THE REVISED TAX RATE ON GASOLINE AND ITS IMPACT ON TAX REVENUES FROM THE SALE OF GASOLINE IN THE COMMONWEALTH OF KENTUCKY*

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Introduction

The total amount of gasoline consumed in the Commonwealth of Kentucky in 1978 was 1,896 million gallons and the corresponding figure for 1980 was 1,708 million gallons. The decline in the total amount of fuel consumed was 188 million gallons. This represents 17 million dollar tax loss from the sale of gasoline in the Commonwealth. In order to prevent a further tax loss and to increase the tax revenue from the sale of gasoline in the Commonwealth, the 9 cent a gallon tax rate was revised to a 9 percent of the average wholesale price per gallon. This law became effective on July 1, 1980.

The decline of 188 million gallons of fuel consumption in a two year period appears to be the result of a rather sharp increase in the price of gasoline. The 17 million dollar decline in tax revenue from the gasoline sale was the result of the decline in fuel consumption. In view of the fact that a new tax rate tends to increase the retail price at the pumps, this new tax rate might further depress consumption and, thus, could decrease tax revenues from the sale of gasoline even further. How will tax revenue be affected as a result of new tax rate? The answer to this question must come from the price and income elasticities of demand for gasoline. Therefore, the purpose of this study is to measure the price and income elasticities of demand for gasoline in the Commonwealth and draw implications of the fuel tax revenues from these elasticities.

A number of studies have attempted to measure the income and price elasticities of demand for gasoline nationally. However, only one previous study endeavored to measure the long-run income and price elasticities of demand for gasoline for the Commonwealth of Kentucky.[1]

This study limits the analysis to gasoline consumption as related to its own price and income changes and excludes the following:

1. The fuel used for aviation, agriculture, water transportation, and other industrial uses. This study includes gasoline used by motorists and business.
2. The impact of the increases in the number of fuel efficient foreign cars and domestically produced compact cars in the stock of vehicles.
3. The influence of inflation on the consumption of general commodities and, thus, on the use of gasoline.

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[1] Song, Inbum and James Conrad, "Can Mr. Carter's Gasoline Conservation Policy Work in the Commonwealth of Kentucky?" Paper prepared for Kentucky Economic Association Meeting on October 13, 1977, Louisville, Ky.

4. The expected impact on gasoline price and supply due to the actions of oil producing countries on the crude price and production of crude oils.

Further, this study limits the analysis to price changes and their effect on the tax revenues and excludes the impact of income changes on the tax revenues from the sale of gasoline.

The Old and New Tax Rates on Gasoline and the Impact of New Tax Rate on Price Elasticity

During the past decades, the tax on gasoline was fixed at 9 cents per gallon. However, the new tax rate pressed in 1980 and made effective as of July 1, 1980, changed the 9 cents fixed rate to 9 percent of the average wholesale price of gasoline in the Commonwealth of Kentucky. Therefore, the relationship between the retail price and the wholesale price of gasoline in the Commonwealth can be expressed in Equation (1) assuming a markup of zero.

$$(1) \quad P_{rt} = P_{wt} + T_o$$

where P_{rt} and P_{wt} represent the retail and the wholesale price of gasoline in t-period, respectively, and T_o refers to the fixed tax rate. Equation (1) represents the relationship under the fixed tax rate which existed in the past. Under the new tax rate, the relationship between the wholesale and retail prices can be expressed in Equation (2) assuming a zero markup.

$$(2) \quad P'_{rt} = P_{wt}(1 + T)$$

where P'_{rt} refers to the retail price under the new tax rate and T denotes the tax rate in percentage of average wholesale price. The fixed rate of 9 cents per gallon means that the tax does not vary regardless of the wholesale price level. Under the new tax rate, the amount of tax imposed per gallon varies as the wholesale price varies.[2]

The main policy objectives of new tax rate on gasoline are presumably (1) to increase tax revenues from the sale of gasoline and (2) to conserve fuel. Whether these two policy objectives can be achieved simultaneously depends upon the price elasticity of demand and the impact of tax on the elasticity at the wholesale price level. Therefore, the analysis of the new gasoline tax rate requires the measurement of price elasticity of demand at the wholesale level and the assessment of the impact of tax on the elasticity.

Expressing the quantity demanded of gasoline as function of its own price and the current income, Equation (3) is obtained.

[2] Refer to Kentucky Revised Statutes, 1980; KRS 138.20, which reads: Notwithstanding the provisions of paragraph (a) above, for purposes of the taxes levied in KRS 138.220, 138.565, 138.660 and 234.320, in no case shall "average wholesale price" be deemed to be less than one dollar ($1.00) per gallon, and in no case shall "average wholesale price" be deemed to be more than one dollar and fifty cents ($1.50) per gallon on or before June 30, 1982. In fiscal year 1982-83 the "average wholesale price" shall not be deemed to increase more than ten percent (10%) over the "average wholesale price" at the close of fiscal year 1981-82; in each subsequent fiscal year the "average wholesale price" shall not be deemed to increase more than ten percent (10%) over the "average wholesale price" at the close of the previous fiscal year. [Effective May 1, 1980.] (4281g-1: amend. Acts 1952, ch. 193, § 1; 1962, ch. 203, § L: L(*), ch. 218, § 1, effective July 1, 1980.

$$(3) \quad Q_t = a + bP_{rt} + cY_t + e_t$$

where Q_t and Y_t denote the quantity of gasoline consumed and per capita income in time t, respectively, e_t represents the random error term, and the coefficients, a, b, and c are the parameters to be estimated under the fixed tax rate in cents. Equation (3) under new tax rate, the fixed percentage rate, will be

$$(4) \quad Q'_t = a' + b'P'_{rt} + c'Y_t + e_t$$

where Q'_t and P'_{rt} denote Q_t and P_{rt} under new tax rate, respectively. Using the relationship in Equation (1), Equation (3) can be expressed as Equation (5).

$$(5) \quad Q_t = a + b(P_{wt} + T_o) + cY_t + e_t$$

Using the relationship in Equation (2), Equation (4) can be expressed as:

$$(6) \quad Q'_t = a' + b'(1 + T)P_{wt} + c'Y_t + e_t$$

On the basis of Equation (5), the price elasticity of demand at the wholesale price can be computed using:

$$(7) \quad E_w = \frac{dQ}{dP} \frac{Pw}{Q} = b \times \frac{Pw}{Q}$$

On the basis of Equation (6), the price elasticity of demand at wholesale price can be computed as follows:

$$(8) \quad E'_w = \frac{dQ'}{dP_w} \times \frac{Pw}{Q'} = b' (1 + T) \frac{Pw}{Q'}$$

The difference between E_w and E'_w is that E_w represents the price elasticity of demand under the old tax rate and E'_w represents the same under new tax rate. The coefficients, a, b, and c in Equation (3) can be estimated by supplying the data observed. However, the coefficients, a', b', and c' in Equation (4) cannot be estimated because the data for Q'_t for Equation (5) do not exist. As a result of this nonestimability of coefficients, a', b' and c', the price elasticity of demand, E'_w, in Equation (8) cannot be estimated.

However, the difference between the coefficients, a, b and c in Equation (5) and the coefficients, a', b' and c' in Equation (6) can be ignored and treated as if they are the same at the initial stage of a new tax rate for the following reasons. When Equations (5) and (6) are compared, we notice that both equations can be expressed as Equation (9).

$$(9) \quad Q_t = a + bP_{wt} + cY_t + e_t$$

Equations (5) and (6) can be obtained from Equation (9) by adding a term representing the impact of fuel tax. That is, Equation (5) is obtained by adding the term, bT_o, to Equation (9) and Equation (6) is obtained by adding the term, bTP_{wt}' to Equation (9). Since the term, bT_o, is a constant and does not vary with the price level, its impact is to shift the demand curve to the right without changing the slope of demand curve. The term, bTP_{wt}, however, changes as wholesale price changes. The new tax rate, T, also depended upon the wholesale price, P_{wt}. As a

result, the impact of bTP_{wt}-term is to rotate the demand curve. For this reason, the long term impact of new tax rate will make the coefficients, a', b' and c' in Equation (6) different from the coefficients, a, b and c in Equation (9). However, the old tax rate does not change the coefficients, a, b and c in Equation (9). At the initial stage, the impact of new tax as expressed in bTP_{wt}-term is not fully worked into Equation (9) and, as a result, we could treat the coefficients in Equations (5) and (6) as not different from each other at the initial stage.

As Equations (7) and (8) are compared, we notice that E_w will be smaller than E'_w in absolute value for the following reasons. During the initial stage of new tax rate, $b' = b$ and Q_t will be greater than or equal to Q'_t. As a result, E'_w can be expressed in Equation (10).

$$(10) \quad E'_w = b\,\frac{Pw}{Q'} + bT\,\frac{Pw}{Q'}$$

The term, $bT\dfrac{Pw}{Q'}$, make E'_w larger than E_w in absolute value. This implies that the price elasticity of demand under the new tax rate will be more elastic than that under the old tax rate. How much more elastic? It is expressed by the term, $bt\dfrac{Pw}{Q'}$.

Income and Price Elasticties of Demand

This paper employs a simple linear statistical model without time lag. The assumption for discounting time lag is that gasoline consumed in t-period is a function of activities to earn income and to provide basic transportation in the same period. For this reason, gasoline consumption is assumed to be directly related to per capita income which indicates the level of economic activities. It is assumed that the time distribution of a price change on gasoline consumption was negligible for the same reason. According to one study, about 70 percent of travel is for earning a living or for conducting a business.[3]

Elsewhere, Houthakker, Verleger and Sheehan employ a double logarithmic linear equation to account for short-run variations in the gasoline demand and lag the dependent variable one period to account for adjustments in the stock of motor vehicles.[4] In this study, however, the annual gasoline consumption was regressed on its own price and Kentucky per capita income and obtained the following equation.

$$(11) \quad Q_t = 988,139,480 - 21,718,757P_{wt} + 385,055Y_t$$

where Q_t refers to the amount of gasoline consumed in gallons, P_{wt} represents the average wholesale price per gallon of gasoline in current cents, and Y_t denotes Kentucky per capita income in t-period in current dollars. The standard error and t-statistics for the estimated parameters were as follows:

[3] U.S. Federal Highway Administration, *Nationwide Personal Study,* Report No. 1 and 7 (1969).

[4] Houthakker, H. S., P. K. Verleger, and D. P. Sheehan, "Dynamic Demand Analysis for Gasoline and Residential Electricity," *American Journal of Agricultural Economics,* (May 1974).

Parameters	Parameters Estimated	Standard Error	t-stat-istics	Significance Level of t-statistics
a (Constant)	988,139,480	33,873,392	29.17	99.99
b (Price)	-21,718,757	2,148,312	-10.11	99.99
c (Income)	385,055	22,718	16.95	99.99

The coefficient of determination, R^2, was 0.976 and the standard error of estimation was 56,757,475. The high coefficient of determination value indicates that over 97.6 percent of the variation of gasoline consumption in the Commonwealth of Kentucky can be explained by its price and Kentucky per capita income. The data used for the computation of Equation (11) are presented in Table 1.

The income and price elasticities of demand for gasoline in the Commonwealth of Kentucky at 1980 data point using Equation (11) were 1.67 and -1.24, respectively. Equation (11) was estimated using 1960-1980 data. The income and price elasticities obtained at 1980 data point are markedly different from the corresponding values computed at 1976 data point using the quantity-price relationship obtained with 1960-1976 data. The income and price elasticities at the 1976 data point were 1.1983 and -0.6783, respectively. When we compare the corresponding elasticities, we notice that both income and price elasticities have increased in absolute value indicating that they are more elastic today than they were four years ago.[5] The most striking finding is that the price elasticity for gasoline computed at the 1980 data point shows it is *elastic.*

Implications of Findings to Tax Revenues from Gasoline Sale

The price elasticity of demand for gasoline at the 1980 data point using the demand equation obtained from the 1960-1980 data indicates that a one percent price increase would result in a 1.24 percent decline in the amount of gasoline consumed, assuming income remains unchanged. The high price elasticity of demand means that the amount of gasoline demanded would decline by 1.24 percent for a one percent price increase. The amount of gasoline consumed increased every year since World War II until 1978. Over 71 million gallons of fuel were consumed less in 1979 than 1978 and about 16 million gallons less in 1980 than 1979. The total amount of fuel used by Kentucky motorists during the first six months of 1981 was 822 million gallons and this was 15 million gallons less than the comparable figure for 1980. The decline in fuel consumption has resulted in a decline in tax revenues from the sale of gasoline; the tax receipts from the sale of gasoline have declined by 7 million dollars in 1979 compared to 1978 and by 10 million dollars in 1980 from 1979. This trend is expected to continue if price continues to increase unless corrected by a revised tax rate. However, the revised tax rate is not a guarantee for higher tax receipts as explained below.

The tax receipts denoted by TAXO under the old tax rate for a given price can be expressed as

$$(12) \quad TAXO = T_o Q$$

where T_o denotes the fixed tax rate in cents per gallon and Q refers to the amount of fuel demanded at a given price. When price increases by z-percent, the amount

[5] Refer to Song, Inbum and James Conrad.

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Table 1. Annual Gasoline Consumption, Average Wholesale Price of Gasoline and Per Capita Income in the Commonwealth of Kentucky 1960-1980

Year	Annual Gasoline Consumption Gallons	Average Wholesale Price Cents	Per Capita Income Dollars
1960	891,952,608	32.80	1586
1961	908,983,156	32.23	1690
1962	955,792,460	32.10	1771
1963	994,238,820	30.81	1864
1964	1,037,630,420	31.15	1925
1965	1,096,015,569	32.90	2036
1966	1,134,116,222	33.35	2284
1967	1,119,402,943	32.90	2448
1968	1,266,345,838	34.00	2668
1969	1,341,488,231	35.74	2885
1970	1,409,855,777	36.57	3112
1971	1,507,048,343	37.90	3313
1972	1,592,930,949	37.32	3600
1973	1,662,324,396	40.32	4047
1974	1,635,620,233	53.83	4564
1975	1,701,352,955	58.10	4886
1976	1,796,428,751	61.25	5423
1977	1,845,015,737	66.40	5964
1978	1,895,709,675	68.40	6605
1979	1,824,484,605	92.20	7342
1980	1,707,999,827	98.00	7442

Sources: Data on annual gasoline consumption and average whole-sale price were obtained from Kentucky Petroleum Marketers Association. Data on per capita income were obtained from Research and Planning Division, Kentucky Department of Commerce, Frankfort, Kentucky.

of fuel demanded, Q, wll be $Q(1 + zE/100)$ where E represents the price elasticity of demand. Thus, the tax receipt after a z-percent price increase, TAXOA, is given by Equation (13).

$$(13) \quad TAXOA = T_oQ(1 + zE/100)$$

The change in tax revenue as a result of a z-percent price change can be expressed in Equation (14).

$$(14) \quad \Delta TAXO = TAXOA - TAXO = T_oQ(zE/100)$$

Since the value for E is negative, the change in tax revenue as a result of z-percent price increase is always negative regardless of the price elasticity, E.

On the other hand, under the new tax rate, the receipts from the sale of gasoline, TAXN, for a given price can be expressed by Equation (15).

$$(15) \quad TAXN = TPQ$$

where T refers to the fixed tax rate in percentage of wholesale price of gasoline. The tax receipts after price is increased by z-percent, TAXNA, can be computed by Equation (16).

$$(16) \quad TAXNA = TP(1 + z/100)Q(1 + zE/100)$$

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The change in tax receipts as a result of a z-percent price increase can be expressed in Equation (17).

$$(17) \quad \Delta TAXN = TAXNA - TAXN = TPQ(z/100)(1 + 2E)$$

The change in tax revenue as a result of z-percent price change can be positive only when $(1 + 2E)$ terms becomes positive and the term can be negative only when the price elasticity of demand is less than -0.5. That is, when the absolute value of E is between zero and 0.5, the change in tax receipts will be positive.

In conclusion, the old tax rate decreases tax revenues as the price increases, regardless of the price elasticity of demand for gasoline when the income effect is disregarded. On the other hand, the new tax rate increases the tax revenue from the sale of gasoline when the price elasticity of demand is greater than -0.5 and the tax revenue from fuel decreases when the price elasticity of demand is less than -0.5, again disgarding the income effect.

What are the meanings of the finding in this study to tax revenues from the sale of gasoline to the Commonwealth of Kentucky? The implications must be analyzed from long-run as well as short-run view point. The value of long-run price elasticity of demand for gasoline in the Commonwealth of Kentucky has been about -0.70 in the past years and, in recent years, the value has decreased further to -1.24. That is, the price elasticity has become more elastic in recent years. This means that tax revenues from the sale of gasoline even under new tax rate would fall in the long-run as price of fuel increases in the future. This is a significant long-run implication.

The fact that long-run price elasticity of demand is less than -0.5 does not mean that the tax revenues would fall with price increase in the short-run under the new tax rate. This is so because short-run price elasticity is normally greater than -0.5.

The price elasticity of demand estimated with 1978-1980 data at the 1980 data point is -0.36. Therefore, the tax receipts from the sale of gasoline in 1981 could be greater than the corresponding figure for 1980.

Conclusion

The revised tax rate on gasoline to increase tax revenues from the sale of fuel in the Commonwealth will be effective under limited conditions and it will not be effective when price elasticity of demand is more elastic than -0.5. In view of the fact that the long-run price elasticity of demand has become more elastic in recent years and that the trend will continue in the future as consumer switch from gas inefficient cars to small fuel efficient cars, the elasticity will tend to increase further in the future. This results in a further decline in the amount of gasoline consumed and, as a result, the tax receipts will further fall in the long-run even under the new tax rate.

In the short-run, however, new tax rate may increase the tax receipts but it is not a permanent phenomenon.

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