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EDGEWORTH PRICE CYCLES

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Edgeworth Price Cycles refer to an asymmetric pattern of prices that result from a dynamic pricing equilibrium among competing oligopolists. The resulting time series takes on a sawtooth shape – many small price decreases interrupted only by occasional large price increases. Maskin & Tirole (1988) formalized the theory and later extensions were provided by Eckert (2003) and Noel (2008). Edgeworth Price Cycles are the leading theory for explaining the asymmetric price cycles that appear in many U.S., Canadian, Australian and European retail gasoline markets (e.g. Noel (2007a), Eckert (2002), Doyle et al. (2010), Wang (2009b)). While the cycles continue to generate public concern with claims of collusion often raised, the current evidence favors that Edgeworth Price Cycles are the result of stronger competition and the source of lower retail gasoline prices.

1 INTRODUCTION

Edgeworth Price Cycles refer to an asymmetric pattern of prices that is generated by a dynamic pricing equilibrium among competing oligopolists under certain simple assumptions. Most notably, the oligopolists are assumed to compete in prices, follow Markov strategies, and face relatively high price elasticities for their good. The time series of market prices under this equilibrium takes on a sawtooth shape with many small price decreases interrupted only by occasional large price increases. The asymmetric price pattern is repeated over and over even in the absence of any supply or demand shocks.

Edgeworth Price Cycles are the leading theory behind the asymmetric price cycles that appear in many retail gasoline markets around the world. First observed in some U.S. cities in the 1960s, they have become commonplace in many U.S., Canadian, Australian and European retail gasoline markets (e.g. Noel (2007a), Eckert (2002), Doyle et al. (2010), Wang (2009b)) and visually are very similar to the theoretical cycles. A single cycle is often a week or two long with amplitude up to about ten per cent of the price.

Two waves of literature examine these cycles empirically. The first investigates the cause of the retail gasoline price cycles. The near consensus in the literature is that the cycles are Edgeworth Price Cycles. The location and shape of the cycles, and the behavior of different types of firms along it, support the Edgeworth Price Cycles theory. The second wave of literature examines the welfare effects of the cycles relative to a stable price equilibrium. The literature is young but the results currently favor the conclusion that the price cycles are indicative of stronger competition and the source of lower prices for consumers.

2 THE THEORY OF EDGEWORTH PRICE CYCLES

The notion of a competitively-driven, dynamic, asymmetric price cycle dates back to Edgeworth (1925). Edgeworth was a strong critic of the Cournot model and argued that when marginal costs were increasing (or firms were capacity constrained in the extreme case), prices in oligopolistic competition would not be stable as in Cournot's model. Instead they would change continually along an asymmetric price cycle. Firms would undercut one another to gain market share, until prices were low enough that one firm could profitably raise price and serve the residual demand leftover from the capacity constrained firm. Interestingly, Edgeworth considered his cycle a disequilibrium, as the notion of equilibrium was then equated to stable prices.

The seminal theory paper on Edgeworth Price Cycles is Maskin & Tirole (1988), who gave the cycles their name. Maskin & Tirole assume two identical and infinitely lived firms with high discount factors that sell homogeneous goods and compete in prices. Firms are restricted to using Markov strategies, which in this context means that a firm's pricing decision depends only on the price of the other firm currently in effect. Demand is constant and costs are zero. Maskin & Tirole show in this setting two possible types of Markov Perfect Equilibria could result. The first generates stable prices over time, while the second results in asymmetric price cycles – that is, Edgeworth Price Cycles – in equilibrium.

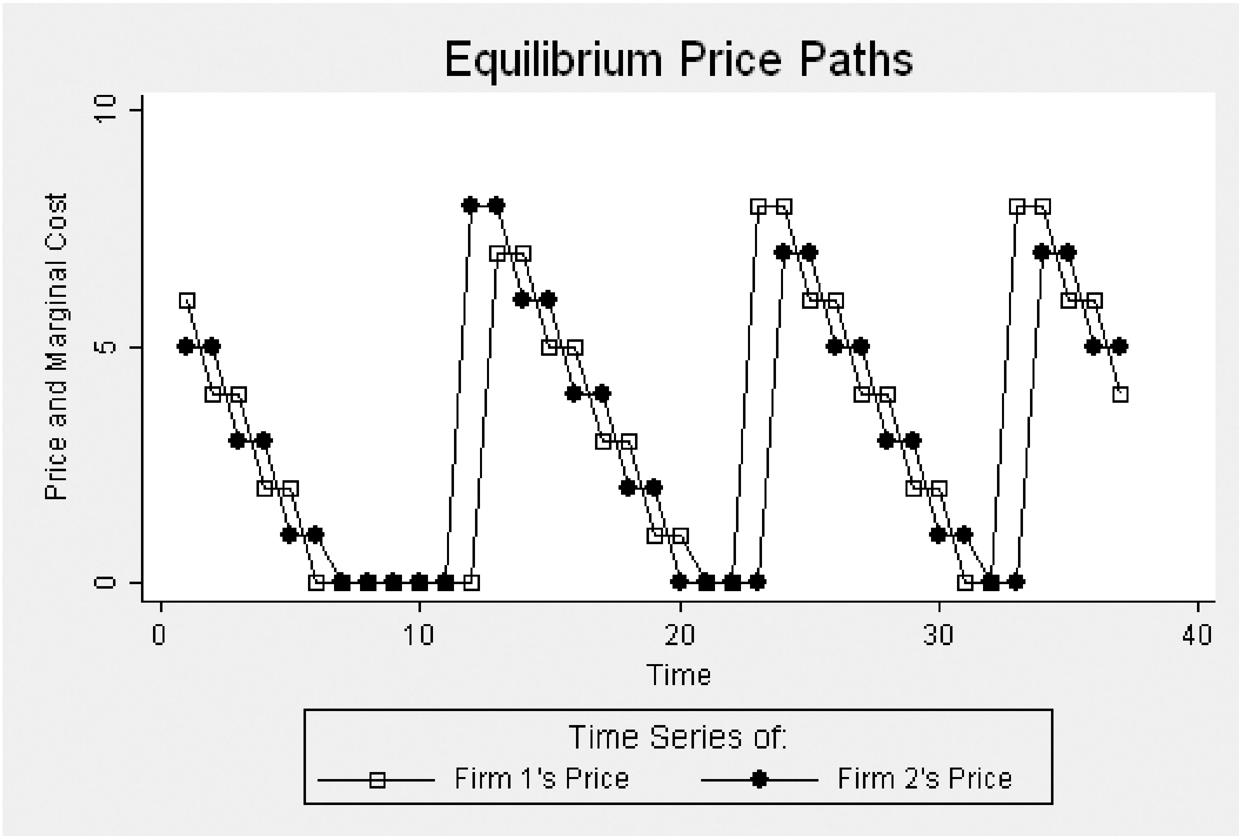

Figure 1 shows firm prices in a cycling equilibrium. The mechanism operates as follows. Starting from prices relatively high above marginal cost, firms alternately and repeatedly undercut one another's price by the smallest possible amount. Because the goods are identical, this is sufficient to fully steal total market demand. Undercutting continues until prices fall all the way to marginal cost, zero in this example. At that point, there is no gain to lowering prices further, but there is a gain to raising them. If one firm were to raise its price to a much higher level, the other firm would surely respond with a higher price too, just slightly undercutting that of the first firm. As a result, when prices are at marginal cost, firms play a war of attrition, each mixing between a higher price and maintaining the marginal cost price. Eventually, one firm relents by restoring its price back to a high level, the other follows, and a new round of undercutting begins. The cycle repeats over and over in the absence of cost and demand shocks.

The theory of Edgeworth Price Cycles is the leading theory for explaining the asymmetric price cycles found in retail gasoline markets. However, not all of its assumptions are well suited to retail gasoline. Retail gasoline is not perfectly homogeneous, marginal costs are not constant, there are more than two firms, and so on. To address this, Noel (2008) extends the model to allow for fluctuating costs, capacity constraints, product differentiation, triopoly situations, and other extensions. Noel shows Edgeworth Price Cycles are robust when product differentiation or capacity constraints are not too strong. Noel also shows cycles are robust to triopoly, but now with challenges in the form of false starts. False starts occur when the first firm to increase price abandons its high price altogether, after waiting too long for others to follow. Since false starts make it more costly for a firm to be first to raise its price, the cycle peak and trough prices move lower and average prices fall from increased competition. In another important extension, Eckert (2003) showed that if firms share the market very unequally at equal prices (interpretable as the case of asymmetrically sized firms), Edgeworth Price Cycles were more likely.

3 Empirical Evidence of Edgeworth Price Cycles

An early criticism of the theory, dating back to at least Nichol (1935), was that the model failed to predict the experience of any known real world markets. There has also been very limited success in generating Edgeworth Cycles in laboratory experiments (Leufkens & Peeters (2008)).

This all changed when - with the availability of new high frequency and station-specific datasets – asymmetric retail price cycles were discovered in gasoline markets in many countries in the 1990s and 2000s. As of 2010, cycles have been observed in many retail gasoline markets in the United States, Canada, Australia, Norway, Germany and Belgium, with other discoveries sure to come. (Cycles had been detected in a few U.S. cities in the late 1960s and early 1970s, but received little attention from economists at the time, and then disappeared from view for thirty more years.) Recently, inverted asymmetric price cycles have also been found in keyword advertising auctions at leading search engines (inverted because competition is among buyers instead of sellers) (Zhang (2005)).

The first generation of studies in the literature sought a cause for the empirical asymmetric cycles, and the results of that literature strongly point to Edgeworth Price Cycles (to name a few: Castanias & Johnson (1993), Lewis & Noel (forthcoming), Lewis(2009a), Lewis(2009b), Doyle et al. (2010), in U.S. retail gasoline markets, Noel (2007a), Noel (2007b), Noel (2009), Noel (2010a), Eckert (2002), Eckert (2003), Eckert & West (2004), Atkinson (2009) in Canada; Wang (2009a), Wang (2009b) in Australia, Zhang (2005) in internet auction markets). One opposing view is that of Foros & Steen (2008) who examine Norway and argue that the cycles there, although similar to those in other countries, are possibly a form of pure collusion.

The first known publication that noted asymmetric price cycles in retail gasoline was Allvine & Peterson (1974) who showed cycles in several U.S. cities in the late 1960s and early 1970s. Castanias & Johnson (1993) reported summary statistics on the cycles in Los Angeles area and noted the resemblance between those cycles and the then newly published Maskin & Tirole (1988) theory article. In Los Angeles, a single cycle lasted about one to two months with amplitude of roughly twenty-five per cent of the price.

The first full length scientific papers were written about Edgeworth Cycles in Canada, where most large cities experienced price cycles beginning from at least the late 1980s. The cycles ranged from weekly up to bimonthly in duration and longer. Eckert (2003) showed that price volatility in retail gasoline prices in Canadian cities were consistent with the general predictions of his extension of the Edgeworth Cycle model.

Noel (2007a) specifically modeled the asymmetric price movements in Canadian cities and found that a greater market share of aggressive independent firms resulted in cycles that were *faster*, *taller*, and *less* asymmetric, consistent with the theory. Noel (2007b) examined station specific data in Toronto, Canada and showed that behaviors of differently sized firms were also consistent with the theory. Large refiner-retailers tended to lead price increases and smaller independents tended to lead price decreases. The duration of cycles in Toronto averaged a week and the amplitude about eight per cent of the price. Atkinson (2009) found similar results with high frequency price data in Guelph, Canada.

Retail gasoline price cycles were rediscovered in dozens of U.S. cities in the early 2000s, although it is uncertain how long they existed prior. The cycles were weekly in most cities but biweekly in a few. Lewis (2009a) and Lewis (2009b) support that the cycles in the Midwest U.S. are Edgeworth Price Cycles. The amplitude of the cycles averaged seven per cent of the retail price. Doyle et al. (2010) present further evidence that cycles were more likely with more large, price aggressive independents, consistent with their extension of the theory.

In major Australian cities and many smaller ones, retail gasoline price cycles were weekly in duration except in Perth where they were sometimes biweekly. Wang (2009a) estimates especially high cross price elasticities in Perth, consistent with the theory, and Wang (2009b) shows the pattern of price increases among the leading firms is consistent with the use of mixed strategies, as predicted in a symmetric Edgeworth Price Cycles model.

Foros & Steen (2008) examine the cycles in Norway which share the characteristics of cycles elsewhere. They offer the opposing view that the Norwegian cycles may be a pure collusion story on the basis that the large price increases occur in a short window on late mornings and early afternoons on Mondays. While there is no direct evidence of widespread collusion in Norway or elsewhere, isolated instances of individual dealers colluding with one another can occur in cycling markets just as they can in non-cycling markets (see Wang (2008) for the case of Ballarat, Australia, and Erutku & Hildebrand (2010) for the case of four towns in Quebec, Canada.)

Edgeworth Price Cycles have not been well understood in many circles and the large sweeping price increases understandably raise antitrust scrutiny. The second wave of the Edgeworth Price Cycles empirical literature examines the impact that cycles have on price and welfare.

Most important and difficult is the question of how markups rise and fall with the presence of Edgeworth Cycles. Noel (2002) shows that in Canada markups within the same city in a nearby time period (i.e. controlling for time-city effects) were one cent lower just after cycles began compared with before. The consumer gain of cycling in his sample cities is CDN$48 million per year. Doyle et al. (2010) show that in the U.S., markups in cycling cities are one to two U.S. cents per gallon lower than in non-cycling cities, controlling for market structure and other observables. Wang (2009b), however, finds that prices were 1.8 cents lower when cycles temporarily ceased in the four months after the passing of the 24 hour price change pre-notification law in Perth, Australia. Noel (2010b) notes it would not be unusual for prices to temporarily fall in such a situation, as firms jostle for position and generate a string of false starts as they adjust to the new notification requirements.

Lewis (2009a) and Lewis & Noel (2010) argue for another pro-competitive aspect to Edgeworth Price Cycles – that they more effectively anchor prices to wholesale costs over the long run. In non-cycling markets, the well known rockets and feathers phenomenon is that prices rise quickly after a cost increase but fall slowly after a cost decrease (Borenstein et al. (1997). Noel (2009) and Eckert (2003) even show that in cycling markets, the presence of the asymmetric cycle can generate or magnify such an effect. However, compared to non-cycling markets, in cycling markets the cycles are effective in returning prices back down to costs at every trough. Lewis (2009a) shows retail gasoline prices in U.S. markets with Edgeworth Price Cycles fell much more quickly in the months after Hurricane Katrina than those cities without, for a relative gain of US$1.33 million per 100,000 people. Lewis & Noel (2010) look more comprehensively at 72 U.S. cities and show cost shocks are passed through two to three times faster in cities with Edgeworth Price Cycles than in cities without, substantially reducing the rockets and feathers welfare loss relative to non-cycling cities.

Noel (2010a) argues for another hidden benefit of Edgeworth Price Cycles. Very simple purchase timing strategies can allow price elastic consumers in Toronto to easily reduce their gasoline expenditures by four per cent relative to purchasing at random times. The gain would be even greater in other markets (eg. Norway or Australia) where cycle troughs are even more easily predictable. Firm price reoptimization in response to large numbers of consumers timing the cycles could limit the gain, of course, but as the Australian experience shows, the cycles remain active and strong even when there is significant consumer awareness of them.

The greater implication of Noel (2010a) is that to the extent consumers use purchase timing strategies that are not observed by the researcher, the benefit of Edgeworth Price Cycles is understated. This is because when consumers can time purchases to periods of lower prices during cycles, the more economically relevant measure of *quantity-weighted* prices is likely to be lower than the unweighted average price in markets with cycles, but the same in markets without. A comparison of average quantity-weighted prices under period of cycling and non-cycling would then reveal a greater price advantage to consumers in markets with Edgeworth Price Cycles.

3 Conclusion

Edgeworth Price Cycles are asymmetric price cycles generated from equilibrium behavior in a game of oligopolistic price competition. Firms repeatedly steal market demand from one another by undercutting down to marginal cost. Firms then sequentially increase prices back to the top of the cycle and begin undercutting again.

The empirical literature strongly favors that the asymmetric price cycles in retail gasoline markets are generated by an Edgeworth Price Cycles process. While research continues, the weight of the current evidence also points to the conclusion that Edgeworth Price Cycles are indicative of stronger competition. They benefit consumers with lower and more efficient prices relative to the less controversial stable price equilibrium.

The literature on Edgeworth Price Cycles continues to grow. An obvious direction for future work is to search for and uncover additional examples of Edgeworth Price Cycles outside of retail gasoline. Further extensions to the theory can help guide this search, and conversely the findings of the search can suggest new extensions to the theory to help identify the factors most critical to cycle generation. Finally, the welfare effects of Edgeworth Price Cycles have only recently begun to be understood. An important direction of future research would be to study and quantify these effects further, with obvious and important antitrust and policy implications.

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