Testing the Alchian-Allen Theorem: A Study of Consumer Behavior in the Gasoline Market

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Abstract

This paper uses a data set of daily sales at a single gasoline station over a seven year period to determine if consumers respond to relative price changes among the three grades of gasoline. Based on the reasoning of Alchian and Allen (1964) and Barzel (1976), market shares of higher quality gasoline should increase at the expense of regular grade gasoline when overall gasoline prices increase. The empirical results do not conform to this expectation. We find instead that the consumers in this sample responded to higher gasoline prices by switching to mid grade gasoline from premium grade gasoline leaving the market share of regular gasoline unchanged.

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1. Introduction

Reports in the popular media (Tse, 2006) suggest that purchasers of gasoline have shifted away from buying premium gasoline in response to recent price increases in gasoline. This is surprising because when gasoline prices rise the price of premium grade gasoline typically falls relative to regular (or mid) grade gasoline.

In gasoline markets it is common practice to charge a fixed price differential between the three grades of gasoline. Regular grade gasoline may sell for $1.00 per gallon and mid and premium grade may sell for $1.10 and $1.20 per gallon respectively. Thus, mid grade is 10 percent and premium is 20 percent more expensive than regular grade gasoline.

If the price of regular gasoline increases to $2.00 per gallon and the industry maintains the same fixed ten cent price differentials between grades, mid and premium gasoline will be priced at $2.10 and $2.20 respectively. While the absolute price differential is the same as before, mid and premium grade gasoline are now just 5 and 10 percent more expensive than regular grade gasoline in relative terms.

It is not clear why stations charge relatively fixed per unit price differentials between the three grades of gasoline regardless of the overall level of gasoline prices. It could be simple custom or may indicate that the additional production costs of mid and premium grade gasoline are fixed costs per gallon. It may just cost ten cents more per gallon to make each grade compared to the next lower grade.

Regardless of the cause, as gasoline prices rise, mid and premium grade gasoline become cheaper relative to regular grade. If these relative prices matter, then we would expect mid and premium grade gasoline to gain sales relative to regular grade gasoline when overall gasoline prices rise.

This prediction is closely related to that identified first by Alchian and Allen (1964) and then by Barzel (1976) who argued that the existence of fixed costs, such as transportation costs or per unit taxes, will lower the price of higher quality products relative to lower quality products. They suggest that such fixed costs will encourage consumers to shift resources toward the purchase of higher quality goods.

Alchian and Allen's original example was to note that native Californians will actually consume lower quality California-grown grapes than New Yorkers. The transportation costs from California to New York, which are the same for both low and high quality grapes, end up making higher quality grapes less expensive relative to lower quality grapes in New York. New York consumers respond to the lower relative price of high quality grapes by buying more of them. Consequently Californians are left with more of the lower quality grapes.

There is small but growing empirical literature attempting determine if consumer behavior conforms to the Alchian-Allen and Barzel theories. Barzel's original article offered evidence from gasoline and alcohol markets where per-unit taxes are common. In early studies of the impact of taxation in the cigarette market, Johnson (1978) found support for Barzel while Sumner and Ward (1981) did not. More recent work by Sobel and Garrett (1995) found that lower quality generic cigarettes lose market share to brand name cigarettes in response to unit taxes—a result consistent with Barzel.

Bertonazzi, Maloney, and McCormick (1993) found that fans traveling longer distances to football games tend to buy better seats than local fans.

Of closer interest to this paper, Nesbit (2006) found that per-unit gasoline taxes lead to increased market shares for premium gasoline and lower market shares for regular gasoline. This result is consistent with Barzel's original claim. Nesbit uses aggregate state-level data while this paper uses firm-level data.

2. The Data

The data set for this paper was collected from a single, rural, independently-owned gasoline station in West Virginia for the years from 1992-1999. For each day, the total amount of gasoline sold at each pump in each of the three grades was obtained, as well as the prices for that day.[1] See Table I for descriptive statistics.

While the data are only from one station, there are advantages to this type of firm-level data. Limiting the scope of the data set to one station eliminates the need to account for variances in location, income of the surrounding population, traffic patterns, and other factors that would vary by location. Also, assuming that a single firm is a price taker, the econometric difficulties with demand curve identification are eliminated.[2]

3. Empirical Models and Results

Empirical Models and Results

Price fluctuations of the three grades of gasoline were highly correlated with each other over time. The median difference in price between premium and regular grade was 17 cents and between mid grade and regular was 8 cents with very little variation (the standard deviation was just 2 cents). It is a fair description of the data to say that the price differentials were essentially constant between the three grades of gasoline.

While absolute price differences among the three grades were relatively constant, the relative price of one grade to another was not nearly as constant. As the mean price of gasoline increased the relatively fixed price differential between the prices of each grade caused the price of premium and mid grade gasoline to decline in relation to regular grade gasoline. For every ten cent *increase* in the average price of gasoline there is a 2.3 percent *decrease* in the price ratio of premium to regular grade gasoline and a 1.6 percent *decrease* in the price ratio of mid to regular grade gasoline. See Table II.

These results are exactly what one would expect in order to measure the relevance of the Alchian-Allen Theorem. As the mean price increases, the premium and mid grades of gasoline become cheaper relative to the regular grade. The relatively fixed gap in absolute prices between the three grades acts in a similar manner as a fixed per-unit tax.

The next step is to determine if consumers respond to the changes in relative prices in a manner predicted by Alchian-Allen, and Barzel.[3] The empirical results present in Table III use the market share of each grade of gas as the dependent variable and the mean price of gasoline as the independent variable. Dummy variables for day of the week, month, and year were included in the regressions (but are not reported). While this is a relatively simple model, with just one primary explanatory variable, the dummy variables should do an adequate job of controlling for omitted factors that vary over time such as the business cycle. In addition, since the data are a time series from only a single

gas station, most variables that one would consider important in a cross-sectional model, such as location, are automatically held constant.

Consideration was given to directly using the relative price ratios instead of the mean price as the primary independent variable. The problem is relative to what? With three grades of gasoline, we have two price ratios for each grade. For example, premium grade prices can be compared to regular or mid grade or even to the mean price of all three grades. To avoid this confusion, we elected to use the mean price of gasoline knowing that increases in the mean price indicate lower relative prices for mid and premium grade gasoline as shown in Table II. Additionally, the popular media reports have focused on the impact of rising *overall* gasoline prices on the demand for premium grade gasoline. Therefore, the specification in Table III is a direct examination of the thesis put forth in the media.[4]

If consumers are responding to relative prices, we should expect to see an increase in the market share of mid and premium grade gasoline as the mean price increases. The results show that the market share of regular grade gasoline was essentially unchanged as the price of gasoline changed. The market share of mid grade gasoline increased as the average price of gasoline increased. A ten cent increase in the average price resulted in a 1.2 percentage point increase in the market share for mid grade gasoline. The market share for premium grade gasoline, however, fell in response to higher overall gasoline prices, indicating a 1.4 percentage point decrease in the market share for premium grade gasoline in response to a ten cent increase in average gasoline prices.

These results do not conform to the expectations of the Alchian-Allen and Barzel theories. Instead of seeing consumers moving from regular grade to mid and premium grade gasoline as overall prices rise, we observe a pattern where regular grade market share is unchanged while premium grade consumers switch to mid grade. These results are simply inconsistent with the expectations of the model.

4. Conclusion

This paper used a data set of daily gasoline sales at a single station over a seven year period to determine if consumers respond to relative price changes among the three grades of gasoline. The Alchian-Allen Theorem suggests that the market shares of mid and premium grade gasoline should increase at the expense of the market share of regular grade gasoline as their relative prices fall when overall gasoline prices increase. The empirical results do not conform to the expectation from the theorem. We find instead that the consumers in this sample responded to higher gasoline prices by switching to mid grade gasoline from premium grade gasoline leaving the market share of regular gasoline unchanged.

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Table I. Descriptive Statistics

Variable	N	Mean	StDev
Price of Regular Grade	2486	1.17	0.09
Price of Mid Grade	2486	1.25	0.08
Price of Premium Grade	2486	1.34	0.08
Price of Premium minus Regular	2486	0.17	0.02
Price of Mid minus Regular	2486	0.08	0.02
Market Share of Regular	2486	0.66	0.07
Market Share of Mid	2486	0.24	0.06
Market Share of Premium	2486	0.10	0.04
Mean Price of All Grades	2486	1.25	0.08

Table II. The Relative Price of Higher Quality Gasoline Falls as the Average Price of Gasoline Increases.

Dependent Variable:	**Price Ratio of Premium to Relative Grade Gasoline**	
	Coefficient	T-Statistic
Intercept	1.44	352.07
Mean Price of Gasoline	-0.23	71.10
R-Sq = 0.671		
Dependent Variable:	**Price Ratio of Mid to Relative Grade Gasoline**	
	Coefficient	T-Statistic
Intercept	1.26	338.42
Mean Price of Gasoline	-0.15	51.06
R-Sq = 0.512		
N=2486		

Table III. Market Share Regressions

Dependent Variable:	**Market Share of Regular Grade Gasoline**	
	Coefficient	T-Statistic
Intercept	0.60	12.39
Mean Price of Gasoline	0.01	0.33
R-Sq(adj) = 11.0%		
Dependent Variable:	**Market Share of Mid Grade Gasoline**	
	Coefficient	T-Statistic
Intercept	0.07	1.71
Mean Price of Gasoline	0.13	3.51
R-Sq(adj) = 8.8%		
Dependent Variable:	**Market Share of Premium Grade Gasoline**	
	Coefficient	T-Statistic
Intercept	0.33	11.16
Mean Price of Gasoline	-0.14	-5.77
R-Sq(adj) = 20.3%		
N=2486		
Note: All regressions include day, month, and year dummies.		

Endnotes

[1] The data were originally recorded by hand daily on tally sheets. After cleaning the data set for obvious errors, we were left with 2486 useable observations.

[2] Having data from just one independent station subsequently limits the generalizations that can be obtained from the results--a small, rural, independently owned station is hardly representative. Unfortunately, attempts to secure data from more gasoline stations were frustrated by fears on the part of station owners about possible anti-trust violations. Because individual station owners set their prices based in large part on the prices of other stations in the area, a study which records these gasoline prices was viewed with suspicion. Another drawback is that the years 1992-1999 were before the dramatic fluctuations in gasoline prices that have been so common in recent years.

[3] Strictly speaking, a change in gasoline prices causes two different effects, an income effect and a substitution effect. The income effect of higher gasoline prices will cause consumers to move down to lower quality gasoline in order to save money. The substitution effect associated with higher gasoline prices should encourage consumers to switch to higher quality gasoline to take advantage of its cheaper relative price. The Alchian-Allen Theorem focuses on the influence of the substitution effect.

[4] We did run empirical specifications using the price of premium (and plus) relative to the mean price of gasoline to explain the premium (and plus) gas market share. The results are consistent with those in Table III.