The Link Between Seller Density, Price Elasticity and Market Prices in Retail Gasoline Markets

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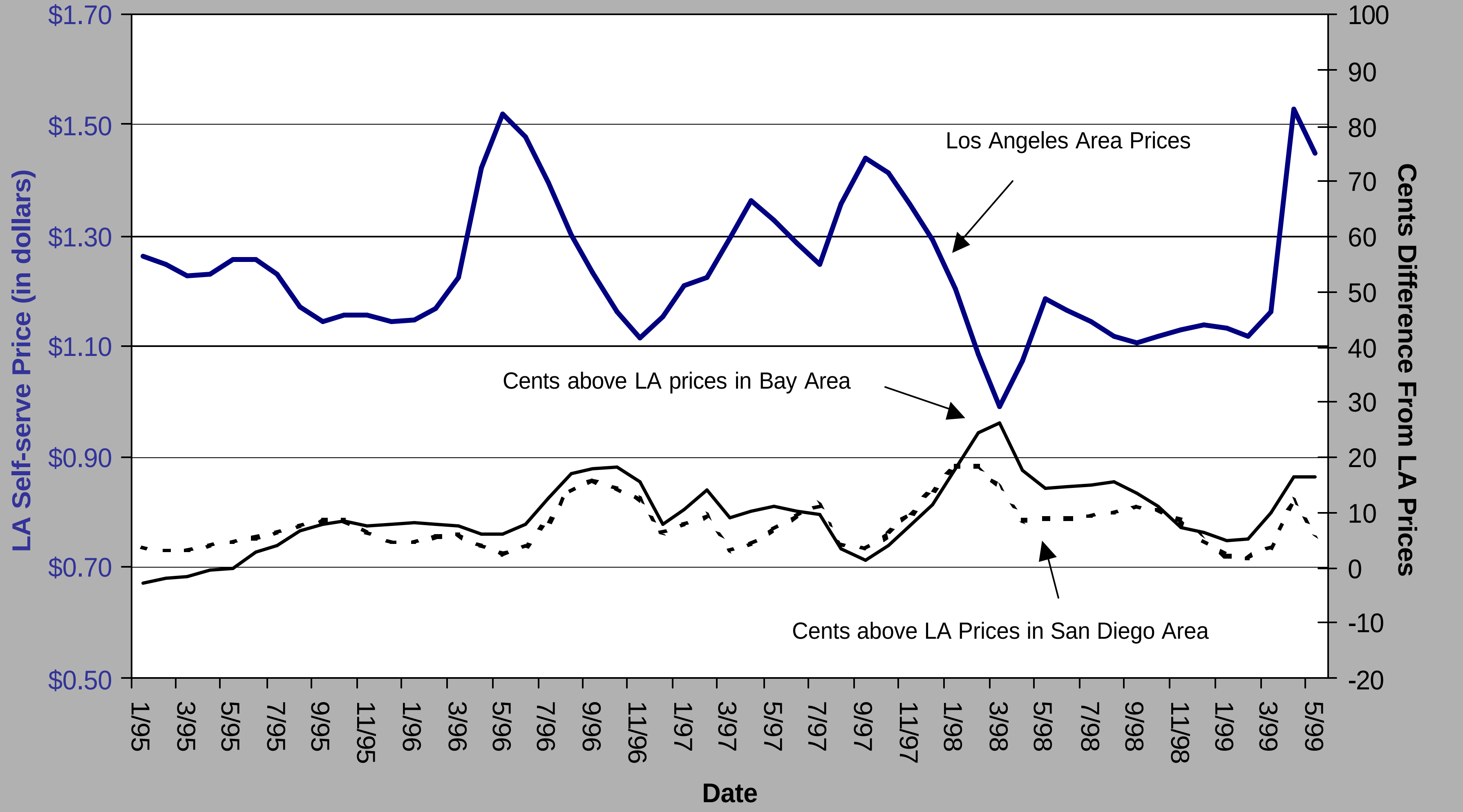
Observation:

- During the latter part of the 1990s one observes significantly lower gasoline prices in Los Angeles than in the San Diego and Bay areas.
  - During 1995 to 1999 prices in the Bay area were 7.1 percent higher than prices in the LA area and prices in the San Diego area were 5.8 percent higher than prices in the LA area (Source: Lundberg bi-monthly price surveys).

Figure 1
Los Angeles Self-Serve Regular Price and Difference Between Prices in the San Diego and Bay Areas and the Los Angeles Area



Outline…

1. The model
    - Asymmetries across markets
2. Experimental procedure
    - Estimating elasticity
3. Results
4. Predicted price differences
5. Concluding remarks

1. The Model

- L consumers, each with unit demand.
- $N \geq 2$ sellers (representative seller sales of L/N).
- Production costs, $C(q_i) = k + a\, q_i$, where $k > 0$, $a > 0$
- Sellers enter the market until expected profits equal zero.

Demand characteristics…

- Demand depends on
  - own price, p_i, and other station prices, p_{-i} ,
  - common consumption value of the good, r,
  - and visiting costs, v, drawn from $F(v)$.
- Each consumer knows the prices and "visiting costs" of all sellers at the time of their decision to purchase.
  - Consumer will purchase from seller i only if $\min_{k \neq i}[p_k + v_k] \geq p_i + v_i$ and $r \geq p_i + v_i$.

- Expected demand for seller i is

$$q_i = \sum_{j=1}^{L} q_i^j$$

where

$$q_i^j = \int \prod_{k \neq i} [1 - F(p_i + v - p_k)]\, dF(v).$$

- Each period, sellers choose a pricing strategy that maximizes profits taking as given the pricing strategies of other sellers.

- Seller *i*'s profit maximizing price satisfies the standard first order condition:

$$p_i = m_i \; a$$

where,

$$m_i = \frac{e_i}{e_i - 1} > 1 \qquad\qquad e_i = -\frac{\partial q_i}{\partial p_i}\frac{p_i}{q_i}\,.$$

- Given identical marginal costs and demands for each seller, the market equilibrium has all firms charging the same price (Perloff and Salop, 1985).

$$p \; = m \;\; a$$

  - The zero-return condition then determines the number of sellers, with the resulting equilibrium characterized by a price set by all sellers that is equal to the common marginal cost plus average fixed cost *k*/(*L*/*N*).

Asymmetries across markets

1. Heterogeneity across markets in marginal production costs.
2. Heterogeneity across markets in sellers' price elasticities of demand.
   - either from differences in the number of sellers in a market or differences in the distribution of consumers' visiting costs across markets, $F(v)$.

Heterogeneous marginal costs

- Consider two monopolistically competitive markets where the markets differ in the (common) marginal cost of sellers in each market.

- The resulting equilibrium price will be higher in the market with the higher marginal cost.
    - If marginal costs are lower for retail gasoline markets in the Los Angeles area relative to the San Diego and Bay areas, prices will also be lower.

- Note that, given $m > 1$, a 2-cent difference in marginal cost can lead to a price difference of more than 2 cents.

- The size of the price differences in the late 1990s between Los Angeles and San Diego often exceeded three times this potential 2-cent marginal cost difference.
    - This would imply an elasticity of demand of less than 1.5.

Heterogeneous demand

- Consider two monopolistically competitive markets in which there is a difference in the number of sellers in the market.

- An increase in the number of sellers that accompanies an increase in market size will tend to increase the price elasticity of demand and lead to a lower equilibrium price (P&S, 1985).
    - Higher price elasticity of demand arises as an increase in the number of sellers introduces more "close substitutes."

- What if consumers consider a fixed subset of sellers $C < N$?
    - An increase in the number of sellers within a specific geographic region will tend to lower the average and maximum costs to consumers of visiting their fixed set of sellers, C.

- We interpret this change as a reduction in consumers' preference intensities for particular sellers.
    - Such a reduction in preference intensity is also shown to lead to a higher price elasticity of demand and lower prices (P&S, 1985).

Hypothesis:

- An increase in the density of alternative sellers will increase a seller's price elasticity of demand.
  - By extension, where station density is higher average prices should be lower as individual sellers face consumers who are more responsive to a given change in price.

2. Experimental Procedure

- How to obtaining estimates of the price elasticity of demand?
  - We must observe the effect of changes in prices on sales holding constant those other factors that can influence the level of demand.
  - Often a price change occurs precisely because of a change in one of these factors.

- ARCO allowed our control and survey of prices at 54 stations of our choice over a three-month period from February 8, 1999 to April 27, 1999.
    - 9 stations from the Bay area, 25 stations from the Los Angeles area, and 20 stations from the San Diego area

- Stations were divided into two groups. Each week, prices at stations in one of the two groups were increased or decreased by 2 cents from the price that existed on the prior day.
  - Only we knew the exact identity of the stations in terms of the direction of its price change until the price change was implemented.

- This new price was maintained for one week after which control of the price at the station would revert to ARCO for one week during which time standard company procedures would determine prices.

- Three data sources were used to measure station density.
    - From Lundberg, Inc., we obtained a census of stations in San Diego and the Los Angeles areas taken in 1996. Lundberg also provided 1997 census data for the Bay and San Diego areas.
    - From Whitney-Leigh, we obtained an annual census of stations for the San Diego, Los Angeles, and Bay areas for the years 1995 to 1998.
    - From MPSI, we obtained a census of specific areas in the Los Angeles and San Diego areas taken in 1999.

Table 3
Distribution of Station Density By Location

Location	Average number of stations within a 1.5 mile radius	Average number of stations within a 2 mile radius	Proportion of stations having fewer than 10 other stations within 1.5 mile radius	Proportion of stations having 10 to 15 other stations within 1.5 mile radius	Proportion of stations having over 15 other stations within 1.5 mile radius	Total number of stations
Bay Area	11.47	18.17	.385	.361	.254	1,651
San Diego Area	11.23	17.45	.477	.296	.227	761
Los Angeles Area	13.85	22.21	.300	.273	.427	4,633
All Three Areas	13.01	20.75	.339	.296	.365	7,045

Source: Lundberg, MPSI, and Whitney-Leigh censuses.

- To estimate the price elasticity of demand for a given grade of gasoline, we specify a log-linear form for the demand equation of a particular station of type *k* such that

$$\ln(S_{it}) = d - b_k \ln(P_{it}) + g_k \ln(\bar{P}_{it}) + l \ln(X_{it}) + u_{it} ,$$

  - $k = l$ for those with a *low density* of alternative sellers (less than 10 other stations within a 1.5 mile radius)
  - $k = m$ for those with a *mid-level density* of alternative sellers (between 10 to 15 other stations)
  - $k = h$ for those with a *high density* of alternative sellers (more than 15 other stations)

Table 4

Expected Signs for Controls for Within-Station Substitution.

	Log of sales volume (self-serve gasoline) at control station		
Independent variable	Regular-Grade	Mid-Grade	Premium-Grade
Log of Regular to Mid-grade price ratio	-	+	
Log of Mid to Premium-grade price ratio		-	+

3. Results

Table 5

Estimating a Random-Effects Model for Gasoline Sales at Stations with Different Densities of Alternative Stations (n = 3,990, 54 unique groups, z-statistics in parentheses).

	Log of sales volume (self-serve gasoline) at control station					
Independent variable	Regular-Grade		Mid-Grade		Premium-Grade	
Log of self-serve price						
Low density of alternatives	-2.142 (8.38)	-2.012 (7.80)	-2.471 (8.04)	-2.223 (7.17)	-3.417 (11.43)	-3.440 (11.32)
Mid-level density of alternatives	-3.586 (18.71)	-3.495 (18.09)	-2.529 (10.42)	-2.257 (9.14)	-3.679 (14.04)	-3.688 (14.03)
High density of alternatives	-5.045 (25.66)	-4.941 (24.88)	-3.824 (15.73)	-3.628 (14.84)	-4.331 (16.70)	-4.345 (16.66)
Control for prices at alternative stations	Yes	Yes	Yes	Yes	Yes	Yes
Control for other prices at control station	No	Yes	No	Yes	No	Yes
Control for day of week	Yes	Yes	Yes	Yes	Yes	Yes

Table 5 (continued…)

Independent variable	Log of sales volume (self-serve gasoline) at control station					
	Regular-Grade		Mid-Grade		Premium-Grade	
Log of average self-serve price at alternative stations within 1.5 miles						
Low density of alternatives	2.407 (8.92)	2.282 (8.40)	1.614 (4.71)	1.428 (4.13)	1.793 (5.33)	1.830 (5.27)
Mid-level density of alternatives	3.777 (18.42)	3.707 (18.03)	1.775 (6.43)	1.550 (5.51)	2.148 (7.17)	2.172 (7.13)
High density of alternatives	5.166 (24.06)	5.088 (23.59)	3.101 (11.22)	2.954 (10.60)	2.765 (9.30)	2.795 (9.21)
Log of Regular-Mid price ratio		-0.698 (3.50)		0.993 (3.94)		
Log of Mid-Premium price ratio				-2.012 (4.66)		-0.214 (0.46)

4. Predicted price differences

Table 7

Differences in Price Elasticity, Predicted Prices, and Actual Prices Across Areas for Regular-Grade Gasoline

Area	Predicted average price elasticity of demand	Predicted price/marginal cost ratio (m)	Predicted percentage difference from LA area price	Actual percentage difference from LA area price (Lundberg 1995-99)
Bay Area	3.29	1.44	4.5% higher	7.7% higher
San Diego Area	3.12	1.47	7.1% higher	6.3% higher
Los Angeles Area	3.67	1.37	---	---

5. Concluding remarks

- Higher prices in San Diego and the Bay areas relative to the Los Angeles area may reflect, in part, lower price elasticities of demand arising from lower station density.
    - Elasticity considerations alone lead to predicted price differences in regular-grade gasoline between stations in the Los Angeles area and stations in the Bay or San Diego areas of magnitudes similar to those observed over the years 1995 through 1999.

- Other things equal, such price differences should translate into a lower relative return to stations in the Los Angeles area.
    - Is their evidence of a decrease in the number of stations in the Los Angeles area relative to the Bay and San Diego areas?
        - Yes.
    - Is there evidence consistent with entry restrictions in the San Diego or Bay areas?
        - Yes. Existing stations in San Diego and Bay areas are utilized more intensively than stations in the LA area.

Table 7

Differences in Price Elasticity, Predicted Prices, and Actual Prices Across Areas for Mid-Grade Gasoline

Area	Predicted average price elasticity of demand	Predicted price/marginal cost ratio (m)	Predicted percentage difference from LA area price	Actual percentage difference from LA area price (1995-99)
Bay Area	2.59	1.63	5.3% higher	6.6% higher
San Diego Area	2.55	1.64	6.4% higher	6.2% higher
Los Angeles Area	2.83	1.55	---	---

Table 7

Differences in Price Elasticity, Predicted Prices, and Actual Prices Across Areas for Premium-Grade Gasoline

Area	Predicted average price elasticity of demand	Predicted price/marginal cost ratio (m)	Predicted percentage difference from LA area price	Actual percentage difference from LA area price (1995-99)
Bay Area	3.76	1.36	1.3% higher	6.7% higher
San Diego Area	3.72	1.47	1.7% higher	6.0% higher
Los Angeles Area	3.89	1.35	---	---