Forthcoming in the *International Journal of Industrial Organization*
Draft date: December 2011

Price Leadership and Coordination in Retail Gasoline Markets with Price Cycles

Matthew S. Lewis*
The Ohio State University

Abstract

This study examines the coordination mechanism used by gasoline stations in the midwestern United States where prices exhibit highly cyclical fluctuations known as Edgeworth cycles. Stations in these markets repeatedly coordinate large marketwide price increases following periods of aggressive price undercutting. By studying these periodic price jumps both over time and across cities, I find that a particular retail chain in each city acts as a price leader initiating each price restoration. The leader signals the new price level to competitors by simultaneously jumping prices at all its stations to a single price. Competitors follow quickly with a large majority of stations jumping to the exact same price within a 24 hour period. The characteristics of the leading firms and the nature of observed price coordination suggest that successful price jumps may be facilitated by the existence of a retailer controlling the prices of a significant number of stations in a city. Identifying the important role of these firms in the market contributes to a broader understanding of price leadership and coordination and highlights another potential reason why price cycles exist in some in retail gasoline markets and not others.

*Department of Economics, 410 Arps Hall, 1945 N. High St., Columbus, OH 43210. I would like to thank Bill Dupor, PJ Healy, Michael Noel, and seminar participants at The Ohio State University, North Carolina State University, the 2009 University of California Energy Institute CSEM Conference, and the 2009 International Industrial Organization Conference for helpful comments and feedback.

1. Introduction

Economists frequently classify outcomes in many imperfectly competitive markets as being tacitly collusive, suggesting that the interaction of competing firms over time enables them to coordinate prices above statically competitive levels. While countless theoretical models illustrate the existence of collusive price equilibria, almost every model suffers from the fact that multiple, and in some cases infinite, collusive equilibria exist. This often leaves us with very little guidance in understanding how firms in these markets determine the prices at which they will coordinate. Empirically studies of these imperfectly competitive markets frequently identify firms charging prices above statically competitive levels, but are usually unable to provide direct evidence of the mechanism the firms use to reach these price levels.

In this study I examine how price leadership is used to facilitate price coordination in retail gasoline markets. In certain parts of the United States and in a number of other countries, competition between gasoline stations results in highly cyclical price fluctuations. The cycles consist of a period of aggressive price undercutting followed by a very rapid and universal *relenting* of prices back to more profitable levels. These price cycles tend to follow fairly systematic and predictable patterns and are not explained by changes in wholesale costs. A number of recent empirical studies have documented such cyclical gasoline pricing patterns in the midwestern U.S. [Lewis (2009); Doyle et al. (2010)], Canada [Noel (2007b); Noel (2007a); Eckert (2003); Eckert and West (2004)], and Australia [Wang (2008)]. This setting is ideal for an empirical examination of price coordination since relatively detailed station level price data are available and we are able to repeatedly observe stations implementing large market-wide retail price jumps.

Existing research has associated gasoline price cycles with the theoretical concept of an Edgeworth price cycle equilibrium introduced by Maskin and Tirole (1988). Maskin and Tirole model price competition between two homogeneous sellers in an alternating move game with a discrete price grid. An equilibrium arises in which firms take turns undercutting each other's price to steal demand. Eventually margins are so low that one firm jumps the price up to a more profitable level and the undercutting begins again. This equilibrium closely resembles the unusual cyclical price movements observed in certain retail gasoline markets. In a typical city exhibiting

cycles in the midwestern U.S., retail prices often fall at an average of a cent per day or more for a week or two and then jump 10 to 20 cents in one day before starting to fall again.

Unfortunately the two firm Maskin and Tirole model abstracts from some of the important details of typical oligopoly markets, including retail gasoline markets. In particular, it does not address coordination problems that might arise in a market with many sellers when it is time to restore prices to higher levels to restart the cycle.[1] With two firms it is natural that the second firm will respond to a price increase from the first firm by also raising its price (to just below that of the first firm). However, in markets with many firms it is much less clear how a firm should respond to a price increase by a single competitor. Noel (2008) points out this coordination problem and simulates an equilibrium for a Maskin & Tirole style model with three firms instead of two. He confirms that while cycles can still exist in equilibrium, coordination problems do arise and *false starts* can occur in which one firm attempts to reset the cycle but other firms do not follow. Noel shows that prices in the three firm model tend to remain closer to marginal cost for longer as firms try to coordinate the next price restoration. If additional firms make coordination of price restorations sufficiently difficult, the firms may no longer have the incentive to undercut in the first place and cyclical price equilibria may no longer exist. Wang (2008) also discusses the difficulties of coordinating Edgeworth price cycle restorations and studies evidence from an antitrust case that details how gas stations in Ballarat, Australia actually communicated by telephone to coordinate price increases. Wang analyzes court evidence showing that the number of phone calls between stations jumped dramatically on days when price restorations occurred.

Short of explicit communication between competitors, how can price restorations be coordinated amongst many firms? There is some evidence of specific firms or stations taking on a *price leadership* role during restorations. Noel (2007b) studies daily data from Toronto and finds evidence that brand name stations were more likely to restore prices first. However, Noel suggests that a particular leader does not appear to exist and that any one of several firms may lead a price restoration. Atkinson (2009) uses a unique data set of prices collected every 2 hours for all 26 stations in Guelph, Ontario, and finds evidence that 5 particular stations (representing two different

[1] The broader theoretical literature on price leadership also largely restricts attention to models with only two firms. See, for example, Rotemberg and Saloner (1990), Deneckere and Kovenock (1992) , and Deneckere et al. (1992).

brands) tend to be the stations most likely to jump prices in the first 2 hours of a price restoration.[2]

In contrast to these previous studies which mostly focus on individual cities, I examine price leadership across 52 different cities representing nearly every cycling gasoline market in the United States. This more comprehensive analysis reveals a large amount of both within and across market price coordination and price leadership. In particular I highlight the important coordinating role played by retailers that own and directly operate a large number of stations in each city. In most cases it appears that a particular firm in each market leads price restorations and is closely followed by all other stations. Often the same firm leads cyclical restorations in many different markets in the region. In each case I find that the *leader* firm is a retail chain that coordinates price restorations citywide by unifying their stations' prices on the day of restoration in order to signal the onset of a restoration and to solidify the new market price level. To further strengthen the signal to competitors in the area, price restorations are frequently initiated by the leader firm simultaneously in a large number of markets within the firm's operating region. There appears to be a high level of awareness and willingness of other sellers to follow these price restorations quickly.

Extremely detailed data allow me to identify specific pricing strategies used to successfully coordinate marketwide price increases even in cities with many competitors spanning fairly large geographical areas. I utilize three different data sources to examine a number of different dimensions of pricing behavior. The first is a nationwide panel of daily average gas prices from 280 U.S. cities which is used to determine where retail price cycles occur. Consistent with previous studies, I find that price cycles only occur in the Midwest region of the country. Interestingly, most of these cycling cities contain a significant market presence of Speedway or Quik Trip: two large retail gasoline & convenience store chains that operate in the region.

The second data set contains daily station specific prices from 52 cycling markets. I use this to study the timing of stations' price restorations and the prices to which they jump. The findings highlight the importance of price leadership in the coordination of price restorations. Several retailers, most notably Speedway and Quik Trip, are far more likely than competing retailers to

[2]It is interesting to note that the ability of stations to respond quickly makes it fairly difficult to definitively identify which stations change price first even when prices are observed every 2 hours.

jump prices at their stations on the first day of a cyclical price restoration. In addition, stations of these firms almost always jump to an identical price citywide regardless of the price each station was charging prior to the restoration. This citywide unification of prices acts as a signal to competitors. I find that other stations in the city are more likely to restore their prices to the new modal price of the leader firm than to the modal prices of any other brands.

The final data set helps to confirm the brand-wide coordination of prices enacted by these price leading firms. I collect station price information for every Speedway station at three hour intervals throughout the day. During virtually every cyclical restoration that occurs in the 38 cities studied, nearly all Speedway stations within the city jump their prices at exactly the same time and to exactly the same price. Furthermore, Speedway frequently coordinates price restorations in every city throughout its core operating region at exactly the same date and time.

The analysis reveals that price restorations in cycling markets are highly coordinated, with most competitors increasing their prices within a short amount of time and to approximately the same price. Such coordination is not observed in non-cycling markets where even large price increases happen more slowly and less uniformly. The evidence strongly suggests that particular retail chains operating a significant share of stations act as leaders of price restorations in most of the cycling markets, signaling to others when a price restoration will occur and to what level prices should be restored to in their respective markets. This mechanism of price coordination during cyclical restorations has not been studied previously, and reveals the important leadership role of firms operating many retail outlets in a given market. The fact that price cycles are observed almost exclusively in markets where these leader retailers hold a significant market share suggests that the coordination of price restorations might play an important role in the existence of price cycles.

2. Data and Market Structure

2.1. Data

This study utilizes three different sources of retail gasoline price data. Each of these data sources have their own distinct advantages (and disadvantages). In this section I describe the details of

each data set and highlight how they contribute to the understanding of cyclical pricing behavior.

The first data source contains daily city average retail prices from 280 cities nationwide from October 2004 to July 2010. The prices are those reported on the American Automobile Association (AAA) website and are frequently cited in various media outlets. They are based on information from a station price survey collected by the Oil Price Information Service (OPIS). The underlying OPIS pricing information is the same as that contained in the station level data set described in more detail below. However, the city level price data are available for many more locations and for a much longer time period than the station level data.

The second data set provides individual gas station prices collected by OPIS for 165 cities for the two years from July 2008 to July 2010. OPIS reports on their website that these station-specific prices are acquired "through exclusive relationships with credit card companies, direct feeds and other survey methods."[3] Prices in the data set are observed as often as once a day, though some stations' prices are not observed every day. The prices are for regular grade (87-octane) gasoline and have been rounded down to the nearest whole cent.[4] The data also include the brand of gasoline sold, the business name of the station, and its street address.

The sample includes all major cities within a selection of 32 states including the Midwestern states where Edgeworth cycles are known to occur. The represented states are: AL, AR, AZ, CA, CO, CT, DE, FL, IA, ID, IL, IN, KS, KY, ME, MI, MI, MN, MO, NC, NH, OH, OK, PA, SC, TN, UT, VT, WA, WI, WV, WY as well as the cities of Tulsa (OK) and Omaha (NE). For the selected cities I use prices of stations within the corresponding urban area rather than the much more broadly defined metropolitan statistical area (MSA). This excludes more remote gas stations in surrounding rural areas that may be fairly isolated from the city's retail gasoline market.

Station price data are crucial to studying the timing and coordination of price movements within cycling cities. The daily station level price data used here represent the most complete and

[3]According to OPIS they receive prices "for most major retailers regardless of whether the station is company operated, jobber owned or dealer operated. Included in the feed are many of the more aggressive c-stores such as WAWA, QuikTrip, Maverik and Sheetz and most of the discount chains and supermarkets such as Wal-Mart, HEB and Kroger." See *http://opisnet.com/methodology.asp* for additional information.

[4]Rounding down truncates the ubiquitous 9/10 of a cent which is always added to prices at U.S. gas stations. The truncated price is arguably the price that most consumers perceive when they read posted prices.

detailed retail gasoline price information typically available to researchers. Nevertheless, they do have some limitations when studying the frequent price fluctuations characteristic of markets with price cycles. In particular, price observations for two particular stations may be recorded at different points throughout the day. This becomes potentially problematic during price restorations if some stations' prices are recorded before they restore prices while other stations' prices are recorded after restoration. Daily observations also limit the researchers ability to observe which stations restore prices first. It is only possible to observe whether a station increased its price by the end of the first day of the price restoration. While much can still be learned from the daily data, studying the relative timing of station price movements using more frequently observed data would clearly be preferable. Unfortunately these data generally do not exist.[5]

The final data source represents a unique and valuable supplement to the OPIS daily station level prices. To help understand the exact timing of price movements during restorations I have collected pump prices for every Speedway station at 3 hour intervals throughout the day from August 2008 to July 2010.[6] The information comes from Speedway's web site which publishes the current prices of all its stations. The site claims that these prices are "updated seven days a week, approximately every 30 minutes." Although the prices are only available for Speedway stations, the frequent observation of prices eliminates the problems experienced with the daily OPIS data. The timing of price movements for every station can be narrowed down to a three hour window rather than a 24 hour window. The data reveal even more clearly the striking coordination with which Speedway stations restore prices.

2.2. Structure of the Retail Gasoline Market

While studying the coordination of price movements I want to highlight the importance of joint ownership or operation of stations within the same market. Therefore, it is helpful to clarify

[5]The one exception is a study of Edgeworth gasoline price cycles by Atkinson (2009) in which prices for 27 stations in Guelph, Ontario are collected eight times daily for several months. Even with bi-hourly observations it is still not trivial to conclusively determine which stations restore prices first or which tend to undercut competitors more frequently.

[6]There are 6 price observations per station per day. Prices are observed at 6:00AM and then at 3 hour intervals until 9:00PM.

the structure of the retail market and the role of retail chains. Usually the *brand* of gas station refers to the brand name of the refining company (for example Shell or Exxon) that supplies the station with gasoline. Stations that do not display a refinery brand and do not exclusively sell gasoline supplied by a particular company are commonly referred to as unbranded or independent stations. As convenience stores have became increasingly important in the gasoline market, chains of convenience stores have grown and developed recognizable retail brand names of their own. While some of these retail chains (such as Circle K or The Pantry) sell branded gasoline, many retail chains remain independent (such as Speedway, Quik Trip, and Casey's). These chains rely on their convenience store offerings and retail market presence to generate brand recognition, rather than using brand name gasoline to lure customers.

Stations displaying a large refinery brand name are often operated by owner-dealers or lessee-dealers, some of which are large retail chains. Over the last decade there has been a strong trend of integrated refining companies abandoning the direct operation of stations and converting most or all of their remaining stores to dealer operated outlets. According to Longo (2010) and individual company sources, BP, Conoco-Phillips, Shell, Citgo and Marathon use nearly 100% dealer operated stations. Chevron and Exxon-Mobil use 90% and 82% dealer stations (respectively), though Exxon-Mobil has recently announced plans to eliminate all company operated stations.[7] As a result, final retail pricing decisions are now largely made by dealer operators or station owners rather than by the branded supplier (i.e. refining company). Retail chains play an important strategic role because they often own and operate all of their stations giving them direct control of the retail prices of many stations in a market.

The OPIS station level data can be used to identify all the stations in each city and construct market shares. Although prices are not observed for every station on every day, the set of stations contained in the sample includes very nearly the entire population of stations located within each of the markets observed. For each station OPIS lists a brand name. For independent stations the brand listed is usually the name of the retail chain operating the station, which can be used to

[7]Most of this information comes from the 2010 Convenience Store News *Top 100 Convenience Stores* report. Additional info comes from the *Company information* pages of the Marathon website.

calculate market shares for each major independent chain.[8] For stations selling branded gasoline constructing the market shares is more difficult because OPIS lists the refinery's brand for these stations rather than the firm that controls prices and operates the station. Fortunately, the data also contain a business name which can be used to identify the dealer or retail chain operating the station (if any) and calculate the retailer's market share. For tractability, any entity operating at least 5 gas stations in my dataset is designated as a retail chain, and any remaining stations are considered as single station operations. A total of 391 multi-station retail chains are identified in the data. Some of these are recognizable convenience store chains while others are simply individuals or companies that operate a number of stations under a refinery brand name.

In order to examine the pricing behavior of particular retailers I construct a list of the major retail chains in my sample area by selecting all of the nation's 100 largest gas station chains that 1) hold a market share greater than 5% in at least one of the cities in my sample, and 2) directly operate the vast majority of their stations.[9] The resulting list of retailers is reported in Appendix Table A along with their primary regions of operation and the number of markets from my sample in which they hold significant market shares. Retailers are also separated by whether or not they sell refinery branded gasoline. Speedway is by far the largest independent dealer in my sample area, but there are several other large chains that sell branded gasoline.

3. Empirical Analysis

3.1. Where Price Cycles Exist

Figure 1 reports the average retail prices for a typical cycling city, Indianapolis, IN, and a typical non-cycling city, Nashville, TN, over a two month period during 2008. Virtually all increases in the average retail price for Indianapolis occur during periodic price restorations, and prices fall fairly consistently during the undercutting phase of the cycle. In contrast, prices in non-cycling cities such as Nashville are generally much more stable and do not move as quickly as in cycling cities. Rapid increases in price are rare and only occur in response to large jumps in wholesale

[8] If the station is not part of a major retail chain OPIS usually lists the brand as "Independent".

[9] The 100 largest retail chains are identified using the 2010 Convenience Store News *Top 100 Convenience Stores* report [Longo (2010)].

cost, such as the one that occurred in late August of 2008 when Hurricane Hanna struck the Gulf of Mexico.

To get the most complete picture of where retail gasoline price cycles occur within the U.S. I examine the panel of 280 city average prices from AAA. I identify cyclical pricing behavior using a simple statistical indicator proposed by Lewis (2009) and also used by Doyle et al. (2010). Lewis (2009) finds that the median daily change in the city's average retail price is a good metric for determining the presence of Edgeworth price cycles. In cycling markets, daily prices typically fall in small increments and increase only occasionally in large jumps, causing the median of these daily price changes to be distinctly negative. In contrast, prices in non-cycling markets only change in response to cost fluctuations and tend to have a median daily price change very close to zero.[10]

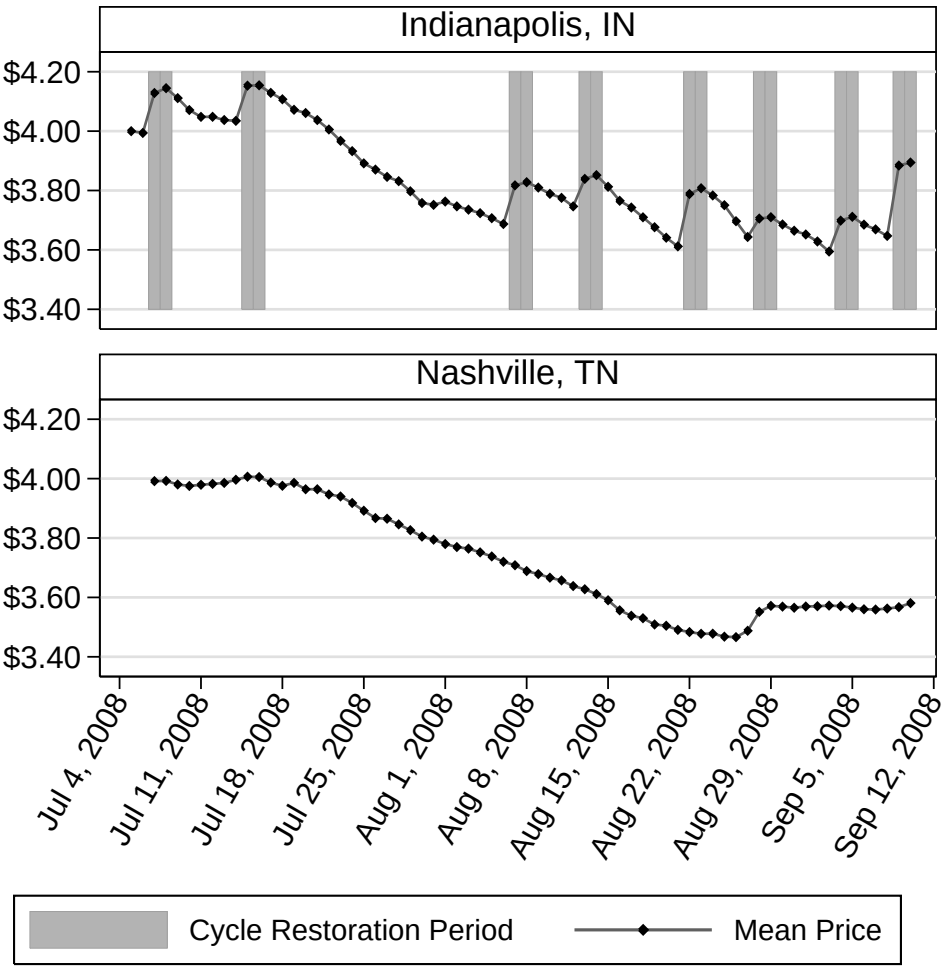
Using the AAA data, I examine the median daily change in average retail price for each city over almost 6 years. Similar to Lewis (2009), I consider a median price change below -.2 cents per gallon as a strong indicator of cyclical pricing. The findings confirm that cycles are isolated to selected Midwestern states. Out of the 280 cities in the sample only 46 exhibit strong signs of cyclical pricing ($Median\Delta p < -.2$), all of these cities are within the following states: MI, OH, IN, KY, IL, MN, MO, WV, IA, KS.

Interestingly, this geographic pattern of cyclical pricing corresponds closely with the combined regions of operation of retail chains Speedway and Quik Trip. Almost every city in Indiana, Kentucky, Ohio, Michigan, Minnesota, and West Virginia exhibits price cycles. Speedway operates almost exclusively in these 6 states, and within these states they hold a significant market share in nearly every city. Most cities in Iowa, Missouri, and Kansas do not exhibit price cycles, but the 4 cities that do have cycles (Des Moines, IA; Kansas City, MO; St. Louis, MO; Wichita, KS) are also the only 4 cities in the region in which Quik Trip operates a significant share of stations.

While I do not have detailed retailer market share data for all the cities in the AAA data,

[10]It may seem tempting to identify cycling markets by examining changes in retail margin rather than changes in retail price (to control for wholesale price changes). It turns out that large jumps in margin are very common in all markets because wholesale gasoline prices tend to be volatile and retail prices move more slowly. Focusing on the margin actually distracts from the very predictable pattern of retail price changes that occurs in cycling markets.

Figure 1. Comparison of average retail gas prices for Indianapolis and Nashville.



I do have accurate measures of retailer market shares for the 165 cities in the OPIS station level data set. Price cycles occur in 52 of the 165 cities contained in the OPIS sample. These consist of the 46 cycling markets identified using the larger AAA sample, plus 6 additional smaller cities that are not in the AAA data but clearly exhibit cycles based on their median daily price changes over the two year period.[11] Speedway has a market share of over 10% in 27 observed markets, and there are an additional 16 cities in which Speedway has over 5% market share. Cycles occur in 38 of these 43 Speedway markets. Similarly, Quik Trip holds over 10% market share in 5 cities, 4 of which exhibit cycles. Of the remaining 121 cities in the sample where these two retailers do not have a major presence, only 10 exhibit cycles.[12] Both Speedway and Quik Trip do operate smaller numbers of stations in various non-cycling markets, but in these markets their stations do not follow the same cyclical pricing pattern used in cycling markets.

So why don't retail price cycles occur in other regions of the U.S., and why do their locations appear to strongly overlap with the regions of Speedway and Quik Trip? A number of studies have investigated factors that might influence the propensity of price cycles. Eckert (2003) presents a theoretical model suggesting that cyclical price equilibria are more likely when smaller firms are present in the market because they have a stronger incentive to undercut their larger rival. Supporting this prediction, Noel (2007a) and Doyle et al. (2010) provide empirical evidence that cycles are more likely to occur in markets with a larger share of small independent retailers. Lewis (2009) finds some evidence that cycles are more likely in cities with more independent stations, but argues that the ownership concentration of these independent stations is a more important predictor of cycles. In addition, Doyle et al. (2010) argue that stations operating convenience stores will also have a greater incentive to undercut their rival's gas price because additional customers can generate profits on in-store purchases. They show empirically that cycles occur more frequently in cities where a greater share of stations have convenience stores.

All of these previous studies are based on the motivation that cycles are more likely to occur in cities where the market structure or the characteristics of the stations make undercutting

[11] These cities are: Bowling Green, KY; De Kalb, IL; Elizabethtown, KY; Kalamazoo, MI; Lima, OH and Muncie, IN.

[12] Eight of the ten remaining cycling cities are located in Illinois.

more profitable. However, the existence of price cycles could also be limited by firms' inability to successfully implement citywide price restorations. The following analysis reveals that price coordination during cyclical restorations is highly systematic and unique to cycling markets. Interestingly, Speedway and Quik Trip appear to play an important leadership role during restorations in their respective regions.

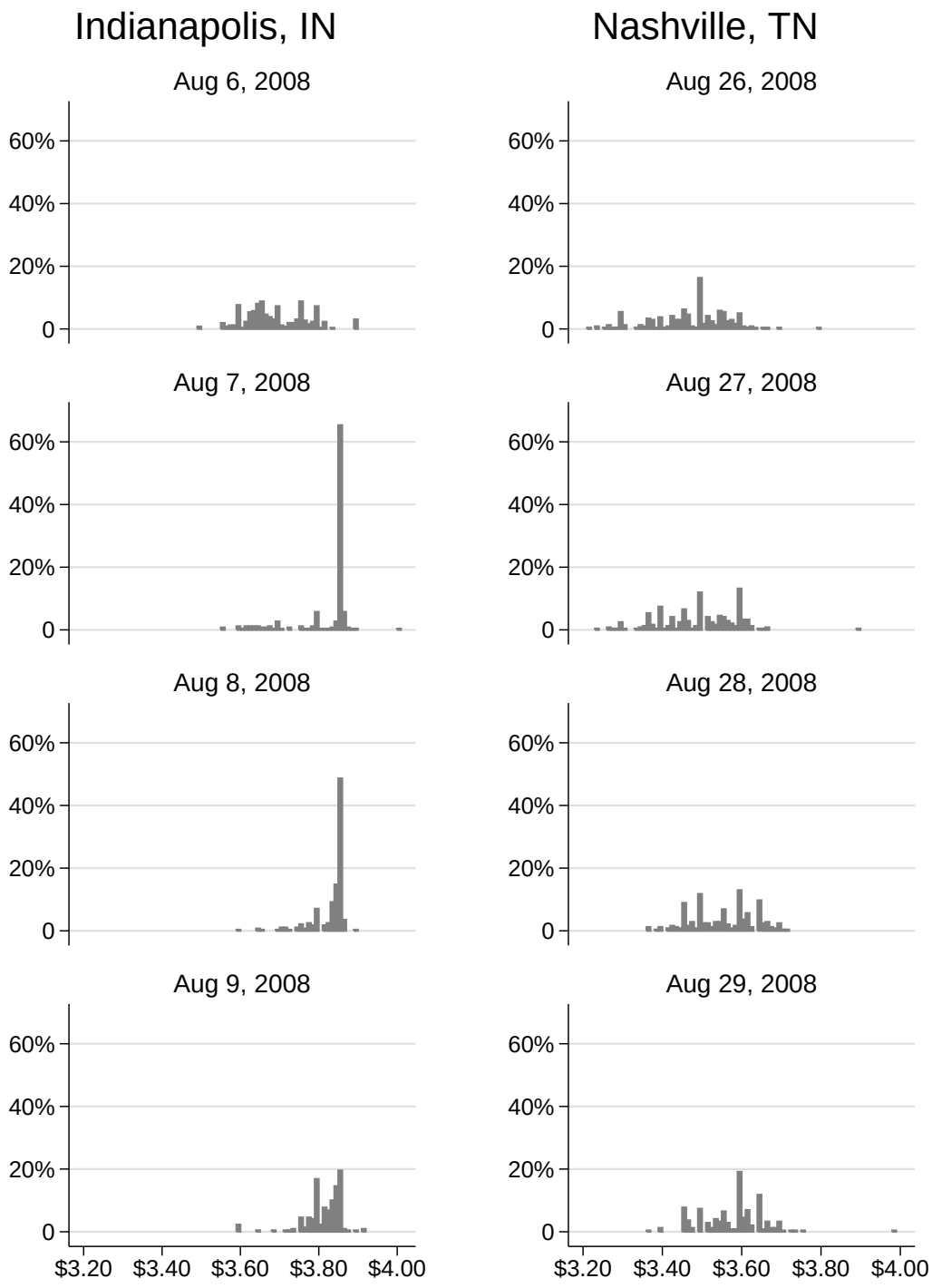
3.2. Coordinating Price Restorations

Perhaps the defining feature of retail gasoline price cycles is the frequency with which we observe large and rapid jumps (or restorations) in retail price, like those observed in Indianapolis in Figure 1. Interestingly, stations in cycling markets also appear to implement these large price increases very differently than those in non-cycle markets. As an example, Figure 2 compares the daily histograms of prices from Nashville during the Hurricane Hanna price jump with prices from Indianapolis during a typical cyclical price restoration. While prices in both cities increase more than 10 cents within a 2 to 3 day period, the changes in the distributions of prices are drastically different in the two cities. Prices in the cycling city of Indianapolis reveal a highly coordinated price restoration. The price distribution increases and collapses, with over 60% of stations charging the new higher modal price level after the first day. In contrast, the price distribution in Nashville does not collapse during the price jump, but rather shifts up more slowly with very little change in overall dispersion.

This pattern holds more generally across the 165 cities in the data. Within cycling markets the probability of a station charging the mode price in the city is 34.1% if the station's price is constant or has fallen, but if the station is increasing its price it raises it to the mode price 62.8% of the time. In contrast, stations in non-cycling markets increase their price to the mode in the city only 21.2% of the time, which is actually 5.7 percentage points lower than the probability of charging the mode price when the price is constant or falling.[13] These distributional patterns suggest that cycling markets are unique not only in the frequency of price jumps but in the way that competitors coordinate their price increases.

[13] All of these differences in the probability of charging the mode price between cycling and non-cycling markets and between stations that are or are not increasing their price are highly statistically significant.

Figure 2. Daily distributions of prices during rapid price jumps in Indianapolis and Nashville.



To more systematically study how prices are coordinated during cyclical restorations, I need a metric to determine when a price restoration event has occurred in a particular city. I restrict attention to cycling markets and rely on a unique and defining feature of price restorations: that nearly all stations in the city implement a relatively large and almost simultaneous increase in prices. The start of a price restoration is identified as as a day in which over 40% of observed stations raise their prices by at least 5 cents per gallon, or a two day period in which over 50% of stations raise their prices by at least 5 cents per gallon with at least 20% of stations raising prices in each of the two days. I define the restoration period as the consecutive days following the start of the restoration in which at least 20% of stations raise their prices by at least 5 cents per gallon.[14] Correspondingly, I define a station as having *jumped* its price on a given day when that station has increased its price by at least 5 cents per gallon from the previous day. The restoration periods determined for Indianapolis using this method are displayed in Figure 1. Within the 52 cities in the sample that exhibit price cycles, I identify 3288 cyclical price restoration events over the 2 year period. The median length of a cycle is 8 days, and the 25th and 75th percentiles of cycle length are 6 days and 14 days respectively.

3.2.1. Leaders of Price Restorations

If a particular retailer is acting as a leader in initiating price restorations, its stations' prices should jump during the earliest stages of the restoration. Unfortunately, the daily OPIS data are not ideal for identifying the earliest movers. At best we can only observe the share of a retailers stations that jump on the first day of a restoration. I calculate this by restricting the sample to stations at which prices are observed on the first day of a restoration, and then measure the fraction of each retailer's stations for which this price reflects a jump of more than 5 cents from the previous day. However, since restorations often begin in the middle of the day, some price observations in the data may be from before the start of the restoration and may not reveal that a specific station

[14]This definition of a restoration is admittedly arbitrary. However, the classifications change very little if one alters the definition by changing the minimum required cents per gallon price increase or by requiring a larger or smaller percentage of stations to jump in a given day.

jumped their price on the first day.[15] The response to price changes by competitors can also be very quick in this market, and firms that simply follow quickly may also have a very high share of stations increasing price on the first day of a restoration. Nevertheless, the fraction of a retailer's stations reporting a jump in price on the first day of a restoration can be seen as a conservative lower bound on the share that actually jump, and it may be useful as a rough indicator of the retailers whose stations are most likely to jump early in a restoration.

To evaluate the relative propensities of retailers to raise prices on the first day of a restoration, I regress an indicator for whether the station jumped price or not on a set of retailer fixed effects and city-restoration fixed effects. City-restoration fixed effects control for differences in the average share of stations that jump in a given city during a particular restoration event, while the retailer fixed effects reveal how much more likely a particular retailer is to jump price on the first day of a typical restoration. I include a fixed effect for each of the large retailers identified in Section 2.2 and Table A.[16] In addition to these large chains, it is common to find dealers that are small on a national scale but operate many stations within in one particular city. It is not feasible to include individual fixed effects for each of these dealers, so I instead include a "Largest Excluded Dealer" fixed effect identifying the dealer with the largest market share in the city that is not included in the list of retail chains.[17] This is intended to reveal whether smaller dealers that hold a large local market share are more or less likely than other stations to jump prices on the first day of a restoration. Results are presented in Table 1. I report robust standard errors that have been clustered at the restoration-event level to allow for any unobserved factors that might influence the prices of a subset of stations in a city during a particular restoration.[18]

[15] In fact, using Speedway prices observed every 3 hours I can confirm that prices at Speedway stations in the daily data set sometimes do not reveal a price jump on the first day of a restore when, in fact, they actually did jump prices during that day. Of the set of Speedway prices observed on restoration days in the OPIS daily data, only around 80% reflect a jump in price, while in the tri-hourly Speedway data the share of prices that jump on the first day is over 92%. Price jumps by other retailers are likely to have a similar downward bias in the OPIS daily data, but I do not have more accurate data on these other brands to confirm this.

[16] There are slightly fewer retailers represented here than in Table A because the sample now includes only cycling cities.

[17] The mean market share of the largest excluded dealer is around 17%, and the observed values range from 10% to over 28%.

[18] Such factors might include a temporary shift in the pricing strategy of a retailer at all its stations, or a localized demand shock that impacts all stations in a neighborhood.

Table 1. Relative Probability of Jumping Price on the First Day of a Cyclical Restoration.

Dependent Variable = 1 if station jumps price by more than 5 cents; 0 otherwise

	(1)		(2)	
Variable	Coef.	S.E.	Coef.	S.E.
Independent Dealer Fixed Effects:				
Speedway	0.220***	(0.009)	0.173***	(0.010)
Casey's	−0.107***	(0.010)	−0.133***	(0.011)
Kum & Go	0.215***	(0.027)	0.186***	(0.023)
Quik Trip	0.279***	(0.017)	0.224***	(0.014)
Turkey Hill	0.118***	(0.011)	0.078***	(0.012)
Kwik Trip	0.168***	(0.028)	0.099***	(0.030)
Holiday	0.063***	(0.021)	0.010	(0.024)
Admiral	−0.101***	(0.018)	−0.155***	(0.019)
Road Ranger	0.166***	(0.018)	0.140***	(0.020)
Thorntons	0.044***	(0.014)	0.010	(0.015)
Meijer	−0.242***	(0.012)	−0.293***	(0.014)
Huck's	−0.015	(0.015)	−0.019	(0.016)
Murphys	−0.149***	(0.014)	−0.203***	(0.015)
Get Go	0.026*	(0.014)	0.020	(0.016)
Branded Dealer Fixed Effects:				
Circle K	0.048***	(0.008)	0.026***	(0.008)
Super Pantry	−0.110***	(0.038)	−0.168***	(0.042)
Village Pantry	−0.001	(0.019)	0.014	(0.022)
Duke & Duchess	0.135***	(0.017)	0.101***	(0.019)
UDF	−0.181***	(0.030)	−0.236***	(0.034)
TrueNorth	0.043***	(0.013)	0.037*	(0.016)
Largest Excluded Dealer Fixed Effect	0.027***	(0.005)	0.037***	(0.006)
Constant	0.566***	(0.003)	0.644***	(0.003)
# of Observations	240,456		172,024	

Note. All specifications include fixed effects for each restoration event within a particular city. Standard errors are robust and clustered to allow correlation across stations within a city during a particular restoration event. The model in Column 2 only includes observations for which the station's price on the previous day was more than 8 cents below the median price level to which stations in the city are jumping price in the current restoration event.

The coefficient estimates for each retailer in Table 1, Column 1 represent how much more likely their stations are to raise prices on the first day of a cyclical restoration than stations in the same city that are not part of one of the identified retail chains. Perhaps the most striking finding is that the coefficients for Speedway and Quik Trip are significantly larger than almost every other retailer. Speedway stations are 21.1% more likely to jump their price on the first day than non-chain stations in the same city, and Quik Trip stations are 28.1% more likely than their non-chain competitors to jump on the first day. There are a few smaller retailers (such as Kum & Go, Turkey Hill, Kwik Trip, and Road Ranger) that also have significant and positive coefficients, but they are smaller in magnitude than those of Speedway and Quik Trip. Interestingly, all of these are independent retail chains. The remaining retailers, including all of the branded retailers, have roughly the same or even lower likelihood of jumping their prices than the non-chain stations in their city. There is also no indication that local dealers with large market share jump prices substantially earlier than the average non-chain station.

These results appear to show substantial differences in the speed with which different retailers restore their prices. There is some possibility, however, that method used to identify when a station restores its price could generate a biased measure of its restoration probability. A price jump is defined as an increase in price of at least 5 cents over one or two days. If a station restores its price to a new peak that is less than 5 cents above its old price this will not be identified as a cyclical price jump. As a result, the probability of observing a jump from a particular retailer could be biased if the prices of that retailer are less likely to have fallen more than 5 cents below the new cycle peak. One way to minimize this bias is to include only observations for which the station's price on the previous day was more than 5 cents below the median level to which stations in the city are currently restoring their prices. To be conservative I restrict the sample to observations for which the station's price on the previous day was at least 8 cents below the current median restoration price. The results using this restricted sample are reported in Column 2 of Table 1. The retailer coefficients maintain the same general pattern as in Column 1, with Speedway and Quik Trip exhibiting a much higher probability of jumping on the first day of the restoration than most of their competitors. Overall, the brand coefficients are smaller in magnitude than in Column 1,

largely because the estimated constant has increased slightly. This pattern suggests that retailers like Speedway and Quik Trip may lower their prices more quickly than some of their non-chain competitors during a typical cycle, and hence it may be more likely for these stations to jump at least 5 cents during a restoration. Nevertheless, the main results seem robust to such bias.

Another possibility is that stations charging prices further below the new restoration price will have a greater incentive or propensity to jump on the first day of the restoration. As a robustness check, I re-estimate the model in Column 2 of Table 1 while including the distance between the new restoration price level and the station's price on the previous day as an additional explanatory variable. The results, which are not reported here, do indicate that stations with lower prices prior to the restoration are slightly more likely to jump on the first day, but the relative propensities of the different retailers remain essentially unchanged from those reported in Column 2.[19] Overall, it appears that a handful of retailers, most notably Speedway and Quik Trip, tend to raise the prices of more of their stations early in the restoration period.

3.2.2. Price Coordination and Signaling

Given that cycles predominantly occur in cities where Speedway or Quik Trip are present, and that these retailers are much more likely than their competitors to jump prices on the first day of a cyclical restoration, the remaining analysis further investigates the possibility that these retailers take on a leadership role during restorations in order to enhance marketwide coordination.

Since Speedway and Quik Trip operate many stations within each city they have the ability to coordinate both the prices they set during a restoration and the timing of the price jump. This could enable them to send a stronger signal to competitors that a marketwide price restoration is being initiated. In general, the restorations show remarkable speed and coordination. Of stations jumping price on the first day of a restoration, on average over 77% of stations jump to the same price as other stations in their city. This contrasts with the 30% of stations charging the modal price in the city on the day before a restoration begins. Among its competitors Speedway

[19]The coefficient on the difference between the median restoration price and the station's price prior to restoration (in cents per gallon) is 0.007, suggesting that a station with a price that was 10 cents lower prior to the restoration will be 7% more likely to jump its price on the first day of the restoration.

stands out in terms of within brand price coordination. Of the Speedway stations that jump on the first day of the restoration, almost 97% of these stations jump to identical prices within their city.[20] In fact, the tri-hourly price data collected from Speedway's website reveal that these stations actually simultaneously jump to identical prices within the same 3-hour window on the day of restoration.[21] Speedway's competitors jump to identical within brand prices at only 76% of stations on average, and Speedway averages a higher within city share of identical prices after restoration than any other competitor in 35 of their 38 markets.[22]

Perhaps even more suggestive is the propensity for competing stations to jump to the same price that Speedway does with its stations. Almost 81% of the time the mode restore price of a brand other than Speedway was equal to Speedway's mode restore price. The mode restore price for the city as a whole is equal to Speedway's restore price over 97% of the time, and the mode restore prices of other brands are much more likely to match those of Speedway than of any other competitor.

To get a better understanding of price coordination I also investigate how prices evolve during a typical cycle after the initial restoration. In order to make cycles comparable between cities and over time I study the level of a particular city's price distribution on a given day relative to the level that stations originally restored their prices to at the beginning of the city's current cycle. I first define the *restoration price* for each cycle as the median of the prices charged by stations that jumped on the first day of the restoration. Then I create a series of normalized prices for each station in each day by subtracting off the city's restoration price for the current cycle.

Examining the distribution of relative prices for Speedway stations on the days following a restoration clearly reveals how the firm's pricing strategy changes over the cycle. For each of the 38 cities in which Speedway holds at least 5% market share I calculate the median price and the

[20] On average, only 24% of Speedway stations in a city charge the within brand modal price on the day before a restoration begins. Just over 27% of Speedway stations charge the within city brand modal price on a typical non-restoration day.

[21] Over 97% of Speedway stations jump within the first 3 hours of the restoration. This is slightly higher than the share observed in the OPIS data because a few stations actually start to cut their price as early as 3 hours after their restoration. OPIS may observe some of these stations after they begin to cut price.

[22] The markets considered here are the 38 cycling markets in the sample in which Speedway has at least 5% market share, and Speedway's competitors include any brands that have at least 5% market share in one of these 38 markets.

5th, 25th, 75th, and 95th percentiles of Speedway's prices in the city during each day following a cyclical price restoration. These percentiles are averaged across restorations within a city and across cities using a weighted average based on the number of stations in the city. The results are reported in Figure 3 for the day of the price restoration and the 14 days following. Note that the prices on Day 1 include only those stations that have already restored their price. If a station does not jump its price until the second day of the restoration its price does not appear in the price distributions until Day 2.

Figure 3 clearly shows Speedway's strategy of dramatically unifying their prices within each city on the day of the price restoration (Day 1). The vast majority of Speedway's prices jump to the exact same level, and the 5th percentile prices are less than two cents below the median on average. This same general pattern can be observed in the tri-hourly price data, though the higher frequency of observation reveals that Speedway's price unification is even more complete and yet more ephemeral than is revealed in the daily data. During the first 3 hours after the restoration, both the 5th percentile and the 95th percentile prices are less than a quarter of a cent away from the median restoration price on average. However, some Speedway stations begin lowering prices as early as 3 hours after jumping their price. As prices fall in the subsequent days of the cycle the distribution quickly becomes more disperse. Speedway appears to set prices somewhat independently across their stations in order to compete with local competitors in each neighborhood. However, on the day of restoration Speedway abandons this localized pricing approach and once again adopts unified prices citywide.

The distribution of prices charged by Speedway's competitors also collapses significantly at the start of each cycle as most stations restore prices to match the Speedway stations. Figure 4 reports the average price distribution of all firms' stations in the 38 Speedway markets on each day during a typical cycle. While the concentration of prices on Day 1 is not as complete as among Speedway's own stations, it reveals that the citywide price restorations are accompanied by a high level of price coordination across firms. Recall that the prices during the first few days of the cycle in Figure 4 are only for stations that have already restored their price. The entire price distribution on the day of restoration is actually much more disperse with some stations still

Figure 3. Citywide Price Distributions of Speedway Stations over a Typical Cycle.

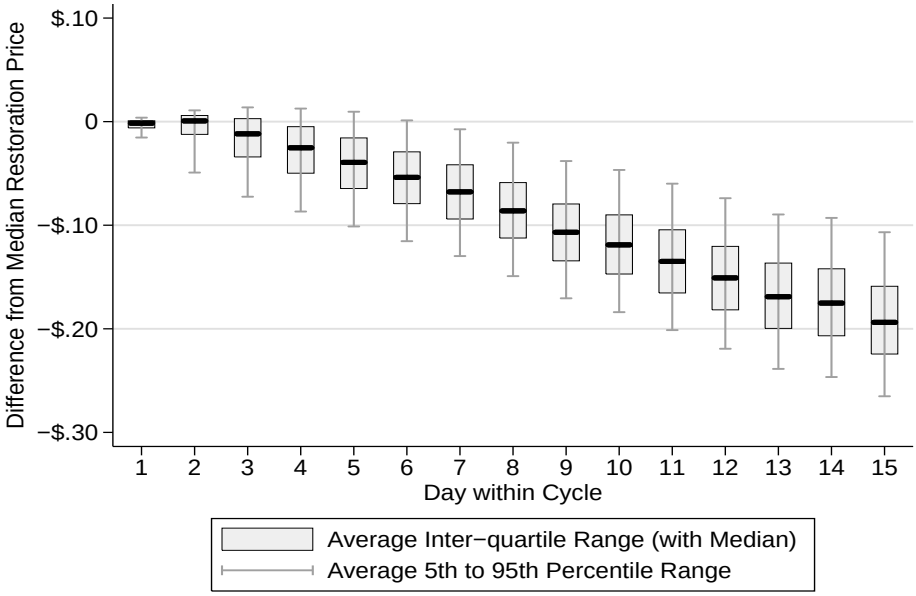


Figure 4. Citywide Price Distributions of All Stations over a Typical Cycle.

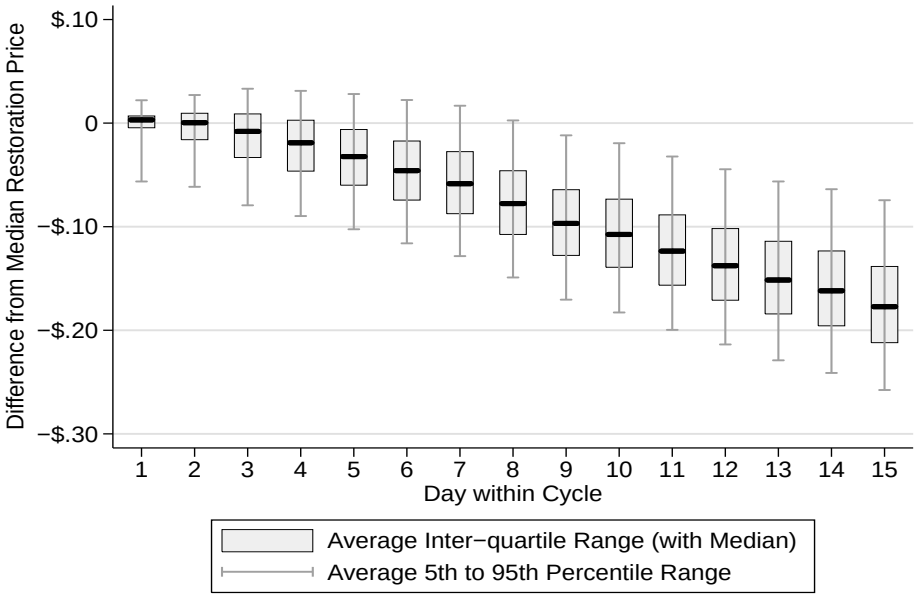


Table 2. Probability of Price Restorations Being Initiated in Other Speedway Cities Simultaneously.

(Number of Cities = 38; Total number of restorations = 2468)

	Number of Other Cities Restoring Prices			
	less than 19	19 to 23	24 to 28	29 or more
Restorations by the number of other cities restoring in the same 3 hour period	23.8%	4.2%	9.6%	62.4%
Restorations by the number of other cities restoring on the same day	13.3%	5.2%	9.3%	72.2%

charging the lower pre-restoration price. By the second day almost all stations have jumped prices and on subsequent days the entire price distribution resembles that in Figure 4.

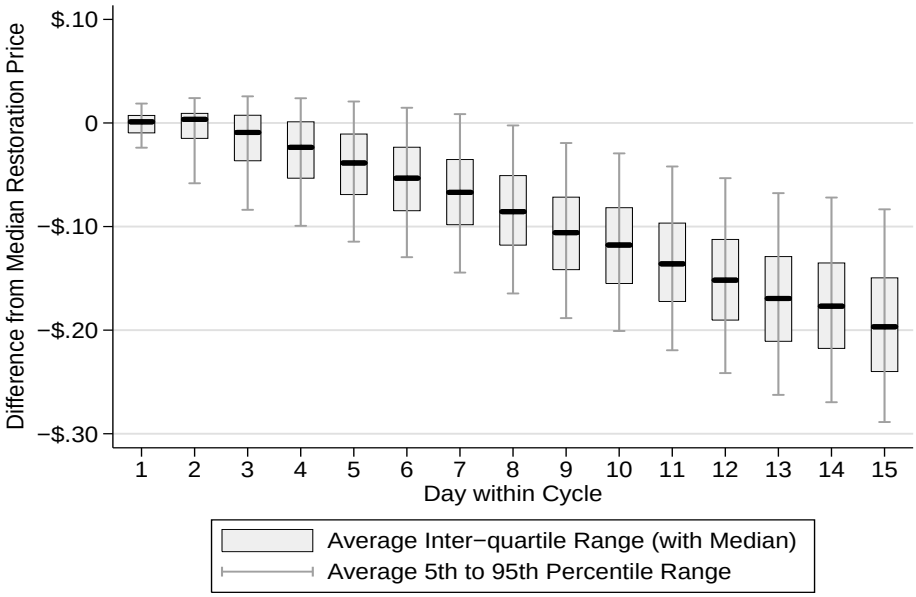
Speedway's highly coordinated price restorations extend beyond the scope of the citywide market. Across the 38 markets in which Speedway has at least a 5% market share, their stations frequently restore prices on the same day, and even within the same 3-hour period, in many markets. This pattern is revealed in Table 2, which shows the frequency with which price restorations were initiated in multiple Speedway markets at the same time. According to the tri-hourly Speedway data, a total of 2468 citywide price restorations occurred within these 38 cities over the 2 year sample period. Over 62% of these citywide price restorations were accompanied by restorations in at least 29 other Speedway markets during the exact same 3-hour period. Occasionally the Speedway stations in one market jump a few hours later than other markets, but still within the same day. As a result, over 72% of all restorations occur on days when at least 29 of the 38 other cities are also restoring prices.[23]

In addition to coordinating the timing of restorations, Speedway commonly restores prices to the exact same level across most or all markets within each state.[24] Consider a typical example of a price restoration occurring in Indiana on July 15, 2008. Of the 124 Speedway station prices from the 7 cities observed in Indiana all but 2 stations jumped their price to exactly $4.19 per

[23]Speedway stations in Minnesota and West Virginia sometimes restore prices on different days than those in the core 4 state region (IN, KY, MI, OH) either because of localized wholesale price shocks or because retail prices have fallen at a different rate than in other states during the undercutting phase.

[24]Restored price levels typically differ across states due in large part to differences in state gasoline tax levels.

Figure 5. Statewide Price Distributions of Speedway Stations over a Typical Cycle.



gallon.[25] This pattern is revealed more generally by examining the statewide distributions of Speedway station prices in Figure 5. This figure is identical to Figure 3 except that the distributions describe the normalized prices of all Speedway stations within a particular state. Once again the distribution on Day 1 is heavily concentrated around the median price, suggesting that Speedway stations usually restore prices to the exact same price at almost all locations within each state. Such a coordinated price movement both within and across markets could provide a strong signal to competitors indicating when they should restore prices and to what price level. In the days following the restoration Speedway stations lower their prices fairly quickly and diverge from the statewide uniform price. This suggests that Speedway places a particular importance on having nearly all their stations at the same price on the first day of a restoration, even though their prices on other days differ widely.

Quik Trip's coordination of price restorations at its stations is similar to Speedway's. Dur-

[25]Gary, IN is excluded because it is more closely tied with the Chicago, IL market. It also requires a different blend of gasoline because it is within the Chicago reformulated gasoline area. The 7 cities included are: Bloomington, Ft. Wayne, Indianapolis, Lafayette, Muncie, South Bend, and Terre Haute.

ing most restorations, the prices of nearly all Quik Trip stations in a particular market jump to an identical price. On average over the sample individual Quik Trip stations jump to the within city mode Quik Trip restoration price 93% of the time. Quik Trip's competitors are slightly less likely than Speedway's to jump to the exact same price as Quik Trip stations. Competitors' mode restoration prices are equal to the Quik Trip mode restoration price only 86% of the time (compared to over 97% for Speedway), though the competitors' mode price is typically very close to Quik Trip's. Quik Trip does not coordinate price restorations across markets with the same regularity that Speedway does. However, this could be due to the fact that Quik Trip's markets are much more isolated from each other, and therefore Quik Trip's potential cross market signaling value is likely to be fairly weak. Nevertheless, the evidence suggests that Quik Trip may play a role in coordinating and leading price restorations in its markets. It jumps price early and unifies prices within each city much like Speedway does, and within Quik Trip's region, cycles only occur in cities where Quik Trip has a dominant market share.

3.2.3. Retailer Price Aggressiveness During the Undercutting Phase

Studies by Eckert (2003), Noel (2008), and Doyle et al. (2010) suggest that certain retailers (such as independent stations or those with convenience stores) may have a higher incentive to undercut competitors' prices, and hence cycles may be more likely to occur in cities with retailers that price more aggressively. If Speedway and Quik Trip tend to aggressively undercut their competitors' prices this could provide an alternative explanation for why cycles seem to exist in markets where these retailers are present. I investigate this possibility by comparing the relative prices of different retailers during the undercutting phase of the cycle.

In order to make pricing behavior comparable across cycles occurring at different times and in different cities I once again rely on the adjusted price measure which describes a station's price relative to the median price that stations jumped to on the first day of the most recent restoration. Column 1 of Table 3 reports the results of a regression of each station's adjusted price during the first day after a cyclical restoration on retailer fixed effects. Column 2 reports the same regression using prices from the 6th day after a restoration. Each coefficient estimate reflects the

corresponding retailer's average adjusted price on that day. The coefficient on the "Largest Excluded Dealer" fixed effect represents the average adjusted price of the largest retailer in the city aside from the retailers listed. The average adjusted price for stations that are not affiliated with one of these retailers is reflected in the "All Other Stations" coefficient. The results in Column 1 confirm that most retailers tend jump their prices fairly closely to the new median restoration price on the first day of the cycle, but there are a few firms that consistently undercut the new citywide price. Interestingly, the two retailers that jump their prices well below those of their competitors' stations are both affiliated with large retail stores: Murphys stations are affiliated with Walmart stores and Turkey Hill stations are affiliated with Kroger supermarkets. These stations may have the strongest incentive to keep their prices low if they can draw customers who will also shop in their retail store.

Comparing prices on the day of restoration with the adjusted prices in Column 2 shows how fast each firm reduces their price during the first week of a typical cycle. Not surprisingly, the variation in prices across retailers grows as the cycle progresses. Retailers such as Admiral, Thorntons, Murphys, Turkey Hill and UDF have consistently lower prices than their competitors six days after the last restoration. In contrast, Speedway and Quik Trip do not appear to be particularly aggressive in undercutting competitors. Their prices after six days are about average amongst the large retailers, and are only slightly lower than the average of other stations in the market. While the existing literature on gasoline price cycles generally links the existence of cycles with the presence of retailers that aggressively undercut rivals' prices, Speedway and Quik Trip do not appear to price particularly aggressively during the undercutting phase of the cycle. Instead, these two firms seem to stand out because of their highly coordinated pricing behavior during cyclical restorations.

4. *Conclusion*

This paper provides the most complete and detailed cross-market investigation to date on price restorations in U.S. retail gasoline markets with price cycles. It reveals new evidence of an unusually high level of coordination both within firms and amongst competing stations. During a

Table 3. Comparing Retailer Prices During the Undercutting Phase of the Cycle.

Dependent Variable: Adjusted Price Relative to Median Cycle Peak

	Day of Restoration		Six Days After Restoration	
	(1)		(2)	
	Coef.	S.E.	Coef.	S.E.
Independent Dealer Fixed Effects:				
Speedway	0.01	(0.03)	-6.74^{***}	(0.22)
Casey's	-2.18^{***}	(0.19)	-5.32^{***}	(0.35)
Kum & Go	3.52^{***}	(0.65)	-0.76	(1.24)
Quik Trip	0.28^{**}	(0.14)	-6.03^{***}	(0.49)
Turkey Hill	-4.50^{***}	(0.19)	-8.93^{***}	(0.27)
Kwik Trip	-0.47^{**}	(0.19)	-4.41^{***}	(0.69)
Holiday	-0.27^{*}	(0.15)	-4.80^{***}	(0.66)
Admiral	-0.48^{**}	(0.14)	-10.98^{***}	(0.37)
Road Ranger	-0.63^{**}	(0.19)	-6.81^{***}	(0.81)
Thorntons	-0.12	(0.12)	-8.61^{***}	(0.35)
Meijer	-1.07^{***}	(0.15)	-6.47^{***}	(0.20)
Huck's	0.30^{**}	(0.14)	-5.75^{***}	(0.67)
Murphys	-7.26^{***}	(0.32)	-9.54^{***}	(0.32)
Get Go	-0.46^{***}	(0.10)	-5.45^{***}	(0.41)
Branded Dealer Fixed Effects:				
Circle K	-0.29^{***}	(0.07)	-6.65^{***}	(0.32)
Super Pantry	-0.90^{***}	(0.37)	-5.69^{***}	(0.76)
Village Pantry	-0.46^{***}	(0.17)	-5.85^{***}	(0.59)
Duke & Duchess	0.07	(0.10)	-7.33^{***}	(0.46)
UDF	-1.53^{***}	(0.35)	-7.71^{***}	(1.18)
TrueNorth	0.15	(0.17)	-4.12^{***}	(0.53)
Largest Excluded Dealer Fixed Effect	-0.24^{***}	(0.04)	-4.99^{***}	(0.19)
All Other Stations	-0.49^{***}	(0.04)	-5.00^{***}	(0.19)
# of Observations	154,585		207,020	

Note. Standard errors are robust and clustered to allow correlation across stations within a city during a particular restoration event.

typical restoration, prices at nearly all stations jump within a 24 hour period and a large majority of these prices jump to the exact same price level. The evidence suggests that a particular firm acts as a price leader for the city, initiating the restoration and unifying prices at its stations to signal to competitors what the new price level should be.

Two specific retail chains appear to be responsible for leading price restorations in most cycling retail gasoline markets in the United States. These firms own and operate a large number of stations, which gives them the ability to directly control and coordinate prices at many stations within each market. Cycles occur in nearly every city in which these two firms operate a significant share of retail stations, and cycles are absent from almost every city in which these firms have little or no market presence. The pricing strategies observed and the strong geographical correspondence between cycles and the presence of these retailers suggest that the role they play during price restorations could be important to the existence of cycles.

Unfortunately, having large retail chains does not appear to guarantee cycles. A number of other retailers, such as Circle K and The Pantry (Kangaroo Express), also own and operate a large number of stations in multiple markets where cycles do not occur. It is not clear whether Speedway and Quik Trip are unique in some way, or whether they have simply chosen to act as price leaders in markets where cycles were already occurring. Future research exploiting variation over time in market structure and the presence of cycles across markets could potentially reveal a more concrete link between market structure and the existence of price cycles. Regrettably, there do not appear to be any U.S. cities in which price cycles have started or stopped within the last 5 years, so this type of variation may be difficult to find.

References

Atkinson, Benjamin, "Retail Gasoline Price Cycles: Evidence from Guelph, Ontario Using Bi-Hourly, Station-Specific Retail Price Data," *The Energy Journal*, 2009, *30* (1), 85–109.

Deneckere, Raymond J. and Dan Kovenock, "Price Leadership," *Review of Economic Studies*, January 1992, *59* (1), 143–162.

_ , _ , **and Robert Lee**, "A Model of Price Leadership Based on Consumer Loyalty," *The Journal of Industrial Economics*, June 1992, *40* (2), 147–156.

Doyle, Joeseph, Erich Muehlegger, and Krislert Samphantharak, "Edgeworth Cycles Revisited," *Energy Economics*, May 2010, *32* (3), 651–660.

Eckert, Andrew, "Retail Price Cycles and the Presence of Small Firms," *International Journal of Industrial Organization*, February 2003, *21* (2), 151–170.

_ **and Douglas West**, "A Tale of Two Cities: Price Uniformity and Price Volatility in Gasoline Retailing," *The Annals of Regional Science*, 2004, *38*, 25–46.

Lewis, Matthew S., "Temporary Wholesale Gasoline Price Spikes have Long-lasting Retail Effects: The Aftermath of Hurricane Rita," *The Journal of Law & Economics*, August 2009, *52* (3), 581–605.

Longo, Don, "Hot 100," *Convenience Store News*, July 26, 2010, *46* (10), 31–36.

Maskin, Eric and Jean Tirole, "A Theory of Dynamic Oligopoly II: Price Competition, Kinked Demand Curves, and Edgeworth Cycles," *Econometrica*, 1988, *56* (3), 571–599.

Noel, Michael, "Edgeworth Price Cycles, Cost Based Pricing and Sticky Pricing in Retail Gasoline Markets," *Review of Economics and Statistics*, 2007, *89* (2), 324–334.

_ , "Edgeworth Price Cycles: Evidence from the Toronto Retail Gasoline Market," *Journal of Industrial Economics*, 2007, *55* (1), 69–92.

_ , "Edgeworth Cycles and Focal Prices: Computational Dynamic Markov Equilibria," *Journal of Economics and Management Strategy*, 2008, *17* (2), 345–377.

Rotemberg, Julio J and Garth Saloner, "Colusive Price Leadership," *The Journal of Industrial Economics*, September 1990, *39* (1), 93–111.

Wang, Zhongmin, "Collusive Communication and Pricing Coordination in a Retail Gasoline Market," *Review of Industrial Organization*, February 2008, *32* (1), 35–52.

Appendix

Table A. Retailer Market Shares and Primary Regions of Operation.

	# of Sampled Cities with Market Share			Primary Regions of Operation
	Over 20%	Over 10%	Over 5%	
Independent Dealers:				
Speedway	7	27	43	IN, KY, MI, MN, OH, WV
Casey's	1	9	15	IL, IA
Kum & Go	2	5	9	AR, IA, WY, Columbia (MO), Tulsa
Quik Trip	2	5	6	MO, Des Moines, Tulsa, Wichita
Turkey Hill	1	3	14	PA, KY, IN, OH, CO, others
Kwik Trip	2	3	5	WI, MN
Holiday	1	3	4	MN, Traverse City (MI)
Maverik	0	3	3	UT, ID
Admiral	0	2	6	MI
Road Ranger	0	2	5	IL, IA
Sheetz	0	2	2	Greenville (NC), Lancaster (PA)
Thorntons	0	1	5	KY, IL
Meijer	0	1	4	MI
Wawa	0	1	3	DE, Reading (PA)
Huck's	0	0	5	IL, Evansville (IN), St. Louis
Murphys	0	0	3	AR, others
Race Trac	0	0	2	AL SC, FL
Get Go	0	0	2	OH
Branded Dealers:				
Circle K	8	22	41	AZ, FL, IN, IL, Akron, Augusta (SC), Louisville
The Pantry	8	18	24	NC, SC, FL
Hess	0	3	15	FL, PA, SC, NH
Mapco	1	3	3	TN
Wilco	1	2	7	NC
Worsley	0	2	5	NC, SC
Super Pantry	0	1	5	IL
Village Pantry	1	1	4	IN
EZ Mart	0	1	3	AR
Duke & Duchess	0	1	2	OH
UDF	0	1	2	OH
Uni-Mart	0	1	1	Youngstown (OH)
Daily's	0	1	1	Nashville
TrueNorth	0	0	3	OH