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THE LIMITS OF INDIRECT APPROPRIABILITY IN MARKETS FOR COPIABLE GOODS

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Abstract. An extensive literature has developed that argues that in many settings the social welfare costs of copying or piracy are limited because of the presence of indirect appropriability. Indirect appropriability is the idea that original good producers can appropriate some of the value derived by the consumers of copies because of the return that buyers of original units receive from allowing copies to be made. In this paper we discuss the limitations of indirect appropriability, where the two we focus on are the "flooding" of the copy market and substitutability between new units and copies. We also discuss the ramifications of our analysis for real world markets.

1. Introduction

A crucial issue for understanding the role of copyright protection is understanding the implications of copying or piracy for the profitability of the producers of original works. The traditional argument, that appears, for example, in Arrow (1962) and Hirshleifer and Riley (1979), is that copying deprives producers of original works substantial profits since potential buyers of what we will refer to as new units shift from the new unit market to copying. In turn, because of this decreased revenue or profit flowing to the producers of new works, there is a subsequent decrease in the variety and qualities of original works produced. In the literature this is referred to as the underproduction loss.[1]

Starting with the work of Liebowitz (1985), this basic argument has been challenged on the grounds that the possibility of indirect appropriability changes the implications of copying. Indirect appropriability refers to the idea that buyers of new units receive a return from allowing copies of their new units to be made. In turn, this raises new unit buyers' willingness-to-pay, which subsequently translates into an avenue through which the producers of new works can capture some of the value that consumers of copies place on their copies. In markets where this perspective is correct and important, copying has much different implications for the operation of the market. At a minimum it should decrease the underproduction loss, and at a maximum it could actually increase rather than decrease the variety and qualities of new works produced.

In this paper we discuss the limitations of the indirect appropriability argument. The way we approach the problem is by drawing an analogy between the argument of indirect appropriability and the related argument of Swan (1980) concerning whether or not a durable goods monopolist would want to eliminate the secondhand

[1]The traditional argument is that such markets are also characterized by an underutilization loss, i.e., because original good producers price new units above marginal cost, some individuals for whom it would be efficient to consume new units do not do so.

market for used units. Swan's argument is that, because the price of a new durable unit reflects the prices at which the unit will be traded on the secondhand market in future periods, a durable goods monopolist has an incentive to allow the secondhand market to operate in an unconstrained fashion. This is analogous to Liebowitz's original argument for copying. In each case, because the willingness-to-pay of new unit purchasers reflects the value of future users of the good or future users of copies of the good, the new unit producer has an incentive not to constrain or interfere with what new unit purchasers do with the good after the purchase.

Given this perspective, there are two limitations on the indirect appropriability argument. The first, which is related to the modeling approach taken in Novos and Waldman (1984), is that competition between new unit buyers who offer their goods for copy drives the price these individuals receive for these copies down toward the marginal cost of taking the action (which in many cases is likely close to zero). To see the basic logic, we start with Swan's argument concerning durable goods. Swan's argument depends on the secondhand market for used goods not being "flooded" with used units. That is, if the number of used units on the secondhand market becomes large relative to the number of potential used unit buyers, then the used unit price falls and does not reflect the average value for used units of the buyers of the units. If this were to occur, then a durable-goods monopolist may want to eliminate the secondhand market and sell new units to these buyers directly because their purchases of used units is having little effect on the willingness-to-pay of current new unit buyers.

Although a theoretical possibility, there is no reason to think that the situation described above for durable goods markets is common. Now think about copies as opposed to used units and the indirect appropriability argument. The same argument as above applies. If copies "flood" the market, then the price of new units will not reflect the value consumers of copies place on the copies and the original works producer would be better off eliminating the ability to copy. The difference is that this possibility is much more likely here than in the durable goods case. That is, if as is frequently true each new unit buyer can make multiple copies of his or her new unit, then the flooding of the market for copies is a very realistic possibility.

The second limitation is that, because of the potential substitutability between new units and copies, the availability of copies limits the price that the original durable goods producer receives for new units. To see the logic here, we start again with Swan's argument concerning durable goods. Waldman (1996,1997) and Hendel and Lizzeri (1999) show that this argument is not robust to settings in which quality deteriorates with age and in which individuals consume either zero or one physical unit per period, i.e., used units cannot be combined to form a perfect substitute for a new unit. In such a setting the availability of used units limits the price the durable goods monopolist can charge for new units. In turn, if used unit buyers have a very low valuation for the used units, then this constraint on the new unit price is quite limiting and the monopolist maximizes its profits by eliminating the secondhand market.[2]

[2]In this analysis, as in Waldman (1996,1997), we use the term eliminate the secondhand market to refer to an action that makes used units unavailable for consumption as opposed to one that prohibits trade but does not stop used units from being consumed.

The same logic can be applied to the issue of copying. Suppose that copies are of lower quality than new units and that, in order to focus on this issue, only one copy can be made from each new unit and a copy cannot be used to make another copy. Then the price at which copies are sold serves to limit the price the original works producer receives for new units. Further, if consumers of copies have a sufficiently low valuation for product quality, then the constraint on the price of new units is sufficiently limiting that the original works producer increases its profits by stopping copies from being made. In other words, the possibility of indirect appropriability again fails to make producers better off from consumers having the ability of making copies.

Overall, the analysis of this paper suggests that indirect appropriability may be important for understanding the role of copying for some real world cases such as how the ability to copy impacts libraries, but for many other cases indirect appropriability is an unimportant factor. That is, as we discussed briefly above and in more detail in the following sections, there are multiple reasons for why copying in many real world cases decreases rather than increases revenue and profitability of original works producers. Hence, as argued in the standard view, the likely outcome of copying in many real world markets is decreased variety and quality of original works.

The outline for the paper is as follows. Section 2 discusses the indirect appropriability argument. It starts by discussing the idea of indirect appropriability in durable goods markets, and then discusses the literature that applies the argument to markets in which copying by consumers is feasible. Section 3 analyzes and discusses the first limitation which is based on the possible "flooding" of the market for copies, while Section 4 analyzes and discusses the second limitation which is based on substitutability between new units and copies. Section 5 uses the analysis of Sections 3 and 4 to discuss the circumstances in which indirect appropriability in the market for copies is likely to help producer profitability. Section 6 presents some concluding remarks.

2. Indirect appropriability

The basic argument of indirect appropriability put forth initially in Liebowitz (1985) builds on the earlier argument of Swan (1980) concerning secondhand markets. In this section we start by discussing Swan's contribution and then provide a brief history of the idea of indirect appropriability as applied to copying.

2.1. **Swan's Perspective on Secondhand Markets.**

Classic issues in the literature on durable goods are the effect that secondhand markets have on the revenue and profitability of the durable goods producer and the related issue of whether the producer has an incentive to eliminate or otherwise interfere in the operation of secondhand markets.[3] Casual empiricism concerning, for example, behavior in the textbook market suggests that the operation of secondhand markets can hurt authors and publishers, and one of the goals of the introduction of new editions is to kill off the the secondhand market.

For a number of years thinking on this subject was dominated by the work of Peter Swan. His position is stated most clearly in the following quote. "The pure monopolist selling such a durable item as an automobile is paid an amount which

[3]See Waldman (2003) for a general discussion of the durable goods literature.

reflects the net present value of the stream of automobile services to possibly a whole host of future owners. Competitive secondhand auto dealers (or scrap merchants and recyclers in the case of aluminum) can then buy and sell the item idefinitely without in any way restricting the power of the monopolist as the original seller." (Swan, 1980, p. 77) In other words, the buyers of new units realize they will be able to sell those units on the secondhand market in subsequent periods. This realization raises the willingness-to-pay of new unit buyers and so the existence and operation of such secondhand markets cannot hurt producer revenue and profitability.

In a later paper, Rust (1986) formally derives results similar to Swan's discussion. Rust considers a durable goods monopoly model in which each individual consumes either zero or one physical unit of the monopolist's product in every period and the quality of a unit deteriorates as it ages. In Rust's analysis monopoly profitability does not increase if the secondhand market is eliminated and, in fact, monopoly profitability is unchanged by such elimination. But Rust assumes that all consumers are identical and given this assumption his results are not at all surprising. In a setting in which all consumers are identical there is no reason for a unit to trade hands as it ages. So Rust's analysis tells us little about the effects of killing off a secondhand market in a setting in which the secondhand market serves an important allocation role.

2.2. **The Indirect Appropriability Argument in Markets for Copiable Goods.** The argument of indirect appropriability and copying is closely related to Swan's argument concerning secondhand markets. The argument was initially put forth by Stan Liebowitz in a 1985 article in the Journal of Political Economy. Liebowitz argued that the revenue or profits received by sellers of copies positively affects the willingness-to-pay of these individuals for acquiring new units. In turn, since this positively affects the price that the original works producer can charge for new units, we have that, although the original works producer is not able to directly charge consumers of copies, there is indirect appropriability through the higher willingness-to-pay of new unit consumers. In conclusion, Liebowitz argues that copying can actually help original work producers as opposed to the standard argument in which copying must hurt such producers.[4]

After presenting the basic argument, Liebowitz extends the argument to consider the implications when there are two types of consumers of new units such as in the case of journal publishing: i) individuals who rarely have their units copied; and ii) libraries for whom copying is common. Since it is only libraries for whom copying is important, Liebowitz argues that the indirect appropriability argument only applies to the demand for new units by libraries. After extending the argument in this way, Liebowitz develops a number of predictions concerning how libraries should operate and the journal publishing industry more generally. These include that: i) there should be larger price differences between prices charged to libraries and individual subscribers for more heavily copied journals; ii) the introduction of photocopying should have caused a larger price increase for libraries than individual subscribers; and iii) the introduction of photocopying should have caused libraries to move away from purchasing books which are rarely copied towards purchasing journals which are frequently copied. He presents evidence that supports all three predictions.

[4]Although Liebowitz does not directly refer to Swan's work, he does draw an analogy with the way in which durable goods markets operate.

Besen and Kirby (1989) formally consider the issue of indirect appropriability in markets for copiable goods (Liebowitz's paper discusses the idea but does not contain any formal analysis). The first analysis in Besen and Kirby's paper shows a set of circumstances in which indirect appropriability is not operative. In this analysis new units and copies are imperfect substitutes and each new unit can be used to produce an unlimited number of copies. As found earlier in the analysis of Novos and Waldman (1984), they show that the competition between new unit purchasers on the copy market drives the price for copies down to marginal cost and thus indirect appropriability does not hold. Our analysis in Section 3 is closely related, where one difference is that we show that the assumption that a single unit can be used to make unlimited copies is not crucial.

Besen and Kirby then consider a second model in which marginal costs are increasing and consumers can form clubs which purchase a single unit and then copies are produced for all club members other than the original purchaser. They first show that, if new units and copies are perfect substitutes, club size is at the value that minimizes the average cost of acquiring a unit (where a unit in this specification is defined as either a new unit or a copy). On the other hand, if copies are lower quality, equilibrium club size is more complicated because smaller sized clubs increase the number of individuals who consume the higher quality units. In each case Besen and Kirby find that copying can either help or hurt profitability, where profitability tends to rise when copies can be made significantly more cheaply than originals.

Bakos, Brynjolfsson, and Lichtman (1999) extend Besen and Kirby's second analysis concerning sharing in teams. They consider a model in which the original work producer has a zero marginal cost of production and copies can also be made at zero cost given a new unit. This assumption of zero marginal costs seems reasonable for numerous information goods that take digital form and that can be copied at very low cost. The other key assumption is that groups are determined exogenously rather than endogenously – think of a group as a family or a circle of friends. Given this basic set-up, they consider three specifications: (i) new units and copies are perfect substitutes, groups are of equal size, and valuations across team members are uncorrelated; (ii) everything is as in the first specification except either team size varies or valuations are correlated; and (iii) the same basic set-up but copies are lower quality than new units.

By focusing on settings in which there is no cost difference between producing another new unit by the original work producer and another copy by consumers, Bakos, Brynjolfsson, and Lichtman move away from Besen and Kirby's focus of minimizing the cost of providing consumers with the good. Rather, their focus is on how teams affect the nature of demand and, in particular, that the effect of copying and teams on demand can, but does not in all cases, improve monopoly profitability. The basic argument here is similar to one of the basic arguments in the literature on bundling. That is, having teams will frequently decrease heterogeneity in demand and decreased heterogeneity can result in higher producer profits.[5] They find that, given new units and copies are perfect substitutes, higher producer profits is always the case in their analysis of equal sized teams. When teams vary in size,

[5]See Stigler (1963), Adams and Yellen (1976), and Schmalensee (1984) for analyses of bundling that focus on this point. See Johnson and Myatt (2004) for a general analysis of the impact of consumer heterogeneity on a seller's profit.

profits tend to rise when variation in team size is small relative to variation in individual valuations. Finally, in their analysis in which copies are inferior to new units, they find that the monopolist can sometimes increase profitability by further decreasing the quality of copies (this result is related to the analysis that appears in Section 4).

So the literature concerning indirect appropriability in markets for copiable goods makes two related arguments. On the one hand, as initially put forth by Liebowitz, one reason that the ability of consumers to make copies may help producer profitability is through a logic analogous to that put forth by Swan for the case of secondhand markets. That is, producer profitability may rise because the new unit price reflects the price that copies will sell for in the future. On the other hand, as initially put forth by Besen and Kirby and later extended by Bakos, Brynjolfsson, and Lichtman, profitability can be positively related to the ability to copy in settings in which teams of consumers share new units and copies amongst themselves.

3. Limitation 1: "flooding" in the market for copies

In this section we discuss the first major limitation of the indirect appropriability argument. The first limitation is that, as discussed in Liebowitz (1981) and Besen and Kirby (1989) and as underlies the analysis in Novos and Waldman (1984), there is "flooding" in the market for copies. That is, so many copies become available that, rather than the price for copies reflecting the value that consumers of copies place on copies, this price is driven down to the marginal cost for copies. We begin by showing the similar point in the operation of secondhand markets and then show the argument in the case of copying.

3.1. **Flooding in Secondhand Markets.**

We consider a simple durable goods monopoly setting which is purposely constructed to clearly illustrate the argument. In this setting there are two groups of consumers who live for two periods and the monopolist's product deteriorates with age. Group 1 consists of n_1 identical consumers who derive a gross benefit of v_1 from consuming a new unit in a period and a value of zero from consuming a used unit in a period. Group 2 consists of n_2 identical consumers who derive a gross benefit of v_2 from consuming either a new unit or a used unit in a period. Further, the monopolist has a constant marginal cost of production equal to c, where $v_1 > c > 2v_2$, there is no discounting, and the scrap value of a used unit equals zero. In this set-up group 1 consumers are the potential buyers of new units while group 2 consumers, because $2v_2 < c$, will never purchase new units but are rather the potential buyers on the secondhand market.[6]

There are two cases. Suppose first that $n_1 < n_2$, i.e., there are more potential secondhand market buyers than new unit buyers. What happens in this case is that in period 1 group 1 individuals buy new units from the monopolist at a price P_1, while in period 2 group 1 individuals sell used units to group 2 consumers at a price v_2 and then purchase new units from the monopolist at a price P_2. Because there are no later periods and thus no future secondhand market sales for new units purchased in period 2, the monopolist sets P_2 equal to v_1. In contrast, because new units sold in the first period are sold at a price of v_2 in the second period on the

[6]Because group 2 consumers never purchase new units, the time inconsistency problem explored, for example, by Coase (1972) and Bulow (1982) does not come into play in our analysis.

secondhand market, the monopolist sets P_1 equal to $v_1 + v_2$. Monopoly profits are therefore equal to $n_1 (2v_1 + v_2 - 2c)$.

This case illustrates Swan's argument concerning the effects of secondhand markets on the profitability of durable goods sellers. Because $n_1 < n_2$, i.e., there are more secondhand market buyers than sellers, the price that used units trade for on the secondhand market in the second period reflects the value that the secondhand market buyers place on the used units. In turn, the anticipation of this by group 1 buyers in the first period increases the group 1 individuals' willingness-to-pay for new units in the first period, so the presence of this secondhand market trade increases firm profits. In other words, the firm earns $n_1 (2v_1 + v_2 - 2c)$ rather than $n_1 (2v_1 - 2c)$ which is what the firm would earn if either the secondhand market was not allowed to operate or the monopolist produced nondurable rather than durable units.

Now suppose that $n_1 > n_2$, i.e., there are more new unit buyers than potential secondhand market buyers. What happens in this case is that in period 1 group 1 individuals buy new units from the monopolist at a price P_1, while in period 2 n_2 group 1 individuals sell used units to group 2 consumers at a price of zero, the remaining used units are scrapped, and all group 1 consumers purchase new units from the monopolist at a price P_2. As before, because there are no later periods and thus no future secondhand market sales for new units purchased in period 2, the monopolist sets P_2 equal to v_1. However, differently than before, because new units sold in the first period are either sold at a price of zero in the second period or scrapped, the monopolist sets P_1 equal to v_1. Monopoly profits in this case are equal to $n_1 (2v_1 - 2c)$.

This case shows that Swan's logic breaks down when used units "flood" the secondhand market. By flooding the secondhand market we mean that there are more used units available for purchase on the secondhand market than potential used unit buyers, so the secondhand market price falls to the scrap value which in this setting equals zero. In other words, rather than the secondhand market price equaling the benefit from consumption of used unit buyers as in Swan's argument, the secondhand market price falls to the scrap value. In turn, what this means is that the presence of the secondhand market has no effect on the willingness-to-pay of new unit buyers in the first period and so, in contrast to Swan's argument, the presence of the secondhand market has no effect on the profitability of the durable goods monopolist.

In the setting we just considered, when the secondhand market is flooded, monopoly profits are not hurt by the existence of the secondhand market. That is, as indicated profits in this case are equal to $n_1 (2v_1 - 2c)$ while, if the secondhand market were eliminated or the monopolist were able to make the units nondurable, profits would again by given by $n_1 (2v_1 - 2c)$. But it would not be hard to change the analysis slightly so that when flooding occurs the monopolist is, in fact, hurt by the secondhand market. For example, suppose we introduced a group 3 set of individuals who enter the market in period 2, where this group consists of n_3 identical individuals who derive a gross benefit of v_3, where $v_3 = v_1$, from consuming either a new unit or a used unit in a period. Further, suppose that similar to the second case $n_1 > n_2 + n_3$.

Analysis of this setting yields that, if the secondhand market is allowed to operate, then the outcome is similar to what happened when there was no group 3

and $n_1 > n_2$. That is, in period 1 group 1 individuals buy new units from the monopolist at a price v_1, while in period 2 $n_2 + n_3$ group 1 individuals sell used units to group 2 and group 3 consumers at a price of zero, the remaining used units are scrapped, and all group 1 consumers purchase new units from the monopolist at a price of v_1. In turn, monopoly profits are the same as when there was no group 3 and $n_2 > n_1$, i.e., profits are equal to $n_1 (2v_1 - 2c)$.

But there is something different about this case. Specifically, now monopoly profits are, in fact, higher if the monopolist has the option of either stopping the secondhand market from operating or similarly producing nondurable units. To see this, suppose the monopolist could stop the secondhand market from operating and decided to do so. Then in period 1 group 1 individuals would buy new units from the monopolist at a price v_1, while in period 2 all used units would be scrapped and all group 1 and group 3 consumers would purchase new units from the monopolist at a price v_1 (remember $v_3 = v_1$). Monopoly profits in this case are equal to $n_1 (2v_1 - 2c) + n_3 (v_1 - c)$, i.e., as indicated monopoly profits here are higher than if the secondhand market were allowed to operate.

In summary, we have considered a simple two-period durable-goods monopoly setting that illustrates that Swan's logic is correct some of the time but not all of the time. When there are more potential used unit buyers than new unit buyers, then the secondhand market price reflects the value that the used unit buyers place on the used units. The result is that, consistent with Swan's argument, new unit buyers in anticipation of the future high price on the secondhand market are willing to pay more for new units with the result that the presence of the secondhand market improves monopoly profitability. In contrast, when there are more new unit buyers than potential used unit buyers, then the secondhand market price falls to the scrap value which in our analysis was zero. In this case, in contrast to Swan's argument, the presence of the secondhand market does not increase the willingness-to-pay of new unit buyers, and so does not improve monopoly profitability. In fact, we showed through the introduction of a third group of consumers that, when the secondhand market price is equal to the scrap value of the good, the presence of the secondhand market can actually hurt monopoly profitability.

3.2. **Flooding in the Market for Copies.** In this subsection we show that the argument of the previous subsection concerning secondhand markets also limits the applicability of the indirect appropriability argument concerning the effects of copying. Consider a one period setting with two groups of consumers and assume that the monopolist's product deteriorates when it is copied. Group 1 consists of n_1 identical consumers who derive a gross benefit of v_1 from consuming a new unit and a value of zero from consuming a copy. Group 2 consists of n_2 identical consumers who derive a gross benefit of v_2 from consuming either a used unit or a copy. Further, the monopolist has a constant marginal cost of production equal to c, where $v_1 > c > v_2$, and $x > 0$ copies can be made from a new unit at costant marginal cost d, where $v_2 > d$.[7] In this set-up group 1 consumers are the potential buyers of new units while group 2 consumers, because $d < v_2 < c$, will never purchase new units but are rather the potential consumers of copies.

As in the secondhand market analysis above, there are two cases. Suppose first that $xn_1 < n_2$, i.e., even if all group 1 consumers purchase new units, there are still

[7]To keep the argument straightforward, we assume a copy cannot be used to produce another copy.

more potential buyers of copies than there are potential copies. What happens is that group 1 individuals buy new units from the monopolist at a price P and then each group 1 buyer turns around and sells x copies to group 2 consumers at a price v_2. Because each new unit purchased allows a group 1 consumer to sell x copies at a price v_2 apiece and the consumer has a constant marginal cost of d for producing copies, the new unit price is given by $P = v_1 + x(v_2 - d)$. Monopoly profits are therefore equal to $n_1 [v_1 - c + x(v_2 - d)]$.

This case illustrates Liebowitz's argument concerning the effects of copying on the profitability of original work producers. Because $xn_1 < n_2$, i.e., there are more potential buyers of copies than the maximum potential number of copies, the price of copies reflects the value that the buyers of copies place on the copies. In turn, the anticipation of this by group 1 buyers at the beginning of the game increases group 1 individuals' willingness-to-pay for new units in the first period so the possibility of copying increases firm profits. In other words, the firm earns $n_1 [v_1 - c + x(v_2 - d)]$ rather than $n_1 [v_1 - c]$ which is what the firm would earn if copying for one reason or another were not a possibility.

Now suppose that $xn_1 > n_2$, i.e., there are more potential copies than potential purchasers of copies. What happens in this case is that group 1 individuals buy new units from the monopolist at price P, and then group 1 consumers sell copies to all group 2 consumers at a price of d. That is, given there are more potential copies than potential purchasers of copies, the competition between the sellers of copies drives the price for a copy down to its marginal cost. This means there is no profit associated with selling copies, so the monopolist sets the price for a new unit at v_1 and monopoly profits are equal to $n_1 [v_1 - c]$.

This case shows that Liebowitz's logic breaks down when copies "flood" the market. Flooding here means there are more potential copies for sale than there are potential buyers of the copies, so the price for a copy falls to the marginal cost of producing a copy which is d. In other words, rather than the price for a copy equaling the benefit from consumption of the consumers of copies as in Liebowitz's argument, the price for a copy falls to the marginal cost of producing copies. In turn, what this means is that the ability to produce copies has no effect on the willingness-to-pay of new unit buyers so, in contrast to Liebowitz's argument, the ability to produce copies has no effect on the profitability of the monopolist.

So far, the flooding of the market for copies does not hurt the profitability of the monopolist. That is, as indicated profits in this case are equal to $n_1 [v_1 - c]$, while if copying were not possible profits would again by given by $n_1 [v_1 - c]$. But, as was also the case with our secondhand market analysis, it would not be hard to change the analysis slightly so that when flooding occurs the monopolist is, in fact, hurt by the possibility of copying. For example, suppose we introduced a group 3, where this group consists of n_3 identical individuals who derive a gross benefit of v_3, where $v_3 = v_1$, from consuming either a new unit or a copy. Further, suppose that similar to the second case $xn_1 > n_2 + n_3$.

Analysis of this setting yields that, if copying is allowed, then the outcome is similar to what happened when there was no group 3 and $xn_1 > n_2$. That is, group 1 individuals buy new units from the monopolist at a price v_1, while $n_2 + n_3$ copies are sold to group 2 and group 3 consumers at a price of d. In turn, monopoly profits are the same as when there was no group 3 and $xn_1 > n_2$, i.e., profits are equal to $n_1 [v_1 - c]$.

But notice there is something different about this case. Specifically, now monopoly profits are, in fact, higher if it has the option of producing units that cannot be copied. To see this, suppose the monopolist can produce noncopiable units. Then the monopolist would sell new units to all group 1 and group 3 consumers at a price of v_1 (remember $v_3 = v_1$). Monopoly profits in this case are equal to $n_1 [v_1 - c] + n_3 [v_1 - c]$, i.e., as indicated monopoly profits here are higher than if copying were allowed.

Comparing this analysis to the previous analysis we see that in each case "flooding" causes indirect appropriability to become nonoperative. In turn, depending on the specifics of the model, the avenue through which indirect appropriability is supposed to operate, i.e., secondhand market sales in the earlier analysis and sales of copies here, can actually hurt rather than help monopoly profitability. The other interesting point to note is that the analyses suggest that flooding is more likely in the copying case than in the case of secondhand markets. In the basic analysis of secondhand markets, flooding occurs when the high valuation group is larger than the low valuation group. In the basic analysis of copying, flooding occurs when the number of high valuation consumers multiplied by the maximum number of copies that can be produced from a single new unit is larger than the number of low valuation consumers. Since for many goods a single new unit can be used to produce many copies, the flooding outcome in the copying case is likely to be quite common.

In related analyses of this issue such as Liebowitz (1981) and Besen and Kirby (1989), one issue that has been discussed is the importance of whether the owner of a new unit faces constant or increasing marginal costs of producing copies. As in the analysis of Novos and Waldman (1984), in the above we have assumed that the marginal cost of copying is constant. We feel that for many real world situations this is a quite reasonable approach. If making a copy means using a copy machine or a professional copying service such as Kinkos, then marginal cost is likely to be constant or possibly even decreasing (the decreasing case follows from the possibility of volume discounts). Similarly, if what is being copied is a digital or electronic document that can be copied through standard computer operation and transmitted over the web, then again the assumption of a constant marginal cost of copying seems realistic.

Although we believe the constant marginal cost case is realistic, we will briefly discuss what would happen in our analysis if the marginal cost of producing copies were increasing but there was still a maximum of x copies that could be made from a single copy.[8] Consider the two group analysis and suppose that were the case. If $xn_1 < n_2$, then the analysis is roughly unchanged, i.e., the only change is that the profitability of selling copies decreases because the price minus marginal cost difference falls as the number of copies made from a single unit increases. Second, if $n_1 > n_2$, then there is no change at all because a single copy produced from each new unit would be sufficient to flood the market for copies. Third, if $n_1 < n_2 < xn_1$, then the analysis changes in the sense that there will be some indirect appropriability due to profits earned on the inframarginal copies. In other words, introducing

[8]One can now think of x as the largest number of copies from a single unit such that the marginal cost of producing the last copy is less than or equal to v_2.

increasing marginal costs of copying does not negate our qualitative conclusions, but it does make the indirect appropriability case more likely.[9]

In summary, we have considered a simple model of copying that illustrates that the indirect appropriability argument is correct some of the time but far from all of the time. When there are more potential buyers of copies than copies, then the price for copies reflects the value that the buyers of copies place on the copies. The result is that, consistent with the indirect appropriability argument, new unit buyers in anticipation of the high copy price are willing to pay more for new units with the result that the possibility of copying improves monopoly profitability. In contrast, when there are more potential copies than buyers of copies, then the copy price falls to the marginal cost of copying. In this case, in contrast to the indirect appropriability argument, the possibility of copying does not increase the willingness-to-pay of new unit buyers, and so does not improve monopoly profitability. In fact, we showed through the introduction of a third group of consumers that, when the copy price equals marginal cost, the possibility of copying can actually hurt monopoly profitability. We also discussed how the analysis changes when the marginal cost of copying is increasing rather than constant.

4. Limitation 2: Imperfect substitutability

In this section we discuss the second major limitation of the indirect appropriability argument. The second limitation is that there is imperfect substitutability between new units and copies. In this argument copies are perceived to be of lower quality than new units with the result that the presence of copies lowers the new unit price and, if this effect is significant enough, also lowers monopoly profitability.

4.1. **Imperfect Substitutability in Durable-Goods Markets.**

The analysis in this section is closely related to earlier analyses that appear in Waldman (1996) and Hendel and Lizzeri (1999).[10] The model we consider is also related to the durable goods model considered in the previous section. There are two important differences. First, in the previous model new unit buyers placed a zero value on consuming used units. This eliminated possible effects on the new unit price due to the substitutability between new and used units. In contrast, here new unit buyers do place a positive value on the consumption of used units. Second, we now abstract away from the flooding issue which was the focus of the previous analysis by assuming there are more used unit buyers than new unit buyers.

As before, we consider a durable goods setting in which there are two groups of consumers who live for two periods and the monopolist's product deteriorates with age. Group 1 consists of n_1 identical consumers who derive a gross benefit of v_1^N from consuming a new unit in a period and a value of v_1^U from consuming a used

[9]Given that as argued above, it is arguably realistic for some situations to assume that the marginal cost of copying is decreasing, one might feel it is worthwhile to consider how the analysis changes with that assumption. However, incorporating that assumption dramatically complicates the analysis because it eliminates the competitive nature of the copy market. Introducing decreasing marginal costs of copying is thus beyond the scope of the current paper.

[10]Related analyses appear in Benjamin and Kormendi (1974), Miller (1974), and Liebowitz (1982). Those earlier papers start by specifying demand functions, while the more recent papers cited above derive results by starting with utility functions and assuming utility maximization. Note also that the argument of this section is closely related to the literature on the monopoly pricing of a product line in a static setting. See Mussa and Rosen (1978) and Maskin and Riley (1984) for analyses. Waldman (1996) discusses the relationship between the two literatures.

unit in a period, $v_1^N > v_1^U$. Group 2 consists of n_2 identical consumers who derive a gross benefit of v_2^N from consuming a new unit in a period and a value of v_2^U from consuming a used unit in a period, $v_2^N > v_2^U$. Further, the monopolist has a constant marginal cost of production equal to c, where $v_1^N - v_1^U > c > 2v_2^N$. We also assume $n_2 > n_1$ (which ensures that there is no flooding), there is no discounting, and that the scrap value equals zero. In this set-up group 1 consumers will want to buy new units in each period, while group 2 consumers never purchase new units but are rather the potential buyers on the secondhand market.[11]

To analyze this case, we start with the second period under the assumption that in the first period all group 1 consumers purchased new units. Because $v_1^N - v_1^U > c$ and $n_2 > n_1$, in the second period group 1 consumers sell used units to group 2 consumers at a price v_2^U and then the monopolist sells new units to group 1 consumers at a price $v_2^U + (v_1^N - v_1^U)$. That is, group 1 consumers sell their used units to group 2 consumers at the valuation group 2 consumers place on the units and then buy new units at a price equal to the used unit price plus the incremental valuation group 1 consumers place on the added quality associated with new units. We now have that second period monopoly profitability is given by $n_1\left[v_2^U + (v_1^N - v_1^U) - c\right]$.

Now consider the first period given this is what happens in the second period if group 1 consumers purchase new units in the first. Because v_2^N is sufficiently small that group 2 consumers never purchase new units, in the first period the monopolist sells new units to group 1 consumers at a price $v_1^N + v_2^U$. The first term here is the valuation that group 1 consumers place on consuming the new unit in the first period, while the second is the price that a group 1 consumer is able to sell a used unit for in the second period. The logic for the value of the first period price for a new unit, denoted P_1, is that this price equates the net benefit a group 1 consumer derives from purchasing a new unit in the first period, i.e., $2v_1^N + v_2^U - P_1 - (v_2^U + v_1^N - v_1^U)$ with the net benefit a group 1 consumer receives from waiting and then buying a used unit in the second period, i.e. $v_1^U - v_2^U$. We now have that first period profitability is given by $n_1\left[v_1^N + v_2^U - c\right]$ and overall profitability is given by $n_1\left[2v_1^N + 2v_2^U - v_1^U - 2c\right]$.

In order to focus on what this analysis tells us concerning Swan's argument about secondhand markets, let us quickly consider what would happen in this model if we made the single change that the monopolist's output was nondurable rather than durable (this is equivalent to assuming $v_1^U = v_2^U = 0$). Given this assumption, the monopolist would simply sell new units to group 1 consumers in each period at a price of v_1^N and overall monopoly profitability would be $n_1\left[2v_1^N - 2c\right]$.[12]

We can now consider what this model tells us concerning the incentives for durable goods producers to eliminate secondhand markets (as mentioned earlier in footnote 2, we now use the term eliminate the secondhand market to refer to an action that makes used units unavailable for consumption such as producing nondurable units). There are two cases. The first case is that $2v_2^U > v_1^U$. In this case the monopolist has no incentive to eliminate the secondhand

[11] As was true in the durable goods analysis of the previous section, because group 2 consumers never purchase new units, the Coase time inconsistency problem does not come into play in our analysis.

[12] An alternative approach would be to assume units are durable but secondhand market trade is not possible. This would yield the same value for overall monopoly profitability given the assumption that in the second period the monopolist can price discriminate between those who own used units and those who do not.

market because indirect appropriability is causing monopoly profitability to be higher rather than lower due to the ability of consumers to trade on the secondhand market. That is, with the secondhand market the monopolist earns $n_1\left[2v_1^N + 2v_2^U - v_1^U - 2c\right]$ while without it the monopolist earns $n_1\left[2v_1^N - 2c\right]$, and if $2v_2^U > v_1^U$ then $n_1\left[2v_1^N + 2v_2^U - v_1^U - 2c\right] > n_1\left[2v_1^N - 2c\right]$.

The other case is that $2v_2^U < v_1^U$. In this case the monopolist has an incentive to eliminate the secondhand market or more generally make used units unavailable for consumption, where the reason is that the negative effects on profitability due to the substitutability between new and used units trumps the positive effects due to indirect appropriability. That is, we again have that with the secondhand market the monopolist earns $n_1\left[2v_1^N + 2v_2^U - v_1^U - 2c\right]$ while without it the monopolist earns $n_1\left[2v_1^N - 2c\right]$, but now since $2v_2^U < v_1^U$ we have $n_1\left[2v_1^N + 2v_2^U - v_1^U - 2c\right] < n_1\left[2v_1^N - 2c\right]$.

To be completely clear, we now describe the logic in a bit more detail. In this model the presence of the secondhand market has two effects on monopoly profitability that work in opposite directions. On the one hand, as emphasized by Swan, the new unit price in the first period reflects the price that used units will sell for on the secondhand market in the second period. That is, the first-period new-unit price is $v_1^N + v_2^U$, so from this standpoint monopoly profitability is $n_1 v_2^U$ higher than monopoly profitability in the case with no secondhand market. On the other hand, the new unit price in the second period is lower due to the substitutability between new and used units. That is, the second-period new-unit price is $v_2^U + (v_1^N - v_1^U)$, so from this standpoint monopoly profitability is $n_1(v_1^U - v_2^U)$ lower than monopoly profitability in the case with no secondhand market. When $2v_2^U > v_1^U$ the first effect dominates and the monopolist is helped by the secondhand market, but if $2v_2^U < v_1^U$ the second effect dominates and the monopolist is hurt by the secondhand market.

Note that what this analysis says is that, if secondhand market buyers have sufficiently low valuations for the used product, i.e., v_2^U is sufficiently small, then the monopolist benefits by eliminating the secondhand market. This is very intuitive. First, if the secondhand market buyers have low valuations, then the secondhand market price is low and the extra profitability due to indirect appropriability is small. Second, if the secondhand market buyers have low valuations, then the resulting low secondhand market price in the second period also causes a low second period price for new units. Both effects work in the direction of increasing the profitability associated with the monopolist eliminating the secondhand market.

As a final point, we have focused on making the product nondurable and stopping secondhand market trade as the tactics a durable goods seller with market power might use to increase profits in this type of setting. But as discussed in the literature on this topic, e.g., Waldman (1996, 1997) and Hendel and Lizzeri (1999), there are actually various other tactics a firm might employ to achieve this outcome. For example, a firm might decide to lease rather than sell its output and then make used units unavailable for consumption by retiring the used units when they are returned. Or, alternatively, consistent with what seems to occur in the textbook market, the producer or publisher can introduce new editions which achieves the goal by making old copies of the book obsolete.

In summary, in this subsection we have shown that, even if the secondhand market is not flooded with used units, Swan's argument can still break down because

of the substitutability between new and used units and the resulting constraint that used unit availability has on the new unit price. In particular, this leads to a reason for the durable goods producer to eliminate the secondhand market when used unit buyers have low valuations for used units.

4.2. **Imperfect Substitutability in Markets for Copiable Goods.** In this subsection we show that the argument of the previous subsection concerning imperfect substitutability in durable goods markets also applies when copying is an issue. That is, if copies are lower quality than originals, then the price at which copies sell constrains the price that the original works producer can charge for new units. In turn, if the valuation that the buyers of copies have for copies is low, then this constraint lowers the profitability of the original works producer below profitability in the absence of copies which means the firm would prefer if copying was not a possibility.[13]

Note that there are two differences between the model we consider here and the model of copying we considered in the previous section. First, in the previous model new unit buyers placed a zero value on consuming a copy. This eliminated possible effects on the new unit price due to the substitutability between new units and copies. In contrast, here new unit buyers do place a positive value on the consumption of copies. Second, we now abstract away from the flooding issue which was the focus of the previous analysis of copying by assuming there are more potential buyers of copies than new unit buyers and each new unit can only be used to produce a single copy (and a copy cannot be used to produce another copy).

As in our previous analysis of copying, we consider a one period setting with two groups of consumers and assume that the monopolist's product deteriorates when it is copied. Group 1 consists of n_1 identical consumers who derive a gross benefit of v_1^N from consuming a new unit and a value of v_1^C from consuming a copy, $v_1^N > v_1^C$. Group 2 consists of n_2 identical consumers who derive a gross benefit of v_2^N from consuming a new unit and a value of v_2^C from consuming a copy, $v_2^N > v_2^C$. Further, the monopolist has a constant marginal cost of production equal to c, where $v_1^N - v_1^C > c > v_2^N$, and each new unit can be used to produce a single copy at cost d, where $v_2^C > d$. In this set-up group 1 consumers are the potential buyers of new units while group 2 consumers, because $d < v_2^N < c$, will never purchase new units but are rather the potential consumers of copies. We also assume $n_2 > n_1$ and no discounting.

Let us start by considering the price in the market for copies. Suppose that all group 1 consumers purchase new units from the monopolist. Because $n_2 > n_1$ and each new unit can only be used to produce a single copy, each group 1 consumer sells a copy to a group 2 consumer at a price v_2^C. In turn, since when purchasing new units group 1 consumers will correctly anticipate that this will be the price at which copies can be purchased or sold, the monopolist will only be able to charge $(v_1^N - v_1^C) + 2v_2^C - d$ for new units. That is, one equates the net benefit a group 1 consumer derives from purchasing a copy at a price v_2^C, i.e., $v_1^C - v_2^C$, with the net benefit derived from purchasing a new unit at P, i.e., $v_1^N - P + (v_2^C - d)$. This means monopoly profitability is given by $n_1\left[(v_1^N - v_1^C) + 2v_2^C - c - d\right]$.

In order to focus on what this analysis tells us concerning the indirect appropriability argument, let us quickly consider what would happen in this model if we

[13]Analyses related to the one considered here appear in Takeyama (1997), Belleflamme (2003), and Bae and Choi (2003).

made the single change that new units could not be copied (this is equivalent to assuming $v_1^C = v_2^C = 0$). Given this assumption, the monopolist would simply sell new units to group 1 consumers at a price of v_1^N and overall monopoly profitability would be $n_1\left[v_1^N - c\right]$.

We can now see what this model tells us concerning the effect of copying on monopoly profitability. There are two cases. The first case is that $2v_2^C > v_1^C + d$. In this case the ability of consumers to make copies helps monopoly profitability, where the increased profitability stems from the ability of the monopolist to appropriate the values consumers of copies place on the copies through the new unit price. That is, when copying is possible the monopolist earns $n_1\left[(v_1^N - v_1^C) + 2v_2^C - c - d\right]$ while, if it is not, the monopolist earns $n_1\left[v_1^N - c\right]$, and if $2v_2^C > v_1^C + d$, then $n_1\left[(v_1^N - v_1^C) + 2v_2^C - c - d\right] > n_1\left[v_1^N - c\right]$.

The other case is that $2v_2^C < v_1^C + d$. In this case monopoly profitability is hurt by the ability of consumers to make copies, where the decreased profitability stems from the negative effect on the new unit price due to the substitutability between new units and copies. That is, we again have that when copying is possible the monopolist earns $n_1\left[(v_1^N - v_1^C) + 2v_2^C - c - d\right]$ while, if it is not, the monopolist earns $n_1\left[v_1^N - c\right]$, but now $2v_2^C < v_1^C + d$ so $n_1\left[(v_1^N - v_1^C) + 2v_2^C - c - d\right] < n_1\left[v_1^N - c\right]$.

The logic here is basically the same as in the analysis of the previous subsection. In this model the ability of consumers to copy has two effects on monopoly profitability that work in opposite directions. On the one hand, as emphasized by Liebowitz, the new unit price reflects the profits that new unit buyers derive from selling copies. That is, the price for new units is higher by an amount $v_2^C - d$ because of the ability of consumers to copy. On the other hand, the new unit price is lower because of the substitutability between new units and copies. That is, the substitution possibility decreases the new unit price by an amount $v_1^C - v_2^C$. When $2v_2^C > v_1^C + d$ the first effect dominates and the monopolist is helped by the ability of consumers to copy, but if $2v_2^C < v_1^C + d$ the second effect dominates and the monopolist is hurt by copying.

Note that the conclusion of this subsection concerning when the indirect appropriability argument breaks down is similar to the previous subsection's conclusion concerning when Swan's argument breaks down. That is, it is when the consumers of copies have low valuations for copies, i.e., when v_2^C is low, that copying hurts monopoly profitability and thus the firm would prefer to make copying impossible. As was true for the similar result in the previous subsection, there are two factors that contribute to this result. First, when the consumers of copies have low valuations on the copies, the price of a copy is low so the direct increase in the new unit price due to indirect appropriability is small. Second, because the copy price is low, the substitutability between new units and copies also causes a low new unit price.

In summary, we have now identified two reasons why the indirect appropriability argument concerning copying can break down. First, if the number of copies available for purchase is sufficiently large, i.e., copies flood the market, then the price of a copy falls to marginal cost. This means there is no profit associated with selling copies and thus no indirect appropriability component of the new unit price. Second, because of the potential substitutability between new units and copies, the price at which copies are available limits the price the monopolist can charge for new units. In turn, if consumer valuation for copies is low so this constraint causes

a low new unit price, then the ability of consumers to copy hurts rather than helps monopoly profitability.

5. Discussion

In the previous two sections we analyzed and discussed two limitations of the indirect appropriability argument for copiable goods. In this section we discuss what we believe are the implications of those analyses for real world markets. Our first focus is on which types of real world markets the indirect appropriability argument is likely to be important. We then briefly discuss optimal copyright policy.

In Section 2 we discussed the literature on indirect appropriability in markets for copiable goods and pointed out that there are two distinct ideas in that literature. The first, due initially to Liebowitz, is that there is an analogy between markets for copiable goods and markets for durable goods. In each case the price for new units should include a component that reflects the profits that a new unit buyer derives from selling either used units or copies in later periods. In turn, this added component in the new unit price can cause profits to rise as a result of either the presence of secondhand markets or of copying being possible.

The second, due initially to Besen and Kirby, is that the ability of consumers to form groups and share new units and copies within a group can also cause profits to rise as a result of copying being possible. One reason is that such copying can be efficient from the standpoint of providing consumers access to the good, while a second reason is that such sharing can reduce heterogeneity of demand.

Our interpretation of the analyses of Sections 2 and 3 is that the first avenue through which consumer copying can improve producer profitability is probably of limited relevance in most real world markets. Our analyses show that there are two important limitations associated with this type of indirect appropriability. First, the market for copies can be flooded in which case the copy price falls to marginal cost and the new unit price contains no added component due to profits associated with copying. Since in many real world markets a single new unit can be used to produce an almost unlimited number of copies and sometimes copies can be used to produce more copies, this seems like a significant drawback of the first indirect appropriability argument. Second, even in the minority of cases in which flooding does not occur, the substitutability between new units and copies constrains the new unit price. If this constraint is sufficiently limiting as would likely be the case if the consumers of copies place a low valuation on copies, then again the ability of consumers to copy will hurt rather than help producer profitability.

On the other hand, the limitations discussed in Sections 3 and 4 are not relevant for the sharing version of the indirect appropriability argument. In fact, our interpretation of Liebowitz's empirical findings concerning libraries is exactly the sharing story. Libraries typically do not charge on a per unit basis for access to their collections. Rather, libraries represent the interests of a set of individuals who share the collection. As copying becomes easier, the collection becomes more valuable to the library's patrons and thus willingness-to-pay of libraries rises. It is in this way, we believe, that the introduction of copying helps original work producers in terms of sales to libraries.

We are not sure, however, how far the sharing argument extends beyond the case of libraries. Both the Besen and Kirby analysis and the analysis of Bakos,

Brynjolfsson, and Lichtman make a strong and to some extent ad hoc assumption. This assumption is that there is no selling or sharing of copies across groups. This assumption seems reasonable for the case of libraries where it would be unusual for a library's collection to consist in any significant way of copies of books and journals that were made by copying parts of other library's collections. But this assumption seems less reasonable for many other applications.

If a small circle of friends share copies of an original recording there is little to stop one of the friends from either selling a copy to or sharing a copy with someone outside of the group. But this type of cross-group sharing potentially has significantly different ramifications than the two sharing analyses discussed in Section 2. That is, our conjecture is that relative to the results found in those two earlier studies, when there is sharing across groups, the introduction of copying is much less likely to result in increases in original work producer profitability. Given that this has not been formally studied as far as we know, however, we believe this is one area of study in which additional theoretical work is important.

As a final point, let us very briefly discuss the ramifications for optimal copyright policy of the assumption that the indirect appropriability argument is important. One might at first think that the correct conclusion is that copyright protection should be weakened. But this is not so clear cut to us. To the extent that copying improves producer profitability in some cases, the producer would have an incentive to allow that type of copying. So, to the extent feasible, it may be optimal to give producers more discretion over which type of copying is allowed and which type is not. Given such discretion, producers would allow copying when copying improves profitability and likely therefore also social welfare, while copying would not be allowed when it hurts producer profitability and possibly also social welfare.

6. Conclusion

In an influential paper, Liebowitz (1985) argued that the traditional argument concerning the effects of copying or piracy is incomplete because it ignores the possibility of indirect appropriability. In this paper we have discussed two important limitations of the indirect appropriability argument. First, if there is a sufficient number of copies available, then indirect appropriability goes to zero because the price on the secondhand market falls to marginal cost. Second, because of potential substitutability between new units and copies, copying does not help original work producer profitability if consumers of copies place a sufficiently low valuation on the copies. We also argued that these limitations are important in real world markets with the result that the traditional argument is closer to reality than one might have thought when the indirect appropriability argument was first put forth.

In this paper we considered simple models characterized by two or three groups and two periods that allowed us to illustrate our main points in an easy to follow manner. However, this approach obviously abstracts from the real world in important ways. One possible avenue for future research would be to investigate some of the same issues that we focus on in richer and more realistic models. Although, as indicated above, we believe our current analysis indicates that indirect appropriability is likely to be of limited significance in most real world markets, analysis of such richer models might give us a clearer picture of the real world role of indirect appropriability.

Note further that, although we conclude that the indirect appropriability argument based on an analogy with durable goods production is of limited importance in many if not most real world markets, we feel that the related idea that copying can have positive effects on profitability when sharing is important is an important and in some settings quite realistic argument. When sharing is important as in the case of libraries, then the ability to copy makes sharing more efficient and also potentially reduces demand heterogeneity. Both factors can increase the profitability of original work producers. There have been some studies of sharing when copying is a possibility. But we feel this is an important but underresearched idea, and that further investigation of this topic would be worthwhile.

To sum up, we believe that Liebowitz (1985) is an important contribution because it points out that the ability of consumers to make copies can in certain circumstances help rather than hurt the profitability of original work producers. In thinking about when this is important, however, we would move away from Liebowitz's original focus which was on drawing an analogy to durable goods production where the new unit price reflects the price the good will sell for in future periods on the secondhand market. We believe that in many cases this avenue for raising the new unit price does not result in the ability of consumers to make copies increasing the profitability of original work producers. Rather, it is settings in which sharing is important in which the ability of consumers to make copies may help producer profitability.

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