Why Tie a Product Consumers Do Not Use?\textsuperscript{†}

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We provide an explanation for tying not based on any of the standard arguments: efficiency, price discrimination, or exclusion. In our analysis a monopolist ties a complementary good to its monopolized good, but consumers do not use the tied good. The tie is profitable because it shifts profits from a complementary good rival to the monopolist. We show such tying is socially inefficient, but arises only when the tie is socially efficient in the absence of the rival. We relate this form of tying to several examples, discuss how it can also arise under competition, and explore its antitrust implications. (\textit{JEL} D42, K21, L12, L25, L40)

Because of the attention paid to Microsoft’s behavior in the marketing of Windows and its various applications programs, significant theoretical attention has recently been directed at why a primary-good monopolist would tie a complementary good. Most of this recent literature, as well as earlier literature on the subject, is based on either efficiency, price discrimination, or exclusionary motivations for tying.\textsuperscript{1} This paper provides a new explanation for the monopoly tying of complementary products that we believe matches a number of real-world cases better than existing alternatives. In our explanation, tying alters the equilibrium to the subsequent pricing game and in this way enables the monopolist to capture some of the profits of a rival producer of the complementary good.

In our argument, tying does two things for the monopolist. First, it commits him to produce the complementary good, which by itself does not change monopoly profitability because in our model, pricing would adjust so that profitability is unchanged. Second, the tie provides consumers with a valuable option. The presence of that option reduces consumer willingness to pay for the rival’s complementary good and thereby affects pricing of the monopolized product, even when the consumer buys the rival’s good. More precisely, in a situation in which, in the absence of a

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† To comment on this article in the online discussion forum, or to view additional materials, visit the articles page at http://www.aeaweb.org/articles.php?doi=10.1257/mic.2.3.85.

\textsuperscript{1} See Carlton and Waldman (2005a) for a recent survey.

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rival tying would be efficient, a monopolist may tie because, in the presence of the rival, the tie transfers profits from the sale of the rival’s complementary good to the monopolist. Because the monopolist’s tied product is never used, this behavior is inefficient, though profitable, and the behavior does not exclude the rival, as in, for example, Michael D. Whinston (1990) and Carlton and Waldman (2002).

To fix ideas with a simple example, consider Microsoft’s tying of Windows Media Player (WMP) to Windows. First, suppose Microsoft is the monopolist of Windows, but that there is a better media player available (as might be arguably the case with QuickTime or RealPlayer). To put numbers to this, suppose that all consumers are identical and if they purchase Windows and WMP separately, and use them together, they derive a gross benefit of $15, whereas if they use Windows and a rival media player their gross benefit is $10 higher at $25. Second, suppose an individual who consumes Windows and WMP derives a higher gross benefit if the two goods are purchased as a tied product rather than purchased separately (either because tying improves functionality or because of savings on installation costs), with a tied Windows and WMP giving consumers a gross benefit of $20 instead of $15. Finally, suppose the marginal cost for supplying either type of media player is $2 (for simplicity, assume the cost of producing Windows is zero).

To examine the incentives for tying, consider what happens when there is no tying and the pricing game is such that the rival captures the full surplus it generates. In this situation, consumers pay $12 for the rival’s media player, $13 for Windows, and do not install WMP. In this outcome, the rival’s per consumer profit equals $12 − $2 = $10, while Microsoft’s per consumer profit equals $13 − $0 = $13.²

Now suppose that, at the time of Windows production, Microsoft can costlessly incorporate WMP, increasing consumers’ gross benefits to $20 if they use WMP. This tying, however, does not prevent a consumer who purchases this tied product from adding the rival’s media player and receiving, as before, a gross benefit of $25 because the individual would employ the superior of the two available players.³ With the tie, as there is a “free option” to use the bundled WMP, a consumer is willing to pay only $5 for the rival’s media player. Assuming the surplus associated with the rival’s media player is still fully captured by the rival, the price for the rival’s media player is $5 and the rival’s per consumer profit falls from $10 to $5 − $2 = $3, while Microsoft’s price for the tied good is $20 and its per consumer profit rises from $13 to $20 − $2 = $18. Note that the tying is socially inefficient since consumers do not use WMP, but it is profitable for Microsoft since it changes

² The surplus generated by the rival is $25 − $15 = $10 which is the rival’s profit in this outcome. Note that, consistent with the formal analysis in Section II, this pricing outcome, where the price of the rival’s complementary good equals marginal cost plus the incremental surplus associated with the rival’s product, is consistent with a Nash equilibrium in prices where the rival chooses prices first.

³ The example is simplified for tractability reasons in a number of ways. Obviously, if the complementary product comes in a base version for free, but upgrades are costly, then it is the revenue from the upgrades that is relevant. The fact that the base product is free does not mean that there are no profits from tying because of the associated revenues from the upgrades and other features. In fact, the base versions of QuickTime and RealPlayer are free, but there are associated revenues from advanced features.
the pricing game in a way that shifts profits from the sale of the rival’s media player to Microsoft.⁴,⁵

In this paper, we consider a model that captures and extends the logic of the previous example.⁶ In our model, there is a monopolist of a primary product and a complementary product that can be produced both by the monopolist and an alternative producer. Also, consumers have a valuation only for systems, where a system consists of one primary unit, and one or more complementary units (although from the standpoint of consumption, an individual uses only one complementary unit even if he owns more than one). At the beginning of the period, the monopolist chooses whether or not to tie, sell individual products, or sell both tied and individual products, where we assume ties are reversible. A reversible tie means that a consumer who purchases a tied product from the monopolist can add the alternative producer’s complementary product to his system, although he cannot return (say for a refund) the tied product. In effect, the consumer has both, but utilizes one. Although most of the literature focuses on irreversible ties, clearly, as in the case of Microsoft, assuming ties are reversible is quite realistic.

What is interesting about this model is that its starting point is on a claim that Microsoft relied upon in its various antitrust cases. That is, that there are efficiencies associated with consuming its products as ties rather than acquired separately.

“On the other side of the equation, are there plausible procompetitive explanations for these practices? Regarding its tying, Microsoft argued that its physical integration of Internet Explorer was no different in nature than its past integration of many other functionalities into Windows (and similar behavior by other software producers) which were done to make a better product,” (Whinston 2001, 74).

Our model embeds the increased functionality that might accompany a tied product, and shows how this is linked to a tying strategy that would have been both profitable for Microsoft, but also inefficient from a social perspective.

Our analysis does not fall into any of the existing theoretical categories for why a monopolist of a primary good would tie a complementary product. Most previous explanations for such tying are based on either efficiency, price discrimination, or exclusionary motivations. As captured by the example above, in our argument the monopolist sometimes ties a product that winds up not being used by consumers in equilibrium, in order to extract surplus from, but not exclude, a rival producer. Specifically, the tying improves the monopolist’s position in the pricing game that

⁴ Note that should there be costs associated with the initial tie, this would not necessarily remove Microsoft’s incentive to tie, and would increase the inefficiency associated with tying.
⁵ There are other strategies that one can conceive that eliminate the inefficiency, but are not (at least currently) feasible for transaction cost reasons. For example, one could imagine a strategy in which Microsoft sells Windows with the condition that if the consumer wishes to also use a rival’s media player, the consumer must pay Microsoft an additional $8. If it is difficult to monitor such consumer behavior, then this strategy is not feasible. We suspect that such strategies are likely to become possible in the future as monitoring technologies improve. However, even if this strategy is feasible, once one recognizes that there may be up front investment for the rival to produce the media player, then we are back to our original case where efficient contracting may be impossible.
⁶ Specifically, we extend the above logic by showing that for some parameterizations the monopolist sometimes ties when tying is socially inefficient, but in contrast to the above example the rival does not sell its complementary product. This outcome arises if, in the above example, we increase the marginal cost for supplying either type of media player from $2 to $6. The reason is that with this higher marginal cost a tie reduces consumer willingness to pay for the rival’s complementary good below the marginal cost of producing the good.
follows and, in this way, serves to shift profits from the rival to the monopolist. Indeed, in contrast to standard results that rely on the exclusion or exit of a rival, here it is the very profitability of the rival that drives strategic tying. Hence, a rival’s presence is required for our results. In addition, in contrast to many models of tying based on price discrimination or exclusion, where the tie hurts consumers, in our monopoly analysis inefficient tying neither hurts nor helps consumers. Rather, when the tie transfers profits from the rival to the monopolist, the tie is inefficient because the profit increase of the monopolist is less than the rival’s profit loss. We also analyze the case of competition and show the somewhat surprising result that consumers always benefit from this form of inefficient tying.

As discussed in more detail in the next section, one of the key points of our analysis is that one of the main results in Whinston (1990) is not robust to the introduction of potential efficiencies associated with tying. Whinston (1990) showed that, in the presence of a rival producer of a complementary good, there is no return for a monopolist in tying as long as its primary good is essential (i.e., required for all uses of the complementary good). But Whinston (1990) considered a setting in which, in the absence of a rival, the monopolist has no incentive to tie. We instead allow for tying to be efficient in the absence of the rival and show that, in combination with our assumption that ties are reversible, Whinston’s (1990) result no longer holds. That is, given a tie that is efficient in the absence of a rival, in the presence of a rival, a reversible tie can be used to increase profits even though the monopolist’s primary good is essential, where this type of tying is frequently inefficient because, for example, consumers do not use the tied good in equilibrium.

Another closely related paper is Joseph Farrell and Michael L. Katz (2000). That paper shows how vertical integration, and related practices, can be used in the type of setting we consider to increase profits via rent extraction. Farrell and Katz (2000) do not consider tying, but we show that if the tie is efficient in the absence of the rival then tying can also be used for rent extraction. In the following sections, we discuss the relationship between our paper and Farrell and Katz (2000) in more detail.

The outline for the paper is as follows. Section I discusses how our analysis is related to the previous literature on tying. Section II presents the main model, analyzes the model, and then discusses various extensions. Section III discusses the possibility of inefficient tying in the presence of competition, and the somewhat unusual antitrust implications of our analysis. Section IV presents concluding remarks.

I. Relationship to Previous Literature

In most of the previous papers in which tying is used to disadvantage rival producers, such as Whinston (1990), Jay Pil Choi and Christoudoulos Stefanadis (2001), Carlton and Waldman (2002), and Barry Nalebuff (2004), the tying results either in the exit of existing rivals or blocks the entry of potential rivals. For example, Whinston (1990) considers a model in which there is one market where

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7 Two exceptions are Jose Carbajo, David de Meza, and Daniel J. Seidmann (1990), and Yongmin Chen (1997). These papers are discussed at the end of this section.
complementary units are used in combination with primary units, while in a second market there is a demand for complementary units by themselves. Whinston (1990) shows that, if there are economies of scale in the production of the complementary good, then tying can be profitable because it causes rival complementary-good producers to exit, and thus allows the primary-good monopolist to monopolize the market in which there is a demand for complementary units by themselves.

In a second analysis, Whinston (1990) shows a rationale for tying in the case of independent products, and Nalebuff (2004) shows a similar result. In each model, there are two markets where there is a single incumbent producer that operates in both, and there is a potential entrant in one of the markets. By tying, the incumbent reduces the profitability of entry, which in some cases will stop entry from occurring and leaves the incumbent as a monopolist in both markets. The difference between the papers is the avenue by which tying reduces the profitability of entry. In Whinston’s (1990) analysis, tying makes the incumbent a more aggressive competitor in setting the bundle price than when he prices the products individually, so tying reduces entry profitability. In Nalebuff’s (2004) analysis, entrant profitability is lower when the incumbent ties because consumers who purchase the tied product do not purchase the entrant’s product, and this reduced market share is what lowers entrant profitability.

Carlton and Waldman (2002) consider a two-period setting in which there is an incumbent monopoly producer of primary and complementary goods, where a rival producer can enter the primary market only in the second period but the complementary market in either period. In their model the alternative producer’s return to entering the primary market in the second period is that this allows the firm to capture more of the surplus associated with its own superior complementary product. Carlton and Waldman (2002) show that, given either entry costs or complementary-good network externalities, the monopolist may tie in order to preserve its monopoly position in the primary market in the second period. The logic is that tying can stop entry into the complementary market by reducing its return and, in their model, the alternative producer does not enter the primary market if it does not plan to enter the complementary market.

The idea captured by the above cited papers, that tying is used to exclude competition, is certainly a plausible explanation for various important real-world cases. For example, Microsoft’s tying of Internet Explorer with the Windows operating system does seem to have eliminated Netscape Navigator as a serious competitor in the browser market and, to the extent that Navigator posed a threat to the Windows monopoly as argued by the Justice Department, also helped to preserve Microsoft’s monopoly in the operating systems market. However, there are other important cases where tying did not eliminate competition in the complementary-good market. For example, the tying of WMP with Windows does not seem to have eliminated all of the serious competition in media player applications programs. In fact, in relation to Windows, there are many similar ties. Instant messaging, movie and photo editing programs, and more recently, computer search and security programs are all provided with Windows, despite the existence of seemingly superior independent alternatives that continue to capture large market
shares.\textsuperscript{8,9} This leads us to the question, can tying be used to disadvantage a rival and improve monopoly profits even if there is no effect on the entry and exit decisions of rival producers?

The analysis of our model yields that there are a number of cases in which the monopolist improves its own profitability, and disadvantages a rival by tying, even though there is no effect on entry and exit decisions. Although this happens only when in the absence of an alternative producer, consumers prefer the monopolist’s tied product to purchasing the monopolist’s primary and complementary products separately.\textsuperscript{10} When consumers are indifferent between these two options, tying does not increase profitability. The logic for this result was first put forth in Whinston (1990). Whinston showed that tying cannot increase profits when the monopolist’s primary good is essential, i.e., as is the case in our analysis, the primary good is required for all uses of the complementary good.\textsuperscript{11} The monopolist can ensure itself profits at least as high as the profits associated with tying by selling the products separately, pricing the complementary good at marginal cost, and pricing the primary good at the optimal bundle price minus the complementary good price. Hence, tying in that case will typically not increase profitability.

But when, in the absence of an alternative producer, consumers prefer the monopolist’s tied good to purchasing the products individually, then there are a number of cases in which the monopolist ties with no effect on entry and exit decisions. The result of such cases, however, is increased monopoly profitability and lower alternative producer profitability and social welfare. The simplest of these cases, as in our example in the introduction, is when consumers are identical, product qualities are given exogenously, and all consumers prefer the alternative producer’s complementary good. In this setting there exists a range of parameterizations in which the monopolist ties, consumers then purchase the monopolist’s tied good and the alternative producer’s complementary good, and the tie decreases social welfare because of the cost the monopolist incurs in producing complementary units when the product is not used by consumers in equilibrium.

To understand why tying can be profitable, it is helpful to understand why Whinston’s (1990) argument, that shows no return to tying when the monopolist’s primary good is essential, does not apply.\textsuperscript{12} In Whinston’s (1990) argument, the monopolist can sell its products individually and price the goods in such a way that it

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\textsuperscript{8} Indeed, the ongoing tie of Internet Explorer has been met with competition from Mozilla’s Firefox and Google’s Chrome, both of which some claim are superior to Internet Explorer.

\textsuperscript{9} This applies to other Microsoft products too. For instance, this paper was written in Microsoft Word. It has a bundled equation editor but the equations here were written in MathType; a better, independently sold program.

\textsuperscript{10} If the model was restated in terms of the monopolist’s cost of producing the tied product relative to its cost of producing primary and complementary goods separately, the corresponding result is that the tie in our model can be profitable only when the monopolist’s cost of producing the tied product is strictly below its cost for producing the two goods separately.

\textsuperscript{11} This argument, in some sense, formalizes the earlier Chicago School argument that a monopolist would never tie a complementary good to its monopolized primary good because it can extract all of the potential profits through the pricing of the monopolized good. See, for example, Aaron Director and Edward H. Levi (1956), Ward S. Bowman (1957), Richard A. Posner (1976), and Robert H. Bork (1978). Also, see J. A. Ordover, A. O. Sykes, and R. D. Willig (1985) for a formal theoretical analysis related to Whinston’s (1990) analysis.

\textsuperscript{12} Carlton and Waldman (2005b) investigate a different setting in which a monopolist’s primary good is essential but Whinston’s (1990) argument does not apply. That argument focuses on durable goods and issues that arise in the presence of upgrades and switching costs.
ensures itself profits equal to tying profits. Hence, the monopolist cannot increase its profits by tying. But here, because of the extra utility consumers derive from the tied product when the alternative producer’s product is not purchased (when the alternative producer’s product is purchased and used there is no extra utility associated with the tie), the monopolist cannot ensure itself tying profits without, in fact, tying. The result is cases in which the monopolist ties even though, in equilibrium, consumers purchase and use the alternative producer’s complementary good so consumers receive no benefit from owning the monopolist’s complementary good. Clearly, in such a case, the tie lowers social welfare because of the direct production costs associated with the monopolist’s complementary good (similarly, in the case where the functionality of the tie is endogenous, any research and development (R&D) costs the monopolist incurs in improving this functionality is a social cost).

Our argument has some similarities to Nalebuff’s (2004) analysis of tying and independent products discussed above. In Nalebuff’s (2004) analysis, tying changes the post-entry game such that entrant profits are reduced and incumbent profits rise with the result that entry is deterred. In our analysis, tying is not used for entry deterrence, but, similar to what is true in the post-entry game in Nalebuff’s (2004) analysis, tying reduces rival profitability and increases monopoly profitability. But note that, since Nalebuff’s (2004) analysis concerns independent products, that analysis does not contradict Whinston’s (1990) result concerning no return to tying when the tying product is essential, while as discussed above one of our main results is that this result of Whinston (1990) is not robust to the introduction of reversible ties and tying efficiencies.

Two other related papers on tying are Carbajo, De Meza, and Seidmann (1990) and Chen (1997). Both papers are related to our paper in the sense that tying is used to increase profits by altering the outcome of the subsequent pricing game between the firms. But there are important differences. First, in our model the role of tying is to shift rents from the rival to the monopolist, while in these earlier papers the role of tying is the creation of product differentiation and thus increased profits in a market where the tying firm faces one or more rival producers. Second, both of these papers focus on the tying of independent products, while we focus on the monopoly tying of a complementary good where the monopolist’s primary good is essential. Similar to our point made above concerning Nalebuff’s (2004) analysis, this means these papers do not capture one of our central points, which is that Whinston’s (1990) result concerning no return to tying when the primary product is essential, is not fully robust.

Finally, Farrell and Katz (2000) examine a market structure similar to ours with a single monopoly provider of an essential primary good and one or more independent suppliers of a complementary good. They consider various strategies the monopolist might engage in, most notably, vertical integration, R&D, and exclusionary deals, in order to squeeze rival producers of the complementary good and appropriate greater

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13 This result depends on our assumption that ties are reversible, i.e., a consumer can add the alternative producer’s complementary product to a tied system consisting of the monopolist’s primary and complementary goods. Whinston (1990) assumes that ties are irreversible, and it is the case that with irreversible ties the type of setting we investigate would never lead to inefficient tying. That is, the monopolist might tie even though the primary good is essential, but this would occur only when tying is efficient.
profits. They do not consider the possibility of tying in their analysis, because in their setting, tying does not increase profitability under the standard, but not necessarily realistic, assumptions that tying is irreversible, and that there are no efficiencies associated with tying. Under our assumptions of reversible tying and tying efficiencies, tying can turn out to be more profitable than vertical integration, and this leads to our result that a firm might tie a product that in equilibrium is not used. We come back to how our paper is related to Farrell and Katz’s (2000) at the end of the next section.14

II. Model and Analysis

Here, we develop our monopoly model, analyze the model, and discuss extensions. In the next section, we discuss how similar results can be found under competition.

A. The Model

We consider a one-period setting characterized by a monopolist (M) and a single alternative producer (A). The monopolist is the sole producer of what is referred to as the primary good (P), while there is also a complementary good (C) that can be produced either by the monopolist or the alternative producer. M has a constant marginal cost, denoted \(c_p\) (> 0), for producing the primary good; while both M and A have a constant marginal cost \(c_c\) (> 0) for producing the complementary good. Further, there are no fixed costs of production for either good, and a unit of either type of good has a zero scrap value.

Primary and complementary goods are consumed together in what is referred to as systems, where a system consists of either M’s primary and complementary products, M’s primary good and A’s complementary good, or M’s primary good and both complementary products. In the last case, although the consumers own both complementary goods, they use and, thus, derive direct benefit from only one of the complementary products. Think of, for example, the primary good as a computer operating system and the complementary good as a media player applications program. The assumption that primary and complementary products are consumed only together means that the monopolist’s primary good is essential in this model, i.e., it is required for all uses of each of the complementary products.

At the beginning of the period, the monopolist decides whether to offer the products individually, sell a tied product consisting of its primary and complementary goods, or sell both tied and individual products, where there is an extra cost \(Z\) (> 0)

14 Related analyses include Patrick Bolton and Whinston (1993), M. Keith Chen and Nalebuff (2006), and Chun-Hui Miao (forthcoming). Like Farrell and Katz (2000), Bolton and Whinston (1993) consider a setting in which vertical integration decreases the profits of the nonintegrated firm, but the mechanism there involves supply assurance rather than a price squeeze. In Chen and Nalebuff’s (2006) analysis there is a monopolist of an essential primary good and a complementary good monopolized by a rival, where the complementary good is not essential for use of the primary good. They show various strategies the primary-good monopolist can employ to squeeze the rival, but tying does not increase profitability in their model. Miao (forthcoming) does consider the role tying might have in achieving the type of price squeeze discussed by Farrell and Katz (2000). However, the setup of that analysis is much different than ours and, in particular, Miao (forthcoming) does not capture why a firm would tie a product that is not used in equilibrium.
associated with selling both tied and individual products. As discussed in David S. Evans and Michael A. Salinger (2005, 2008), such costs can be due to additional production and packaging costs associated with increasing the variety of products produced or retail costs associated with stocking additional products in a store.

In contrast to most of the previous theoretical literature on tying used to disadvantage rival producers such as Whinston (1990), Choi and Stefanadis (2001), Carlton and Waldman (2002), and Nalebuff (2004), we assume that ties are reversible. That is, a consumer that purchases $M$’s tied product can add $A$’s complementary good to create a system consisting of $M$’s primary good and both complementary goods. Especially in terms of Microsoft, whose behavior is the motivation for much of the recent attention to tying behavior, the assumption of reversible ties is quite realistic.

There are $N$ identical consumers. We make several assumptions on the gross benefits derived by a consumer from various combinations of purchases. First, $M$’s primary good is essential for all uses of the complementary good and vice versa. Hence, each consumer’s gross benefit equals zero if they only consume one or the other of the primary and complementary goods. Second, if a consumer uses the primary and complementary goods, each bought separately from $M$, the consumer’s gross benefit is $V^M$, where we assume that $V^M > c_p + c_C$. Third, if $P$ and $C$ are purchased and consumed as a tied product from $M$, the consumer’s gross benefit equals $V^M + \Delta$, $\Delta \geq 0$. Note, $\Delta = 0$ means that consumers derive no direct added benefit from consuming a tied product, while $\Delta > 0$ means that a consumer with a system consisting of $M$’s primary and complementary goods derives a strictly positive added benefit from having purchased and consumed a tied product. For example, $\Delta$ could represent increased functionality made possible through the tie. Notice that this means that, given there are no additional costs beyond $c_p + c_C$ to producing a tied product, when $\Delta > 0$, tying would, in fact, be privately and socially desirable if no alternative complementary product existed.

What happens if the consumer purchases $A$’s complementary product? First, by consuming a system consisting of $M$’s primary good and $A$’s complementary good, then the consumer’s gross benefit equals $V^A$. We also assume that $V^A > V^M$, i.e., in the absence of tying, $A$’s product is superior. Second, if the individual consumes a system consisting of $M$’s primary good and both complementary goods (as may occur if $M$ sells only a tied product), then the complementary good that yields the highest gross benefit is used. For example, if a consumer adds $A$’s complementary good to $M$’s tied product, then the consumer’s gross benefit is given by $\max\{V^M + \Delta, V^A\}$. Note, in this specification, even when $\Delta > 0$, the tie is only valuable in terms of gross benefits when the consumer uses $M$’s complementary good.

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15 See William James Adams and Janet L. Yellen (1976) for an earlier analysis that allows the sale of both tied and individual products, although that analysis is in the setting of a pure monopoly seller.

16 To be precise, in these earlier papers it was either assumed that tying is irreversible or, as in Nalebuff (2004), equilibrium behavior is independent of whether ties are reversible or irreversible.

17 See Carlton and Jeffrey M. Perloff (2005) and Evans and Salinger (2005, 2008) for more extensive discussions of efficiency-based arguments for tying.

18 If the consumer adds $A$’s complementary good to a system consisting of primary and complementary units purchased separately from $M$, then the individual’s gross benefit is given by $\max\{V^M, V^A\} = V^A$. 
The timing of events is as follows. First, \( M \) decides whether to offer a tied product, individual products, or both tied and individual products. Second, \( A \) chooses a price for its complementary product. Third, \( M \) chooses prices. Fourth, consumers make their purchase decisions.\(^{19}\) Note that throughout the paper, we focus on sub-game perfect Nash equilibria.

Alternative assumptions concerning the timing of the pricing game would yield qualitatively similar results. For example, we could assume that there is a strictly positive probability \( A \) chooses prices first and a strictly positive probability \( M \) chooses prices first. We discuss this case in Section IIC.\(^{20}\) Similarly, we would find similar results by assuming that \( A \) and \( M \) choose prices simultaneously and the resulting multiple equilibria problem is resolved using the surplus sharing assumption found in Choi and Stefanadis (2001) and Carlton and Waldman (2002).\(^{21}\) In fact, any specification where at the pricing stage \( A \) receives some share of the surplus associated with its superior, complementary product would yield similar results. We have chosen to present the case where \( A \) chooses prices first with probability one because that case is a bit simpler; so the logic behind the main results is easier to follow.

B. Analysis

To begin, we characterize the socially optimal outcome. First, if \( V^M + \Delta > V^A \), then it is efficient for consumers to purchase and use \( M \)’s tied product. Second, if \( V^M + \Delta < V^A \), then it is efficient for consumers to purchase \( M \)’s primary good and purchase and use \( A \)’s complementary good (if \( V^M + \Delta = V^A \), then the two outcomes are equally efficient). In other words, from an efficiency standpoint, consumers purchase and use a tied product if the benefit of tying is sufficiently large, but when it is small, tying is not efficient and consumers purchase and use \( M \)’s primary good and \( A \)’s complementary good. Note that a key point here is that, from an efficiency standpoint, \( M \) should tie only when consumers actually use \( M \)’s complementary good.

We now turn to equilibrium behavior. We begin with a preliminary result concerning when tying is not profitable in this setting. Proposition 1 considers what happens in the case of identical consumers when \( \Delta = 0 \), i.e., tying does not increase the gross benefit a consumer receives from purchasing and using both of \( M \)’s products. Below, \( \pi_M \) denotes per consumer monopoly profitability, while \( \pi_M^* \) denotes per consumer monopoly profitability in the absence of a rival.

\(^{19}\) Throughout the paper we assume consumers purchase \( A \)’s complementary product when prices are such that they are indifferent between purchasing and not purchasing the product. We also assume \( A \) chooses to sell its complementary product whenever it is indifferent between selling it and not selling it. These assumptions are not essential, but serve to simplify the exposition and proofs.

\(^{20}\) The results are not found if \( M \) chooses prices first with probability one. In that case, \( M \) is able to capture all the potential surplus without tying. For example, in the example discussed at the outset of this paper, if \( M \) chooses prices first then it can capture all the surplus by not tying, setting the primary good price at $23, in which case \( A \) charges $2 for its complementary good. This equilibrium can also arise when prices are chosen simultaneously, see Carlton, Gans, and Waldman (2007) for a discussion.

\(^{21}\) This case is analyzed in Carlton, Gans, and Waldman (2007).
PROPOSITION 1: Suppose that \( \Delta = 0 \). Then there are multiple equilibria, where in any equilibrium the monopolist either sells a tied product only and \( \pi_M = \pi^*_M \), or the monopolist sells individual products only and \( \pi_M = \pi^*_M \).

The proof is in the Appendix. Proposition 1 tells us that, if \( \Delta = 0 \), tying does not increase \( M \)'s profits. That is, although there is a tying equilibrium, this is not because tying increases \( M \)'s profitability. Rather, in the tying equilibrium, \( M \) is indifferent between tying and not tying because it anticipates that, if it were to sell individual products, then its profitability would be the same as with tying. Note that this result is similar to Whinston’s (1990) finding that a monopolist of an essential primary good has no incentive to tie. Whinston (1990) implicitly assumes \( \Delta = 0 \), but his analysis is different than ours because he assumes irreversible ties while we assume ties are reversible. However, Proposition 1 shows that even given this difference, consistent with Whinston’s (1990) finding, when \( \Delta = 0 \) there is no incentive in our model for \( M \) to tie.

To get a sense of the logic here, consider parameterizations in which \( V^A - V^M > c_C \), i.e., the incremental value consumers place on \( A \)'s complementary good is larger than the marginal cost of producing that product. Suppose \( M \) chooses to sell a tied product only. Let \( P_c^A \) be \( A \)'s price for its complementary product, \( P_T^M \) be \( M \)'s price for its tied good, and \( \pi_A \) is \( A \)'s per consumer profitability. In that case, the equilibrium to the resulting subgame is \( P_c^A = V^A - V^M, \ P_T^M = V^M \), consumers purchase \( M \)'s tied product and \( A \)'s complementary product, and profits are \( \pi_A = V^A - V^M - c_C \) and \( \pi_M = V^M - c_P - c_C = \pi^*_M \).

Now suppose, instead, \( M \) chooses to sell only individual products, where \( P_P^M \) is now \( M \)'s price for its primary good, and \( P_C^M \) is \( M \)'s price for its complementary good. Then any pricing equilibrium satisfies \( P_c^A = c_C + V^A - V^M, \ P_P^M = V^M - c_C, \ P_C^M \geq c_C \), consumers purchase \( M \)'s primary product and \( A \)'s complementary product, and profits are \( \pi_A = V^A - V^M \) and \( \pi_M = V^M - c_P - c_C = \pi^*_M \). In other words, because \( A \) is the Stackelberg leader, and can push down \( M \)'s profits to the level achievable by \( M \) in the absence of the rival, \( M \) earns the same profitability whether or not it ties. Table 1 describes the equilibrium outcomes.

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\( ^{22}\) If \( \Delta = 0 \) and \( Z = 0 \), then there are also equilibria in which \( M \) offers both individual and tied products but it is still the case that \( \pi_M = \pi^*_M \).
We now consider what happens when $\Delta > 0$. Here we begin by taking, as fixed, $M$’s choice concerning whether to sell only a tied product, only individual products, or tied and individual products, and describe the equilibrium to the subgame that follows. When $M$ sells individual products only, the subgame equilibrium is the same as described above for the case $\Delta = 0$ since the positive $\Delta$ is immaterial if $M$ sells individual products only. That is, consumers purchase $M$’s primary good and $A$’s complementary good, while prices and profits are given in Table 1.

The case in which $M$ offers a tied product only, and $\Delta > 0$ is a bit more complicated. It hinges upon whether tying is reversed by consumers or not. The tie will not be reversed if $V_M + \Delta > V_A - c_c$, since the incremental value from $A$’s superior complementary product is less than its production cost. In this case, the monopolist sets $P_T^M = V_M + \Delta$, consumers purchase only the tied product, $\pi_M = V_M + \Delta - c_p - c_c$, and $\pi_A = 0$. However, if $V_M + \Delta \leq V_A - c_c$, the tie would be reversed since the incremental value associated with $A$’s product exceeds its production cost. In this case, consumers would purchase $A$’s complementary product and $M$’s tied product. Further, $M$ again chooses $P_T^M = V_M + \Delta$, $A$ sets $P_C^A = V_A - (V_M + \Delta)$, while $\pi_M = V_M + \Delta - c_p - c_c$ and $\pi_A = V_A - (V_M + \Delta) - c_c$. The prices and profits for each of these cases are listed in Table 2.

The last possibility is that $M$ offers both tied and individual products and $\Delta > 0$. There are again two cases. If $V_M + \Delta > V_A$, then it is efficient for $M$ to sell the tied product and this is the outcome. That is, $M$ sets $P_T^M = V_M + \Delta$, consumers purchase the tied product only, and $\pi_M = V_M + \Delta - c_p - c_c - (Z/N)$ and $\pi_A = 0$. The other possibility is $V_M + \Delta \leq V_A$. In this case the threat that $M$ can sell the tied product for $V_M + \Delta$ limits what $A$ can charge for its complementary good. Specifically, $A$ sets $P_C^A = V_A - (V_M + \Delta) + c_c$, $M$ chooses $P_T^M = V_M + \Delta - c_c$, $P_C^M \geq c_C - \Delta$, $P_T^M \geq V_M + \Delta$, consumers purchase $M$’s primary good and $A$’s complementary good, $\pi_M = V_M + \Delta - c_p - c_c - (Z/N)$, and $\pi_A = V_A - (V_M + \Delta)$. The prices and profits for each of these cases are listed in Table 3.

We can now use the analysis concerning what happens when $M$’s product choices are taken as fixed to derive equilibrium product choices and consumer purchase decisions when $\Delta > 0$. This is done in Proposition 2. The prices and profitabilities that relate to these are those in Tables 1, 2, and 3.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$V_M + \Delta &gt; V_A - c_c$</th>
<th>$V_M + \Delta \leq V_A - c_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_T^M$</td>
<td>$V_M + \Delta$</td>
<td>$V_M + \Delta$</td>
</tr>
<tr>
<td>$P_C^A$</td>
<td>$V_A - (V_M + \Delta)$</td>
<td>$V_A - (V_M + \Delta)$</td>
</tr>
<tr>
<td>$\pi_M$</td>
<td>$V_M + \Delta - c_p - c_c$</td>
<td>$V_M + \Delta - c_p - c_c$</td>
</tr>
<tr>
<td>$\pi_A$</td>
<td>0</td>
<td>$V_A - (V_M + \Delta) - c_c$</td>
</tr>
</tbody>
</table>

Table 2—Outcomes under Tying ($\Delta > 0$)
PROPOSITION 2: Suppose that $\Delta > 0$. Then, in equilibrium,

(i) if $V^M + \Delta \geq V^A$, M offers a tied product only and consumers purchase the tied product only;

(ii) if $V^M + \Delta + c_C > V^A > V^M + \Delta$, M offers a tied product only and consumers purchase the tied product only;

(iii) if $V^A \geq V^M + \Delta + c_C$, M offers a tied product only and consumers purchase M’s tied product and A’s complementary product.

For (i), consumers receive a higher gross benefit from M’s tied product than from consuming M’s primary product and A’s complementary product. It is straightforward to see that, in this case, tying is profitable for M. For (ii) and (iii) the proof (omitted) involves employing Tables 1, 2, and 3 to conduct a simple comparison of M’s profits under tying only versus its other options.23

Proposition 2 tells us that for many parameterizations the equilibrium is efficient, but there are others characterized by inefficiency. Beginning with the efficient outcomes, in (i), $\Delta$ is sufficiently large that consumers derive the highest gross benefit from purchasing and using M’s complementary product when it is part of a tied product. So, in this case, when M offers a tied product only the tying is efficient.

We now consider parameterizations with inefficient outcomes, or more precisely, inefficient tying. Let us start the discussion with (iii) of the proposition. These are the parameterizations consistent with the example at the outset of this paper. Here, $\Delta$ is sufficiently small that the first-best outcome is that M sells individual products, and consumers purchase its primary product, and purchase and use A’s complementary product. But, instead, what happens in equilibrium is that M offers a tied product only, and consumers purchase its tied product and use A’s complementary product. Since consumers use A’s complementary good, the tie

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23 If $Z = 0$, then (i) of Proposition 2 would be close to unchanged. But in (ii) and (iii), there would also be equilibria where M offers both tied and individual products, and consumers purchase M’s primary product and A’s complementary product. In these equilibria there is no deadweight loss, although adding an R&D decision as discussed in the following subsection would result in inefficiency even in these equilibria.
causes a deadweight loss to society equal to $M$’s cost of producing the complementary units for its tied systems. The reason that $M$ ties is that tying raises the value consumers place on its goods in the absence of an alternative producer, and lowers the surplus associated with $A$’s complementary product. Since $M$ captures all of the former and none of the latter, when $V^A \geq V^M + \Delta + c_C$ it increases its own profits but lowers social welfare by tying, though consumers are unaffected.

The other parameterizations characterized by inefficient tying is the set considered in (ii) of Proposition 2. Here, it is, again, the case that $\Delta$ is sufficiently small that the first-best outcome is that $M$ sells individual products and consumers purchase its primary product and $A$’s complementary product. But what happens here, in equilibrium, is that $M$ offers a tied product only, and consumers purchase its tied product only. Since production costs are the same across the first-best and equilibrium outcomes, the deadweight loss here is the reduced gross benefit received by consumers—because they consume the tied product rather than $M$’s primary good and $A$’s complementary good. The logic is, as before, that $M$ ties because it captures all of the value consumers place on its products in the absence of an alternative producer, and none of the surplus associated with $A$’s complementary product. The difference here is that after $M$ ties, this surplus is negative, so $A$ does not sell complementary units.

In summary, when $\Delta > 0$, there is a broad range of parameterizations characterized by inefficient tying. In some of these parameterizations, like in the example in the introduction, $M$ ties a product that consumers purchase but do not use. Consequently, the cost that $M$ incurs in producing the good represents a pure deadweight loss. In the other parameterizations characterized by inefficient tying, $M$’s complementary good is used in equilibrium. But because $V^A > V^M + \Delta$, societal surplus would be higher if $M$ had instead sold individual products and consumers had purchased $M$’s primary product and $A$’s complementary product. Note that, as indicated in the introduction, the inefficient tying in this model is not driven by any of the standard rationales in the literature for why a firm would tie—efficiency, price discrimination, or exclusion. Rather, the tying is used to change the pricing game so that some of the surplus associated with $A$’s superior complementary product is shifted from $A$ to $M$, with no effect on consumers.

C. Extensions

In this subsection, we briefly discuss various extensions of the model, where the main conclusion of the discussion is that the qualitative results of Section IIB are robust to numerous extensions of our model. One extension is to consider the impact of our timing assumption concerning pricing. We previously assumed that $A$ is the Stackelberg leader in the pricing stage, so $A$ is able to capture all of the surplus

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24 In our model, if the marginal cost associated with adding $M$’s complementary good to a tied product was zero, there would be no inefficiency. However, this is an artifact of some of our simplifying assumptions. For instance, below we discuss that $M$ has an incentive to engage in R&D that would create inefficiencies even when the marginal cost of the complementary good equals zero. Moreover, in an analysis related specifically to computer applications, Gans (2007) demonstrates a range of inefficiencies that can be generated by tying of the sort analyzed here.
associated with its superior complementary product. An alternative assumption is that at the pricing stage there is a probability $\rho$, that $A$ is the Stackelberg leader; and a probability $1 - \rho$, that $M$ is the Stackelberg leader; and when $M$ makes its tying decision, the firm knows $\rho$, and $1 - \rho$, but not the eventual realization of who will be the Stackelberg leader. Analysis of this setting yields parameter ranges with inefficient tying similar to those found in Section IIB, i.e., in one range $M$ ties and consumers purchase $M$’s tied product, yet still purchase $A$’s complementary product, while in another range consumers purchase $M$’s tied product only, but welfare is maximized when consumers purchase $M$’s primary good and $A$’s complementary good. What is new here is parameterizations with inefficient tying where $M$ offers both tied and individual products. For example, in one range of parameterizations, consumers purchase $M$’s primary good and $A$’s complementary good when $M$ turns out to be the Stackelberg leader—while $M$ inefficiently sells its tied product when $A$ turns out to be the Stackelberg leader.

A second extension is to allow the efficiency associated with tying, i.e., the size of $\Delta$, to be endogenous. For example, suppose $M$ can either invest 0 in R&D, in which case $\Delta = 0$, or invest $R$ ($> 0$), in which case $\Delta = \Delta^H > 0$ and $N\Delta^H > R$. Then, in equilibrium, $M$ always invests $R$, and the rest of the analysis is exactly the same as in Section IIB. One result that is new here is that the welfare costs of tying, when the tied good is purchased, but not consumed in equilibrium, are not just the marginal costs associated with producing complementary units that are not consumed, but in addition the R&D cost associated with increasing the value of $\Delta$ for these units.

One advantage of this extension is that it allows us to more clearly see the relationship between the arguments here and the arguments in Farrell and Katz (2000). In Farrell and Katz’s (2000) paper, a primary good monopolist has an incentive to vertically integrate into a complementary good market where there are rival producers. The monopolist then invests in R&D to improve its complementary product and create what Farrell and Katz (2000) call an “investment squeeze.” That is, even if the monopolist’s complementary product will not be the best one even if the R&D is successful, there can be an incentive for the monopolist to invest because it shifts rents in the ex post pricing game from a rival to the monopolist. The logic of our argument is similar except that in our model the monopolist employs tying, and further R&D that creates tying efficiencies, to improve its investment squeeze. As mentioned earlier, Farrell and Katz (2000) do not consider tying, probably because in their setting, tying is not profitable under the standard, but not necessarily realistic, assumptions that tying is irreversible and that there are no efficiencies associated with tying. But our analysis shows that, given reversible ties and tying efficiencies, tying can sometimes be used to improve what Farrell and Katz (2000) call an investment squeeze.25

A third extension concerns consumer heterogeneity. In our basic analysis, consumers are homogeneous. But it is easy to show that similar results can arise in settings characterized by consumer heterogeneity. To see this, suppose everything is the

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25 Another related analysis appears in Richard J. Gilbert and Michael H. Riordan (2007), who investigate the returns to technological tying when there is ex-ante investment in product improvement.
same as in our basic model, except now there is a second group of consumers who are indifferent between $M$’s complementary good and $A$’s complementary good. Analysis of this model yields various ranges of parameterizations characterized by inefficient tying. The main difference is that now whether or not tying is inefficient sometimes depends on the magnitude of $Z$. Remember that $Z$ is $M$’s extra cost of producing both tied and individual products. For example, consider parameterizations in which the first group of consumers receives a slightly higher gross benefit from consuming $M$’s primary good and $A$’s complementary good, rather than $M$’s tied good by itself. For these parameterizations, $M$ sells a tied product only, and both groups of consumers purchase $M$’s tied good only. If $Z$ is small, then this tying is inefficient because social welfare would rise if $M$ also sold individual products and the first group of consumers purchased $M$’s primary good and $A$’s complementary good. But if $Z$ is high, then the equilibrium outcome is efficient because of the costs associated with $M$ offering both tied and individual products.

Our final extension concerns entry costs and entry deterrence. Suppose that everything is the same as in our basic model except that, for $A$ to be able to produce, $A$ must pay an entry cost where this decision takes place, after $M$’s tying decision. If we restrict the analysis to parameterizations in which this entry cost is small, i.e., the entry cost is small enough that entry occurs if $M$ does not tie, then results are similar to what happens in our basic analysis. If $\Delta$ is sufficiently large, then $M$ ties and consumers purchase the tied product only. While for small values of $\Delta$, $M$ ties and consumers purchase $M$’s tied product and $A$’s complementary good. The only difference here is that, for parameterizations in which consumers purchase the tied product only, $A$ also decides not to enter.

Although this extension has tying that results in entry deterrence, it is useful to note that $M$’s motivation for tying in these parameterizations is not, in fact, entry deterrence. That is, in every parameterization that results in entry deterrence, eliminating the entry cost would affect neither $M$’s tying decision nor its profitability. In other words, $M$’s motivation for tying is that the tie transfers profits from the sale of $A$’s complementary good to $M$. Whether or not the tie also prevents entry is immaterial to $M$.26

### III. Effects of Competition and Antitrust Implications

In previous sections, we showed how a monopolist of a primary good may tie an inferior complementary good that consumers do not use, where the goal is increased profits through a more advantageous outcome in the pricing game between the monopolist and the complementary good’s alternative producer. Further, this behavior can lower social welfare by creating inefficiencies in various ways, such as the production of units that are purchased but not used in equilibrium, and the creation of distortions in the monopolist’s R&D decisions. In this section, we discuss how

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26 In this extension, it is also the case that entry deterrence does not harm consumers since, whether or not entry is deterred, in equilibrium all consumer surplus is extracted by $M$ and $A$, so entry deterrence has no effect on consumer welfare. It is possible that, in a variant of the model where not all surplus is extracted, tying that deters entry would harm consumers.
competition affects our results concerning tying and decreased social welfare. We then discuss the implications of our results for antitrust policy.

The first question we examine is how results change if we introduce competition. To analyze this, suppose there are two symmetric suppliers of the primary product and each can supply a complementary product that has value in its own system. Similarly, with each primary product there is an associated alternative complementary product provider who provides a complementary good of value to that specific system. That is, complementary goods are associated with one primary good, but not the other. Thus, there are four firms. Moreover, the products they supply are homogeneous in the eyes of consumers in the sense that, as before, \( V^M \) is the value of a system comprising a primary product and that primary good producer’s complementary good, \( V^A \) is the value of a mixed system, \( \Delta \) is the incremental value associated with a tie, and \( V^M \) and \( V^A \) are the same for each system. Costs are as before.

Suppose, first, that similar to our monopoly analysis the timing is that each primary product producer first chooses whether to offer tied, individual, or tied and individual products. Then the alternative producers choose prices, then the primary product producers choose prices, and finally consumers make their choices and payoffs are realized. Also, let us focus on the case where \( V^A \geq V^M + \Delta + c_C \); the set of parameterizations in our monopoly analysis where there was inefficient tying and consumers did not use the monopolist’s complementary good.

In this case, it is easy to show that all firms would have an incentive to price their products at marginal cost. Deviating from this would cause the “system” and themselves to lose all of their consumers and would not be worthwhile. In this situation, it would be worthwhile to tie a product only if consumers would not want to reverse the tie. Hence, there would be no opportunity for rent extraction through tying when \( V^A \geq V^M + \Delta + c_C \), and thus no inefficiency.

In order to better understand how competition is constraining behavior, let’s slightly change the timing in the model. Suppose that each primary good producer first sets its prices (for individual products and/or a tied product as the case may be). Then following this, consumers purchase primary products and, having observed this, each firm competes for sales of complementary products.

Each primary good producer would be forced under competition to set its prices so as to just break even. Thus, in the absence of a tie, \( P^M_P = c_p \), while \( P^M_C = c_C \) and \( P^A_C = c_C + (V^A - V^M) \). The prices for the complementary goods mirror those in the monopoly case. Notice that in the subgame perfect equilibrium of this game, each alternative producer of the complementary good has market power and earns rents, while primary good producers do not. Compared to the monopoly case, consumers benefit from the competition between the primary good producers, and therefore enjoy additional surplus. The alternative producers of the complementary good exploit the lock-in effect in their pricing.\(^{27}\) This exploitation would not occur if there was initially competition among producers of the complementary good in up-front payments to consumers, before consumers chose which primary product to

\(^{27}\) See Severin Borenstein, Jeffrey K. Mackie-Mason, and Janet S. Netz (1995) and Carl Shapiro (1995) for previous discussions and analyses of pricing in the presence of consumer lock-in.
purchase. Because we do not have that price flexibility in the model, the complementary good producers earn a rent. In the initial formulation of the model where alternative producers chose prices first, that type of competition occurs, in effect, and so consumers benefit and no producer earns rents.

Now suppose that a primary good producer offers a tied product only. The break-even price of the tied good is $P^M_T = c_P + c_C$. Critically, however, given this, the alternative provider is free to price up to the incremental value of the alternative system. That is, $P^A_C = V^A - (V^M + \Delta)$ so that it appropriates all of the surplus given the availability of the tied product. A primary producer will tie if, in doing so, it can make consumers better off. This will happen if the joint surplus between the primary producer and a consumer under tying, $V^M + \Delta - c_P - c_C$, exceeds the surplus when there is no tie, $V^M - c_P - c_C$, as is always the case with $\Delta > 0$. Thus, tying is possible even when primary producers have no market power. Note that this tying is inefficient since consumers purchase the tied product, and purchase and use the alternative producer’s complementary product, causing a deadweight loss. But it increases consumer welfare.

What is illuminating about this formulation is that it reveals that there can be an incentive for an inefficient tie, even under competition. The reason is that, by tying, a primary good producer can, as before, alter the pricing of the complementary product and transfer rents away from the complementary good producer. In the model without competition, the transfer went to the monopolist of the primary product. But with competition between primary good producers, the transfer goes to consumers. Competition guarantees, therefore, that the tie occurs to the benefit of consumers, even though we know the tie is inefficient since consumers never use the tied complementary product. One way to eliminate the inefficiency in this model is to allow primary and complementary good producers to merge, in which case we get back to the equilibrium in the specification in which the primary good producers choose prices first where there is no tie, no inefficiency, firms earn no rents, and consumers benefit.

What, if anything, do our results imply for antitrust policy? The social inefficiency that arises from tying, in the model with market power or in the competitive model above (where the market power resides with the complementary good producers), has nothing to do with harming the competitive process in the sense that the tie creates additional market power. Unlike other examples in the literature, rivals are not excluded nor do consumers pay a higher total price for the system. The tie is a clever strategic tool to transfer rents from the producer of the complementary good to either the monopolist when there is no competition, or to consumers when there is competition among primary good producers. Accordingly, we see little grounds to justify intervention on antitrust grounds, even though we are aware that there might be a social inefficiency. Some might advocate intervention on social engineering grounds to eliminate the inefficiency, but that course of action is fraught with the usual difficulties of figuring out when to intervene and interfering with the functioning of markets.

Although the results of our model do not provide a basis for aggressive antitrust intervention, there is an important antitrust policy prescription that emerges regarding mergers and contracting between rival producers. Consider, for example, merger policy. In our basic model, a firm sometimes ties an inferior
complementary product that consumers do not use in order to improve the outcome in the ex-post pricing game between the monopolist and the alternative producer. This lowers social welfare because of the production costs associated with the tied but unused complementary product (and, as discussed in Section IIC, welfare can also fall because of distortions concerning the monopolist’s R&D choices). Allowing a merger between the firms in this setting may raise welfare by avoiding these unnecessary and inefficient production costs. Similar considerations arise in evaluating contracts between the firms that allow the monopolist, for example, to tie the alternative producer’s superior complementary good to its monopolized good. The same insights hold true when there is competition between primary good producers. In such a case, allowing mergers or contracts between primary good producers and the supplier of the superior complementary good may be welfare enhancing with the consumers reaping the benefit.

IV. Conclusion

Most previous analyses of tying have focused on efficiency, price discrimination, or exclusionary rationales for the practice in the context of irreversible ties. In this paper, we focus on the empirically important case of reversible ties, and develop a new rationale for the practice in which a monopolist ties a complementary good in order to alter the outcome of the subsequent pricing game between itself and the rival producer of the complementary good. Interestingly, we find that this motivation for tying arises only when tying by the monopolist is efficient in the absence of the rival producer. But, in the presence of the rival, this type of tying is frequently inefficient because, for example, consumers do not use the monopolist’s complementary good even after they have purchased the monopolist’s tied product. Clearly, in such a case, the monopolist’s expenditures on developing and producing the complementary good represent a deadweight loss to society.

We believe this new explanation for tying has wide applicability. There are many instances in which a firm ties a complementary good when rivals sell superior complementary products with the result that few consumers use the monopolist’s tied good. For example, we believe this is a good description of Microsoft’s behavior in its tying of various complementary products such as instant messaging, movie and photo editing, and security programs. Note that, although our analysis indicates that tying in many of these instances may be socially inefficient, we explain why our results do not provide a basis for antitrust intervention. Indeed, the implication of our results is that antitrust policy should, under some circumstances, look kindly on certain types of vertical contracting and mergers because they may improve total and consumer welfare.

APPENDIX

PROOF OF PROPOSITION 1:

Suppose first that $M$ sells a tied product only. Given this, suppose $V^A - V^M \geq c_C$. Then $A$ sets $P^A_C = V^A - V^M$, $M$ responds by choosing $P^M_T = V^M$, and consumers

28 Subject, of course, to potential strategic issues that may arise if $A$ could itself engage in R&D expenditures.
purchase $M$’s tied product and $A$’s complementary product (see footnote 19). The reason is that if $A$ sets $P^A_C$ at a higher value, it sells nothing, and $\pi_A = 0$. The result is that $\pi_M = V^M - c_P - c_C$. Suppose $V^A - V^M < c_C$. Then $A$ cannot profitably sell complementary units and $M$ responds by choosing $P^M_T = V^M$, consumers purchase $M$’s tied product only, and we again have $\pi_M = V^M - c_P - c_C$.

Suppose $M$ sells individual products only. Then $A$ sets $P^A_C = V^A - V^M + c_C$, $M$ responds by choosing $P^M_P = V^M - c_C$, and consumers purchase $M$’s primary product and $A$’s complementary product (see footnote 19). The reason is again that if $A$ sets $P^A_C$ at a higher value it sells nothing and $\pi_A = 0$. The result is that $\pi_M = V^M - c_P - c_C$.

Suppose $M$ sells both tied and individual products. Then $A$ sets $P^A_C = V^A - V^M - c_C$, $M$ responds by choosing $P^M_P = V^M - c_C$, and consumers purchase $M$’s primary product and $A$’s complementary product (see footnote 19). The result is $\pi_M = V^M - c_P - c_C - (Z/N)$.

Comparing the values for $\pi_M$ across $M$’s three possible choices concerning which products to produce yields that $M$ either sells a tied product and $\pi_M = \pi^* M$ or sells individual products and $\pi_M = \pi^* M$.

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