

RETAIL GASOLINE MARKETS

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ABSTRACT

In this chapter, a survey of the recent literature on retail gasoline markets is presented. Over a hundred papers explore static and dynamic pricing models and the determinants of gasoline price levels and price dispersion. Price phenomena like “rockets and feathers” and Edgeworth price cycles have received particular attention. Retail gasoline prices and firm behavior in both an antitrust context, e.g. merger and cartel studies, and in a regulatory context, e.g. sales-below-cost and divorcement laws, among others, are also explored. A discussion of the recent transformation in the structure of gasoline retailing, and fruitful areas for future research, concludes the chapter.

1 INTRODUCTION

Retail gasoline is one of the most studied retail markets and for good reason. From a policy perspective, gasoline and other fuel purchases represent a significant portion of many consumers’ budgets. Gasoline demand is inelastic – very inelastic in the short run – so price increases can have significant effects on consumers’ disposable incomes and, because gasoline is a key input in production, put upward pressure on prices of other consumer goods in the economy.

It is not uncommon during periods of rising prices to hear calls from consumers and Congress for investigations as to why prices are rising and whether anti-competitive behavior is

behind it. Former Federal Trade Commission (FTC) Commissioner William Kovacic recently said in a speech he counted 40 investigations into the petroleum industry in just the past 30 years alone (Wait (2011)). The FTC now monitors oil and gasoline price data and reports its findings to Congress biannually. It is yet to uncover any widespread wrongdoing in the U.S. Many states have responded to the general concern with their own sets of laws that limit what prices stations can set, such as sales-below-cost laws, divorcement laws and so-called price gouging laws.

In light of all these concerns, economists have written extensively on gasoline price competition. They have studied the causes and effects of gasoline price dynamics and gasoline price dispersion, as well as the effects on gasoline prices resulting from state laws and regulations, taxes, mergers and, in rare cases, from collusion. They have looked at ownership choice and the effects of that choice, consumer sensitivity to price changes, and a myriad of other questions.

Two unusual types of retail gasoline pricing dynamics have piqued special attention – the “rockets and feathers” phenomenon – in which prices rise more quickly after a cost increase than they fall after a cost decrease – and the Edgeworth price cycles phenomenon – in which prices in some areas rise and fall in a rapid sawtooth pattern, largely independent of costs.

The excellent and relatively recent availability of high quality price data has made it possible for researchers to conduct many studies on a wide range of questions in retail gasoline pricing not before possible. Researchers can now obtain high-frequency price data on a daily or hourly basis or, in some cases, up to the minute, and on a station by station basis. Station location data is also readily available for spatial analysis. The one continuing data limitation is the lack of station-specific volume data at a similar frequency to match the price data. Should

matching volume data ever become widely available, it would open up yet another new avenue for insights into retail gasoline competition. In the meantime, most research studies focus on prices alone.

More than a hundred research studies addressing retail gasoline markets have been published in the past few decades. The collective findings of the literature tell a complicated but important story. They help economists and policymakers understand gasoline price dynamics and help separate the fact from the fiction when it comes to how prices are set.

This chapter surveys the recent literature on retail gasoline markets. Sections 2 and 3 focus on two specific pricing patterns that have generated particular interest – the “rockets and feathers” phenomenon and the Edgeworth price cycles phenomenon. Section 4 looks at pricing and price dispersion more generally outside those contexts. Section 5 discusses price fixing, mergers, and other combinations, and Section 6 looks at various laws that regulate gasoline pricing. Section 7 deals with the recent transformation of the gasoline retailing market, and Section 8 examines vertical relationships and other topics. Section 9 concludes.

2 ROCKETS AND FEATHERS

One of the more popular areas of research is the so-called “rockets and feathers” phenomenon. This is the notion that when oil prices rise, gasoline prices rise quickly – like a rocket – but when oil prices fall, gasoline prices fall slowly – like a feather.² Many papers have been written on the topic using different methodologies, different geographies, and different degrees of data frequency, all in search of price response asymmetry. Some papers look only to document its existence while others attempt to explain its causes.

Most papers in this strand of the literature use a form of error-correction vector autoregressive model which allows positive and negative shocks to upstream prices to asymmetrically affect downstream prices. The models also allow for different rates of return to the long run steady state markup after a shock. Some early papers (Karrenbrock (1991) and Duffy-Deno (1991)) were criticized for lacking an error correction term, with nothing bringing the market back to a long run steady state margin. Repeated but offsetting shocks would yield permanent markup changes. Other early papers incorporated error correction but relied on specific functional forms (e.g. adding quadratic terms) to generate asymmetry (Bacon (1991) and Shin (1994)).

An early and influential paper on the topic is Borenstein, Cameron, and Gilbert (1997). They use weekly U.S. data and a flexible error correction model to find the Rockets and Feathers effect present in regular grade gasoline at the crude-to-spot transmission level and at the wholesale-to-retail level. They suggest tacit collusion and asymmetries in consumer search intensity as possible explanations for the asymmetry at the wholesale-to-retail level. Bachmeier and Griffin (2003) caution that the results are sensitive to the frequency of data employed and to small differences in the specification of the error correction model. Bettendorf et al. (2003) come to a similar conclusion for the Netherlands.

Results from the literature as a whole are mixed, including among papers using a similar set of cities and time period. A sampling of papers, looking at different countries and time periods, include Manning (1991) and Reilly and Witt (1998) for the U.K.; Kirschgassner and Kubler (1992) for Germany; Balke et al. (1998), Al-Gudhea et al. (2007), Davis (2010), and Chesnes (2012) for the U.S.; Godby et al. (2000) for Canada, Asplund et al. (2000) for Sweden; and Galeotti et al. (2003) for Europe as a whole. Some degree of rockets and feathers is found more often than not, and the extent varies widely.

More of the recent papers focus not only on identifying rockets and feathers but also on testing its potential causes. The consumer search hypothesis has found support in Lewis (2011) and Lewis and Marvel (2011).³ Lewis (2011) presents a reference price model in which rising costs force prices to rise and triggers consumer search, but falling costs do not immediately force prices to fall and do not trigger search. In the latter case, consumers are still expecting the high price, are happy if they stumble across a lower one, but do not search as actively. He finds the Rockets and Feathers effect in Southern California, and shows that, controlling for high or low margins, the asymmetry goes away, consistent with his search model explanation. Lewis and Marvel (2011) measure search intensity more directly using traffic statistics from gas price websites and show that consumers in fact do search more when prices are rising than when prices are falling. Yang and Ye (2008), Tappata (2009), and Cabral and Fishman (2012) present alternate theoretical search models to explain Rockets and Feathers, incorporating rational expectations, multiple consumer types, heterogeneous cost shocks, and other features and in each case show how changing costs can lead to differences in search intensity and ultimately to Rockets and Feathers.

The market power story has also found some support. Deltas (2008) finds more asymmetry in U.S. markets where margins are high, while Verlinda (2008) observes more asymmetry in local Southern Californian neighborhoods where stations are less densely situated. Radchenko (2005) finds more asymmetry when oil prices are less volatile and argues, absent a theoretical model, that his finding is consistent with a market power story. In a study of Santiago, Chile, Balmaceda and Soruco (2008) argue that greater asymmetry at high-margin branded stations than low-margin unbranded ones is probably outright collusion, since they argue collusion should more easily be sustained at branded stations.

An interesting presumption in some Rockets and Feathers studies is that the asymmetry necessarily imposes a cost on consumers. Borenstein et al. (1997) calculate the consumer cost due to Rockets and Feathers from a pair of 1 cent price changes – one increase and one decrease – to be 2.6 cents per gallon. Balmaceda and Soruco (2008) calculate it as 2.3 cents per gallon.

However, it remains unclear whether rockets and feathers entails any real cost at all. Obviously, if the asymmetry were due to outright collusion, there is a clear policy response. If instead it is merely the result of some local market power from spatial or quality differentiation in a free-entry market, or the result of differential search behavior by consumers, Rockets and Feathers may not be a problem in need of a solution.

The confusion lies in the counterfactual – what would happen in the absence of Rockets and Feathers. The calculations and arguments implicitly assume there would either be no cost changes at all, or that price responses to cost changes would be symmetric. The former case represents a wholly unrealistic world inappropriate to use as a counterfactual in the first place. The latter case assumes symmetry and that prices would instead fall as fast as they rose absent the asymmetric “behavior.” But why?

Imagine a competitive market with free entry and exit. Now assume, unrealistically, the first counterfactual is true – that there would be no cost (e.g., wholesale price) changes at all. The calculations referenced above would seem to imply that, absent cost changes, margins would fall overall. But in a competitive market with free entry and exit and fixed costs that need to be covered, the reduction in overall margins would induce exit until margins returned to break-even or competitive levels. Margins in the new cost-stable world would need to be higher than they were during past periods of cost stability, to compensate for the fact there are no

more high-margin “feathers” periods. Otherwise, firms would not maintain overall profitability and stations would exit until stable and symmetric margins are high enough to earn the necessary rate of return.

Now assume more realistically there are cost changes but that price responses are symmetric. The usual assumption is that prices would now fall as fast during the feathers periods as they rise during the rockets periods.⁴ However, if margins are actually at competitive levels already, this would drive profits negative and induce exit. It is well known that station operators will readily admit they earn their money “on the way down” and earn little “on the way up” (Brewer, Nelson, and Overstreet (2014)). The reality is that if retail margins are very thin on the way up (sometimes negative), and now are very thin (or negative) on the way down, this would not be sustainable and exit would occur. Thus, the argument that Rockets and Feathers are harmful is circular, “proving” anti-competitive effects by assuming an anti-competitive world.

It is easy to see the disconnect with the following analogy. Imagine imperfectly competitive sellers have some ability to price discriminate between two consumers – an elastic consumer and an inelastic consumer. They also have substantial fixed costs. Given each consumer’s demand curve, a seller charges \$10 to the elastic consumer and \$20 to the inelastic consumer. Its revenues are \$500 and it just covers the \$500 fixed cost. Assume the seller is now prohibited from price discriminating. Is it likely the seller will now choose a price of \$10 to both consumers? No, of course not. Such a price would not be profit maximizing and would actually lead to negative profits. Standard theory teaches that an intermediate uniform price (e.g. \$15) is the more likely outcome.

Now return to the Rockets and Feathers story and imagine the search story is correct. Firms are essentially price discriminating between two groups of consumers – an elastic group and an inelastic group. As expected, there are higher margins to the inelastic group, lower margins to the elastic group. What is interesting is that these groups consist of the same people. When prices are rising, consumers search more and as a group act more elastically. When prices are falling, consumers search less and as a group act more inelastically. Equilibrium prices differ accordingly – yielding a higher margin when prices fall, a lower one when prices rise.

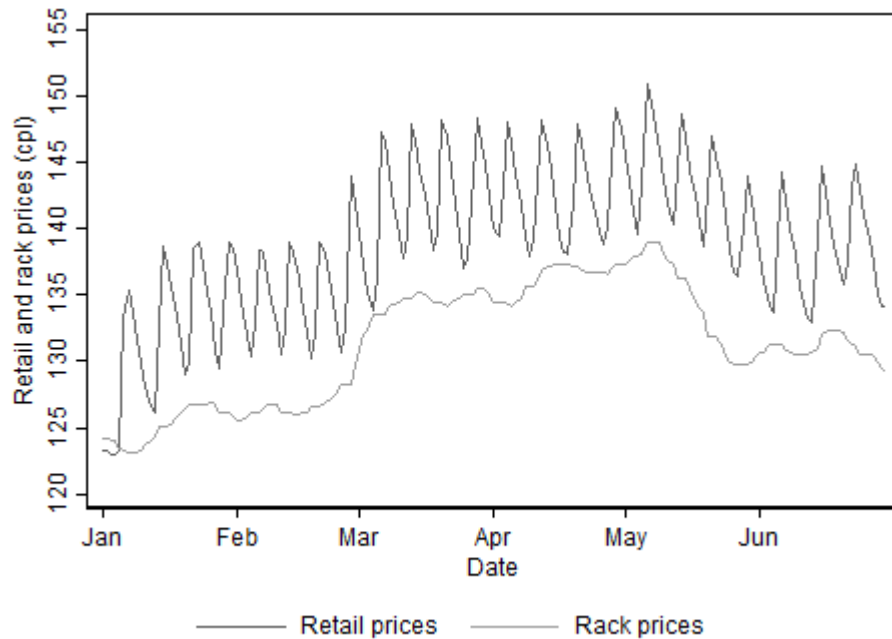
If symmetry were somehow forced on firms, one realistic outcome would be that the new stable margins would be intermediate, somewhere above rockets margins and below feathers margins. Overall margins may not change, or even increase since firms are no longer pricing optimally in each period. Little work has been done to ascertain whether Rockets and Feathers represents any kind of welfare loss at all. For individual consumers, it may mean nothing more than paying a little more on one day and a little less on another.

Asymmetry due to Rockets and Feathers is related, yet conceptually different, to another asymmetric phenomenon which has received attention, known as Edgeworth price cycles. Edgeworth price cycles are discussed next, followed by a discussion of articles examining the subtle interaction between Edgeworth price cycles and Rockets and Feathers.

3 EDGEWORTH PRICE CYCLES

Edgeworth price cycles are best described with a picture. Figure 1 shows an example of Edgeworth price cycles in the city of Melbourne, Australia, in 2011. The distinctive sawtooth pattern in the price is clear.

Figure 1. Retail and Rack Prices for Gasoline in Melbourne, Australia, January-June 2011



In an Edgeworth price cycle, firms undercut one another by small amounts each day until retail prices fall close to cost. Then one firm raises its price substantially, other firms follow within a few days or even a few hours, and another round of undercutting begins. The cycle repeats itself.

Asymmetric price cycles such as those in Figure 1 have been detected a large number of retail gasoline markets in the U.S., Canada, Australia and several European countries.⁵ Amplitudes and periods vary, but a typical amplitude is eight to ten percent of the price. Periods are most commonly weekly, but can be as long as monthly and as short as daily. Once cycling has started in a market, it typically persists for a long time, often decades.

Retail gasoline cycles in the United States were first noted by Allvine and Patterson (1974) occurring in the late 1960s and early 1970s in several U.S. cities. In Los Angeles, a single cycle lasted one to two months and had an amplitude of roughly 25%. The cycles came to a halt

when large oil companies discontinued their price support programs to branded dealers. They then reappeared in dozens of cities in the U.S. Midwest in 2000 (Zimmerman, Yun, and Taylor (2013)). The cycle period was weekly in most cities but biweekly in a few (Lewis and Noel (2011)) with amplitudes of about 8%. In Canada, most large and many medium-sized Canadian cities experienced price cycles from at least the late 1980s through to the mid-2000s, at weekly or monthly frequencies (Noel (2007a)). By the mid-2000s, the cycles sped up to a daily period in many cities, with price changes three or four times a day, and then stopped in some Canadian cities altogether in 2007 (Atkinson, Eckert, and West (2014)). The five major cities in Australia and many smaller ones have experienced cycles, with occasional breaks, since at least the 1980s. Cycles in Norway have generally been weekly (Foros and Steen (2013)) while cycles in Germany were as long as weekly but gradually shortened to a period of just a few days over the 2000s.

The theoretical notion of an Edgeworth price cycle dates back to Edgeworth (1925) and was formalized by Maskin and Tirole (1988) as the outcome of a dynamic oligopoly game. Maskin and Tirole assume a symmetric Bertrand duopoly, in which homogeneous-goods firms set prices in an alternating fashion. They restrict their attention to Markov strategies, i.e. strategies that depend only on the payoff relevant state (cost, demand, and the price of the other firm still in effect). They show two sets of Markov Perfect Equilibria are possible under the same demand conditions -- focal price equilibria and "Edgeworth price cycle" equilibria. The latter produces a time path of prices similar to Figure 1.

Castanias and Johnson (1993) were first to note the visual similarity of the retail gasoline price cycles in U.S. cities in the 1960s and 1970s with the theoretical cycles of Maskin and Tirole. While striking, formally testing the Edgeworth price cycle theory remained difficult because of a

lack of testable predictions beyond noting the basic sawtooth shape. The theory was restricted to a simple, symmetric, homogeneous Bertrand duopoly.

Several articles extended the theory to generate testable predictions that could be used to test the applicability of the theory to the empirical cycles. Eckert (2003) allows firms to split the market unevenly when prices were equal—with the “larger” firm getting the larger share at equal prices. The key prediction is that Edgeworth price cycles were more likely with more asymmetric firms, and that the large firm was more likely to relent to a higher price first while the small firm more likely to undercut first. Noel (2008) extends the model to the case of stochastic marginal costs, capacity constraints, product differentiation, and other kinds of asymmetric equilibria. He shows that stochastic cost shocks do not destabilize the cycles, and that cycles are robust to mild (but not strong) differentiation and to mild (but not strong) capacity constraints. Demand levels, elasticities, and discount factors do not destabilize the cycles either but do influence their shape – periodicity, amplitude, and asymmetry — in testable ways. Also, cycles are not restricted to duopoly situations but are feasible under triopoly, but with new challenges that did not exist in the duopoly model. In particular, “false starts” can occur when the first firm to raise price abandons its increase if others do not follow soon enough.

The predictions of the extended Edgeworth price cycle models were largely borne out by the data. The first full length papers focused on Canadian markets. Eckert (2003) finds that price volatility was greater in Canadian cities that had more independent firm presence. Noel (2007a) shows that asymmetric price cycles specifically were more likely with a greater share of independent firms, the opposite of what one would expect in a collusion story. He also shows that the cycles were faster, taller, and less asymmetric with more competition. Byrne and Leslie

(2013) revisit Canadian cycles after cycles had ceased in a number of large cities in 2007 and conclude they are most common in moderately concentrated markets.⁶

Other papers use station specific data. Noel (2007b) finds that large firms in Toronto, Canada, are more likely to initiate price increases and independents more likely to initiate undercutting, as predicted by the model. Looking at Guelph, Canada, Atkinson (2009) and Atkinson, Eckert, and West (2009) reach similar conclusions with two-hourly data. Notably, the empirical false starts predicted by Noel (2008) are observable in the two hourly Guelph data. The same sets of conclusions in a larger cross-section of smaller Canadian cities and towns are reported by Byrne, Leslie and Ware (2013).

Lewis (2009) and Lewis (2012) first examine the cycles in the Midwest U.S. An interesting result from these papers is that while firms initiating price increases need a large presence to do so, they do not have to be integrated refiner-retailers. Relenting phases in the U.S. are generally initiated by two large independent chains, and a market share of 8% appears sufficient. Doyle, Muehlegger, and Samphantharak (2010) divide independents into two groups and find U.S. cycles are more likely where there are more large independents, in contrast to “mom and pop” operations, and where attached convenience stores are more common.

The first papers looking at Australian markets are Wang (2009a) and Wang (2009b). While most large cities in Australia experience cycles, Wang focuses on Perth where a state regulation known as FuelWatch requires firms to report their prices to the regulator one day in advance of going into effect. The reporting and simultaneous posting of prices by the regulator online creates in effect simultaneous price changes each morning. Wang (2009b) exploits this simultaneity feature to show that major firms BP, Caltex, and Mobil play mixed strategies, consistent with the Edgeworth price cycles model.⁷ Additional support for the model is given in

Wang (2009a), which estimates own price elasticities at cycling stations in the range of -5.6 to -20.4. In another paper on Perth, Bloch and Wills-Johnson (2010) use a node network model of competition to argue that the rate of undercutting varies, with faster undercutting among stations with stronger network links.

Not all authors reach the same conclusion. De Roos and Katayama (2010) and De Roos and Katayama (2013) reexamine the Perth cycles and argue they are potentially collusive rather than competitive in nature.⁸ They claim that the Maskin and Tirole Edgeworth price cycle theory can be trivially ruled out since most stations in Perth change prices on most days, and do not decrease price sequentially one station at a time as in the original Maskin and Tirole model. Foros and Steen (2008) and Foros and Steen (2013) express reservations about the underlying causes of cycles in Norway. As with most Australian cities prior to 2010, cycles in Norway had an interesting feature – prices would rise on the same day of the week every week. That day was Mondays through mid-2004 and then it changed to Thursdays after. They argue that such timing is “hardly consistent” with Edgeworth price cycles.

Ultimately, the most relevant policy question is whether the presence of cycles is good or bad for prices and welfare. Identifying the effect has been a challenge since cycles tend to persist for decades at a time and generally only cross-market comparisons have been possible.

In an early paper, Noel (2002) finds that prices and margins were about 2.5 cents per liter lower on average in Canadian cities with cycles than those without. Within cities, margins were 1 cent per liter lower with cycles than without. He cautions against a causal interpretation, however – false starts and disrupted cycles are common and what might appear to be a “flat spot” of no cycling may in fact be an integral part of the cycling process itself. This is a possible influence on the Wang (2009b) result that prices were 0.9 to 1.8 cents per liter lower when

cycles appeared to break down during the transitional months following the introduction of FuelWatch. Elsewhere, in another cross sectional comparison, Doyle et al. (2010) report that margins in Midwest U.S. cities with cycles were 1 to 2 cents per gallon lower than in cities without, but caution against a causal interpretation.

The best identification comes from Zimmerman et al. (2013) using panel data for the U.S and Noel (2015) using panel data for Canada. Zimmerman et al. (2013) use data going back prior to the start of the Midwest cycles in 2000, and show in a differences-in-differences estimation that prices fell by 1-3 cents per gallon in cities where cycles started compared to cities that never had them. The one concern is that the start of cycles may have coincided with the expansion of several large independent chains there. The results are consistent with Noel (2015), however, who exploits a natural experiment in Canada. Cycles that had been present in some Canadian cities for decades suddenly stopped after a refinery fire in 2007. When the supply problem was resolved, the cycles never restarted, providing a uniquely exogenous estimate of the effect of Edgeworth price cycles on margins. Price cycles do not lead to higher prices.

Noel (2012) points out an underlying bias inherent in all these price or margin comparison studies that works against finding lower prices with Edgeworth price cycles. Consumers in cycling markets have the option of timing purchases to periods of predictably low prices near the cycle trough and in so doing can routinely pay less than the average (unweighted) price given typically recorded in the data. In contrast, in non-cycling cities, consumers cannot time purchases and have no alternative but to pay the average price. The bias thus tends to work against a finding that Edgeworth price cycles lead to lower prices. The more consumers attempt to time their purchases to cycle troughs, the larger is the bias. The Australian Competition and Consumer Commission (ACCC (2007)), for example, reports that 75%

of Australian consumers were aware of the weekly cycle and 74% of those knew which day of the week was the low price day. Foros and Steen (2008) report that a third of Norwegian consumers were aware of the weekly cycle in Norway in 2006. Noel (2012) and Noel and Chu (2015) confirm that consumers can indeed systematically pay less than the average price when there are cycles, in Canada and Australia, respectively.

Finally, several papers explore the subtle relationship between Edgeworth price cycles and Rockets and Feathers. Recall that Rockets and Feathers refers to an asymmetric response to cost changes and that absent cost changes, prices are flat. In contrast, Edgeworth price cycles creates asymmetric price changes independent of costs so that even if costs are flat, prices are not. The interdependency occurs because a cost increase when margins are already very low can trigger a new relenting or price restoration phase of the cycle and thus create an apparent passthrough rate in the hundreds or thousands of percent. Meanwhile, a cost decrease creates no such dramatic or visible response – it just allows more room for tit-for-tat undercutting. Averaged across all periods, this creates a Rockets and Feathers effect (Eckert (2002)). Noel (2009) demonstrates how to decompose and separately estimate asymmetry due to Edgeworth price cycles and asymmetry due to rockets and feathers, so that both can be quantified.

Lewis and Noel (2011) compare Rockets and Feathers effects, and the speed of response more generally, in cities with and without cycles. They find cost shocks are passed through two to three times faster in cycling cities than non-cycling ones and conclude that cycles help improve market recovery. The result is consistent with Lewis (2009) who demonstrates faster market recovery in cities with cycles than those without in the aftermath of Hurricane Rita.

Edgeworth price cycles continue to be controversial with consumers. They have been the subject of investigations by competition authorities in many countries, including the United

States, Australia, Norway, and Germany. In the United States, the FTC has not taken action but continues to monitor the cycles (FTC (2011)).

4 PRICE LEVELS, PRICE DISPERSION, AND ELASTICITIES

Many studies have examined gasoline pricing outside the context of any particular dynamic pattern such as Rockets and Feathers or Edgeworth price cycles. Studies that examine the determinants of price levels or price dispersion, or studies that estimate gas price elasticities are common.

In early work, Slade (1987) and Slade (1992) estimate best response functions for stations in Vancouver, Canada and compares prices to various competitive equilibria. She finds equilibrium prices in the supergame to be well under monopoly prices but still greater than what they would be if firms played the static Nash equilibrium in every period.

Numerous other studies look at the relationship between prices or margins and market concentration. For example, Shepard (1993) and Barron, Umbeck and Taylor (2004) both conclude that greater station density leads to lower prices, for Boston and the Southwest U.S. respectively. Sen (2005) similarly shows that more independents result in lower prices in Canadian cities. Taking a commuter-route-centric approach, Cooper and Jones (2007) concur for Lexington, Kentucky. Another study that focuses on commuting routes is Houde (2012), who concludes that consumers with longer commutes (and more choices) pay less on average.

A series of stylized facts about gas prices are presented in Hosken, McMillan, and Taylor (2008) in their study of Washington, D.C. For example, it appears stations tend not to use simple rules of thumb and that price rankings across stations vary over time. There is also no consistent relationship between prices and local competition or between prices and station attributes

other than the price-brand relationship. This latter results contrasts earlier studies, like Shepard (1991) for Boston, which finds positive relationships between pricing and other attributes such as size, the presence of a convenience store, or a recent renovation.

Many of these and other studies examine the determinants of price dispersion. Barron, Umbeck and Taylor (2004) show that price dispersion is lower when stations are more densely located, and use this finding to support a monopolistic competition story over a search story. Interestingly, Chandra and Tappata (2011) interpret a similar result – that price dispersion among pairs of stations is higher when there is a greater distance among those stations – as evidence in favor of a search story. In the latter study, the authors rely on the observation that price rank reversals are less common for stations that are at the same intersection, compared to those further apart. While Lewis (2008) also concurs in his study of San Diego that price dispersion is greater with lower station density, his result is strongest for independent stations but largely absent for majors.

A few papers search for the so-called long weekend effect in gasoline prices, the claim that stations anti-competitively raise prices just prior to long weekends. Putting aside the obvious question of why it would be objectionable for a station to increase its price in periods of high demand (just compare weekday and weekend hotel prices in Las Vegas), no such effect is generally found (e.g. Erutku (2007)).

One of the oldest strands in the literature estimates aggregate demand elasticities for gasoline, in the short and long run. The tradition continues with new updates from time to time (Nicol (2003), Hughes, Knittel, and Sperling (2008), Brons et al. (2008), Lin and Prince (2013)). Studies generally agree that aggregate elasticities of demand are, of course, quite low and lower

in the short run than the long run. Hughes, Knittel, and Sperling (2008) present evidence that short run elasticities have been decreasing over time, and were close to zero by the early 2000s.

While aggregate demand elasticities are estimable with fairly aggregate price and volume data, few papers have been able to calculate price elasticities at the retail station level since high frequency volume data is difficult to obtain. Exceptions include Wang (2009a), discussed above, and Barron, Umbeck, and Waddell (2008). The latter study is unique in that the authors were able to take control of pricing decisions, within limits, at a Southern California retail gasoline chain. By exogenously and randomly increasing or decreasing price by two cents (or leaving it unchanged) from the station's suggested price, they cleanly estimate elasticities in the range of -3 to -6 in the short run, with higher elasticities in higher density areas. The authors show that the greater the station density, the *smaller* will be each competitors' price response to an exogenous price change by the controlled station.

Another series of papers look at the passthrough rate and incidence of excise taxes into retail prices. Manuszak and Moul (2009) exploit changes in taxes on the Illinois-Indiana border to find that consumers are willing to travel an additional mile to save 6-8 cents on a gallon of gasoline. Doyle and Samphantharak (2008) use exogenous changes in tax rates in Illinois and Indiana to show that 70-100% of tax changes were passed through to retail prices. Similarly, Barron, Hunt Blanchard, and Umbeck (2004) report that two thirds of the reduction in the excise gas tax in Connecticut during the large price spike in 2000 was passed through to consumers. The same price spike inspired the paper by Bulow, Fischer, Creswell and Taylor (2003) who argued its cause was mainly due to supply pressures from a new blending mandate and not collusion.

Comparing federal and state excise taxes, Chouinard and Perloff (2004) calculate that the incidence of the federal gasoline tax fell equally on consumers and wholesalers, but that state taxes fall almost fully on consumers. In a different split of the data, Li, Linn and Muehlegger (2014) differentiate between changes in excise taxes and changes in tax-exclusive prices and argue that consumers respond more to the former than the latter, attributing the difference to the permanent rather than transitory nature of tax increases.

An unusual situation occurred in 2011 and 2012 when increased production in Alberta and North Dakota led to an oil supply bottleneck in the Midwest U.S. and the price spread between West Texas Intermediate (WTI) and Brent crudes widened to record levels. The downstream effects of this crude bottleneck are explored by Borenstein and Kellogg (2014), who conclude that the lower WTI crude prices were not passed on to consumers but rather the margins of refiners increased.

Throughout the vast majority of literature, the focus is typically on regular grade gasoline, which accounts for 70-90% of total gasoline volumes (depending on the geography). There are a few exceptions, however. For example, in early work, Borenstein (1991) shows that higher margins on unleaded versus leaded gasoline (during the transition away from leaded fuels) may have resulted from price discrimination, as vehicles compatible with unleaded tended to be newer. Setiawan and Sperling (1993) attempt to explain buying choices across regular, midgrade, and premium grades. Interestingly, premium grade (and to a lesser extent midgrade) gasoline is often considered by consumers to be a higher quality fuel, even though there is little engineering evidence to support it. The defining difference between grades is in the octane rating, and vehicles that do not require a higher octane to avoid engine knock do not require nor benefit from premium. The authors conclude that consumers are overbuying midgrade and premium, with a stronger effect for women and higher income individuals, and that they make

this choice based on somewhat vague reasons. Barron, Taylor and Umbeck (2000) add that the premium-regular price gap increases in areas with higher incomes, decreases with distance from competitors, and is larger if midgrade is also offered.

Other work looks at the non-linearity of pricing across all three grades of gasoline (Leach, Sterbenz, and Wermers (2008). Midgrade and premium prices are generally set as fixed differentials over regular, but grade pricing is not linear in octane as one might expect. Although a 50-50 mix of regular and premium grades, midgrade generally sells for more than the average of its two constituent prices.

Noel and Roach (forthcoming) examine the premium-regular grade choice after the introduction of an Australian ethanol mandate. Consumers switched from the ethanol-blended regular grade gasoline to the still ethanol-free premium grade gasoline en masse, to the point that premium grade gasoline became the number one selling grade of gasoline. While the mandate did not affect relative grade prices, consumers who switched paid an additional 12 cpg, or \$150 per year per vehicle to avoid ethanol blended fuel.

In an early paper, Shepard (1991) considers the ability of certain retailers to price discriminate not across fuel grades per se but across station types. She shows that stations that sell both self-serve and full-serve charge similar prices for self-serve gasoline as stations that offer self-serve only, but charge 9 cents per gallon more for full-serve gasoline relative to stations that sell full-serve only. She attributes the difference to local market power.

5 PRICE FIXING, MERGERS, AND OTHER COMBINATIONS

The competitiveness of gasoline prices and the potential for collusion is always a contentious topic with consumers and in the press. Investigations into price fixing at various

levels and in various jurisdictions are routine and usually turn up little, but not always. A recent cartel prosecution in Quebec, Canada, in which several companies and dozens of individuals were found guilty, inspired a series of papers. Erutku and Hildebrand (2010) showed that with the collapse of the cartel came lower prices, but the results were not robust to the choice of control city. In a broader sample of cities, Clark and Houde (2014) show margins fell by 15%-30%. The functioning of the cartel is explored in more detail by Clark and Houde (2013), in particular how cartel members staggered price changes so stronger members attained additional market share. Half a world away, Wang (2008) documents how station operators in an Australian town communicated collective price changes to one another. In an earlier paper, Borenstein and Shepard (1996) test maximum-sustainable-cartel-price model of Haltiwanger and Harrington (1991) and argue that stations across the U.S. were tacitly colluding.

As with other industries, there are often acquisitions in wholesale and retail gasoline markets and there has been a general consolidation of market share over the past several decades. One branch of research performs merger retrospectives to see if those mergers led to higher consumer prices. While every merger is different and must be evaluated on its own merits, the increasing number of merger retrospectives is helpful in understanding the typical or most common price effects of merger activity in the industry. Most retrospectives find no negative impact. Hastings (2004) is an exception – she shows retail prices *increased* about 5 cents per gallon after independent chain Thrifty leased retail sites in Southern California to Arco. Using an alternate data source, Taylor, Kreisle, and Zimmerman (2010) revisit the same event and are unable to find any noteworthy price effects. Other papers that find no harm include Taylor and Hoskin (2007) on the Marathon-Ashland joint venture, Simpson and Taylor (2008) on the Marathon-Ashland-Ultramar merger, Silvia and Taylor (2010) on several refinery mergers in the northeast, and Hosken, Silvia, and Taylor (2011) on several refinery mergers in California. In

Canada, the Sunoco Ultramar merger is reviewed by Houde (2012) who does report a small effect of about half a cent.

6 SALES BELOW COST, DIVORCEMENT, AND PRICE

GOUGING LAWS

Sales-below-cost (SBC) laws are essentially minimum margin laws, in which retail gasoline stations are prohibited from pricing either below cost, or below some positive minimum-margin price. Wisconsin, for example, requires a 6% minimum margin over actual cost or 9.18% over posted rack, whichever is greater (Noel (forthcoming)). Divorcement laws are laws that prevent an upstream refiner from owning or operating retail stations. In each case, the laws are designed to insulate small independents from perceived predatory behavior on the part of the large firms. Price gouging laws are laws that prohibit stations from charging “excessive” or “unreasonable” prices (or similarly vague language) during declared emergencies, for the stated purpose of protecting consumers against opportunistic profiteering.

About half of the U.S. states have some form of SBC law. Several laws have been repealed, including in Kentucky and Georgia, and portions of them have been repealed in other states (Noel 2014). The FTC actively advises states considering new SBC laws to refrain from passing a SBC law due to its protectionist nature (FTC (2002)). Several academic studies have addressed the effects of these laws, and most find they increase prices (e.g. Anderson and Johnson (1999), Brannon (2003)). An exception is Skidmore, Peltier, and Alm (2005) who conclude that SBC laws in the U.S. increase the number of stations and lower prices a penny. In Quebec, Canada, Carranza, Clark and Houde (2013) similarly report the number of stations

increased following the enactment of the SBC and, in spite of a reduction in efficiency, lower prices by 3 cents per liter.

Only a handful of U.S. states have divorcement laws. The laws were originally intended to prevent large integrated oil companies from squeezing independent firms out of the retail business. Interestingly, as integrated oil companies have largely left the downstream market (even though the brand names are still ubiquitous), it is now lower pricing on the part of supermarkets, hypermarkets and other large convenience store chains that is most tempered by the law. Vita (2000) shows that divorcement laws in six states and Washington, D.C. increased prices by about 3 cents per gallon. A similar result is reported by Barron and Umbeck (1984), and is more pronounced for full-service than self-service stations. Station opening hours were also reduced following the introduction of the law. More generally, Shepard (1993) contrasts different forms of ownership and concludes that prices at company operated stations tend to be lower than at their lessee dealer counterparts.

Price gouging is a controversial topic. The term carries an anti-consumer moniker but many economists disagree that the practice, even vaguely defined, is anti-consumer at all. Price gouging is essentially supply and demand economics in the context of supply shortages. Following Hurricane's Katrina and Rita, the U.S. Congress instructed the FTC to investigate instances of price gouging, and Congress defined the term as any instance where retailer margins in September 2005 were larger than margins in August 2005 (FTC (2006)). Of the 24 retailers targeted by state authorities, the FTC found six cases of retail price gouging as defined by Congress, but noted the behavior of all but one was consistent with local market conditions.⁹ Incidentally, Neilson (2009) found that margins in College Station, Texas, during Hurricane Rita fell overall.

In addition, two additional states, Oregon and New Jersey, have an unusual regulation – they prohibit self-serve at the pumps on purported safety grounds. Johnson and Romeo (2000) report the bans modestly increase retail prices while Vandegrift and Bisti (2001) conclude the New Jersey ban, among other things, kept station sizes smaller. The bans, in spite of restricting individual choice, are quite popular in those states.

7 STRUCTURAL MARKET TRANSFORMATION

There has been a fundamental change in the structure of gasoline retailing over the past 20 years. First, the number of stations has fallen dramatically – from 203,000 in 1994 to 156,000 in 2012 in the United States (NACS (2013)) – a process known as “station rationalization”. A similar reduction has occurred in Canada. While the number of stations is lower, the scale of individual stations has increased greatly. Disappearing are the one and two island operations with a service garage attached or a small booth in the center just large enough for an attendant to sell cigarettes and a few small items. Now, stations increasingly have eight or more pumps, often with a large convenience store attached, and may also offer food service ranging from hot dogs or tacos to fast food to a full-service restaurant. Convenience store operators now sell about 80% of gasoline sold in the U.S. (NACS (2013)). Increasingly, supermarkets and hypermarkets are entering the industry with high throughput service stations located in their front parking lots.¹⁰

Large integrated firms have largely left the retail arena to refocus on more profitable upstream operations. The major integrated brand names are still visible at the retail level – but these stations are only supplied by the branded refiner – the stations are generally owned and operated by others.

The brand recognition of national convenience store chains, supermarkets, and hypermarkets is also changing the way gasoline is branded and marketed. Traditionally, most retailers purchased fuel at a “branded” wholesale price, which came with the right to sell fuel under the brand of the refiner (Exxon, Shell, BP, etc.). Others purchased at “unbranded” prices which, while cheaper, did not allow the operator to use or benefit from the refiner’s brand name. Now, supermarkets, hypermarkets and an increasing number of convenience store chains with their own brand identity purchase gasoline at the lower, unbranded wholesale rate and sell gasoline under their own trusted brand name (e.g. Costco, QuikTrip, Flying J). Slowly, refiner brands are becoming a little less common.

The transformation is a natural one. There are little economies of scope across gasoline refining and gasoline retailing operations – but there are substantial economies of scope across gasoline retailing and retailing of other consumer products. In fact, gasoline retailing is less and less about gasoline and increasingly more about selling sodas, tacos, cigarettes, and other convenience or general merchandise items (at higher margins). More and more, gasoline canopies act as a storefront and gasoline itself acts as a loss leader to drive foot traffic into the attached store. It is natural that convenience store chains and other kinds of retailers have taken over this role.

Several recent papers examine supermarket and hypermarket entry into gasoline retailing. Zimmerman (2012) finds that hypermarket entry in the U.S. has led to lower prices and margins. While the growing practice by supermarkets of offering discounts on gasoline with a minimum in-store purchase has been controversial, Wang (2010) defends it as pro-competitive.¹¹ Such bundling has been contested by smaller operators in the U.S. and elsewhere, and has given rise to antitrust challenges at the state level with mixed results (Noel (forthcoming)).

Several papers turn to rationalization in Canada. Eckert and West (2005) show that stations have become larger and fewer in number in the Toronto market, while Eckert and West (2004) report a similar result in Vancouver following the large-scale entry Arco stations. Sen and Townley (2010) find that retail prices actually increased as stations became larger and fewer over the 1990s in Canada. Turning to the causes of rationalization, Eckert and Eckert (2011) argue that more stringent environmental regulations play a role.

Another important, but less recent development, is the disappearance of full service stations (except in New Jersey and Oregon) in favor of self-service stations (Johnson and Romeo (2000), Vandegrift and Bisti (2001), and Basker, Foster, and Klimek (2015)). Basker, Foster, and Klimek (2015) find a substantial cost saving to stations from the reduction in service levels. This, and the popularity of other innovations, such as pay-at-the-pump, has substantially decreased the time spent filling up and changed the way consumers purchase gasoline.

Finally, the product itself has changed over time – gasoline was originally leaded in the 1970s, then unleaded with oxygenates such as MTBE (which was then banned after being detected in groundwater) and finally over the past decade, blended with increasingly high percentages of ethanol. Various formulations of gasoline and boutique blends exist in different regions of the country, as well as winter and summer blends. Examples of papers discussing the transition from one formulation to another, from a competition and consumer choice point of view, include Borenstein (1991), Anderson (2012), and Noel and Roach (forthcoming).

8 VERTICAL RELATIONSHIPS AND OTHER ISSUES

Other issues in retail gasoline markets have attracted the attention of researchers. Prior to the entry of convenience store chains, supermarkets, and mass merchandisers into gasoline

retailing, there was much interest in choice of station ownership form and the effects of that choice. Stations could be owned and operated by a major integrated firm, owned by an integrated firm but operated by a lessee dealer, or owned and operated outright by an independent dealer. The first is now quite rare, the second is declining in importance, and the latter is becoming increasingly common due to entry from large format stores. Other ownership structures are possible – wholesalers and jobbers, for example, can also own and operate or lease out stations to others. A chapter-length treatment of vertical relationships in the retail sector is provided by Smith in chapter 5 of this Handbook; in this section we discuss the unique aspects of vertical relationships in the context of gasoline markets.

Shepard (1993) explains that vertical contract choice depends on the observability of the station operator and the complexity of the operation. She finds stations with convenience stores or other ancillary operations, for which the effort invested in operating it is more difficult to observe, are more likely to be operated by independent dealers rather than the integrated firm. Vertical separation of refiner and retailer is more likely when the own price elasticity is low, cross-price elasticity is high, and reaction functions are steep, according to Slade (1998).

Researchers have explored other topics as well. While virtually all the studies discussed in previous sections take station locations as exogenous, a few model station location choice. The socially optimal station location choice model of Chan, Padmanabhan, and Seetharaman (2007) highlights the importance of demand factors in Singapore, as one would expect. Pinske and Slade (1998) note that spatial clustering of stations of common ownership types in Vancouver. (For a discussion of retail locations models see chapter 9 in this Handbook by Aguirregabiria and Suzuki.)

Another strand of literature involving retail gasoline examines the effect of changes in gasoline prices on other industries. According to Molloy and Shan (2013), for example, higher gasoline prices cause more new house construction in areas with shorter commutes than in areas with longer ones. Other studies care less about gasoline prices per se, but use it as a plausibly exogenous change in disposable income. Gicheva, Hastings, and Villas-Boas (2010) estimate that negative income effects from increases in oil prices led consumers to be more frugal and purchase grocery store items on sale more often.

Finally, a small literature examines the importance of data quality on estimating empirical models on gasoline pricing. One of the reasons gasoline markets are so well studied is exactly because of the wide availability of data. However, as Bachmeier and Griffin (2003) first noted, data frequency can matter – conclusions can differ with daily data versus weekly data. Along this same theme is Eckert and West (2004) and Atkinson, Eckert and West (2014), who note that the rapid nature of Edgeworth Price Cycles may make price dynamics difficult to see in weekly or even daily price data when the period of the cycle is short.

Finally, Atkinson (2008) considers the reliability of data provided by gas price websites, where consumers self-report prices to online websites. Such data are increasingly used by researchers because of its broad reach. By comparing GasBuddy data to data manually collected from stations in the same area every two hours, Atkinson (2008) concludes the former tends to be reliable on the whole, but can be deficient when high frequency data is needed for underreported independent stations.

9 CONCLUSION

This chapter presents a survey of the recent literature on pricing and pricing dynamics in retail gasoline markets. More than a hundred papers have been published over the past few decades examining retail gasoline pricing in a wide range of situations and geographies. The number of papers has increased over time, in part due to increased availability of good data. Papers have addressed price levels, price dynamics, price dispersion, price effects from government interventions, mergers, and even price fixing, and the price effects resulting from the recent industry transformation.

The results of the literature as a whole are difficult to summarize in a few sentences. Each area of research addresses a different issue, and each contributes to an understanding of how competition is played out in retail gasoline markets. In some cases, the findings of the literature suggest a particular conclusion on a particular question, and in other cases, findings vary, suggesting more research is needed to separate the exceptions from the rule.

For example, the majority of studies on Edgeworth price cycles have found the price cycles are beneficial, or at least not harmful, and the majority of merger retrospectives have found that the recent series of consummated mergers have not raised prices. Even still, there can be exceptions.

On the other hand, results on whether Rockets and Feathers exist and to what extent they exist are often disagreement with one another. And the most important questions of Rockets and Feathers –why and so what – are still actively being debated. Meanwhile, several recent studies on the effects of sales-below-cost laws have challenged the common finding of earlier studies that such laws raised prices. Also, the causes for price dispersion universally found in local markets is still largely an open question.

There is much work still to be done. Understanding retail gasoline markets in particular, and the retail trade, in general, is important in understanding how competition works, how it unfolds, what makes it stronger, what makes it weaker, what policies are effective in protecting it, and which do more harm than good. This paper contributes to our understanding of retail competition by surveying the literature on retail gasoline markets and bringing together many of the key findings and insights into a single place. The literature has come a long way in only a few decades, and with the new broader access to detailed price and other data, will only continue to grow and enhance our understanding of retail competition.

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² Peltzman (2000) finds this is a common phenomenon across a wide range of industries.

³ Ellison (Chapter 13 of this Handbook) provides a general discussion of pricing and consumer search.

⁴ The converse argument – that prices will now rise as slowly as they fall, causing below cost pricing and losses during the rockets periods and high profits during the feathers periods – is virtually never argued, though it is just as “symmetric”. The data provides no support for one argument over the other.

⁵ A similar cycle has also been found in certain online auctions (Zhang (2006), Edelman and Ostrovsky (2007)).

⁶ To the extent that cycles became daily in large cities, they would be difficult to see in daily frequency data.

⁷ Noel (2008) shows that mixing is not a necessary feature of cycle equilibria with asymmetric firms.

⁸ The special attention given to Perth appears mainly because of data availability – a census of prices at Perth stations are readily available from the FuelWatch website.

⁹ Price changes for a quarter of refiners met the definition of price gouging set out by Congress, but the FTC noted the increases were comparable to similar firms in other geographies.

¹⁰ Ellickson's chapter (chapter 17) in this Handbook discusses the evolution of grocery stores and supermarkets in general, and the role of differentiation and product scope in particular.

¹¹ The Australia government investigation supermarkets for this practice and the parties agreed to limit the size of the discount to 4 cents per liter in January 2014.