GASOLINE DEMAND BY OWNER CHARACTERISTICS

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This report is a preliminary analysis of gasoline demand in New York State by automobile-owner characteristics. It establishes a base-year (1971) average weekly gasoline demand for male and female automobile owners ages 16 to 85. This demand is based on vehicle type, percentage distribution in the automobile mix, annual mileage, and fuel economy. The report examines the impact of a 10-gal (38-liter) per-vehicle rationing policy, its effects on owner demand, and possible reductions in fuel consumption that can be expected by increasing the percentage of smaller cars in the automobile mix.

•BEFORE the average weekly gasoline demand can be established, information pertaining to vehicle type, annual vehicle mileage, vehicle type by percentage of the automobile mix by age and sex of the owner, and fuel economy has to be identified. The Vehicle Mileage Exposure Study performed by the New York State Department of Motor Vehicles (NYSDMV) for base year 1971 (1) provided the necessary data. 1971 was relatively free from the influencing market conditions being exerted on consumer demand and driving and purchasing habits because of currently depressed gasoline supplies within the public market. The exposure study provided information regarding vehicle type and annual vehicle mileage by age and sex of the registered owner. Subsequent correspondence with NYSDMV provided information for 1971, relating vehicle type by age and sex to the total number of registered vehicles in the automobile mix. Information pertaining to fuel economy in miles per gallon (kilometers per liter) for various model years and inertia weight classes was obtained from A Report on Automotive Fuel Economy (2). Classification of vehicles on the basis of inertial weight was available from weight figures in the National Automobile Dealers Used Car Guide (3).

PROCEDURE

So that the data (1, 2, 3) can be applied to the analysis of gasoline demand of vehicles, several assumptions are required:

1. The vehicle mileage is attributable to the registered owner;
2. There are no identifiable differences in an individual's physical driving habits resulting from ownership of different vehicle types;
3. Variation in driving habits exists only between age groups;
4. All computations refer to the average vehicle driven by the average owner-operator within each age group; and
5. No distinctions will be made among the various grades of gasoline, driving conditions, and urban or rural locations.

Table 1 gives the line models for the various vehicle types that are to be considered based on 1971 data. The various vehicle types given distinguish themselves by their

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actual weight rather than by their common vehicle descriptions. This is particularly important as manufacturers begin changing vehicle descriptions in their shift to smaller cars. For example, today's full-sized luxury vehicle weighs 5,500 lb (2495 kg); however, several years from now it may weigh only 3,500 lb (1588 kg), be twice as economical, and continue to be referred to as a full-sized luxury vehicle. Similarly, future intermediate vehicle types may refer to vehicles in the compact or subcompact range today. Table 2 gives the fuel economy in miles per gallon (kilometers per liter) for various model years and inertial weight categories. The fuel economy data given in Table 2 may in certain cases vary with the fuel economy obtainable under actual operating circumstances. However, in view of the consistent and uniform methodologies applied by the Environmental Protection Agency in the calculation of fuel economy for all vehicle types, these figures are equitable for comparative purposes.

In the calculation of fuel economy for each vehicle class, consideration was given to the representation of vehicles older than model year 1971 in the stratification of the automobile mix. Based on the New York State vehicle-age percentage distribution of registered vehicles by vehicle mileage (4) and the values of fuel economy for each model year before and including 1971, a corrected vehicle class fuel economy value was obtained. The difference between this corrected value and the value for model year 1971 was marginally significant. Therefore, values of fuel economy for model year 1971 are used in all calculation in this paper.

Table 3 gives the percentage distribution for males and females respectively by age of the owner for automobile ownership of the various vehicle types in the automobile mix (2). Vehicle type is also given as the percentage of the whole automobile mix, and age group ownership is given as the percentage of all cars owned.

It should be noted that there are only seven types of vehicle classification in Tables 3 and 4. This results from the combination of the subcompact and foreign vehicle categories, since their inertial weight and fuel economy, as given in Table 2, are both the same. This combined category is labeled subcompact vehicle type in these tables.

Table 4 gives the average annual vehicle mileage for the seven vehicle types, stratified by age group for both male and female owners. Since the average annual vehicle mileage data (1) by sex did not distinguish between the three types of full-sized automobiles (low, medium, luxury), the annual vehicle mileage for the Monte Carlo was selected to represent the full-sized, low-priced category, the annual vehicle mileage for the Chevrolet was selected to represent the full-sized, medium-priced category, and the annual vehicle mileage for the full-sized, luxury category was based on an extrapolation of the vehicle mileages for the other vehicle types and the average group annual vehicle mileage.

Using the data mentioned (1, 2, 3), two methods were examined for the calculation of weekly gasoline demand. The first method could be called the disaggregate approach, and the second could be called the aggregate approach. In the first method, the individual average annual mileages for each vehicle type within an age grouping are used for determining the gasoline consumption rates for male- and female-owned automobiles. This procedure is as follows:

$$\text{Miles per week (j)} = \frac{\sum_{i=1}^{7} \text{PDF ji} * \text{AAM ji}}{52} \tag{1}$$

$$\text{Gallons per week (j)} = \frac{\sum_{i=1}^{7} \frac{\text{PDF ji} * \text{AAM ji}}{\text{MPG i}}}{52} \tag{2}$$

Table 1. Line models for various automobile types.

Specialty	Sub-compacts	Compacts	Foreign	Intermediate	Full-Sized, Low-Priced	Full-Sized, Medium-Priced	Full-Sized, Luxury
AMX	Gremlin	Chevy 2	Datsun	Belvedere	Ambassador	Buick	Cadillac
Barracuda	Pinto	Corvair	Fiat	Buick Special	Chevrolet	Chrysler	Imperial
Camaro		Dart	Jaguar	Chevelle	Dodge	Mercury	Lincoln
Challenger		Falcon	MG	Classic	Ford	Oldsmobile	
Corvette		Hornet	Mercedes	Comet	Fury	Pontiac	
Cougar		Maverick	Opel	Coronet	Monte Carlo	Toronado	
Firebird		Rambler	Peugeot	Fairlane			
Javelin		American	Renault	F-85			
Mustang		Valiant	Saab	Marlin			
Thunderbird			Simca	Montego			
			Toyota	Rebel			
			Triumph	Tempest			
			Volvo				
			Volkswagen				

Table 2. Automobile type, inertial weight, and average mileage per gallon (kilograms/liter).

Vehicle Type	Inertial Weight (lb)	Avg Miles per Gallon
Specialty	3,500	12.2
Foreign	2,250	21.4
Subcompact	2,250	21.4
Compact	3,000	14.8
Intermediate	3,500	12.2
Full-sized, low-priced	4,000	11.7
Full-sized, medium-priced	4,500	10.7
Full-sized, luxury	5,000	9.6

Note: 1 lb = 0.45 kg, 1 mile/gal = 0.43 km/liter.

Table 3. Percentage distribution for male and female automobile ownership by automobile type and age of owner.

Automobile Owners		Automobile Type							
Sex	Age Group	Special	Sub-compact	Compact	Inter-mediate	Full-Sized, Low-Priced	Full-Sized, Medium-Priced	Full-Sized, Luxury	All
Male	16 to 20	23.6	1.2	14.2	35.4	20.2	5.27	0.2	0.7
	21 to 30	17.8	1.0	13.3	35.2	21.0	10.3	1.5	15.0
	31 to 40	7.3	0.5	10.4	26.6	33.2	18.5	3.4	19.4
	41 to 50	6.3	0.4	9.8	23.4	34.4	21.3	4.3	24.5
	51 to 60	6.3	0.4	10.6	24.6	31.4	22.0	4.7	22.8
	61 to 85	3.6	0.2	13.4	26.3	28.4	22.3	5.9	17.6
	All	7.9	0.5	11.3	26.7	30.3	19.2	4.1	
Female	16 to 20	24.9	3.2	21.9	28.9	16.5	4.3	0.4	0.9
	21 to 30	21.2	1.6	19.1	32.3	17.1	7.6	1.2	20.6
	31 to 40	9.6	0.7	14.4	27.7	28.7	15.7	3.2	16.5
	41 to 50	9.3	0.6	14.8	27.8	27.1	16.7	3.7	23.0
	51 to 60	7.7	0.4	16.7	30.0	24.9	16.7	3.9	22.5
	61 to 85	3.8	0.2	22.0	31.3	22.5	15.8	4.5	16.6
	All	10.7	0.7	17.3	30.0	24.0	14.4	3.3	

Table 4. Average annual mileage for male and female automobile ownership by automobile type and age of owner.

Automobile Owners		Automobile Type							
Sex	Age Group	Special	Sub-compact	Compact	Inter-mediate	Full-Sized, Low-Priced	Full-Sized, Medium-Priced	Full-Sized, Luxury	All
Male	16 to 20	14,436	14,145	13,300	12,114	11,035	13,759	15,235	13,432
	21 to 30	12,735	13,355	12,753	12,425	14,362	12,503	10,123	12,608
	31 to 40	11,463	11,764	10,953	11.145	12,932	11,674	10,485	11,488
	41 to 50	11,362	12,179	10,982	11,122	13,116	11,805	10,921	11,641
	51 to 60	10,613	11,376	10,130	10,409	10,975	11,165	11,800	10,924
	61 to 85	9,989	9,535	7,452	7,981	10,159	9.250	7,087	8,779
	All	11,725	12,091	10,232	10,718	12,544	11,263	9,575	11,164
Female	16 to 20	12,302	13,473	11,832	12,199	14,164	11,769	11,061	12,400
	21 to 30	11,223	11,742	10,857	11,024	12,397	11,705	10,124	11,296
	31 to 40	9,961	10,385	9,293	9,960	12,151	11,238	10,554	10,506
	41 to 50	11,031	11,333	9,773	9,826	13,016	11,165	8,644	10,684
	51 to 60	10,060	10,322	8,376	8,692	10,637	9,892	7,821	9,400
	61 to 85	8,105	7,309	5,781	6,242	7,506	7,732	5,317	6,856
	All	10,795	10,948	8,715	9,284	11,113	10,370	8,376	9,943

Note: 1 mile = 1.6 km.

$$\text{Miles/gallon (j)} = \sum_{i=1}^{7} \frac{\text{PDF ji} * \text{AAM ji} * \text{MPGi}}{\sum_{j=1}^{7} \text{PDF ji} * \text{AAM ji}} \quad (3)$$

where

i = vehicle type,
j = age group,
PDF ji, PDF ji = percentage distribution of the seven vehicle types in the automobile mix (Table 3),
AAM ji, AAM ji = individual average annual mileage for each vehicle type within an age grouping (Table 4), and
MPG i = average fuel economy in miles per gallon (kilometers per liter) for each vehicle type (Table 2).

In the case of the second method, the average mileage for all vehicle types within an age group is used for determining the gasoline consumption rates for male- and female-owned cars. This procedure is almost identical to the previous procedure, except that the individual average annual mileage for each vehicle type within an age grouping (AAM ji) is replaced with the average age group mileage AAGM j (last column, Table 3).

For the purpose of this paper, the first method is used exclusively. However, during this analysis, it was necessary to determine the accuracy of the second method in the event that a stratified automobile mix would not be available for the analysis of fuel consumption in years after 1971. The use of the average annual vehicle mileage for all vehicles in the automobile mix proved to be representative of the mileage of the automobile mix when the individual vehicle types were taken into consideration. This indicated that, for the purpose of calculating fuel consumption and economy, the average annual vehicle mileage when weighted by the number of vehicles in each class is a reasonable approximation of the mileage for all vehicles in the automobile mix.

The calculation of miles per gallon (kilometers per liter) for each age class, as represented by equation 3, is much more sensitive to changes in the automobile mix than is an equation for miles per gallon (kilometers per liter) based on equation 1 divided by equation 2. As a result, it is possible to obtain the value of gasoline consumption in gallons (liters) per week in two ways: (a) by calculating it from equation 2 and (b) by dividing equation 1 by equation 3 (for this paper, mileage is the given). The difference between the two values of gasoline consumption is due to the differences in equations 2 and 3. Equation 3 is weighted to best reflect the economy of scale, that is, the economy due to the percentage of the market occupied by a particular vehicular type. Equation 2 is based on the relative empirically determined fuel economy of each vehicle type in miles per gallon (kilometers per liter) and the relative proportional annual mileage. Both of these fuel consumption values are given in Table 5.

DEMAND CHARACTERISTICS

The results of the calculations based on equations 1, 2, and 3 are given in Table 5, which contains the average weekly mileage, fuel consumption rates, and the relative miles per gallon (kilometers per liter) in fuel economy for each age group.

Table 5 clearly indicates that gasoline demand in terms of the average number of gallons (liters) consumed by the automobile on a weekly basis decreases as age of the owner increases. This is because, annually, fewer miles are driven. Gasoline consumption in general is lowest for cars driven by females and by the 51 to 60 and 61 to 85 age groups. This second observation is understandable since most people stop driving automobiles during these years. There is one exception, however, and it is in the 16 to 20 male age group when the calculation is done with equation 2. In this instance, cars driven by males have a lower gasoline consumption rate than those driven by females. This may, in part, be due to the higher insurance risk grouping for young male drivers, which tends to discourage vehicle registrations at such a young age. Since the data used in calculating Table 3 are based on the number of registrants by vehicle type, age, and sex, it is quite possible that cars driven by males may actually have a high consumption rate but that their cars are registered in their parents' or guardians' names.

For the cars driven by the 21 to 50-year-olds, gasoline demand is high and relatively constant in terms of the number of gallons (liters) consumed each week. Furthermore, there is a definite upward trend in car ownership from the compact to the full-sized car. This trend in increasing car size with increasing age also continues into the 61 to 85 age group (Table 3). This trend more or less parallels family growth (and increasing affluence) in the middle years when the need for a larger car in which to drive the family around becomes a predominant factor in vehicle selection. This, coupled with the possible retention of an older or the addition of a smaller, more economical car, might explain the relatively constant consumption rate for ages 21 to 50.

Gasoline demand is generally lower for women than for men, and, similarly, fuel economy is generally higher for cars driven by women than for cars driven by men. This is partially explainable by the data in Table 3. It is apparent that women tend to purchase and own a greater percentage of the more economical, compact, and subcompact automobiles than men. The trend also follows for young people in general. Similarly, the trend to move up to a bigger and heavier vehicle type is not as pronounced for women as it is for men. This again concentrates ownership of more economical vehicles among women.

IMPACT OF RATIONING POLICY ON GASOLINE DEMAND

The nature of the gasoline demand discussed so far has been examined only in terms of identifiable trends, relating age, sex, and vehicle preference based on registration to gasoline consumption on a weekly basis. Because of the imminence of nationwide gasoline rationing, various rationing schemes had been proposed. In view of this, it was necessary to examine the existing data on gasoline demand to determine whether gasoline rationing would possibly impact one automobile-owner age group more severely than another.

The gasoline requirements of 1971 (Table 5) indicate that for cars owned by males aged 16 to 50 demand is at a reasonably constant average of 19 gal (72.2 liters) per week (no distinction is made among the various grades of gasoline available). However, this demand significantly decreases from 19 gal (72.2 liters) per week for male owners aged 51 to 60 to a low of 14 gal (53.2 liters) per week for male owners aged 60 and above. Similarly, gasoline demand for female owners is approximately 2 to 3 gal (7.6 to 11.4 liters) per week less than that for male owners at all ages. Obviously, any gasoline rationing plan advocating allotments on the order of 10 gal (38 liters) per week (such as those proposed during the midst of the fuel crisis) would severely restrict automobile use and availability to most owners in their principal earning years, ages 21 to 50. It would not, however, really impose any severe hardship on those 60 and older (assuming of course that the registered owner is the only driver of the vehicle).

Monthly average daily vehicular travel counts (recorded at continuous counting stations throughout New York State) were compared with those of the previous year to measure the margin of excess driving that had been eliminated as a result of voluntary conservation on the part of the public. During February 1974, when the impact of the gasoline shortage was at its worst, the value for the average daily vehicular travel in New York State indicated a 14.2 percent decline from the previous year. This decline, when applied to a gasoline demand of 19 gal (72.2 liters) per week, represents a reduction in demand of 2.7 gal (10.2 liters) of gasoline per week for the average owner. Even with this reduction, demand is still much above a proposed rationing level of 10 gal (38 liters) per week.

Table 5. Miles (kilometers) per week, gallons (liters) per week, and miles per gallon (kilometers/liter) for males and females by age of owner.

Automobile Owners		Miles per Week	Gallons per Week[a]	Gallons per Week[b]	Miles per Gallon
Sex	Age Group				
Male	16 to 20	206.26	13.88	19.75	14.86
	21 to 30	249.55	20.23	20.47	12.33
	31 to 40	227.35	19.01	19.20	11.96
	41 to 50	229.83	19.36	19.57	11.87
	51 to 60	207.73	17.52	17.72	11.86
	61 to 85	169.88	14.30	14.46	11.88
Female	16 to 20	239.38	18.61	18.97	12.86
	21 to 30	217.69	17.29	17.54	12.59
	31 to 40	206.07	17.03	17.24	12.10
	41 to 50	210.13	17.35	17.66	12.11
	51 to 60	180.80	14.88	15.02	12.15
	61 to 85	95.32	7.81	10.59	12.21

Note: 1 mile = 1.6 km. 1 gal = 3.8 liters. 1 mile/gal = 0.43 km/liter.

[a]Calculated with equation 2. [b]Calculated with equation 3.

Table 6. Observed distribution of New York State automobiles by weight class.

Item	Sub-compact	Compact	Intermediate	Standard, Full-Sized
Current 1971[a]	0.0060	0.1438	0.3748	0.4765
DMV 1980 forecast	0.15	0.20	0.30	0.35
Ad hoc committee 1980 estimate				
Low	0.30	0.20	0.25	0.25
High	0.35	0.25	0.25	0.15
Empirical vehicle fuel economy (Table 2)	21.4	14.8	12.2	10.67

[a]Calculated from Table 3 by a weighted percentage distribution based on the combined male and female distributions and, when necessary, consolidated into the above categories on the basis of fuel economy.

Table 7. 1980 market changes in consumption and economy.

Item	Fuel Economy (miles/gal)	Gallons per Week
Current 1971	11.84	18.15
DMV 1980 forecast	13.64	16.58
Ad hoc committee 1980 estimate		
Low	15.29	15.33
High	16.07	14.47

Note: 1 mile/gal = 0.43 km/liter. 1 gal = 3.8 liters.

In addition to an examination of the measure of excess driving that in part makes up gasoline demand, the overall shift to smaller cars and its subsequent effect on this demand had to be estimated. As such, the data for 1971, on which the analysis in this paper has been based, provide the necessary starting point to observe the changing trend in consumer preference for smaller or just plain economical automobiles. An analysis of vehicle registration at this time indicates that the percentage of subcompact cars within the entire automobile mix is relatively small, since the impact of the subcompact car (or the most economical car) is not yet significant enough to be reflected in relative gasoline consumption. Therefore, if we assume that the shift toward more economical cars has been accelerated because of the psychological impact of the severity of a reduced gasoline supply, then we must recognize that this shift will also impact the used-car market and the 13-year automobile life cycle to the extent that the larger, less economical automobiles will be forced out of the market at an earlier date. This would then raise the relative fuel economy of the automobile market as a whole, since people would become more selective in their used-car purchases.

To estimate what the probable change in gasoline demand could be, the Ad Hoc Committee on Energy Efficiency in Transportation estimates for the 1980 automobile distribution were used (Table 6) (5). These distributions were analyzed to determine the probable reduction in gasoline demand resulting from increases in the percentage of economical vehicles making up the market distribution (Table 7). The results indicate, that if the number of economical vehicles registered in 1980 were to significantly increase to represent 30 percent of the total automobile mix, then the corresponding effect on gasoline consumption would be equivalent to a 20 percent reduction in the current (1971) weekly gasoline demand. However, this observation is based on two assumptions:

1. The annual mileages for each of the following vehicle categories remain consistent with those previously observed (1 mile = 1.6 km):

Automobile Type	Mileage
Specialty	10,991
Foreign	11,602
Subcompact	13,004
Compact	9,912
Intermediate	10,781
Full-sized, low-priced	11,591
Full-sized, medium-priced	11,306
Full-sized, luxury	11,354

2. The economy for all the vehicle types remains the same as that observed in 1971. (Based on the procedures discussed in this paper and the average annual mileages above, a similar analysis can be done for the four vehicle categories. These mileage values are used for Table 7 since stratification of the automobile mix by age and sex is not required. When necessary, the categories above were combined into the four categories of Table 6 on the basis of fuel economy, and a corresponding average mileage and average fuel economy were then used. The net predicted market changes in consumption and economy are given in Table 7.)

As such, the predicted change in consumption depends on whether energy conservation as observed during the crisis (1973-1974) will continue or will yield to the wasteful driving habits previously in existence when gasoline supplies return to normal. In addition, automobile efficiency has continually declined as automobile emission controls have increased.

Therefore, if a 14.2 percent reduction in vehicle travel due to conservation efforts were to be experienced in 1980, in addition to the estimated change in vehicle distribution, a reduction of 34.2 percent in the 1971 gasoline demand would result. This reduction would make the weekly gasoline demand for male owners aged 21 to 50 about 12 gal (45.6 liters) per week or just slightly above the 10 gal (38 liters) given as a proposed rationing level.

CONCLUSIONS

The analysis of gasoline demand in New York State and the relative impact of a nationwide gasoline rationing policy on that demand serve to emphasize the seriousness of an energy shortage in the private transportation sector. As such, the following observations can be made relating owner characteristics based on present gasoline demand and the effects of rationing and changes in the automobile mix on that demand.

1. Gasoline demand decreases as owner age increases and as annual mileage decreases.
2. Gasoline demand is lower for women than for men because women have a greater preference for smaller, more economical compact and intermediate vehicles. Similarly fuel economy is higher for cars driven by women than for those driven by men.
3. The trend to purchase larger, heavier, and consequently more expensive vehicles and a relatively constant rate of gasoline demand are most pronounced in the 21 to 50 age group. This trend parallels the period of increasing family size and financial security when the need for a large car or second car exists.
4. Subcompact and foreign cars are clearly more economical than the other vehicles. They travel in excess of the average annual mileage for the entire automobile mix. However, they are present in too small a proportion of the total automobile mix (in 1971) to have a significant impact on the reduction of the gasoline market demand and fuel economy at this time.
5. Based on estimates of future automobile mixes, an increase in the proportions of more economical automobiles to 30 percent of the automobile mix (with the economies of all other vehicle types remaining the same) would yield a 20 percent reduction in market gasoline demand.
6. Based on current (1971) estimates for gasoline demand, a 10-gal (38-liter) per-week, per-vehicle rationing scheme would most severely impact owners in the 21 to 50 age group. Assuming no reductions in vehicular travel through public conservation efforts, demand would exceed the allotted supply by a ratio of 2 to 1. Given the maximum reduction in vehicular travel, as observed during February 1974, demand would still exceed the allotted supply by a somewhat lower ratio of 1.5 to 1. If the present vehicle distribution were to be equivalent to that expected for 1980, where the percentage of subcompact cars represents 30 percent of the market distribution, then the ratio of demand to supply would be just slightly greater than 1 to 1.

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