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by

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Abstract

The effect of spatial factors on competition and the price of gasoline have been sparsely explored by previous studies. Existing work examines how gasoline prices differ based on distance from the distribution site as well as how cost factors influence gasoline prices. Using market data from six midsized U.S. metro areas with similar isolation from neighboring retail markets, this paper examines the effects of location on retail price, while controlling for brand effects. Spatial regression analysis accommodates the potential of spatially correlated errors, and sensitivity analysis tests for several measures of retail location concentration. Results point to reproducible brand premiums and some location-based price differences, but also show the counterintuitive finding that areas with more market competition do not show significantly lower retail gas prices.

I. Introduction

Gasoline prices command the attention of consumers, competitors, and legislators on a daily basis. The constant fluctuation seems to motivate consumers to drive across town to save a few cents per gallon. While prices may differ even between stations located at the same intersection, the question remains whether competition actually affects the retail price of gasoline? Does the spatial distribution and concentration of stations significantly impact gas prices? The effect of spatial factors, more specifically competition among retail stations, upon the price of gasoline has been sparsely explored by previous studies. Several previous studies (Pinske, Slade, and Brett, 2002; Greenhut and Greenhut, 1975; Spiegel, 1982) examine how gasoline prices differ across varying distances from the distribution site. However, most studies focus on the wholesale prices or the work of jobbers and distributers, rather than the competition among gas stations and the effect this has on posted prices. Additional studies have focused on general factors affecting gasoline prices (Livingston and Levitt, 1959; The Federal Trade Commission Report, 2005). This study goes beyond these studies in its aim to evaluate the impact of competition on retail gasoline prices. We also analyze the effect of different brands of gasoline in order to determine the significance of competitive factors potentially affecting price.

To establish the impact of competition, we examine the factors which influence the retail price of gasoline in seven midsized-US-metro areas: Bakersfield, CA; Colorado Springs, CO; Pittsburgh, PA; Raleigh, NC; Toledo, OH; Tulsa, OK; and Wichita, KS. We collected data in the summers of 2009 and 2010 on retail prices, fuel grade, retailer brand and geographic concentration. We utilize various measures of spatial concentration, ranging from a simple count of the number of stations within a tenth of mile radius to the number of stations within one mile of each gas station, as well as a nonlinear Hirschman-Herfindahl type measure.

Section II of this paper reviews the relevant literature on the gasoline market, as well as different methods of measuring spatial competition in the gas market and other consumer markets. Section III describes our data set, designed for compatibility with the literature. Section IV explains the calculations and analysis performed on the gasoline data. Section V presents the results of the regression analyses. Section VI concludes with implications for policy and future research.

II. Literature

Given the importance of gasoline in today's economy, there is an abundance of literature devoted to the study of crude oil and gasoline markets. The focuses of these papers have a large range, however, and the majority tends to ignore or briefly mention competition in favor of distribution factors, retail outlet characteristics, or wholesale market prices. Livingston and Levitt found a distinct difference in gasoline prices depending on the type of retail outlet; larger national outlets associated with specific refineries versus smaller independent local businesses that purchased their gas at the lowest price possible. The smaller outlets competed with one another on price, while the larger ones compete on brand name, and therefore had higher prices than the smaller outlets. Deltas (2007) determined that gasoline stations adjust their prices quicker in response to a wholesale price increase than to an equivalent wholesale price decrease. The gas stations do not pass the entire amount of the increase or the decrease to customers, but they do pass a larger percentage of price increases to consumers than price decreases. The extent is dependent upon the retail margin at the individual gas station. The presence of market power in the retail gasoline market was confirmed by Deltas.

Marvel (1976) found that the more information that consumers choose to acquire, the more responsive they are to changes in price. He also found that there is a distinct difference between the high priced gasoline market and the low priced market due to the different factors affecting each market. A higher priced gas station typically has a contractual arrangement with a specific refiner, whose prices tend to be determined on a national scale, not on the local market as with lower priced gas. While branded gasoline is more expensive, price fluctuation is smaller in the high priced market because of these long-term contracts and guaranteed supply. Thus, consumers are less likely to be driven away by huge price increases, or turned away due to a shortage caused by prices that are too low. These high priced market findings were confirmed by Deck and Wilson (2008). Shortages and sporadic price increases tend to occur frequently in the lower priced market, and are due to a lower priced gas station's ability to shop around for the lowest price supplier. Lower priced gas stations do not generally have a long term contract with a refiner and therefore purchase their gas through jobbers, who compete in the spot market. Price warfare is also common in the lower priced market, but does not occur between higher priced stations. The prices at lower priced stations fluctuate due to the amount of information consumers choose to obtain about competing stations. Consumers of higher priced gasoline, on the other hand, tend to shop around for lower prices much less, and therefore the amount of information obtained by consumers significantly separates the high and low priced markets.

The Federal Trade Commission (2005) presented a paper highlighting the dynamic factors found to be most significantly impacting gas prices, as collected from various research sources. This study stresses that the world price of crude oil is the most important factor affecting U.S. gasoline prices. Specifically, changes in crude oil prices are responsible for 85% of the changes seen in the US gasoline market. The report highlights that California's relative oil isolation plays into the higher prices generally experienced in this state, but also stresses that disruptions to oil supply pipelines across the US have the ability to cause significant price spikes. State and local factors impacting gas prices are briefly mentioned, and the assertion that increased competition leads to lower gas prices is stated, but the focus of the report is increasingly on crude oil and what factors impact crude oil prices.

Because a number of gasoline studies focus on the refiners or the retailers above the gasoline stations, they focus on competition under conditions of monopoly, instead of monopolistic competition, which is a better model for retail gasoline stations. For example, Greenhut and Greenhut (1975) make four assumptions typically associated with spatial price discrimination, one of which is a simple monopoly market. This assumption clearly does not hold for the retail gasoline market. Their assumptions that buyers are distributed evenly across space and have identical and spaceless demands are similarly inappropriate in the context of retail gasoline. Certain individuals, commuters for example, have a much higher gasoline demand than individuals who have no commute, and a rural gas station has much less population density than a station located in a metropolitan area, and this significantly impacts their sales.

In another gasoline study, Hastings (2000) determined that local market gas prices are impacted by changes in the number of independent gas stations in the market area. By examining local price changes once an independent (Thrifty) station became a vertically integrated (ARCO) station in the San Diego and Los Angeles metropolitan areas of California, Hastings was able to determine that the presence of independent, unbranded, gas stations drove prices down. Specifically, she found that the presence of an independent station led to prices five cents below market price at other gas stations located within a mile of the independent station (gas stations a mile or less apart are assumed to be in direct competition with one another). The loss of an independent station, and its replacement by a branded station, led to prices five cents above market price for all gas stations within one mile of one another. Interestingly, Hastings also determined that there was little difference in prices that could be attributed to the demographics of the area or specific characteristics of the stations itself. Within cities, she found small regions where gas stations were competing on price. This finding was common among gasoline studies; gas price competition is commonly characterized by small, local markets.

Hasting's work on the effects of vertical integration on gas prices represents one of a number of studies that discuss the different franchise arrangements within the retail gasoline industry. Hastings presented the two main categories, independent gas stations with no brand affiliation that purchase unbranded gasoline from the cheapest distributer and branded outlets that sell a specific brand of gasoline and are directly affiliated with the refining company. Comonor and Riddle (2003) further define the different franchise distinctions by separating branded stations into two categories, direct-supply outlets, where the refiner sells and ships the branded gasoline directly to the gas stations, or circumstances that involve a middle-man, the distributer or jobber, who delivers the gasoline from the refiner to the gas station. Within direct-supply outlets, there are three types of stations. The first are operated by the refiner, who dictates hours and prices, and hire employees. The second is lessee-owned, where the refinery owns the physical gas station, but leases it to an owner who operates the gas station and sets prices and hours. The third option is known as "contract dealers," where the operator owns the gas station, but is under contract to sell a specific refiner's brand of gasoline. The three different options, refiner-operated, lessee-owned, and contract dealers occur with jobbers or distributers, but there are two levels of sales, between the refiner and the distributor and then between the distributer and the gas station. These different franchise arrangements mean that there are different prices being charged for gasoline. For example, the prices paid by the jobbers for branded gasoline (which contains brand-specific additives) are different than the prices that the unbranded stations pay for additive-free gasoline.

Barron and Umbeck (1984) delve further into the different franchise arrangements, focusing on refiner-operated gas stations and lessee-owned stations. They investigate the effects of a forced transition from refiner-operated to lessee-owned, as enacted by the Maryland "divorcement law" of 1974. The results of their research indicate that if the business incentives differ for the refiner and the employee, who became the lessee owner after the passage of divorcement legislation, then the contract change led to a loss of consumer welfare. Once the terms of the contract changed, average gasoline prices rose 6.7 cents per gallon for full-service gasoline, and 1.4 cents per gallon for self-service gasoline. Another interesting finding was that once hours were set by the lessee and not the refiner, hours of operation for gas stations affected by the legislation fell by 9.7 hours. As expected, the increase in price and decrease in hours by affected stations impacted their competitors as well. Before legislation, refiner-operated gas stations posted lower prices and longer hours, on average, compared to their competitors. Because this trend was reversed, competitors now had an advantage, and they responded by raising their prices and lowering their hours, but not as drastically. Consequently, Barron and Umbeck found that the Maryland gasoline market after legislative action was characterized by higher prices and shorter hours, clearly a loss for consumers.

Accompanying their characterization of different franchise arrangements, Comonor and Riddle examine the effects of forced price uniformity among distribution sites of the same refiner. They find that the imposition of open supply, where the refiners can purchase the refiner's gasoline for the same price across their distribution network, has a negative effect on the competition among refineries and distributers by increasing the size of gasoline markets. The transition from small, local markets to larger markets inhibits the competitive pricing policies of refiners and distributers alike. The consequence of this is higher delivered prices, which are immediately transferred to consumers in higher retail prices.

Meyer and Fischer (2004) investigated another area of proposed regulations, the practice of price zones and territorial restrictions by larger refiners. Price zones are an area specified by a refiner where all the lessee dealers in the zone pay the same dealer-tank-wagon price (the price paid by lessees to refiners for gasoline before retail markup and transportation costs are added). Price zones are therefore one specific instance of uniform pricing. Stations within these zones tend to have similar competitive factors. However, because the distance between refiner and gas station vary, the employment of price zones is often considered to be a form of price discrimination. Territorial restrictions are said to help maintain price zones, and represent restrictions set upon jobbers regarding the stations to which they are allowed to sell gasoline. Meyer and Fischer find evidence that the elimination of price zones would lead to higher average prices in many areas, and that both price zones and territorial restrictions have significant business explanations, and can actually promote efficiency and competition within the gasoline market. They conclude that price zones and territorial restrictions need to be evaluated on an individual basis, for they have proven to be neither procompetitive nor anticompetitive in all situations.

Deck and Wilson's 2008 study on price zones found definitive evidence that zone pricing does not harm consumers, therefore countering the claim that forcing refiners to adapt uniform pricing benefits consumers. They found higher prices in all retail markets, and a significant loss of consumer welfare for the majority of consumers. Interestingly, even though zone pricing is often contested because it is in the interest of refiners and increases their profits, Deck and Wilson found that the eliminating zone pricing had no effect on refiner profits, and concurrently raised station profits. Uniform pricing therefore benefits individual gas stations owners or lessees but does not diminish refiner profits, a goal often cited in legislative restrictions of zone pricing. Another finding was that vertical integration lowers prices, supposedly because the double mark-up of gasoline that occurs with lessee dealers is eliminated.

While uniform gas pricing commonly occurs in price zones, this topic is also addressed by Spiegel (1982). Defining uniform pricing as when the same price is charged for a unit of gas regardless of distance between refiner and the distribution site, or other transportation costs, Spiegel concludes that uniform pricing, given its discriminatory nature, is not preferable for individual distributers since it does not take into account differing costs depending on the location of the gas station to which gas is being sold. Overall, the evidence points to the presence of uniform pricing in the US. Greenhut, Greenhut, and Li (1980) found that a majority of firms price discriminatory, not taking into account differences in transport distance. They also find that increased competition among refiners lowers distributor prices.

In a study more related to effects of competition in retail gasoline markets, Barron, Taylor, and Umbeck (2004) analyzed gas prices and the amount of price dispersion in four cities, Phoenix, Tucson, San Diego, and San Francisco in order to determine the effect of competition density. They looked at the two prevailing theories associated with the presence of price dispersion, monopolistic competition and search-theoretical, in order to determine which one more closely represented gasoline market circumstances. Using gasoline price data from 3000 stations across the four cities for a one-day period, they found that price dispersion and regular self-serve gasoline prices decrease with an increase in station density. These findings are more consistent with the monopolistic competition model. This is surprising since the search-theoretical model seems to more accurately reflect the circumstances of search costs and consumer preferences of the gasoline market and is more commonly cited in gasoline literature.

In another similar study by two of the same authors, Barron, Umbeck, and Waddell (2008) studied three California cities in an effort to discover the effects of competition in the retail gasoline market. They had two sets, for a total of 54 gas stations, in San Diego, Los Angeles, and San Francisco that were owned by the same refiner. Through an agreement with this refiner, the prices were increased or decreased by 2 cents from their current prices at one set of stations each week, and kept at that price for one week. At the end of the week, pricing returned to the control of the refiner. They found that that an increase in price by 2 cents led to a decrease in sales volume that was different depending on the level of competition in the area. If there were less than 18 gas stations within a 2 mile radius of the treatment station (low density of competition), the gas station saw a 2.4% reduction in sales volume. For stations with at least 27 stations within a 2 mile radius (high density), the treatment gas stations experienced an 8.4% decrease in volume of gasoline sold. This study thus provides initial support for the argument that competition between gas stations tends to lower prices because consumers have a greater number of alternatives to choose from. This finding is confirmed by Deck and Wilson's finding. Pinske, Slade, and Brett (2002) found that a larger number of competitors cause the price of gasoline to fall; however competition was only one of a number of factors that affected prices in their study. Moreover, their investigation was of wholesale prices, not retail prices, and therefore did not take into account retail markup.

Beyond the gasoline industry, Davis (2005) investigated the impact of spatial competition on movie theaters. He found that an increase in population within five miles of a theater led to a significant increase in revenue, but the increased revenue lessened as the population increase moved farther away from the theater. Increases in ticket prices only affect other theaters that are less than ten miles away; however the revenue that can be captured by rivals due to an increase is small. This finding is interesting since it implies that it is not particularly advantageous to rivals when their competitor increases prices since the benefits accrued are minimal. One finding that is clearly related to the gasoline market is Davis's finding that transport cost follows a quadratic model, but that the marginal costs of transport are decreasing. His model found that the marginal cost of traveling one mile is 31 cents, and decreases eight cents with every additional mile driven until it is effectively zero after almost four miles. Given that gas prices tend to be within a couple cents, the cost of filling up a 15 gallon tank from a cheaper gas station could be nullified by search costs. Therefore, Davis's finding indicates that search costs are not necessarily prohibitive, but are present and could exceed gains from finding lower gas prices farther away. Instead of defining competition within a certain linear distance, as is typically done in gasoline studies, (1 mile being the distance generally preferred, see Hastings) Davis re-introduces a measurement using Euclidian distance, characterizing competition as being within a certain radius of the theater. The use of Euclidian distances was also used by Pinske, Slade, and Brett, alongside three other measures of competitive distance. Our approach will look not only at the distance to the nearest competitor, but will take into account how close all of the surrounding gas stations are, allowing for a more complete determination of the density of gas stations reminiscent of the methods employed by Barron et al., (2008).

III. Data

This study focuses on retail gasoline prices for mid-sized U.S. cities which constitute their own market, so were chosen for their similar population sizes (250,000 to 450,000) and non-proximity to another urban center. Of the 29 cities in the United States with a population between 250,000 to 450,000 residents[1], ten cities were rejected for analysis because they represent twins of other large cities (e.g. St. Paul, MN; Tampa, FL) or suburbs of even larger cities (e.g. Aurora, CO; Arlington, TX), such that they do not constitute distinct markets. Of the 13 cities isolated enough to present a distinct market, six were removed from consideration as they are distinguished as the only sizable city within the entire state or region. Therefore, there are six cities considered in the analysis here: Bakersfield, CA; Colorado Springs, CO; Pittsburgh, PA; Raleigh, NC; Tulsa, OK; and Wichita, KS. Each is treated separately to see if the same model applies.

For each of the six of the cities selected, retail gas prices were collected between June 19, 2009 and July 2, 2009 for regular, premium, and diesel gasoline. During this period, the U.S. national average retail price for regular grade gasoline was $2.65/gallon (EIA, 2009). Prices were collected from two user-maintained online resources, gasbuddy.com and gaspricewatch.com, for all observations within those metropolitan centers over the observation period. The resulting data represent at least one observation per station, but frequently multiple observations across multiple days. For each station, data were recorded for retail prices of each available fuel grade, the station address and the gasoline brand.

We recognize that the data that is provided for these six cities by these websites does not necessarily include all stations within a city, or even a given intersection. Further, as user-maintained websites, postings may not represent a random sample of prices within a given area, as users may be prone to report exceptionally high or low prices to inform other system users. Moreover, the data may suffer from reporting bias if users are inaccurate in their postings to the service.

[1] The complete list of 29 isolated mid-sized US cities includes: Anaheim, CA; Anchorage, AK; Arlington, TX; Aurora, CO; Bakersfield, CA; Cincinnati, OH; Cleveland, OH; Colorado Springs, CO; Corpus Christi, TX; Henderson, NV; Honolulu, HI; Lexington, KY; Lincoln, NE; Long Beach, CA; Mesa, AZ; New Orleans, LA; Oakland, CA; Omaha, NE; Pittsburgh, PA; Raleigh, NC; Riverside, CA; Sacramento, CA; St. Louis, MO; St. Paul, MN; Tampa, FL; Toledo, OH; Tulsa, OK; Virginia Beach, VA; and Wichita, KS.

In order to consider the importance of these biases, we collected supplementary data from the universe of all gas stations in the city of Colorado Springs, CO during a control period outside of the observation period, almost precisely one year later on July 17-July 18, 2010, when the U.S. national average retail price for regular grade gasoline was an almost identical $2.69/gallon (EIA, 2010). This dataset was compiled from two sources: OPIS (a national source of gas prices that uses credit card purchases to track gas prices for U.S. cities), and direct telephone calls to every remaining gas station to inquire about current prices. We complemented these control observations with the corresponding Colorado Springs gas price data from gasbuddy.com and gaspricewatch.com over the same 2010 period. In order to test whether our "online user-provided data" sample is drawn from the same distribution as the complete set of gas stations, we calculated the Kolmogorov-Smirnov D statistic for our Colorado Springs sample. The resulting value of 0.0691 indicates 99% certitude that our 2009 sample is drawn from the same distribution as the population of stations not represented in our sample.

In order to determine proximity, we geo-coded the address of each gas station to a precise latitude and longitude. With this information, we computed the pair-wise distances (in feet) between every station within each city. The resulting sample represents 5009 observations across 786 separate gas stations (an average of 6.4 price observations per station). As it is unclear what specific distance might be relevant to consumer purchase or producer location decisions, we calculated several alternative measures of spatial concentration in order to run sensitivity tests on different definitions. Following Davis (2006), we calculated the following measures for each station, and therefore for each gas price observation: distance to nearest competitor, and number of stations within different radii (tenth-mile, quarter-mile, half-mile, three-quarter-mile, mile). Further, we calculated the mean distance between a station to all other stations in the city, and a nonlinear measure of geographic concentration as $\Sigma[1/(\text{distance} + 1)]^2 - 1$ from each station to all other stations within a particular city. This measure places greater weight on the closest geographic competitor stations.[2]

Table 1 summarizes the 2009 sample data, using price observations as the unit of analysis. Notice that, confirming popular opinion, there is considerable variation in price not only between cities but within cities. For example, the range between cheapest and most expensive regular grade gasoline is always more than ten percent and ranges as high as nineteen percent.

Further, while each city contributes at least one hundred separate stations in our sample, the cities vary markedly in terms of brand diversity, ranging from Wichita (where fifty-eight percent of all stations are split equally between QuikTrip and Phillips 66), to Raleigh (where the largest single brand is BP, at fourteen percent of all stations). Naturally, there is no evidence that these frequencies correspond perfectly to market share, as we do not have access to market-specific, brand-based sales data for the industry. Nevertheless, it is sufficient reason to include brand share as a potential explanatory variable in our analysis.

[2] The constant (one) was added to the distance measure in order to prevent division by zero in making the calculation. To then prevent a value of one from appearing on the distance matrix diagonal, one was subtracted from the sum.

Table 1: Summary Statistics

		Bakersfield	Colorado Springs	Pittsburgh	Raleigh	Tulsa	Wichita
Number of price observations		845	1007	682	814	719	942
Price for regular grade	mean	4.46	3.92	4.04	3.99	3.87	3.82
	min	4.19	3.79	3.89	3.79	3.69	3.63
	max	4.99	4.29	4.39	4.24	4.07	4.04
Price for premium grade	mean	4.61	4.11	4.30	4.21	4.06	4.02
	min	4.38	3.99	4.13	4.01	3.89	3.83
	max	5.69	4.39	4.49	4.45	4.45	4.34
Price for diesel grade	mean	5.05	4.68	4.92	4.74	4.53	4.71
	min	4.85	4.51	4.79	4.60	3.67	3.99
	max	5.19	4.99	5.59	4.88	4.79	4.89
Number of stations		106	134	141	160	129	116
Share of largest brand		0.17	0.17	0.21	0.14	0.18	0.29
Share of stations located in a highway location		0.46	0.29	0.26	0.25	0.26	0.29
Distance (in miles) to closest station	mean	0.48	0.49	0.40	0.42	0.54	0.55
	min	0.01	0.01	0.02	0.01	0.01	0.01
	max	3.88	4.04	1.48	2.03	2.59	3.00
Number of other stations within:							
0.1 miles	mean	1.26	1.08	0.69	1.08	0.41	0.46
	min	0	0	0	0	0	0
	max	4	4	5	6	3	3
0.25 miles	mean	2.50	3.14	1.78	2.76	0.87	1.56
	min	0	0	0	0	0	0
	max	8	11	8	13	5	6
0.5 miles	mean	7.95	10.60	4.37	7.24	4.29	7.02
	min	0	0	0	0	0	0
	max	21	24	15	20	15	17
0.75 miles	mean	14.80	20.42	7.53	13.58	8.96	14.81
	min	0	0	0	0	0	0
	max	31	47	23	32	28	30
1 mile	mean	24.36	32.63	11.04	21.79	14.77	24.06
	min	0	0	0	0	0	0
	max	46	75	30	51	40	44

Suspecting that a highway-side location might differentiate between types of consumers, or offer a marketing advantage to certain stations, we used GIS maps to identify stations which were obviously located in this manner. Aside from Bakersfield which confirms public stereotypes about California by having nearly half of all gas stations located next to a freeway, all other cities show a little over a quarter of all stations located near a highway.

In terms of spatial concentration, there is also some difference between the sample cities. Across all cities, the average distance from any given gas station to the nearest competitor is 0.40 and 0.55 miles. In all cities, there are ample examples of adjacent competitors. However, the Pittsburgh sample includes no examples of truly isolated stations (the maximum distance from any station to a competitor is 1.48 miles) while the Bakersfield and Colorado Springs samples include more isolated examples (where the distance to a nearest competitor is close to four miles). Drawing concentric rings around each station, we counted the number of competitors within given arbitrary radii, also presented in Table 1.

IV. Model and estimation

We propose a simple reduced-form analysis of prices, in line with the literature (Hastings, 2004) as follows:

$$price = \alpha_0 + \sum_{i=1}^{2} \alpha_i grade_i + \sum_{i=1}^{10} \beta_i brand_i + \delta_1 highway + \delta_2 distance + u \tag{1}$$

where price is the observed price;
grade is an indicator for regular or premium (with diesel as the excluded category);
brand is an indicator for each distinct brand of station that occurred in more than three locations within a given market (with the remaining brands alongside independent stations serving as the excluded category);
highway is an indicator of a highway-side location; and
distance is a measure of proximity to competing gas stations (for which we use eight alternative measures).

We also consider an alternative model with brand shares, to permit the possibility that it is the relative presence of a brand in the market that predisposes particular pricing strategies, rather than a brand-specific effect. As noted above, we approximate brand share as the share of all observed stations in the sample that display a particular brand, as we cannot obtain data on sales shares. The alternative model is therefore:

$$price = \alpha_0 + \sum_{i=1}^{2} \alpha_i grade_i + \beta_1 brandshare + \delta_1 highway + \delta_2 distance + u \tag{2}$$

where brandshare is the share of all gas stations in this market sharing the same brand as the observation;

We stop short of endogenizing location, leaving it for other scholars to model the location decision location by firms. Instead, we simply estimate equations (1) and (2) separately for each city, using a spatially-weighted regression to account for the presence of spatially-correlated errors. Spatial weights were created using a matrix of the pair-wise distances (in feet between property lines) between the station charging each observed price and every other price offered. Traditional unweighted regressions result show similar results, and tests are ambivalent about whether spatially correlated errors exist, varying by city. We elect to accommodate them.

Table 2 presents our primary results, using the number of competing stations within a quarter-mile radius as the measure of spatial concentration, controlling for brand-specific effects, highway-adjacent locations, and grade of fuel. All other radii or concentration measures considered show very similar results. The alternative model, including brand shares rather than brand-specific effects, is presented in Table 3 for comparison.

Notice first that the baseline price, represented by the estimated constant of each model, is fairly similar in each city (varying by less than ten percent from cheapest city to most expensive). Second, there was much more variation in the price discount from diesel grade fuel (the omitted grade for the purposes of estimation) to regular grade, a discount ranging from 57 cents per gallon in Bakersfield to 89 cents per gallon in Wichita. Premium-grade fuel prices fell between regular and diesel prices in all cases, with an average discount from diesel of 39 to 68 cents per gallon.

Brand effects are strong, when compared to the omitted category (which contains all other stations, including smaller brands in a particular market and independent stations). Some brands are consistently more expensive--- BP averages 3 to 5 cents a gallon higher than its peers depending upon the market, Citgo 7 to 9 cents, Conoco 0 to 15 cents, Exxon 6 to 7 cents, Mobil 4 to 9 cents, Phillips 0 to 2 cents, Shell 0 to 13 cents. The fact that there are no brands consistently cheaper than their peers in all sample cities is either a function of the value of branding in this sector, or could be explained by the fact that notable discount retailers (such as Costco and Sam's Club) infrequently had enough locations in a given market to permit an indicator variable. However, they generally averaged 1 to 10 cents below the market average.

There were also of course regional brands that showed dramatic results in particular locations, but which cannot be extrapolated across locations (e.g. Chevron at 18 cents above market in Bakersfield, Gulf at 9 cents above market in Pittsburgh). We also found it interesting that Safeway, a supermarket chain that advertises gas price savings to card members, averages prices almost exactly 3 cents per gallon higher than market prices, the precise amount of their savings to card members. King Soopers, a competing grocery chain in the same market with similar membership benefits, offers gas prices no different than market price to all customers, thus offering true savings to members.

Highway-side stations are demonstrably cheaper in three of our six sample markets (where again, Wichita is the statistically significant counter-example), averaging one or two cents per gallon cheaper than their neighborhood-based peers.

Table 2: Spatial regression results, considering competitors within a quarter-mile radius, using brand-specific effects

	Bakersfield		Colorado Springs		Pittsburgh		Raleigh		Tulsa		Wichita	
Constant	4.975	(510.09)***	4.658	(531.08)***	4.896	(388.71)***	4.731	(567.28)***	4.562	(224.39)***	4.678	(437.63)***
Regular grade	-0.567	(75.20)***	-0.778	(126.23)***	-0.882	(95.65)***	-0.736	(111.10)***	-0.657	(53.26)***	-0.889	(117.48)***
Premium grade	-0.389	(43.45)***	-0.567	(95.87)***	-0.627	(70.97)***	-0.517	(79.23)***	-0.455	(34.48)***	-0.684	(85.89)***
Brand												
7-11	---	---	0.015	(1.96)**	---	---	---	---	---	---	---	---
76	---	---	---	---	---	---	-0.026	(2.38)**	---	---	---	---
AAFES	---	---	0.010	(0.79)	---	---	---	---	---	---	---	---
ARCO	0.007	(0.82)	---	---	---	---	---	---	---	---	---	---
BJs	---	---	---	---	---	---	-0.081	(6.28)***	---	---	---	---
BP	---	---	---	---	0.034	(2.41)**	0.054	(5.58)***	---	---	---	---
Cenex	---	---	---	---	---	---	---	---	---	---	0.023	(1.89)*
Chevron	0.180	(17.48)***	---	---	---	---	---	---	---	---	---	---
Citgo	---	---	---	---	0.089	(6.31)***	0.066	(7.38)***	---	---	---	---
CoGos	---	---	---	---	0.015	(0.49)	---	---	---	---	---	---
Conoco	---	---	0.145	(15.90)***	---	---	---	---	0.003	(0.18)	0.047	(5.03)***
Crown	---	---	---	---	---	---	-0.020	(1.89)*	---	---	---	---
Diamond	---	---	0.039	(5.06)***	---	---	---	---	---	---	---	---
Dillons	---	---	---	---	---	---	---	---	---	---	0.002	(0.24)
Exxon	---	---	---	---	0.060	(4.48)***	0.071	(6.98)***	---	---	---	---
FasTrip	0.028	(2.11)**	---	---	---	---	---	---	---	---	---	---
GetGo	---	---	---	---	-0.017	(1.05)	---	---	---	---	---	---
Gulf	---	---	---	---	0.089	(2.26)**	---	---	---	---	---	---
Hess	---	---	---	---	---	---	-0.012	(1.17)	---	---	---	---
Kangaroo	---	---	---	---	---	---	0.023	(1.50)	---	---	---	---
King Soop	---	---	-0.002	(0.26)	---	---	---	---	---	---	---	---
KumNGo	---	---	---	---	---	---	---	---	-0.076	(4.21)***	-0.016	(0.67)
KwikStop	---	---	---	---	---	---	---	---	---	---	-0.005	(0.56)
Midway	---	---	---	---	---	---	---	---	---	---	-0.001	(0.08)
Mobil	0.091	(8.56)***	---	---	---	---	0.039	(3.39)***	---	---	---	---
Murphy	---	---	---	---	---	---	---	---	---	---	---	---
Loaf & Jug	---	---	0.027	(3.02)***	---	---	---	---	---	---	---	---
Phillips 66	---	---	---	---	---	---	---	---	-0.015	(1.22)	0.016	(2.10)**

Resco	---	---	---	---	---	---	0.058	(3.51)***	---	---	---	---
Quik Trip			---	---	---	---			-0.046	(3.18)***	---	---
Safeway	---	---	0.028	(2.99)***	---	---	---	---	---	---	---	---
Sams Club	---	---	---	---	-0.027	(0.61)	---	---	---	---	---	---
Sheetz	---	---	---	---	-0.038	(2,97)***	-0.010	(0.64)	---	---	---	---
Shell	0.130	(14.22)***	0.088	(9.93)***	0.038	(1.80)*	0.070	(7.12)***	-0.002	(0.09)	0.089	(3.29)***
Sinclair	---	---	---	---	---	---	---	---	-0.030	(1.71)	---	---
Sunoco	---	---	---	---	0.010	(0.74)	---	---	---	---	---	---
Texaco	0.094	(8.56)***	---	---	---	---	---	---	---	---	---	---
Valero	---	---	---	---	---	---	---	---	---	---	0.051	(5.41)***
Western	---	---	-0.041	(5.89)***	---	---	---	---	---	---	---	---
Highway	-0.015	(2.38)**	-0.013	(2.52)**	-0.006	(0.84)	0.004	(0.72)	-0.024	(2.81)***	0.012	(1.78)*
Competitors	-2.34×10^{-3}	(1.09)	-2.56×10^{-3}	(3.58)***	1.41×10^{-3}	(0.69)	-0.010	(10.05)***	-3.75×10^{-3}	(1.10)	1.49×10^{-3}	(0.62)
R^2	0.878		0.958		0.938		0.958		0.864		0.949	

Table 3: Spatial regression results, considering competitors within a quarter-mile radius, using brand share

	Bakersfield		Colorado Springs		Pittsburgh		Raleigh		Tulsa		Wichita	
Constant	4.981	(391.76)***	4.655	(529.43)***	4.916	(438.66)***	4.724	(691.58)***	4.556	(229.68)***	4.700	(476.69)***
Regular grade	-0.575	(70.79)***	-0.768	(119.43)***	-0.880	(90.37)***	-0.745	(114.70)***	-0.649	(53.85)***	-0.887	(118.08)***
Premium grade	-0.409	(44.21)***	-0.584	(92.22)***	-0.624	(66.33)***	-0.531	(89.34)***	-0.456	(34.98)***	-0.686	(83.92)***
Brand share	0.790	(11.54)***	0.536	(11.58)***	0.136	(2.21)**	0.635	(10.83)***	-0.080	(1.09)	-0.059	(2.23)**
Highway	-3.60×10^{-3}	(0.50)	-1.63×10^{-3}	(0.26)	-2.98×10^{-2}	(3.83)***	-1.66×10^{-2}	(2.81)***	-1.89×10^{-2}	(2.40)**	1.86×10^{-2}	(2.65)***
Competitors	-1.03×10^{-2}	(4.57)***	-2.77×10^{-3}	(3.34)***	2.22×10^{-3}	(0.11)	-1.02×10^{-2}	(11.68)***	-2.76×10^{-3}	(0.84)	1.45×10^{-3}	(0.68)
R^2	0.840		0.937		0.929		0.951		0.854		0.946	

Reflecting on the importance of branding, Table 3 shows that in four of our sample cities, brands with greater representation in the market charged higher prices, a result consistent with the microeconomic theory of oligopolistic behavior. Wichita shows the reverse pattern presumably because two brands (Phillips and QuikTrip) effectively control the Wichita market, and apparently lead in keeping gas prices lower in that city.

Finally, to reflect on the central hypothesis, *ceteris paribus*, it appears that greater spatial concentration of gas stations only serves to lower prices in a statistically significant manner in two (or perhaps three) of our six sample markets, Colorado Springs and Raleigh (with Bakersfield joining that list in the alternative specification of Table 3). This result is robust across all grades of fuel, as ancillary regressions (not reported here) that permit every coefficient to vary by market by grade of fuel show the same finding: only Colorado Springs and Raleigh see any effects of spatial concentration on price. In both cities, the effect is seen quite evenly across grades of fuel.

In each of these cases, the effects are economically trivial, a decline averaging one cent per competitor in Raleigh (and Bakersfield) and a quarter of a penny per competitor in Colorado Springs. In other words, prices might average by one to four cents per gallon on a particularly congested corner or block, an effect amounting to less than one percent of the purchase price.

This lack of evidence that spatial concentration matters is probably not due to brand effects. A model that excludes all information about brands (no brand-specific indicators and no brand share information) shows similarly insignificant effects of spatial competition on price. While we recognize that brand location may be endogenous, as some brands may choose to locate in areas congested with competitors (or that congestion may follow particular brand location choices), we are not equipped with the historical data to test that possibility, as it would require a model of the dynamic choices by firms to choose particular locations. We encourage future scholars to pursue this direction.

Naturally, there may be other factors which exert influence on the prices charged by individual stations. For example, the presence of a car wash, the hours of operation, the friendliness of the staff, the accessibility and cleanliness of the location might all play into a consumer's willingness to pay for gas (or a firm's ability to charge for it). However, the coefficients of determination, ranging from 0.84 to 0.95, are sufficiently high to cause us to reflect that most of the story is either told by our chosen variables or is tightly correlated with them. In fact, the authors made phone calls to ascertain various other details about the stations in our sample, and were met with universal paranoia that we represented either a terrorist or collusion-based industrial threat, to the degree that we discontinued our phone investigations.

V. Conclusions

To our knowledge, this is the first spatial econometric analysis of the retail gas market, and we present it to stimulate discussion about the topic and method. Microeconomic theory indicates quite clearly that firms located proximate to one another should charge lower prices, whether you argue that point via Hotelling's Theorem of spatial competition within markets, or oligopolistic competition and Bertrand's model of duopoly.

Yet our evidence across six U.S. cities indicates either that spatial concentration largely does not matter, or that it is so very co-related with brand positioning that it is therefore impossible to identify statistically. In either case, it appears that gas station location does not, in itself, affect retail gas price at an appreciable level.

This result could be interesting for firms choosing their next location, or for city planners aiming to distribute commercial space in a thoughtful manner. It is probably of most interest to consumers, who might now take this simple advice: on average, shopping around for an intersection congested with gas stations will not pay off with discounted prices. Instead, find an appropriate station brand near a highway, and leave the rest up to statistical averages.

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