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CONSUMER DEMAND FOR GASOLINE AND U.S. PUBLIC POLICY

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The United States was unprepared for the energy crisis brought on by the Arab oil embargo of 1973-74. To that point in time, American oil demand had raced ahead of domestic production. In 1973, the U.S. imported one-third of the 17 million barrels consumed each day (Time, Nov. 26, 1973). In addition, domestic oil prices were still regulated under the 1971 wage and price controls imposed by President Nixon. Gasoline prices were based on a complicated formula which accounted for relative proportions of domestic and imported crude oil used at different refineries (Time, April 22, 1974). As a result, even though oil prices on the international market quadrupled between 1971 and 1974, the U.S. domestic price of gasoline remained well below world levels.

A serious allocation problem soon resulted. Refiners were forced to sell their product below the cost of production and quantity of gasoline demanded by consumers was artificially high because the market price was controlled by a price ceiling (Time, November 26, 1973). U.S. oil policy was faced with a choice. Either a rationing program using direct allocations or coupons could be imposed, or price controls could be lifted to allow the domestic price to increase thereby reducing consumer demand.

The success of a price decontrol program depends on the price and income elasticities of demand for gasoline. If demand is price inelastic then a price decontrol program is not likely to be effective in the short run. On the other hand, an elastic demand will lead to more immediate changes in consumption with price changes.

This study examines the demand elasticities for gasoline by U.S.

consumers. Data for the model was collected on an annual basis for the period 1960-1979 and includes observations on the price of gasoline, disposable personal income and the number of registered autos in the U.S. Results from the model are used to evaluate the responsiveness of consumer demand for gasoline and the potential success of a price decontrol program during the 1970's.

Conceptual Model

The formulation and interpretation of the models used stem from the economic concepts of demand, income, elasticity and market structure.

Demand for a particular good is defined as a schedule showing the amounts of a good or service which consumers are able and willing to purchase in a given market at a given array of prices in a given time period with all other factors held constant. Market demand is the horizontal summation of all individual demand schedules. Prices and quantities vary inversely so the demand curve has a negative slope. Factors which shift the demand schedule are (1) income of the consumer (2) tastes and preferences of the consumer and (3) prices of substitutes or complements.

An increase in consumer's income will lead to a rightward shift in the demand curve for a commodity if it is a normal good and a decrease in income will lead to a leftward shift in the demand curve indicating that the commodity is considered an inferior good.

A favorable change in tastes and preferences shifts the demand curve to the right and an unfavorable change in tastes and preferences shifts the demand curve to the left.

If quantity demanded of a commodity varies in the same direction as the price of another commodity, they are called substitute goods. Commodities are complementary goods if the quantity of one varies in the

opposite direction as the price of the other good.

Also increases in population causes shifts in aggregate demand simply because there are an increasing number of people willing and able to purchase a given commodity.

Factors affecting the elasticity of a good are (1) number of uses for the commodity (2) number of substitutes that exist for a commodity and (3) the importance of the expenditure on the commodity relative to the consumer's income.

The own price elasticity is interpreted as the percentage change in quantity demanded given a very small percentage change in the price of the commodity, other factors held constant. If the absolute value of the coefficient is greater than one then demand is said to be elastic--i.e. a percentage change in quantity demanded is greater than the corresponding percentage change in price. A coefficient of one indicates unitary elasticity--i.e. a percentage change in quantity demanded equals the percentage change in price. If the absolute value of the coefficient is less than one then demand is inelastic--i.e. a percentage change in quantity demanded is less than the corresponding percentage change in price.

Income elasticity of demand is defined as the percentage change in quantity corresponding to a one percent change in income, other factors held constant. A commodity is considered inferior if income elasticity of demand is less than zero--i.e. an increase in income results in lower consumption of that good. A commodity is considered a normal good if income elasticity of demand is greater than zero. Normal goods can be further categorized into necessities and luxuries. A necessity is an item for which the income elasticity of demand is between zero and one. Thus a one percent increase in income results in consumers increasing expenditure

for this commodity by less than one percent. A luxury, on the other hand, is a commodity for which income elasticity of demand is greater than one. So a one percent increase in income results in consumers increasing their consumption of the commodity by more than one percent.

Within a competitive market structure, price is the integrating force between the market levels of supply and demand. An equilibrium price is obtained when the price at which quantity demanded and quantity supplied are equated. If prices are above equilibrium then the quantity consumers are willing to buy is less than the quantity supplied. If prices are below equilibrium then quantity demanded exceeds quantity that will be supplied.

A form of policy that affects market equilibrium is a price ceiling. A restrictive price is imposed at a level below that of the market equilibrium price. At this lower price, consumers demand more of the commodity while firms each cut back supply thus creating a shortage. Two observed features of a price control program are: (1) shortages appear to become greater the longer the controls are in effect due to demand shifts that arise from population and income growth, (2) the longer the controls are in effect the greater will be the rise in price needed to clear the market in the short run (Figure 1).

The objective of the paper is to estimate the own price effect and the income effect on the consumer demand for gasoline. The quantity demanded of gasoline will be considered the dependent variable. The independent variables are the retail price of gasoline, disposable personal income and the number of registered vehicles in the United States.

The reasons for using these variables are:

1. <u>retail price of gasoline</u>: Retail price was used in compliance

with the definition of primary demand and also with regard to the assumption by economists that the American motorist, confronted with increases in the price of gasoline, would forego other expeditures rather than cut back on driving the family car (Business Week, July 27, 1974).

2. disposable personal income: Income of the consumer affects the demand schedule and changes in real income may affect the demand of gasoline based on studies which show that income and auto travel tend to go up and down together (Business Week, July 27, 1974).
3. number of registered vehicles in the U.S.: This variable was used as a quantity adjuster.

Empirical Model

This study assumes that the aggregate consumption of gasoline is a function of its own price, disposable income and the number of registered vehicles in the U.S. Data for the analysis was obtained from the "Petroleum Data Book" for prices, quantities and number of registered vehicles in the U.S. Disposable income data was obtained from the "Historical Statistics of the U.S. Colonial times to 1970." All data collected was for the years 1960 through 1979.

A linear and logarithmic equation least squares models were used to relate the quantity demanded of gasoline to the retail gasoline price, disposable income and number of registered vehicles.

The linear demand model for gasoline at the retail level is expressed as:

$$QG_t = a + bPG_t + cDI_t + dNRV_t + eNRVT_t$$

and the double logarithmic equation is expressed as:

$$\log QG_t = \log a + b \log PG_t + c \log DI_t + d \log NRV_t$$

where:

QG = motor fuel consumption during period t in million of gallons.

PG = retail price of gasoline (service station price includes taxes) in cents per gallon.

DI = disposable personal income in billions of dollars.

NRV = number of registered vehicles (passenger cars and motorcycles included) in the U.S. in thousands.

NRVT = interactive dummy variable and slope shifter.

a,b,c,d,e = parameters to be estimated.

The resulting equations are listed in the following table:

Table of Results

Variable	Linear	Double logarithm
PG	-421.95 (.001)	-0.3718 (.0004)
DI	13.97 (.085)	0.414 (.0339)
NRV	0.7719 (.0001)	0.668 (.0314)
NRVT	-0.0116 (.406)	---
Intercept	-724.069 (.90)	2.065 (.39)
R^2	0.9947	0.9943
F-Ratio	708.84	934.58

The coefficient of determination, R^2, indicates the amount of total variation explained by the regression line. An R^2 of 0.9947 for the linear

model and 0.9943 for the double logarithm model means that 99.47% and 99.43% of the variability in quantity demanded of gasoline is being explained by the independent variables.

The F-Ratio indicates the overall significance in the regression equation and must exceed a value of 5 to indicate significance for the sample size of 20 observations in the study. The F-Ratio is significant for both models, 708.84 and 934.58 respectively, which indicates that the model explains a significant portion of the variability in the quantity demanded.

The t-test establishes whether or not each independent variable contributed to explaining the dependent variable. The values of t for all the variables, except for NRVT and the intercepts, are high enough to reject the null hypothesis at the 10 percent level. Thus those coefficients are statistically significant from zero.

Resulting elasticities are:

Elasticity	Linear Model	Double Log Model
N_i	-0.2848	-0.3718
N_i^m	0.1714	0.4145

The own price elasticity of demand for gasoline in the linear model is -0.2848 and -0.3718 for the double logarithmic model. Demand is inelastic for both models. Every one percent price increase will cut demand.0.28% and 0.37% respectively. The model by Houthaker and Verleger in which they suggest that gasoline prices would have to be doubled to produce significant cuts in demand supports the above results of the models run. (Business Week Dec. 15, 1973).

Values for the income elasticity of demand were 0.1714 in the linear model and 0.4145 in the double logarithm model. Based on these values,

gasoline is considered a normal good but may be further categorized as a necessity since the elasticities are greater than zero but less than one.

The NRV variable was used in an attempt to account for changes in the mode of transportation and/or type of car demanded. The NRV variable was significant from zero in both models.

NRVT was an interactive variable and slope shifter in the model. With a parameter estimate of -0.0116 and t-score of 0.406, NRVT had a slight but not significant effect on the model.

The study excluded substitute goods for gasoline from the models formulated due to the inaccessability to data on the substitute commodities for gasoline marketed.

Conclusion

The empirical model demonstrates that the demand for gasoline is inelastic. Therefore the percentage change in the quantity of gasoline demanded at the pump would be less than the percentage change in the retail price. Under a domestic price decontrol program, the U.S. petroleum market would not clear in the short run.

Alternative plans designed to augment market clearing forces in the short run were a gas rationing plan and a tax-rebate proposal. The gas rationing plan was designed to substitute coupon rationing for gas allocation controls. Coupons were to be distributed on the basis of registered vehicle ownership, to firms on the basis of historical use and to priority and hardship users. Since the coupons could be sold, market forces would have determined the price (Bezdek, p. 1359).

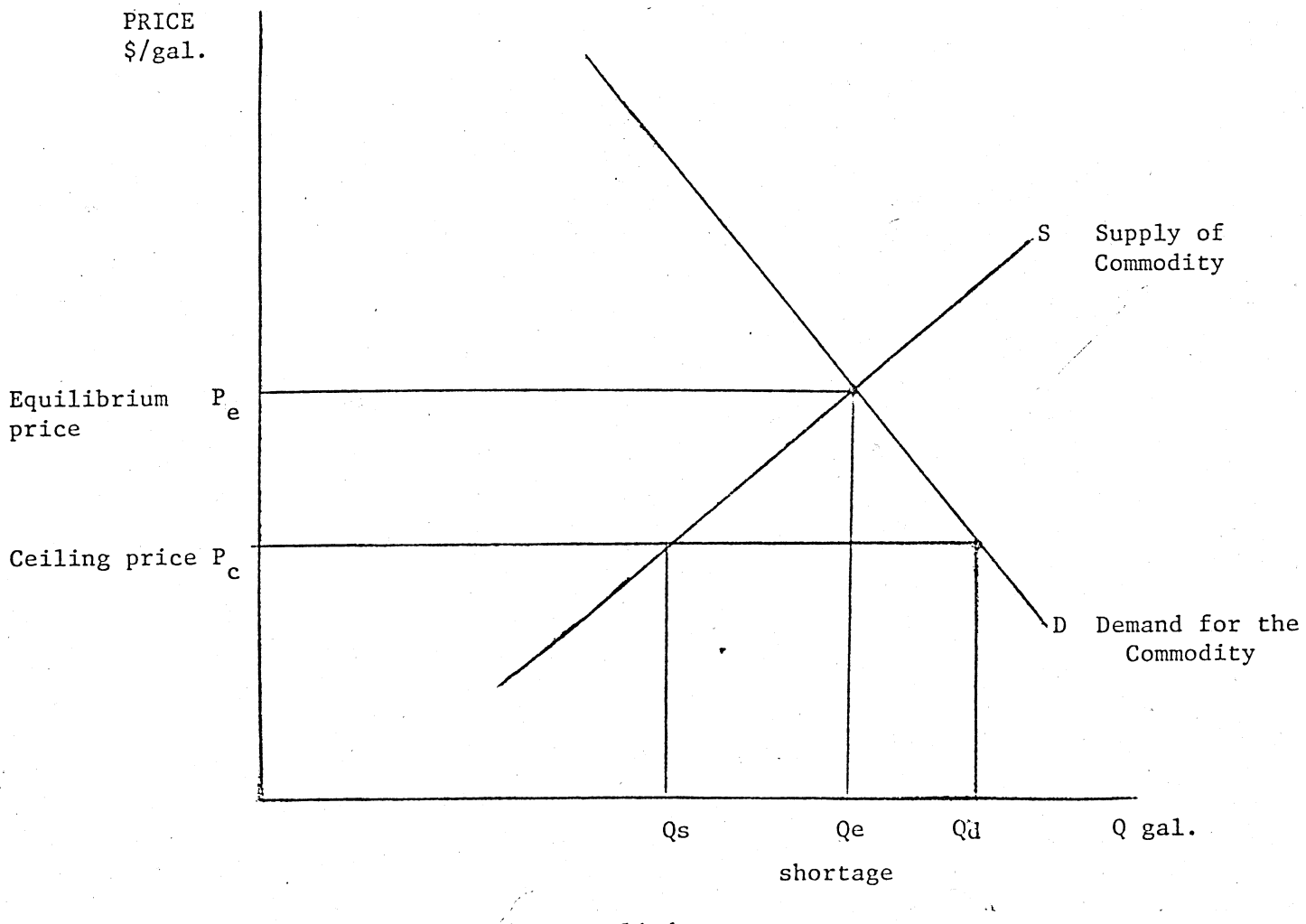
The tax rebate proposal by Senators J. Bennet Johnston and Charles Percy consisted of a system of emergency gasoline taxes and rebates

structured to have effects similar to gas rationing with a free market in coupons. Price and allocation controls on gasoline would be prohibited, but would be required on crude oil and petroleum products. The level of the excise tax on gasoline would be set so that refiners could pass through increases in average crude oil prices. Thus as world oil prices and gasoline demand changed, the size of the tax would change (Bezdek, p. 1359).

However, the actual plan that was implemented to decrease the demand for gasoline was based on proportional allocation of supply. The allocation regulations required suppliers to sell proportionately reduced volumes to their historical purchasers. Thus each gasoline station received reduced supplies of gasoline based on their historical purchases (Bezdek, p. 1358). Without the presence of a price signal to the consumer, the demand for gasoline at the controlled price continued to be greater than the quantity supplied. Thus gasoline had to be rationed by nonprice means, which included long waiting lines, limitation of sales and closing gas stations nights and weekends. These devices were very costly to the economy in terms of consumer work time and leisure (Howe).

Throughout the 1970's, the U.S. faced a policy dilemma in the domestic petroleum market. Normal market forces could not bring the gasoline market into equilibrium quickly; proposed solutions were complicated in design and imposed indirect costs on consumers. Thus, understanding the nature of the U.S. domestic demand for gasoline gives insight into the difficult problem that faced U.S. policymakers.

Figure 1. U.S. Market for Gasoline in 1973-74 (Howe).



Qs = Quantity supplied
Qd = Quantity demanded
Qe = Quantity at equilibrium

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