Title

Market Power in California's Gasoline Market

Authors

Borenstein, Severin
Bushnell, James
Lewis, Matthew

Publication Date

2004-05-02

CSEM
Center for the Study of Energy Markets

CSEM WP 132

MARKET POWER IN CALIFORNIA'S GASOLINE MARKET

Severin Borenstein, James Bushnell and Matthew Lewis

May 2004

This paper is part of the Center for the Study of Energy Markets (CSEM) Working Paper Series. CSEM is a program of the University of California Energy Institute, a multi-campus research unit of the University of California located on the Berkeley campus.

UCEI
University of California Energy Institute

2547 Channing Way
Berkeley, California 94720-5180
www.ucei.org

MARKET POWER IN CALIFORNIA'S GASOLINE MARKET

by

Severin Borenstein, James Bushnell and Matthew Lewis

ABSTRACT: In recent months, prices for California's special (CaRFG) gasoline have again exceeded U.S. average prices by much more than the difference in production costs. A number of observers have attributed the widening average differential to increasing scarcity of refinery capacity among plants that are equipped to manufacture CaRFG gasoline. While these arguments have generally been sound, the dismissals of market power concerns have not been well supported. We study the potential for firms in the CaRFG wholesale gasoline industry to exercise market power, examining the refining, importation and storage of the fuel. We don't dispute arguments that the elevated prices are consistent with competitive markets, but we illustrate that the data are also consistent with some firms exercising market power. We then discuss methods for, and difficulties in, distinguishing between competitive pricing and market power.

Borenstein: Director, University of California Energy Institute (www.ucei.org) and E.T. Grether Professor of Business Administration and Public Policy, Haas School of Business, U.C. Berkeley, (www.haas.berkeley.edu). Email: borenste@haas.berkeley.edu. *Bushnell:* Research Director, UCEI, and Lecturer, Haas School of Business. Email: bushnell@haas.berkeley.edu. *Lewis:* Research Associate, UCEI (after August 1, 2004, Assistant Professor of Economics, Ohio State University). Email: mlewis@econ.berkeley.edu. We thank the California Energy Commission for supporting this research. The views presented here do not necessarily reflect those of the CEC or anyone else other than the authors. We thank Karen Notsund and Frank Wolak for helpful comments and discussions.

TABLE OF CONTENTS

1. Introduction

In March 2004, California gasoline prices once again increased rapidly to more than 30 cents above those seen in the rest of the country. This price differential substantially exceeds the long-run cost differences from the cleaner-burning (CaRFG) gasoline that the state uses. A number of observers have attributed the periodic price spikes, and the widening average differential between California and U.S. average prices, to increasing scarcity of refinery capacity among plants that are equipped to manufacture CaRFG gasoline. Many, including authors of a November 2003 report by the Department of Energy's Energy Information Administration, have discounted or dismissed the possibility that refiners in the market could exercise market power in order to drive price above the levels that would be observed in a completely competitive market.[1]

The arguments that previous studies have made attributing high California prices to competitive market conditions and scarcity have generally been sound. Their dismissals of market power concerns, however, have not been well supported. In this study, we examine the potential for firms in California's CaRFG gasoline industry to exercise market power. We don't discount or dispute previous analyses that have found that the elevated prices are consistent with competitive markets. Rather, we build on those analyses, demonstrating that the data are also consistent with some firms exercising market power. We then discuss methods for and difficulties in distinguishing between competitive pricing and market power.

We focus in this study on market power in the wholesale gasoline market, including the refining, importation and storage of CaRFG gasoline and the components that go into making it. We do not consider the downstream retail organization of the industry. In a later study, we hope to analyze assertions of market power in the retail gasoline industry and concerns about the structure of vertical contracts.

In section 2, we present the basic model of pricing and market power in the absence of storage or an import supply that can respond as prices rise. We demonstrate how prices can be volatile even in the absence of market power, and can at times significantly exceed the average cost of production. We then show why this is not the whole story. The same circumstances that are likely to cause price volatility in a competitive market -- inelastic demand and capacity constrained supply -- are also likely to create incentives for sellers to exercise market power. It is often said that gasoline prices follow the simple economics of supply and demand; we argue that equally simple are the economics of market power, a firm recognizing that increasing supply will tend to drive the price down for all product that it sells. In fact, in the complex calculation that goes into a California refiner's product mix decision it would

[1] “Price gouging, when it occurs (which is rare), is usually a very localized phenomenon and only at the retail level." (EIA, 2003, p. 49). We refer to the “exercise of market power” meaning any attempt by a firm to profitably increase the market price.

be quite surprising to learn that they do not consider the effect of their production decisions on market prices.

In section 3, we expand the analysis to recognize the ability to store gasoline. Not surprisingly, storage limits the price swings that occur in a market, whether those swings are due to market power or true scarcity of the product. We discuss the long-run equilibrium investment in storage that one would expect if there is free entry into the gasoline storage business. We then analyze the potential barriers to entry in this line of business and the possibility for a company that is in the gasoline storage business to exercise market power in that function.

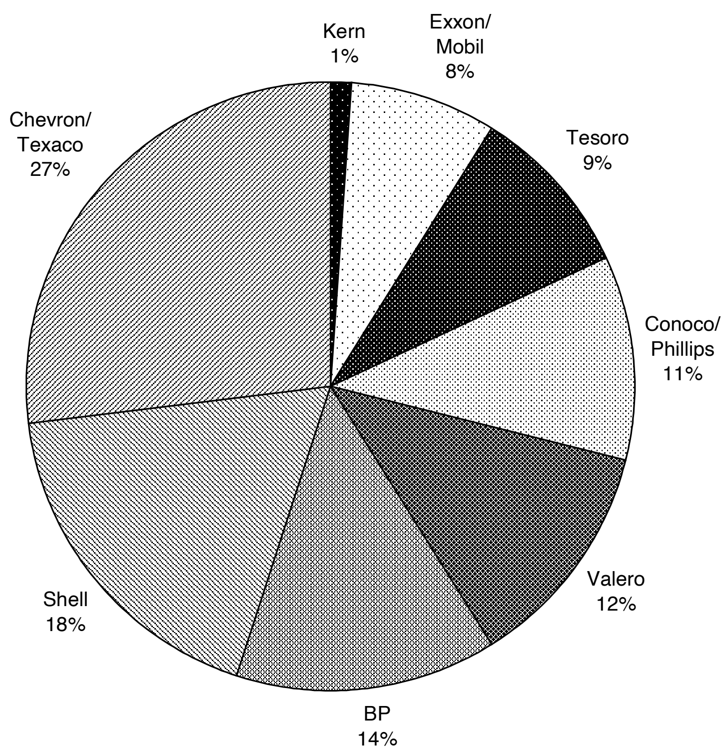
We also look at interactions between storage, pipeline control, and refining in the incentive to exercise market power. The movement of refined product is a market in itself. While there is little evidence of market power in international or interstate shipping of gasoline, the same is not true of interstate or intrastate pipeline distribution. In fact, the larger pipelines are regulated as common carriers by the Federal Energy Regulatory Commission (FERC) to prevent exercise of market power in pipeline distribution. Some of the smaller feeder lines are privately operated generally for use by a single company. Regulation may effectively control direct exercise of market power through high prices for pipeline transportation, but pipeline owners may have other troubling incentives if they are active in the refining or storage businesses as well.

Through sections 2 and 3, we focus on a closed market, but gasoline and components of CaRFG can be supplied to California from out of state: the gulf coast of the U.S., nearby foreign refineries in the Caribbean and Venezuela, and more distant locations, such as Finland. In section 4, we discuss how these alternative sources can augment west-coast refinery production, but note that they have disadvantages for California. First, due to their distant location, they have higher transportation costs, raising incremental cost by 5 to 20 cents per gallon. Second, distant imports have longer travel time, so they cannot respond as quickly as in-state production to unforeseen shifts in the supply/demand balance. Finally, there are, thus far, few refineries outside of California that are equipped to produce CaRFG gasoline, though that is a short-run phenomenon that would probably change if California prices remained persistently high. These factors are widely cited in discussions of gasoline scarcity in California. We show in section 4 that the presence of imports, and such constraints on importation, changes the timing and effect of the incentives in-state firms have for exercising market power.

We should state at the outset that we do not present evidence that any firms unilaterally or collectively have exercised market power in California's gasoline market. In section 5, we discuss why it would be very difficult to demonstrate to any reasonable level of certainty that a firm is not acting completely competitively. We point out that these are the same reasons that attempts to regulate gasoline prices have in the past harmed consumers and would be likely to fail again if attempted now. Rather, we show that firms in the California gasoline market may face significant incentives to exercise market power, and that it would be natural in an unregulated market for a firm to respond to those incentives. Because it is very difficult to diagnose market power and antitrust laws do not address unilateral exercise of market power, we argue that prevention is a much more attractive public policy than prosecution. Finally, we discuss policy options for reducing market power incentives within California's gasoline markets.

2. Price Volatility and Market Power

Well-functioning competitive markets result in socially efficient prices and levels of production. In these markets all firms are price takers, meaning that their individual production decisions do not affect the overall market price. However, if firms are able to exercise market power the result can be inefficiently high prices and low levels of production. In this section, we discuss the economics of refinery supply and gasoline demand in the California market (abstracting from storage and import issues for now). We then identify the reasons why refiners may have market power and how this affects production decisions and market prices.



Source: CEC website: http://energy.ca.gov/oil/refineries.html and EIA (2003), Table 4-1

Figure 2.1: Market Shares of Companies Producing Reformulated Gasoline in California

The 22 refineries located in California are capable of refining just over 2 million bbl (barrels) of crude oil per day.[2] Thirteen of these refineries are equipped to produce reformulated (CaRFG) gasoline[3]. Ownership of gasoline producing refineries is divided among 8 companies. Individual company market shares of crude distillation capacity at gasoline producing refineries are shown in Figure 2.1. In 2003, California refineries produced around 15 billion gallons of CaRFG gasoline, almost identical to the 14.8 billion gallons consumed.[4] California also produces about 2 billion gallons per year of conventional gasoline that it supplies to neighboring states. To meet growing demand for gasoline, refiners have been increasingly configuring operation to produce more gasoline relative to other refined products. From 1995 to 2002, the percentage yield of gasoline from refinery inputs has increased from 51% to 55%.[5]

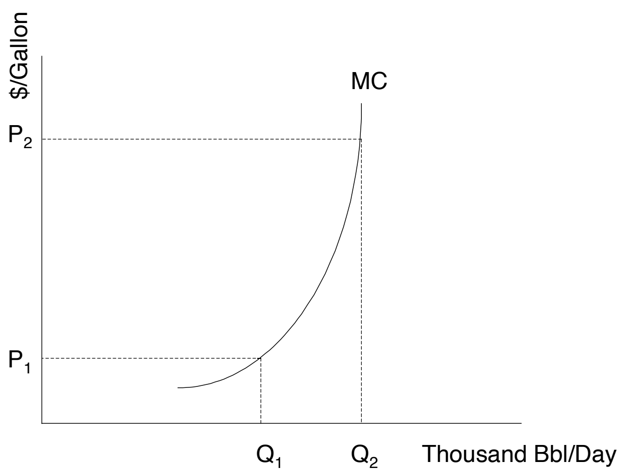


Figure 2.2a: Firm Production

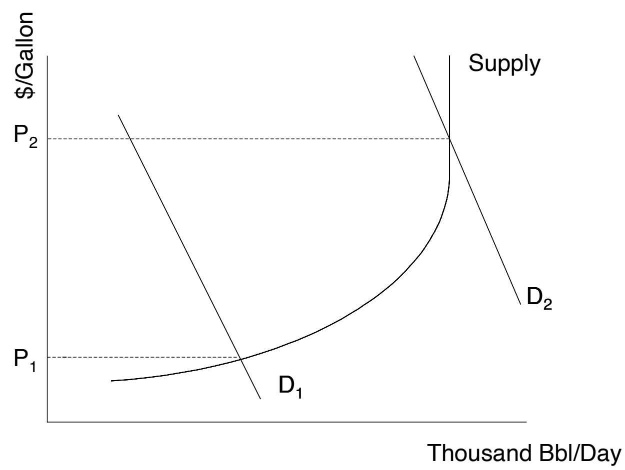
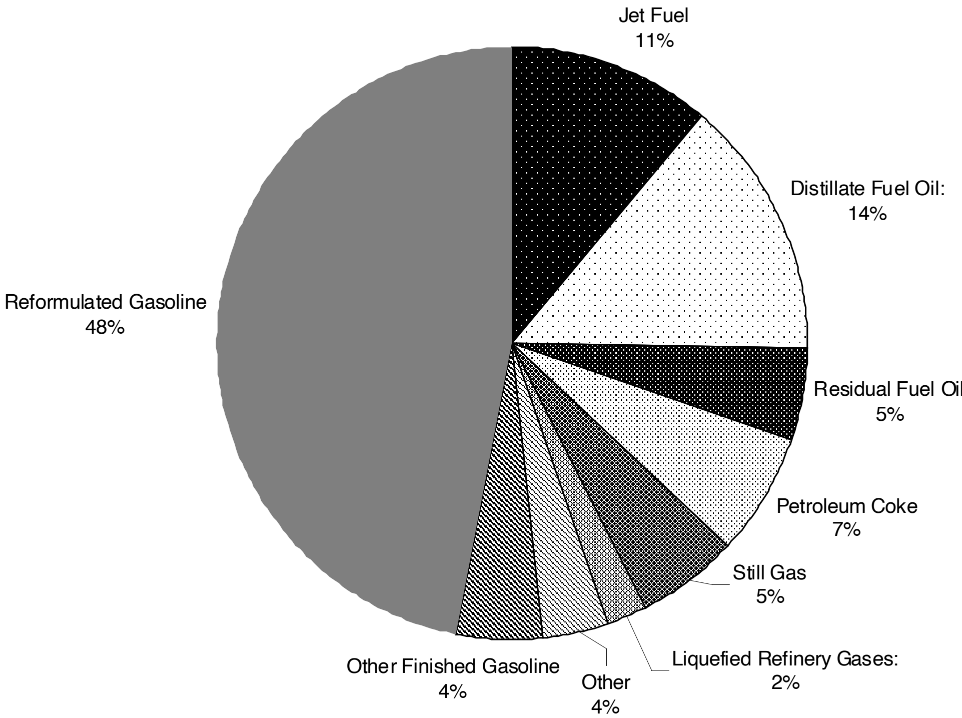


Figure 2.2b: Market Equilibrium

Refined gasoline in California is a nearly homogeneous commodity with a fairly well-defined wholesale market. Each refiner chooses how much to supply based on demand conditions and their marginal cost of producing gasoline. The marginal production cost of gasoline includes all the additional costs incurred when a refinery decides to increase gasoline production. Other production and operating costs (including refinery construction costs) that do not change when an additional gallon of gasoline is produced are called fixed costs. Unlike marginal costs, fixed costs do not affect the refiner's short run decision of how much product to supply. A price-taking refiner simply will produce gasoline until the cost of producing an additional

[2] Refining capacity reported by California Energy Commission: http://energy.ca.gov/oil/refineries.html. Bbl is an abbreviation for "Blue Barrel" and is equivalent to 42 gallons.
[3] Eight refineries are not capable of producing CaRFG, but they constitute only 9% of California refining capacity.
[4] Production numbers taken from CEC Weekly Fuels Watch Report. Consumption numbers taken from US DOE Petroleum Marketing Monthly (Prime Supplier Sales Volumes).
[5] EIA (2003) Table 4-2.

gallon (i.e. the marginal cost) rises above the revenue he will receive for the additional gallon (i.e. the marginal revenue). Since the supply decision of a price-taking refiner will not affect the market price, the marginal revenue will simply be the market price at which he will sell the additional production. So, the refiner produces up to the quantity at which marginal cost rises above the market price (See Figure 2.2a).



Source: CEC California Refining Industry Operating Reports, http://energy.ca.gov/oil/refinery_output/1999_refinery_report.html

Figure 2.3: Net Output Share of Products Produced by California Refineries in 1999

Calculating marginal costs is not such a straightforward exercise, however, since refining is a complex process of turning crude oil (and possibly other chemicals) into a variety of different petroleum products such as gasoline, fuel oil, jet fuel, petroleum coke, etc. Figure 2.3 shows a typical breakdown of products produced at California refineries. There is even some flexibility in the amount of each product that can be produced from refining a single barrel of oil. Over some range, refiners can reconfigure the process to produce more of one product and less of another, if certain products become more profitable to sell.[6]

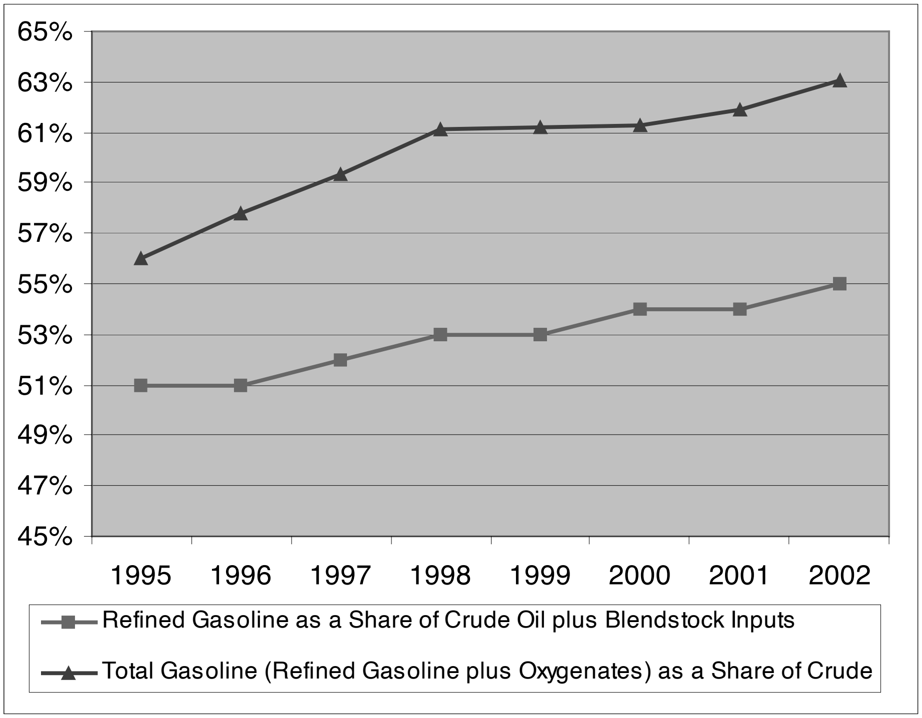
[6] For example, when CaRFG prices increase relative to conventional gasoline prices, the incentive to produce conventional gasoline decreases because refiners must give up the opportunity to produce CaRFG in order to produce conventional gasoline.

Above a certain level of gasoline production, a refinery's marginal cost is likely to increase with level of output, since increasing output requires either pushing more oil through the refinery or squeezing more gasoline out of a barrel of oil than is most cost efficient. As is depicted in Figure 2.2a, the marginal cost of producing gasoline begins to increase sharply once the refinery starts hitting its production capacity limits. Similarly, for a given amount of oil run through the refinery, the marginal cost of producing an additional gallon of gasoline rises as the refinery reaches the technological limits of its ability to substitute towards gasoline in its mix of refined product outputs. The quantity supplied by all price-taking refineries in the market at a given price is simply the sum of all the gasoline that can be produced from each refinery at a marginal cost that does not exceed this market price. The market price adjusts until the amount of gasoline demanded is equal to the amount supplied by all the refiners in the market (See Figure 2.2b). If a large quantity of gasoline is demanded, prices must rise in order to stay above the increasing marginal costs of refiners.

Scarcity and Price Volatility

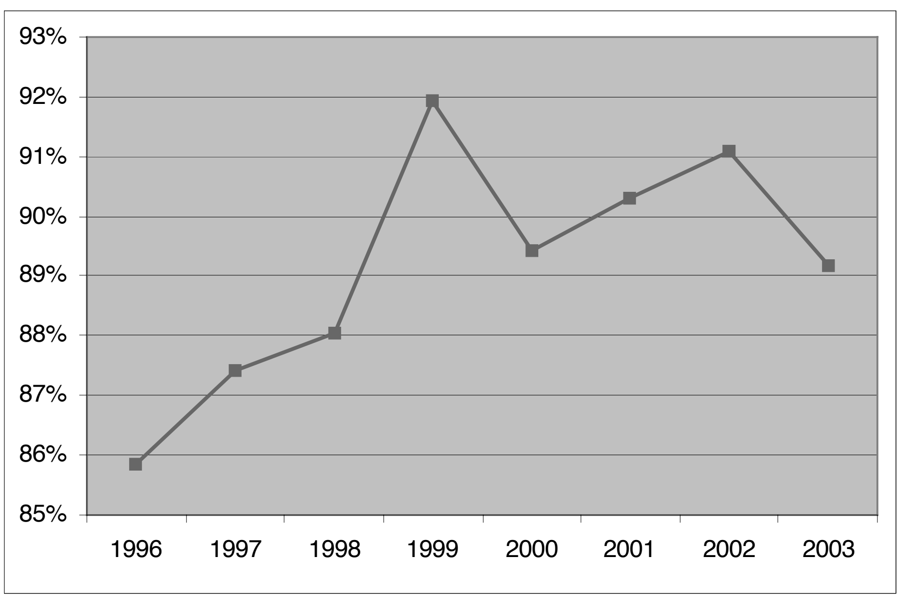
In recent years California refineries have been pushing the limits of CaRFG production in order to meet the growing demand from California drivers. Capacity utilization rates are very high, meaning that refiners are refining nearly the maximum amount of crude oil possible given their technology. In addition, refineries have been reconfigured to produce more and more CaRFG relative to other petroleum products. Recently California refineries have been producing more and more gasoline relative to other products (Figure 2.4) as well as producing more CaRFG relative to conventional gasoline (Figure 2.5). One way refineries increased gasoline production was by incrementally increasing the crude oil throughput and the ratio at which they can refine crude into gasoline. The gasoline yield from crude oil has increased from 51% to 55% over from 1995 to 2002. Refiners have also been able to increase gasoline production by introducing higher amounts of blendstocks and oxygenates that are added in the gasoline refining process. This has helped total gasoline production as a share of crude oil inputs to increase from 56% to 63% over the same period.

As EIA (2003) describes, the oxygenate changeover from MTBE to ethanol has put additional pressure on California refineries' ability to produce gasoline. Producing CaRFG now involves adding Ethanol at 6 percent by volume instead of adding MTBE at 11 percent by volume, which leads to a reduction in the volume of finished gasoline. In addition, blending requirements make it harder for refineries to produce as much gasoline for ethanol blending (CARBOB) as they could for blending with MTBE, which further decreases production. To compensate for these reductions refiners are further increasing the use of gasoline blendstocks brought in from outside California. The relationship these increased imports have with price volatility and market power will be discussed later in the *Market Power and Imports* section.



Source: EIA (2003) Table 4-2

Figure 2.4: Gasoline Yields at California Refineries 1995-2002



Source: CEC Weekly Fuels Watch Report

Figure 2.5: Annual Percent CaRFG vs. Total Gasoline Production in California

The result of refineries constantly operating at such high levels of gasoline production is that there is less flexibility left to increase CaRFG production if needed. The marginal costs are likely to increase significantly when moving to higher output levels, as is seen moving from the lower to higher demand levels in Figure 2.2b. In the short run, price-taking refiners would only attempt to increase production if prices rose significantly. If more supply suddenly becomes necessary, large increases in price would be required to encourage refiners to ramp up production.

If California's gasoline demand were fairly flexible it could prevent the need for a sudden increase in production. However, gasoline demand in the short run is not very sensitive to price; in economic terms, gasoline demand is price-inelastic. This is represented in Figure 2.2b by a steeply sloped market demand curve. In the short run consumers are often unable to change their gasoline consumption because they rely on their cars to get where they need to be. Consumption of gasoline changes very little when prices rise and fall. Common estimates indicate that over a period of 1-2 months, a 10% increase in the price of gasoline reduces quantity demanded by only 2%-3%.[7] Over a longer period, significant responses such as purchasing more fuel efficient vehicles or moving closer to work contribute to greater demand elasticity, but these are not common responses to price spikes that last a few months or less.

The combination of inelastic demand and fairly inflexible (inelastic) supply when refiner utilization is high means that any unexpected increase in demand or decrease in supply results in large price spikes. The market can easily become out of balance if there is an unexpected jump in demand, or more commonly, if a refinery experiences a supply disruption or outage and output is reduced. Large price movements are required in order to encourage consumers to decrease consumption or to make it profitable for other refineries to increase production and balance the market. As refiners constantly produce closer and closer to their capacity constraint, market prices will become more and more volatile due to inherent system shocks.

It is interesting to note that many of these same characteristics are present in the electricity generation market. When generation resources are tight, prices must rise significantly to encourage supply from additional, higher cost generators. In addition, consumers' demand for electricity (like that for gasoline) is not very sensitive to price. This means that market imbalances must be made up with very expensive generation. Californians have become very familiar with the consequences of short run scarcity and market volatility in electricity markets over the last few years.

[7] Dahl and Sterner (1991) survey studies of gasoline price elasticity and find an average estimates of short run price elasticity from different types of studies range from .22 to .31. More recently Kayser (2000) estimated a price elasticity of .23.

Market Power

So far the discussion of production and price volatility has focused on the behavior of a competitive market with price-taking firms. If refiners have market power their production incentives change. Unlike a price taker, a refiner with market power realizes that changes in its own level of supply will affect the market price. As a result, the marginal revenue of the refiner is no longer simply the market price. The refiner recognizes that producing more output reduces the price that it will receive for *all* of the output it is sending to the market. As a result, the marginal revenue of a refiner when it sells an extra unit of production is less than the market price. The refiner with market power maximizes its profits by producing less than it would if it were a price taker and forcing the market price to increase to balance demand with the new lower level of supply. The refiner ends up selling less gasoline, but it earns a higher price for each gallon it does sell. This enables the refiner to earn higher profits than if it were to produce all the way to the point at which marginal cost rises above the market price.

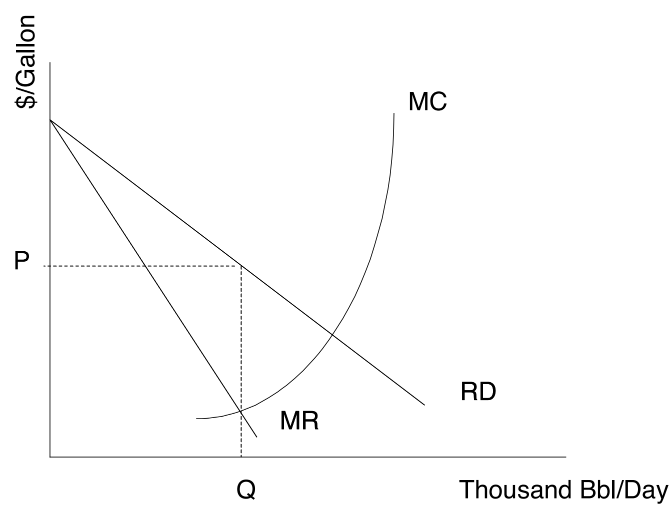


Figure 2.6 Firm Production with Market Power

For a refiner with market power, production decisions are a function of the residual demand the firm faces. Residual demand is the demand in the market that is not being met by the supply from all other producers. The refiner produces the quantity that maximizes profits earned from meeting this residual demand. Its marginal revenue will be the additional revenue earned from serving another gallon of this demand. As is depicted in Figure 2.6, the refiner maximizes profits by producing the quantity that equates marginal revenue with its marginal costs, and earns the price that is determined by the residual demand curve at the quantity produced.

The nature of both consumers' demand for gasoline and other refiners' willingness to produce gasoline determine whether a refiner has or is able to exercise significant market power. Market power can be limited if consumers' demand is very sensitive to price, so that their gasoline purchases decrease significantly when prices increase. Even large reductions in supply do not lead to a substantial price increase, because consumers choose not to purchase rather than pay a higher price. Exercising market power is not profitable in this situation. However, in the gasoline market, consumers' lack of flexibility prevents the demand side from limiting market power.

A refiner's market power is also constrained by other sources of supply if those other sources are very sensitive to price. When other suppliers are willing to produce more gasoline in response to a small price increase, then one refiner cannot drive up the price by producing less. Exercising market power is not profitable because higher production from other refiners simply replaces the decreased supply without a significant increase in price. However, the willingness of other firms to increase supply when prices go up depends on how much their marginal costs increase when they increase production. If refiners in the market are nearing their refinery capacity constraints and the marginal cost of producing more gasoline is high, then prices must rise significantly before additional output is realized. In that situation, supply for other refiners does not significantly constrain the exercise of market power.

Market power is often associated with a firm’s share of the market production. This is because a firm that has a large share in the market is likely to face a less elastic supply from its competitors. If, for instance, a firm with five percent of a market cuts its output by one-tenth, then other firms that constitute 95% of the market must increase their output by only 0.5 percentage points to compensate. But if a firm with 60% of the market reduces its production by one-tenth, then the remaining firms with 40% of the market must increase their output by six percentage points, a much larger change relative to the likely production capabilities of these other firms. In the latter case, other firms are less likely to be able to compensate for a similar proportional production cut.

If consumers’ demand is not sensitive to price *and* refiners are producing near their capacity constraints, then it is likely to be profitable for a refiner to reduce production to drive up prices, possibly even if that refiner does not have a large market share. In these situations, firms with market power supply less gasoline than they would if they were price takers, leading to higher market prices and a less than socially efficient level of gasoline production. Refiners can exercise market power in the gasoline market simply by refining less oil, or by adjusting their refineries to produce less gasoline and more of some other petroleum products than is socially optimal.

The existence of market power raises the average price level in the market. However, it is important to notice that the same inflexibility of demand and supply that leads to price volatility in a competitive market also increases refiners' ability to exercise market power. As a result, price spikes are likely to be exacerbated by the presence of market power. When resources are scarce, firms have greater ability to exercise market power and raise prices further above competitive levels.

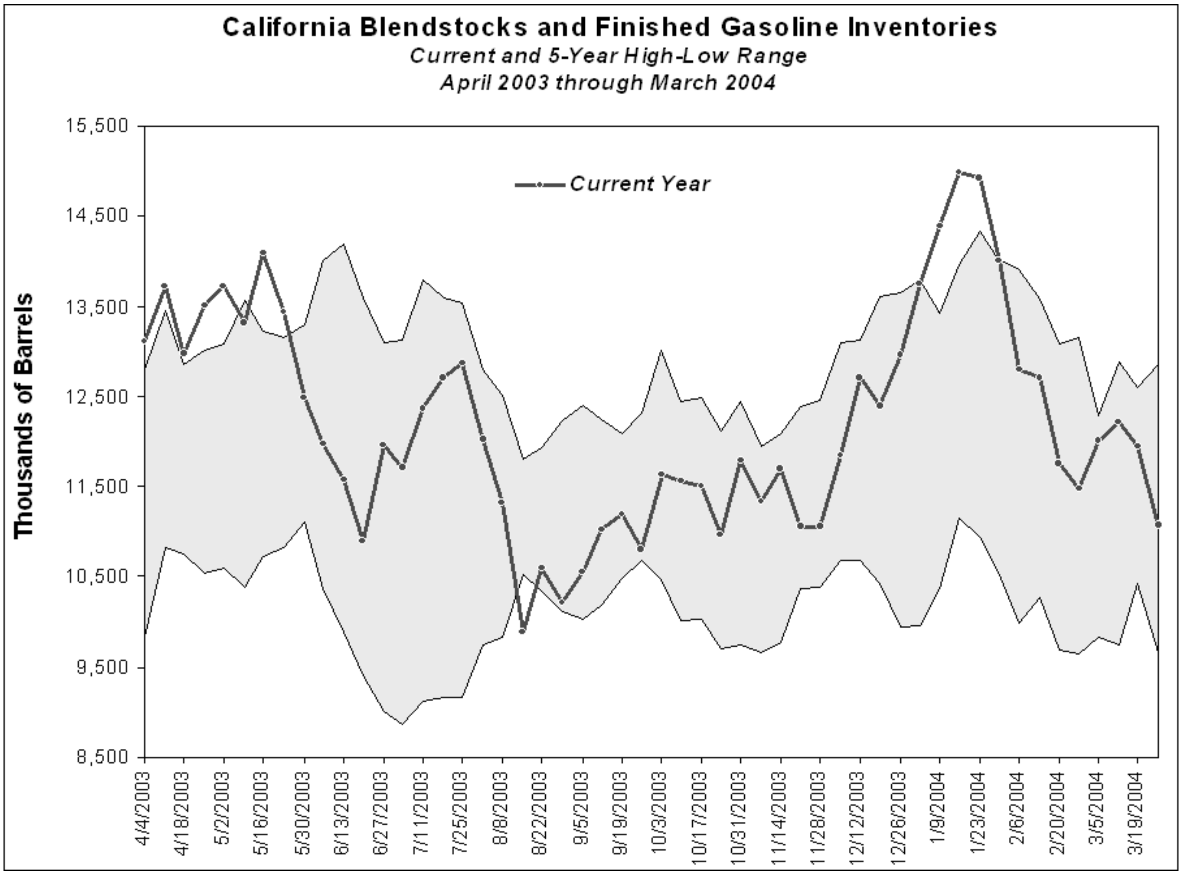
Again, we need only to look to electricity markets to see the consequences of market power. In recent years, California has experienced periods of extremely high wholesale electricity prices. Analysis has shown that firms with market power were able to raise prices to levels well above the competitive price (i.e. the marginal cost of generation). Moreover, when generation became scarce and costs increased, prices increased even more because firms where more able to exercise market power and maintain higher profit margins.

3. The Role of Storage in Gasoline Markets

In markets where production capacity is potentially constrained, and the ability of consumers to shift their demand is somewhat limited, storage capacity can play a key role in dampening price volatility. This is certainly true in the California gasoline market, where the combination of special formulation requirements and the phase out of MBTE have created an environment where production capacity is stretched to keep up with demand. As described above, a tight capacity situation makes gasoline markets more vulnerable to periodic supply disruptions and to the exercise of market power. To a degree, storage capacity can help to alleviate tight supply conditions by effectively shifting production capacity across time - allowing producers in high demand periods to borrow production from low demand periods. Ample low cost storage will certainly reduce price volatility, and, to the extent that off-peak periods have sufficient slack capacity, can reduce overall average price levels.

The extent to which a market such as California's gasoline market can benefit from storage capacity depends upon the availability and cost of that capacity. It also depends upon its distribution of ownership. As we will demonstrate in this section, the way in which storage capacity can profitably be put to use will vary depending upon who controls that capacity. Small entities not involved in other aspects of the wholesale business will utilize storage capacity differently than large refiners. Large firms that control substantial storage capacity will prefer yet another utilization pattern. In this section, we discuss the way in which storage impacts the market, and how the ownership of that storage plays a role in those impacts.

It is very difficult to get a clear picture of the potential maximum storage capacity in California. Overall tank capacity numbers are available, but the stylized fact is that actual inventory numbers come no where close to approaching the formally reported capacity numbers. Part of the reason for this is that a large portion of the tank capacity is utilized for operations and other process needs, and cannot therefore be filled to capacity during periods where prices might indicate that it would be worth doing so based upon arbitrage considerations alone. Stillwater Associates reports that roughly 42 MM bbl of tankage capacity is reserved for gasoline and blendstocks in California at large refineries (24 MM bbl) and terminals (18 MM bbl). Stillwater reports that there is another 16 MM bbl of tankage capacity located at small terminals and with end-users.



Source: CEC, Weekly Fuels Watch Reports, Various Issues

Figure 3.1: Inventories at California Refineries

However, it is difficult to gauge how much of this capacity is actually available for market-based storage purposes. Figure 3.1 shows the 5 year range (from 1998-2002) of inventory levels of gasoline and blend-stocks at large refiners, as well as the inventory levels during 2003-04. Inventory levels never dip below 8.5 MM bbls and max out at 15 MM bbls. A conservative lower bound on the amount of storage available for strategic purposes at refineries could be taken from the difference between these levels, about 6 MM bbls. To our knowledge, comparable inventory figures for small terminals and end-users are not available.

Competitive Usage of Storage

Although we will focus our discussion on the impact storage can have on the volatility and levels of wholesale prices, it is important to recognize that firms utilize inventories for many purposes beyond a simple arbitrage of seasonal price differences. Refiners hold inventories of crude, blendstocks, and finished product in order to minimize the consequences of a supply disruption and to provide buffers to the production process. These types of usages are generally called operational storage. In addition, firms may keep inventories of refined product to reduce the chance of a retail shortage, and the ensuing potential loss of costumer good will. Even in the absence of any price swings, we would therefore expect to see firms holding inventories as long as these various tangible and intangible benefits exceed the cost of storage. Indeed, as Stillwater Associates reports, California's gasoline inventory levels fluctuate within a relatively narrow band around 50% of estimated total capacity.[8]

Of course the California gasoline market does experience large price swings, adding a second speculative benefit to holding inventories. The ability to store product allows a firm to buy low and sell high, thereby arbitraging the price difference across time periods. In a competitive market that is at times capacity constrained, the redistribution of ample inventories from the low demand to high demand periods allows for a reduction in supply needed during high demand periods, thereby lowering peak prices. If there is slack capacity during the low demand periods, then the increase in demand due to the additions to inventories will not raise prices during this period nearly as much as it lowers prices during the high demand period (see Figure 3.2). This is because the supply curve is relatively flat as long as capacity constraints are not binding. Thus additional storage capacity can lower average prices as well as reduce volatility. This is the effect of production smoothing, which allows for the expansion of production at times when marginal costs are low and the reduction of production at times when marginal costs are high. In a competitive market, these cost reductions are translated directly into market prices.

[8] Stillwater Associates(2002)

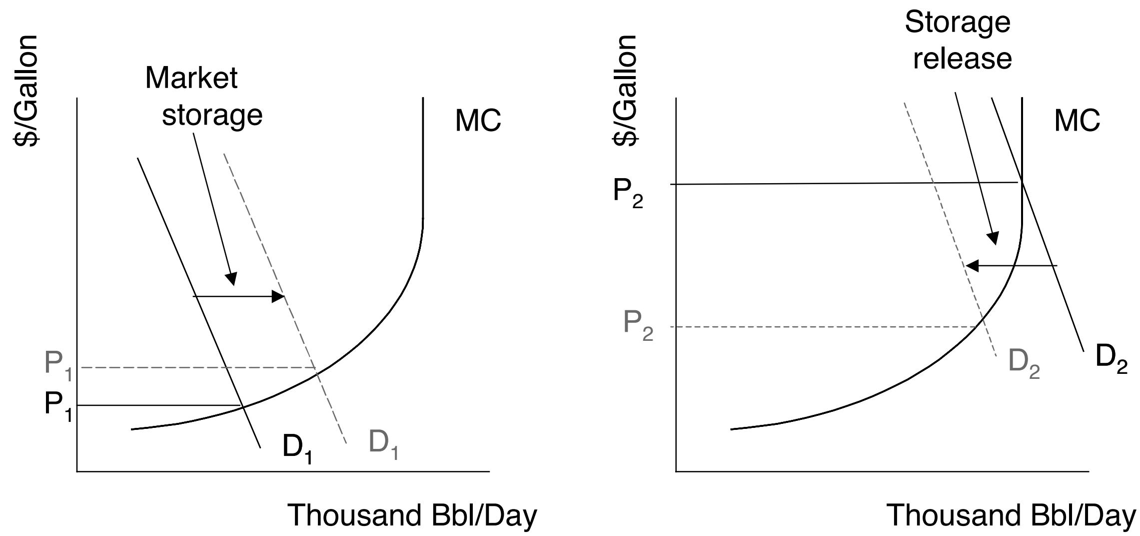


Figure 3.2: Average Price Reductions from Production Smoothing

These beneficial effects of storage become even more pronounced if prices are also impacted by market power. In capacity constrained markets, the degree of market power – measured as the proportional price/cost margin -- tends to increase with demand. At higher levels of demand, more suppliers are producing at or near their maximum capacity, leaving few producers with much remaining capacity to compete to supply any additional increases in demand. In other words, the elasticity of supply - the rate of additional supply that would be stimulated by a price increase - usually decreases at higher levels of demand. The reduction in competition during periods of high demand thereby produces higher margins over competitive levels even in the absence of strict capacity constraints. This implies that the supply curve for gasoline increases more sharply than it would in the complete absence of market power, and that the rate at which prices climb will also increase with demand. The competitive and scarcity effects combine to create an even sharper contrast between supply conditions during low and high demand periods. As figure 3.3 illustrates, the more convex the supply curve, the more benefit accrues from being able to shift supply from low demand periods to high demand ones.

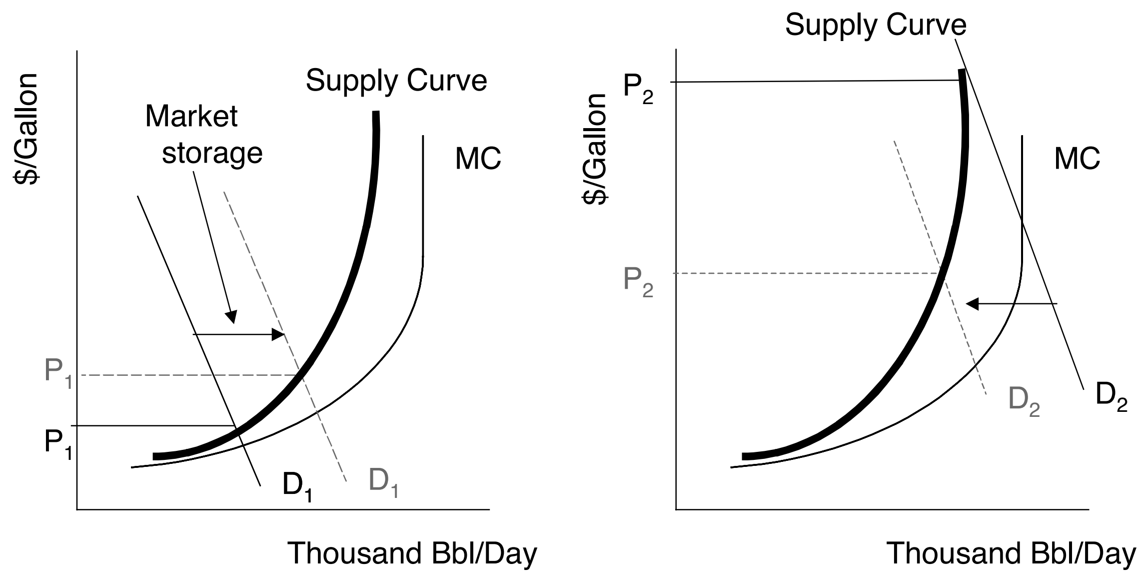


Figure 3.3: Storage and Market Power in Production

Even this figure understates the potential competitive benefits of storage, however, as the supply curves in the two periods remain unchanged with the introduction of storage. This is because the same amount of storage activity is depicted regardless of overall price levels. However, the amount of storage utilized for inter-temporal arbitrage will likely depend upon the actual market prices and in particular on the volatility of prices. In other words, higher price spikes will likely produce more storage activity. During higher demand periods, a price increase would reduce market demand *and* draw more of a market response from those holding inventories. To the extent that the storage response is anticipated by producers, the combined effect makes residual demand during these high demand periods more elastic. A more elastic residual demand reduces the market power enjoyed by firms, and will have the effect of shifting the supply curve more toward the competitive, MC curve.

One last competitive benefit of storage comes from its interaction with imports. As we discuss in Section 4, imports have played an increasingly important role in the California gasoline market. However, many studies have noted the particular difficulty in relying upon imports to mitigate periodic price spikes caused by unforeseen shocks to supply or demand. The time lag between the dispatching of additional imports from the Gulf coast or even more distant locations and its arrival in California can be several weeks. By the time the product arrives, prices very well may have dropped again. The risk that the market for imported product may have disappeared before the product arrives reduces the incentives of firms to divert product from other regions in the first place. A lack of available storage capacity into which excess imports could be diverted during periods of slack capacity in California contributes to the problem. If firms could store extra imports to be drawn upon during high-price periods, the flow of imports could be more effectively managed. The offloading of tankers could be handled more quickly and efficiently, thereby reducing somewhat the transport costs of imports. As we describe below, in the absence of sufficient competition for storage capacity, these benefits may not be fully realized.

Market Power in Storage

To this point, we have considered the impacts of storage capacity on the market under the assumption that the storage capacity was being utilized in a fully competitive manner. This is equivalent to assuming that the storage capacity is distributed amongst many relatively small owners. In fact, the ownership of storage capacity is more concentrated than that. Roughly 140 Million bbl of the approximately 190 Million bbl petroleum product storage tank capacity in California is located at either large refiners or bulk terminals.[9] It is therefore important to consider how prospective market power in the provision of storage might change the dynamics described above.

Large Storage Providers

Other than Refiners, much of the remaining gasoline storage capacity is controlled by a relatively small number of firms such as terminal and pipeline operators. Although much of this storage capacity is then made available to jobbers or other potential competitive arbitrageurs, it is worth considering the economics of the storage business for large firms with at least some market power in the storage business. Unlike refiners, large storage operators derive no explicit cost savings from the smoothing of gasoline production. Rather the benefits of storage for these firms includes the convenience yield of holding inventories for their own operations, and the ability to provide storage convenience to other firms, such as jobbers, who are willing to pay for these services. A last advantage to controlling storage is the ability to arbitrage price differences. Unlike small arbitrageurs, however, a large storage firm that is optimizing its operations would need to consider the impact of its arbitrage activities on the resulting market prices.

A large storage firm, just as small storage firms, makes arbitrage profit from buying low and selling high. A large number of very small storage operators would continue to buy low and sell high until the expected price differences were equal to the incremental cost of storage. Once the costs exceed the expected arbitrage profits, no further arbitrage trades would be expected to be profitable. Thus, in a market with many small storage operators, we would expect to see average spot prices fluctuate within a band roughly equal to the incremental cost of storage. Two things could cause prices to swing in larger increments: a lack of storage capacity available for arbitrage trades and the concentration of storage capacity amongst firms with market power.

[9] Stillwater Associates(2003)

If storage capacity were limited, then firms would be unable to take advantage of price volatility, even if the prices swings exceeded incremental storage costs, because there would be no way to physically shift further product from the low price to the higher price periods. If the resulting price volatility were such that the prospective benefits from storage exceeded the costs of new storage facilities, we would expect to see new storage capacity enter the market. Despite the environmental and other restrictions on the construction of new storage capacity, there is some indication that this is now occurring in California.

However, if there are sufficient barriers to entry to the storage business, we would not expect the entry of new storage to drive down the volatility of prices to levels that reflect the long-run costs of new storage capacity. To the extent that existing firms control a significant amount of storage capacity, there is another reason to expect price spreads to remain wider than the costs of storage: the market power of storage firms gives them an incentive to maintain profitable arbitrage opportunities.

Consider a single large storage operator confronted with an expected pair of off-peak and high demand prices such as those described in figure 3.2. Also assume for now that the marginal cost of storage for the firm is negligible. The firm can therefore earn profits from buying gasoline in the low demand period and selling it in the high demand period. This large storage operator would not want to conduct trades to the point where the price spreads between the two periods disappears, even if it controlled sufficient storage capacity to do so. If the firm engaged in sufficient trade that it equilibrated prices, it would earn no profits on its trades, effectively killing the golden goose. Rather, a large storage firm would need to consider the impact of its arbitrage trade on market prices, and balance the profit from an additional gallon of arbitrage with the impact that incremental trade would have on the value of the product it already has in storage. Just as a large refiner would not want to flood the market during high demand periods, a large storage operator would also not want to dump so much supply on the market as to seriously depress prices.

Combined Refiner-Storage Operations

Another relevant consideration is the combination of storage capacity and refining capacity. A large amount of the storage capacity in California is located at refineries and large terminals and is therefore under the control of the same firms that produce gasoline. It is also worth noting, however, that refiners have by far the largest needs to hold inventories for their own internal production purposes. Thus, the apparent large share of storage capacity owned by refiners is offset by the fact that much of that storage capacity is not available for strategic usages, either competitive or not.

As we described above, when many small arbitrageurs use storage to buy low and sell high, it leads to a convergence of prices and to a reduction in overall average prices. Jobbers and other small traders would not consider the impact of their individual trades on the reduction in average prices, but large refiners naturally would. Large refining firms may control enough storage to potentially impact prices and also have a financial incentive to avoid lowering average prices. Thus, for such a refiner, the benefits of the arbitrage of time-varying price differences must be balanced against the impact of that arbitrage on overall prices, and therefore overall profits. A producer can still utilize storage to smooth production and reduce costs, but the shift in production will not necessarily translate to dramatically more output during high demand periods. In short, a producer with market power would prefer to avoid the pro-competitive effects of storage that were described in the previous section.

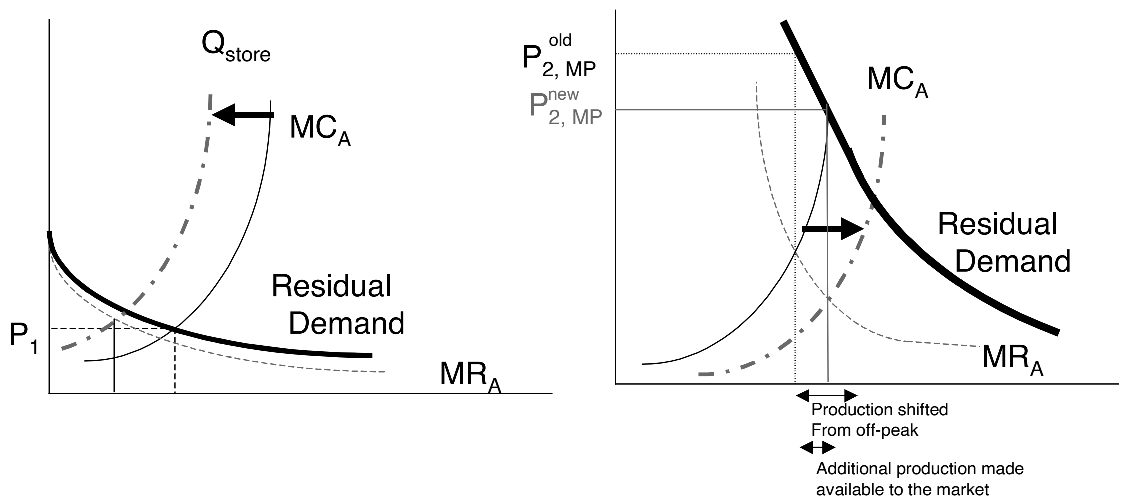


Figure 3.4: Combined Refiner Storage Activities

Interestingly, however, the joint ownership of storage capacity and production will not be anti-competitive in all cases. In this example, illustrated in Figure 3.4, the reduction in peak production for firm A is greater than the reduction in production that would result in a competitive market. This is because the marginal revenue curve for firm A is steeper than the residual demand curve over the relevant range of production. In general this may not be the case as marginal revenue curves can have a greater or smaller slope than the demand curves from which they are derived, depending upon the shape of that demand curve.

Sources of Market Power in Storage

The previous sections have described the role storage capacity can play in the gasoline market. There are several indications that if entry into the storage business were relatively easy, it would in fact constitute a profitable investment under current market conditions. However, there are many political, regulatory, and economic barriers to entry to the storage business. Given the potentially dramatic differences in the way storage capacity may be utilized, it is worth discussing the structure of the storage market in California. Storage capacity is primarily located at or near refineries, terminals, and port facilities. Much of the capacity at refineries is utilized for managing refining operations. Much of the remaining capacity at terminals is owned by refiners or pipeline companies. As the EIA reports, “Only one independent trader in California controls enough storage capacity to unload an entire gasoline tanker”.[10] If the owners of the storage capacity are unwilling to make their capacity available to importers at competitive prices, this further restricts the elasticity of import supply into California.

The addition of new storage is hindered by an extensive permitting process (up to 3 years according to an estimate reported by EIA) and local political resistance. The EIA paints a rather pessimistic picture, citing a mismatch between the commercial needs of traders, who would prefer short-term storage arrangements and the financial needs of potential investors in storage capacity who would prefer long-term commitments by their customers. The difficulties in bringing new storage into the market are compounded by the fact that, to be economic, storage facilities need to have access to the distribution network. This restricts the possible options for locating storage facilities. The space devoted to the storage of bulk liquids at the ports of Los Angeles and Long Beach has been reduced in favor of infrastructure dedicated to handling container cargo.

However, there are many recent indications that market conditions have indeed stimulated entry into the storage business. Stillwater Associates reports that 1.4 MM bbl of “clean product” (including gasoline, blending components, jet fuel, and ethanol) have been added during 2003 and 2004, and that another 1.1 MM bbl of capacity is in the planning stages.[11] The ownership of this new capacity is divided amongst refiners, terminal operators and traders, but a large portion (about 800,000 bbl) is owned by refiners. Stillwater also notes that all of the current additions made use of existing permits, so the system for permitting new tankage capacity remains untested.

It is also important to note that the firms that control access to the distribution network may also have a financial incentive to discourage the development of new storage capacity. To gain access to the distribution network, a firm needs to either site their storage capacity at or near terminal or port facilities, and gain pipeline access to terminal facilities. However, most of the firms in a position to grant either pipeline or onsite access to terminal and port facilities are large players in either the storage business, the refining business, or both.

The regulations in this area are somewhat ambiguous. Although pipeline rates are regulated by FERC, other related activities by pipeline companies - such as the operation of storage tank farms - may be allowed market-based prices. It is clear that the value of these unregulated storage assets could be reduced by the introduction of additional, competitive tankage facilities. However, for those new facilities to be viable competitors they must have access to the rest of the distribution system. In many cases this means they require a pipeline connection. In recent

[10] Energy Information Administration (2003)
[11] Stillwater Associates (2003)

cases, the FERC, has determined that it does not have the authority to compel a pipeline to extend existing facilities or make particular physical connections.[12] To the extent that the inability to interconnect with the rest of the distribution system constitutes a barrier to entry, the ability of some firms with a strategic interest in preventing entry to do so is a potential concern going forward that could restrict storage activities.

4. Market Power and Imports

We have thus far treated California gasoline as a closed market. While that is true in the very short run, there are some refiners outside California that are able to produce CARBOB, the refined product to which ethanol is added to produce fuel that meets the California standard. These refiners can deliver supplies to California with a lag of 2-5 weeks. In the longer run, consistently high prices for California gasoline will incent firms outside the state to retrofit their refineries to be able to meet the CaRFG standard.

While imports can mitigate high prices, in the gasoline business, their impact is reduced due to both the cost of transporting gasoline and the long time lag relative to the time frame in which prices can change. To see the impact of these constraints, it is useful to first examine the market if imports did not face them.

If imports could be moved costlessly and without delay, they would obviously be considered part of the same market. Markets that could exchange product in this way would essentially be merged. In that case, the discussions of section 2 and 3 would apply to the merged market. Such a larger market would generally result in less market power.

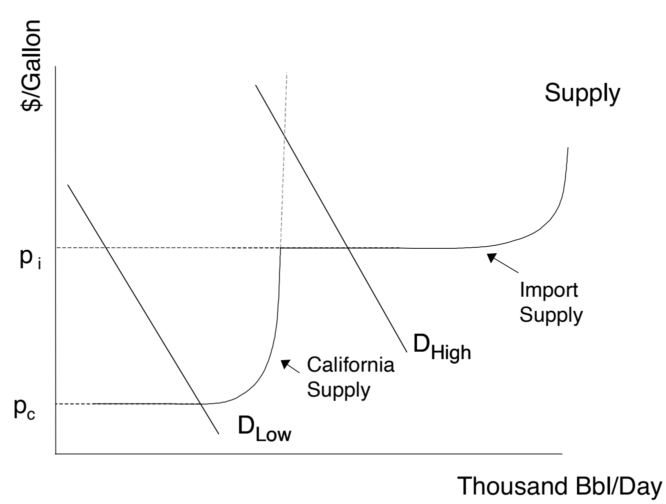


Figure 4.1: Market Equilibrium with Imports

[12] See FERC, "Order Dismissing Complaint," Docket No. OR03-4-000, September 11, 2003.

Incorporating the transport cost effect changes the scenario and weakens the ability of imports to discipline efforts to exercise market power. Consider first the effect of imports in the absence of market power. The in-state competitive supply function would be as shown in figure 2.2b.[13] If there were a supply of imports with similar production costs as in-state, but an additional transport cost of t, then the competitive supply curve would be as shown in Figure 4.1. If price rose sufficiently in California, it would become economic to bring in imports. If demand were low enough, the market would clear with only in-state supplies and the market clearing price would be p_c. If demand shifted out far enough, then the market would clear with imports on the margin and the market price would increase by t.

Once this market dynamic is understood for a competitive market with imports, it is straightforward to see how market power is altered by the possibility of imports. In section 2, if a firm restricted its output when other firms were at capacity, price had to rise sufficiently to ration back demand to the constrained supply. The same effect occurs with imports, but supply can now also play a role if price rises high enough to make imports economic. If transport costs are low and imports are potentially abundant, then market power would be used only to raise price slightly, to the level at which imports become economic. If transport costs are large, however, this would not provide much protection against market power.

Note that the threshold at which imports enter the market would be associated with a significant price spike whether or not any in-state producer is exercising market power. Such a spike could occur in a completely competitive market or if one or more firms restrict output sufficiently to force the market to clear at the cost of imported product. As discussed at greater length in the next section, this is indicative of the problems associated with regulatory controls on gasoline prices.

This static model of markets with imports ignores the second critical characteristic: long time lags in delivery. Unlike electricity, which is transported instantly, or pipelines, which can change the quantity delivered very rapidly, imports of gasoline by barge or tanker cannot adjust quickly. This is not a problem caused by infrequent imports that would be solved if the state relied on a steady supply of imports. Even if the state had a tanker arriving every day with gasoline, if there was a need to a change the delivered quantity, the increased (or decreased) quantity generally couldn't begin arriving for many weeks, because the change in quantity would first have to be implemented at the exporting location.

The result of these lags is that imports have a very low elasticity in the very short run, *i.e.* less than the time for a tanker to fill and sail to California. Even over the time period during which import quantities can arrive, they face significant risk due to the time lag. A decision to bring gasoline to California based on high prices in the state

[13] We ignore storage effects here. Including storage does not change the basic analysis, though it would add complexity.

at one point in time could turn out to result in large losses if prices drop during the weeks between the decision and the actual arrival of the gasoline.

These difficulties in the timing of imports exist even when the market is completely competitive, but they can be exacerbated if an in-state producer has market power. First, changes in import quantities do not discipline market power over a few-week period, because imports cannot effectively be adjusted during that period. In addition, if an in-state seller with market power is aware of the timing of import deliveries, that seller can systematically raise prices for short periods before additional imports arrive and then lower them sufficiently when those imports do arrive to make the additional imports unprofitable. This would be a form of economic predation, but would probably not be prosecuted under current interpretations of U.S. antitrust laws, because the in-state firm would not have to price below its own costs in order to impose losses on the importer.

If an in-state firm pursued such a strategy of inducing large price spikes for short periods and then significantly lowering prices when imports arrived, it could possibly discourage importers, who might then not respond to price spikes by increasing imports. Without the import threat, the in-state firm might be able to maintain its market power for longer periods.

Buyers might respond to this problem by contracting with importers in order to mitigate the importers' price risk. The problem with this response is that the buyer would likely be a retailer who would still have to sell the gasoline, competing with other sellers who would be buying at the spot wholesale price. Thus, if the in-state refiner depressed spot wholesale prices, the buyer of the imported gasoline would still lose money on the deal.

It is not clear that in-state refiners with the market shares we observe in California would find it in their interest to sacrifice some short-run profits in order to discourage import response to price spikes. It would depend on the degree of market power firms could exercise absent imports and the magnitude of profits they would have to sacrifice before importers would stop or reduce their response to price spikes. Still, this discussion points out that the transportation costs and time lags that importers face limit their ability to discipline exercise of market power by in-state producers.

5. Prosecution, Regulation and Alternate Policy Responses

It seems likely that the larger refiners and possibly some other players in California's gasoline market have an incentive to exercise market power. An understandable policy reaction to this reality is to advocate legal or regulatory action to prevent firms from abusing their positions. For a number of reasons, however, such responses are probably more likely to do harm than to benefit consumers.

First, it is extremely difficult to distinguish between market power and true scarcity in gasoline markets. Refiners attempt to solve very complex engineering and forecasting problems in order to determine how much oil to refine and what mix of products to produce in the refining process. Absent “smoking gun” documents, similar to those that appeared in some of the electricity investigations, determining whether a refiner has exercised market power requires solving those same complex engineering and forecasting problems for a refiner that does not exercise market power. This would require understanding the capabilities of the refinery, which are multi-product, multi-technology processes. It would also require replicating the dynamic product allocation and demand forecasts that the refiners use to determine the quantity and mix of products. In the end, if an outside party produced a competitive counter-factual production level and argued that the company's failure to meet that production level indicated market power, the company could easily respond by saying that their own beliefs about refinery costs and capabilities, and demand forecasts were simply different from those of the outside investigator.

Second, possibly the most likely manifestation of market power would not be detected by such an investigation even if it could be done reliably. A refiner in California with market power will have less incentive to invest in expansion of production capability. This includes not just the incentive to build a new refinery, but also the incentive to improve production processes in order to be able to squeeze more output from a refinery's existing footprint. Again, absent internal documents that explicitly credit a business decision to the desire to exercise market power, it would be extremely difficult to second-guess a company's decision not to add additional processing units to an existing refinery or not to begin the lengthy and difficult process of obtaining clearance to build a new refinery.

Third, unilateral exercise of market power is not illegal under U.S. antitrust laws. A legal response to a showing of unilateral exercise of market power would have to rely on state laws. It has been suggested that laws requiring fair business practices could be used to prosecute firms that exercise market power, but these laws have not as yet been used successfully against electricity generators, where the cases are much more clear cut. U.S. antitrust laws do forbid collusive action by unaffiliated firms in the same market, but proving collusion without “smoking gun” documents is extremely difficult.[14]

It might be possible to respond with gasoline price regulation rather than legal prosecution, but that would still raise a fourth issue: the costs of mistaking scarcity-induced price spikes for market power and forcing price below the competitive level would probably far outweigh the benefits that would accrue from reducing market power. As was made clear in the 1970s, regulating gasoline prices to below

[14] See Borenstein (2004) for a discussion of a price-fixing case against U.S. airlines that demonstrated how difficult it is to prove such a case on circumstantial and economic evidence.

competitive levels will cause shortages that will lead to rationing, possibly through government allocation processes and possibly through queuing.[15]

Comparing California prices to those in the rest of the U.S., and accounting for the higher cost of producing CaRFG gasoline, it is clear that up through 2003 the degree to which gasoline prices have exceeded competitive levels almost certainly averaged less than 10 cents/gallon. For a family with two cars using a typical 1000 gallons/year, this would be less than $100/year. It would not take many gas lines or much inconvenience in purchasing or availability of gasoline for that family to be better off without intervention.

Still, California's demand continues to grow and in-state supply is unlikely to keep up from the existing refineries. As the market tightens, the incentives of sellers to exercise market power will increase and the actual market power problem could greatly exceed the levels we have observed in the last few years. The State should take action now to try to assure more supply and a more competitive gasoline market.

Implied in this approach is the need to move the focus away from price *spikes* and towards high average prices. Price spikes are annoying to customers and draw media attention, but the real detrimental economic impact of gasoline prices is in the long-term increase, not in volatility. While California gasoline prices have been volatile since the switch to CaRFG in 1996, the average price has exceeded the U.S. average by an amount approximately cover the additional long-run costs of CaRFG. If customers had ignored price volatility during 1996-2003 and just made their auto, gasoline and driving decisions based on the long-term average price, they would have been only slightly worse off than customers using conventional gas, and most of the difference could fairly be attributed to CaRFG production costs. The real threat in California's gasoline market is indicated by the fact that California gasoline prices have recently exceeded U.S. averages by an amount that is much greater than the cost differential, and that this phenomenon of higher average prices is likely to worsen in the next few years.

Beyond prosecution and price regulation, a number of proposals have been suggested to increase supply and competition. Each would require a much more detailed study to analyze completely. In the remainder of this section, we comment on each proposal briefly and explain how such proposal might impact the exercise of market power.

---

[15] In the 1970s, the state resorted to ``even-odd'' rationing: cars with license plates ending in an even number could be fueled only on even-numbered days and with plates ending in odd numbers could only be fueled on odd-numbered days. It reduced the gas lines, but caused a different inconvenience and was still met with widespread complaints.

- ***Strategic Fuel Reserve:***

The idea of a state controlled inventory of CaRFG gasoline has been debated at length. It is a difficult policy to justify if there are not significant identifiable barriers to entry in the fuel storage market. Some of the motivation for an SFR might also stem from the excessive focus on price spikes we just mentioned. Still, if there are barriers to competitive entry in storage that cannot be addressed directly, then state-owned storage may be used to dampen *inefficient* price fluctuations. By inefficient fluctuations, we mean volatility that would not occur if entry into storage were not impeded. This inefficient volatility could occur even absent market power in storage or refining, resulting simply from insufficient capacity of storage, but it would likely be exacerbated if market power were present in either storage or refining. That said, the argument that there are inefficient barriers to entry in storage remains unproven, though there seem to be valid concerns with regard to the relationship between pipeline ownership and storage ownership. The first recourse for dealing with such problems, however, should be to work to weaken or eliminate the barriers to entry, rather than force the entry of the State into the storage business.

- ***Changing Regulation of Winter/Summer Gas Changeover:***

A frequently-suggested cause of low inventories in California is the regulation of storage tanks at the time of the fuel change between winter and summer gasolines (which differ in RVP). Tanks must be emptied in the spring during the switchover to summer blend. Some have argued that this lowers inventories and makes the market more vulnerable to shocks. While it is true that the state has experienced price spikes during February/March at the time of the changeover, the aggregate inventory data we have seen do not indicate substantial drops in state inventories at that time. If the changeover does induce at least spot shortages in some areas, then an alternative policy that allows gradual changeover might reduce these shortages. As with most of these policies, reducing the frequency of scarcity also reduces the frequency of opportunities to exercise market power.

- ***Fee-Based CaRFG Variance:***

A high price for CaRFG gasoline relative to U.S. RFG or conventional gasoline may be the result of scarcity or market power. Regardless of which is the case, allowing non-CaRFG gasoline to be sold in California after the importer pays a non-CaRFG variance fee (*e.g.* 15¢/gallon) would restrict the difference in prices that could persist. If the difference is due to market power, however, this policy is especially attractive, because it would be likely to limit CaRFG price increases without actually inducing imports of fuels that create greater pollution. The reason is that if withholding of CaRFG gasoline from the market is the cause of the price difference (*i.e.* the price difference is due to market power), then in the presence of a fee-based variance, CaRFG producers with market power would have no incentive to drive the price up to the point that importation of non-CaRFG fuel (inclusive of the non-

CaRFG variance fee) becomes economic. Instead, their optimal strategy would be to produce at least enough to keep the price of CaRFG below the price of non-CaRFG plus the variance fee.

- ***Intervening in Shell Refinery Closure:***

Shell's recent announcement that it will close its Bakersfield refinery has increased concerns about CaRFG gasoline shortages. It is possible that a decline in local oil supply has made the refinery uneconomic on its own. However, the fact that the closure could increase CaRFG gasoline prices, and that Shell has two other California refineries, raises concerns that the refiner's motivation could include market power considerations. It would be very surprising if Shell in evaluating the closure did not consider the impact it would have on the overall profitability of the firm, which necessarily includes the effect on the profitability of its other refineries. Requiring Shell to sell the refinery seems, at first, to be the solution to the potential market power motive. The problem is that if Shell is allowed to set the sale price, its chosen price would include the premium resulting from the higher profits it would make if no one purchased it and the plant instead closed. On the other hand, if the State attempted to use its powers to take over the refinery, paying Shell less than its asking price, it is not clear how that price should be set. The compensation should, from a social welfare perspective, cover Shell's opportunity cost of the facility, but that would be a difficult number to calculate. To the extent that the State intervenes to keep operating a refinery that is truly uneconomic (absent any market power effect), it is subsidizing an inefficient competitor in the market, which is likely to reduce the long-run efficiency of the gasoline market.

- ***State Participation in Long-Term Gasoline Markets:***

The state of California is a significant consumer in the gasoline market, accounting for nearly 2% of gasoline demand. There have been a number of proposals for the state to make its purchases in ways that help to foster a more competitive market. One barrier to market participation by some potential entrants is the risk associated with importing CaRFG gasoline from distant locations. So, some have suggested that the State could purchase its fuel requirements through forward contracts in order to increase the volume in forward markets for gasoline and allow sellers in those markets to hedge their risk. This policy might actually reduce the volatility of the State's gasoline costs while at the same time increasing the number of potential competitors. Careful implementation would be necessary to assure that the State was only reducing volatility, not subsidizing new entrants on average, but this approach does seem to offer significant promise. During price spikes, if they are caused or exacerbated by market power, the State's willingness to lock in a purchase price a month in advance might allow it to undermine potential attempts by in-state sellers to discourage importers by pushing down prices when imported shipments arrive.

6. Conclusion

Most of the economic analyses of California's gasoline market have attributed higher prices to costs or scarcity, while many in the general population and press have suspected "gouging." While explanations for the State's high gas prices can be constructed based entirely on assumptions of competitive markets, these are not the only possible explanations. In fact, as California's gasoline market continues to tighten, the result will be *both* greater price premiums due to real scarcity and the potential for greater premiums due to the ability of some firms to exercise market power. We have presented the theoretical foundations for an analysis of market power in California gasoline and have shown that such explanations are consistent with the basic facts of the market.

Many of the "solutions" to the State's gasoline problem are similar regardless of whether the high prices are due to real scarcity or market power. The impacts one would expect, however, are not necessarily the same. If market power is the primary driver of price premia in the future (which does not seem to have been the case in most of the period since the introduction of CaRFG), then it will be critical for analysis of policy options to include a recognition of the effects on market power.

References

Borenstein, Severin. "Rapid Communication and Price Fixing: The Airline Tariff Publishing Company Case," in John E. Kwoka and Lawrence J. White eds., *The Antitrust Revolution: The Role of Economics*, Oxford University Press, 4th Edition, 2003.

Dahl, C.A. and Sterner, T., 1991. Analyzing Gasoline Demand Elasticities: A Survey. *Energy Economics* 13(3), 203-210.

Energy Information Administration. U.S. Department of Energy (2003) *2003 California Gasoline Price Study*

Kayser, Hilke A., 2000. Gasoline Demand and Car Choice: Estimating Gasoline Demand Using Household Information. *Energy Economics* 22(3), 331-348.

Stillwater Associates, presentation at the California Strategic Fuel Reserve public workshop, CEC, April 24, 2003.

Stillwater Associates, 2002. “California Strategic Fuels Reserve”, report prepared for the California Energy Commission. March 2002.