

Excise Taxation and Product Quality: The Gasoline Market*

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Abstract

Following Barzel (1976), product quality increases in response to unit taxation but remains unchanged by ad valorem taxation. While many tax theorists agree this argument is theoretically sound, empirical support of Barzel's theory is limited to the cigarette market. This paper tests and confirms his theory in the gasoline market, a market in which Barzel failed to find supporting evidence in his original article. Using a direct test proposed by Sobel and Garrett (1997) and improved data, I find the market shares of premium and mid-grade gasoline rise in response to per-unit taxation but are unaffected by ad valorem taxation.

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I. Introduction

Standard tax theory shows that as the tax rate rises, individuals will purchase less of the taxed good or resource. This quantity substitution, however, is not the only margin on which individuals can act to minimize their tax liability. Barzel (1976) explains that individuals may also alter their purchases of quality in response to changes in the tax rate. He theorized that for unit taxation individuals will substitute away from the taxed attribute of the good (which is quantity) and into its untaxed attribute (which is quality). Barzel's theory suggests that while both per-unit and ad valorem taxes lead to a decline in product sales, per-unit taxes will also lead to an increase in average product quality. An alternative explanation of this quality substitution can be drawn from the Alchian and Allen (1967) theorem because the imposition of a per-unit tax (a fixed fee) causes the price of the higher-quality version of a good to fall relative to a lower-quality substitute. Ad valorem taxes, however, do not alter the relative prices of the different quality levels of the product and, thus, do not impact the purchase of quality.¹

While Barzel's idea is both novel and widely cited, it has received limited support empirically, with nearly all of the tests having been conducted in the cigarette market. Indeed, only Barzel's original article attempted to test his theory in a market other than cigarettes.² While he found empirical support for his theory in the cigarette market, his results were inconclusive in the markets for gasoline and alcohol. The goal of this paper is to reexamine the gasoline market using data that was not available when Barzel first analyzed this market, allowing for a better empirical model. This reexamination of

Barzel's theory is important because there is a need to determine whether the theory is unique to the cigarette market or whether it can be applied more generally. As will be explained in the next section of the paper, Barzel's model is inherently biased toward rejecting his theory, which may explain his inability to find evidence of quality substitution in the market for gasoline. The method used in this paper corrects this bias.

The paper proceeds as follows. In the next section, the previous empirical literature is reviewed, making note of the drawbacks of Barzel's original method and the benefits of the model used here. Section III presents the empirical model used in this study and discusses the results. Concluding remarks are offered in section IV.

II. A Review of the Empirical Literature

Barzel originally tested his hypothesis in the cigarette market using data from 1954 to 1972. While his hypothesis was that state per unit cigarette taxes should increase the quality of cigarettes, this was impossible to test directly without objective data on the quality of cigarettes. Instead, Barzel relied on an indirect test using the price of cigarettes. His model assumed that the full burden of the tax would fall upon consumers, causing the retail price of cigarettes to increase by the full amount of the tax. Thus, if the imposition of a unit tax also causes an increase in product quality, the price change resulting from the unit tax should be greater than the amount of the unit tax itself (reflecting also the value of the quality improvement). This can be illustrated by the following equation:

$$\Delta P = T + \Delta V$$

where ΔP is the observed after-tax price change, T is the unit tax, and ΔV is the value of the change in product quality.

The following numerical example may aid in this discussion. If a twenty cent unit tax caused the price to rise by twenty-five cents, Barzel would attribute this difference to an increase in product quality valued at five cents. However, Barzel's results are critically sensitive to his assumption that the full burden of the unit tax falls on consumers. If consumers bear less than the full burden of the tax, which depends on the relative elasticities of demand and supply, increases in quality may go unmeasured in Barzel's model. Consider the same twenty cent unit tax and same increase in product quality valued at five cents discussed above, but assume instead that consumers and producers equally share the burden of the tax. The observed price increase is only fifteen cents, potentially leading to the rejection of the theory when it is actually true.

Barzel tested his theory with the following empirical model:

$$P_{it} = \alpha_0 + \alpha_1 TAX_{it} + \alpha_2 NHTAX_{it} + \alpha_3 DISTANCE_i + year\ dummies + \varepsilon_{it}$$

where P_{it} is the average retail price per pack of cigarettes in state i and year t , TAX_{it} is the per unit tax on cigarettes in state i and year t , $NHTAX_{it}$ is the product of a dummy variable for New Hampshire with TAX_{it} , $DISTANCE_i$ is the road distance from North Carolina to the largest metropolitan area in state i , and also included in the regression is a set of year dummy variables. Despite the potential bias of the model used by Barzel, data limitations forced him to adopt such an indirect test of his theory.

Barzel's test of his hypothesis that unit taxation leads to increased product quality centered on whether the coefficient on the TAX variable is greater than one.

Additionally, to test the hypothesis that a specific ad valorem tax causes a quality reduction, a separate variable for New Hampshire was included, as it was the only state to levy a specific ad valorem tax on cigarettes. Barzel interpreted his empirical results, reproduced in Table 1, as supportive of both of his hypotheses, as the coefficient on the TAX variable was significantly greater than one, and the coefficient on the New Hampshire variable was negative and significant.

[Table 1 about here.]

Johnson (1978) refined Barzel's model by adding state dummy variables to control for any state specific differences in the retail prices of cigarettes. Johnson's model can be represented as:

$$P_{it} = \alpha_0 + \alpha_1 TAX_{it} + \alpha_2 NHTAX_{it} + \text{year dummies} + \text{state dummies} + \varepsilon_{it}$$

His model was also estimated using data from 1954-1972. Johnson pointed out that Barzel had incorrectly structured the test of the New Hampshire coefficient, and that Barzel's results had in fact rejected his own hypothesis. The structure of the New Hampshire variable is such that it shows the marginal impact of New Hampshire's ad valorem cigarette tax. Barzel had tested whether the coefficient on the New Hampshire variable was significantly less than zero, while Johnson argued that the correct test is that the sum of this coefficient and the coefficient on the TAX variable was less than one. A test of whether the New Hampshire coefficient is negative is a test of whether the specific ad valorem tax has a different impact than a similar unit tax, while a test of whether the sum of the coefficients is less than one is a test of whether the specific ad valorem tax lowers product quality. After including state dummy variables, Johnson's results

supported those of Barzel, even for the New Hampshire variable. Reproductions of Johnson's results are also given in Table 1.

Sumner and Ward (1981) further extended Barzel's model by adjusting for the impact of backlogged inflation. Their idea was that an increase in the cigarette tax presents an opportunity for cigarette retailers to adjust prices to reflect all inflation since the last tax change. Thus, Sumner and Ward provide an alternative explanation of why prices may rise by more than the amount of the tax. Their model, which adjusted for this phenomenon, can be written:

$$\Delta P_{it} = \alpha_0 + \alpha_1 \Delta TAX_{it} + \alpha_2 \Delta \Pi_t + \alpha_4 \Delta t_{it} \bullet \sum_{k=m+1}^t (\Delta \Pi_k) + \alpha_5 \Delta W_t + \varepsilon_{it}$$

where all values are now in nominal terms, and their first differences are used. Their model was estimated using data from 1955-1976. In this model, W_t is the wholesale price of cigarettes, Π_k is the consumer price index, and the summation term measures the cumulative inflation since the last state tax increase. The results of this model are also reproduced in Table 1. Sumner and Ward reject Barzel's hypothesis by finding a coefficient on the TAX variable strictly less than one. Thus, they conclude that unit taxes do not have a positive impact on product quality. While no separate variable was included for New Hampshire, the residuals for this state were not abnormal, leading to their second conclusion that the impacts of ad valorem taxes and unit taxes are not significantly different.

All three of these previous models are subject to some extreme data limitations. First, Barzel's theory was originally formulated in terms of the quality of the product, not the price, which is used as the basis for testing his hypothesis in each of the models

discussed above. This indirect test using price requires an additional assumption that the full amount of the tax is passed on to the consumer. If this is not the case, then the coefficient on the TAX variable could be less than one but still consistent with Barzel's hypothesis. For example, if only half the tax is passed on to the consumer, then a coefficient less than 1.0, but still greater than 0.5, would suggest a quality improvement consistent with Barzel's model. As a result, Sumner and Ward's finding that the tax coefficient was significantly less than one could be a rejection of the assumption that the full amount of the tax is passed on to consumers, and not a rejection of Barzel's theory. Sumner and Ward even point to some reasons why the price should not rise by the full amount of the tax, such as the ability of consumers to do cross-border shopping.

The second, and more important, limitation of these earlier models is that they all estimate the quality improvement from a specific state's tax rate change in terms of a change in the price of cigarettes *in that state*. Because the empirical model is cross sectional, empirical confirmation of Barzel's theory requires that the quality of cigarettes in a specific state can vary with the unit taxes imposed in that state *independent of the quality of cigarettes in all other states*. Sumner and Ward cite this as a major limitation to Barzel's and Johnson's empirical studies. Even Barzel points to the limited ability of cigarette quality to differ across states in response to differing unit taxes.³ If there are conditions in the cigarette market that constrain quality from differing across states, then one might expect a coefficient near one because a change in a single state's unit tax on cigarettes should result in only a small impact on the overall quality level of cigarettes in the U.S. as a whole.

Improving upon the indirect method used in the three studies discussed above, Sobel and Garrett (1997) conduct the first direct test of Barzel's theory using data that directly measures product quality. Lower quality, generic-brand cigarettes began acquiring a sizable share of the cigarette market in 1982. Generic-brand cigarettes are of a lower quality level relative to premium-brands on many margins, including taste, quality of tobacco, and freshness. The arrival of generic-brand cigarettes permitted the development of a better empirical model than had been previously estimated. In their model, Sobel and Garrett look at the market share of the higher-quality, premium-brand cigarettes relative to the market share of lower-quality, generic-brand cigarettes to directly measure the impact of state taxes on the average quality of cigarettes consumed in a state. Because state unit taxes on cigarettes are the same for both generic and premium brands, Barzel's theory predicts that the unit tax should cause consumers to substitute out of generic- and into premium-brand cigarettes. His theory also predicts that general ad valorem retail sales taxes, which have no impact the relative prices of generic- and premium-brand cigarettes, do not cause a change in the market share of premium brand cigarettes.

Sobel and Garrett's test is much stronger and more direct than the previous tests using only price data. Additionally, testing Barzel's hypothesis using price data is subject to many limitations, such as the assumption about how much of the tax burden falls on consumers. Their model can be expressed as follows:

$$\% \text{PREMIUM}_{it} = \alpha_0 + \alpha_1 \text{UNITTAX}_{it} + \alpha_2 \text{SALESTAX}_{it} + \text{year dummies} + \text{state dummies} + \varepsilon_{it}$$

where %PREMIUM_{it} is the market share of premium brand cigarettes in state *i* and year *t*, UNITTAX_{it} is the per unit state tax on cigarettes in state *i* and year *t*, SALESTAX_{it} is the ad valorem sales tax rate applicable on cigarette sales in state *i* and year *t*, and also included in the regression are a set of year dummy variables and a set of state dummy variables. Their model was estimated using data from 1990-1994. Barzel's theory predicts that the coefficient on UNITTAX is positive and significant, while the coefficient on SALESTAX is zero.

Sobel and Garrett interpret their results as supportive of Barzel's theory. The authors find that the market share of premium-brand cigarettes is significantly larger in states with larger unit taxes on cigarettes than it is in low-tax states. Their estimates suggest that for every three cents of a state unit tax, the market share of premium-brand cigarettes increases by about one percentage point. The ad valorem sales tax is found to be insignificant in determining the market share of premium-brand cigarettes. Furthermore, New Hampshire's cigarette specific ad valorem tax, which was the only ad valorem excise tax on cigarettes at the time of their study, is found to be an insignificant determinant of product quality. Their results are also reproduced in Table 1.

Based on the empirical work examining Barzel's theory as applied to the cigarette market, it is difficult to draw concrete inferences about the validity of his theory. The early tests of Barzel's theory, using a formulation based on changes in product price, produced mixed results. Sobel and Garrett (1997), through the availability of improved data, were able to use a direct method to find empirical evidence of Barzel's theory in the market for cigarettes. Yet, it remains unclear whether Barzel's theory can be applied generally to all cases of unit and ad valorem taxation, or whether the theory describes

behavior that is unique to the cigarette market. This question is of concern, particularly given that Barzel, himself, was unable to find supporting evidence of his theory in any market other than cigarettes. This paper now turns to a reevaluation of the market for gasoline, one of the markets in which Barzel could not find empirical support of his theory.

III. Empirical Test of the Market for Gasoline

Much of the existing literature studying gasoline markets focuses on estimating the demand and price elasticity of demand for gasoline, where quantity serves as the dependent variable.⁴ This paper alternatively estimates the market shares of the three quality grades of gasoline (regular, mid-grade, and premium). Because only the *relative* quantities of these quality grades are of importance, many of the complications associated with estimating demand directly are avoided.⁵ In addition, the use of market share data allows for the average quality of gasoline to vary independently across states, addressing an issue that Sumner and Ward (1981) cite as a major limitation of earlier tests using the indirect approach to testing Barzel's theory.

The effects of gasoline taxation on the quality of gasoline consumed, as measured by changes in the market shares of each grade of gasoline (regular, mid-grade, and premium), is estimated following the method introduced by Sobel and Garrett (1997).⁶ Annually averaged state-level daily volume sales (retail plus wholesale) by grade of gasoline for 1991-2001 are obtained from the Energy Information Administration. Data on gasoline taxes were collected from *Highway Statistics* while per capita income was obtained from the Census Bureau. Descriptive statistics of the data used in this study can

be found in Table 2. The year 1991 is chosen as the first observation year to avoid any interactions between leaded and unleaded gasoline.⁷ All states levy a per-gallon tax on gasoline and seven states apply their ad valorem sales tax to gasoline sales during the sample period.⁸

[Table 2 about here]

A state-fixed effects model is estimated for each grade of gasoline.⁹ The market share for each grade of gasoline is estimated as a function of the unit tax amount, the ad valorem (sales) tax rate, and a set of control variables (Γ). The empirical model can be written:

$$\%MARKET_{it} = \beta_0 + \beta_1 * UNIT TAX_{it} + \beta_2 * SALES TAX_{it} + \beta * \Gamma_{it} + \epsilon_{it}$$

where $\%MARKET_{it}$ is the market share of the specified grade of gasoline (regular, mid-grade, or premium), $UNIT TAX_{it}$ is the sum of the federal and state tax on gasoline in cents per gallon, $SALES TAX_{it}$ is the sales tax rate applied to gasoline, and Γ is a matrix of other control variables, where i and t represent state and time, respectively. In specification [1], Γ includes the constant, a time trend, and a FTC dummy variable (explained below). Specification [2] differs from specification [1] by only a set of variables added to Γ to control for driver characteristics: per capita income, percent male licensed drivers, and percent licensed drivers in various age groups.

The FTC dummy variable is included in all specifications of the model to estimate the impact of education campaigns resulting from the 1997 settlement between the Federal Trade Commission (FTC) and Exxon. In 1996 the FTC charged Exxon with making exorbitant advertising claims concerning the ability of Exxon 93 Supreme to clean engines and reduce automobile maintenance costs. Exxon agreed to replace their

previous advertisements with educational advertising concerning the choice of gasoline grades. The primary message of the new advertising was that premium gasoline does not significantly improve engine performance. If the FTC's efforts were effective, there should be a significant decline in the market share of premium gasoline starting in 1997, which needs to be controlled for in the analysis.

According to Barzel, the coefficient on $UNIT\ TAX_{it}$ should be positive and significant in the %PREMIUM model and negative and significant in the %REGULAR model. The sign of this coefficient in the %MIDGRADE model is less clear. However, it is reasonable to expect it to be positive because of the sheer size differential between the two markets. The market share for regular gasoline is nearly seven times that of mid-grade gasoline during the period studied. Thus, the potential for consumers to substitute from regular to mid-grade is much larger than the potential for consumers to substitute from mid-grade to premium. The coefficient on $SALES\ TAX_{it}$ should be insignificant from zero for all three grades because the tax induces no change in relative prices. The results from both specifications using market share data for all grades all gasoline are provided in Table 3.

[Table 3 about here]

While the results are robust to different specifications, only the results from the specification with the driver characteristic variables are discussed, namely specification [2]. The coefficient on $UNIT\ TAX_{it}$ is significant at the one percent level and is of the predicted sign in all specifications. These estimates imply that a one cent increase in the unit tax, either at the state or federal level, causes a 0.21 percentage point increase in the market share of premium gasoline while causing the market share of regular gasoline to

fall by about 0.22 percentage points. Interestingly, the coefficient on $UNIT\ TAX_{it}$ in the mid-grade gasoline case is always positive and significant at the one percent level in both specifications, suggesting greater consumer inflow from regular gasoline than outflow to premium gasoline. The estimates imply that a one cent increase in the unit tax on gasoline causes the market share of mid-grade gasoline to rise by about 0.07 percentage points. The coefficient of $SALES\ TAX_{it}$ is insignificant in all specifications and grades. Thus, the imposition of an ad valorem tax exerts no significant effect on consumers' purchases of gasoline grade.

The results suggest that the educational advertisements mandated by the FTC to educate consumers of the limited benefits of using high-octane fuel were effective in reducing the use of premium gasoline relative to the other two quality grades. The market share of premium gas fell by 1.35 percentage points in response to these campaigns. The impact of these advertisements should be interpreted as economically significant because the mean market share of premium gasoline is only about 17% over the sample period.

IV. Conclusion

Although Barzel's theory has become accepted as a standard idea in tax theory, supporting empirical evidence has been somewhat scarce. The early literature employed a model biased against the theory and failed to find empirical support for the theory in markets other than cigarettes. Although Sobel and Garrett (1997) use an unbiased empirical model to find evidence in support of Barzel's theory, one may still question

whether the theory is general to all markets or whether this result is unique to the cigarette market.

This paper tests and confirms Barzel's theory in the gasoline market, a market in which Barzel himself was unable to find supporting evidence in his original article. The results presented here suggest that per-unit gasoline taxes lead to proportionately more consumption of higher-quality, premium gasoline and proportionately less of lower-quality, regular gasoline. For every five cents of combined state and federal unit tax on gasoline, it is shown that the market share of premium gasoline increases by approximately one percentage point, while the market share of regular gasoline falls by approximately the same amount. Given that the combined state and federal unit tax for the average state was 44.608 cents per gallon in the year 2001, these results suggest that the market share for premium gasoline is about 9.3 percentage points greater than it otherwise would have been without the tax. The market share for regular gasoline in the average state is approximately 10.0 percentage points smaller due to unit taxation. Ad valorem taxes are shown to have no effect on the relative purchase of gasoline grades. This paper is the first to confirm the implications of Barzel's theory in a market other than the cigarette market, suggesting that his theory is not unique to the cigarette market, but can be applied more generally to all cases of unit taxation.

Endnotes

¹ See Borchering and Silberberg (1978), Umbeck (1980), Leffler (1982), Bertonazzi, Maloney, and McCormick (1993), Cowen and Tabarrok (1995), and Razzolini, Shughart, and Tollison (2003) for more detailed discussions of Barzel's theorem and the Alchian and Allen theorem.

² In a related analysis, Barzel and Hall (1977) find evidence of quality substitution in response to import quotas on crude oil.

³ Barzel mentions that some within state changes in consumer choices of quality levels could be toward higher-priced 100mm cigarettes and those from vending machines.

⁴ Archibald and Gillingham (1980) and, Kayser (2000) estimate gasoline demand using household-level data with the latter finding a price elasticity of -0.23.

⁵ There is also a strand of literature examining the long-run adjustment, namely the choice of fuel type (gasoline, diesel, and LPG), in response to tax policy changes, such as Rouwendal and de Vries (1999). These studies are different from the current study in that they reflect long-run adjustments rather than short-run adjustments to a change in tax policy.

⁶ Barzel's theory also suggests that the octane rating for all grades of gasoline may rise in response to unit taxation. I am indebted to Barzel for this insight. Data limitations prevent the testing of this effect here.

⁷ Prior to 1991 both leaded gasoline and unleaded gasoline were sold at retail stations, whereas only unleaded gasoline has been sold at retail stations since 1991. All

observations from North Dakota, South Dakota, and Wyoming were excluded from the sample due to data limitations.

⁸ These seven states are CA, GA, HA, IN, IL, MI, and NY.

⁹ The Hausman test was conducted, and the results indicate marginal support for the random-effects specification. The seemingly unrelated regression (SUR) model is generally more efficient than ordinary least squares (OLS) since my dependent variables (market shares) are correlated. However, since all right-hand-side variables are identical, there are no efficiency gains to using SUR. Thus, single-equation OLS is the efficient estimator.

Table 1
Summary of Previous Empirical Results¹

Barzel's Results		Johnson's Results	
Constant	14.801 (73.564)	Constant	13.651 (31.08)
TAX	1.065 (101.439)	TAX	1.101 (87.028)
NHTAX	-0.072 (5.078)	NHTAX	-0.503 (3.156)
DISTANCE	0.011 (3.072)		
State Dummy Variables	Yes	State Dummy Variables	Yes
Year Dummy Variables	No	Year Dummy Variables	Yes
R-squared	0.93	R-squared	0.965
Observations	931	Observations	1,162
Sumner and Ward's Results		Sobel and Garrett's Results	
Constant	-0.034 (0.670)	Constant	62.810 (0.845)
Δ TAX	0.928 (25.792)	UNIT TAX	0.327 (2.007)
Δ Π	8.228 (6.480)	SALES TAX	-0.344 (0.389)
$\Delta t \cdot \Sigma (\Delta \Pi)$	2.469 (3.691)	Per Capita Income	0.0003 (0.073)
ΔW	1.020 (9.151)	Unemployment Rate	-0.7385 (0.763)
State Dummy Variables	No	State Dummy Variables	Yes
Year Dummy Variables	No	Year Dummy Variables	Yes
R-squared	0.744	R-squared	0.552
Observations	784	Observations	255

¹Absolute t-ratios in parenthesis. Results from Barzel, Johnson, and Sumner and Ward based on indirect test while those from Sobel and Garrett are from a direct test of the theory.

Table 2
Descriptive Statistics, 1991-2001

Variable	Mean	Std.Dev.	Minimum	Maximum
Market Share--Regular	72.177	10.284	30.779	93.376
Market Share--Mid-grade	10.469	4.471	0.056	22.261
Market Share--Premium	17.025	6.878	4.305	48.494
Unit Tax	44.608	7.012	25.263	70.934
Sales Tax	0.725	1.797	0.000	6.250
Per Capita Income (\$1,000)	27.378	4.526	17.816	44.731
Percent Male Drivers	50.304	1.341	46.050	55.431
Percent Drivers under Age 35	34.916	3.137	23.967	44.756
Percent Drivers over Age 54	25.539	2.753	14.481	32.728

Table 3
State-Fixed Effects Models¹
1991-2001

	Market Share for Regular Gasoline		Market Share for Midgrade Gasoline		Market Share for Premium Gasoline	
	[1]	[2]	[1]	[2]	[1]	[2]
Unit Tax (cents)	-0.249*** (7.91)	-0.224*** (6.83)	0.102*** (4.10)	0.072*** (2.81)	0.220*** (13.28)	0.209*** (12.01)
Sales Tax Rate	0.062 (0.12)	-0.043 (0.09)	-0.143 (0.35)	-0.041 (0.10)	0.124 (0.45)	0.178 (0.66)
Constant	69.582*** (25.12)	57.017*** (3.49)	6.894*** (3.15)	21.672* (1.69)	18.481*** (12.69)	19.521** (2.25)
Trend	0.994*** (10.79)	0.508*** (3.44)	-0.321*** (4.40)	0.092 (0.79)	-0.419*** (8.65)	-0.170** (2.16)
FTC Dummy	0.210 (0.38)	0.044 (0.08)	0.812* (1.84)	0.973** (2.26)	-1.465*** (5.00)	-1.345*** (4.62)
Per capita income (\$1,000)		0.293 (1.52)		-0.287* (1.89)		-0.205** (2.00)
Percent Male Licenced Drivers		-0.090 (0.42)		0.142 (0.85)		0.116 (1.03)
Percent licenced drivers under the age of 35		-0.292** (2.36)		0.156 (1.61)		0.143** (2.17)
Percent licenced drivers over the age of 54		0.760*** (3.29)		-0.756*** (4.16)		-0.248** (2.02)
R-squared	0.918	0.924	0.729	0.751	0.949	0.952
Observations	466	466	466	466	466	466

¹Only two models are independent as the sum of the market shares add to 100.
Significance levels of 1%, 5%, and 10% are denoted by ***, **, and *, respectively.
Absolute t-ratios appear in parenthesis. Regressions also include state dummy variables, which are not reported in the table.

References

- Alchian, Armen A. and William R. Allen. *University Economics: Elements of Inquiry*. Belmont, California: Wadsworth, 1964.
- Archibald, Robert and Robert Gillingham. "An Analysis of the Short-Run Consumer Demand for Gasoline Using Household Survey Data." *The Review of Economics and Statistics* 62, No. 4 (Nov. 1980): 622-28.
- Barzel, Yoram. "An Alternative Approach to the Analysis of Taxation." *Journal of Political Economy* 84 (Dec. 1976): 1177-97.
- Barzel, Yoram and Christopher D. Hall. *The Political Economy of the Oil Import Quota*. Stanford, California: Hoover Institutional Press, 1977: 65-71.
- Bertonazzi, E., M.T. Maloney, and R.E. McCormick. "Some Evidence on the Alchian and Allen Theorem: The Third Law of Demand?" *Economic Inquiry* 31, No. 3 (1993): 383-93.
- Borcherding, T.E., and E. Silberberg. "Shipping the Good Apples Out: The Alchian and Allen Theorem Reconsidered." *Journal of Political Economy* 86, No. 1 (1978): 131-38.
- Cowen, Tyler and Alexander Tabarrok. "Good Grapes and Bad Lobsters: Applying the Alchian and Allen Theorem." *Economic Inquiry* 33 (Apr. 1995): 253-56.
- Energy Information Administration. *Petroleum Marketing Annual*, various years.
- Johnson, Terry R. "Additional Evidence of the Effects of Alternative Taxes on Cigarette Prices." *Journal of Political Economy* 86, No. 2, Pt. 1 (April 1978): 325-328.
- Kayser, Hilke A. "Gasoline Demand and Car Choice: Estimating Gasoline Demand Using Household Information." *Energy Economics* 22, No. 3. (Jun. 2000): 331-48.
- Leffler, KB. "Ambiguous Changes in Product Quality." *American Economic Review* 72, No. 5 (1982): 956-67.
- Office of Highway Policy Information. *Highway Statistics*, various years.
- Razzolini, Laura, William F. Shughart II, and Robert Tollison. "On the Third Law of Demand." *Economic Inquiry* 41, No. 2 (April 2003): 292-298.
- Rouwendal, Jan and Frans de Vries. "The Taxation of Drivers and the Choice of Car Fuel Type." *Energy Economics* 21, No. 1 (Feb. 1999): 17-35.

Sobel, Russell S. and Thomas A. Garrett. "Taxation and Product Quality: New Evidence from Generic Cigarettes." *Journal of Political Economy* 105, No. 4 (1997): 880-87.

Sumner, Michael T. and Robert Ward. "Tax Changes and Cigarette Prices." *Journal of Political Economy* 89 (December 1981): 1261-1265.

Umbeck, J.R. "Shipping the Good Apples Out: Some Ambiguities in the Interpretation of 'Fixed Charge.'" *Journal of Political Economy* 88, No. 1 (1980): 199-208.