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A Brief Reference on Fuel Costs and Fuel Price Elasticity

Introduction

The sharp rise in the price of oil has renewed concerns about the impact of rising energy costs on the U.S. economy. The national average retail price of motor gasoline (all types) has increased by over 60 percent from $1.03 per gallon in January 1999 to $1.67 in June 2000[1], largely as a consequence of the nearly tripling of crude oil prices during the same period. Of particular interest to ODOT is the impact of fuel price changes on driving, fuel consumption and tax revenue collection. This article provides a brief reference on fuel cost trends and studies of gasoline demand in the United States, with the focus on price elasticity.

Historical Trends

While gasoline prices have gone up significantly in the last 18 months, after taking inflation into account they are not nearly as high today as they have been (Fig. A). In fact, gasoline prices have fallen in real terms since the second oil shock of 1980-1982. Expressed in constant 2000 dollars, the data show that average real gasoline prices in 2000 (Jan.-June) are close to the levels seen in the early 1990s (about $1.50/gallon), but far below the highest level observed in the early 1980s (about $2.50/gallon).

While real gasoline prices have declined over the last two decades, fuel economy of passenger cars has improved over the years (Fig. B). Measured by the ratio of total vehicle miles traveled (VMT) to total fuel consumption of passenger cars, fleet average fuel economy has increased by about 50% from 14.3 MPG in 1978 to 21.4 MPG in 1998. As a result, fuel cost per mile traveled (calculated as the real price of gasoline divided by average fuel economy) has declined significantly (Fig. C). In 1980, the average real cost per mile traveled was about 15.8 cents (in 2000 dollars); by 1998, it was about 5.5 cents. Holding other things constant, the decline in fuel cost per mile traveled tends to encourage driving (Fig. D), resulting in higher fuel consumption.

Models of Gasoline Demand

Many econometric studies of gasoline demand have been conducted over the years, particularly during the 1970s and 1980s when fuel prices were high and concerns about energy conservation and security of supply were prominent. Typically, the demand for gasoline can be modeled directly by specifying the quantity of gasoline consumed (Q_f) as a function of real gasoline price, real income and other variables. When all the variables are expressed in logarithm in the demand equation, the price elasticity of gasoline demand is captured by the coefficient of the real price of gasoline.

Since gasoline consumption is, by definition, equal to total vehicle miles traveled divided by miles per gallon (Q_f=VMT/MPG), the effects of changes in gasoline prices on gasoline consumption can be thought of as resulting from their effects on VMT and MPG. Based on this decomposition, the price elasticity of gasoline demand is equal to the price elasticity of VMT minus the price elasticity of MPG ($E_{g,p} = E_{VMT,p} - E_{MPG,p}$). In economic terms, the overall effect of changes in gasoline prices can be decomposed into scale and substitution effects. For example, when gasoline prices increase,

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the first response entails a reduction of total number of miles traveled. Second, motorists can improve fuel economy by changing their driving and maintenance behavior, such as reducing acceleration rates, maintaining slower highway speeds, servicing cars more frequently, etc. In addition, motorists with two or more automobiles can be expected to drive a larger percentage of their miles in their more fuel-efficient car(s) (Archibald & Gillingham 1981). Therefore, by estimating the demand equations for both VMT and MPG, one can examine how motorists alter their VMT and fuel economy in response to changes in gasoline prices. Finally, by incorporating fuel cost per mile as a single variable in the VMT equation, one can obtain the combined effects of changes in fuel prices and fuel economy on driving.

Empirical Results

Studies show that gasoline demand is fairly price inelastic in the short-term because motorists respond to higher prices primarily by reducing discretionary travel. However, as time passes and gasoline prices remain high, motorists may purchase more fuel-efficient vehicles, move to locations closer to where they work and shop, find alternative means of transportation, and perhaps demand alternate fuels. Therefore, gasoline demand is more sensitive to price changes over longer time horizons. Estimates of the short-run price elasticity of gasoline demand cluster in the range from –0.1 to –0.4, and the long-run estimates are generally between –0.6 and –1.1 (Nivola & Crandall 1995).

A more recent study by Agras & Chapman (1999) using annual US data from 1982-1995 shows that the short-run price elasticities of VMT and MPG are –0.15 and 0.12 respectively, summing to an overall short-run gasoline price elasticity of –0.25[2]. Their long-run price elasticity estimates for VMT and MPG are –0.32 and 0.60 respectively, implying an overall long-run gasoline price elasticity of –0.92. In the short run, a 10 percent price increase is likely to reduce driving by 1.5 percent and improve fuel economy by 1.2 percent, resulting in a total 2.5 percent reduction in fuel consumption. Hence, somewhat over half of the reduction in gasoline consumption is attributable to a decrease in driving, while less than half is attributable to an increase in fuel economy or gasoline efficient miles[3]. In the long-run, fuel consumption is expected to drop by 9.2 percent; however, only 1/3 of the decline is attributable to reduced driving, while about 2/3 is attributable to increased fuel economy. In terms of the combined effects of changes in fuel prices and fuel economy on driving, Haughton & Sarkar (1996) find that the short-run elasticity of VMT per driver with respect to gasoline cost per mile is between –0.09 and –0.16, while the long-run elasticity is about –0.22.

Endnotes

1. Motor Gasoline Retail Prices, U.S. City Average, U.S. Department of Energy, Energy Information Administration. http://www.eia.doe.gov/pub/energy.overview/monthly.energy/txt/mer9-4.

2. Price elasticities of VMT and MPG do not exactly sum to that of gasoline demand in this particular example due to interaction effects between VMT and MPG specified in the authors' demand equations.

3. Studies using household data appear to show a larger price elasticity of VMT in the short-run compared to those using aggregate data. Archibald and Gillingham (1981) find that roughly 75% of the reductions in gasoline consumption is attributable to reduced VMT, while about 25% is attributable to improved fuel economy. Puller & Greening (1999) find that the price elasticity of MPG is negative, suggesting that households reduce long trips (gasoline efficient miles) causing MPG to decline and fuel consumption to rise. Nonetheless, their results show that the scale effect is 3.5 times larger than the substitution effect, and that households make the largest adjustment within 1 year of a price change by reducing miles traveled.

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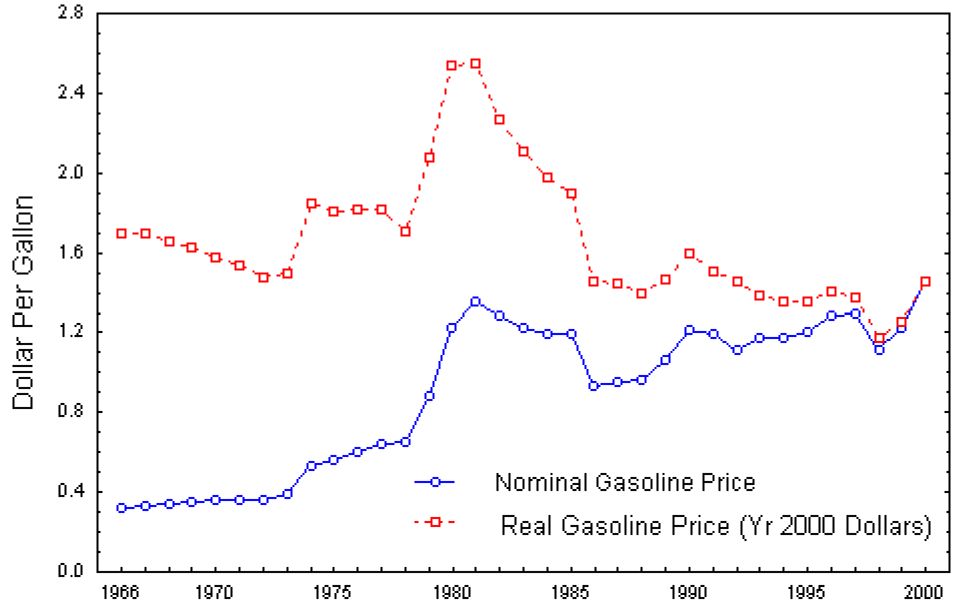
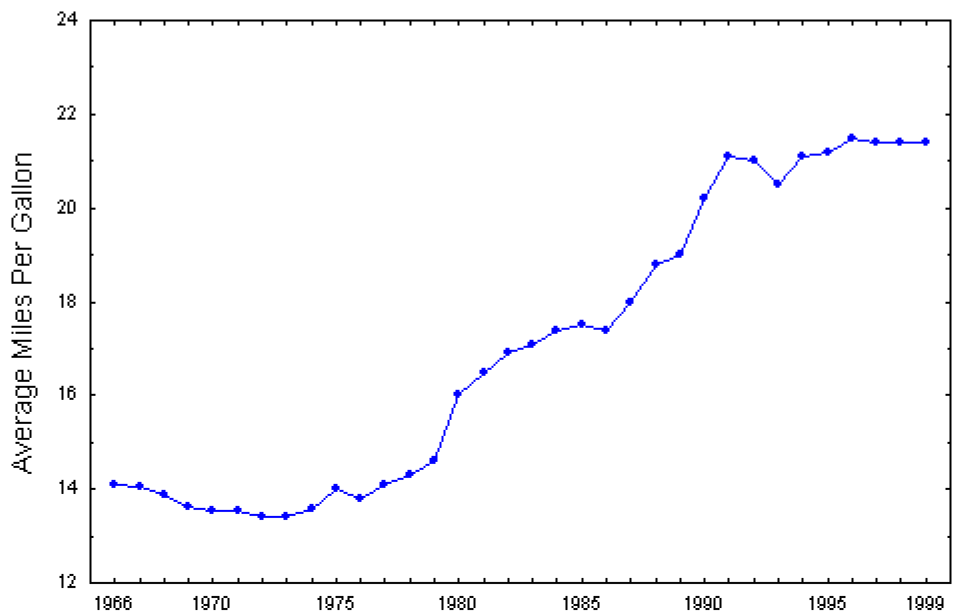


Year
Fig. A



Year
Fig. B

Source: American Petroleum Institute and Annual Highway Statistics

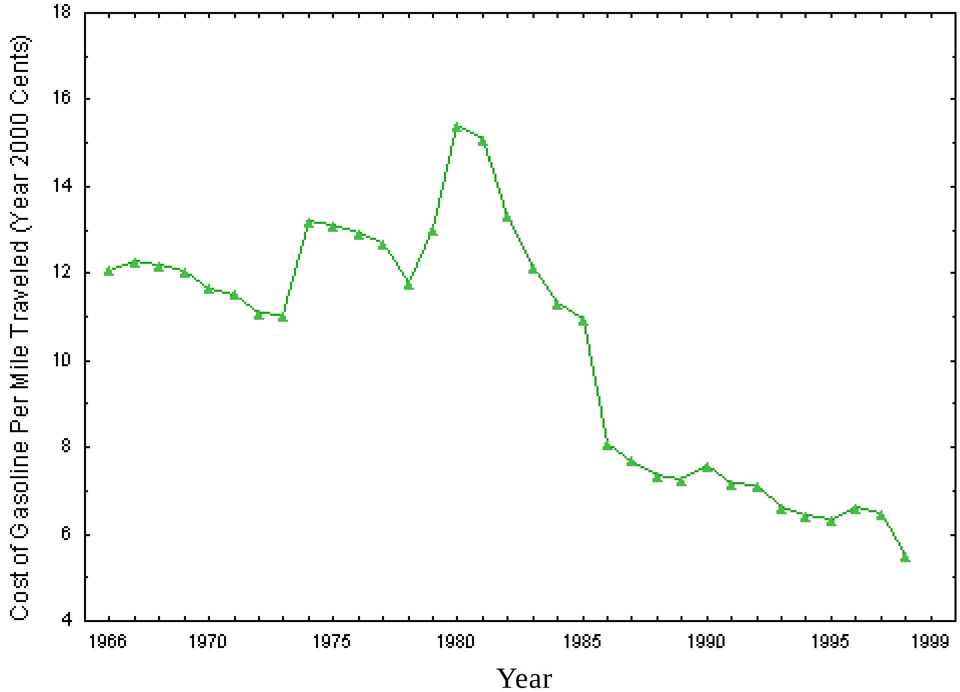


Fig. C

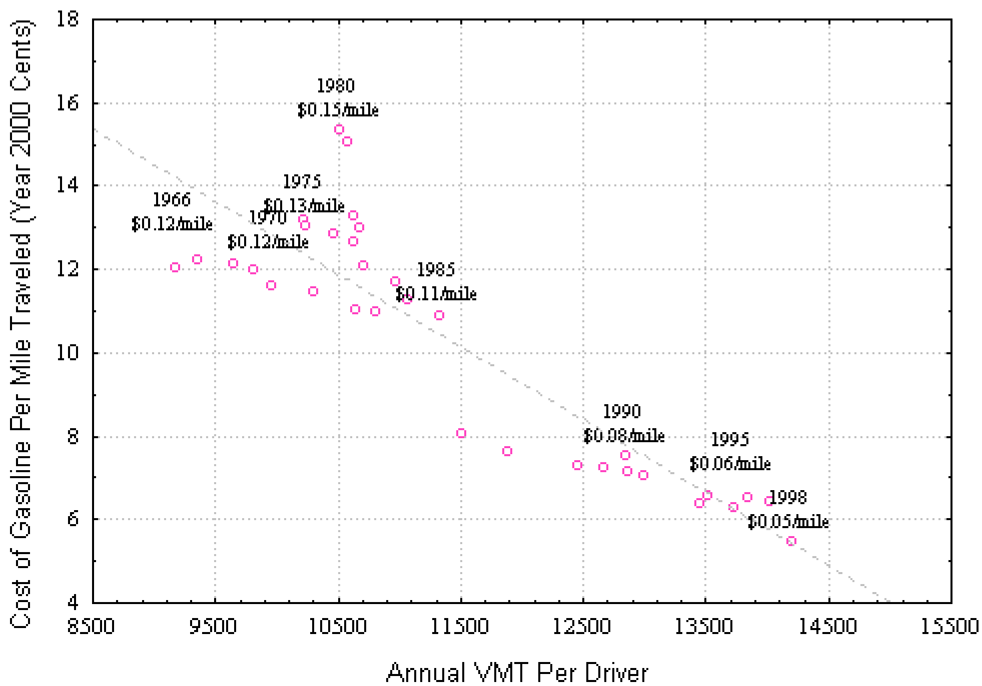


Fig. D

Source: American Petroleum Institute and Annual Highway Statistics