Assessing the Impact of Fuelwatch:

A Submission to the Senate Standing Committee on Economics' Inquiry into the National Fuelwatch Regulation

July 20, 2008

Zhongmin Wang

Assistant Professor of Economics
Department of Economics
Northeastern University
Boston, MA 02115
Phone: (617) 373-2883
Fax: (617) 373-3640
Email: Zho.Wang@neu.edu
Website: http://www.economics.neu.edu/zwang

1. Introduction

My name is Zhongmin Wang. I am an Assistant Professor of Economics at Northeastern University, Boston, USA. I was a lecturer at Monash University from August 2002 to June 2005. I have a Ph.D. in economics from Georgetown University, Washington D.C. Mr. John Hawkins, secretary of the Senate Standing Committee on Economics, invited me to make a submission to the Senate inquiry into Fuelwatch. I have been conducting independent, academic research that is closely related to petrol pricing issues in Australia since 2003, well before the current national debate on Fuelwatch. My research was designed to answer specific academic questions, and was not motivated by the current debate. Nonetheless, my research contains results that are highly relevant to the current debate on Fuelwatch. I have written three academic papers related to petrol pricing issues in Australia. The title and the abstract of the three papers are listed in the Appendix. In particular, I have analyzed the (regular unleaded) petrol price cycle dynamics in the Perth metropolitan area before and after the introduction of the Fuelwatch in Western Australia, and estimated the station level petrol demand in the Perth area. My independent research and my acquired understanding of the relevant economics literature form the basis of this submission.

There are two possible ways to predict the impact of the proposed Fuelwatch regulation on prices consumers pay. One is theoretical, and the other is empirical. In this submission, I wish to emphasize the following points:

- Economists have a theory that helps us understand what is driving the observed petrol price cycles in Australia. This theory makes some predictions as to the impact of the Fuelwatch regulation, and these predictions are borne out by the Fuelwatch experience in the Perth metropolitan area.

- However, this theory has little to say about the potential impact of the Fuelwatch on the *level* of petrol prices that consumers will pay. Therefore, whether the proposed Fuelwatch regulation would increase or decrease the petrol price in the eastern states is largely an empirical question.

- Researchers face many methodological and data issues when empirically assessing the impact of the Fuelwatch on the price consumers pay. Due to these issues, it is difficult to reach a convincing conclusion on the impact of the Fuelwatch on the price consumers pay.

2. What can we learn from theory?

To make sense of petrol price cycles, we need a theory that is capable of explaining its existence and characteristics.

A. Edgeworth cycle theory captures the key characteristics of petrol price cycles

The Edgeworth price cycle theory of Maskin and Tirole (1988) captures some of the key characteristics of the observed price cycles.[1] Figure 1 shows a numerical example of the Edgeworth price cycle. Figure 2 shows five regular unleaded petrol price cycles in the Perth market under the 24-hour-rule, using daily brand average prices. The observed petrol price cycles look remarkably similar to the theoretical Edgeworth price cycle. In both figures, firms hike their prices significantly and sequentially, and then undercut each other gradually over a longer period of time.

Figure 1: Maskin and Tirole's Edgeworth Price Cycle

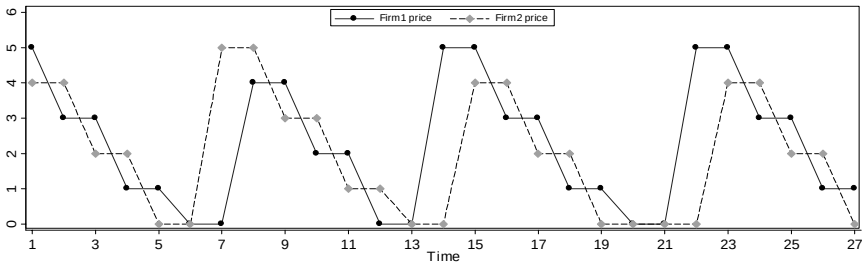
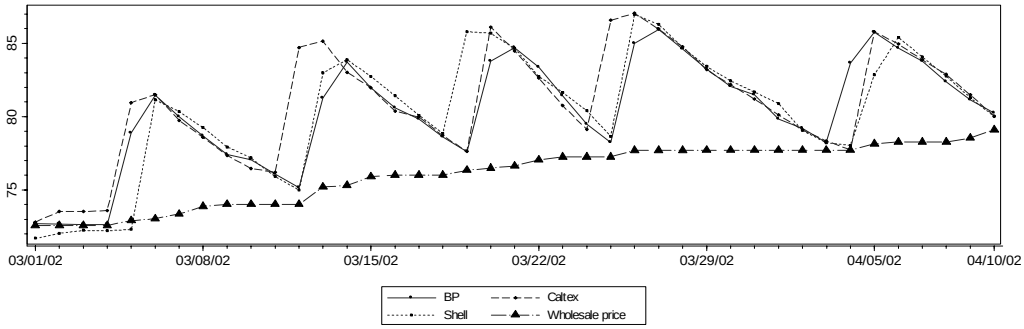


Figure 2: Daily Brand Average (Regular Unleaded) Petrol Price in the Perth market



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

B. Edgeworth cycle theory captures the basic characteristics of petrol markets

Edgeworth price cycle arises as an equilibrium in a model that assumes the following strategic environment: (1) the market structure is oligopolistic, (2) the oligopoly firms are engaged in repeated competition over time, (3) firms compete over the pricing of a relatively homogenous product, (4) and price information is observable to both firms and consumers.

The Perth petrol market, as well as many other petrol markets in Australia, satisfies these assumptions reasonably well. Hundreds of gasoline stations are present in the major metropolitan areas, but they are not all independent price setters. For example, a multi-site franchisee can set the prices for a large number of gasoline stations. We would not be able to see the clear pattern of sequential price hikes in figure 2 if it were not for intrabrand synchronization and uniformity in price hikes. By intrabrand synchronization, I mean a large percent of the retail prices posted by a particular brand were hiked during a short period of time before the 24-hour-rule or on the same day under the 24-hour-rule. By intrabrand uniformity, I mean a large percent of the retail prices posted by a particular brand were hiked to a uniform level. Intrabrand synchronization and uniformity is very weak, if exists at all, during the cycle falling phase, and why this is the case will be explained later. Intrabrand synchronization and uniformity suggests the existence of intrabrand pricing coordination.

Petrol firms clearly compete repeatedly with each other over time and price. Petrol is a relatively homogenous. I estimated station level petrol demand in the Perth market and the results confirm this presumption. I also found Perth petrol stations have very low petrol profit margins – the margins are so low that many petrol stations would not be able to survive without the profits from the sales of nonfuel products.

Petrol prices in metropolitan areas, even without the 24-hour-rule, are posted on large price board, thus observable to firms and to consumers. There are only a few prices in the theoretical model, so all consumers are perfectly aware of any price change by any firm. In reality, there are hundreds of gasoline sites, and no individual consumer, even under the 24-hour-rule, is aware of all price changes. What matters is that those price sensitive consumers are able to observe and compare petrol prices.

Since Edgeworth price cycle theory captures the key characteristics of both the petrol market and the petrol price cycles, it naturally captures the basic strategic force behind the petrol price cycle. Why does petrol price cycle arise? Since petrol is relatively homogeneous product, the natural tendency of competition is for its price to be close to the wholesale price, but such a situation of low or no profit is unsustainable so firms have the incentive to raise price. Why increase price in a single step rather than small steps? Hiking price to a higher level has the strategic effect of inducing other firms to follow. Given that your competitors' price is hiked, the best course of action for you is to raise your price to a level slightly lower than your competitors'. Increasing price in small steps loses market share without achieving the strategic effect. Why petrol price cycles typically do not exist in rural areas? Because market structure in such areas

may not be oligopolistic, petrol may not be a relatively homogenous product because of spatial differentiation, and petrol prices may not even be displayed on a board.

C. Edgeworth cycle theory has little to say about cycle amplitude or duration

Edgeworth price cycle is the theory that best explains the petrol price cycles. However, the academic literature in this area is still in its early stage. The existing literature has little to say about the amplitude or overall duration of petrol price cycles, though it captures the fact that the rising phase of a petrol price cycle is shorter than the falling phase. One reason is that one can construct Edgeworth price cycles of various amplitudes or durations by changing market demand or the possible prices firms could set. A second reason is that even though Edgeworth price cycle captures the key strategic force behind the observed petrol price cycles, it does not capture all the economic forces behind the petrol price cycles. For example, the existing versions of this theory assume away intertemporal substitution. In other words, consumers in the model make their purchase decisions by comparing price across different firms within a given period, but not over time periods. However, a major issue in the current debate is the realization that if petrol price cycles always start on the same weekday and its duration is always weekly, price-sensitive consumers would benefit from intertemporal substitution.

D. Edgeworth cycle theory has limited predictive power as to the impact of the 24-hour-rule

Since this theory has little to say about the amplitude or duration of petrol price cycles in the first place, it naturally has little to offer about the impact of the 24-hour-rule on these two cycle parameters.

More importantly, this theory is essentially silent as to the impact of the 24-hour-rule on the level of petrol price. That is, the impact of the 24-hour-rule on the level of petrol price in a cycling market is ambiguous. Therefore, we do not have a theory that is able to predict how the 24-hour-rule would impact the price consumers pay.

Despite these limitations, this theory does make certain predictions with regard to some aspects of the petrol price cycle dynamics. It predicts that under the 24-hour-rule, (1) firms need to resolve more carefully the issue of which brand is the first to hike price for a given cycle, (2) intrabrand synchronization in price hikes becomes stronger, (3) the sales volume of a petrol station becomes more volatile.

The key to understand these changes is the ‘frequency’ aspect of the 24-hour-rule – a firm can only change its price once 24 hours. The impact of the ‘timing’ aspect of the 24-hour-rule, a firm has to set its price without knowing its rivals’ price, is more subtle.

The Edgeworth cycle theory suggests a petrol price cycle has three phases. Other than the obvious rising and falling phases, a third phase, called the war of attrition phase,

exists at the bottom of each cycle. At the cycle bottom when retail price is at or near the wholesale price, all firms would like the retail price to be hiked, but none would like to be the first to do so.[2] If all prices are increased, all firms are better off. However, the first firm to hike price loses market share to rival firms in the short run. Put differently, the first firm to hike price provides a service (called price leadership in the literature) at its own cost but benefits all firms. The existence of this war of attrition problem at cycle bottom explains why there is strong intrabrand synchronization in price hikes but not price decreases. Without intrabrand synchronization, the war of attrition problem is hard to overcome. Suppose a single site hikes its price first, would other sites have the incentive to follow? It is easy to see that all have the incentive to be the last to hike price to enjoy increased sale volume. It is this war of attrition problem that explains why some firms in the Ballarat petrol markets once made phone calls to each other before they hiked their prices, but not before they lowered their prices. For more discussions on this war of attrition problem at the cycle bottom, see my paper on collusive communication and pricing coordination.

The disincentive to be the first to hike price is much greater under the 24-hour-rule. Without the rule, the price leader for a cycle knows that once its price is hiked, other firms can respond very quickly (within hours) by hiking their prices as well. If other firms do not respond quickly, the price leader can quickly retract its price hike to avoid losing much market share. However, under the 24-hour-rule, after a price leader hikes its price, other firms cannot respond within 24 hours. The price leader has to lose market share for an entire day – it cannot retract its price hike either. This analysis suggests that a single firm may be willing to serve as the price leader for most price cycles without the 24-hour-rule, but price leadership must be somehow allocated among the firms under the 24-hour-rule.

Intrabrand synchronization in price hikes has to be higher because of the much limited opportunity to change price. Without the 24-hour-rule, the price of a particular brand may be increased at various times within a certain period. Under the rule, however, the same practice of increasing a brand's price at various times means increasing its price over several days. This is at odds with the need to increase price quickly.

It is easy to see why an individual site' sale volume becomes much more volatile. If a site's price turns out to be higher than its rivals', it has to be at that high level for an entire day. This site cannot lower its price even if it is not selling anything. If a site's price turns out to be much lower than its rivals', this site would enjoy increased sales volume for an entire day. Because firms hike price sequentially, prices would differ significantly across sites of different brands during the cycle rising phase. Consequently, on those days, many sites would experience extreme volatility in sales volume.

[2] This situation is in essence the same as the situation in which two animals are fighting over a dead prey – both animals would like the fight to end as quickly as possible, but neither wants to be the first to give up.

3. What have we learned from the Perth experiment?

In one of my research papers, I compared the petrol price cycle dynamics before and under the 24-hour-rule. I analyzed site-specific high-frequency petrol price data from July 1 through December 20, 2000, which were provided by Informed Sources in 2003. In the same paper, I also analyzed the daily site-specific price data from the start of the 24-hour-rule to October 31, 2003, which were downloaded from the Fuelwatch internet website. As part of my ongoing research, I have been following the petrol pricing dynamics in the Perth metropolitan area up to now.

A. Price cycles before Fuelwatch

There are 21 price cycles from July 1 through December 20, 2000. There are strong intrabrand synchronization and uniformity in price hikes but not in price decreases. BP-branded stations were the first to hike price over 18 of these price cycles. The leader of a price cycle always started to hike price between 11 am and 2 pm on Tuesday, Wednesday or Thursday. The duration of a price cycle is between six and nine days. The rising phase of a price cycle is typically less than 24 hours as the brands usually follow each other's price hike rather quickly. If other brands do not follow their price hike within hours, BP-branded stations would retract their price hikes. The independent chains are typically the last to hike price and they usually undercut the major brands' price hikes by about 0.2 cents per liter.

B. Price cycles after Fuelwatch

The 24-hour-rule in Western Australia took effect at the start of 2001, and it changed the petrol pricing dynamics in the Perth area in significant ways. In the first four months of the rule, there were no regular price cycles. This is not surprisingly since firms need to adjust to the new rule. Regular price cycles reappeared in early May 2001.

As expected, the 24-hour-rule had a dramatic impact on the distribution of price leadership. For example, over the 102 price cycles between May 10, 2001 and October 21, 2003, Caltex-branded stations were among the first to hike price over 52 cycles, BP-branded stations were among the first to hike price over 49 cycles, and Shell-branded stations 30 cycles. In fact, there are seven price leadership types during this period: (1) BP brand alone is the first to hike price, (2) Caltex brand alone, (3) Shell brand alone, (4) BP and Caltex brands together, (5) BP and Shell brands together, (6) Caltex and Shell brands together, and (7) BP, Caltex, and Shell brands all together. My research uncovers the underlying mechanism used by the firms to generate the observed price leadership patterns and shows the mechanism is consistent with the prediction of the Edgeworth price cycle equilibrium.

Also as expected, intrabrand synchronization in price hikes is much stronger, and price retraction is observed much less often. My research on station level petrol demand

in the Perth market also confirms that individual petrol stations' sales volume is highly volatile and closely related to the price cycle dynamics.

Consistent with the fact that the existing theories have little to offer with regard to cycle duration, the duration of petrol price cycles in the Perth area has exhibited three distinct regimes since the start of the 24-hour-rule.

- *Regime 1* is from May 2001 through October 2003. During this period, cycle duration, ranging from 3 to 16 days, is unpredictable in that it is characterized by a white noise process. This means that even the petrol firms themselves are not sure about when the price cycle will end or when a new price cycle will start. The rising phase of a price cycle is either 2 or 3 days, reflecting the fact that BP, Caltex, or Shell brands almost always follow on the second day if they are not a price leader and that Mobil and independent gasoline chain firms follow on the second or third day. A price cycle could start on any day of the week, and most of the price cycles start on Tuesday, Wednesday, Thursday or Sunday.

- *Regime 2* starts in late 2003, when Caltex-Woolworths co-branded stations started to appear in the Perth area, and ends in mid-September 2005, when regular price cycles disappeared because of Hurricane Katrina. During this period, price cycle is largely weekly. Before the entry of Coles, most of the price cycles in this period start on Sunday. After the entry of Coles on March 16, 2004, the vast majority of the price cycles start on Tuesday. Price leadership essentially falls on either BP- or Caltex-branded sites. Coles Express and Caltex-Woolworths sites never led in this period.

- *Regime 3* starts in January 2006 when price cycle reappeared after Hurricane Katrina and continues to the present. The duration of the price cycles in this period is largely bi-weekly. Most of the price cycles start on Monday or Tuesday. Price leadership in this period still falls essentially on BP- and Caltex-branded stations, but Coles Express is among the first to hike price over a number of cycles. Over many price cycles in this period, the price leader, on the first day of a new cycle, may hike the prices of only a small number of gasoline sites. Through this mechanism, the price leader of a price cycle is able to signal the start of a new cycle without losing much sales volume. In contrast, during the period of regime 1, the price leader of a cycle typically hiked most of its branded sites' prices on the first day of a new cycle.

Since each of the three regimes is observed for a significant period of time, it is safe to make the inference that each of them is an equilibrium behavior. My research has shown that the first regime in which cycle duration is unpredictable is indeed consistent with equilibrium behavior. Unfortunately, economic theory offers little as to why one equilibrium prevails over another, even though it is clear that the entry of supermarkets upset the regime 1 equilibrium. Since regime 3 is the last one observed, and it has been continuing for over two and half years, it is tempting to infer that a 2-week cycle would also appear in Melbourne or Sydney under the proposed Fuelwatch regulation. However, further research is needed to validate this inference.

4. What is the impact of Fuelwatch on the price consumers pay?

We do not have a theory yet to predict the impact of the Fuelwatch on the price consumers pay, so we have to assess the impact empirically. However, because of methodological and data issues, this empirical exercise is inconclusive at this stage. Below, I discuss the methodological and data issues.

A. Methodological issues

A good way of discussing the methodological issues is to use an analogy. The exercise of assessing the impact of Fuelwatch is similar to the exercise of assessing the impact of a new drug. To reach convincing conclusions on the effectiveness of a new drug, medical researchers need to conduct random experiments with a large number of subjects. Some subjects are given the drug, thus in the treatment group, and some subjects are given placeboes, thus in the control group. This research design allows us to observe how the drug affects the subjects in the treatment group relative to the subjects in the control group. The statistical technique used to identify the effect of a treatment is called the difference-in-difference method.

Imagine Fuelwatch as the treatment. The various geographical petrol markets in Western Australia are then the subjects in the treatment group. Suppose for the moment petrol markets in the rest of Australia can serve as the control group. The exercise of comparing the average price differential between Perth and a group of control cities before and after the Fuelwatch is equivalent to the exercise of observing the impact of a drug on a *single* subject in the treatment group. It does not pass the laugh test if medical researchers reach their conclusion on the effectiveness of a drug by examining a single treated subject. This analogy suggests that, to observe the impact of the Fuelwatch, we need to study all the affected geographical markets in Western Australia and on all fuel products to increase the number of subjects in the treatment group. This is consistent with this inquiry's goal of studying not only metropolitan areas but also regional and rural areas, not only unleaded petrol but also diesel and LPG. Unfortunately, there are few studies on the regional or rural areas or on diesel or LPG.

In this research design of treatment versus control group, it is important to be sure that the control group is actually comparable to the treatment group, and that the only major difference between these two groups over time is the treatment. Perth is the only subject in the Fuelwatch treatment that is arguably similar to Melbourne or Sydney in terms of price cycle, market size, and market structure. Ideally, we want the treatment group includes a large number of cities very similar to Melbourne and Sydney. Since the Fuelwatch affects a fairly large number of regional and rural areas in Western Australia, we have a better chance of assessing the impact of the Fuelwatch on the price consumers pay in regional and rural areas, if price data for such areas are available.

The current debate has realized that many things other than the Fuelwatch may differentially affect Perth and cities in the eastern states. One has to control the impact of those factors before reaching a convincing conclusion. It may be difficult to separate out

the impact of the Fuelatch from the impact of other factors, such as the entry of supermarkets into petrol retailing. If one finds supermarkets sites have differentially affected the Perth market and the other markets, we cannot conclude that the effect is due to the supermarkets alone. The drug analogy is useful here as well. Suppose a group of subjects are treated with drug A (e.g., Fuelwatch). After observing that nothing happened to these subjects for a while, doctors treat these subjects with drug A together with drug B (supermarkets). Now, significant effects are found in these subjects. There are two possible explanations for the observed effects: the combination of drugs A and B or drug B alone. To separate out the effects of supermarkets from that of the Fuelwatch, one has to compare one group of markets in which Fuelwatch is present and supermarkets entered and another group of similar markets in which Fuelwatch is present and supermarkets did not enter. One cannot separate out the effect of the Fuelwatch from that of Coles or Woolworths by comparing the Perth market and the Melbourne or Sydney markets. Supermarkets entered all the major petrol markets.

I should also point out that the validity of the treatment versus control group methodology is based on the idea that the subjects in the treatment group are randomly assigned. One may argue whether this is the case with regard to the Fuelwatch.

The timing of the treatment in this methodology is known *a priori* – researchers know in advance when the subjects are given the treatment and when the treatment may start to have an impact on the subject. The timing of the Fuelwatch treatment is, unfortunately, not clear-cut. We know the 24-hour-rule took effect in the Perth area at the start of 2001. We know the price cycle dynamics changed dramatically right at the start of 2001. We may be tempted to conclude that the timing of the Fuelwatch treatment is January 2 or 3, 2001. However, the data suggests that the price cycle dynamics started to change at the end of December 2000. This is not surprising. The very idea of dynamic pricing is about setting the current price by taking the future into account. Anticipating the Fuelwatch, something new, is about to take effect, the firms naturally may start to change their current behavior. However, is it reasonable to argue that the firms in the Perth market started to change their pricing behavior around October 2000 when the Select Committee on Pricing of Petroleum Products released its report? The pricing dynamics did not change around October 2000. Some may even make the argument that the firms started to change their pricing behavior even earlier, say, around the time when the Select Committee was established. But such an argument hinges on the assumption that the firms knew in advance what the Select Committee would do.

B. Data issues

The current debate has come to realize that the ideal measure of the average petrol prices paid by consumers should be volume-weighted. The simple arithmetic average price across stations and over time may differ from the average price paid by consumers. If some consumers are price sensitive, which is certainly the case, they would search a cheaper price on a given day. Such search behavior means that a petrol site with a higher price sells less than a petrol site with a lower price. The simple average between these

two stations may thus differ from the volume-weighed average price paid by consumers. Similarly, price sensitive consumers may choose to purchase their petrol when petrol price cycle is near or at the cycle bottom, and such intertemporal substitution again implies that the simple average over time may differ from the average price paid by consumers. It should also be pointed out that a volume-weighted measure should take into account the fact that many price sensitive consumers use their shopper-dockets to save 4 cents per liter. These volume-weighted averages may be hard to construct.

Appendix: My Research on Petrol Pricing

This appendix lists the title and abstract of my three academic papers that are related to petrol pricing in Australia. All three papers can be downloaded from my website: http://nuweb.neu.edu/economics/site/zwang/ I wish to thank those who provided me with the data and those who helped me with obtaining the data used in these three papers.

*"Mixed Strategy in Oligopoly Pricing: Evidence from Gasoline Price Cycles before and under a Timing Regulation***."** (The latest version is March 1, 2008)

Abstract: In their Edgeworth cycle equilibrium, Maskin and Tirole (1988) presume firms play mixed strategies to decide price leadership at the bottom of each cycle. This paper takes the mixed strategy assumption seriously. This paper finds the retail gasoline price in the Perth area of Western Australia is well characterized by the cycle equilibrium before and under a unique simultaneous-move timing regulation, but the firms in the market play the presumed mixed strategies under but not before the regulation. This result is consistent with the idea that a player's mixed strategy represents other players' uncertainty of that player's pure choice.

"Station Level Gasoline Demand in an Australian Market with Regular Price Cycles" (The latest version is May 5, 2008)

Abstract: Regular and frequent gasoline price cycles are being observed in many Australian and Canadian markets. What is driving these price cycles has been the subject of academic studies and government investigations. The existing explanations for these price cycles all rely on the presumption that drivers are intensively sensitive to gasoline price differentials at the station level. However, no empirical evidence exists in the literature to support this presumption. This paper provides the first piece of empirical evidence. This paper uses a unique price and quantity data set to estimate the station level gasoline demand in the cycling market of Perth, Australia. The elasticity estimates confirm that drivers in the Perth area are indeed very sensitive to gasoline price differentials.

"Collusive Communication and Pricing Coordination in a Retail Gasoline Market," *Review of Industrial Organization (2008) 32: 35-52.*

Abstract: This paper studies how communication is used by a retail gasoline cartel in Australia to coordinate price increases, a role of communication in collusion not highlighted by Genesove and Mullin (2001). A unique data set from the trial record allows for quantifying not only the pricing dynamics, but also the communication patterns. Both empirical and narrative evidence suggests the collusive communication and pricing behavior is well captured by the price cycle equilibrium of the Maskin and Tirole (1988) model.