allotments to hardship applicants. Responsibility for providing supplemental allotments that take into account the mobility needs of the handicapped would be delegated to the state and, in turn, to local offices by the states.

PRIORITY CLASSES

Priority status would be limited to activities that provide for national security, public transportation, protection of public health, safety and welfare, energy production, and maintenance of telephone and telecommunications services. Special status would also be given to farmers, who would receive sufficient allotments adequate to fully meet food and fiber production goals approved by the President.

RESERVES

State ration reserves would be established in each state for use by state and local offices in issuing hardship allotments. States would have considerable discretion in the use of their ration reserves, subject to limited DOE standards and guidelines. The responsibilities of state and local governments would increase in accordance with their capability and willingness to handle them, with the state ration reserves increased accordingly. DOE would establish and maintain a National Ration Reserve for use in meeting special national emergency needs and for such other purposes as DOE found necessary.

ISSUANCE OF RATION ALLOTMENTS

Ration allotments would be issued in the form of government ration checks, which would be exchanged for ration coupons at designated coupon-issuance points. These checks would be issued in advance of each ration period, with the allotment amount printed on the check. DOE or the states would issue supplemental allotment checks for priority activities, farms, and other eligible firms. Checks would also be issued to states for their ration reserves.

COUPONS

DOE might adopt simplified procedures for establishing coupon eligibility (such as accepting walk-in applications) if it were necessary to impose rationing before the necessary preparatory measures had been completed. DOE would enlist the participation of a variety of qualified organizations as coupon-issuance points. These organizations would be supplied with coupons by DOE and would serve as ration-check-cashing points for recipients of government ration checks. Different series of coupons would be distributed. For each series, DOE would establish the date at which it becomes valid. Coupons would be valid until used, or until the end of the rationing program.

DOE would permit the sale or transfer of ration coupons on a voluntary basis. DOE would impose no price controls or other controls on this market, except as may be necessary to prevent activities disruptive to the rationing program.

RATION BANKING

Individuals and organizations would open ration banking accounts at participating ration banks, subject to DOE regulations concerning these accounts. Account holders could deposit valid coupons or ration checks to their accounts and could write ration checks against their accounts. Gasoline suppliers could open redemption accounts at ration banks. These redemption accounts would be used for deposit of redeemed (or canceled) ration coupons and ration checks received by the supplier in gasoline sales. These suppliers in turn would write checks on their redemption accounts to pay their suppliers for resupply of gasoline.

Economic Allocation of Gasoline Shortages

Carmen Difiglio

The purpose of this paper is to evaluate ways of restoring economic allocation of gasoline supplies if severe interruptions of U.S. petroleum imports occur. Cost and benefits of gasoline price controls, taxes, rationing, and the time required to implement each approach will be estimated. Each plan will be defined and evaluated in terms of its likely impact on the gasoline market and the equity provided for gasoline consumers. The costs and benefits provided in this paper are necessarily based on certain assumptions, especially in terms of the degree of shortfall, the price elasticity of demand for gasoline, and other aspects of consumer behavior in the face of a shortage. However, the conclusions reached would survive a wide variation of assumptions used to calculate the various costs and benefits. In addition, the waste implied by mismanaging a severe gasoline shortage is enormous—at least $75 billion annually or more. Therefore, we cannot afford to be casual about how gasoline shortages are dealt with. As discussed below, existing public opinion on this issue and the conclusions reached in this paper are entirely at variance with each other.

Much of the controversy regarding gasoline problems results from a wide difference of views as to what causes them and who is responsible. However, since the Iranian and Afghanistan crises, there is a growing realization that our future supply of Persian Gulf petroleum is not secure and that some external and uncontrollable event could interrupt or terminate a significant proportion of U.S. petroleum imports.

Approximately 25 percent of the petroleum consumed in the United States is imported from Persian Gulf suppliers (1, pp. 5-9 and 5-22). If the supply of Persian Gulf oil were interrupted, considerably more than 25 percent of our normal oil supply would be unavailable because of increased worldwide demand for the exports still produced by suppliers outside of the Persian Gulf. If supplier countries rationed out the remaining petroleum, the United States could experience up to a 40 percent reduction in available petroleum (1, pp. 5-9 and 5-21).

Political scenarios that result in a substantial proportion of Persian Gulf oil being withdrawn from the world market are all too easy to imagine. These scenarios can involve domestic upheavals similar to what has occurred in Iran or can involve aggression as in Afghanistan (although not an oil producer, it is in the same geographic area). In addition, foreign intervention may help destabilize existing supplier-country governments by supporting revolutionary movements. Regardless of exactly how such upheavals may occur, future events could result in a loss of oil exports from major supplier countries. Also, the supply interruptions may not be of short duration. Changes in political regimes could result in an indefinite reduction of production (while providing more than adequate foreign exchange). Any serious violence in the area could result in the destruction of production or transshipment facilities that would eliminate exports for several years, possibly even a decade.

The possibility of a severe drop in petroleum supply concerns the transportation sector more than any other component of the economy because transportation is an

energy-intensive activity that depends almost completely on petroleum as an energy source. Consequently, about 54 percent of total U.S. petroleum demand is used by the transportation sector (1, p. 2-15). About 30 percent of this petroleum demand is used as gasoline in passenger cars (1, p. 2-15). The message is clear: If a severe interruption in petroleum supply occurs, one of the most significant policy problems facing the United States is how to allocate scarce supplies of gasoline and diesel fuel to consumers. If this policy problem is solved for the transportation sector, only 46 percent of the problem is left to the remaining economic sectors. Also, the remaining sectors have a substantial capacity to switch from one fuel to another—for example, from oil to natural gas for buildings, from oil to coal for electric utilities, and from oil to coal or natural gas for industrial processes. Opportunities for fuel switching in the transportation sector are relatively limited and are virtually nonexistent in the short term.

In order to calculate various costs and benefits, a 30 percent shortfall of gasoline is assumed—a level that could correspond to a major catastrophe in the Middle East. Only gasoline will be considered in this paper because the focus of the analysis will be on the private automobile and not on the commercial sector. A more precise and comprehensive analysis would include both gasoline and diesel fuel use by the private and commercial sectors. The number of private automobiles that use diesel fuel is increasing, and the commercial sector uses a substantial amount of gasoline. However, for the level of analysis to be presented here, we will assume that preemergency consumption is 7 million bbl/day of gasoline by private end-users (i.e., cars and trucks) and that only 4.9 million bbl/day will be available within two or three months after some precipitating event (2).

GASOLINE SHORTAGES

A gasoline shortage results from a specific chain of events that would normally begin with a major reduction of petroleum supply. However, any given reduction in petroleum supply is insufficient in and of itself to cause a gasoline shortage. As is illustrated by the gasoline shortages of 1973-1974 and 1979, interference with market-clearing processes is required before shortages of gasoline result. A severe reduction in petroleum availability results in reduced gasoline production at the refinery. In the past, DOE regulations have caused larger declines in gasoline production than might have otherwise occurred because the public policy was based on ensuring adequate heating oil reserves. Sharp decreases in gasoline production result in allocation of motor fuel to jobbers and retailers in accordance with DOE allocation regulations. When gasoline supplies are sufficiently tight, retailers either start running out of their monthly quotas of gasoline or restrict their hours of operation. Consumers are unable to purchase the gasoline they want at the controlled price (according to DOE price regulations), and queuing occurs as a way of rationing the shortage of gasoline. Service stations are not legally able to increase the price of gasoline to allow sales of supplies without queues. Otherwise, increases in the retail price of gasoline would suppress demand until queues and the gasoline shortage disappeared.

A gasoline shortage represents an imbalance of supply and demand at the controlled price. The purpose of the controlled price is to significantly reduce the windfall profits that would accrue to the petroleum industry when shortage conditions occur. If price controls were not used, a sharp reduction in gasoline availability would cause substantially increased revenues to the petroleum industry. (The effects of the Windfall Profits Tax are not discussed in this paper in order to simplify the analysis. However, the tax is considered in Appendix D.) The reduction in the volume of gasoline sales that results from a supply interruption would cause a loss in gross revenue if the price of gasoline did not change. However, the change in the price of gasoline is so severe that supply interruptions cause a dramatic increase in revenue from gasoline sales. A review of several models of gasoline demand (3-9) suggests that the short-term price elasticity of demand for gasoline is between -0.10 and -0.30. An elasticity of -1.0 would be required in order for sales revenue to remain constant after a supply interruption. Assuming the midpoint price elasticity (i.e., -0.20), the petroleum industry would receive $101 billion more annual revenue without price controls than with price controls on their domestic gasoline sales. My calculation also assumes that U.S. price controls are set to maintain an unchanged gross revenue from gasoline sales before and after a supply interruption of 30 percent. This assumption is used to approximate the DOE price control set after consideration of postemergency crude oil acquisition costs and the allowable cost and profit margins for refining, wholesaling, and retailing of a significantly reduced supply of product. It is not suggested as a criterion for establishing price controls.

With these assumptions, the price of gasoline would be $1.34/gal higher without price controls than with price controls. (See Appendixes A and B for a discussion of price elasticities.) Therefore, the immediate benefit of price controls to consumers is to sharply reduce their expenditures for gasoline. Of course, because price controls prevent an income transfer, there is also an income loss to the petroleum industry equal to the consumer benefit that results from lower prices. Unfortunately, price controls have not only effected an income transfer of $101 billion from producers to consumers but have also caused a shortage of gasoline—an imbalance of supply and demand. As the recent and relatively minor shortages of gasoline have demonstrated, the consumer is hardly immune to the consequences of a shortage and must also assume a substantial cost in addition to the substantial benefits provided by price controls.

COST OF SHORTAGES

The cost of a gasoline shortage is represented by the loss of the market-clearing process that is inherent to uncontrolled markets. This is not to say that a perfectly competitive market exists for gasoline or for any other commodity. It is simply a theoretically sound and empirically verified observation that uncontrolled markets are characterized by product availability to all consumers who wish to purchase at the available price. Although specific instances of product shortage have occasionally occurred in uncontrolled markets, they are generally the result of a price control imposed by manufacturers in anticipation of increasing production to meet unexpected product demand. This behavior results from the desire of a manufacturer to maintain relatively stable prices during a temporary period in which product demand and anticipated demand are seriously imbalanced. Product introductions provide several examples of these voluntary shortages such as those that occurred in 1970 and 1971 after the introduction of the Datsun 240Z sports car.

Although uncontrolled markets are characteristically in balance (i.e., market clearing), controlled markets are characterized by conditions of shortage when the controls result in lower-than-market-clearing prices. Rent controls provide the classic example of the controlled market in which shortage conditions are indefinitely perpetuated. As the rental market has amply demonstrated, price controls are a mixed blessing to renters. Apartments under rent control are typically hard to find and waiting in line becomes the prevailing requirement to get one. The product is rationed by one's willingness to wait rather than by what one is willing to pay.

We have already calculated the benefit to consumers of not having to pay higher prices. But what about the cost? Something tangible has been lost when markets do not clear. One either waits or pays some black-market price to move up in line. Based on the recent gasoline shortages of 5-10 percent that occurred in many urban areas, an across-the-board 30 percent shortage is estimated to result

in an average waiting time of 2 h. If personal time were valued at $4.00/h, approximately $60 billion of time will be lost in queues waiting to buy gasoline.

In addition to lost time, there will also be lost gasoline: 325 000 bbl/day will be used up idling in queues (10). (No data exist regarding the waiting times experienced during the 1973-1974 and 1979 gasoline shortages. My personal observation was that, while Washington, D.C., experienced a 10 percent shortage, waiting times of about 1 h were typical. A 30 percent shortage is conservatively estimated to produce an average 2-h wait time, all other things being equal. The $60 billion estimate of the lost value of waiting time is offered as a conservative estimate of the economic loss to individuals represented by the opportunity cost of the time lost waiting in queues.) To put this loss into perspective, the mandatory fuel economy standards are estimated to provide a saving of 380 000 bbl/day by 1985 (11). Therefore, the likely waste of gasoline from a gasoline shortage is nearly equivalent to the fuel saving in 1985 provided by the most significant transportation conservation program in place in the United States. In addition, the estimated market value of the wasted fuel is $16 billion annually.

The full cost of gasoline shortages is hard to quantify. Thus far, estimates have been made of the easiest costs to quantify. They are summarized in the following list, which identifies the annual costs and benefits to consumers, producers, and society that result from price controls after the assumed supply interruption:

1. Benefit to consumers resulting from lower, controlled gasoline prices, $101 billion/year;
2. Loss to petroleum industry resulting from controlled gasoline prices, $101 billion/year;
3. Value of waiting time lost in gasoline queues, $60 billion/year;
4. Value of wasted gasoline, $16 billion/year;
5. Net social cost, $76 billion/year; and
6. Percentage of income transfer to consumers lost in waiting lines, 75 percent.

The direct benefits to consumers and losses to producers resulting from gasoline price controls are exactly equal. However, because the loss of the market-clearing process has caused additional consumer costs, the net social cost of gasoline price controls implied by the above list is $76 billion annually. This figure is conservative and does not include these potential costs: (a) the loss in capital value of the automobile stock as a result of shortage conditions, (b) the opportunity costs of activities that could no longer be planned due to uncertainties in acquiring gasoline, and (c) the economic losses to individuals who depend on automobile transportation for their work. It is entirely possible that inclusion of these costs could raise the cost of a shortage to more than 100 percent of the income retained by consumers and kept from the petroleum industry. The loss of the market-clearing process causes costs that are so large that one need not have a precise estimate of them to realize how unacceptably high they are. A transfer of $101 billion of wealth from oil producers to oil consumers can be more efficiently accomplished than at a higher-than-75 percent deadweight loss. The U.S. economy cannot afford the waste of $76 billion or more annually in gasoline queues. In order to prevent such waste, it is necessary to restore the market-clearing process.

REESTABLISHING ECONOMIC ALLOCATION

There are several scenarios that would restore an economic allocation of the shortfall and avoid the waste associated with a severe gasoline shortage. Decontrol of gasoline and petroleum would restore the market, but gasoline consumers would lose an additional $101 billion. Many would, doubtless, prefer to pay their money and get their gasoline, while others would rather pay less and put up with the inconvenience of the shortage.

Alternatives to these two scenarios are only vaguely understood. We have learned about price controls and gasoline shortages and can readily envision higher prices without lines, but ways of avoiding shortages and preventing the petroleum industry from reaping a huge windfall profit in the midst of a national emergency are available. Policies to prevent windfall profits without the loss of the market process to distribute gasoline include the following:

1. Administratively determined gasoline tax ($1.34 estimated for a 30 percent reduction in gasoline availability)—Revenues from this tax would be used to reduce other taxes;
2. Administratively determined gasoline tax with rebate—Revenues from this tax would be rebated to the public according to some entitlement criteria (e.g., equal distribution to all persons 16 years or older, equal distribution to all licensed drivers, proportional—i.e., one share per vehicle—distribution to all vehicle owners, and other variations); and
3. Gasoline rationing with white market—This plan would have the same entitlement criteria as the administratively determined gasoline tax with rebate.

There are also policies that can eliminate gasoline lines. However, these do not restore the market process to gasoline distribution: (a) strict gasoline rationing (no white market), (b) restrictions on motor fuel purchases (e.g., use of license digit schemes), (c) still days for automobiles (the sticker plan), and (d) other contingency plans that restrict the use of the automobile. These four policies can prevent queues but only by strictly allocating gasoline entitlements to individuals or by imposing other restrictions on personal behavior relating to the use of the automobile. Instead of restoring the market process, they shift the control of gasoline prices to direct control of gasoline purchasing (strict rationing) or employ proscriptions on behavior that reduce gasoline demand. The sticker plan is a good example of this. Automobiles would have windshield stickers that identify the days of the week on which the vehicle is permitted to operate. Thus, gasoline demand can be reduced sufficiently to eliminate gasoline queues even though a market process is not really functioning. For example, under the sticker plan individuals who value or require more-than-average driving cannot buy extra traveling privileges, as they would be able to buy extra ration coupons or to pay increased excise taxes—two actions that would permit the "purchase" of extra travel. Therefore, while gasoline lines would be eliminated, new inefficiencies would have been introduced by directly mandating personal behavior. Individuals who require an automobile for their livelihood either have to reduce travel and therefore income or have to appeal to the bureaucracy to receive special privileges not accorded others. Therefore, the impact of these policies on personal income can be significant, whereas market processes always insulate such individuals from a monetary disadvantage larger than the increased price of gasoline. A plan that simply eliminates mobility causes direct personal losses that are often larger than the waste caused by waiting in line. As bad as gasoline queues are, they do provide an upper limit on the cost of the gasoline shortage to individual users. The monetary losses to individuals who are denied access to transportation in specific situations can be far larger than from waiting in line.

A detailed analysis of plans that do not restore market processes will not be provided in this paper. Because one or more alternative public policies can restore market processes while providing a wide range of desired income-distribution objectives, plans that shift the shortage from one arena (purchase of gasoline) to another (use of the vehicle) are not required and are not constructive.

Before exploring the aggregate economic benefits of alternative gasoline-allocation plans, it is important to address the income and equity objectives that the plans should fulfill. The three plans reviewed here include two

types of gasoline rationing and a gasoline tax with rebate. Rationing is often perceived as a nonmarket mechanism for providing a fair share of gasoline to all users. In order to achieve this objective, rationing would somehow allow each driver to still travel a constant percentage of his or her current travel level at no increase in cost. However, ration coupons could never be distributed in such a way as to achieve this objective. In order to do so, all drivers would have to be surveyed and some procedure developed for verifying their responses. Any feasible distribution scheme will result in some individuals receiving far too many coupons for their needs, while others receive far too few. Therefore, a market is required that allows drivers to purchase extra coupons or realize income on coupons that individuals do not want to spend on travel.

The equity of this market ultimately depends on how resources with which to participate in the market are distributed. Under rationing, coupons are negotiable whether permitted or not. If this is accepted and coupons are openly allowed to be negotiable, then ration coupons and money would become close substitutes for each other in that they would function as currencies or negotiable assets. Therefore, the resources that individuals have to participate in the gasoline market are the income and assets they normally have plus the additional distribution of gasoline ration coupons or gasoline tax rebates. No gasoline-allocation scheme can change the fact that high-income people will have the resources to maintain travel if they choose to, while low-income people will be substantially more constrained and will face more difficult trade-offs between travel and other needs. The impact on equity derived from alternative gasoline-allocation plans is completely dependent on how they affect the net-income position of individuals. Allocation plans cannot be evaluated in terms of the fairness of the distribution of gasoline because they do not distribute gasoline but rather the economic resources with which to purchase gasoline. Both the rationing and tax with rebate plans provide recipients with purchasing power either in the form of ration coupons or gasoline tax receipt rebates. The ultimate distribution of gasoline to consumers depends on their original purchasing power, the extra purchasing power derived from the allocation plan, and the trade-offs consumers will make among their demands for mobility, other goods and services, and savings. Therefore, the equity of the plans to be reviewed is independent of all their characteristics except how they affect the purchasing power of individuals. The gasoline tax with rebate is neither more nor less equitable than the rationing of negotiable coupons unless coupons and tax rebates are distributed differently. The equity of alternative-distribution criteria will be reviewed in the following section of this paper.

GASOLINE TAX WITH REBATE

Gasoline taxes can be used to suppress the demand for gasoline. When shortage conditions occur, large gasoline taxes would be required to suppress gasoline demand sufficiently in order to reduce the market price received by retailers to levels that prevent large windfalls to the petroleum industry. Large gasoline taxes are required because of the low price elasticity of demand for gasoline. This is illustrated in Figure 1. Before a shortfall occurs, consumers are using Q_1 gasoline (107 billion gal/year) at price P_1 ($1.25/gal). Before shortfall conditions occur, the gasoline market is providing equilibrium between supply and demand without imposing any nonprice costs on consumers (gasoline lines).

When a shortfall occurs, the supply of gasoline shifts from S_1 to S_2. The new market-clearing price is now P_2, substantially above the allowed price P_c ($1.79/gal). The quantity of gasoline available at price P_1, P_c, or P_2 is approximately Q_2 because the supply curve of gasoline is assumed to be quite inelastic. Although the supply of gasoline would be larger at P_2 than at P_c or P_1, the differences are not likely to be large enough to affect the analysis and Q_2 is assumed to be the quantity of gasoline supplied at price P_1, P_c, or P_2. (Appendix E discusses the elasticity of the supply of gasoline.) Therefore, all of the market-clearing process has to occur on the demand side. In an uncontrolled market, this would occur with a price rise to P_2 ($3.13/gal) where the amount supplied and the amount demanded were both equal to Q_2. However, with price controls, only P_c can be charged and Q_c-Q_2 more (22.6 billion gal/year) is demanded at price P_c than is supplied (a 23 percent shortfall).

A large tax on gasoline that results in an after-tax price of gasoline of P_2 would just eliminate the shortage of demand (Q_c-Q_2) and force the market-clearing price to P_c at quantity Q_2. This is illustrated in Figure 2. The demand curve D_1 is lowered to D_T by the vertical distance P_2-P_c, which equals the gasoline tax. By using the midpoint estimate of the price elasticity of gasoline (-0.20) and by assuming that $P_1 = \$1.25$/gal, a $1.34/gal tax would be required to reduce the amount demanded from Q_c to Q_2. The gasoline retailer receives P_c.

The gasoline tax has restored the market-clearing process and has prevented a transfer of $101 billion from gasoline consumers to the petroleum industry. Instead, consumers have paid their government $101 billion more in federal gasoline taxes. The original objective of the price control of P_c was to prevent the $101 billion income transfer to the petroleum industry from gasoline consumers. Imposition of a $1.34/gal gasoline tax would shift the income gain of the petroleum industry to the federal treasury instead of gasoline consumers and simultaneously eliminate the consumer costs of the gasoline shortage by doing away with the shortage itself.

Rebates of gasoline tax revenues can be used to shift the income transfer from consumers to the federal treasury back to consumers. However, the income received by the treasury cannot be distributed back to consumers in exactly the way it was received. If it were, the tax would not have any demand-reducing effect. The rebate must be distributed to consumers by using some criteria that is independent of the amount of gasoline tax that individual consumers pay. Therefore, the marginal cost of the first and last gallon of gasoline purchased by individuals is independent of any rebate received.

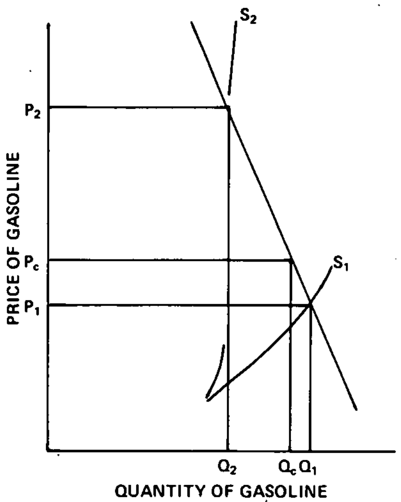
The use of rebates with a gasoline tax can accomplish the overall objective of gasoline price controls without the huge deadweight loss caused by gasoline shortages. Consumers as a group would receive the increased gasoline tax payments in the form of rebates. Although gasoline users will have to pay a much higher price at the pump (P_2 in Figure 2), the average consumer will also receive his or her increased gasoline tax payments in rebates. Consumers face a market-clearing price and avoid the costs of shortage but do not experience any loss of net income. Specific consumers may receive more rebates than taxes paid or less rebates than taxes paid. The exact relation between taxes paid and rebates received will depend on the rebate-distribution scheme and how much gasoline a person uses.

Rebates can be provided in several ways. The more obvious approaches include an equal distribution of rebate revenues to all—persons over 16 (potential automobile users), licensed drivers, and vehicle owners. In addition, rebate revenues can be increased to residents of high-use states so that the revenues generated within a state are distributed there. The usefulness of the gasoline tax with rebate is independent of the particulars of rebate distribution so long as the particular method chosen is workable and can be implemented without unnecessary costs and delays. Therefore, complicated rebate schemes that attempt to make rebates proportional to a specific need for gasoline by consumers are not recommended. Such action would require unavailable data regarding the specific circumstances of all individuals. In addition, consumers as a group do not benefit by rewarding high-volume gasoline users with extra shares of tax rebates—more tax rebates for

high-volume users mean less tax rebates for moderate- and low-volume users.

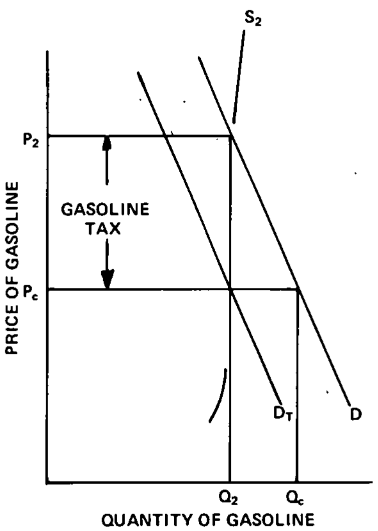
Of the three rebate mechanisms identified above, equal rebates to all adults would be the simplest to administer and

Figure 1. Relation between gasoline price and quantity.



Q_1 = 107 x 10^9 gal/year P_1 = \$1.25/gal
Q_c = 98 x 10^9 gal/year P_c = \$1.79/gal
Q_2 = 75 x 10^9 gal/year P_2 = \$3.13/gal

Figure 2. Impact of gasoline tax on price and availability.



GASOLINE TAX = P_2-P_c = \$1.34/gal
Q_c = 98 x 10^9 gal/year P_c = \$1.79/gal
Q_2 = 75 x 10^9 gal/year P_2 = \$3.13/gal

would be the most progressive scheme among consumers by income groups. For these reasons, it is used to estimate the costs and administrative requirements of a gasoline tax rebate system. However, other rebate systems could be used if there were some compelling reasons to do so.

Equal rebates to all adults would tend to transfer income from high-income consumers to low-income consumers. A \$1.34/gal gasoline tax would result in a \$382 rebate (annually) to each adult and a \$932 rebate to each household. (It is assumed that 70 percent of gasoline taxes is collected from noncommercial users and rebated to households.) As shown in Table 1 (derived from unpublished data from the 1977 nationwide personal transportation survey conducted for FHWA by the U.S. Bureau of the Census), low-income households pay substantially less in increased taxes than high-income households. Households in the lowest income category (\$0-\$5999) will gain \$329 net annual income, while the highest income category (more than \$50 000) will lose \$978 net annual income. High-income households are paying more in increased taxes than they are receiving in rebates, while low-income households are paying less in increased taxes than they are receiving in rebates. This is not to say that all low-income households will benefit and all high-income households will lose. Specific instances of hardship or windfall will occur in all income groups or within almost any other socioeconomic classification. More-complicated rebate-allocation schemes would not eliminate these instances but would distribute them differently.

The administrative requirements of a gasoline tax and rebate program are very modest. Gasoline taxes are currently collected by state and federal bureaucracies that are in place. No significant cost could be incurred by increasing the federal tax from \$0.04/gal to \$1.34/gal. The proposed gasoline tax would have to be administratively determined, and occasionally changed, to maintain a given level of income to the petroleum industry under prevailing market conditions. Therefore, some increase in the tax-collection bureaucracy may be required in order to change gasoline taxes every month or so. While the level of income transfer cannot be assured in any particular month due to the uncertainties of estimating supply and demand, the errors accumulated over a year could be averaged out by using a sequential tax-setting strategy. The annual income allowed the petroleum industry can be controlled by adjusting gasoline taxes—and without any gasoline price controls and the costs of shortages created by them. (This issue is explored further in the section on Accounting for Uncertainty and Appendix B—Reliability of Price Elasticity Estimates.)

The rebate system will require substantially more administrative effort than the imposition of a gasoline tax. Fortunately, new bureaucracies do not have to be created. The U.S. Internal Revenue Service (IRS) can be used to distribute gasoline tax rebates. If the withholding system is used by the IRS, most rebate recipients would be paid without any additional check-distribution expenses. Tax forms would be slightly modified, and each taxpayer would establish rebate status in the context of his or her annual tax return. Approximately 85 percent of eligible rebate recipients can be served via the withholding system (12). Some 50 percent of the remaining rebates could be handled

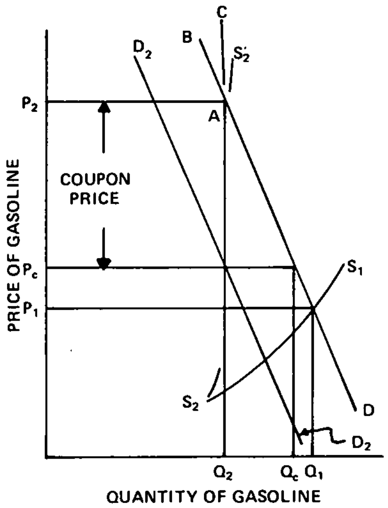
Table 1. Net annual income effects of a \$1.34/gal tax on gasoline with an equal rebate of revenues to all adults.

	Net Annual Income Effect by Income Group (1977 dollars)					
Factor	0-5999	6000-14 999	15 000-24 999	25 000-34 999	35 000-49 999	50 000+
Tax paid per household	382	1016	1570	1895	2055	2059
Rebate received per household[a]	711	917	1085	1150	1127	1081
Income transfer per household	+329	-99	-485	-745	-928	-978

Note: Adult persons are defined as all individuals 16 years or older. It is assumed that 70 percent of gasoline taxes is collected from noncommercial users and distributed to all adult persons.

[a]Average rebate per household = \$932/year.

Figure 3. Illustration of the prevailing market condition that results from a successful gasoline-rationing system.



	DEMAND CURVE FOR GASOLINE	SUPPLY CURVE FOR GASOLINE
Without Rationing:	BD	$S_2(S_2')$
"Fixed-Quantity" Rationing:	BAQ_2	S_2AC
"Fixed-Price" Rationing:	D_2	$S_2(S_2')$

$Q_1 = 107 \times 10^9$ gal/year $P_1 = \$1.25$/gal
$Q_c = 98 \times 10^9$ gal/year $P_c = \$1.79$/gal
$Q_2 = 75 \times 10^9$ gal/year $P_2 = \$3.13$/gal

by using other federal disbursements, such as Social Security or Health and Human Resources accounts (12). This would leave less than 10 percent of rebate recipients who would have to establish new reporting relations in order to receive rebate checks. This group could do so simply by filing an amended 1040A short form.

Based on the above-described distribution system, full implementation of rebates would require less than six months. Approximately 85 percent of adults would receive rebates within one month (via modified withholding), 93 percent within three months (via Social Security and Health and Human Resources payments), and the remaining group within six months (via new reporting relations). If interest were paid on delayed rebates, the equity of such an approach would be improved.

The estimated cost of the gasoline tax and rebate system outlined above is less than \$100 million annually and is as close to being administratively certain as possible (13). That is, the tax-rebate scheme requires bureaucratic operations that are very similar to ongoing activities and do not require substantial increases in the size of existing bureaucracies.

GASOLINE RATIONING

Another approach to reestablishing market equilibrium is to institute gasoline rationing. The term gasoline rationing can cover several systems that appear very similar but actually are substantially different. One immediate distinction is between white-market gasoline rationing and the rationing of nonnegotiable coupons. The latter system does not reestablish market processes. Consumers who wish to travel more than their coupon allotment allows cannot enter a market and buy more gasoline. At least that is the official position. In actuality, an illegal market (black market) would provide consumers with market-clearing opportunities. If the inevitability of this illegal market is accepted, little is to be gained by imposing strict rationing. It will merely result in a market that is more costly and excludes individuals who are unwilling to purchase gasoline coupons illegally. A substantial motivation to purchase illegal coupons would often exist for individuals who require more-than-average amounts of gasoline for work-related travel or other travel thought to be essential. Therefore, such a system would probably criminalize a significant portion of the current law-abiding population.

If a disruption of gasoline supply occurs, gasoline rationing (white market) can prevent a transfer of income from consumers to the petroleum industry without resulting in shortage conditions (i.e., gasoline queues). However, certain conditions must be met in terms of bureaucratic accuracy and efficiency for rationing to be successful in reestablishing market-clearing processes.

The prevailing market condition resulting from a successful gasoline rationing system is illustrated in Figure 3. As in Figures 1 and 2, the interruption in gasoline supply is represented by the shift of supply from curve S_1 to curve S_2. The market-clearing price P_1 existed before the supply interruption, and the use of price controls would result in a 23 percent shortage of gasoline. If gasoline rationing that made Q_2 coupons available were implemented, the demand for gasoline would shift from D to BAQ_2, resulting in price P_2.

Because a white market exists for gasoline coupons, individuals can either purchase gasoline or sell their coupons for the prevailing price. If the white market were perfectly efficient, the cost of gasoline coupons would be P_2-P_c, which is \$1.34 according to our midrange price elasticity estimate. Note that under the assumed conditions, the coupon price under market-clearing rationing is identical to the gasoline tax that allows a market price to gasoline sellers of P_c (Figure 2). Therefore, the marginal cost of gasoline to consumers is identical (\$3.13) with either a gasoline tax or gasoline rationing; both satisfy the conditions identified in Figures 2 and 3. (Departures from these conditions are discussed in the next section, Accounting for Uncertainty.)

There are two important variants of negotiable coupon rationing. In the usual system, the government allocates all coupons to users and lets a private market handle the transactions of coupons among individuals. The supply of coupons is fixed at Q_2, resulting in a market-clearing price of gasoline to users of P_2. An alternative system is to have the government offer to buy and sell coupons at coupon price P_2-P_c in Figure 3 (\$1.34). Instead of moving the demand curve from D to BAQ_2, the latter rationing system establishes demand curve D_2. The government is prepared to sell or buy as many coupons as consumers want at price P_2-P_c. According to the assumed data, a coupon cost of \$1.34/gal would shift the demand for gasoline to D_2 and result in a market price to retailers of P_c (\$1.79/gal). [This second variant of rationing will be referred to in later sections of this paper as fixed-price rationing (demand curve = D_2) and the first type as fixed-quantity rationing (demand curve = BAQ_2). As with the gasoline tax, fixed-price rationing does not require any gasoline price controls. The level of income provided to gasoline suppliers is controlled by setting the price of coupons. Note that consumers would receive the same number of free ration coupons under either system.]

Gasoline rationing as shown in Figure 3 has established a marginal cost of gasoline P_2 (\$3.13/gal) and a price for retailers of P_c (\$1.79/gal). Often it is not realized that the true cost of gasoline is P_2, not P_c. Because coupons are negotiable and worth \$1.34/gal, their use to purchase gasoline raises the marginal cost of gasoline (i.e., price) from the pump price of \$1.79/gal to \$3.13/gal.

The price of gasoline has risen to the market-clearing level of P_2. Because of this, gasoline rationing has eliminated the shortage and its associated costs. The \$101 billion income transfer to the petroleum industry does not occur because its revenue per gallon is held at P_c—the price allowed by price controls. As with the above-described gasoline tax with rebate system, gasoline rationing restores market processes and achieves the desired withholding of windfall profits to the petroleum industry.

The equity impacts of gasoline rationing depend on the entitlement criterion used to distribute gasoline coupons. If gasoline coupons are distributed in the same manner as

Table 2. Net annual income effects of a gasoline-rationing system based on providing coupons ($1.34/gal) to vehicle owners on the basis of number of vehicles owned.

Factor	Net Annual Income Effect by Income Group (1977 dollars)					
	0-5999	6000-14 999	15 000-24 999	25 000-34 999	35 000-49 999	50 000+
Value of coupons used by households to purchase gasoline	382	1016	1570	1895	2055	2059
Value of coupons received by households[a]	482	915	1240	1421	1505	1571
Income transfer per household	+100	-101	-330	-474	-550	-488

Note: It is assumed that 70 percent of gasoline coupons is distributed to private households and the remainder to owners of commercial vehicles.

[a]Average value of coupons received by households = $932/year.

gasoline tax rebates, the equity impacts of gasoline rationing and the gasoline tax-rebate system are identical. For example, Table 1 indicates the estimated impact on households of a $1.34/gal tax redistributed equally to all adults. If, under gasoline rationing, coupons were made equally available to all adults, the income impact of rationing on households is also evident in Table 1. All households would receive an average value of $932/year because each coupon is negotiable at $1.34/coupon. Low-income households gain $329 net income annually, while high-income households lose $978 net income annually.

The current DOE standby gasoline-rationing plan provides ration coupons for each registered automobile. The distributional impact of this entitlement criterion tends to favor higher-income households somewhat more than does an equal adult entitlement. As shown in Table 2 (derived also from unpublished data in the 1977 nationwide personal transportation survey), the average value of coupons distributed to households is also $932/year. Low-income households gain $100 net annual income, while the high-income category will lose $488 net annual income. High-income households tend to buy gasoline coupons from lower-income households in order to sustain higher-than-average gasoline consumption. Of course, specific low- and high-income households could either be net purchasers or net sellers of coupons. On average, the per-vehicle coupon entitlement criterion is less progressive than a per-adult criterion but still results in a transfer of income from high-income households to low-income households.

The administrative requirements of gasoline rationing are not fully understood. An important uncertainty concerns the time required to authorize, appropriate, plan, hire, organize, and begin implementation of a ration-coupon-distribution system. One critical difference between gasoline rationing and gasoline taxes is that gasoline taxes can be implemented immediately but rationing cannot. Also, rebates of gasoline tax revenues can be rebated to 85 percent of the eligible population within a month by using withholding adjustments. In comparison, rationing requires that a coupon-distribution network be established before the system can be implemented. DOE is currently estimating that the standby gasoline-rationing plan will require one year to complete preimplementation after authorization and appropriation of $100 million. Once preimplementation is completed, DOE has established a 90-day mobilization goal. The estimated cost of the rationing system is between $2 billion and $4 billion per year and will involve 40 000 to 50 000 federal, state, and local employees (14). The reader can evaluate whether a 90-day period will prove sufficient to authorize and appropriate the funds, plan the bureaucracy, hire employees, establish procedures, procure contract services, and train 40 000 to 50 000 federal, state, and local employees. Every month of delay will result in an estimated $6 billion loss to consumers from waiting in gasoline queues.

ACCOUNTING FOR UNCERTAINTY

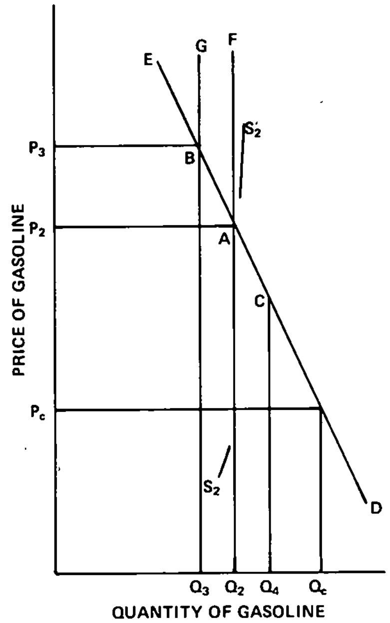
Gasoline taxes and gasoline rationing appear to produce identical market impacts. Each was estimated to result in a market-clearing price of $3.13/gal for 75 billion gal/year of gasoline sales. Each resulted in the same level of gross income to the petroleum industry as under price controls ($134 billion annually). Each prevented $101 billion additional revenue from accruing to the petroleum industry if gasoline price controls were eliminated without also implementing the tax-rebate or rationing systems. For gasoline-allocation plans to have the above-described market-clearing characteristics, it was assumed that the markets possessed perfect information, had zero transaction costs, and were in static equilibrium. In addition, the quantitative estimates of the market-clearing gasoline tax or coupon price depended on specific estimates of gasoline supply (Q_2 and Q_1), price (P_1), and the price elasticity of demand for gasoline (assumed equal to -0.20). Our purpose in this section is to acknowledge uncertainty, transaction costs, and disequilibrium, as well as their effects on the market-clearing process provided by each approach. Three specific approaches are defined:

1. Gasoline rationing with a fixed allocation of coupons, maintenance of price controls, and an uncontrolled white market for coupons (i.e., fixed-quantity rationing);
2. Gasoline rationing with government sales and purchases of ration coupons at an administratively determined price and elimination of price controls (i.e., fixed-price rationing); and
3. Administratively determined gasoline tax with revenue rebate and elimination of price controls.

The first uncertainty faced in managing a motor fuel shortage involves the magnitude of the shortage and the actual amount of gasoline available for distribution. Under fixed-quantity rationing, DOE would be required to issue ration coupons that allow the available gasoline to be purchased. As shown in Figure 4, Q_2 gasoline remains available after some supply-interrupting event occurs. Let us assume that Q_2 allows gasoline consumption of 4.9 million bbl/day (75 billion gal/year). However, let us also assume that DOE estimates Q_2 to be 10 percent lower and higher than it actually is. Under fixed-quantity rationing, instead of distributing coupons with which Q_2 gasoline can be purchased, DOE distributes coupons that permit Q_3 (10 percent less than Q_2) and Q_4 (10 percent more than Q_2) gasoline to be purchased at the controlled price P_c ($1.79/gal). As shown in Figure 4, these errors would result in a supply of coupons that allows either 67 billion gal/year to be purchased (Q_3) or 83 billion gal/year to be purchased (Q_4). Looking at the low-side error, Q_3 coupons would mean that only Q_3 gasoline would be legally sold. The cost of gasoline to consumers would rise from P_2 ($3.13/gal) to P_3 ($4.70/gal), resulting in a 50 percent increase in the price of gasoline. If gasoline production continued at Q_2 while only Q_3 could be purchased, transshipment and storage facilities would eventually fill up; this would force a reduction of gasoline refining to Q_3. The 10 percent DOE low-side error results in (a) making the economic cost of the gasoline shortage worse by allowing only Q_3 worth of mobility instead of Q_4 worth of mobility and (b) raising the price of gasoline by 50 percent. A 10 percent DOE high-side error would result in Q_4

worth of coupons being made available. The issued coupons would permit the purchase of 83 billion gal/year, even though only 75 billion gal/year is available—a shortage of 10 percent. The immediate result of this shortage would be gasoline queues. The ration coupon system would not reestablish a market-clearing process but would reduce the

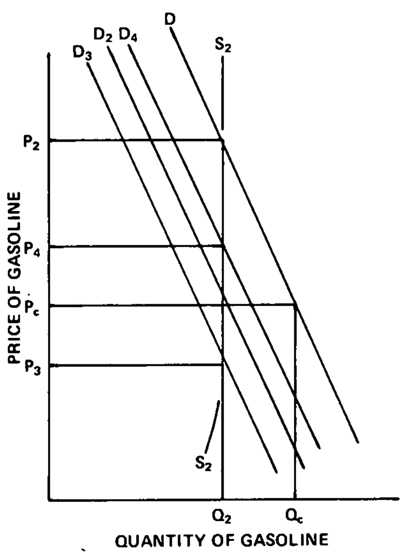
Figure 4. Incorrect coupon allocation based on fixed-quantity rationing.



DEMAND CURVE FOR GASOLINE		SUPPLY CURVE OF GASOLINE
Without Rationing:	ED	$S_2 (S_2')$
With Q_2 Ration Coupons:	EAQ_2	S_2AF
With Q_3 Ration Coupons:	EBQ_3	Q_3BG
With Q_4 Ration Coupons:	ECQ_4	$S_2 (S_2')$

$Q_c = 98 \times 10^9$ gal/year P_c = \$1.79/gal
$Q_2 = 75 \times 10^9$ gal/year P_2 = \$3.13/gal
$Q_3 = 67 \times 10^9$ gal/year P_3 = \$4.70/gal
$Q_4 = 83 \times 10^9$ gal/year

Figure 5. Incorrect price of gasoline given the fixed-price rationing or gasoline tax-rebate approaches.



P_2-P_c = \$1.34/gal P_2 = \$3.13/gal
P_2-P_3 = \$1.61/gal P_c = \$1.79/gal
P_2-P_4 = \$1.07/gal P_3 = \$1.52/gal
P_4 = \$2.06/gal

shortage from 23 percent of Q_c (23 billion gal/year) to 10 percent of Q_c (8 billion gal/year). The monthly cost of this error would be approximately \$2 billion due to lost time and gasoline wasted in queues. Under the high-side error, the price of gasoline is indeterminate. The demand curve ECQ_4 intersects the supply curve S_2 at price P_2 and quantity Q_2; however, the coupon price P_2-P_c could not be sustained because there are Q_4-Q_2 more coupons available at P_2 than are required to purchase Q_2 gasoline (75 billion gal/year).

With fixed-price gasoline rationing or the administratively determined gasoline tax with rebate, DOE would not decide what quantity of gasoline could be purchased as is required under fixed-quantity rationing. With the gasoline tax, the policy instrument is instead the amount of the tax. Under fixed-price rationing, the policy instrument is the price that DOE would set to buy and sell coupons. As illustrated in Figure 5, setting the coupon price or tax at P_2-P_c shifts the demand curve for gasoline from D to D_2 and results in a market-clearing price of P_2, with P_c being received by retailers. However, establishing the coupon price-tax at P_2-P_c requires even more information than setting the quantity of coupons at Q_2 under fixed-quantity rationing. S_2 must be known as well as the shape of D (the elasticity of demand for gasoline between P_c and P_2). In considering this increased uncertainty, let us assume that DOE makes a 20 percent error in estimating P_2. Instead of setting a coupon price (or tax) of \$1.34, let us assume that low-side and high-side errors are made that result in a coupon price-tax of \$1.61/gal and \$1.07/gal—i.e., 20 percent higher and lower, respectively, than P_2-P_c.

As illustrated in Figure 5, the high-side error results in shifting the demand curve from D to D_3 instead of to D_2. The marginal cost of gasoline remains P_2 because the nontax demand curve D still intersects the supply curve at P_2 and Q_2. However, the price that retailers receive drops to P_3 instead of P_c—a drop in revenue from \$1.79/gal to \$1.52/gal. Therefore, the consequence of a high-side coupon price-tax error of 20 percent results in a 15 percent decline in gross revenue to the petroleum industry. Note that consumers still purchase Q_2 gasoline at a market-clearing price of P_2 despite DOE's high-side error.

The low-side coupon price-tax error results in a \$1.07 price-tax instead of the correct \$1.34 price-tax (20 percent lower). As before, the market-clearing price and quantity remain unchanged at P_2 and Q_2, but the price to retailers increases to P_4 or \$2.06/gal. Therefore, the consequence of DOE's low-side error is to increase gross revenues from gasoline sales to the petroleum industry by 15 percent. In either case, market-clearing processes have not been interrupted, and the total cost to society of the DOE error is zero. If DOE established the correct coupon price-tax of \$1.34/gal, the petroleum industry would maintain a gross revenue from gasoline sales of \$101 billion/year or \$8.4 billion/month. The DOE high-side error would decrease monthly revenue to \$7.2 billion, and the low-side error would increase monthly revenue to \$9.7 billion. It is important to realize that the only impact of the price error is to change the income distribution between consumers and the petroleum industry, while the impact of quantity error (fixed-quantity rationing) is to result in real economic losses to consumers only or to both consumers and the industry. These losses can never be recovered because they represent real losses in queues (too many coupons) or in reduced mobility (too few coupons). The transfers between consumers and industry can always be recovered or readjusted simply by monitoring the price that gasoline retailers receive and by adjusting the tax or coupon price to achieve an average value of P_c over the year.

Another issue, which was not accounted for in the static-equilibrium analysis, concerns transaction costs. There is no transaction cost for the gasoline tax with rebate implied by establishing a tax because it is collected at the pump. The transaction cost for fixed-price rationing

depends, however, on the arrangements made by DOE to buy and sell coupons and the cost of arbitrage provided by private entrepreneurs. Transaction costs for fixed-quantity rationing depend on the behavior of speculators who buy and sell coupons.

It is difficult to estimate transaction costs of either fixed-price or fixed-quantity rationing. Further analysis of fixed-price rationing transaction costs is required to develop workable institutional arrangements and to determine the costs associated with them to the government and the consumer. An analysis of fixed-quantity transaction costs would require estimating the profits and behavior of speculators. Speculators could consistently operate at a high profit and tend to significantly raise transaction costs for purchasers of extra coupons. Also, speculators could lose money and subsidize either sellers or purchasers of coupons, or both. Either way, price variations under fixed-quantity rationing could be large, and the white market might be characterized by a high degree of uncertainty for coupon sellers and purchasers.

Therefore, although there is no attempt to quantify transaction costs, it can be concluded that the gasoline tax with rebate has the least (none) transaction costs, fixed-price rationing would add consumer transaction expenses, and fixed-quantity rationing would add a speculator's losses or profits to the costs incurred in fixed-price rationing. Transaction costs under fixed-quantity rationing would be potentially large and inherently uncertain.

A final consideration in this section on uncertainty concerns the availability of data required to administer rationing or a tax plan. Total gasoline sales volume data are available from DOE (as reported in DOE's Monthly Energy Review) and FHWA. However, these data sources often differ by more than 5 percent (15). Of the two, FHWA data are more reliable because of its end-of-year accounting requirement to validate gasoline tax receipts. But, at any given time in a year, the FHWA data can be up to a year out of date for the United States as a whole. States are not required to report sales to FHWA except at the end of each calendar year. In contrast, DOE data are available with only about a three-month time lag. In order to administer a fixed-quantity gasoline-rationing system, DOE would have to rely on forecasts of gasoline availability of three months to one year, and these forecasts would necessarily be based on a data source of questionable accuracy. Therefore, errors in estimating Q_2 (available supply) are likely to be substantial.

If price is used as the controlling variable, neither the price elasticity of gasoline nor the quantity of gasoline need be known. DOE would establish a gasoline tax or coupon price and monitor its effectiveness by observing the market price of gasoline received by retailers (P_4, P_c, and P_3 in Figure 5). If DOE uses an iterative price-setting procedure, it can set the coupon price-tax, observe return to retailers, reset the coupon price-tax, reobserve the return to retailers, and so forth, until, over a longer time period, the return to retailers is fine-tuned to achieve the same income-transfer objectives for which gasoline price controls were established. The price of gasoline to retailers can be monitored with little lag time by using a sample of retail outlets to estimate the prevailing national price of gasoline. (It is estimated that a weekly sample of the gasoline prices charged at 20 percent of all service stations would cost less than $15 million annually or about $0.0002/gal of gasoline sold, as shown in Appendix B.) Therefore, the fixed-price rationing system and gasoline tax with rebate are much more practical to administer because they require information that is relatively available (gasoline prices). On the other hand, the fixed-quantity rationing system requires information that has to be forecasted (quantity available).

CONCLUSIONS

Three distinct approaches to avoiding gasoline shortages have been evaluated. All of them can provide the same equity to gasoline consumers in that they keep the average net cost of gasoline equal to the controlled price of gasoline. All of them raise the marginal cost of gasoline (price) to a market-clearing level that is substantially higher than the controlled price. All of them cause high-volume consumers to pay low-volume consumers either by purchasing their coupons (rationing) or by financing their rebates with higher-than-normal gasoline tax payments (tax with rebate). The differences among the plans do not relate to how fair they are but to how effectively they will work.

The fixed-quantity gasoline-rationing plan has been found to rely on information that must be forecast at least three months ahead of the most recent data available. If the forecasts of gasoline availability are wrong, substantial inefficiencies are imposed on gasoline users. A 10 percent high-side error results in approximately $2 billion/month lost in gasoline queues, while a 10 percent low-side error reduces gasoline availability and forces the market-clearing price to be 50 percent higher.

Both the fixed-price rationing and gasoline tax with rebate do not require precise estimates of gasoline availability. Both systems require that price controls be eliminated and use the pump price of gasoline as an observed variable to set future gasoline taxes or coupon prices. Although achieving the exact desired pump price in the first month of operation may be as difficult as identifying the exact number of coupons to distribute, the average revenue to the petroleum industry over several months can be precisely controlled by using an iterative price-tax-setting scheme. In any month for which the pump price does not equal the controlled price, consumers still face the same market-clearing price and will not have to wait in lines. Instead, their rebates or coupon subsidies will be somewhat larger or smaller than they would have been if the pump price and controlled price were equal. Over a year of operation, the average net cost to consumers and gross revenues to the petroleum industry can be fine-tuned simply by monitoring current pump prices and by using an effective iterative tax-price-setting scheme.

Comparison of the fixed-price rationing system and the gasoline tax with rebate reveals that they are almost identical in the way they work. However, fixed-price rationing imposes several operations on the government (DOE) and consumers that serve no purpose. For example, with rationing, consumers who wish to purchase more than their coupon allotment allows must make a trip to some coupon purchase-sales outlet or buy them from some individual who has some to sell. With the tax-rebate system, this is unnecessary because the extra cost is paid at the pump. With rationing, DOE must physically distribute ration coupons to approximately 140 million recipients, but the tax-rebate system will require physical distribution of rebate checks to only 21 million recipients. The remaining recipients would receive their rebates via reduced withholding payments. Rationing has, in effect, created a second national currency and requires new bureaucracies to manage it. The tax-rebate system uses the existing national currency and, therefore, requires only a slight increase in responsibility for existing bureaucracies (IRS, Health and Human Services, and Social Security).

Two final considerations are lead time and availability. Rationing is likely to require significantly more than three months to begin to function, and it may require significantly more time to iron out the bugs once it is implemented. A gasoline tax-rebate system can be operational within one month. If some event terminates the supply of oil from the Middle East, gasoline lines are likely to begin within two, and certainly three, months of the cutoff. For each month that the gasoline-rationing plan is not available, consumers will lose more than $6 billion in wasted time and gasoline.

What does gasoline rationing offer to compensate for the increased bureaucratic cost and uncertainty that it implies? The answer is very little. The gasoline tax with rebate system is in almost every regard identical or superior to either fixed-price or fixed-quantity rationing.

There are some differences, however, that favor gasoline

rationing. Because of accounting conventions, a tax with rebate would impact the Consumer Price Index (CPI) and appear inflationary while rationing would not. However, any excise tax that rebates revenues back to consumers should not be counted in the CPI for the same reason that the cost of gasoline ration coupons should not be accounted for in the CPI.

Coupon rationing also differs from the gasoline tax with rebate system with regard to macroeconomic impacts that result from temporary federal surpluses or deficits. The surpluses or deficits in the tax-rebate system are caused by differences between the total rebate payments and the total gasoline tax payments that will inevitably result. In the fixed-price rationing system, even larger deficits or surpluses are likely to occur in the government coupon market. The surpluses or deficits will be larger because the government's transactional surpluses or deficits are not disposed of through a rebate mechanism. In the fixed-quantity rationing system, direct federal surpluses and deficits do not occur because the coupons are given away and the government has no further involvement with the white market in which they are traded. The coupons represent a second currency whose exchange rate with dollars is determined by the white market. However, despite the absence of a federal surplus or deficit with fixed-quantity rationing, significant macroeconomic disruptions can still occur because a significant amount of purchasing power will be changing hands in the white market. Because the true purchase price of gasoline (pump price plus coupon price) and the mobility available vary considerably more with fixed-quantity rationing than with fixed-price rationing or the tax with rebate plans, the macroeconomic disruptions of fixed-quantity rationing can be even more significant than the other alternatives. Therefore, considerably more study is required to better understand the macroeconomic implications of all proposed contingency plans.

Despite the detailed differences outlined among alternative gasoline-allocation plans, there are many substantive similarities. It has been shown that a type of rationing (fixed-price rationing) is operationally more similar to the gasoline tax with rebate system than it is to fixed-quantity rationing. In particular, the equity impacts of each plan are identical because coupon allocation criteria and tax rebate criteria need not be different. Yet there is a strong public antipathy toward the gasoline tax with rebate system. For example, one survey found that consumers preferred gasoline rationing to higher prices by a more than five-to-one margin (16). I am not aware of any survey data that contrast the popularity of rationing and the gasoline tax with rebate scheme outlined in this paper. However, it is clear that consumers associate rationing with fairness and associate gasoline taxes with being "ripped off". Unless the rebate scheme is carefully explained to a receptive audience, the distinction between a gasoline tax and a gasoline tax with rebate will likely be obscure to most consumers. Likewise, Congress has twice prohibited (through passage of the Energy Policy and Conservation Act of 1975 and the Emergency Energy Conservation Act of 1979) DOE from using any tax or user fee in developing a plan to deal with gasoline shortages.

Although the numerical estimates in this paper can vary substantially if different gasoline price elasticity estimates and other assumptions were used, the conclusions remain unaltered. A gasoline tax with rebate system (a) provides equity equal to that of any rationing system, (b) operates at a fraction of the cost, (c) provides consumers with a simpler system and no transaction costs, (d) is virtually certain of working as described, and (e) is the only system available soon enough to prevent a severe gasoline shortage following a significant interruption of imported petroleum.

APPENDIX A—Glossary of Elasticity Concepts

Demand function. The demand function is the relation between the demand for some commodity or service and one or more demand-influencing variables. The most ubiquitous demand-influencing variable is price, and demand is often stated simply as a function of price. However, other variables besides price can also be included in a demand function. Regardless of how many variables a demand function possesses, the relation between any one of them and demand can be graphed by holding the values of all others constant. This relation is often called the demand curve, especially when price is the variable graphed, as illustrated in Figure 6. The price-quantity demand curve (which need not be curved) usually slopes downward. This indicates more demand as price decreases.

Elasticity. Elasticity is a measure of the sensitivity of demand with respect to changes in a variable that influences demand. If this variable is price, the elasticity is called a price elasticity. For example, a price elasticity of -1 implies that a 1 percent reduction in price will result in a 1 percent increase in quantity demanded. There are, however, three ways by which elasticity can be measured.

Point elasticity. A point elasticity measures the instantaneous proportional rate of change between demand and a demand-influencing variable at a specific point on the demand curve. The definition of point elasticity requires that the demand curve be differentiable around the specific point at which it is calculated. For any demand-influencing variable x and demand variable q, point elasticity is defined as

$$(\partial q/\partial x)_{x_1} \cdot (x_1/q_1) \qquad (1)$$

where x_1 and q_1 are the ordinates of the point in question (Figure 7).

Shrinkage ratio. A shrinkage ratio is the proportional change in demand that results from a given change in a demand-influencing variable. Two points on the demand curve are involved (Figure 8). Assume that at time period 1, demand $= q_1$ and price $= x_1$. Assume a price increase to x_2 with a resulting decrease of demand to q_2. The shrinkage ratio is defined as

$$[(q_2 - q_1)/q_1]/[(x_2 - x_1)/x_1] = (\Delta q/\Delta x) \cdot (x_1/q_1) \qquad (2)$$

where x_1 and q_1 are the price and quantity levels before the change in price.

Arc elasticity. An arc elasticity is also calculated from two points on the demand curve (Figure 8). It is defined as

$$[(\log q_1 - \log q_2)/(\log x_1 - \log x_2)] = \Delta \log q/\Delta \log x \qquad (3)$$

The arc elasticity is often preferred to the shrinkage ratio because it comes much closer to preserving an important property of point elasticity. That is, when the point price elasticity is equal to -1, gross revenue is maximized. When the point elasticity is numerically greater than unity, gross revenues may be increased by reducing price. Similarly, when the point elasticity is numerically less than unity, gross revenues may be increased by increasing price. This relation does not hold true for the shrinkage ratio unless Δx approaches zero. However, this revenue-maximizing relation is approximately true for the arc elasticity under all conditions.

Sign of elasticity. As defined above, for the normal downward-sloping relation between price and quantity demanded, price elasticities have negative values. The more sensitive demand is to price, the more negative the elasticity will be.

Income elasticity. Income elasticity is a measure of the sensitivity of demand with respect to changes in income. Such an elasticity implies that the income of the consuming group or individual is included as one of the

Figure 6. Example of demand curve when price is the variable.

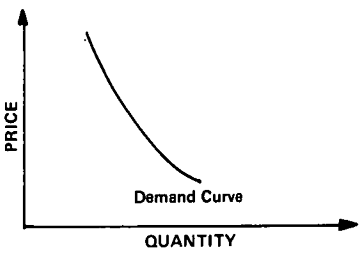


Figure 7. Example of point elasticity—a measure of proportional rate of change on a demand curve between demand and a variable.

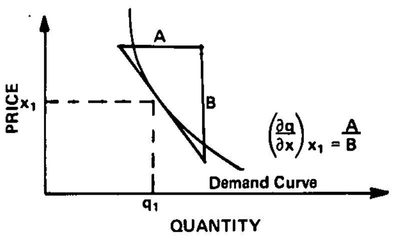
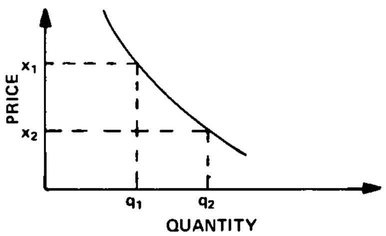


Figure 8. Example of shrinkage ratio or arc elasticity that is estimated by observed changes in demand and price.



demand-influencing variables in the demand function. Income elasticity can either be positive, negative, or zero. A good that has a negative income elasticity is called an inferior good. As income increases, an individual will spend less on inferior goods and purchase more-desirable substitutes.

APPENDIX B—Reliability of Price Elasticity Estimates

As described in Appendix A, there are three different ways of calculating the change in price implied by movement along a demand function characterized by a price elasticity. The point elasticity characterizes the elasticity relation at a particular point on the demand function and, in general, it is only valid for the region around that particular point. The shrinkage ratio and arc elasticity are methods of calculating changes in price or quantity implied by given elasticity relations applied over a discreet interval. The larger the interval, the more imprecise these elasticity calculations become in estimating either changes in price or quantity unless the demand function has particular characteristics. Also, the larger the interval used, the divergence between estimates derived from using the shrinkage ratio or the arc elasticity is increased. If the demand function is a constant elasticity (exponential) relation between quantity and price—that is, $Q = aP^e$ or $\ln Q = \ln a + e \ln P$—then the arc elasticity should be used to estimate changes in price or quantity implied by a price elasticity. If the demand function is not of the exponential variety, little guidance can be provided because any application of a constant elasticity will produce the wrong result unless applied only to small percentage changes in price or quantity. A review of gasoline demand models presented or reviewed elsewhere (3-9) reveals that the demand for gasoline has a complex relation to price that cannot be effectively characterized by a log-linear relation or any other single-equation approach. Therefore, price elasticities that characterize the behavior of these models cannot be reliably used to forecast price-quantity relations except over the range of data used to calculate the price elasticity employed. Indeed, the models themselves cannot be employed to forecast price-quantity relations far beyond the range of data used to estimate model parameters.

To illustrate the divergence implied by shrinkage ratio or arc elasticity calculations, recall that a market-clearing price of $3.13/gal of gasoline was estimated if the supply of gasoline were reduced from 107 billion gal/year to 75 billion gal/year—a $1.87 increase over the original $1.25/gal price. This calculation was based on an elasticity estimate of -0.2 by using the shrinkage ratio method of calculation. If, instead, the arc elasticity had been used, the new market-clearing price would have been $7.17/gal. I chose the shrinkage ratio largely because I used shrinkage ratio calculations to determine that -0.1 to -0.3 was a reasonable range of elasticities characterizing several demand models. However, there is little certainty achieved when applying such a low price elasticity to a 30 percent reduction in gasoline availability.

The estimates provided in the paper are meant to illustrate the size of income transfers implied by alternative gasoline-shortage strategies and to illustrate the likely range of coupon values or gasoline taxes that would be associated with particular policies. The conclusions in the paper do not depend on those particular estimates.

In addition, the suggested fixed-price rationing or gasoline tax with rebate plans do not administratively depend on knowing the price elasticity relation that would actually occur. Even if the price elasticity relation were known, one still does not know the change in gasoline supply until well after the fact. The suggested approach depends on monitoring an uncontrolled pump price to provide the required information needed to set the appropriate level of tax or coupon value for the tax-rebate or fixed-price rationing plans. If the established tax or coupon value results in an observed pump price of gasoline that is below the desired pump price (P_c), then the tax or coupon value should be reduced. Likewise, if the observed pump price is above P_c, it should be increased. Knowledge of price elasticities could aid this process only if detailed movements in the available supply of gasoline were known shortly after they occurred. Since the estimated lag time of acquiring these data is three to six months, price elasticity data cannot alone suggest at what levels to establish taxes or coupon values. Therefore, perfect knowledge of the price elasticity relation would not alleviate the need to use an iterative tax-setting (coupon value) scheme based on the observed pump price of gasoline in relation to the desired price that the petroleum industry should receive (P_c). The variable P_c is a policy variable set to minimize windfall benefits while accounting for increased costs incurred by the petroleum industry. The same variable (P_c) is set by using identical criteria when administering gasoline price controls.

P_c is a variable that can be observed with great accuracy within a very short time period (one week). The bureaucratic cost of pump price data is modest because there are less than 180 000 service stations nationwide, and a relatively small sample of their prices for gasoline would yield a statistically reliable average price. Government observers could simply visit their assigned sample of service stations and record their pump prices. While I cannot offer tested estimates, it is likely that an observer can easily record the prevailing prices of 10 service stations daily. That modest requirement would imply that 720 observers could provide a 20 percent weekly sample of the prices of all service stations nationwide. That is a small personnel requirement in relation to other aspects of administering

either a gasoline-rationing or gasoline tax with rebate program. At a salary of $17 000/year for each observer, price data would be available for $12.2 million/year or a 0.012 percent share of the estimated tax collected ($101 billion/year) or $0.000 16/gal. It is likely that a substantially smaller sample than 20 percent will prove statistically reliable and, if so, would reduce estimated data costs proportionately.

APPENDIX C—Sample Calculations

Assumptions

1. Preemergency price of gasoline = $1.25/gal = P_1.
2. Preemergency consumption of gasoline = 7.0 million bbl/day = 107 billion gal/year = Q_1.
3. 30 percent shortfall reduced available consumption to 4.9 million bbl/day = 75 billion gal/year = Q_2.
4. Price elasticity of gasoline (shrinkage ratio calculation) = -0.2 = e.
5. Controlled price of gasoline (P_c) set to maintain an unchanged gross revenue resulting from gasoline sales before and after the supply interruption.
6. Average waiting time associated with a 30 percent reduction in petroleum supplies = 2h (11).
7. Average fill-up of gasoline = 10 gal.
8. Value of time = $4.00/h.

Calculations

1. Market-clearing price of gasoline:

Market-clearing price of gasoline after 30 percent shortfall of supply = P_2.

$[(Q_2 - Q_1)/Q_1]/[(P_2 - P_1)/P_1] = e$

[(75 billion gal/year - 107 billion gal/year)/(107 billion gal/year)]/[(P_2 - $1.25/gal)/$1.25/gal] = -0.2

$1.25/gal • (-0.30/-0.2) + $1.25/gal = P_2

P_2 = $3.13/gal

Note: Gasoline price and quantity relations, identified in Figures 3, 4, and 5, are determined as shown above.

2. Controlled price of gasoline:

Controlled price of gasoline = P_c. Unchanged gross revenue requires the following calculation.

$Q_1 P_1 = Q_2 P_c$

$P_c = Q_1 P_1/Q_2$

P_c = (107 billion gal/year x $1.25/gal)/75 billion gal/year

P_c = $1.78/gal

3. Income transfer of price controls:

(a) Gross petroleum industry revenue from gasoline sales after a shortage without price controls = $P_2 Q_2$.

$P_2 Q_2$ = $3.13/gal x 75 billion gal/year

$P_2 Q_2$ = $235 billion/year

(b) Gross petroleum industry revenue from gasoline sales after a shortage with price controls = $P_c Q_2$.

$P_c Q_2$ = $1.78/gal x 75 billion gal/year

$P_c Q_2$ = $134 billion/year

(c) Income transfer to consumers implied by price controls = $P_2 Q_2 - P_c Q_2$.

$P_2 Q_2 - P_c Q_2$ = $235 billion/year - $134 billion/year

$P_2 Q_2 - P_c Q_2$ = $101 billion /year

4. Economic waste implied by gasoline shortage:

Assumed waiting time associated with a 30 percent reduction in petroleum supplies = 2 h. Assumed average fill-up of gasoline = 10 gal. Assumed value of time = $4.00/h.

Number of fill-ups per year = Q_2/10 gal = 75 billion gal/year/10 gal = 7.5 billion/year

Total excess wait time = 2 h x 7.5 billion/year = 15 billion h/year

Value of total excess wait time = $4.00 /h x 15 billion h/year = $60 billion/year

Excess idle time = 15 billion h/year

Average fuel consumption at idle (10) = 0.33 gal/h

Amount of fuel wasted by idling = 15 billion h/year x 0.33 gal/h = 5.0 billion gal/year

Value of wasted fuel = P_2 x 5.0 billion gal/year = $3.13/gal x 5.0 billion gal/year = $16 billion/year

Estimated cost of shortage due to lost time and gasoline waiting in queues = $60 billion/year + $16 billion/year = $76 billion/year

The calculations in Appendix C do not account for the opportunity cost of activities that could no longer be planned due to uncertainties in acquiring gasoline, the economic losses to individuals who depend on automobile transportation for their income and the loss in the capital value of the automobile stock that results from shortage conditions.

APPENDIX D—Effect of the Windfall Profits Tax

The recently passed Windfall Profits Tax (WPT) Act of 1980 will have a dramatic effect on the disposition of windfall profits resulting from gasoline sales during a petroleum emergency. Approximate base prices are established for three classifications of domestic crude petroleum, and a fixed percentage of the difference between the selling price and base price is taxed by the federal government. The percentage of tax varies with the classification of petroleum as shown below (base price is adjusted for inflation):

Oil Classification	Base Price (1980 $/bbl)	Tax (%)
Lower- or upper-tier oil if the pre-June 1979 price controls had remained in effect	13	70
Stripper production and oil produced from a national petroleum reserve	15	60
Newly discovered oil, certain heavy oil, and incremental tertiary oil	17	30

The WPT will be phased out after a 33-month period after December 31, 1987, or when cumulative revenues raised by

the tax reach $227.3 billion, whichever is later.

The WPT was not accounted for in the discussion of gasoline shortage for several reasons. Althouth the WPT strongly implies that there will be no price controls on crude petroleum, it is unclear if petroleum product prices would be used during emergency conditions. If gasoline price controls were used, the price of crude petroleum would be allowed to be passed through at 100 percent. However, the relation between the market-clearing price of gasoline, other petroleum products, and crude oil are not well understood under emergency conditions. The products with the smallest price elasticities will have the highest increases in market prices and the greatest potential for shortages if price controls are used.

The estimated market-clearing price of gasoline of $3.13/gal was determined strictly from demand-side considerations, assuming a perfectly inelastic supply of gasoline at 4.9 million bbl/day. The increased price per gallon compared to preemergency conditions is $1.88. On the supply side, much of this increased price could be accounted for in higher crude petroleum costs. However, the price of crude petroleum would have to increase by $79/bbl or reach a total price of almost $110/bbl in order to absorb the increased windfall of gasoline price increases under emergency conditions. It is likely that a significantly higher price elasticity of demand for crude petroleum could be encountered than for gasoline. It is a matter for speculation without a comprehensive model of the supply and demand of all petroleum products, but I would guess that equilibrium world petroleum prices could be far less than $110/bbl under emergency conditions during a period when U.S. gasoline prices would have to be $3.00 or higher to avoid gasoline shortages.

Without employing a complex, comprehensive, and accurate petroleum products supply-and-demand model, the gap between the windfall implied by the increased price of gasoline that is not absorbed by the windfall profits tax is highly uncertain. (The uncertainty is complicated by the possibility of direct government control of refinery output; see Appendix E.) If an oil price increase of $50/bbl of oil is assumed, an $0.83/gal price increase for petroleum can be passed through to gasoline to pay for WPT liabilities. This represents 44 percent of the estimated increase in gasoline prices required to prevent or eliminate gasoline shortages after an emergency occurs (as defined). But this implies a controlled price of gasoline that is only $0.34/gal more than already assumed. Recall that the estimated controlled price of $1.79/gal assumed that oil revenues would remain constant before and after the emergency. Therefore, by using the very rough assumption of a $50/bbl increase of the world price of petroleum, the estimated windfall of $101 billion that would accrue to the petroleum industry without price controls would be reduced to $76 billion by the WPT. With the WPT, instead of a controlled price of $1.79/gal, a controlled price of $2.13/gal would be permitted, a smaller shortage would exist and $76 billion of income transfer between consumers and the petroleum industry would shift if price controls were or were not used.

In summary, large uncertainties in the market environment are introduced by the WPT, depending on the relation between market-clearing crude oil prices and market-clearing gasoline prices. If the market-clearing price of gasoline does not move up any faster than implied by the market-clearing price of petroleum, the WPT would itself capture much of the windfall (up to 70 percent) resulting from the increased price of gasoline required to prevent gasoline shortages under emergency conditions. If the uncontrolled price of gasoline moves up much faster than petroleum prices, then the WPT will capture only a small proportion of the windfall generated after a petroleum emergency.

APPENDIX E—Elasticity of the Gasoline Supply

The static equilibrium analysis used to analyze gasoline markets assumes that the supply of gasoline is perfectly inelastic after a petroleum emergency occurs. In referring to Figure 1, the supply curve S_1 shifts to S_2—a straight vertical line above Q_2 between gasoline price P_1 and P_2. As stated in the text, the supply of gasoline would be larger at P_2 than at P_c or P_1, but the differences are not likely to be large enough to affect the analysis and Q_2 is assumed to be the quantity of gasoline supplied at price P_1, P_c, or P_2. This is more likely to be true in the short term rather than the long term. For example, refineries can be technically modified to process a larger percentage of heavy petroleum into gasoline and distillate. Also, the supply of crude oil available for gasoline production will be dependent on the market for all petroleum products and the actions DOE takes in regulating the price and availability of any petroleum products. Therefore, it is impossible to draw a supply curve for gasoline without knowing the specific market environment for all petroleum products and the technological changes that can be made in refining processes. Under emergency conditions, the market environment will prove particularly important if DOE allocations control the inputs and outputs of refineries. The supply function of gasoline will depend on how much gasoline DOE allows to be refined, the economics of alternative uses of petroleum, and refinery capacity as affected by allocations and regulations that pertain to alternative petroleum products.

In summary, we do not really know how elastic the supply of gasoline will actually be. In the short term, the supply of gasoline will be inherently inelastic. In the longer term, government behavior may contribute to a very inelastic supply of gasoline in order to prevent the percentage of gasoline production to increase at the expense of other petroleum products. Also, national policy may allow more gasoline to be refined from each barrel of crude oil at the expense of less-valuable petroleum products (residual oil) as alternative energy sources (coal and natural gas) are used to replace them. This would contribute to a more elastic supply of gasoline.

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Household Characteristics and the Determinants of Travel Behavior

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Due to the existing energy situation, there is a distinct possibility that motor fuel may be rationed. DOE is currently in the process of developing a standby fuel-rationing plan. Under the proposed plan, motor fuel will be allocated primarily on the basis of vehicle registrations. Fuel will first be allocated to individual states on the basis of current or recent fuel consumption, and the states will then allocate their supplies to consumers in accordance with the number of vehicles registered. How much discretion a particular state will have in developing a final allocation procedure is uncertain at this time.

The purpose of this paper is to present an analysis of household travel characteristics that may aid in the understanding of the reasons for and extent of such travel. Currently, although considerable discussion on how rationing should be accomplished has taken place, much of this discussion has occurred with limited factual data to support the various positions. If some of the data that we already possess becomes more widely known, a more rational discussion and allocation can take place.

The following analysis is based on the 1977-1978 National Personal Transportation Survey, which was conducted for the U.S. Department of Transportation by the U.S. Bureau of the Census. (Some of the figures used may differ from those of the Federal Highway Administration—a result of classifying data by slightly different categories or definitions.) This was the second survey of household travel; the first took place in 1969-1970. The 1977-1978 survey interviewed approximately 18 000 households throughout a 12-month period. Information was collected on household characteristics, each person within the household, all trips taken on the travel day, as well as all trips over 75 miles in length taken during the preceding two-week period, and on each vehicle available for use in the particular household. Although none of the summary findings from this survey has yet been published, a series of reports will be available in the near future.

VEHICLE TRAVEL BY PLACE

People have argued that rural areas should receive more fuel than urban areas, or that suburbanites are more dependent on automobiles than are residents of the central city. Table 1 shows the annual vehicle miles of travel (VMT) per household by area population and the number of vehicles the household owns. Among households owning only one vehicle, there is little variation in the amount of travel, regardless of whether they live in rural areas, small towns, or large cities. In fact, the range in values is less than 1800 miles. It is interesting that the households in the largest cities (with more than 1 million population) travel more than residents of small towns and rural areas.

Although the range in values is slightly higher for two- and three-vehicle households, the distribution of average annual VMT is also very compact. Regardless of the number of vehicles owned, residents of small towns and rural areas travel less than the average. Since this refutes some commonly held ideas on the subject, a further explanation of the reasons is appropriate.

Vehicle ownership rates are lowest (1.24) in the central cities and the average number of vehicles a household owns is higher (1.71) in rural areas. This factor is the most significant reason for higher fuel consumption outside central city areas. In small towns, the ownership rate is 1.54 and in the suburbs, 1.68. Although the data for 1977-1978 could not be segregated by state or region, previous analysis of the 1969 survey revealed little differences between states and regions after automobile ownership was considered.

Another surprising result is that travel seems to be linearly related to the number of vehicles a household possesses. Two-car households travel a little more than two times, and three-car households three times, as much as one-car households. One might have expected that travel would increase with the number of vehicles owned, but at a decreasing rate. This is true, but the breakpoint exists at a level above three vehicles.

If a rationing scheme seeks to replicate existing travel patterns, a vehicle registration plan would probably be the least disruptive. However, a plan that allocates fuel on the basis of registered vehicles may encourage households to obtain additional vehicles. Evidence suggests that, once a household obtains an added vehicle, it is used. Thus, such a plan might encourage travel behavior that is contrary to the national goal of fuel conservation. Also, it might have disruptive effects on central-city neighborhoods by fostering additional car ownership.

VEHICLE OWNERSHIP

On average, there are 1.5 vehicles per household. The distribution of households by number of vehicles owned is shown in Figure 1. There are almost as many two-vehicle households as there are one-vehicle households. Approximately 85 percent of the households owns at least one vehicle. The number of households owning three or more vehicles exceeds 15 percent of the total households.

The extraordinary number of multivehicle households will have some important implications concerning allocating fuel on the basis of registered vehicles. Almost 16 percent of households has more vehicles than drivers. This relation, as well as the percentage of households with matching drivers and vehicles, is indicated by these data: households without licensed drivers, 13 percent; more licensed drivers than vehicles, 19 percent; equal number of licensed drivers and vehicles, 52 percent; and more vehicles than licensed