment and variable costs are being given a more equal weight, which tends to favor plastics on a new material application selection.

Through tool cost vs piece cost considerations.

People are driving cars longer and paying more money for them. They demand more durability and better performance.

Lower unit volumes allow alternative materials (e.g., plastic) with lower tooling cost than steel to be introduced as cost effective.

Break-even more difficult with low volume. Stress will be on lower initial costs.

Yes, because of reduced profit opportunity to offset risk factors for material development.

In some cases capacity limitations affect materials choice.

Break-even points between competing materials are dependent on fixing tooling cost, variable costs, and volumes.

C. (If "No"): Why not?

Volume reductions have actually not been significant enough to have major impact on material trade-off decisions.

Vehicle volume forecasts are not reduced; therefore they cannot influence choices.

Volumes still significant and will be cost-effective.

(Mat-16 continued)

Mat-16 Discussion

Sixty-four percent of the respondents indicate that reduced vehicle volume forecasts are influencing materials choices. Several reasons are given for this influence, but the main one would appear to be that lower volume allows a trade-off of materials and processing costs against tooling costs and, for example, might encourage substitution of plastics for metal.

Strategic Considerations

Over one-third of the respondents see no volume impact on materials. Such a lack of consensus suggests the need for an open mind on the subject. Material usage must be closely monitored to avoid unpleasant surprises.