IBIMA Publishing
Journal of Research in Industrial Organization
http://www.ibimapublishing.com/journals/JRIO/jrio.html
Vol. 2014 (2014), Article ID 688538, 13 pages
DOI: 10.5171/2014. 688538

Research Article

An Examination of Edgeworth Price Cycles in the Indianapolis Retail Gasoline Market

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Received date: 20 September 2013; Accepted date: 30 January 2014; Published date: 14 February 2014

Academic Editor: Najiba Benabess

Abstract

Gasoline prices in Indianapolis, Indiana are characterized by significant increases followed by gradual decreases over time. This paper illustrates and extends a stylized graphical model of intertemporal price discrimination. Supplemented with institutional details and empirical evidence, this model explains the Edgeworth price cycle mechanism in the Indianapolis retail gasoline oligopoly. With effective price leadership, stations can extract consumer surplus from customer groups while increasing their variable profits. Policy implications are discussed showing the welfare gains that can be obtained by making consumers aware of these cycles, allowing them the opportunity to re-capture some of their surplus.

Keywords: Edgeworth Price Cycle; Intertemporal Price Discrimination; Variable Profits; Consumer Welfare

Introduction

Oligopolies are one of the most interesting, yet complex, product markets to analyze from an industrial organization perspective. Since there are relatively few firms producing in this type of market structure, it is believed these firms recognize their pricing and output decisions are mutually interdependent. Green, et al. (2013) suggests this mutual interdependence results in strategic complementarities among firms. Therefore, the assumed economic objective of oligopolists is to maximize their interdependent profits and distribute them equitably subject to the capacity constraints of each firm.

While there are many theories of oligopolistic behavior, the focus of this research examines the theory of Edgeworth price cycles in the geographical context of the Midwestern U.S.A.[1]. Specifically, the existence and performance of these cycles are examined in the Indianapolis, Indiana retail gasoline market.

Cite this Article as: Jeffrey G. Woods (2014), " An Examination of Edgeworth Price Cycles in the Indianapolis Retail Gasoline Market," Journal of Research in Industrial Organization, Vol. 2014 (2014), Article ID 688538, DOI: 10.5171/2014. 688538

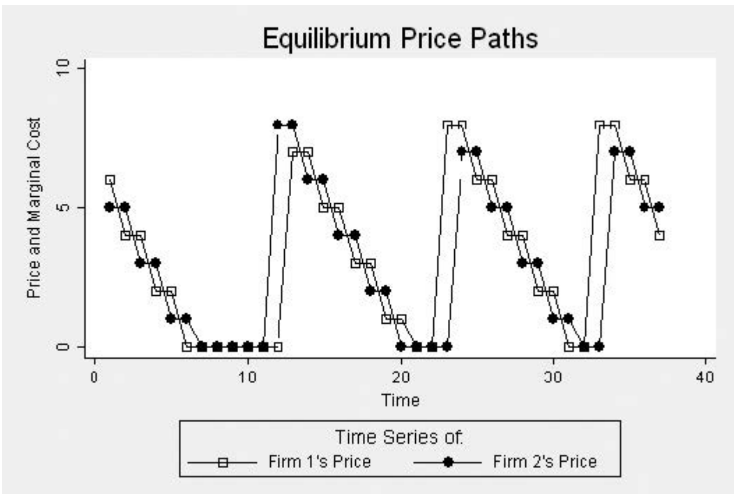
This research contributes to the literature by presenting a stylized graphical model of intertemporal price discrimination supplemented by institutional details that are characteristic of the Indianapolis retail gasoline market. This extended model provides the basis for interpreting price cycles by linking its theoretical implications to empirical and observational evidence.

Section 2 illustrates and describes the theory of Edgeworth price cycles and includes graphical evidence of an empirically derived cycle for the Indianapolis retail gasoline market. The structure, geography, and economic characteristics of retail gasoline stations and their role as multi-product firms will be discussed in Section 3. Section 4 explores how stations knowledge of heterogeneous consumer preferences fosters the practice of intertemporal price discrimination. The model illustrates intuitively how this practice can result in Edgeworth price cycles and increase the variable profits of retail gasoline stations. The importance of price leadership, market coordination, and communication among competing stations is examined in Section 5. Section 6 discusses the policy implications and welfare gains from consumer learning and search. A summary of this research and concluding remarks are offered in Section 7.

Edgeworth Price Cycles

In certain oligopolistic product markets, a competitive equilibrium generating a unique price may not exist. Edgeworth (1925) argues that prices in a competitive oligopoly may continually change resulting in an indeterminate equilibrium[2]. A type of equilibrium exists, however, where the indeterminacy of outcomes is bounded by a monopoly level price and a price that converges to marginal cost (Vive, 1993)[3]. The result may be that the price indefinitely oscillates along an asymmetric price cycle. The price cycle theory assumes changes in prices are not related to changes in wholesale costs (Lewis, 2012).

For example, as Indianapolis gasoline stations undercut one another to gain market share, the price of gasoline eventually becomes low enough that some stations could profitably raise price and serve the residual demand leftover from capacity constrained stations (Noel, 2011a). This form of dynamic pricing creates an asymmetric price cycle with more price decreases than increases (Zimmerman, 2012). This price response dynamic generates a cyclical path of prices illustrated as a type of equilibrium in Figure 1. Figure 1 illustrates a theoretical Edgeworth price cycle with two competing firms.



Source: Noel (2007b). Reprinted with permission from the publisher.

Figure 1: Model of a Theoretical Edgeworth Price Cycle

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Assuming gasoline stations have constant marginal costs, prices are initially in the neighborhood of the monopoly level price. At this point, station 2 will begin to undercut station 1 by a small amount. This action has the potential to steal total market share as gasoline stations are selling fuel, a homogeneous product. Station 1 responds by lowering its price to match station 2. The process of lowering the price by one station, with the price being matched by the other, continues until prices eventually converge to marginal cost. At this point, lowering prices further results in no gain but raising prices does. A war of attrition begins and eventually one station relents by raising the price to a monopoly level. The price restoration is followed by the other station and the price cycle repeats itself indefinitely.

Noel (2007b) indicates that a given price cycle has three relevant dimensions: 1) cycle period, 2) amplitude and 3) degree of asymmetry. The horizontal dimension measures the cycle period. This is the period of time when gasoline stations begin to aggressively undercut one another followed by a very rapid and market-wide restoration of prices. Lewis (2012) observes that in a typical Midwestern city like Indianapolis, retail gasoline prices often fall at an average of one cent per day or more for a week or two before a market-wide price restoration.

The amplitude of a cycle is a measure of the relenting phase or the difference between the restoration price and marginal cost. In the Indianapolis market, this can range from 10 to 30 cents above marginal cost before prices begin to fall again.

The degree of asymmetry of price cycles is a measure of gasoline price decreases relative to increases. Noel (2007b) emphasizes that the degree of asymmetry is the Edgeworth price cycle's most defining characteristic. Lewis (2012) uses the median daily change in a city's average retail gasoline price as a measure of asymmetry. He benchmarks a median daily price change below -0.2 cents per gallon as a strong indicator of cyclical pricing (degree of asymmetry). This finding was confirmed using daily data from October 2004 to July 2010 for the Indianapolis retail gasoline market.

Lewis (2012) provides graphical evidence of price cycles in Indianapolis by comparing data from 2008 for Indianapolis with Nashville, Tennessee[4]. Figure 2 compares the average retail gasoline prices for both cities from July 4, 2008 to September 12, 2008. Notice the overwhelming majority of average price increases in Indianapolis occurred during periods of price restorations (the shaded area in Figure 2). However, prices slowly descend between restoration periods. Nashville does not exhibit cycling behavior where prices are more stable compared to the Indianapolis market. One exception occurred during Hurricane Hanna in the Gulf of Mexico. Wholesale gasoline prices did jump in the Nashville market.

Why do price cycles occur in some cities but not others? Lewis (2012) suggests price cycles are related to particular market structures, geographical location, and the economic characteristics of retail gasoline stations that make the practice of undercutting more profitable. Section 3 focuses on market structure related issues. Gasoline stations profitability is explored in Section 4. Specifically, the model shows how variable profits from gasoline sales increase at a decreasing rate during the undercutting phase of the price cycle when stations sell gasoline in oligopolistic product markets.

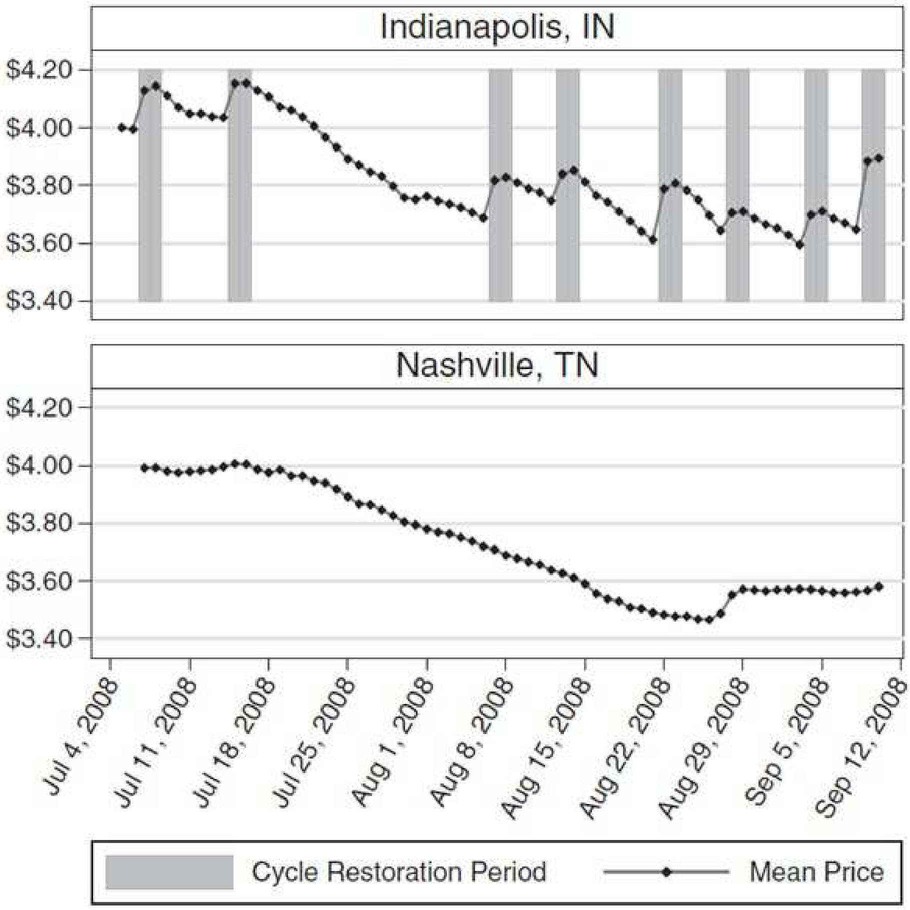
Indianapolis Retail Gasoline Market Structure, Geography and Economic Characteristics

The retail gasoline market in Indianapolis is an oligopoly composed of relatively few stations, both branded and independent. These include brands such as BP, Marathon, Phillips 66 and Shell. Independent stations include Speedway and Quick Trip.

The fuel sold in these stations, like all cities, is essentially a homogeneous product[5]. Most stations have evolved into multi-product retail establishments. In addition to gasoline, they also sell grocery and convenience store items. Some stations may offer car washes and automotive services (Eckert, 2013).

Adding to the complexity of the Indianapolis retail gasoline market is the presence of grocery stores such as Kroger and Walmart. Some of these stores also sell gasoline. How gasoline stations are affected by grocery chains will be discussed in Section 4.

The geographic location of gasoline stations is related to their density within Indianapolis. Major roads with high levels of traffic tend to have the greatest number of stations. These stations, both branded and independents, tend to be clustered close together on intersections or within a few blocks from one another. There is significantly less clustering of stations when one moves outward to the fringe of the city.



Source: Lewis (2012). Reprinted with permission from the publisher.

Figure 2: Comparison of Average Retail Gasoline Prices for Indianapolis and Nashville

The number of stations, their size, and visibility, can vary depending on available land. For example, Speedway, unlike many of its competitors, has a relatively large number of stations. Each station, compared to most of its competitors, typically has larger capacity underground fuel storage tanks coupled with many gasoline dispensing pumps. Most Speedways have relatively large convenience stores offering a greater depth and breadth of products compared to many competitors. Speedway's stations are constructed with high visibility store fronts and tall billboards displaying gasoline prices. With its significant real estate, large capital/labor ratios, number of stations, and visibility, Speedway is a dominant firm in the Indianapolis retail gasoline market.

While Indianapolis gasoline stations sell fuel, a homogeneous product, they are differentiated according to size, brand, product mix, geographic density, and visibility.

Model of Intertemporal Price Discrimination, Edgeworth Price Cycles, and Profitability

Managers in the Indianapolis retail gasoline market appear to recognize that gasoline consumers have heterogeneous preferences with respect to fuel purchases. These preferences are reflected in their different price elasticity of demands and timing of their fuel purchases. With this knowledge, stations can increase their variable profits by practicing intertemporal price discrimination. This pricing strategy involves targeting consumers with different demand functions by separating them by groups and charging each group a different price for gasoline at varying points in time (Pindych and Rubinfeld, 2013). When most gas stations in the Indianapolis market adopt this pricing strategy, they will be able to capture most of the consumer surplus from the targeted consumer groups. If stations can successfully capture this surplus from different consumer groups over time, they will be able to increase their variable profits. This is because each consumer group is charged a price for a gallon of gasoline exactly equal to what they are willing to pay. This essentially evaporates the consumer surplus for each group.

The model in Figure 3 illustrates the intertemporal price discrimination strategy for a representative Indianapolis gasoline station[6]. Those consumer groups unwilling to wait to purchase gasoline have a relatively inelastic demand curve ($D_1 = AR_1$). More patient consumer groups have a relatively elastic demand curve ($D_2 = AR_2$). To differentiate consumer groups based upon purchase timing decisions, notice that quantities are indexed to account for price discrimination based on time intervals. The objective of practicing intertemporal price discrimination is to extract most of the consumer surplus from each consumer group over time. This involves charging each group a price for a gallon of gasoline equal to what they are willing to pay. As stations engage in price undercutting and expand fuel sales over time, variable profits will increase at a decreasing rate compared to the case where the actual price all consumers pay is less than the price they are willing to pay for a gallon of gasoline.

For example, from the demand curve ($D_2 = AR_2$), suppose the price some consumers are willing to pay for Q_{t+3} gallons of gasoline is P_4, but all consumers actually pay a price equal to P_8 for an amount of gasoline measured from Q_{t+3} to Q_{t+7} gallons. Here, consumer surplus = area (ODL) and total variable profit (TVP1) = area (OLME). For an actual price of P_8, consumer surplus > total variable profit.

If each Indianapolis gasoline station successfully price discriminates over time, they can extract most of the consumer surplus from each customer group and generate higher total variable profits compared to the above alternative. For example, over price range P_4 to P_8 from Q_{t+3}

to Q_{t+7}, total variable profit (TVP2) = area (IFGE) + area (UHIG) + area (VJKI) + area (RLMK)[7] Clearly, TVP2 > TVP1 if each gasoline station can follow an intertemporal price discrimination strategy.

Practicing intertemporal price discrimination has a desynergizing effect on the variable profits of gasoline stations in the Indianapolis market. In essence, the sum of the variable profits of each station is greater than what they would be in the absence of price discrimination.

The underlying structure of an Edgeworth price cycle can be seen from Figure 3 approximated by the cyclical path of prices (OP_1ADNS). Note that point S on Figure 3 represents a price restoration back to P_1 indicating the beginning of the next cycle.

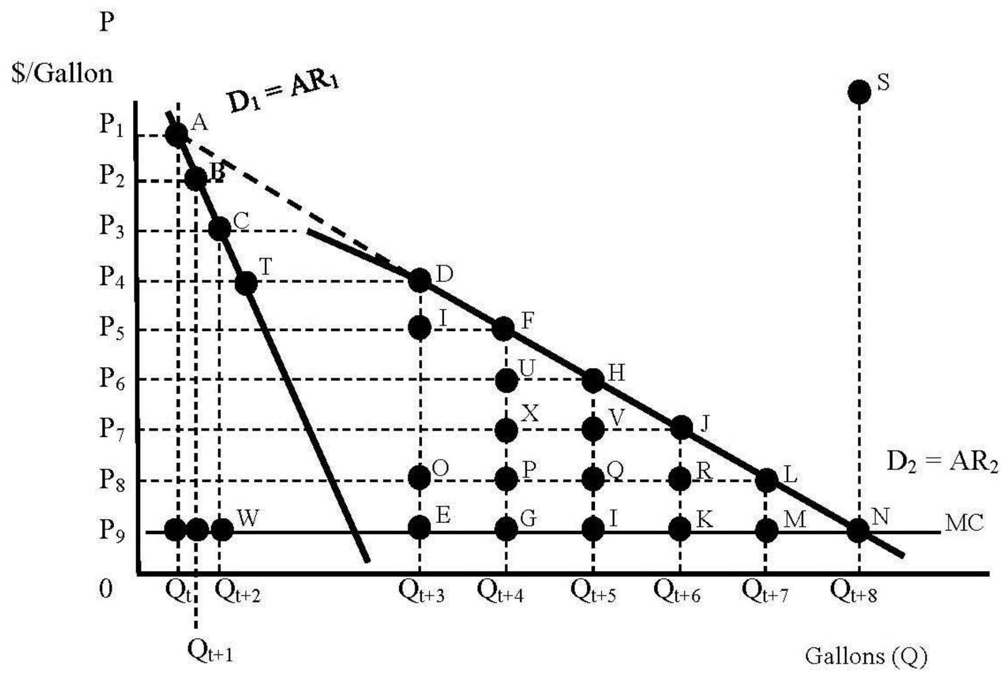


Figure 3: Model of Intertemporal Price Discrimination in the Indianapolis Retail Gasoline Market

Profitability and Indianapolis Retail Gasoline Stations as Multi-product Firms

Since most gasoline stations in Indianapolis are multi-product firms, selling convenience goods is an important part of their overall profitability. Doyle et al. (2010) argues that gasoline stations that operate convenience stores have a greater incentive to undercut competitors during the undercutting phase of an Edgeworth price cycle. While growth in variable profits from gasoline sales increase at a decreasing rate the closer prices get to marginal cost, this can be offset by the gain in additional customers purchasing convenience goods that have higher profit margins. However, with technological improvements allowing customers to pay for gasoline at the pump, the additional profit from selling convenience goods may be less than stations expect[8].

Many customers will purchase convenience goods with no intention of buying gasoline. As long as the transaction costs of convenience store purchases are less than the alternative, such as driving to a distant grocery store, gasoline stations profits will rise. These stations enjoy higher profit margins on the sale of convenience goods while the customer lowers transaction costs.

Gasoline stations that sell convenience goods in the Indianapolis market have faced additional competitive pressure from grocery chains such as Kroger and Walmart. These chains will engage in non-price competition by offering "loyalty points" earned from grocery purchases. When customers accumulate enough points based upon the amount of their expenditures, they are entitled to discounted gasoline prices. Grocery chains offer products at lower prices compared to convenience stores due to economies of scale. This results in lower profit margins per-unit for these chains. However, these lower margins are offset by a high volume of sales making overall profits larger compared to convenience stores.

What is the likely result of the intense competition gas stations face in Indianapolis? The outcome is a relatively fast cycle period during the Edgeworth undercutting phase, as gasoline stations aggressively undercut one another, attempting to increase variable profits and capture higher profit margins from convenience good sales. At the same time, Kroger and Walmart attempt to capture profits from convenience store operations by rewarding consumers with lower prices for groceries and gasoline.

The challenge for Indianapolis consumers is to lower overall costs for groceries and gasoline by planning purchases in advance, reducing the need to patronize gasoline stations with convenience stores. Many consumers find it difficult to plan all purchases and will attempt to lower transaction costs on occasion by patronizing convenience stores. To the extent that gasoline stations can lure these customers to their convenience store by aggressively undercutting their competitor during the cycle period, they will enjoy higher variable profits from gasoline sales and healthy profit margins from the sale of convenience goods.

Price Leadership and Edgeworth Price Cycles

Coordinating the Edgeworth price cycle mechanism in the Indianapolis retail gasoline market depends on how effectively price signals are communicated to market participants.

Lewis (2012) observes that price cycles occur when a leader retailer holds significant market share. Large firms are often viewed as more natural and effective leaders, especially during price restoration periods (Noel, 2007a). Firms with many gasoline stations and larger capacity fuel storage tanks per station often dominate a market as price leader. Speedway's market share in Indianapolis is over 10 percent (Lewis, 2012). As a recognized price leader, it coordinates citywide price restorations by unifying stations' prices on the day of restoration to signal and solidify the new market price level. To reinforce this signal, Speedway will simultaneously restore prices in its larger Midwestern operating region. Speedway can use their network of stations to signal the start of a restoration period to their spatially diverse competition (Byrne and Ware, 2013). Observational evidence suggests there is a high level of awareness and willingness of Speedway's competitors to quickly respond to its initiation of a price increase during the restoration phase of an Edgeworth price cycle.

Market level price dispersion narrows once a successful price restoration is completed. However, when Speedway begins to initiate the undercutting phase of the cycle, price dispersion begins to rise. Price variation rises as the undercutting phase progresses as Speedway and other stations attempt to compete with local stations in different neighborhoods (Lewis, 2012). For example, within the Indianapolis market, observational evidence suggests price dispersion increases as one move from an intersection, to street, to the edge of the city.

Speedway's Role as a Price Leader

In order for Speedway to serve as an effective price leader in the Indianapolis retail gasoline market, it must solve two problems: 1) it must be able to initiate a collusive arrangement and 2) it must determine how to implement a collusive agreement (Green et al. 2013).

It is unknown how Speedway might initiate an agreement among competitors. Green et al. (2013) indicates that competing stations may observe and react repeatedly to Speedway's price changing behavior. In fact, this type of learning behavior could arise spontaneously in a highly concentrated market. Also, competing stations may simply "blunder" into a cyclical equilibrium by accident.

Fundamentally, some type of communication is required during the initiation and implementation stages of a price leadership regime. Tacit collusion is the commonly observed method of communicating within an oligopoly coordinated by a price leader (Harrington, 2012). As a communication strategy, tacit collusion involves indirect or implicit communication with competitors in order to avoid violation of U.S. anti-trust laws.

It is difficult to precisely characterize the market conditions that must be present in order for Speedway to establish its collusive intent. Perhaps its visibility, gasoline capacity per station, and its relatively large number of stations is sufficient to establish its role as price leader (Deneckere and Kovenock, 1992).

How does the Indianapolis retail gasoline market decide on what type of mechanism will be used to maximize the joint profits of gasoline stations and distribute them equitably? Establishing a cyclical equilibrium in order to extract consumer surplus and distribute this surplus in the form of higher variable profits to the retail gasoline oligopoly is the implementation challenge for Speedway as a price leader.

Observational evidence indicates that Speedway implements the price cycle mechanism by initiating both price increases during the relenting phase, as well as price decreases during the undercutting phase. During the war of attrition that occurs prior to the relenting phase, Speedway must forecast the likely time when its average competitor becomes capacity constrained and then restore the monopoly level price, allowing competitors time to replenish gasoline supplies. Relenting price increases are not typically small in the cycle equilibrium, because such a move would cause Speedway to lose market share (Wang, 2005). Monopoly level price increases serve as a strategic benefit as variable profits per gallon of gasoline sold increases (price effect) at each station. Also, those firms with multiple stations earn higher variable profits per gallon of gasoline sold (scale effect).

When Speedway initiates the undercutting phase of the cycle, price decreases tend to be small and frequent. These price decreases are not designed to punish competitors (Wang, 2005). Speedway's price cuts are quickly followed by its competitors as they travel back to the bottom of the cycle. Variable profits increase at a decreasing rate, while the increase in the complementary sale of convenience goods adds to the marginal profit of gasoline stations.

Tacit collusion is self-sustainable if and only if gasoline stations put sufficient weight on future profits. Stations that have a lower discount rate (impatient stations) put more emphasis on short-run profits whereas those with a higher discount rate (patient stations) focus more on future profits.

Speedway must lead the distribution of gasoline stations in the Indianapolis market through the cycle equilibrium based upon the optimal discount rate in order to insure an equitable distribution of profits (Ivaldi et al. 2003).

The welfare gains to Indianapolis gasoline stations in a cyclical equilibrium are in the form of supra-normal profits. Given that this is a concentrated market, information costs are relatively low, helping to insure enforcement. However, the next section will explore how better informed consumers could affect the duration and amplitude of the cycle equilibrium. If consumers learn to time their gasoline purchases more strategically, it could diminish the duration and amplitude of the price cycle (Noel, 2007a). Consumer learning could potentially cause the Edgeworth price cycle to collapse. The result would be a convergence towards a competitive equilibrium. This would allow consumers to re-capture some of their surplus and move Indianapolis gasoline stations closer to normal profit levels.

Welfare Gains from Consumer Search and Learning

The existence of Edgeworth's cyclical equilibrium in the Indianapolis retail gasoline market requires that the distribution of heterogeneous consumer preferences match the distribution of prices. Clearly, consumers have incentives to disrupt the cycle equilibrium by responding to non-price competition such as loyalty rebates at Kroger or Walmart. They could also re-capture their consumer surplus by more strategically timing their gasoline purchases.

Gasoline stations in the Indianapolis market can successfully practice intertemporal price discrimination because some consumer groups are impatient, myopic or simply make gasoline purchases randomly. The variation in price sensitivity across consumer groups also contributes to the Edgeworth price cycle (Ekert, 2013). Clearly, it is easier for consumers to search for the lowest gasoline price when there is a high density of stations (Noel, 2007b). However, as price dispersion increases during the undercutting phase of the cycle, there is less price transparency causing search costs to rise. The willingness of consumers to search is also influenced by the magnitude of currently observed and past price changes (Ekert, 2013).

Indianapolis consumers may adopt different gasoline search strategies. These strategies use various amounts of information and may or may not be related to the timing of the price cycle. Noel (2011b) offers five possible consumer search strategies:

a. Myopic Strategies: Indianapolis consumers may 1) purchase gasoline when their fuel gage reading falls below a comfortable level, 2) choose a station with no queue, 3) purchase gasoline from a preferred major brand or independent station.
b. Position Based Strategies: Consumers 1) check wholesale and retail prices and calculate the current position of the cycle, 2) purchase gasoline when the price reaches a given threshold.
c. Spike and Wait Strategy: Consumers purchase gasoline a fixed number of days after the last observed price increase.
d. Spike and Buy Strategy: When consumers observe a large price difference between any two stations, they will buy from their preferred station if it has the low price or a nearby station with the lowest price.
e. Calendar Based Strategy: Consumers purchase gasoline at a specific time given that they know cycle periods are serially correlated.

Indianapolis consumers may adopt any one of the above strategies or choose a hybrid one. For some consumer groups, the non-monetary search costs related to time and effort may overwhelm the monetary gains from adopting a gasoline search strategy (Noel, 2011b). While the model illustrated in Figure 3 does not directly specify the non-monetary costs of intertemporal substitution of gasoline purchases, Noel (2011b; 2012) indicates these costs include:

a. The cost of collecting price information that is necessary to predict the timing of the troughs under most timing strategies.
b. The cost of extra visits to the gasoline station to fill a consumer's fuel tank.
c. The cost of queuing.
d. The utility cost of brand switching.

As long as these costs are less than the benefits of adopting timing strategies, consumers willing to pay higher prices may even find it optimal to choose a lower price strategy.

Using Public Policy to Improve Consumer Welfare

When examining potential consumer welfare gains from Edgeworth price cycles, one can look at differences *between* cycling and non-cycling cities and *within* cycling cities. Doyle, et al. (2011) estimated that cycling cities in the Midwest (including Indianapolis) had, on average, lower prices by 1 to 2 cents per gallon compared to non-cycling cities. Using daily data from April 1, 2000 to March 31, 2001, they found that cycling cities have price cycles that spend about equal time above and below the price levels in non-cycling cities.

If all consumers within the Indianapolis market were homogeneous and equally informed, the average price paid for 1 gallon of fuel would be lower compared to a market with heterogeneous consumer preferences. In practice, consumer groups have different time preferences, price elasticity of demands, and degree of myopia. Therefore, it may be very difficult for all groups to re-capture their consumer surplus.

Impatient consumers with low discount rates and more inelastic demands may not respond to price cycle information. Lack of learning is surprising, given the general interest in gasoline prices (Noel, 2011b). However, if gasoline stations' attempt to charge a higher than monopoly price during price restorations, consumer groups may invest in learning how to time their gasoline purchases (Noel, 2007a).

Clearly, welfare gains could be realized by informing myopic consumers of the existence of price cycles. Public policy should focus on increasing the awareness of these cycles in Indianapolis by providing accessible information to consumers giving them an opportunity to reduce their myopia and improve welfare.

Public service announcements, letters to the editor, and local television station broadcasts have a large reach across the Indianapolis retail gasoline market. Web-site information posting daily gasoline prices at branded and independent stations is available from GasBuddy[9].

Informing consumers of timing strategies needed to take advantage of cycles would lead to a re-optimization towards a new long-run gasoline price equilibrium (Noel, 2007a, 2011b). A greater awareness of price cycles, coupled with faster learning, could reduce their duration and amplitude in the Indianapolis market. This would at least allow myopic consumers to recover some of their surplus, while moving gasoline stations profits closer to a normal level. The result would be improved economic efficiency in the Indianapolis retail gasoline market.

Conclusion

Empirical and observational evidence indicate the existence of Edgeworth price cycles in the Indianapolis retail gasoline market.

The dynamic nature of these cycles results in a cyclical equilibrium. This type of equilibrium generates a sequence of prices creating a pathway gasoline stations can follow. This allows stations to increase their variable profits by capturing consumer surplus from a distribution of consumer groups with heterogeneous preferences.

Price leadership provided by Speedway insures that competing stations within the Indianapolis retail gasoline oligopoly are able to earn supra-normal profits.

Public policy should focus on increasing the awareness of price cycles, especially to myopic consumer groups. This would give them an opportunity to re-capture some consumer surplus and lead to more normal profit levels in the Indianapolis retail gasoline market.

Economic efficiency would be enhanced by reducing the duration and amplitude of these cycles. The result would be gains to consumer welfare moving the Indianapolis retail gasoline market closer to a competitive equilibrium.

Acknowledgements

I thank an anonymous referee for providing useful comments on an earlier draft of this paper. Also, I thank Anna Lang and Traci L. Moyer for technical research assistance.

Notes

[1] For surveys of theories of oligopoly see Shapiro (1989) and Friedman (1983).

[2]Maskin and Tirole (1988) formalized Edgeworth's theory by developing a more mathematically rigorous treatment of the model and some implications.

[3]This result is not necessarily characteristic of an Edgeworth price cycle equilibrium. The model proposed by Maskin and Tirole (1988) predicts that the price at the top of the cycle may be above or below the monopoly price and many amplitudes are possible in equilibrium.

[4] Details of data sources are available in Lewis (2012).

[5] Most stations sell gasoline with three octane levels as well as diesel fuel.

[6]This stylized model builds upon and extends a model proposed by Pindych and Rubinfeld (2013). I ignore fixed costs that are independent of gasoline stations' fuel output decisions.

[7] Incremental variable profit ($\Delta\pi$) = (P-MC) ΔQ. I ignore residual consumer surplus. For example, I ignore area (DFI) + area (FHU) + area (HJV) + area (JLR). This residual consumer surplus results from discontinuities in gasoline quantities as these quantities represent different consumer groups based upon their purchase timing decisions. If Figure 3 was a model of a monopolist practicing perfect first-order price discrimination, all residual consumer surplus would be eliminated because the monopolist could charge each and every individual customer a different price for each marginal quantity (gallon) of gasoline sold, e.g. quantities between Q_{t+3} and Q_{t+4}, and Q_{t+4} and Q_{t+5}, etc. Total variable profit is the sum of all $\Delta\pi$'s. Total Profit = Total variable profit – Total fixed costs.

[8]Stations' however, heavily advertise products at each point-of-sale gasoline pump to induce consumer purchases of convenience goods in their establishments. If this advertising is successful, stations' profits would rise. This however, would defeat the purpose of customers paying for gasoline at point-of-sale pumps in an effort to reduce transaction costs.

[9]For daily Indianapolis gasoline price information from GasBuddy see: http://gasbuddy.com/Gas_Prices/Indiana/Marion/index.aspx

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