The Economics of Customer Lock-In and Market Power in Services

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Abstract: *Many businesses provide aftermarket services, including parts, maintenance, consulting, upgrades and modifications to durable consumer and business equipment. We investigate the effect on the original equipment manufacturer and on consumers if the manufacturer is the only (monopoly) service provider for the equipment it sells. Controlling the service market may be a profitable strategic objective, but there are several possible problems. The firm needs a durable intellectual property advantage to dominate independent service organizations. Even with such an advantage, active competition from vendors of alternate original equipment may force the manufacturer to dissipate service profits through equipment market competition to obtain market share. Further, the courts appear to be sympathetic to antitrust claims against manufacturers when they attempt to extend their proprietary control over one component of service to monopoly control overall all service provision. We also find that reputation effects may prevent manufacturers from fully exploiting their monopoly power in the aftermarket, but that reputation does not generally lead to competitive prices.*

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1. Introduction

Many service businesses provide aftermarket services, which may include parts, maintenance, consulting, upgrades and modifications to durable consumer and business equipment. A diverse group of products, such as dishwashers, automobiles, and highly complex electronic equipment (computers, telephone switches, medical imaging devices, etc.), spawn service markets. Typically, the first firm offering service to owners of durable equipment is the original equipment manufacturer (OEM) itself; after all, it already has parts and expertise. Often, the *only* service provider is the manufacturer. The broad question in this paper is the effect on the manufacturer and on consumers if a manufacturer is the only service provider for equipment it sells.

For a manufacturer the benefits of a monopoly over service are obvious. However, the manager must compare these benefits to the costs of maintaining the monopoly, which may be quite high. After any initial advantages have diminished, the manufacturer may have to invest in further entry barriers. Alternatively, the costs of monopoly may be felt in declining market share for the original equipment sales.[2] Finally, as we shall see below, there may be substantial legal costs and risks from attempting to maintain a monopoly for service on one's own products. Our analysis explores when a manufacturer will find it profitable to exploit a service monopoly that it has obtained.

While the manufacturer usually will have an initial service advantage due to its knowledge of the workings of the equipment, for durable equipment that advantage can quickly depreciate. Within a year or so of model introduction, independent service technicians can master new auto engine designs, VCR circuitry, even complex computer components. In addition, engineers trained by the manufacturer will leave-often involuntarily given the rapid restructuring of many equipment manufacturing industries in recent years-and these engineers often start or join independent service operations.

Besides the initial knowledge advantage, how can a manufacturer maintain a service

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[1]MacKie-Mason has testified as an expert witness for the plaintiffs in some of the cases cited below.

[2] Even if a manufacturer does not exploit its monopoly over service, customers might try to shift to other equipment manufacturers if they have a strong preference for second sourcing on service (that is, the value the option of obtaining service from more than one vendor). We are unaware of any research on second-sourcing for services (this issue is beyond our scope) but there is a relevant literature on second-sourcing for manufactured products (Shepard (1987); Riordan and Sappington (1989).

monopoly on its own products? Often ongoing service will require one or more *proprietary* components, such as patented parts or copyrighted diagnostic software. The equipment's value to the consumer often depends on these ancillary, proprietary materials. A manufacturer might use its control over the proprietary components to maintain a monopoly over the provision of all aftermarket service by, for example, conditioning access to the proprietary materials on simultaneous purchase of the manufactureræs service.[3]

A manufacturer's proprietary rights over essential service components or ancillary products might seem to provide a costless device for perpetuating a service monopoly. In fact, as with second-sourcing, customer preferences may make the monopoly strategy too costly to be worthwhile. The manufacturer's problem is the possible availability of alternate sources for the original equipment. Although durable equipment generally differs by brand, many customers (perhaps most) will find that another brand offers an attractive alternative given a sufficient price difference. If a manufacturer *exploits* a service monopoly by charging above-competitive prices, equipment buyers may simply choose a different equipment brand in the first place.[4] If the equipment sales loss were large enough it might not pay to monopolize service.

On the other hand, the manufacturer may have some power to exploit in the aftermarket. The critical issue is the extent to which customers are "locked-in" to the manufacturer of the original equipment. There are often high costs of switching to another brand of equipment. A consumer must balance the switching costs with the benefit of saving money in a competitor's aftermarket. Switching costs are particularly important for complicated electronic equipment. For example, custom software may have to be rewritten, and data archives converted; switching a large enterprise computer may take years and cost millions of dollars. Costs of switching once committed to a particular brand may provide the manufacturer with room to raise service prices above cost, and to collect some monopoly rents on the provision of service.

In fact, over the past decade independent service firms have initiated antitrust suits some twenty-odd against manufacturers such as Kodak, Prime Computer, Data General, Northern Telecom, Picker, Unisys, Xerox, and Siemens, alleging that these manufacturers are behaving anticompetitively in aftermarkets. In these cases, the manufacturer sells one brand of complex equipment in a market that may be competitive (*e.g.*, the market for minicomputers), and aftermarket service products to customers who purchased the original equipment. The

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[3]Of course, in the extreme the manufacturer might condition the initial equipment sale on the simultaneous purchase of a lifetime service contract. Although this seems quite rare, in fact leasing is an example of this, since manufacturer service is usually required. However, one almost always has the choice of buying the equipment without mandatory service.

[4]If, for example, Maytag monopolized Maytag service through a restrictive parts policy, and started charging monopoly service prices, it might not be long before Maytag lost substantial market share to Kitchen Aid and General Electric, *et al*.

services include hardware maintenance, spare parts, and software upgrades and revisions. Due to proprietary rights, the original manufacturer is often the exclusive seller of at least one aftermarket product, such as upgrades to the operating system software. Plaintiffs charge that the manufacturer exploits its special position in the proprietary product in violation of the antitrust laws.

The central economic dispute in these cases is whether the manufacturer *profitably* can exploit its proprietary advantage over the service products. For example, according to the Supreme Court, "Kodak [states] that even if it concedes monopoly *share* of the relevant parts market, it cannot actually exercise the necessary market *power* for a Sherman Act violation. This is so, according to Kodak, because competition exists in the equipment market" (*Kodak*, Supreme Court 90-1029 at 11; emphasis in original). The question becomes whether competition in the upstream market prevents anticompetitive behavior in downstream markets. For instance, Kodak argued to the Supreme Court that "equipment competition *precludes* any finding of monopoly power in the derivative aftermarkets" (emphasis added; *Kodak*, S. Ct. 90-1029 at 12).[5] The manufacturer might appear to have an opportunity to exploit its economic power over service customers, but the attempt might be unprofitable (at least in the long run) because of customers lost in the equipment market, as explained above. Indeed, if the manufacturer is no longer able to sell any equipment, it eventually will have no service customers to exploit.

Along these lines, a "starving monopolist" paradox appears in many recent cases. Wang Laboratories has stopped manufacturing equipment, and has entered Chapter 11 reorganization proceedings. Prime Computer has liquidated its equipment manufacturing operations, and reorganized as Computervision. Data General and Unisys have suffered repeated years of massive losses, and have drastically declined in size. If these are monopolists exploiting their market power over service customers, where are all the profits?

In this paper, we address the following questions: Can economic power over locked-in service customers be profitably exploited if the original equipment market is competitive? If so, under what circumstances? What happens when there is product differentiation and imperfect competition in the original equipment market? Among other things, our answers to these questions show that there *is* a role for antitrust enforcement in service aftermarkets. We also resolve the "starving monopolist" paradox.

We first review the recent legal history, emphasizing how the central economic questions have emerged from the facts of the cases. We then describe some simple theoretical models to answer the questions. Analysis of these markets in a free-entry competitive market reveals an important flaw in the common argument that competitive equipment markets lead to efficient pricing of the aftermarket product for locked-in customers: competition will eventually drive profits from *any* pricing strategy to zero. If reputation is not a factor, then the firm charges monopoly service prices and below-cost equipment prices. The firm earns

[5]The *Kodak* case concerned a motion for summary judgment before discovery was complete.

zero profits overall but unambiguously lowers output and makes consumers worse off. If a firm follows a "reputation" strategy it can raise profits by exploiting its reputation in the short run (*i.e.*, raising service prices *despite* a low-price reputation) and then exiting the market or reverting to a pricing strategy that requires no reputation.

Those who believe that service pricing will be competitive emphasize reputation as the key element in ensuring competitive service pricing. Since reputation is ineffective in our analysis of a free-entry, perfectly competitive equipment market, we next consider an imperfectly competitive equipment market. We find that reputation does have some value in a model with imperfect competition and that firms will price service below its locked-in monopoly level. We also find, however, that they will always price above cost for the aftermarket product. The degree to which they exploit locked-in consumers by pricing the aftermarket product above cost will depend on the discount rate and the nature of demand for the aftermarket product. But surprisingly, as the equipment market becomes more competitive, the price of service does not approach cost.

We show that in general the presumption should be that an equipment manufacturer with a dominant position in a service aftermarket *can* profitably exploit its position despite competition in the equipment market.[6] It is worth emphasizing that our results assume throughout that consumers are fully informed and have perfect foresight about changes in costs, technology and demand. In practice complete information is very costly and long-run forecasts of high-technology markets are rarely accurate. In practice these imperfections provide the manufacturer with even greater opportunities to exploit its economic power over service customers than we show below.

Our results have several implications for managers. Controlling the service market for one's own manufactured products may be a profitable strategic objective. But there are several problems that may eradicate profitability. In particular, it will generally be necessary to have some long-term intellectual property advantage to prevent independent service organizations from gaining a nearly equal competitive footing. But even with such a proprietary advantage, service monopolization may not be particularly attractive. If there is active competition between alternatives for the original equipment, the firm may find itself making profits on service but dissipating those profits through equipment discounts to maintain market share. Further, when manufacturers have the needed intellectual property to dominate the service market, if they do so it now appears that they may run afoul of the antitrust laws.[7]

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[6]This is consistent with the Supreme Court ruling in *Kodak*.

[7]Klein (1993) argues that the problem of aftermarket exploitation should be a problem for contract law, not antitrust law. His argument is strong, but abstracts from the fact that the Supreme Court has stated that power in service aftermarkets *is* a proper matter for antitrust consideration.

2. Aftermarket Economic Power in the Courts

There are many cases before the federal courts that involve claims of antitrust violations in aftermarkets for service products. Two, both concerning alleged tie-ins, have recently reached the Supreme Court. The Court ruled on the *Kodak* case in June 1992. Firms selling service for Kodak micrographic equipment alleged that Kodak adopted a restrictive policy on the availability of spare parts, including tying the sales of spare parts to the purchase of other maintenance services from Kodak. The Court upheld the Circuit Court's denial of Kodak's motion for summary judgement, concluding that "it is clearly reasonable to infer that Kodak has market power to raise prices and drive out competition in the aftermarkets . . . [and] to infer that Kodak chose to gain immediate profits by exerting that market power where locked-in customers, high information costs, and discriminatory pricing limited and perhaps eliminated any long-term loss" (*Kodak*, S. Ct. 90-1029 at 24).[8] Kodak, and the United States as *amicus curiae*, argued that as a matter of economic theory competition in the equipment market prevents manufacturers from exercising market power in the service market in all circumstances. The Supreme Court rejected the idea that Kodak's theory *must* hold. Rather, the Court argued that while Kodak's theory is *plausible*, whether it actually holds will depend on the particular circumstances of each case.

In October 1992 the Supreme Court ruled on an appeal in the *Prime Computer* case. An independent service company alleged and won a unanimous jury verdict that Prime (now Computervision) illegally tied software support and upgrades to the purchase of hardware maintenance from Prime. Prime appealed and the Sixth Circuit reversed the jury verdict. In its appeals, Prime argued that it could not take advantage of its locked-in customers because of competition for new equipment sales (see, e.g., Prime's Brief for Judgment N.O.V., E.D. Mich., Case 89-CV-71762, 29 November 1990, at p. 7). The Supreme Court vacated and remanded the Circuit Court decision for reconsideration in light of *Kodak*.

Nearly all of the service aftermarket cases in the courts include a claim of tying. Tying is a popular business strategy that under some restrictive circumstances can be illegal. A tie requires customers to purchase one good or service (the tied product) if they wish to purchase a second good or service (the tying good). Not all ties are illegal; it is perfectly permissible for General Motors to require you to buy tires from them when you buy a new car. Whether a particular tying strategy is illegal is largely an economic question. A tie is illegal if the tying firm has sufficient economic power over the tying product to adversely affect competition in the market for the tied product.[9] We might announce, for example, that you can buy pencils from us only if you also send your children to Davis, Michigan, or Delaware

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[8]This is not a final determination in the case, but merely a decision that the case can go forward to trial.

[9]This criterion was first established in *International Salt v. U.S.*, 332 U.S. 392 (1947), and has been recently restated and somewhat clarified in *Jefferson Parish Hospital District No. 2 v. Hyde*, 466 U.S. 2 (1984).

and pay our salaries to teach them. Since you can easily buy pencils elsewhere, we have no power over you, and this tie will harm the price, quantity or quality of university education. But if we were the exclusive sellers of a cancer cure rather than a competitive seller of pencils, we might well be able to raise tuition at our schools and force many people to attend unwillingly. Thus the issue largely depends on whether the seller has market power in the tying good which she is trying to extend to the tied good market.[10]

The many service industry tying suits in the past decade introduce a new wrinkle. There are usually at least *three* products or services that are relevant. The firm imposes a tie between one aftermarket service product and another (such as spare parts and equipment maintenance in the *Kodak* case). But the defense relies on claims that competition in a *third* market-for original equipment sales-prevents them from having any economic power to exploit with the tie in the service aftermarkets.

In *Kodak* the Supreme Court ruled that while original equipment competition may enforce competitive behavior in the service aftermarkets, competition is not assured. The theory's applicability must be analyzed on a case by case basis. As the Court of Appeals stated in *Kodak*, "market imperfections can keep economic theories about how consumers will act from mirroring reality" (*Kodak*, 903 F.2d 612 at 617).

Ties are not the only way that an equipment manufacturer can affect competition in the service markets. In several cases, manufacturers allegedly monopolize the market for equipment maintenance on their brand of equipment, in violation Section II of the Sherman Act. (See, for example, *Grumman v. Data General*, *Datasat v. Unisys*, *Comm-Tract v. Northern Telecom*, and others.)[11] To prevail in a monopolization claim in a service aftermarket, the plaintiff must show that the manufacturer has substantial economic power in the aftermarket and is exploiting that power.

Thus, whether the allegations are tying (Section I) or monopolization (Section II), the crucial question at issue is whether a manufacturer that faces competition in the original equipment market can have sufficient economic power over customers for the aftermarket service product to profitably raise service prices or otherwise burden the customers.

In the remainder of this section we examine how three parts of the central economic

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[10]This point was made, for example, in *Carbice Corp. of America v. American Patent Development Corp*, 283 U.S. 27 (1941), in which the Supreme Court decided against allowing the owner of a patent to "secure a partial monopoly on the unpatented supplies consumed in its operation."

[11]As another example, Dimidowich filed a case quite similar to the Kodak case, though under California's Cartwright Law, not under the Sherman Act. Dimidowich was a third-party maintainer of Bell and Howell micrographic equipment, who accused Bell and Howell of conspiring to restrain trade by refusing to sell parts to Dimidowich. There was evidence that Bell and Howell became concerned with increasing competition in the market for service of their equipment and hence instituted the policy in order to reduce competition.

question have emerged in the recent cases: the role of customer "lock-in" in establishing economic power; the paradox that failing or low-profit businesses are so often the subject of service antitrust suits; and the extent to which reputation can prevent manufacturers from profitably exploiting whatever economic power they have in service aftermarkets.

2.1. Customer Lock-In

The manufacturer's ability to charge above-competitive prices for its aftermarket service product depends largely on the availability of substitutes to the customer. For example, an existing customer could sell or scrap the used equipment and purchase anew from a different manufacturer if the original seller raises the service price enough. A central issue in the cases has been the extent to which the opportunity for customers to switch constrains the manufacturer to price service competitively.

Once a customer purchases a piece of complex durable equipment, she may find that switching to another brand is costly. There can be significant costs for retraining personnel, converting data files, rewriting critical software programs, and so forth. The higher the costs of switching, the more the customer is "locked-in" to the original manufacturer's brand of equipment. Thus, for these customers the manufacturer may be able to substantially raise service prices without fear of significant switching.[12]

A distinguishing feature of most of the recent service antitrust cases is that the equipment involved is complex and proprietary. The products include minicomputers, hospital CT scanners, telephone PBX switches, and micrographic reproduction equipment. In every case, users and experts have testified to the high costs of switching.[13] Evidence introduced in the *Wang* case showed that typically about 80 percent of minicomputer consumers buy the same brand when they replace their equipment, suggesting a low degree of switching between minicomputer brands.

Switching costs must also be weighed against the amount that supracompetitive pricing increases the lifetime cost of owning the machine. A five percent increase in the price of service can be enough to trigger antitrust concern,[14] yet may only raise the present value of

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[12]This point was emphasized by the Supreme Court in *Kodak*: "If the cost of switching is high, consumers who already have purchased the equipment, and are thus 'locked-in,' will tolerate some level of service-price increases before changing equipment brands" (*Kodak*, S. Ct. 90-1029 at 23).

[13]For example, a senior design systems manager for Ford Motor Co. testifying on behalf of Prime stated that if forced to switch quickly from Prime minicomputers to another brand Ford could not "stay a competitive auto manufacturer in the world market," *Virtual*, Plaintiffs Response Brief on Appeal. See also, *Kodak*, S. Ct. 90-1029 at p. 23.

[14]U.S. Department of Justice Merger Guidelines (1992 rev.).

lifetime costs on the equipment by half a percent.[15] With significant switching costs, even sizable increases in the cost of service may not induce customers to switch brands.

Several authors show how lock-in can create market power.[16] But these studies all examine a single market where the customer becomes locked-in for repeat purchases. There has been little attention to a firm with locked-in service customers that faces competition in the upstream market for the initial sale of the equipment. When there are two interrelated markets the central question becomes the ability of the manufacturer to exploit economic power in one market without a larger adverse impact on profits in the other market.[17] In section 3 we explicitly incorporate lock-in in our discussions of competition and market power in equipment markets and service aftermarkets.

2.2. The "Starving Monopolist"

One peculiarity in this area of the law is that so many of the antitrust cases have been against low-profit and failing firms. Prime has gone out of business; Wang (subject of two suits) has stopped producing equipment and is in bankruptcy proceedings; Data General (two suits) experienced 16 straight quarters of losses and has downsized considerably; Unisys (two suits) has been struggling. Other defendants have low profit margins and do not appear to be classic monopolists: Northern Telecom, Hewlett-Packard, Siemens, Picker, etc.

If manufacturers are monopolistically exploiting locked-in service customers, where are all the profits? We provide an answer to the "starving monopolist" paradox in section 3, below. In short, while firms may obtain above-normal service profits, they may dissipate these profits through competition in the equipment market to "buy market share." This market share provides locked-in customers to exploit.[18]

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[15]For example, an independent study in 1989 by the Sierra Group estimates that the hardware maintenance costs represent 11.9% of the five-year life-cycle total costs for a Data General MV/1000 DC system. A 5% increase in hardware maintenance prices would thus increase total five-year system costs by only 0.6%. Memorandum in Support of a Motion for Summary Judgment on Grumman's Antitrust Concerns, Exhibit 6, 23 March 1990, U.S. District (Mass.) No. 88-0033-S.

[16]See, for example, Beggs and Klemperer (1992), Farrell and Shapiro (1988), and Klemperer (1987).

[17]This is of course the fundamental question of market definition and economic power in antitrust analysis, thrown into a new light because of the derivative, or aftermarket, status of the service products in question.

[18]The Supreme Court dissolved a merger between Ford Motor and Autolite in part because Autolite's practice of selling original spark plugs at below cost was evidence that Autolite was exploiting customers for replacement Autolite spark plugs. (*Ford Motor v. U.S. et al.*, 405 US 562 (1971)). In this case customer lock-in to Autolite for replacement spark plugs was important, even though that lock-in was more psychological than technologically or

import Oddly, *both* the defendant and the United States (filing as *amicus curiae* in *Kodak* on behalf of Kodak) argued along these lines. Even if firms were charging supracompetitive prices in service aftermarkets, they wrote, that might be part of an overall pricing strategy in combination with subcompetitive prices for the original equipment (see *Kodak*, S. Ct. 90-1029 at 18). They then asserted that such a strategy is "competitive." In fact, such pricing is not as efficient as competitive pricing in both markets, as we show below. Consumers are harmed, and it is appropriate to invoke the antitrust laws, even if the monopolist appears to be, or is, starving.

2.3. Reputation and Imperfect Competition

A manufacturer faces two types of customers: those who already own the manufacturer's equipment and those who do not.[19] Although customers with equipment may face significant costs of switching brands and thus provide the manufacturer with an opportunity to price supracompetitively, *de novo* customers do not. Is it possible that competing for potential new customers provides sufficient discipline that manufacturers will not exploit their economic power over aftermarket service products?

The claim that potential new customers provide the competitive discipline in the service market is central to the position taken by defendants in the recent cases. Kodak, for instance, argued that "there will be some large-volume, sophisticated purchasers who will undertake the comparative studies and . . . hold down the package price for all other customers" (*Kodak*, S. Ct. 90-1029 at 22). Prime argued that

> The quality and price of post-sale service are critical to the competitiveness of each firm's computer systems. No firm has the power or incentive to take advantage of its current system users by lowering the quality or raising the price of such service. Any firm attempting to do so would quickly lose future system sales and place its entire business at risk (Prime's Brief for Judgment N.O.V., E.D. Mich., Case 89-CV-71762, 29 November 1990, at p. 7).

The argument depends on reputation effects. The manufacturer claims it cannot afford to exploit locked-in service customers because the information will become widespread and new consumers will purchase other brands. That is, a reputation for exploiting locked-in customers will result in a loss of equipment sales.

The tradeoff between profits from aftermarket service and from original equipment sales causes confusion in the courts. The appellate court in *Virtual* argued that "lock-in theory is

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economically necessary.

[19]The distinction between customers who own another brand already and customers who are making their first purchase is not important for our point in this section.

viable only when the producer can charge its customer monopoly prices without fear of being replaced by competitors due to the customer's substantial investments" *(Virtual*, 957 F.2d 1318 at 1328). However, it is not necessary to charge full monopoly prices for service in order to exploit economic power, nor does the loss of *some* customers for new equipment necessarily offset the profits from service. The Supreme Court observed in *Kodak* that even monopolists have to give up sales when they raise prices, yet they find it profitable to charge higher than competitive prices (S. Ct. 90-1029 at 17). Short of charging the full monopoly price for service, "there could be a middle, optimum price at which the increased revenues from the higher-priced sales of service and parts would more than compensate for the lower revenues from lost equipment sales" (*id*.).[20] The proper question, then, is the extent to which monopolistic behavior in the service aftermarket reduces profits in the equipment market.

If a manufacturer can establish a credible reputation for low service prices, then it might be able to charge higher equipment prices than its competitors and earn some profits in the equipment market. This strategy is sensible if the profit potential in the equipment market is greater than the profits foregone on service. However, since there is a tradeoff, this doesn't mean that service prices will be lowered all the way to the competitive level (at which price equals cost).

To have an incentive to invest in a reputation, the manufacturer must anticipate the possibility of earning above-normal profits. Thus, there must be some product differentiation or other source of profits in the equipment market. To address the role of reputation we need to consider that the equipment market is not perfectly competitive.

Vigorous but imperfect competition in the equipment market is a reasonable characterization for most of the cases. Complex, high-technology products tend to be differentiated, even if they are similar enough that customers can consider them as partial substitutes. For example, Wang minicomputers might be favored by customers who need strong document and image processing capabilities; DEC computers by scientific and engineering users; and IBM minicomputers by those with significant data processing needs. Northern Telecom designs PBX telephone switches to maintain complete "upward" compatibility so that customers can expand and upgrade their system without replacing it. ATT, on the other hand, produces different lines of switches that are not all upward compatible, but provide other advantages. With imperfect competition manufacturers may earn above normal returns or quasi-rents on their new equipment business and thus face the profit tradeoff described above.

Curiously, the proponents of the reputation defense never identify the source of the excess profits that manufacturers are so anxious to protect by establishing low-service-price reputations. Rather, they emphasize strong competition in the equipment market and the

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[20]Notice that the Supreme Court here is assuming that firms want to maximize total revenues, not profits. Most evidence indicates that firm behavior is generally more consistent with profit than revenue maximization. But the Court's point is valid if "revenues" is replaced with "profits."

availability of good substitutes for the consumer. This suggests there should be no excess profits in the equipment market to protect.

The recent cases raise interesting legal and economic issues. The following sections discuss the economic issues. In particular, we address the strong theoretical claim that it is impossible for a competitive equipment firm to profitably exploit the aftermarkets. We analyze a theory of power in the aftermarkets that is motivated by the descriptive features of equipment and service markets, in particular including switching costs. We find that the theoretical presumption should run in the other direction: equipment market competition in general will not prevent exploitation of economic power in service markets.

3. A Competitive Equipment Market and a Non-Competitive Service Aftermarket

To think through the economics of competition in service aftermarkets, we begin with a very simple case.[21] Consider a market in which original equipment sales are perfectly competitive, but the brand manufacturer monopolizes aftermarket service of the brand. What possibility is there for a manufacturer to exploit market power in the service market?

Suppose that the equipment has a two-period life-cycle. In the first period a customer decides whether to buy a unit of equipment. If she buys, then in the second period the customer can: (1) use the depreciated equipment as is; (2) buy some service from the original manufacturer to enhance the equipment; or, (3) reenter the market to purchase new equipment. To keep things simple, we assume that all firms can produce equipment and service (on their own equipment) at the same cost, and that these costs are constant for each unit produced.

We also assume that all consumers are identical. In the spirit of a free-entry, perfectly competitive equipment market, consumers consider equipment brands to be homogeneous. That is, at a given price they do not care from which producer they purchase. This ensures that if one producer cuts price a small amount below the price of other producers, all consumers will buy that low-priced brand. Similarly, we assume that each unit of service on a machine is equally valuable to a consumer, whatever the brand of equipment. That is, the value of the enhanced equipment to a consumer with brand *X* equipment and one unit of service is the same as the value to a consumer with brand *Y* equipment and one unit of service.

These assumptions grant the benefit of the doubt to the proponents of the defendant, such as espoused by Kodak and the U.S. Solicitor General in that case. The model assumes the equipment market is competitive with consumers who respond instantaneously and completely to price differences. This is the most likely setting in which competition in the equipment market can prevent manufacturers from exploiting their market power in service markets. However, we shall see that to get a completely efficient outcome-in which firms price both equipment and service at cost-requires that firms can credibly commit to charging a low service price. As discussed below, this assumption is generally implausible.

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[21]This section is based in part on technical results derived in Borenstein, MacKie-Mason, and Netz (1992).

To ensure that a service market can exist, we assume that if equipment and service are priced at cost the consumer would have a higher net benefit from keeping and buying service for old equipment than if she sold the used equipment and purchased new equipment. We also assume that the purchase of a small amount of service yields a benefit to the consumer worth more than the cost of producing that service. Together, the two assumptions imply that the socially most efficient outcome in these markets is for producers to charge prices equal to cost, and for consumers to use each unit of the equipment for two periods and to purchase some positive quantity of service in the second period.

3.1. Forward-Looking Customers but No Reputation Effects

We first consider the manufacturer's profit-maximizing strategy if the decision horizon is two periods long, and no new customers who enter after the first period.[22] With no new customers, and no future equipment purchases by the original customers, there is no role for reputation.[23] We do assume, however, that customers look ahead and correctly anticipate the manufacturer's service pricing decisions. This setting allows us to show the generic inefficiencies that can result from the absence of competition in the service aftermarket.

To solve for profit-maximizing strategies, we follow the standard method of backward induction for a finite decision horizon. That is, we first consider what the producer does in the second (last) period, given past history. Then, with the producer knowing its optimal second-period pricing strategy, we step back and solve for the optimal first-period pricing strategy.

In the second period, each firm decides what price to charge for service. At this point its customers are locked-in: everyone made their brand choice in the first period, and only the manufacturer can offer service for its proprietary equipment. That does not mean the firm can charge any price it wishes. If it sets the service price too high customers will abandon the used equipment and purchase new equipment from another vendor to use during period two.[24] We call the price at which customers abandon their used equipment the "switch price." The firm must choose a monopoly price to maximize service profits, subject to the constraint that price can be no higher than the switch price that induces customers to leave. If the unconstrained monopoly price is above the switch price, the producer should charge the switch price.

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[22]The assumption that there are no new consumers of equipment in the second period may seem extreme, but relaxing this assumption in the context of a two-period model does not change our results. If consumers purchase equipment in the second, final period, there is no period in which they can purchase service, and hence service prices will be irrelevant to their purchasing decision.

[23]We introduce reputation effects in section 4, below.

[24]Our results are unchanged if there is a market for used equipment so that the customer can sell rather than scrap her equipment.

Why isn't the switch price equal to cost? That is, why don't customers switch brands in the second-period if the producer charges a price for service that is higher than cost? This is where lock-in is crucial. We assumed that the customer's net benefit from keeping the used equipment and buying some service at cost is *greater than* the net benefit from selling the used equipment and switching to a different brand of new equipment. This assumption will typically be true for some equipment (*e.g.*, computers, telecommunications switches, imaging equipment) because there are significant costs of switching, as we discussed earlier. The switching costs provide the firm with some room to charge more than cost for service; the user's switching costs determine the maximum price the firm can charge (the switch price). It is the switching costs that create lock-in, and lock-in that allows the firm to earn above-competitive profits in the service market.

If consumers know that a manufacturer is going to charge them above-competitive prices for service in period two, why don't they prevent this by buying their equipment from a different manufacturer in period one? This is the crux of the issue: can competition in the equipment market prevent the exploitation of market power in the service aftermarket? The problem is that when period two arrives, if a firm has any customers at all it will maximize profits by charging the constrained monopoly price. This is true for *all* firms. Thus, in period one the customer can know that the manufacturer will charge her above-competitive prices, but she has nowhere to turn.

What, then, happens in period one? Each of the perfectly competitive sellers realizes that in period two it can earn above-competitive profits on servicing each unit of equipment sold in period one. Thus, there is a premium on attracting equipment customers. The sellers enter a classic battle for market share by cutting equipment prices to attract customers who can be profitably exploited in the next period. With free entry and exit into the market, price-cutting will continue until the firms in the market break even overall. Thus, the equilibrium price for equipment will be equal to the equipment's production cost less the discounted future service profits. That is, each customer obtained in period one is worth $\$X$ in discounted period two profits, so the manufacturer breaks even if it charges $\$(C - X)$ for equipment, where C is the cost of producing one unit of the equipment.

The result of this analysis is that even when (a) the equipment market is perfectly competitive, (b) customers correctly anticipate future service prices, and (c) firms earn zero excess profits, there is still above-competitive pricing for service and below-competitive pricing for the equipment. This outcome resolves the "starving monopolist" paradox mentioned in the first section. Above-competitive prices in the service market combined with below cost equipment prices provide the firm with zero total profits.

For producers the profits in the service market are equal to the losses in the equipment market, leaving producer welfare unchanged from efficient, cost-based prices. However, below-cost pricing in the equipment market does not offset the loss to consumers from above-cost pricing in the service market. Thus, consumers are worse off than if both markets

were competitive, and producers are no better off since they still earn zero economic profits.[25]

To see why this is so, recognize first that consumers will buy less service than they would if they faced a service price equal to cost. As usual in a monopoly situation, the consumer loss from high service prices is greater than the producers' extra profits, because consumers respond in part by reducing their purchases. The reduction in quantity represents a loss to consumers with no corresponding gain to producers, *i.e.*, a "deadweight loss."

Competition in the equipment market forces the firm to "give back" the service profits through below-cost prices on equipment. The equipment price is below cost by the amount of (discounted) profits earned on service, but the service profits are less than the consumer loss from above-cost service pricing. Thus, the discount on equipment does not fully compensate consumers for the loss of benefits in the service market. As a result, the combined package of equipment and service is less attractive, and fewer consumers choose to buy the equipment. This is precisely the outcome that the antitrust laws seek to prevent: higher prices and lower quantities that result in consumer losses.

3.2. Pre-commitment

The strong result above holds because each firm's only rational pricing strategy in the second (and last) period is to charge a (constrained) monopoly price.[26] Customers can't buy first-period equipment only from firms that will charge competitive service prices because there aren't any. This may seem peculiar. If a firm could attract all the customers in the first period by promising to charge a price on service less than the monopoly level, why won't such a firm exist?

The problem is the credibility of such a promise. We assumed above that firms could not credibly commit to competitive service pricing. Once the second (final) period arrives, past behavior is irrelevant. A profit-maximizing firm will charge the price that maximizes second period profits whatever it promised in the first period. With no future sales to anyone, there is no cost to breaking a promise and charging the monopoly price. Since consumers anticipate this behavior, they will purchase equipment from whichever firm has the lowest equipment price since all firms will charge the monopoly service price.

If a firm *could* credibly commit to charging a low service price, then it would because it would want to try to attract all of the first-period equipment customers. Why is commitment impossible? In our simple abstract analysis it might seem trivial to write a legally-binding contract that guarantees that second period price would be set equal to cost. If and only if a credible commitment is possible, then equipment competition between firms offering

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[25]Thus societal welfare, the sum of producer and consumer welfare, falls relative to welfare under non-cost-based pricing, since producer welfare is the same and consumer welfare is decreased.

[26]The results derived above hold so long as there is a finite period, regardless of whether the last period is after two periods or after twenty periods.

credible contracts would lead to efficient pricing (equal to cost) for both equipment and service. To see this, start from the situation with competitive equipment prices and supracompetitive service prices. Each firm would try to undercut its competitors, up to the point where the service price is equal to the cost of service.

In fact, fully credible complete commitments are usually impossible. To begin with, they require low-cost external enforcement, presumably through the courts. But contracts predicating price on cost are almost impossible to enforce, because it is almost impossible to precisely measure unit cost in the real world. How much of the R&D department costs should be attributed to the unit cost of service? What about marketing and headquarters staff? In practice a manufacturer is selling several different types of service (including service for multiple varieties of hardware and software) with several different levels and qualities (e.g., one-hour response, four-hour response, evening-and-weekend calls, etc.). Enforcement would require the calculation of the cost of each type of service.

It is also impossible to write a complete contract, *i.e.*, one that covers all possibilities. The constant and unpredictable changes in technology, service needs and service offerings make it difficult to write contracts or offer price guarantees much in advance. Equipment of the sort involved in the pending antitrust suits often has a useful life of 10 years or more. It is infeasible for customers and sellers to envision all possible contingencies and write those explicitly into service contracts at the time of original purchase.

For example, in the *Virtual* case, Ford Motor Company committed its engineering design software to run exclusively on Prime minicomputers several years before Prime began tying software upgrades to hardware maintenance. (*Virtual Maintenance v. Prime Computer*, Court of Appeal Appendix at 526-560.) To obtain a binding commitment from Prime that Prime would not exploit service customers, Ford needed to anticipate Prime's policy when the minicomputer industry was in its infancy, before there had been experience with restrictive policies[27].

Thus, for a fully efficient outcome to occur with a perfectly competitive equipment market and proprietary service, it is necessary that customers and firms enter fully-specified contingency contracts. Such contracts must be enforceable by courts, and prevent the firm from exploiting market power over service customers for many years to come. Long-term contracts that control service prices over the life of the equipment have been absent from the evidence in the recent antitrust cases. In general we believe such contracts are infeasible. In practice, of course, the existence of binding precommitments is a question of fact, not theory. Since it is a question of fact, the economic theory again supports the Supreme Court's conclusion in *Kodak, i.e.* precommitment must be analyzed on a case by case basis.

3.3. Building a Reputation

[27]Likewise, most of the owners of Wang equipment at the time *Systemcare, Inc. v. Wang Laboratories* was filed had purchased their equipment before Wang introduced its policy of tying software support to hardware maintenance.

The problem with credible commitments we described largely follows from assuming that there is a final period. What happens in the situation where decisions are made over an infinite horizon? Then firms may attract consumers by building a reputation for pricing service at cost, or at least below the monopoly level. If consumers believe in the reputation, then reputation building and competition in the equipment market might achieve efficient pricing for both equipment and service.

We now go to the other extreme and assume the firm makes decisions over an infinite horizon, though it still discounts future cash flows using a positive interest rate. Machines continue to be useful for only two periods. Thus, in period *t* a consumer is only concerned about the price of service in period *t+1*. However, because firms make decisions over an infinite horizon, the service price in period *t+1* depends on future periods. In the simple two-period approach-or in any finite-horizon model-consumers could form expectations of future service prices by solving backwards for the firm's optimal pricing strategy. In an infinite-horizon setting there is no "last period" that to solve, and so no place to begin the backward induction. Therefore, we have to assume another method for consumers to set price expectations.

We assume that consumers believe that service prices will remain constant over time. That is, they forecast that tomorrow's service price will be the same as today's. This is plausible if we assume that real production costs are constant over time. Of course, assuming constant costs abstracts from the need to forecast changes in technology, which would clearly affect equipment and service prices. Testimony in many of the legal cases we discussed suggested that when consumers think ahead about service prices at all they make roughly this assumption. This also allows for maximal reputation-building. That is, consumers fully react to a firm's behavior in prior periods.

Now suppose firms are in the pricing equilibrium derived in the two-period model, charging monopoly prices for service and below-cost prices for equipment. How might a firm try to profit from building a reputation for lower service prices? The firm could lower its current service price, leading equipment buyers to believe that it will charge low service prices in the future. The firm will sacrifice some current profits on service, but the payoff to the firm is that it could then charge a higher price for equipment.[28] The firm will sacrifice the present discounted value of current and future service profits only if the present discounted value of future increased equipment profits is greater.

To learn how much profit reputation building yields, we need to know how quickly other firms will imitate the strategy of low-price service. Surely, in a free-entry competitive equipment market, if reputation-building turns out to be profitable there will be quick imitation of this strategy by competitors. Other firms also price service at cost, driving the competitive price of equipment down to its production cost and eliminating profits on equipment sales. That is, if all firms are charging service at cost, the firm with the lowest

[28]Alternatively, the manufacturer could charge the same equipment price but obtain a higher market share, which would increase profits if the equipment price is higher than cost.

equipment price attracts the customers. Thus firms will have an incentive to lower the price of equipment until it equals cost. Thus, building a reputation is worthwhile only if the short period of above-normal equipment profits exceeds (in present value) the loss of service profits while building the reputation.

Once competition between firms with low-service-price reputations sufficiently erodes profits, these firms will begin to exploit their reputations by suddenly reverting to a monopoly price for service. The switch does not raise firm profits in the long run, but it temporarily increases profits from the higher service price charged than buyers anticipated when they bought the equipment.

Clearly the speed of imitation by other firms is crucial. If other firms imitate the strategy of cost-based service pricing very quickly, profits from that strategy are zero. Then no firm will recoup the profits foregone to build the reputation for cost-based service pricing.

Thus, one plausible outcome is that firms will not attempt to build reputations, because the expected return does not reward the current loss in service profits. Alternatively there may be a series of cycles in which firms in the industry build reputations and then exploit their reputations by again raising service prices. Most important, however, there is a not a long-run equilibrium in which competitive, zero-profit firms all maintain a reputation for low service prices.

It is unlikely that a permanent reputation strategy would be optimal for a profit-maximizing firm for several other real-world considerations. For example, customers cannot easily observe service production costs. Thus they cannot easily distinguish between a firm that is deviating from cost-based service pricing and a firm experiencing an increase in costs. This uncertainty gives firms some room to raise their service prices without significantly harming their pricing reputation.

Perhaps the most serious drawback to the reputation theory is the infinite-horizon assumption. Business lives are short for many, perhaps most, firms in highly-complex equipment markets. Once a firm anticipates that it has a finite horizon, it becomes immediately profitable for that firm to revert to monopoly service pricing.[29] The firm increasingly obtains its revenue from service, rather than from new equipment sales. Accordingly, the firm's incentive to exploit its market power over its locked-in existing customers increases.[30]

Indeed, even ongoing firms may experience the finite-life-cycle constraint on the efficacy of reputation-building. The products at issue often have finite marketing lifetimes, even if

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[29]We show this for the finite-horizon, N-period game in Borenstein, MacKie-Mason and Netz (1992). We are assuming that in the finite-horizon game, customers again form forward-looking rational expectations about future prices since they can solve the firm's optimal pricing problem backwards in time, as we did above.

[30]This may be precisely the case with Prime, which during the course of its lawsuit has abandoned manufacturing and changed its name to sell only software.

the company continues. New product families replace old, often within just a few years. If the reputation effects do not carry over completely to the new product line there is another incentive to deviate from a low-service-pricing reputation.

For example, before 1980 IBM was viewed as a firm that sold large computers to large corporate customers through a direct sales force. After the introduction of the PC desktop computer, IBM very rapidly became a company with extensive sales to small end-users, often through distributed sales outlets. It is unlikely that IBM's prior reputation with its corporate mainframe customer would influence new customers without IBM experience, buying products radically different from the machines on which IBM built its reputation.

More recently, several defendant minicomputer companies have been either entirely replacing their existing product line, or completely dissolving. For example, Prime Computer liquidated (and reorganized its design software branch as Computervision) and Wang Laboratories has entered bankruptcy proceedings and stopped producing its own minicomputers. Data General has moved rapidly away from its proprietary MV line of minicomputers that are the subject of the suit by Grumman. It now focuses on entirely different open-architecture UNIX machines with the brand name Aviion.

4. Imperfect Competition in the Equipment Market

A central problem with the theories advanced by antitrust defendants in these cases is the following: If the equipment market is perfectly competitive, then where are the profits that the manufacturers are afraid of losing if they exploit their locked-in customers for service? The hallmark of a fiercely competitive equipment market is the absence of excess profits. Yet, without excess profits in the equipment market, firms will prefer to charge monopoly service prices to make at least some profits.

We have shown the futility of a reputation strategy in a free-entry, zero-profit market. We now examine markets in which there is some opportunity for above-normal profits without entry driving them to zero. Such profits might be a return on a new technological innovation that differentiates one firm's equipment from another's. We show that the presence of an imperfectly competitive equipment market does not induce competitive pricing of service at cost in the aftermarket. However, firms now have an incentive to maintain a low-service-price [31]reputation.

In this environment, it is feasible and rational for a firm to maintain a reputation for pricing service below the monopoly level, but it is still not profit-maximizing to price service at cost. The firm will instead trade off current profits from high service prices for locked-in customers against future equipment profits that are possible with low service prices. The firm thus sets a service price between the monopoly price and the competitive price.

The most extreme form of imperfect competition-monopoly-illustrates the intuition for the result. Consider a new monopolist selling equipment and service, with no locked-in

[31]This section is based in part on technical results derived in Borenstein, MacKie-Mason, and Netz (1992).

customers. She would maximize profits by pricing service at cost to maximize consumer benefits, while extracting those benefits through a high price for equipment. However, while pricing service at cost maximizes profits earned from all *new* generations of consumers, it is below the profit-maximizing price for already locked-in customers. Raising today's price of service slightly above cost raises profits earned from locked-in customers today, but lowers profits earned on all future generations of customers. For at least a small increase of price above cost, we can show that the increased profits from locked-in customers exceed the present value of decreased profits from future customer generations.[32] As the discount rate on future profits increases, so that future profits are less valuable today, the service price can profitably be raised further above cost. Pricing service at cost is profit maximizing only when the discount rate is zero (so that future profits are as valuable today as are current profits).

The opposite argument shows why the monopolist wouldn't set the price of service at the monopoly level. Monopoly prices maximize profits earned on the currently locked-in customers, but diminish profits earned on future generations of customers. Suppose the monopolist considers profits on both locked-in and future generations of customers, so that reputation has some value. Then we can show that for at least a small decrease in service price below the monopoly level (with an associated increase in the price of equipment), the profit gains from future customers are greater than the profit losses from currently locked-in customers. As the discount rate on future profits decreases, the price of service can be lowered further below the monopoly level and still improve the present value of profits. Only with an infinite discount rate is the present value of all profits maximized by setting the price of service at the monopoly level.

The reasoning that applies to a monopolist holds equally well for imperfectly competitive firms, whose entry does not drive profits to zero. Faced with the actions of competitors that produce imperfect substitutes for its own products, a firm still faces downward sloping demand for both equipment and service. It must still make pricing decisions in which it is trading off current profits from locked-in customers against future profits from new customers.

In fact, greater competition among existing firms-which would occur if the firms' products were better substitutes for one another-may not move service prices closer to cost. High service prices would cause the loss of more future business when there is a close substitute product. However, the profits from that future business are small to begin with due to the more intense competition. This is the same effect that discouraged reputation formation in the perfectly competitive market. In contrast, the presence of close substitutes in the

[32]In technical terms, the reason that this is true is that the loss in profits on new generations is second order when the price of service is raised slightly above cost and there is an associated profit-maximizing adjustment in equipment prices, but the gain in profits on locked-in customers is first order from this change.

equipment market does not reduce the profits from exploiting locked-in customers.[33] In our model of imperfect competition presented in Borenstein, MacKie-Mason, and Netz (1992), the degree of differentiation among equipment products does not affect the equilibrium markup on service. Each imperfect competition model relies on special assumptions, but clearly in general greater equipment market competition will not necessarily discipline prices in the service market.

5. Conclusion

The Kodak Co. recently sought summary judgement on antitrust charges of the sort discussed in this paper. Dismissal in summary judgement relies on theory rather than factual inquiry. According to the U.S. Supreme Court, Kodak argued that "even if it concedes monopoly *share* of the relevant [replacement] parts market, it cannot actually exercise the necessary market *power* for a Sherman Act violation. This is so, according to Kodak, because competition exists in the [original] equipment market" (*Kodak*, Supreme Court 90-1029 at 11; emphasis in original). The Court recognized that "In the end, of course, Kodak's arguments may prove to be correct. It may be that its parts, service and equipment are components of one unified market, or that the equipment market does discipline the aftermarket so that all three are priced competitively overall" (*Kodak*, S. Ct. 90-1029 at 33). The Court believed, however, that imperfect information and other market conditions might prevent equipment market competition from fully protecting service customers. Thus, the Court decided that the charges were worthy of a factual inquiry.

To our knowledge, there has not been previous economic research that supports either view. Our results, however, support the Supreme Court's conclusions in *Kodak* and go further. We find that equipment market competition does not prevent service market exploitation, even in theory. Our result holds even without imperfect information or other market barriers. The only exception we have found occurs when firms and customers sign fully-contingent, long-term contracts for service over the entire life of the equipment. Such contracts are not feasible, nor do we observe them in practice. Thus, it appears that theory compels us to presume that firms with a dominant position in a service aftermarket *can* profitably exploit their power despite competitive pressures from the equipment market.

References

Beggs, A. and P. Klemperer, (1992). "Multi-Period Competition with Switching Costs," *Econometrica 60*, 65--66.

[33]This is true so long as we maintain the assumption that no customer abandons her equipment "prematurely." To the extent that competition in the equipment market lowers the service price at which consumers will abandon their old machines, such equipment competition will have an indirect effect on profits from locked-in customers.

Borenstein, S., J. K. MacKie-Mason and J. S. Netz (1992). "Exercising Market Power in Proprietary Aftermarkets," Working paper, University of Michigan (Ann Arbor, MI).

Farrell, J. and C. Shapiro (1987). "Dynamic Competition with Switching Costs," *Rand Journal of Economics 19,* 123-37.

Klemperer, P. (1987). "The Competitiveness of Markets with Switching Costs," *Rand Journal of Economics 18,* 138-50.

M. H. Riordan and D. E. M. Sappington (1989). "Second Sourcing," *Rand Journal of Economics 20*, 41-58.

A. Shepard (1987). "Licensing to Enhance Demand for New Technologies," *Rand Journal of Economics 18,* 360-368.