Consumer myopia, compatibility and aftermarket monopolization

Miao, Chun-Hui

1 May 2005

Consumer Myopia, Standardization and Aftermarket Monopolization

Chun-Hui Miao*

Abstract

In this paper, I show that the standard Bertrand competition argument does not apply when firms compete for myopic consumers who optimize period-by-period. I develop the model in the context of aftermarket. With overlapping-generations of consumers, simultaneous product offerings in the primary market and aftermarket establishes a price floor for the primary good. This constraint prevents aftermarket rents from being dissipated by the primary market competition. Duopoly firms earn positive profits despite price competition with undifferentiated products. Nonetheless, government interventions to reinforce aftermarket competition such as a standardization requirement may lead to the partial collapse of the primary market. (JEL D40, L40)

Keywords: aftermarket, Bertrand competition, bounded rationality, standardization.

*Department of Economics, University of South Carolina, Columbia, SC 29208. miao@moore.sc.edu.

Over the lifetime of a printer, the average consumer spends more money on replacement cartridges than on the printer itself.[1] Yet many consumers ignore cartridge costs when buying a printer. A survey conducted by the Office of Fair Trading (OFT) finds that 3 out of 4 individual printer buyers do not have any idea of cartridge costs.[2] Business customers are not much different: 61 percent of 200 UK financial directors polled by printer manufacturer Lexmark International (Lexmark) do not know and have no plan to reduce the printing costs of their companies.[3] Some agencies, such as the US Federal Government, have purchasing systems that "do not lifecycle price, but rather choose the lowest price in each market".[4]

The printer/cartridge industry is just one example of many industries that involve two markets: a primary market and an aftermarket.[5] Consumers make initial purchases of systems in the primary market and then buy additional supplies, services, and upgrades in the aftermarket. Aftermarket goods or services are essential to the use of primary goods, but are bought at a point in time after the purchase of primary goods. Because of the temporal relationship between primary markets and aftermarkets, some consumers may make myopic purchase decisions, focusing on the initial price but ignoring long run costs. The existence of consumer myopia raises a number of interesting questions: How do profit-maximizing firms respond to consumer myopia? Can they take advantage of myopic consumers? Is competition in the primary market sufficient to protect myopic consumers?

This paper addresses these questions. I model myopic consumers as individuals who optimize period-by-period. I find that firms monopolize aftermarkets through the strategic use of incompatibility. I show that in a dynamic model with overlapping-generations of consumers, duopoly firms earn positive profits despite price competition with undifferentiated

[1] Estimates on cartridge expenses vary. According to the Office of Fair Trading, the average consumer will spend between 2 and 17 times the purchase price of an inkjet printer on ink during an average three year printer lifetime. "Consumer IT goods and services", 2002.

[2] "Consumer IT goods and services", the Office of Fair Trading, 2002.

[3] "Lexmark reveals UK companies are unaware of document production costs", *Telecom World Wire*, January 22, 2004.

[4] Excerpt from the US Supreme Court Opinion on Eastman Kodak Company, Petitioner v. Image Technical Services, Inc., et at., 112 S. Ct. 2072 (1992).

[5] The aftermarket pattern is ubiquitous (Shapiro, 1995). It includes software/upgrades, durable goods/consumables (e.g. equipement/supplies, appliances/parts, etc.) and all post-sale services.

products. Moreover, neither firm has an incentive to compete by educating myopic consumers. Consequently, aftermarket monopolization persists in a competitive industry and causes substantial consumer injury. These results suggest that consumer myopia may play an important role in firms' market conduct, and may therefore merit serious policy discussions.[6]

A belief widely held by economists is that as long as there is significant competition in the primary market, firms do not gain from consumer myopia because aftermarket rents are dissipated by the competition. This view is best expressed by Carl Shapiro (1995) in his criticism of the Supreme Court decision that permitted a jury trial to determine whether Kodak was guilty of monopolization on an aftermarket theory:[7]

> Sellers are surely aware of the life-cycle profits associated with selling a piece of equipment, even if buyers are poorly informed about aftermarket costs. Therefore, systems competition pushes manufacturers to discount their equipment to capture any aftermarket 'monopoly' profits, ... [thus] substantial ongoing consumer injury from exclusionary aftermarket policies is unlikely to occur in competitive equipment markets. ... Furthermore, manufacturers in a competitive equipment market have incentives to avoid even this inefficiency [i.e. consumption distortion] by providing information to consumers (Parentheses added).

In his view, any attempts to monopolize aftermarkets are futile and competition in the primary market is sufficient to protect even myopic consumers. Shapiro's intuition has since found support in a number of formal models. Although these models generate aftermarket overpricing with various economic arguments, they share one common feature: all competitive firms earn zero profit when the degree of product differentiation approaches zero.[8]

[6]"The OFT has criticised printer manufacturers for using customer loyalty and trust to 'effectively set prices' in the post-sale market, after it found that 75 per cent of people it surveyed had no idea of printing costs. ... Meanwhile the European Competition Commission has requested submissions on pricing policies from the inkjet industry before it decides whether or not to investigate it for anti-competitive behaviour. If found guilty, companies could be fined up to 10 per cent of their sales." (*Financial Times*, March 6, 2003)

[7]Eastman Kodak Company, Petitioner v. Image Technical Services, Inc., et at., 112 S. Ct. 2072 (1992).

[8]Severin Borenstein, Jeffrey K. MacKie-Mason and Janet S. Netz (1995, 2000) find that competing firms may set aftermarket prices above marginal cost, if commitment technologies are unavailable. They conclude

In an important sense, however, Shapiro and other authors fail to recognize the inherent connection and conflict between primary market competition and aftermarket monopolization. I use a simple example to illustrate this point.

Static v. Dynamic Consider two printer manufacturers, each of whom produces printers at unit cost of c^A and cartridges at unit cost of c^B. They compete in prices à la Bertrand. A consumer buys a printer system (including a cartridge) in period 1 and then buys another cartridge from the original manufacturer in period 2. The consumer values each unit of cartridge consumption at $v^B > c^B$.

The consumer is myopic in the sense that she only compares printer system prices. Hence a firm sets the cartridge price $p^B = v^B$ and earns a profit of $v^B - c^B$. Anticipating this profit, firms compete by cutting printer system prices, which become $p^{AB} = c^A + c^B - (v^B - c^B)$ by the standard argument (assuming no discounting). In the end, each firm earns zero profit and the consumer obtains all surplus, even though she acts myopically and pays a monopoly price for the cartridge. There is no welfare loss. This is the essence of Shapiro's argument.

However, a careful inspection reveals that the printer system price is exactly equal to the cartridge price less the total surplus (of 1 printer and 2 cartridges):

$$p^{AB} = p^B - (\overbrace{2v^B - 2c^B - c^A}^{\text{social surplus } >0}) < p^B \tag{1}$$

This means that in order for aftermarket rents to be dissipated by primary market competition, the printer system price has to be lower than the cartridge price.[9] While this is possible

that aftermarket monopolization can cause significant efficiency loss. My model lends support to their conclusion on welfare, but relies on a different mechanism and has a different policy implication. Zhiqi Chen and Thomas W. Ross (1999) adopt a variation of the "metering" story (Ward S. Bowman, 1957) and argue that aftermarket overpricing can help firms cover the costs associated with high intensity users' warranty services. Kenneth G. Elzinga and David E. Mills (2001) find that pricing both equipment and services above costs is socially optimal because it allows manufacturers to recover fixed R&D and production costs. Dennis Carlton and Michael Waldman (2006) and Hodaka Morita and Waldman (2006) show that firms may have an incentive to monopolize the maintenance market in order to avoid the inefficiency associated with maintaining a used unit. See Shapiro (1995) and Chen et al. (1998) for an excellent survey.

[9] The above constraint holds as long as the aftermarket product is essential and its demand is inelastic. The reason is simple: monopoly pricing under inelastic demand yields zero consumer surplus in all future periods.

in a static game with one generation of consumers, it cannot hold in a dynamic model with overlapping-generations of consumers; otherwise, a cartridge buyer may instead buy a new printer system. In other words, simultaneous product offering in the primary market and aftermarket establishes a price floor for the primary good ("no arbitrage"):

$$p_t^{AB} \geq p_t^B \tag{2}$$

Therefore, the standard Bertrand competition argument no longer applies.[10]

This example exhibits the limitation of the traditional view, and gives us the basic intuition of why primary market competition may not dissipate aftermarket rents. When there are both old and new customers, any price cut in the printer system to attract new customers forces a firm to lower its cartridge price thus reducing the firm's profit from old customers, the cartridge buyers. Each firm faces a tradeoff between gaining market share and harvesting captive consumers. Because of this, firms soften competition and earn higher profits.

In my model, two printer manufacturers first make compatibility choices then compete in prices. Through incompatibility, a firm commits not to invade its rival's installed base and this induces the rival to compete less aggressively for new customers (a strategy that I call "feed-then-overtake"). In the equilibrium, firms gain market share in alternating periods and earn positive profits from myopic consumers. Furthermore, firms use loss leader pricing to prevent myopic consumers from pooling with consumers with perfect foresight, resulting in a complete market segmentation, with both firms competing for myopic consumers and the more efficient firm alone serving foresighted consumers. Interestingly, the more efficient firm earns a higher profit from myopic consumers, even though it has an apparent competitor

In a dynamic model, Shapiro's argument might hold only if demand is elastic, but then the consumption distortion from aftermarket overpricing is more severe. This constraint can also be modified to accommodate cases in which the aftermarket product is not essential. See Lemma 1 and its footnote in Section B.

Other authors (Borenstein et al. 1995; Fudenberg and Tirole 1998; Chevalier, Kashyap and Rossi 2003) have also noted the possibility of such constraints in similar contexts.

[10] The same result holds if firms cannot commit to future prices. However, while firms have incentives to make commitments, they have no incentive to eliminate consumer myopia. Please see Section IV.A and IV.B. for further discussions.

in that market. Rather than advertise a low aftermarket price and capture all consumers, the firm chooses to share the market and take advantage of myopic consumers. At the same time, the less efficient firm, unable to compete for foresighted consumers, targets myopic consumers and obtains a small but positive market share.

There has been renewed interest in aftermarket pricing following Glenn Ellison (2005) and Xavier Gabaix and David Laibson (2006). It may therefore be useful to compare my results with those of the two. Under the assumption that higher willingness to pay consumers also have stronger brand preferences, Ellison (2005) shows that firms can use add-on pricing (advertising the primary good price only) to generate price discrimination over perfectly rational consumers and soften competition.[11] However, add-on pricing is not an equilibrium outcome: while firms jointly benefit from add-on pricing, an individual firm is better off by deviating. In my model, a firm may want to steal business from its competitor by educating a myopic consumer and offering a lower add-on price, but such an attempt is self-defeating because it changes the consumer's type and renders the deviation unprofitable. Accordingly, a collusive outcome (the no-education result) can be supported in the equilibrium.

More closely related to my study is a paper by Gabaix and Laibson (2006). In their model, some consumers are naive: they make myopic purchase decisions in the printer market and underestimate cartridge costs thereby consuming more than the optimal amount. (Note that this is a stronger notion of consumer myopia than the one I use.) Firms use printers as a loss leader and reap profits from selling expensive cartridges. Add-on pricing emerges as an equilibrium outcome. However, due to the static nature of their model, Shapiro's argument applies and firms still earn zero profit.

The remainder of the paper is organized as follows: Section I presents some empirical evidence to motivate my model. Section II presents the main result: in a dynamic model with overlapping-generations of myopic consumers, duopoly firms earn positive profits via

[11] It should be noted that add-on goods is a more general class than aftermarket goods, on which my analysis focuses. It includes both aftermarket goods that are required for the use of primary goods and pure add-on goods, such as extra services offered by hotels or car rental companies, that are not required for the use of primary goods.

aftermarket monopolization despite price competition with undifferentiated products. Several extensions are then considered. In Section III, I show the monopoly paradox: a primary market monopolist's profit decreases with the percentage of myopic consumers. Section IV discusses implications of my paper and concludes. Any formal proofs omitted from the main text are contained in the appendix.

I. Motivation and Evidence

Printer and Cartridge About 85 percent of the US printer sales are inkjet products.[12,13] The inkjet printer market is remarkably concentrated, with Hewlett-Packard alone making half of all sales and three other manufacturers, Lexmark, Epson, and Canon, supplying a combined 40 percent. Each printer manufacturer supplies ink cartridges for its own range of printers. There is very limited entry into the cartridge market by non-OEM suppliers, accounting for just over 13 percent of the total sales in the US. This means that a printer manufacturer is effectively able to set prices in its own aftermarket. Each cartridge costs less than $10 to make but is typically priced at $20 to $40.[14] Consumer purchases (as opposed to business purchases) account for around 60-70 percent by value. In practice, consumers spend more money on replacement cartridges than on printers themselves.[15] However, retailers responding to the OFT survey said that some 75 percent of their customers did not have any idea of printing costs and "first time or inexperienced buyers tended to carry out the least research".[16]

[12] "PC Printers - US - July 2004", Mintel, 2004.

[13] There are two main types of printers: laser printers and inkjet printers. Laser printers tend to be the most suitable for black and white printing and inkjet printers are more versatile, particularly when it comes to color printing.

[14] "Printing a Record of Growth", *Business Week Online*, 2/17/2004.

[15] According to the OFT report ("The Consumer PC Market in the US", The Office of Fair Trading, 2002.), "the single largest proportion of retail information technology revenue in the US - $7.47 billion during 2001 - is generated from sales of printing consumables such as ink cartridges, laser toners and specialist printing papers". The comparable figure for printers is only $2 billion.

[16] "Consumer IT Goods and Services", The Office of Fair Trading, 2002.

To further examine the market structure and the pricing pattern, I collected data from the web sites of the four printer manufacturers. Only inkjet printers available for purchase in their online stores were included. In total, there were 78 models offered, 40 by HP, 6 by Lexmark, 14 by Epson and 18 by Canon. I recorded product information such as printer model number and price, compatible cartridge model number and price, cartridge yield (number of pages per cartridge) and number of cartridges included with the printer.[17] I calculate the per page cost for each cartridge by dividing its price by its yield.

An inkjet printer is typically equipped with a black ink cartridge and either a tricolor cartridge or three single-color cartridges.[18] Based on the type of cartridges they use, I divide all printers into two groups.[19] Descriptive statistics for the two groups are reported in Appendix C. Table 3 compares the two groups. The per page costs of tricolor cartridges are significantly higher than those of single color cartridges ($t = 19.499$). Even the per page costs of black ink cartridges of single-color inkjets are lower than those of tricolor inkjets ($t = 7.367$). At the same time, the price of tricolor inkjet printers are significantly lower than single-color inkjets ($t = 3.821$). There appears to be a high degree of market segmentation.

Interestingly, the low-end market with higher cartridge prices appears more competitive than the high-end market. From Table 1 and 2, we can see that in the Sub-$100 category, all manufacturers offer about the same number of models, which is indicative of the "intense" competition in that category, whereas in the above-$700 category only HP is active. Moreover, from Table 2, we can see that Lexmark, the second largest printer manufacturer, currently does not sell any single-color inkjets. All its printers fall in the sub-$100, tricolor category. At the same time, the average printing cost of Lexmark printers is the highest

[17] 9 models offer two compatible black ink cartridges but I only include the cartridge that yields closer to 450 pages, the median (as well as the mode) yield of all printers.

[18] A tricolor cartridge is formed by combining cyan, magenta, and yellow (CMY).

[19] I only list the price and yield information for one of the three single-color cartridges because prices and yields are identical for the other two colors.

among all manufacturers.[20] In spite of this, Lexmark's market share grew almost threefold from 1997 to 2001, as shown in Figure 1.

Insert Figure 1 here

The leading explanation of aftermarket overpricing is price discrimination:[21] a firm with market power can use discriminatory pricing to extract more surplus from customers who use printers more intensively. This mechanism relies on the existence of a sufficient degree of product differentiation in the printer market such that each firm has some market power. Accordingly, more firms should be selling high-end products than selling low-end products, which tend to be more homogeneous. However, we observe the opposite, as shown in Figure 2. Furthermore, in a model based on the price discrimination story, Eric R. Emch (2003) finds, when primary market competition intensifies, aftermarket markups disappear before those in the primary market. This is contrary to the evidence presented above.

Insert Figure 2 here

Antivirus Software and Virus Definition Updates The worldwide antivirus software market totaled $2.2 billion in 2002, where Norton Antivirus leads with 68.3% market share and McAfee VirusScan has 25.5%. Use of antivirus software requires up-to-date virus definitions, which are provided by the software maker as an annual subscription service. The marginal cost of providing such a service is close to zero,[22] but firms typically charge considerably higher. Whereas a retail version of the software program only includes one-year virus definition updates, enterprise users can pay a higher upfront license fee in exchange for an extended period of free updates. Since demand for virus updates is inelastic, the markup on virus definition updates cannot be attributed to price discrimination.

[20] By some accounts, Lexmark's printer supplies make up just over half of its total revenue and an even greater share of its total profit. ("Protecting the Family Jewels", *Forbes*, 12/8/2003; "Legal Battle Could Determine Future Price of Printer Cartridges", *USA Today*, 1/29/2003.)

[21] Emch (2002) tests opportunism as an alternative explanation for aftermarket markups in laser printer and computer memory but finds mixed evidence.

[22] The program automatically downloads the virus definition updates on a weekly basis from the server, which is maintained by the software maker.

The latest version of Norton Antivirus is sold at \$49.95. It includes one-year of free virus definition updates, which normally costs \$19.95. An upgrade from a previous version costs \$29.95, but it does not include virus definition updates. McAfee VirusScan offers an almost identical package (\$49.99/\$19.95/\$29.95). It is noteworthy that \$49.95 is also the lowest that a firm can charge for a new version, since no customer will buy an upgrade otherwise.

To summarize, there are both a widespread consumer bias in overlooking long-run costs and the existence of significant aftermarket markups. In the following, I develop a model to explore their implications to the market structure and social welfare. It is worth emphasizing that the purpose of this paper is to introduce one of the models that can potentially account for the above empirical facts, but there may well be other models that can replicate the evidence.

II. A Duopoly Model

A. The Basic Setup

In this section, I introduce the basic elements of my model, including consumers' preferences and firms' production technology. For concreteness, I use printers (A) to refer to primary goods and cartridges (B) to refer to aftermarket goods or services.[23]

In each of infinitely many discrete periods, $t = 0, 1, 2, ..., \infty$, a unit mass of consumers enters the market and leaves after two periods. In period 1, a consumer buys a printer system worth v^{AB} to her;[24] in period 2, the consumer buys an additional q^B units of cartridges to maximize $u(q^B) - p^B q^B$, where p^B is the cartridge price and $u(\cdot)$ satisfies $u(0) = 0$, $u' \geq 0$,

[23] AB represents a printer system that includes a printer and a cartridge.

[24] For tractability, here I implicitly assume that the demand (normalized to 1) for cartridges is inelastic in period 1. Without further loss of generality, I assume that the demand is elastic in period 2, but the same results hold under inelastic demand, a condition satisfied in the opening example.

While this change in elasticity creates asymmetry in the demand structure, it does allow me to capture the observation that myopic consumers respond to cartridge prices only after they start to shop for replacements. Borenstein et al. (2000) also assume inelastic demand in period 1 and elastic demand in period 2.

$u'(\infty) = 0$ and $u'' < 0$.[25] Thus at every period a cohort of printer buyers and a cohort of printer owners (cartridge buyers) are in the market.

Since a printer system includes a cartridge, (with a little abuse of notation) I define $u(q^{AB}, q^B) = u(q^{AB} + q^B)$, where q^{AB} is the number of printer systems bought in period 2. This specification implies that a printer system and a cartridge are perfect substitutes and that a printer owner will buy a new printer system (of the same brand) if it is cheaper than a cartridge.[26] She, however, faces a prohibitively high cost of switching to a different brand of printer.[27]

There are two printer manufacturers, who also sells cartridges. Each firm produces printers at a constant marginal cost of c^A and cartridges at a constant marginal cost of c^B. Two printer systems (interbrand or intrabrand) are compatible (respectively, incompatible) if they use (respectively, do not use) the same cartridge. As in Nicholas Economides (1989), I only consider full compatibility or full incompatibility. Along with the high switching cost, system incompatibility helps a firm to lock in its customers.[28] To make the prediction less trivial, I allow for unilateral compatibility, i.e., one firm can achieve compatibility and compete for customers by simply replicating the other's cartridge design. Each firm maximizes total profits with a discount factor of $\delta < 1$. I assume that firms cannot condition prices on a consumer's purchase history.[29]

[25] I ignore the integer constraint on the number of cartridges. Or, to put it another way, q^B can be seen as the number of pages printed and p^B as the cost per page. This means that the capacity of a cartridge is irrelevant in this model.

[26] If depreciation, loss of warranty or an increased chance of breakdown, etc., causes a consumer to value a used printer less than a new one, then we can obtain the same results by redefining $u(q^{AB}, q^B) = q^{AB}V^A + u(q^{AB} + q^B)$, where V^A is the new printer premium. I normalize V^A to 0 in order to cut down the number of parameters of which we keep track.

[27] The switching cost can be due to brand loyalty, search cost, the cost of learning a new user interface or the network effects in an organization setting. My results will not change qualitatively if I introduce a small but positive switching cost that allows equilibrium switching: firms' profits will then be proportional to the switching cost, as in Farrell and Shapiro (1988) and A. Jorge Padilla (1995). Beggs and Klemperer (1992) also assume that the switching cost in their model is so high as never to bind.

[28] It is important to note that switching costs associated with system incompatibility are different from the cost of switching brands. Two systems of different brands can be compatible yet involve high switching costs because they have different user interfaces. Conversely, two systems of the same brand may share the user interface but use different cartridges.

[29] This assumption is supported by the OFT report: "[printer] suppliers were unlikely to be able to discriminate between first time and second time buyers in retail outlets". However, this assumption does rule

Denote by i the index of available printer/cartridge systems, $p_{i,t}^{AB}$ the price of a printer system and $p_{i,t}^{B}$ the price of a cartridge.[30,31] A fully rational consumer (henceforth "foresighted consumer") maximizes discounted sum of utilities when selecting a printer system, that is, she solves $\max_i\{(v^A B - p_i, t^A B) + \delta \max_q^A B, q^B[u(q^A B + q^B) - q^A B p_i, t+1^A B - q^B p_i, t+1^B]\}$.

However, some consumers are myopic. They have limited foresight and choose to optimize period-by-period: in period 1, they select the lowest-priced printer system; in period 2, they optimize over cartridge consumption.[32] Formally, a myopic consumer solves $\max_i(v^{AB} - p_{i,t}^{AB})$ at time t (suppose that the solution is i^*), then solves $\max_{q^{AB},q^B}[u(q^{AB} + q^B) - q^{AB}p_{i^*,t+1}^{AB} - q^B p_{i^*,t+1}^{B}]$ at time $t+1$. In the remainder of the paper, for notational simplicity, the subscripts i and t are suppressed when it is unambiguous.

Since myopic consumers also optimize their cartridge consumption, the two types of consumers have the same demand for cartridges. For a cartridge or a (lower-priced) printer system priced at p_B, let $D(p^B) = \arg\max_{q^B}[u(q^B) - p^B q^B]$ be a consumer's second-period cartridge demand, $V(p^B) = u[D(p^B)] - p^B D(p^B)$ be the corresponding consumer surplus, and $\pi(p^B) = (p^B - c^B)D(p^B)$ be a firm's undiscounted second-period cartridge profit per customer, I assume that $\pi(p^B)$ is single-peaked and denote by $p^m = \arg\max_{p^B} \pi(p^B)$ the monopoly price of a cartridge. The following results are standard:

$R1$. (downward-sloping demand) $D' < 0$. This follows from the assumption that $u'' < 0$.

$R2$. (deadweight loss) $V(c^B) > V(p^B) + \pi(p^B)$, $\forall p^B \neq c^B$. The strict inequality follows from $R1$.

$R3$. (individual rationality) $V(p^B) \geq 0$, $\forall p^B$; the equality holds if and only if $D(p^B) = 0$.

out the applicability of my analysis to non-anonymous subscription services for which new and old customers pay different rates. Two notable examples are cable and telephone services.

[30] If firms sell printers and cartridges as separate products, then p^{AB} should be replaced by $p^A + p^B$, where p^A is the price of a standalone printer. I use the notation p^{AB} instead of p^A because there is no demand for a standalone printer in the model.

[31] If multiple compatible cartridges are available for printer i at time t, then $p_{i,t}^{B}$ should be understood as the lowest price among such cartridges.

[32] It should be noted that my assumption of consumer myopia is weaker than the one used by Gabaix and Laibson (2006), where consumers optimize aftermarket consumption only as a result of education. In fact, in the (pooling) equilibrium they derive, an educated consumer behaves no differently from a myopic consumer in my model.

Finally, I make the following assumptions on the range of parameter values:

Assumption 1 (Positive Monopoly Profit) $(p^m - c^A - c^B) + \delta\pi(p^m) > 0$. *This assumption is not restrictive. It states that if a firm sells a printer system at the monopoly price of a cartridge and earns a monopoly profit in cartridges, then the total profits are positive.*

Assumption 2 (No Inefficient Replacement) $v^{AB} \geq p^m$. *This assumption says that a myopic consumer's reservation price of a printer system is higher than the monopoly price of a cartridge. It guarantees that the consumer will not choose to replace an old printer system with a new one when the latter and cartridges are sold at their respective monopoly prices.*

B. The Game

Firms are long-lived and their competition takes place on an infinite horizon. I look for symmetric stationary Markov Perfect Equilibria (MPE), in which a firm's strategy depends only on the firm's current (printer) market share and not otherwise on history. I assume that all consumers buy from the same firm if firms charge the same price for their printer systems.[33] Since printer systems are ex ante homogeneous,[34] only one firm makes positive sales each period. Hence, the state variable (market share) is a binary variable. As in Farrell and Shapiro (1988), I call a firm that has sold printer systems in the most recent period the "incumbent" (I) and its rival the "entrant" (E). Note that incumbency is not fixed, but is determined by market share evolution. Thus, in each period, there are two printer systems and two cartridges available, denoted by (p_I^{AB}, p_I^B) and (p_E^{AB}, p_E^B).

[33] This assumption allows me to define the state variable as a binary one. The same assumption is used by Farrell and Shapiro (1988) and Padilla (1995). It guarantees the existence of an equilibrium in a game with discontinuous payoffs (Dasgupta and Maskin 1986). My result also holds if firms charging the same price have equal chances of selling to all consumers (i.e., "winner-take-all" in Baye and Morgan 2002). However, whether an equilibrium exists if firms split sales remains an open question.

[34] Although the assumption of ex ante homogeneous products has an undesirable consequence, namely, in each period one firm makes all printer sales, it allows me to eschew the problem that assuming product differentiation may confound the effect of switching cost on the intensity of competition, as pointed out by Padilla (1995). More importantly, in the mixed strategy equilibrium I describe later, a firm makes all printer sales only in the probabilistic sense. This is a common feature among models involving captive consumers (Hal R. Varian 1980; Chakravarthi Narasimhan 1988; A. Jorge Padilla 1992, 1995).

Within each period, firms make moves in the following order: the entrant moves first by announcing its choice of compatibility, that is, it decides whether to sell a printer system compatible with the incumbent's; then the two firms set prices simultaneously and consumers make purchases.[35] The game repeats itself every period afterwards.

To avoid the trivial open-set problem when the price space is a continuum, I assume the following tie-breaking rules: (i) a printer buyer prefers the entrant; (ii) a printer owner prefers cartridge over printer systems; and (iii) a firm prefers making positive sales to exit.

Although a printer owner can purchase either replacement cartridges or printer systems, the following lemma allows us to significantly narrow down the players' strategy space.

Lemma 1 (No Arbitrage) $\forall t \geq 1$, $p_{i,t}^{AB} \geq p_{i,t}^{B}$.[36]

The intuition behind this result is rather straightforward: a printer system and a cartridge are perfect substitutes for a cartridge buyer, but the former costs more to produce. To prevent cartridge buyers from buying a new printer system, a firm can always cut the cartridge price while holding the system price constant. Lemma 1 also implies that the sale of cartridges to existing customers establishes a price floor for the printer system, thus dampening a firm's incentive to cut system prices.

[35] It is without loss of generality to assume that each firm sells one printer system when all consumers are myopic. If an entrant sells multiple systems, at most one will be sold in the equilibrium given my assumption of identical new customers and high switching cost of old customers. If the incumbent sells multiple systems with the same user interface, then again old and new customers will make the same choice due to zero intrabrand switching cost; on the other hand, the cost (e.g., the fixed cost of design) of introducing a system with a new user interface (in order to raise the intrabrand switching cost) cannot justify the benefit, which is zero according to Shapiro's argument (1995).

Later in the paper when foresighted consumers are included, firms will choose to sell multiple systems.

[36] If $V^A > 0$ (see footnote 26), then $p_{i,t}^{AB} \geq p_{i,t}^{B} + V^A$.

Let $\mathbb{C} = \mathbf{1}(\text{compatible}) \in \{0,1\}$. The two firms' instantaneous profit functions are

$$\pi_I[\mathbb{C},(p_I^{AB},p_I^B),(p_E^{AB},p_E^B)] = \begin{cases} p_I^{AB} - c^A - c^B, \\ \quad \text{if } p_I^{AB} < p_E^{AB} \text{ and } p_I^B > p_E^B \text{ and } \mathbb{C} = 1; \\ p_I^{AB} - c^A - c^B + \pi(p_I^B), \\ \quad \text{if } p_I^{AB} < p_E^{AB} \text{ and either } (p_I^B) \leq p_E^B \text{ and } \mathbb{C} = 1) \text{ or } (\mathbb{C} = 0); \\ 0, \\ \quad \text{if } p_I^{AB} \geq p_E^{AB} \text{ and } p_I^B > p_E^B \text{ and } \mathbb{C} = 1; \\ \pi(p_I^B), \\ \quad \text{if } p_I^{AB} \geq p_E^{AB} \text{ and either } (p_I^B) \leq p_E^B \text{ and } \mathbb{C} = 1) \text{ or } (\mathbb{C} = 0). \end{cases}$$

$$\pi_E[\mathbb{C},(p_I^{AB},p_I^B),(p_E^{AB},p_E^B)] = \begin{cases} \pi(p_E^B), \\ \quad \text{if } p_I^{AB} < p_E^{AB} \text{ and } p_I^B > p_E^B \text{ and } \mathbb{C} = 1; \\ 0, \\ \quad \text{if } p_I^{AB} < p_E^{AB} \text{ and either } (p_I^B \leq p_E^B \text{ and } \mathbb{C} = 1) \text{ or } (\mathbb{C} = 0); \\ p_E^{AB} - c^A - c^B + \pi(p_E^B), \\ \quad \text{if } p_I^{AB} \geq p_E^{AB} \text{ and } p_I^B > p_E^B \text{ and } \mathbb{C} = 1; \\ p_E^{AB} - c^A - c^B, \\ \quad \text{if } p_I^{AB} \geq p_E^{AB} \text{ and either } (p_I^B \leq p_E^B \text{ and } \mathbb{C} = 1) \text{ or } (\mathbb{C} = 0). \end{cases}$$

Denote by $W_I(W_E)$ the present value of the incumbent (entrant), $F_I^{AB}(F_E^{AB})$ the probability measure that represents the randomized pricing strategy in printer system to be played when a firm is the incumbent (entrant) and $F_I^B(F_E^B)$ the corresponding measure for cartridge. Starting from any initial condition, a mixed strategy profile $\{\mathbb{C},(F_I^{AB},F_I^B),(F_E^{AB},F_E^B)\}$ forms a stationary MPE if

$$W_E = \max_{\mathbb{C}\in\{0,1\}} W_E(\mathbb{C}) \tag{3}$$

$$(4) \quad W_I(\mathbb{C}) = \max_{p_I^{AB}, p_I^B} \{\pi_I[\mathbb{C}, (p_I^{AB}, p_I^B), (p_E^{AB}, p_E^B)] + \delta W_E F_E^{AB}(p_I^{AB}) + \delta W_I[1 - F_E^{AB}(p_I^{AB})]\}$$

$$(5) \quad W_E(\mathbb{C}) = \max_{p_E^{AB}, p_E^B} \{\pi_E[\mathbb{C}, (p_I^{AB}, p_I^B), (p_E^{AB}, p_E^B)] + \delta W_E F_I^{AB}(p_E^{AB}) + \delta W_I[1 - F_I^{AB}(p_E^{AB})]\}$$

and $W_I = W_I(\mathbb{C})$, where $\mathbb{C}$ is a maximizing choice in (3), $W_I(\mathbb{C})$ and $W_E(\mathbb{C})$ are the incumbent and the entrant's present values respectively, given the entrant's compatibility choice and given that firms play according to $\{(F_I^{AB}, F_I^B), (F_E^{AB}, F_E^B)\}$.

C. The Main Result

In this section, I study duopoly firms' market behavior when all consumers are myopic and derive the main result: aftermarket monopolization may exist in an equilibrium, where competitive firms sell incompatible systems and earn abnormal profits.

Proposition 1 *No pure strategy MPE, in which $W_E = 0$ and $\mathbb{C} = 0$, exists.*

Proposition 2 *A symmetric stationary MPE, in which both firms earn positive profits, exists. Each period the entrant chooses incompatibility ($\mathbb{C} = 0$), both the incumbent and the entrant randomize their printer system price on the support of $[\underline{p}, p^m]$, where $\underline{p} - c^A - c^B + (1+\delta)\pi(\underline{p}) = \pi(p^m)$. The incumbent also sets $p_I^B = p_I^{AB}$.[37] The equilibrium is unique if the equation for $\underline{p}$ has a unique solution.*

If firms chose to produce compatible systems, then they would engage in Bertrand competition in both printer and cartridge markets and earn zero profits. By choosing incompatibility, an entrant commits not to invade the incumbent's installed base.[38] This gives the incumbent a monopoly in cartridges. In some sense, it "feeds" the cartridge buyers to

[37] However, a printer system will have a higher price than a cartridge if $V^A > 0$ (see footnote 26).

[38] Carmen Matutes and Pierre Regibeau (1989) have also considered the choice of standardization when there is competition between an incumbent and an entrant. They show that the "incumbent" chooses to standardize its own products as a way of committing to uniform pricing, which softens competition. My model complements theirs by considering the issue of standardization across manufacturers.

the incumbent, who becomes a "fat cat" (Fudenberg and Tirole, 1984) facing a trade-off between attracting new printer buyers and harvesting old cartridge buyers. Compared to the entrant, the incumbent has more to lose from a price war so it competes less aggressively. This softens competition and allows both firms to earn higher profits.

While I have not tested the prediction that printer manufacturers use promotions to compete for market share, a casual glance of the Sunday newspaper ads indicates that such behavior is common.[39] In the marketing literature, Lal (1990) provides several examples which suggest that manufacturers tend to offer discounts at different times rather than at the same time. More recently, using data from the printer market, Kutsal Dogan, Ernan Haruvy and Ram C. Rao (2008) find that market share is negatively correlated with the frequency of promotional rebates. This result is worth noting because, in a static model of consumer demand, one would expect the opposite, but it is consistent with the prediction of this model.

It should also be noted that I obtain the no-standardization result even when allowing for unilateral standardization. In the standardization literature involving network externalities (Michael L. Katz and Shapiro, 1985), at least one firm (usually the entrant) prefers standardization. In the "mix and match" literature, Matutes and Regibeau (1988, 1992), and Economides (1989) predict that system makers choose to produce compatible components, because incompatibility is a commitment for aggressive pricing in the system market. In my model, firms adopt incompatibility as a commitment to limited entry.

[39] The following quotes by the CEO of Lexmark is perhaps instructive: "Although price promotion moves have negatively impacted gross margins and revenue, our goal is to drive ... long-term supplies demand. ... [When] we talk about price, I think we have to differentiate between tactical near-term and strategic long-term. Long-term we do not want to be in a price war or in an aggressive price strategy (Emphasis and parentheses added)." "Q3 2005 Lexmark International, Inc. Earnings Conference Call", *Thomson StreetEvents*, 10/25/2005.

D. Extensions

In this section, I consider three extensions of the model. First, I take into account consumer and firm heterogeneity; second, I consider firms' incentives to educate myopic consumers; third, I examine the market outcome of a standardization requirement.

a. Some Consumers Are Myopic

Many economists hold the view that the existence of a small fraction of nonrational agents does not affect market efficiency, because any "noise" generated by these agents is eliminated by market forces. Shapiro (1995) applies this view to refute the aftermarket monopolization hypothesis:

> It is not necessary for all consumers to have good information in order for aftermarket prices to be disciplined by equipment competition. Poorly informed buyers may be protected by informed buyers, whose presence forces sellers to compete on a TCO basis and penalizes sellers with high aftermarket charges, especially since it may be difficult for sellers to identify the poorly informed buyers so as to price discriminate against them.

My analysis below shows that Shapiro's intuition does not apply in my model, because myopic consumers do not make the same choice as foresighted consumers.[40] In fact, a firm can perfectly "identify" myopic consumers using the standard self-selection mechanism: foresighted consumers choose a printer with lower cartridge costs whereas myopic consumers, without taking into account cartridge costs, opt for a cheaper printer.

I consider the same game as the one in the basic model, but each period a fraction of new customers are foresighted. In the pricing game involving myopic consumers, it does not matter whether a firm changes its cartridge price after a printer system is bought, because a myopic consumer does not condition her system purchase decision on the cartridge

[40] Thus my result differs from Gabaix and Laibson (2006), which predicts that consumers of different types choose the same primary good.

price. But for foresighted consumers, it matters. To focus on the impact of consumer myopia and rule out aftermarket over-pricing due to "inability to commit" (Borenstein et al., 1995, 2000), I assume that firms can keep their promises on aftermarket prices, i.e., there is no "surprise" price increase in period 2. There are two justifications for this assumption: first, there are many forms of commitment technology available, either through contracts (e.g., a price protection clause) or through advertising;[41] second, hardware supplies can be stored; anticipating its inability to commit, a firm can simply offer a quantity discount to (foresighted) consumers who choose to buy and store supplies for their second-period usage.

With the addition of foresighted consumers, firms may choose to sell multiple printers and cartridges in order to price discriminate.[42] I assume that printer systems and cartridges from the same firm have the same technology, but may be priced differently. They may also be incompatible with each other, meaning that two printer systems do not use the same cartridge. Hence, each period there are up to four printer systems and four cartridges available, $\left(p_i^{AB}, p_i^B\right)$, $i = 1, 2, ..., 4$.

I also consider firms that differ in costs. Without loss of generality, I assume that firm 1 is a (weakly) more efficient printer producer, i.e., $c_1^A \leq c_2^A$. Since there are only two types of consumers, For ease of exposition, I further assume that

Assumption 3 (Loss Leader) $c_2^A + c^B > v^{AB}$.[43] *This condition implies that the less efficient firm cannot make money from only selling printer systems.*

One might expect that firm 1, being more efficient, can exclude firm 2 from the market. This is indeed true in the market segment for foresighted consumers, but not for myopic

[41] According to Shapiro (1995), "A manufacturer can promise for some period of time not to change certain of its policies, such as its policy to sell replacement parts to ISOs on the same terms as they are sold to final customers. Or a manufacturer can promise to support open systems or second sources for service or software upgrades. Protections like these are sought by some customers and offered by some sellers in the real world."

[42] Since firms can successfully use second-degree price discrimination, third-degree price discrimination is unnecessary and therefore ruled out in the model.

[43] It is easy to see that, if $c_2^A + c^B \leq v^{AB}$, then an equilibrium exists where $\min(c_2^A + c^B, p^m)$ becomes the upper support of the randomized prices for printer systems sold to myopic consumers.

consumers. My method of solution is constructive. I first solve for the equilibrium prices of printer systems and cartridges sold to foresighted consumers and then compare them with those sold to myopic consumers to verify incentive compatibility.

Lemma 2 *If all consumers are foresighted, then only firm 1 (the more efficient firm) is active. It sells a printer system for* $c_2^A + c^B$ *and a cartridge for* c^B*.*

Comparing Proposition 2 and Lemma 2, we can see that the availability of other printer systems changes neither type of consumers' choice. Therefore, I conclude,

Proposition 3 *The market is segregated. (i) Firm 1 sells to foresighted consumers with a printer system and a cartridge priced at* $(c_2^A + c^B, c^B)$*; (ii) The two firms compete for myopic consumers in the same way as described by Proposition 2 (with* c^A *being replaced by* c_1^A*); (iii) a printer system sold to myopic consumers is incompatible with any other systems.*

Standard Bertrand competition is efficient in the sense that only the most efficient firm can survive the competition. This efficiency property fails to hold when firms compete for myopic consumers. For foresighted consumers, a firm can compete by cutting either the system price or the cartridge price. Its price constraint is binding at its rival's cost, so a more efficient firm can exclude the rival and earn a profit equal to its cost advantage. For myopic consumers, cutting the cartridge price is useless. A firm can only compete by cutting the system price, which is nonetheless bounded below by the cartridge price, and this shifts up the binding price constraint. Neither firm has an advantage over the other and the two have to share the market.

As a result, aftermarket monopolization persists (in the market segment of myopic consumers) even if the fraction of myopic consumers is small. Firms use loss leader pricing to attract myopic consumers and use system incompatibility to prevent them from buying cheap cartridges. Intense competition for foresighted consumers has no effect on the cartridge price paid by myopic consumers.

Corollary 1 *The less efficient firm has a smaller market share (in terms of total sales over time) and derives all of its profit from the aftermarket.*

Unable to compete for foresighted consumers, the less efficient firm targets myopic consumers and obtains a small but positive market share. This means that even a firm without market power in the primary market may still have the incentive and ability to monopolize aftermarket.[44] This prediction is not inconsistent with the fact that Kodak, a small player in the photocopier industry, has been accused of monopolizing its service market.[45]

b. No-Debiasing

Paradoxically, being the only seller for foresighted consumers does not always bring greater rewards to the more efficient firm, who actually enjoys a higher (per customer) profit in the seemingly more competitive market for myopic consumers. Rather than capture all consumers via education, the firm may choose to share the market (when the cost difference is not too big) and take advantage of myopic consumers.

Now I consider competing firms' incentive to educate myopic consumers.[46] As in Gabaix and Laibson (2006), I assume that a firm can costlessly inform myopic consumers so that all (the current generation) consumers become foresighted. Firms make choices of education before competing in prices.

Proposition 4 *If* $\frac{1+2\delta}{1+\delta}(c_2^A - c_1^A) \leq \delta[\pi(p^m) - \pi(\underline{p})]$, *where* $\underline{p}$ *is such that* $\underline{p} - c_1^A - c^B + (1+\delta)\pi(\underline{p}) = \pi(p^m)$, *then no firm educates consumers in any period.*

[44] Blackstone (1975) documents high aftermarket prices and related antitrust lawsuits involving the SCM corporation, a firm with very limited market power in the copy machine industry.

[45] Nevertheless, there are reasons to believe that other factors may have led to Kodak's alleged practice of refusal to deal. As argued by Shapiro (1995), Dennis W. Carlton and Michael Waldman (2006) and demonstrated in my monopoly model, Kodak, already a monopoly in its component supply, should have no incentive to monopolize the service market through refusal to deal, since it can adopt the "price squeeze" strategy to capture its rent if so desired or simply raise the component price to an exorbitantly high level to deny other service suppliers. Also, in the market for high-volume copiers, in which Kodak competes, buyers are mostly big businesses, so my assumption of anonymous buyers may not readily apply.

[46] Learning through experience, however, is not modeled in this paper.

In the traditional literature of pricing games, best responses in prices are always local deviations. A collusive outcome cannot be supported in a Nash equilibrium because the incentive to undercut is too strong. In my model, the "nonlocal" property of education forces firms to compare the payoff of a global deviation to the collusive outcome: to increase its profit, a firm may want to steal business from its competitor by educating a myopic consumer and offering a lower cartridge price, but such an attempt is self-defeating because it changes the consumer's type and effectively turns away the consumer. Therefore, firms may have no incentive to educate even if doing so is costless.

Gabaix and Laibson (2006) also consider firms' incentive to educate naive consumers. They find that whether firms choose to educate consumers depends on the ratio between the aftermarket profit and the social welfare distortion due to price deviations from marginal cost; education (unshrouding in their terminology) arises if and only if the ratio is smaller than 1. Since they consider only the case of equally efficient firms, in order to facilitate comparison, I use the following result.

Corollary 2 *If firms are equally efficient, then no firm educates consumers in any period.*

To understand the difference between their result and mine, it is useful to contrast the equilibrium outcomes of the two models. Their model generates a pooling equilibrium, in which both naive and sophisticated consumers buy the same product, but the former consume more than the optimal amount. Firms earn zero profits because of competition. Profits earned from naive consumers end up being subsidies to sophisticated consumers. An "educated" consumer would rather receive the cross-subsidy and therefore switches supplier only if the subsidy is small, in which case education may be profitable. My model, however, generates a separating equilibrium, in which myopic and foresighted consumers buy different products. Firms earn positive profits from myopic consumers, but zero profits from foresighted ones. An "educated" consumer <u>always</u> switches; but instead of switching to the firm who educates so that the firm can increase its profit, the consumer switches to products offered at marginal costs and therefore education is never profitable between two symmetric firms.

The above comparison also suggests that the no-education outcome may be more pervasive than predicted by Gabaix and Laibson. In their model, if the social welfare loss due to aftermarket over-pricing is so large that it exceeds the aftermarket profit, then firms will choose to educate consumers and restore the efficient outcome; so the welfare loss predicted by their model is, to some degree, muted by firms' incentive to educate. That is not the case in my model, in which firms will hold onto the aftermarket profit regardless how small it is and a firm will choose to educate consumers only when its cost advantage is so big that it is no longer willing to share the market.

c. Standardization Requirement

Although aftermarket monopolization due to consumer myopia is potentially harmful, remedies such as a standardization requirement that aim to reinforce aftermarket competition have to be prescribed with caution.[47] Under realistic parameter values, myopic consumers may suffer even more if cartridges are standardized, as shown in the following:

Proposition 5 *If (equally efficient) firms*[48] *are required to sell a standardized cartridge, then both firms sell the printer system at* $c^A + c^B$ *and the cartridge at* c^B*. If* $c^A + c^B > v^{AB}$*, then no myopic consumer makes purchases.*

Proof. Obvious.

Standardization reduces or even eliminates firms' cartridge profits. If printers are sold at a loss, then the loss of cartridge profits may lead firms to completely abandon myopic consumers, leaving both sides worse off. Therefore, the correct policy response necessarily

[47] Although standard requirements have rarely been used in the past, it does become an issue in a recent antitrust case involving compatibility between a Windows client PC and a work group server (E.U. v. Microsoft, 2006). Microsoft has been ordered by the European Commission to disclose interoperability information to other server producers for the development of compatible products.

[48] If firms differ in costs, then whether to cover myopic consumers also depends on their population size.

depends on the empirical estimates of model parameters. This result also shows that granted consumer bias exists, there is no strong case for government intervention, once the logic is allowed to run its full course.

III. Primary Market Monopoly

To complete the analysis, I also consider the case of primary market monopoly. The purpose of carrying out this analysis is twofold: on one hand, it allows me to compare the performances of myopic decision making under different market structures, and I show myopic decision making may serve as a useful heuristic for consumers who trade with a monopolist; on the other hand, I argue that consumer myopia does not necessarily entail aftermarket monopolization. I find that a monopolist's profit decreases with the percentage of myopic consumers, hence it has a strong incentive to educate myopic consumers and commit to marginal cost pricing in the aftermarket.

To gain some intuition for the results, the following observation is useful.

Observation 1 *A myopic consumer obtains a nonnegative surplus each period. Moreover, she obtains a positive surplus in the second-period for any positive amount of consumption.*

This observation is important for us to understand why consumer myopia may be a mixed blessing for firms. While it allows firms to raise aftermarket prices, it makes consumers tough bargainers in their initial purchases: they refuse to pay for anything beyond the immediate benefits. In a different context, Shlomo Benartzi and Richard H. Thaler (1995) show that a myopic investor demands a higher risk premium. This is consistent with my observation.

Proposition 6 *(i) A monopolist's profit decreases with α, the proportion of myopic consumers; (ii) A monopolist earns a higher profit from a foresighted consumer than from a myopic consumer; (iii) A monopolist obtains the maximal social surplus when $\alpha = 0$.*

The monopolist faces a standard problem of designing two two-part tariffs for consumers with different willingnesses to pay. Foresighted consumers have higher willingness to pay thus receiving a lower price and buying more cartridges. This enables the monopolist to extract more consumer surplus. In fact, when all consumers are foresighted, a monopolist can capture its full rent by pricing the cartridges at cost and raising the system price (Bowman, 1957). The presence of myopic consumers constrains a monopolist's ability to capture its full rent in three ways: (1) suboptimal consumption of a myopic consumer reduces total surplus; (2) the downward sloping demand for cartridges leaves a myopic consumer with a positive residual surplus; (3) the option to mimic a myopic consumer guarantees a foresighted consumer a positive surplus. Therefore a monopolist has a strong incentive to educate myopic consumers.

Next, I consider two extreme cases in which all consumers are either foresighted or myopic. We can think of them as situations under which an individual buyer bargains with a seller, who makes a take-it-or-leave-it offer.

Corollary 3 *When $\alpha = 1$, each myopic consumer obtains a positive surplus; when $\alpha = 0$, each foresighted consumer obtains zero surplus.*

Simply being myopic does not make a consumer necessarily worse off: when bargaining with a monopolist, a myopic consumer's focus on immediate payoff allows her to obtain a higher surplus than she otherwise might get by being foresighted. This result suggests that the myopic approach might be a useful heuristic for an inexperienced buyer, even though its generalization into a competitive setting turns out to be harmful, as shown earlier.

It should be noted, however, that the above results are directly linked to the special features of the demand functions assumed in the model, namely, a unit demand for the primary product and a downward-sloping demand for the aftermarket product.[49] The results in Proposition 6 and Corollary 3 would disappear if I assumed unit demands for both the primary product and the aftermarket product. In other words, if we take the simple case discussed in the introduction, a monopolist of the primary product should be able to make

[49] I am grateful to an anonymous referee who made this point together with a detailed discussion.

the same profit from the myopic consumers as from the foresighted consumers. Similarly, if demand curves for the primary product and aftermarket product are both downward-sloping, both types of consumers would obtain positive surpluses.

IV. Discussion and Conclusion

In this paper, I show that the standard Bertrand competition argument may not apply when firms compete for myopic consumers. I develop the model in the context of aftermarket. I find that primary market competition does not dissipate aftermarket rents, because of the arbitrage constraint in aftermarket pricing. While my result suggests that aftermarket monopolization is harmful to consumers, the policy implication is less than clear-cut. The right policy prescription is highly sensitive to the parameter values of the model, as shown in Proposition 5. A policy aiming to curb market power, such as a standardization requirement, may lead primary good producers to abandon myopic consumer altogether.[50]

The model developed in this paper may also help us think about the issue of planned obsolescence under intense price competition. Existing literature shows that a durable goods monopolist has an excessive incentive to introduce new products that make old units obsolete.[51] My result suggests that competing sellers may also have an incentive to practice planned obsolescence, because their profits from selling upgrades are not competed away by low prices in the system market. Essentially, firms create their aftermarket, the market of upgrades. For example,[52] Intuit retires old versions of Quicken, a personal finance management software, by disabling the online components of those programs so that users have to buy the upgrades every other year. Intuit calls this phase-out of older software its "sunset

[50] This is a familiar theme in the antitrust literature: any policies designed to mitigate a firm's pricing power also reduce its incentive to invest.

[51] Important contributions to this literature include, but are not limited to, Waldman (1993, 1996), Choi (1994) and Ellison and Fudenberg (2000).

[52] The antivirus software market mentioned earlier in the paper is another example.

policy."[53] Microsoft Money, the product's main competitor, also comes with only two years of online services included with purchase.[54]

A remaining question is why consumers act myopically. In my model, the myopic approach has no adverse effect when a buyer deals with a single seller, but leads to significant detriment for a buyer choosing between competing sellers. While it is beyond the scope of this paper, I speculate that focusing on the immediate payoff may serve as a useful heuristic in some situations involving complex decision making, but that individuals may over-generalize the heuristic to other situations when it is not optimal. The tendency of an individual to over-generalize a useful heuristic is a recurring theme in the psychology literature but has not yet been systematically studied by economists. Using analytical tools to compare performances of a certain heuristic in different economic environments can be the first step towards bridging the gap.

In order to compare my result with that of Bertrand competition in the easiest way, I have made a number of simplifying assumptions: first, firms are assumed to sell ex ante homogeneous products; second, I assume a duopoly with no potential entry; third, I choose to focus on primary market competition and ignore possible aftermarket competition from third-party suppliers.[55] Future studies that incorporate more realistic elements can help us better understand the issues discussed in this paper.

---

[53] The "sunset policy" can also be viewed as a lease-only policy. According to Waldman (1996, 1997) and Hendel and Lizzeri (1999), firms employ the lease-only policy to eliminate old units from the market in order to charge more for new units. However, this explanation is applicable to hardware with a secondhand market but less so to software, of which a secondhand market is prohibited due to copyright concerns (Fudenberg and Tirole, 1998).

[54] "'Sunset Policy' Stymies Loyal Quicken Users," Mike Musgrove, *Washington Post*, 02/06/2005.

[55] Firms have a powerful incentive to foreclose competition in the aftermarket (Michael D. Whinston, 1990). For example, printer manufacturers have developed "smart chips" that can practically disable the printer if third-party cartridge are detected ("Consumer IT goods and services", the Office of Fair Trading, 2002).

A Proofs

Proof of Lemma 1. Suppose $p_I^{AB} < p_I^B$, then a cartridge buyer buys a new system. The incumbent's instantaneous profit is $\pi(p_I^B) = (p_I^{AB} - c^A - c^B)D(p_I^{AB})$ from such a customer. But if the firm lowers the cartridge price to p_I^{AB} (This does not affect a new customer's purchase decision hence the firm's evolving market share and future profits), then its instantaneous profit from the cartridge buyer increases to $(p_I^{AB} - c^B)D(p_I^{AB}) > \pi(p_I^B)$. Contradiction. Last, we note that the strategy of not selling cartridges can be seen as setting an infinitely high price for the cartridge, but this strategy is weakly dominated by selling cartridges for the same price as printer systems.

Proof of Proposition 1. In a pure strategy equilibrium, if $\mathbb{C} = 0$, then we must have $W_I \geq \pi(p^m) + \delta W_E$, since the incumbent can always set $p_I^B = p^m$ and abandon printer buyers. Suppose that in the equilibrium $p_I^{AB} < p^m$, then we have $p_I^{AB} - c^A - c^B + \pi(p_I^B) + \delta W_I \geq \pi(p^m) + \delta W_E$, where $p_I^B \leq p_I^{AB}$. Since the entrant can always set $p_E^{AB} = p_I^{AB}$ to attract all printer buyers, we must have $W_E \geq p_I^{AB} - c^A - c^B + \delta W_I$. Hence $W_E \geq \pi(p^m) - \pi(p_I^B) + \delta W_E \geq \pi(p^m) - \pi(p_I^{AB}) + \delta W_E > 0$. Now suppose that $p_I^{AB} \geq p^m$, then $W_E \geq p_I^{AB} - c^A - c^B + \delta W_I \geq p_I^{AB} - c^A - c^B + \delta(\pi^m + \delta W_E)$. Solving, we get $W_E \geq (1 - \delta^2)(p^m - c^A - c^B + \delta\pi^m) > 0$, (Assumption 1).

Proof of Proposition 2. If the entrant chooses incompatibility, then only the incumbent sells cartridges. Since $p_I^{AB} \geq p_I^B$, we must have $p_I^B = \min(p_I^{AB}, p^m)$. Hence, we only need to solve for F_I^{AB} and F_E^{AB}. For notational simplicity, I suppress superscript "AB" in the proof. Since printer systems from the two firms are ex ante homogeneous, the equilibrium distributions of their prices have the same support. (This is true even if firms are not equally efficient, as is the case discussed later.) Denote it by $[\underline{p}, \bar{p}]$. My proof proceeds in four steps:

First, I show that $F_I(p^{AB})$ and $F_E(p^{AB})$ are atomless in the interior of $[\underline{p}, \bar{p}]$. Suppose that the incumbent names the printer system price at $p \in (\underline{p}, \bar{p})$ with some positive probability q, then the entrant cannot be indifferent between p and $p + \varepsilon$: when the entrant changes its price from $p+\varepsilon$ to p, it increases its probability of winning all new customers by q but lowers its average price in the order of ε. Therefore, it must strictly prefer p over $p+\varepsilon$. This means that $p+\varepsilon$ cannot be on the support of $[\underline{p}, \bar{p}]$, for a player must be indifferent among the prices which it mixes over given its opponent's price distribution. In other words, p cannot belong to the interior of $[\underline{p}, \bar{p}]$. By similar reasoning, one can show that $F_E(p^{AB})$ is also atomless in the interior of $[\underline{p}, \bar{p}]$.

Second, I show that $\bar{p} = p^m$. Substituting $p_I^B = \min(p_I^{AB}, p^m)$ into Eq. (4), we get

(A1)

$$W_I(\mathbb{C}=0) = (p_I^{AB} - c^A - c^B)[1 - F_E(p_I^{AB})] + \pi(\min[p_I^{AB}, p^m]) + \delta\{W_I[1 - F_E(p_I^{AB})] + W_E F_E(p_I^{AB})\}$$

By definition, $F_E(\bar{p}) = 1$. Thus we have $W_I(\bar{p}) = \pi(p^m) + \delta W_E$ if $\bar{p} \geq p^m$ and $W_I(\bar{p}) = \pi(\bar{p}) + \delta W_E$ if $\bar{p} < p^m$. Therefore, $W_I(\bar{p})$ is increasing in $\bar{p}$ when $\bar{p} < p^m$ but a constant when $p^m \leq \bar{p} \leq v^{AB}$. Suppose that $\bar{p}$ takes a value between p^m and v^{AB}, then the two firms' equilibrium pricing strategy can be characterized by the following first-order conditions:

(A2)
$$[1 - F_I(p_E^{AB})] - [p_E^{AB} - c^A - c^B + \delta\pi(\underline{p})]F_I'(p_E^{AB}) = 0$$

(A3)
$$\begin{cases} [1 + \pi'(p^{AB}) - F_E(p_I^{AB})] - [p_I^{AB} - c^A - c^B + \delta\pi(\underline{p})]F_E'(p_I^{AB}) = 0, & \text{when } \underline{p} \leq p^{AB} \leq p^m \\ [1 - F_E(p_I^{AB})] - [p_I^{AB} - c^A - c^B + \delta\pi(\underline{p})]F_E'(p_I^{AB}) = 0, & \text{when } p^m < p^{AB} \leq \bar{p} \end{cases}$$

In the range between p^m and $\bar{p}$, we have $F_E(p_I^{AB}) = 1 - \frac{K}{p_I^{AB} - c^A - c^B + \delta\pi(\underline{p})}$ and $F_E(\bar{p}) = 1$, hence $K = 0$. It follows that $F_E(p^m) = 1$. Therefore, $\bar{p} = p^m$. Solving, we get $F_I(p_E^{AB}) = 1 - \frac{\underline{p} - c^A - c^B + \delta\pi(\underline{p})}{p_E^{AB} - c^A - c^B + \delta\pi(\underline{p})}$ for $p^{AB} \in [\underline{p}, p^m)$ with $F_I(p^m) = 1$, and $F_E(p_I^{AB}) = 1 + \pi'(x) - e^{-x} \int_{x(p_I^{AB})}^{x(p^m)} e^z \pi'' dz$, where $x(p^{AB}) = \ln[p^{AB} - c^A - c^B + \delta\pi(\underline{p})]$.

Third, I solve for $\underline{p}$. Since $F_E(\bar{p}) = 1$, we have $W_I = \pi(p^m) + \delta W_E$. At the same time, $F_E(\underline{p}) = 0$ and $F_I(\underline{p}) = 0$. Therefore, $W_E = \underline{p} - c^A - c^B + \delta W_I$ and $W_I = \underline{p} - c^A - c^B +$

$\pi(\underline{p}) + \delta W_I$.[56] Thus we have $W_E(\mathbb{C}=0) = \frac{\pi(p^m)-\pi(\underline{p})}{1-\delta}$ and $W_I(\mathbb{C}=0) = \frac{\pi(p^m)-\delta\pi(\underline{p})}{1-\delta}$, where $\underline{p}$ is such that $\underline{p} - c^A - c^B + (1+\delta)\pi(\underline{p}) = \pi(p^m)$. Since the LHS increases in $\underline{p}$, equals $-c^A$ when $\underline{p} = c^B$, and equals $p^m - c^A - c^B + (1+\delta)\pi(p^m) > \pi(p^m)$ (Assumption 1) when $\underline{p} = p^m$, we must have $c^B < \underline{p} < p^m$. By the assumption that π is single-peaked, we know that the present values of both firms are positive. If the equation for $\underline{p}$ has a unique solution, then $[\underline{p}, \bar{p}]$ completely determines the support of equilibrium strategies so the equilibrium we have constructed is also the unique equilibrium when $\mathbb{C} = 0$.

Last, if the entrant chooses compatibility, then the two firms also compete in the cartridge market. Competition for cartridge buyers is a standard one-shot Bertrand competition. Therefore, $p_I^B = p_E^B = c^B$. (Since the monopoly profits are bounded, allowing mixed strategies does not lead to positive profits equilibria.) Due to zero aftermarket profit, competition in the printer market becomes a standard Bertrand competition with an infinite horizon. Since punishment strategies are ruled out, the only subgame-perfect strategies involve marginal cost pricing. Thus $W_E(\mathbb{C}=1) = 0$. Therefore, $\mathbb{C} = 0$ is the optimizing choice for the entrant.

Proof of Lemma 2. If $p^B \neq c^B$, then a firm can set a new price schedule $(p^{AB} + \delta[V(c^B) - V(p^B)], c^B)$, which gives foresights consumers the same surplus but increases the firm's profit by $\delta[V(c^B) - V(p^B) - \pi(p^B)] > 0$, by $R2$. Contradiction. The arbitrage constraint has no bite, since $p^{AB} + \delta[V(c^B) - V(p^B)] \geq c^A + c^B - \delta\pi(p^B) + \delta[V(c^B) - V(p^B)] \geq c^A + c^B > c^B$. Due to zero aftermarket profit, competition in the printer market is a standard Bertrand competition with an infinite horizon. Since punishment strategies are ruled out, printer systems are priced at the less efficient firm's marginal cost.

Proof of Proposition 3. (i) The printer system $(c_2^A + c^B, c^B)$ gives all foresighted consumers the maximal surplus, but it attracts neither old myopic consumers nor new myopic consumers because $c_2^A + c^B > v^{AB} > p^m$; (iii) must hold, otherwise an old myopic consumer can buy

[56] Without the arbitrage constraint, we would have $W_I = \underline{p} - c^A - c^B + \pi(p^m) + \delta W_I$ and thus $W_E = 0$.

cheap cartridges sold to foresighted consumers. In addition, by Proposition 2 the two printer systems sold to myopic consumers are incompatible.

Proof of Proposition 4. It is obvious that firm 1, when it is the incumbent, benefits most from educating myopic consumers. So I only consider its incentive to educate.

The present values of the two firms are determined by the following set of equations:

$$\begin{cases} W_{1I} = \pi(p^m) + \delta W_{1E}, \\ W_{1I} = \underline{p} - c_1^A - c^B + \pi(\underline{p}) + \delta W_{1I}, \\ W_{1E} = \underline{p} - c_1^A - c^B + \delta W_{1I}, \\ W_{2I} = \pi(p^m) + \delta W_{2E}, \\ W_{2E} = \underline{p} - c_2^A - c^B + \delta W_{2I}, \end{cases}$$

Solving, we get $W_{1I} = \frac{\pi(p^m) - \delta\pi(\underline{p})}{1-\delta^2}$, $W_{1E} = \frac{\pi(p^m) - \pi(\underline{p})}{1-\delta}$, $W_{2I} = W_{1I} - \frac{\delta}{1-\delta^2}\Delta c$, and $W_{2E} = W_{1E} - \frac{1}{1-\delta^2}\Delta c$, where $\Delta c = c_2^A - c_1^A$ and $\underline{p}$ is such that $\underline{p} - c_1^A - c^B + (1+\delta)\pi(\underline{p}) = \pi(p^m)$.

Now suppose that firm 1 chooses to educate myopic consumers, then they will buy the printer system sold to foresighted consumers. In addition, firm 1 can freely charge a monopoly price to its cartridge buyers. This gives it an instantaneous payoff of $\pi(p^m) + \Delta c$. In the next period, it can use its cost advantage to keep firm 2 out of the market and gain all myopic consumers. To find the price that allows firm 1 to exclude firm 2, we need to find the value of a captive consumer to firm 2. Since firm 2 gets δW_{2E} if it loses this period's printer buyers but gets $p - c_2^A - c^B + \delta W_{2I}$ if it wins, it is willing to price its printer system as low as $p = c_2^A + c^B - \delta(W_{2I} - W_{2E})$. Thus firm 1's net payoff from (1-period) education is $\pi(p^m) + \Delta c + \delta[\Delta c - \delta(W_{2I} - W_{2E})] + (\delta^2 - 1)W_{1I}$. This is positive if and only if $(\frac{1+2\delta}{1+\delta})\Delta c > \delta[\pi(p^m) - \pi(\underline{p})]$.

Proof of Proposition 6. (i) According to Observation 1, any printer system bought by a myopic consumer generates a positive discounted sum of surplus. Hence a foresighted consumer will always make purchases in the equilibrium, but there are two possible cases:

(a) only foresighted consumers are covered. A monopolist can use the printer system price to extract full surplus hence cartridges are priced at cost. The monopolist's profit is $\pi_1 = (1-\alpha)[v^{AB} + \delta V(c^B) - c^A - c^B]$, decreasing in α.

(b) foresighted consumers buy printer system 1 and myopic consumers buy printer system 2. As in (a), we know $p_1^B = c^B$. Since a foresighted consumer can mimic a myopic consumer, her IC constraint is binding. Hence, $p_1^{AB} = v^{AB} + \delta[V(c^B) - V(p_2^B)]$. At the same time, a myopic consumer's IR constraint is binding, $p_2^{AB} = v^{AB}$. Since $p_2^{AB} < p_1^{AB}$, a myopic consumer's IC constraint is satisfied. Thus the monopolist's profit can be written as $\pi_2 = \max_{p_2^B}\{v^{AB} - c^A - c^B + \delta[V(c^B) - V(p_2^B)] + \delta\alpha[\pi(p_2^B) + V(p_2^B) - V(c^B)]\}$. It is decreasing in α, by the envelop theorem and R2.

Since the monopolist's profit is $\pi = \max\{\pi_1, \pi_2\}$, it must be decreasing in α too.

(ii) This follows from (i) in both cases.

(iii) If $\alpha = 0$, then $\pi = v^{AB} + \delta V(c^B) - c^A - c^B$, the maximal social surplus.

B Data and Statistics

Table 1: Descriptive Statistics for tricolor Inkjets

	HP	Lexmark	Epson	Canon	All Printers
Number of Models	28	6	2	7	43
Price Range ($)	39.99-499.99	49.99-99.99	399.00-399.00	49.99-249.99	39.99-499.99
Sub-$100	10	6	0	5	21
$100-$300	17	0	0	2	19
$300-$500	1	0	0	0	1
$500-$700	0	0	2	0	2
Above-$700	0	0	0	0	0
Median Price ($)	149.99	79.99	399.99	79.99	129.99
Average Price ($)	178.56	73.65	399.00	119.99	172.2
Black-White Printing Per Page Average Cost ($)	0.052	0.068	0.060	0.043	0.053
Color Printing Per Page Average Cost ($)	0.092	0.092	0.086	0.086	0.091

Table 2: Descriptive Statistics for Single-color Inkjets

	HP	Lexmark	Epson	Canon	All Printers
Number of Models	12	0	12	11	35
Price Range ($)	199.99-1399.99	N/A	69.99-$699.00	89.99-$499.99	69.99-1399.00
Sub-$100	0	N/A	4	2	6
$100-$300	1	N/A	4	7	12
$300-$500	3	N/A	2	2	7
$500-$700	2	N/A	2	0	4
Above-$700	6	N/A	0	0	6
Median Price ($)	599.99	N/A	199.50	179.99	229
Average Price ($)	702.49	N/A	289.25	208.17	402.7
Black-White Printing Per Page Average Cost ($)	0.019	N/A	0.040	0.026	0.029
Color Printing Per Page Average Cost ($)	0.020	N/A	0.035	0.043	0.031

Table 3: Comparisons of tricolor and Single-color Inkjets

	tricolor	Single-color	t-statistics
Printer Price ($)	172.2	402.7	3.821***
	(19.2)	(57.2)	
Black-White Printing Per 100 Page Cost ($)	5.28	2.85	7.367***
	(0.26)	(0.21)	
Color Printing Per 100 Page Cost ($)	9.05	3.06	19.499***
	(0.26)	(0.17)	

Note: Standard Deviations are reported in parentheses. *** significantly different from 0 at the 1-percent level.

References

Beggs, Alan W. and Paul Klemperer, "Multi-period Competition with Switching Costs," Econometrica, 1992, 60 (3), 651–66.

Benartzi, Shlomo and Richard H. Thaler, "Myopic Loss Aversion and the Equity Premium Puzzle," The Quarterly Journal of Economics, 1995, 110 (1), 73–92.

Blackstone, E.A., "Restrictive Practices in the Marketing of Electrofax Copying Machines and Supplies: The SCM Corporation Case," The Journal of Industrial Economics, 1975, 23 (3), 189–202.

Borenstein, Severin, Jeffrey K. MacKie-Mason, and Janet S. Netz, "Antitrust Policy in Aftermarkets," Antitrust Law Journal, 1995, 63, 455–482–.

——, ——, and ——, "Exercising Market Power in Proprietary Aftermarkets," Journal of Economics and Management Strategy, 2000, 9 (2), 157–88.

Bowman, W. S. Jr, "Tying Arrangements and the Leverage Problem," Yale Law J., 1957, 67 (1), 19–36.

Carlton, Dennis W. and Michael Waldman, "Competition, Monopoly, and Aftermarkets," 2006. National Bureau of Economic Research, Inc, NBER Working Papers: 8086.

Chen, Zhiqi and Thomas W. Ross, "Refusals to Deal and Orders to Supply in Competitive Markets," International Journal of Industrial Organization, 1999, 17 (3), 399–417.

——, ——, and W. T. Stanbury, "Refusals to Deal and Aftermarkets," Review of Industrial Organization, 1998, 13 (1-2), 131–51.

Chevalier, J., A. Kashyap, and P. Rossi, "Why Don't Prices Rise During Peak Demand Periods? Evidence from Scanner Data," American Economics Review, 2003, 93 (1), 15–37.

Choi, J. P., "Network Externality, Compatibility Choice, and Planned Obsolescence," The Journal of Industrial Economics, 1994, 42 (2), 167–182.

Cleland, Todd A., "Printed Electronics: The Next Inkjet Revolution?" PhD dissertation, MASSACHUSETTS INSTITUTE OF TECHNOLOGY 2003.

Dasgupta, Partha and Eric Maskin, "The Existence of Equilibrium in Discontinuous Economic Games, I: Theory," Review of Economic Studies, 1986, 53 (1), 1–26.

Dogan, K., E. Haruvy, and R.C. Rao, "Who should practice price discrimination in an asymmetric duopoly?," June 2008. University of Texas at Dallas.

Economides, Nicholas, "Desirability of Compatibility in the Absence of Network Externalities," American Economic Review, 1989, 79 (5), 1165–81.

Ellison, Glenn, "A Model of Add-On Pricing," Quarterly Journal of Economics, 2005, 120 (2), 585–637.

—— and Drew Fudenberg, "The Neo-Luddite's Lament: Excessive Upgrades in the Software Industry," The RAND Journal of Economics, 2000, 31 (2), 253–272.

Elzinga, K.G. and D.E. Mills, "Independent Service Organizations and Economic Efficiency," Economic Inquiry, 2001, 39 (4), 549–560.

Emch, Eric R., "Does Opportunism Explain Markups in Laser Printer Toner and Memory?: No and Yes: Evidence on Pricing in Laser Printer Aftermarkets," 2002. Antitrust Division and Dept. of Justice and United States and Economic Analysis Group.

—— , "Price Discrimination via Proprietary Aftermarkets," Contributions to Economic Analysis & Policy, 2003, 2(1).

Farrell, Joseph and Carl Shapiro, "Dynamic Competition with Switching Costs," Rand Journal of Economics, 1988, 19 (1), 123–37.

Fudenberg, Drew and Jean Tirole, “The Fat-Cat Effect, the Puppy-Dog Ploy, and the Lean and Hungry Look,” American Economic Review, 1984, 74 (2), 361–66.

——— and ———, “Upgrades, Trade-ins, and Buybacks,” Rand Journal of Economics, 1998, 29 (2) (2), 235–258.

Gabaix, X. and D. Laibson, “Shrouded Attributes and Information Suppression in Competitive Markets,” Quarterly Journal of Economics, 2006, 120 (3), –.

Hendel, Igal and Alessandro Lizzeri, “Interfering with Secondary Markets,” Rand Journal of Economics, 1999, 30 (1), 1–21.

Katz, Michael L. and Carl Shapiro, “Network Externalities, Competition, and Compatibility,” American Economic Review, 1985, 75 (3), 424–40.

Lal, R., “Price promotions: limiting competitive encroachment,” Marketing science, 1990, pp. 247–262.

——— and C. Matutes, “Retail Pricing and Advertising Strategies,” Journal of Business, 1994, 67 (3), 345–370–.

Matutes, Carmen and Pierre Regibeau, “"Mix and Match": Product Compatibility without Network Externalities,” Rand Journal of Economics, 1988, 19 (2), 221–34.

——— and ———, “Standardization across Markets and Entry,” Journal of Industrial Economics, 1989, 37 (4), 359–71.

——— and ———, “Compatibility and Bundling of Complementary Goods in a Duopoly,” Journal of Industrial Economics, 1992, 40 (1), 37–54.

Morita, H. and M. Waldman, “Durable Goods, Monopoly Maintenance, and Time Inconsistency,” Journal of Economics and Management Strategy, 2004, 13, 273–302.

Narasimhan, Chakravarthi, "Competitive Promotional Strategies," Journal of Business, 1988, 61 (4), 427.

Padilla, A. Jorge, "Mixed Pricing in Oligopoly with Consumer Switching Costs," International Journal of Industrial Organization, 1992, 10 (3), 393–411.

——, "Revisiting Dynamic Duopoly with Consumer Switching Costs," Journal of Economic Theory, 1995, 67 (2), 520–30.

Shapiro, Carl, "Aftermarkets and Consumer Welfare: Making Sense of Kodak," Antitrust Law Journal, 1995, 63 (483-511), –.

Varian, H.R., "A Model of Sales," The American Economic Review, 1980, 70 (4), 651–659.

Waldman, Michael, "A New Perspective on Planned Obsolescence," The Quarterly Journal of Economics, 1993, 108 (1), 273–283.

——, "Durable Goods Pricing When Quality Matters," The Journal of Business, oct 1996, 69 (4), 489–510.

——, "Planned Obsolescence and the R&D Decision," The RAND Journal of Economics, 1996, 27 (3), 583–595.

——, "Eliminating the Market for Secondhand Goods: An Alternative Explanation for Leasing," Journal of Law and Economics, apr 1997, 40 (1), 61–92.

Whinston, M. D., "Tying, Foreclosure, and Exclusion," American Economic Review, 1990, 80 (4), 837–859–.