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WHAT LIMITS INDIRECT APPROPRIABILITY?*

by

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I. INTRODUCTION

When a consumer makes an illegal copy of an original work such as a recording or a book, the result is typically one less potential sale of a legal copy. In the traditional argument as found, for example, in Novos and Waldman (1984), the result is less potential revenue for the producers of the original work and thus less investment in the production of original works. The subsequent reduction in the quality and variety of original works is referred to in the literature as the underproduction loss.¹ This idea of an underproduction loss due to illegal copying, in turn, serves as a foundation for copyright protection which makes copying harder and thus in the standard argument reduces the underproduction loss.

Starting with the work of Liebowitz (1985), an alternative argument referred to as indirect appropriability has been put forth that challenges the standard argument. This alternative argument draws an analogy with the market for durable goods. As argued, for example, in Swan (1980), the original price that a durable good sells for will reflect future prices this good will

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¹ The analysis in Novos and Waldman (1984) builds on earlier related analyses found in papers such as Arrow (1962) and Hirshleifer and Riley (1979) which focus on underproduction due to issues other than copying.

trade for on the secondhand market. When applied to copying the argument is that a new unit of a creative work will reflect the prices that copies of the work can be sold for and thus the benefits received by buyers of copies is reflected in the revenues received by the creators of the original works. If these “indirect” revenue streams are substantial, then underproduction losses due to copying may be much smaller than is claimed in the standard argument.

In this paper I present a series of simple related models to show the circumstances in which indirect appropriability is effective and those in which it is not. Similar to arguments in Johnson and Waldman (2005), I focus on two factors that limit the effectiveness of indirect appropriability. First, building on an argument that first appeared in Novos and Waldman (1984) (see also Besen and Kirby (1989)), I show that competition between the creator of the original work and consumers selling copies or competition just between such consumers can drive down the price of copies and thus limit indirect appropriability. Second, drawing an analogy to the durable goods literature focused on imperfect substitutability between new and used units such as Anderson and Ginsburgh (1994), Waldman (1996,1997), and Hendel and Lizzeri (1999), I show that imperfect substitutability between units sold by the original works creator and copies can also serve to limit the price the creator can charge and thus can also reduce indirect appropriability.

The conclusion is that indirect appropriability is important in certain real world settings like that of a library which was Liebowitz’s original example. But in many other settings the factors limiting indirect appropriability are important and in such settings indirect appropriability is likely to have minor effects on equilibrium behavior.

The outline for the paper is as follows. Section II presents the standard argument and the indirect appropriability argument in more detail. Section III presents a simple two-period, two-

consumer model in which indirect appropriability is important when the monopolist can commit but not important when it cannot. Section IV extends the analysis to the cases of more periods, more consumers, and both more periods and more consumers. Section V explores the issue of imperfect substitutability between new units and copies. Section VI then discusses a number of real world examples and how they fit into the analysis. Section VII presents concluding remarks.

II. THE BASIC ARGUMENTS

Before providing a more formal analysis starting in Section III, in this section I describe the traditional argument concerning copyright and the indirect appropriability argument in more detail than in the Introduction. The traditional argument concerning copyright is that copyright policy is designed to optimally trade-off inefficiencies associated with underproduction with those stemming from underutilization. Underproduction here refers to the idea that in a world in which original works are copied and the copies result in no payment to the producers of the original work, the result is that these producers have insufficient incentives for creation. In other words, too few original works will be created and the ones that are created will be of insufficient quality.

The underutilization loss, on the other hand, focuses on inefficiencies created by copyright and the resulting limits on the ability of consumers to copy freely. The basic idea here is that when the private cost of copying significantly exceeds the social cost of copying (maybe because of government prohibitions on copying due to the copyright laws), the typical result is that the price of consuming the original work exceeds the societal cost and many consumers whose valuation for the good exceeds the societal cost wind up not consuming the good. This is analogous to the standard deadweight loss due to monopoly behavior wherein some consumers

whose valuation or willingness to pay exceeds the monopolist's marginal cost wind up not consuming the monopolist's good because the monopoly price exceeds marginal cost.

In the standard argument copyright is designed to optimally trade-off these two inefficiencies. Changing copyright policy to make copying harder reduces the underproduction loss but increases the underutilization loss, while making copying easier has the opposite effect. That is, making copying harder moves some consumers from copying to the consumption of a new unit and so the return to creation and the return to increasing the quality of a creative work both increase. The result is that both the variety and qualities of creative works should rise. But the underutilization loss moves in the opposite direction when copying becomes harder. That is, when copying is made more difficult some consumers are pushed out of the market entirely and this increases underutilization since the consumers who are pushed out will typically have valuations or willingness to pay that is above the marginal cost of making a copy.

But the above discussion ignores the indirect appropriability argument. In the above discussion the original producers of the creative works receive no payment either directly or indirectly from consumers who copy the good, so copying unambiguously reduces the incentives for individuals to produce creative works. But the market is not guaranteed to work this way. Consider, for example, a consumer who purchases a creative work from the original producer of the work for his or her own consumption but also sells copies of the creative work to friends. If the revenue this consumer derives from selling copies is substantial, the result can be that the consumer's willingness to pay for an original unit rises rather than falls with copying which, in turn, improves the incentives for the producers of original works to create, i.e., underproduction is reduced rather than increased.

In other words, the indirect appropriability argument draws an analogy with durable goods production. Think, for example, of a firm that produces cars and the quality and durability this producer builds into the cars. The quality will not just reflect the added utility that a new-car buyer directly receives from added quality before eventually selling the car on the secondhand market. Because the new-car buyer will eventually be able to sell the car on the secondhand market for a higher price if the car is higher quality and more durable, the new-car buyer's willingness to pay for a higher quality and more durable car will reflect the extra utility of the used-car buyer. So the quality and durability built into the new car should reflect both the extra utility the new-car buyer directly derives from higher quality and durability and also the extra utility received by subsequent owners of the car.

The first step of the indirect appropriability argument simply substitutes copies for secondhand market trade. That is, the quality of a creative work will not just reflect the direct utility that the purchaser of the work receives from consumption. If a purchaser is able to sell copies for a positive profit, the purchaser's willingness to pay for a higher quality creative work will also reflect the extra utility of those who purchase copies from this consumer. So the quality of the creative work should reflect both the extra utility the purchaser of the creative work directly receives from consuming a higher quality unit and also the extra utility received by those who purchase copies from this consumer.

The second step of the argument then applies the first point to optimal copyright policy. As discussed above, in the standard argument optimally setting the degree of copyright protection trades off the size of the underproduction loss with the size of the underutilization loss. But if indirect appropriability is important, there might not be a tradeoff because lowering the degree of copyright protection can reduce both the underutilization loss and the underproduction loss. The

idea that the underutilization loss falls is just the standard argument since, if it is easier to copy, then more individuals will consume either new units of the creative work or copies, so fewer are inefficiently excluded from the market. But in contrast to the standard argument, the underproduction loss can also fall. The logic is that, if copying is easier, then buyers of new creative works can derive more profits from selling copies, so willingness to pay for the creative work rises. The result, in turn, is more creative works and higher quality creative works so underproduction falls.

In the next sections I explore the validity of this argument. I show that the analogy between durable goods production and copying is not exact and the differences limit the extent to which the indirect appropriability argument applies. Also, there are circumstances in which secondhand market trade can reduce producer profit in durable goods markets and I show that a similar argument can be applied to markets where copying is possible.

III. A SIMPLE MODEL

In this section I explore a simple model of copying characterized by a monopolist, two identical consumers, and two periods. I show that indirect appropriability can be important, in particular, when the monopolist has commitment ability. But even in this simple case there are factors that can reduce or even eliminate the effectiveness of indirect appropriability.

In this section's model I assume a monopolist and two consumers. The monopolist has a constant marginal cost of production equal to c where the quality of the monopolist's output depends on the monopolist's investment in quality, denoted r . Specifically, $Q(r)$ denotes the quality of the monopolist's output, where $Q'(0)=\infty$, $Q'>0$, $Q''<0$, and $Q'(\infty)=0$. Also, there is no discounting.

The two consumers are identical in terms of their valuation or willingness to pay for the monopolist's product. In particular, vQ denotes each consumer's gross benefit from consuming a unit of quality Q , where I assume v is sufficiently large that efficiency requires both individuals to consume the good.² It is also the case that a consumer who purchases the monopolist's product in period 1 can make a copy of the product which he or she can then sell to the other consumer in period 2.³ In this section I assume that copies are perfect substitutes for the original product (Section V explores what happens when the perfect substitutability assumption is relaxed). I also assume that copies can be made at per unit cost c , so holding the quality of the monopolist's output fixed, it is equally efficient for each consumer to purchase an original unit from the monopolist as to have one consumer purchase an original unit and the other purchase a copy sold by the consumer who purchased directly from the monopolist.

Note that assuming the two consumers are identical abstracts away from the standard durable goods monopoly time inconsistency problem first investigated in Coase (1970) and Bulow (1982).⁴ In these analyses a durable goods monopolist loses some or all of its market power because of an inability to commit and a resulting incentive to reduce price over time as more and more of the high valuation consumers have purchased the product. By focusing on a setting where consumers are identical I avoid the incentive for the monopolist to reduce its price

² The specific restriction is that v is sufficiently large that there exists a value for r such that $2vQ(r) > 2c + r$.

³ As indicated, a consumer derives a gross benefit of vQ from consuming the good over the two periods whether the good is purchased in period 1 or period 2. It is also implicitly assumed that the part of this gross benefit derived in period 2 when a unit is purchased in period 1 exceeds c . This ensures that a consumer who purchases a unit in period 1 will prefer to sell a copy rather than sell the original unit in period 2. Note that an alternative specification would have the gross benefit from consuming the good over the two periods be higher when the good is purchased in period 1 rather than in period 2. In this case indirect appropriability could never result in first best behavior because of the lower gross benefit of consumption associated with purchasing a copy in period 2 rather than purchasing a new unit from the monopolist in period 1.

⁴ Although, see Bagnoli, Salant, and Swierzbinski (1989) for an analysis in which the monopolist avoids time inconsistency even when consumers are heterogeneous. Also, see Waldman (2003) for a survey that discusses the durable goods time inconsistency literature.

over time after higher valuation consumers have purchased units. One reason I make this assumption is that I want to explore the extent to which copying affects market power in a setting in which the firm has significant market power in the absence of copying. If the durable goods monopoly time inconsistency problem is present, then the monopolist can lose much of its market power even when copying is not possible. Note that I relax the assumption that consumers are identical in Section V's analysis.

The timing of the game is as follows. The first period starts with the monopolist choosing an investment level which determines the quality of the monopolist's output. Then the monopolist sets a period 1 price for its output and each consumer decides whether or not to purchase a unit. If a new unit is sold to only one of the consumers in period 1, then in period 2 the monopolist can offer a new unit to the other consumer while the consumer who purchased a new unit in period 1 can offer a copy where prices are chosen simultaneously. On the other hand, if either both consumers purchase a unit from the monopolist in period 1 or neither consumer purchases a unit, then the game ends at the end of period 1. I focus on pure strategy Subgame Perfect Nash equilibria.⁵

I begin by considering how a social welfare maximizing planner who can control investment and consumption levels would behave. Given the assumption that v is large, the planner would have both individuals consume either a new unit or a copy (at least one would have to consume a new unit since copies cannot be made without the production of a new unit).

⁵ The assumption that the game ends at the end of the first period if neither consumer purchases a unit in the first period is an unusual assumption. The reason I impose it is that it allows me to capture in a two-period setting that, in any equilibrium in which both consumers purchase a unit in the same period, each consumer's behavior must yield the consumer at least as high utility as delaying purchasing to the following period. As will be seen below, this serves as an important constraint on monopoly behavior. If I assumed that the game did not end when neither consumer purchased a unit in the first period, then the monopolist could avoid this constraint by selling nothing in the first period and then selling a unit to each consumer in the second period.

Further, the efficient investment level, denoted r^* , equates the marginal cost of increasing the investment level with the aggregate marginal benefit of increasing the investment level. That is, r^* satisfies $2vQ'(r^*)=1$.

The question is whether the monopolist achieves an efficient outcome when there is no social planner and the monopolist sells its output. If there is no copying the analysis is easy. In the absence of copying the social planner's solution does not change much because new units produced by the monopolist are perfect substitutes for copies. Further, when the monopolist sells and there is no social planner, then equilibrium behavior achieves the efficiency of the planner's solution. For example, in one equilibrium the monopolist invests r^* , prices the good in period 1 at $vQ(r^*)$, and both consumers purchase the good in period 1.⁶

Introducing the possibility of copying complicates the problem but it is still sometimes possible for the monopolist to achieve an efficient outcome and capture all of the surplus. For example, suppose that I add to the model the assumption that at the beginning of period 1 the monopolist can commit to sell only a single unit. Then it can use indirect appropriability to achieve an efficient outcome. In particular, the firm will commit to sell only a single unit, invest r^* , and then offer the single unit for a price equal to $2vQ(r^*)-c$. The result will be that one of the two consumers purchases the unit in period 1, makes a copy at cost c in period 2, and then sells the copy to the other consumer at the price $vQ(r^*)$. As suggested, the idea of indirect appropriability explains the logic behind this behavior. The consumer who purchases the unit from the monopolist has a direct willingness to pay for the unit equal to $vQ(r^*)$ but also earns $vQ(r^*)-c$ by selling a copy to the other consumer in period 2. The result is that the consumer's

⁶ The logic here is that, whatever value for r the monopolist chooses, it sets the price at $vQ(r)$ to extract all the surplus. So profit equals $2vQ(r)-2c-r$ which yields as a first order condition $2vQ'(r)-1=0$. Comparing this equation

full willingness to pay for a new unit in period 1 is $2vQ(r^*)-c$ which reflects both the consumer's direct utility from consuming the unit and the consumer's net profit from selling a copy in period 2 to the other consumer.

Also, even if it cannot commit to a quantity, it would still be able to achieve an efficient outcome if it can commit to a period 2 price or simply commit to not lower its price in the future. For example, if the firm can simply commit not to lower its price, then in every pure strategy equilibrium the monopolist commits not to lower its price in the future, chooses an investment level equal to r^* , and sets a period 1 price equal to $2vQ(r^*)-c$. Then one of the consumers will purchase a unit in the first period at this price and in period 2 this consumer will sell a copy to the other consumer at the price $vQ(r^*)$. This yields the same profit to the monopolist and utility and consumption levels for the consumers as the equilibria when the monopolist can commit to sell only a single unit.⁷

It is worth noting, however, that these equilibria are in a sense less robust than might first appear. For example, by assuming that in period 2 the consumer selling copies chooses a price and then the other consumer chooses whether or not to purchase a copy basically gives the consumer selling the copy all the bargaining power since the price for the copy equals the buyer's willingness to pay. But alternatively it might be more realistic to assume that the bargaining power is shared across the buyer and seller in period 2 so the consumer selling the copy only captures part of the surplus (if the potential buyer sets the price then the consumer selling the copy would capture none of the surplus). If this is the case, then monopoly profitability will be

to the earlier expression that defined r^* yields that the monopolist chooses r^* . Note also that there are other similar equilibria in which one of the consumers purchases in period 2.

⁷ By restricting the discussion to pure strategy equilibria I rule out the possibility of an outcome in which coordination across consumers is not achieved, i.e., an outcome where either both consumers purchase from the monopolist or neither does. See footnote 8 for further related discussion.

lower than in the above analysis and so will the investment level. Let r' be the investment level in this equilibrium. The logic is that the price of the copy will be below $vQ(r')$ which, in turn, means the monopolist's price will be below $2vQ(r')-c$ and the monopolist chooses $r' < r^*$.⁸

So the commitment analysis tells us that, if the firm can commit to sell a single unit or has price commitment ability, then there exist equilibria in which the outcome is efficient and the monopolist captures all of the surplus, although this result is not fully robust. But suppose that the monopolist does not have the ability to commit. Then in every equilibrium the outcome will not be efficient and the monopolist will not capture all of the surplus.

To see this, I will first argue that there cannot be an equilibrium in which the monopolist sells a unit to both consumers in period 1 at a price above c . Suppose this was the case. If one of the consumers deviated and decided not to purchase the monopolist's product in period 1, then in the following period the monopolist and the period 1 buyer would be in a Bertrand competition type setting and the price of both a new unit and copy would equal c . Given this, starting from a situation in which both consumers are simultaneously purchasing a unit in period 1 at a price above c , each consumer would have an incentive to deviate and not purchase from the monopolist in period 1 because each consumer would anticipate that doing so would allow him or her to purchase a new unit or copy at a price equal to c in period 2.

Now consider an equilibrium in which the monopolist sells a single unit in period 1. Based on the same logic as above, in period 2 the firm and the buyer will compete in a type of Bertrand pricing game so the result would be that the other consumer would purchase either a

⁸ There is also an issue concerning mixed strategy equilibria. Suppose we focus on the original specification where, if a single consumer buys a copy in period 1 this consumer sets the period 2 price, but we allow for mixed strategy equilibria. It is unclear that the most plausible equilibria are the pure strategy equilibria focused on above in which in period 1 the monopolist sells a single new unit with probability one and then in period 2 the buyer sells a copy to the other consumer.

new unit or a copy at a price equal to c . This means that neither the monopolist nor the first period buyer derive any profit from selling to the second consumer. In turn, since the consumer purchasing from the monopolist does not derive any profit from selling a copy to the second consumer, this first consumer will not pay more than his or her own direct utility from consumption. This means the monopolist does not extract all the potential surplus from the two consumers which also means that it invests less than r^* in product quality.

In summary, in this section I considered a very simple model of monopoly behavior and copying. There were two consumers and two periods, where in the first period only the monopolist sells its output while in the second new units produced by the monopolist and copies can both be sold (if no units are sold in the first period or both consumers purchase in the first period, then the game ends at the end of the first period). I found that in this simple model the indirect appropriability argument can apply if the monopolist has commitment ability but does not apply if it does not. If the monopolist can commit in period 1 to sell only a single unit, then there are equilibria in which, because of indirect appropriability, the monopolist is able to extract all potential consumer surplus and, in turn, this gives the monopolist an incentive to invest efficiently. I also found a similar result when the monopolist had price commitment ability.

But the equilibria in which the monopolist extracts all of the surplus and invests efficiently are not the only plausible outcomes under commitment. For example, if the monopolist can commit to sell a single unit but a consumer selling a copy in period 2 splits the surplus with the buyer of the copy as opposed to capturing all of the surplus, then indirect appropriability only partially applies and the monopolist's investment in product quality will be below the efficient level. And even more importantly, if the monopolist is not able to commit to either an output level or subsequent prices, the result is no indirect appropriability. The reason is

that the buyer of a new unit in period 1 will compete with the monopolist in period 2 in trying to sell a copy or a new unit to the other consumer. The result is that the price is driven down to marginal cost as is standard in Bertrand competition type settings and there is no indirect appropriability in the sense that the price the monopolist receives for a new unit does not reflect any subsequent profits the buyer receives from selling copies.

So in this simple model the conclusion is that indirect appropriability can operate if the monopolist has commitment ability. But in the absence of the ability to commit, the monopolist has an incentive to compete in the market for copies and this eliminates the effectiveness of indirect appropriability.

IV. COMPETITION BETWEEN COPIERS CAN LIMIT INDIRECT APPROPRIABILITY

The main point of this section's analysis is that making the model more realistic can reduce the effectiveness of indirect appropriability, where the argument is that competition between copiers is what reduces the effectiveness of indirect appropriability. That is, in the previous section I showed that, if the monopolist cannot commit, then indirect appropriability is eliminated by the competition a consumer selling copies faces from the monopolist itself. The main point of this section is that, if there are more periods and more consumers, then even with commitment competition between buyers who sell copies can reduce or eliminate the effectiveness of indirect appropriability.

A) Increasing the Number of Periods

One change to the model of interest is increasing the number of periods. That is, suppose we continue to assume a single monopolist and two identical consumers, but now there are $T+1$

periods in which selling can occur. Specifically, in the first T periods the monopolist can sell a new unit to one or both consumers and, if a unit is sold to only one of the consumers prior to period t , $t \leq T+1$, then in period t the monopolist can offer a new unit to the other consumer while the consumer who purchased a unit from the monopolist can offer a copy (note that there is only the possibility for sales in period $T+1$ if the monopolist sold a new unit to one of the consumers but not if there were zero sales or two units sold by the monopolist previously). I also assume that the monopolist makes a one time choice concerning investment in product quality at the beginning of period 1.

This change by itself has little effect on the nature of equilibrium outcomes. The reason is that commitment still allows the monopolist to eliminate itself as a competitive alternative to the potential future sale of a copy, while in the absence of commitment such competition eliminates the effectiveness of indirect appropriability. For example, suppose the monopolist can commit to sell only a single unit. Then equilibria are characterized by the monopolist committing to sell only a single unit, selling the unit to one of the consumers at a price $2vQ(r^*)-c$, that consumer subsequently selling a copy to the other consumer at the price $vQ(r^*)$, and the monopolist investing r^* in product quality. In other words, the extra periods do not interfere with the effectiveness of indirect appropriability given the monopolist can commit.

On the other hand, suppose the monopolist cannot commit. Then the extra periods do not help the monopolist avoid the problem that, once a consumer buys a unit from the monopolist, the monopolist becomes a competitor of this consumer in trying to sell a new unit or copy to the other consumer. The result is that, just like in the two-period case, indirect appropriability is not operative, monopoly profitability is reduced below what it achieves in the commitment equilibria

described above, and the monopolist underinvests in product quality from an efficiency or social welfare standpoint.

B) Increasing the Number of Consumers

A second change of interest is increasing the number of consumers. That is, suppose there is a single monopolist and two periods like in Section III, but now assume there are N identical consumers rather than two. This change by itself will also have little effect on the nature of equilibrium outcomes. That is, when the monopolist has commitment ability there will be equilibria in which the monopolist extracts all the surplus and the monopolist chooses the efficient investment in product quality, but in the absence of commitment ability the result is that indirect appropriability is ineffective.

For example, consider again the case in which the monopolist can commit to sell only a single unit of output. Then all the equilibria are characterized by the monopolist selling a single unit in period 1 at the price $vQ(r^*)+(N-1)[vQ(r^*)-c]$, the single buyer selling copies to the remaining $N-1$ buyers in period 2 at the price $vQ(r^*)$ per copy, and the monopolist choosing the efficient investment in product quality, r^* .⁹ That is, the monopolist extracts all the potential surplus and invests efficiently, where the outcome is driven by indirect appropriability. As in the basic indirect appropriability argument, the buyer profitably sells copies after purchasing a new unit from the monopolist and the monopolist benefits from this because the anticipation of the future sale of copies increases the buyer's willingness to pay today for a new unit produced by the monopolist.

⁹ r^* now satisfies $NvQ'(r^*)=1$.

But just like in the two-consumer case, if the monopolist cannot commit, then indirect appropriability is ineffective. To see this, suppose commitment is not possible and the monopolist sells fewer than N units in period 1. Then competition between the period 1 purchasers and the monopolist drives down the period 2 price for a new unit or copy to c , so there are no future profits driving up a period 1 purchaser's willingness to pay. Also, there cannot be an equilibrium where the monopolist sells more than a single unit in period 1 at a price above c . The reason is that, if there was and given that the period 2 price falls to c when there is at least one unit purchased in period 1, each period 1 buyer would have an incentive to deviate and delay purchasing until period 2.

C) Increasing the Number of Periods and the Number of Consumers

In the previous two subsections I showed that increasing either the number of periods or the number of consumers does not change the main results found in Section III – indirect appropriability can be important when the monopolist can commit but is not important if commitment is not possible. In this subsection I consider what happens in the more realistic case in which there are both more consumers and more periods, where the main point is that this does significantly change the conclusions of the analysis. Specifically, I show that when there are both more periods and more consumers the result is that indirect appropriability is unimportant even if commitment by the monopolist is possible.

Before discussing this case, however, it is worth providing some perspective on the issue of commitment. The analysis in Section III already shows that indirect appropriability will typically not be effective if the monopolist is unable to commit to either quantity or future prices. If one thinks that this type of commitment is infeasible, then one might already interpret Section

III's analysis as showing that indirect appropriability is of limited importance. But I believe this is an incorrect interpretation of that analysis. In that analysis there are two periods, a single cohort of consumers, and for all consumers a new unit and a copy are perfect substitutes. As a result, if the monopolist is not able to commit, then immediately after selling a unit, the monopolist has an incentive to lower its price to compete with copies and the result is that the price is driven down to marginal cost and there is no indirect appropriability.

But there are aspects of the real world not captured in that model that would make it less likely that the firm would drop the price to compete with copies as soon as a new unit is sold. In particular, suppose there are many periods and many consumers as is assumed in this subsection, some consumers prefer a new unit to a copy, and there is a constant inflow of new consumers into the market. Then the monopolist would not want to significantly reduce its price after the initial sale of a new unit because it would want to keep the price high in order to extract more surplus from the new consumers in the market each period who prefer new units to copies. In other words, one need not interpret the commitment assumption as literally meaning the monopolist can commit which might be unrealistic. Rather, one can interpret it as a substitute for assuming realistic features such as consumers who prefer new units to copies and a constant inflow of consumers which like commitment could result in the monopolist not dropping the price significantly in later periods. Note that Section V considers a simple model with some of these features.

Given this, consider a model with multiple periods and multiple consumers. Specifically, assume N consumers and $T+j$ periods, where j is an indeterminate number of periods whose properties are described next. The monopolist can sell a new unit of output in the first T periods and the game ends at the end of the T periods if there are no purchases of new units or copies in

period T . However, if there is a purchase in period T , then the game extends another period.

Also, the game continues to extend for additional periods until there is a period in which no new unit or copy is sold. By modeling the game this way I allow every buyer of a new unit or copy, given there is at least one consumer who owns neither a unit purchased from the monopolist or a copy, to have at least one opportunity to sell a copy.

Not surprisingly, if the monopolist cannot commit in this model, the result is that indirect appropriability is not effective. And the logic for the result is the same as for the similar result in earlier specifications. First, if the monopolist sells a unit in some period t , then beginning in the next period competition drives the price of new units and copies to marginal cost so there is no increased willingness to pay for a new unit based on future profits associated with selling copies. Further, the monopolist cannot sell more than a single copy at a price above c in any period because each consumer would have an incentive to deviate and delay his or her purchase to the following period in which the consumer could obtain a new unit or copy at a price equal to c .

In contrast to the similarities between this model and the previous models in the case of no commitment, when commitment is possible equilibrium in this model is quite different from what happened in the analysis of previous models when commitment was possible. Suppose, for example, the monopolist can commit to a maximum number of units it will sell. In each of the previous models the ability to commit in this way resulted in the monopolist extracting all of the potential surplus and also investing efficiently. That is not the case in this subsection's model.

For example, in previous models when quantity commitment was possible, in equilibrium the monopolist was able to extract all of the surplus by committing to sell only a single unit of output. Suppose the monopolist commits to sell only a single unit of output in this model and call the investment level r' . In the period immediately after purchasing the new unit the buyer

will be the only consumer with a new unit and thus the only buyer who can make a copy. So in a sense this buyer is in a situation similar to the monopolist at the beginning of the game. If I were to assume, however, as I think is plausible that in selling copies consumers cannot commit to quantity levels or restrictions on future prices, arguments like those above yield that this first buyer will earn profits from copying no more than $vQ(r') - c$ because competition between this buyer and subsequent purchasers of copies will cause a copy to become available at a price of c in the period after the first copy is sold. This means that through indirect appropriability the monopolist can do no better than extract the full potential surplus from two consumers and zero potential surplus from other consumers, where this is the case even if the number of consumers in the market gets very large.

In other words, if I assume the monopolist can commit to either output levels or future prices but that consumers selling copies do not have the ability to commit, then indirect appropriability becomes mostly ineffective. The reason, as captured in the above discussion, is that competition between consumers who sell copies drives the copy price down to marginal cost and under Bertrand type competition only two consumers selling copies is required to achieve this result. So giving the monopolist the ability to commit improves potential profitability a little. Without commitment ability the best the monopolist can do is extract all the surplus from a single consumer because after a single consumer purchases a unit the competition between this consumer and the monopolist means price will be driven down to marginal cost. With commitment the monopolist can avoid this type of competition, but if consumers cannot commit then the best the monopolist can do is extract all the surplus from two consumers because after two consumers purchase a new unit or a copy the competition between the two consumers will drive the copy price down to marginal cost. And, as indicated, this result that the ability to

commit results in potential monopoly profitability increasing at most by the surplus of a single consumer is independent of the number of consumers in the market.

This is an important result because giving the monopolist the ability to commit but not giving this ability to consumers is the most realistic set of assumptions concerning who has commitment ability. As discussed above, giving the monopolist commitment ability is in a sense a reduced form way of capturing monopoly behavior when some consumers prefer new units over copies and there is an inflow of new consumers each period. But these additional realistic assumptions do not provide a rationale for giving consumers commitment ability. Further, another reason for assuming an individual or firm has commitment ability is that the individual or firm is in a repeated game setting and assuming commitment ability allows the model to capture the outcome of a reputation formation process without actually modeling a repeated game. This logic provides a rationale for assuming commitment ability for the monopolist but seems like a weak argument for consumers.

In summary, a major reason that indirect appropriability is limited in real world markets is that competition drives down the price of copies to marginal cost. This can occur with as few as two consumers in the market if the monopolist cannot commit because then competition between the monopolist and a consumer selling copies drives the price of new units and copies to zero. And with more consumers, even if the monopolist can commit, competition between consumers selling copies will drive the price of copies to marginal cost. So, since most markets of interest where copying is an issue have many consumers, the possibility that competition drives the copy price to marginal cost serves as a major constraint on the indirect appropriability argument.

V. SUBSTITUTABILITY BETWEEN NEW UNITS AND COPIES LIMITS INDIRECT APPROPRIABILITY

In this section I show another factor that serves to limit indirect appropriability. As discussed earlier, the indirect appropriability argument draws an analogy with the standard argument in the durable goods literature that the new-good price should reflect the price the good will eventually sell for on the secondhand market. In discussing this point, Swan (1980) argues that as a result the availability of secondhand markets should not reduce the new-unit price or the profitability of a new-unit seller. But building on the classic analysis of Mussa and Rosen (1978) concerning how a monopolist prices a product line, more recent papers such as Anderson and Ginsburgh (1994), Waldman (1996,1997), and Hendel and Lizzeri (1999) have shown that the availability of used units can indeed reduce profitability of a new-unit seller because the availability of used units can reduce willingness to pay for a new unit.¹⁰

In this section I show how this argument can be applied to the market for copies. In contrast to the models considered earlier, in this section's model I assume consumers are heterogeneous in terms of their valuations for product quality and that copies are an inferior substitute product. The basic result is that the availability of copies limits the price the monopolist can charge for a new unit and this, in turn, limits the effectiveness of indirect appropriability in reducing inefficiencies due to underproduction.

A) The Model

The model I construct is similar to Section III's model but consumers are heterogeneous

¹⁰ These papers also build on earlier arguments that can be found in Miller (1974), Benjamin and Kormendi (1974), and Liebowitz (1982).

and copies are lower quality than new units. I show that, given two consumers – one high valuation and one low valuation, the model works in a fashion similar to what was found in Section III. But when a second high valuation consumer enters the market in period 2 there is a new factor limiting indirect appropriability.

Consider a two-period setting characterized by a monopolist and either two or three consumers. As earlier, the monopolist has a constant marginal cost of production equal to c and the monopolist's investment in quality, r , determines quality, $Q(r)$, where $Q(\cdot)$ has the same properties as before. And there is again no discounting.

I consider two cases. In the first case there are two consumers as before, but now the two consumers have different valuations for product quality. Consumer 1 is the high valuation consumer and consumer 2 the low valuation consumer, where $v_j Q$ is the gross benefit consumer j , $j=1,2$, derives from consuming a unit of quality Q and v_2 is sufficiently large (or c sufficiently small) that consumer 2's gross benefit from consuming a copy in equilibrium always exceeds the cost of making a copy. The second case is identical to the first except that there is a third consumer, where $v_3=v_1$. In both cases the first two consumers are present in the market starting in period 1, while in case 2 the third consumer enters the market in period 2. I also assume $v_1 \gg v_2$ so that whenever it has a choice the monopolist chooses a high price and sells only to the high valuation consumer or consumers rather than choosing a low price and selling to both high and low valuation consumers.

As before, a consumer who purchases the monopolist's product can make a copy that he or she can potentially sell to the other consumer or consumers. But now copies are not perfect substitutes for new units. In particular, if Q is the quality of the monopolist's product, then αQ , $0 < \alpha < 1$, is the quality of a copy. I also again assume that c is the marginal cost of making a copy.

The timing of the game is as follows. The first period starts with the monopolist choosing an investment level. The monopolist then sets a period 1 price and each consumer present in the market decides whether or not to purchase a unit. If one or more new units are sold in period 1 and in period 2 there is at least one consumer who does not own a unit purchased from the monopolist, then in period 2 the monopolist can offer a new unit and consumers who own used units can offer copies where prices are chosen simultaneously. On the other hand, if no units are sold in period 1, then the game ends at the end of period 1 (see footnote 5). Also, the focus is again on pure strategy Subgame Perfect Nash equilibria.

B) Analysis

I start with case 1, i.e., the two consumer case. Let r^* again denote the first best efficient effort level which is now characterized by $(v_1+v_2)Q'(r^*)=1$. Suppose the firm cannot commit and let r_{NC}^1 denote the investment level chosen by the monopolist in this case. If the monopolist sells a new unit in period 1 to consumer 1, then in period 2 the price for a copy equals c , the price for a new unit is $c+v_2(1-\alpha)Q(r_{NC}^1)$, and consumer 2 buys a new unit. Given this and $v_1 \gg v_2$, equilibrium is such that the monopolist chooses an investment level $r_{NC}^1 < r^*$, sells a new unit in period 1 to consumer 1 at the price $v_1Q(r_{NC}^1)$, and a new unit to consumer 2 in period 2 at $c+v_2(1-\alpha)Q(r_{NC}^1)$. In other words, because of competition between new units and copies in period 2, the profitability of selling a copy in period 2 drops to zero and thus there is no indirect appropriability. Monopoly profitability in this case equals $v_1Q(r_{NC}^1)+v_2(1-\alpha)Q(r_{NC}^1)-c-r_{NC}^1$.¹¹

Now suppose the monopolist can commit and chooses to commit to sell only a single unit. Now if the monopolist sells a new unit to consumer 1 in period 1, then in period 2

consumer 1 sells a copy to consumer 2 at the price $v_2\alpha Q(r_C^1)$, where r_C^1 is the investment level under commitment in this case. Given this and $v_1 \gg v_2$, equilibrium given the monopolist commits to sell only a single unit is that the monopolist chooses an investment level $r_C^1 < r^*$, sells a new unit in period 1 to consumer 1 at the price $v_1 Q(r_C^1) + [v_2\alpha Q(r_C^1) - c]$, and consumer 1 sells a copy to consumer 2 in period 2 at the price $v_2\alpha Q(r_C^1)$. Monopoly profitability in this case equals $v_1 Q(r_C^1) + v_2\alpha Q(r_C^1) - 2c - r_C^1$.¹² Since the monopolist could choose $r_C^1 = r_{NC}^1$, a comparison of the profit expressions yields the monopolist will commit to sell a single unit when commitment is possible as long as α is sufficiently high, i.e., as long as new units and copies are sufficiently close substitutes.

The above analysis shows that when new units and copies are close substitutes and there are just two consumers, then the analysis works basically the same way as the two-period/two-consumer analysis of Section III. Without commitment, competition between new units and copies in period 2 drives the profit of selling copies to zero so there is no indirect appropriability. With commitment, there is a positive profit associated with selling a copy in period 2 and as a result there is indirect appropriability and monopoly profits increase. Also, in the commitment case indirect appropriability allows the monopolist to capture all the profits associated with the sale of copies in period 2.¹³

Now consider case 2, i.e., there is a third consumer who enters the market in period 2, where as indicated earlier this consumer is a high valuation consumer identical to consumer 1.

¹¹ Taking the derivative of monopoly profitability with respect to r_{NC}^1 yields $[v_1 + v_2(1-\alpha)]Q'(r_{NC}^1) = 1$ as the first order condition. Comparing this expression to the equation that defines r^* yields $r_{NC}^1 < r^*$.

¹² Taking the derivative of monopoly profitability with respect to r_C^1 yields $(v_1 + \alpha v_2)Q'(r_C^1) = 1$ as the first order condition. Comparing this expression to the equation that defines r^* yields $r_C^1 < r^*$.

¹³ One difference is that here $r_C^1 < r^*$. But one might argue that the appropriate comparison is to a second best investment level defined by which consumers actually consume a unit or copy. Call this investment level r^{**} . In this

Let r^* again denote the first best efficient investment level, which is now characterized by $(2v_1+v_2)Q'(r^*)=1$. Again, start with the case in which the firm cannot commit and let r_{NC}^2 denote the investment level chosen by the monopolist in this case. Suppose the firm sells a new unit in period 1 to consumer 1. Given $v_1 \gg v_2$, in period 2 consumer 1 sells a copy to consumer 2 and the monopolist sells a new unit to consumer 3. The price for the copy is $v_2\alpha Q(r_{NC}^2)$. Further, since consumer 3 could also purchase a copy from consumer 1 at this price, the monopolist is constrained in terms of the price it charges and thus in period 2 it sells a new unit to consumer 3 at the price $v_2\alpha Q(r_{NC}^2)+v_1[(1-\alpha)Q(r_{NC}^2)]$. Since consumer 1 anticipates this in period 1, the monopolist sells a new unit to consumer 1 in period 1 at $v_1Q(r_{NC}^2)+[v_2\alpha Q(r_{NC}^2)-c]$. So overall monopoly profitability equals $v_1Q(r_{NC}^2)+2v_2\alpha Q(r_{NC}^2)+v_1[(1-\alpha)Q(r_{NC}^2)]-2c-r_{NC}^2$ which, in turn, yields $r_{NC}^2 < r^*$.¹⁴

Now suppose the monopolist can commit and let r_C^2 denote the investment level chosen by the monopolist in this case. If it sells a new unit or units in period 2, the best it can do is the no commitment solution above since the period 2 price above is the maximum price the firm can charge and get consumer 3 to purchase a new unit rather than a copy. Alternatively, it could commit not to sell a new unit in period 2. Then, if consumer 1 purchases a new unit from the monopolist in period 1, it would then sell a copy to consumer 3 in period 2 at $v_1\alpha Q(r_C^2)$ (this is better for consumer 1 than selling copies to both consumers given our assumption $v_1 \gg v_2$). This

case r^{**} satisfies $(v_1+\alpha v_2)Q'(r^{**})=1$, which in turn means $r_C^1=r^{**}$. So, viewed from this perspective, in this case indirect appropriability does solve the underinvestment problem.

¹⁴ Taking the derivative of monopoly profitability with respect to r_{NC}^2 yields $[v_1(2-\alpha)+2v_2\alpha]Q'(r_{NC}^2)=1$ as the first order condition. Given $v_1 \gg v_2$, a comparison of this expression with the equation that defines r^* yields $r_{NC}^2 < r^*$.

means the period 1 price would be $v_1Q(r_C^2)+[v_1\alpha Q(r_C^2)-c]$ and monopoly profitability equals $v_1Q(r_C^2)+v_1\alpha Q(r_C^2)-2c-r_C^2$ which also yields $r_C^2 < r^*$.¹⁵

Given $v_1 \gg v_2$, comparing the two profit expressions (and realizing that in the commitment case the monopolist could choose $r_C^2 = r_{NC}^2$) yields that if α is sufficiently close to 1 then the firm commits not to sell anything in period 2. Also, in this case $r_C^2 > r_{NC}^2$.¹⁶ But if α is sufficiently below 1 then the equilibrium in the commitment case is identical to equilibrium behavior when the monopolist could not commit.

There are a few things different concerning this case relative to the case with two consumers. First, in the two-consumer case there was no indirect appropriability in the absence of commitment. But here consumer 1 profitably sells copies in period 2 even without commitment which means there is indirect appropriability even in that case. Second, in the two-consumer case when there was indirect appropriability monopoly profit was increased by an amount equal to the profit consumer 1 earned by selling copies in period 2. That is true here when the monopolist can commit and chooses not to sell anything in period 2. But when the monopolist either cannot commit or can commit and chooses not to, then the monopolist sells a new unit in period 2 to consumer 3 and monopoly profitability does not fully reflect the copying profit earned by consumer 1 in period 2. Rather, because of the substitutability between new units and copies, the copy price limits the new unit price which means the profit associated with indirect appropriability is reduced and so indirect appropriability in this case has a limited effect

¹⁵ Taking the derivative of monopoly profitability with respect to r_C^2 yields $v_1(1+\alpha)Q'(r_C^2)=1$ as the first order condition. Comparing this expression with the equation that defines r^* yields $r_C^2 < r^*$.

¹⁶ That $r_C^2 > r_{NC}^2$ when α is sufficiently large follows immediately from comparing the equations that define r_C^2 and r_{NC}^2 in footnotes 14 and 15.

on reducing the underproduction problem.¹⁷ In other words, in addition to the limits of indirect appropriability discussed in Section III, the returns to indirect appropriability can also be limited by the potential substitutability between new units and copies when the monopolist finds it profitable (even under commitment) to sell new units in later periods.

VI. DISCUSSION

The main point of the analysis in Sections III through V is that there are factors that can serve to limit indirect appropriability. So the question is, to what extent are these factors important in real world markets? And my sense of the answer is that any serious consideration of markets in which copying is possible suggests that indirect appropriability is important in some selected markets, but in many markets where copying is possible indirect appropriability is either not present or of limited significance.

As pointed out originally by Liebowitz (1985), a good example of a market in which indirect appropriability is important is that of libraries and journals. A library's users will typically place a higher value on visiting the library if copies can be made on the premises. To the extent that the library can then increase the payments it receives from users based on this higher value, the library's willingness to pay for journals increases which should then translate into higher quality and a larger variety of journals. And note that this argument can apply more generally than what are called subscription libraries where members pay a membership fee. For example, this argument can apply to a university library where the university is able to increase

¹⁷ As discussed in footnote 13, in this model the appropriate comparison is arguably to a second best investment level, r^{**} , defined by which consumers consume a copy or unit. In this case r^{**} satisfies $(2v_1 + \alpha v_2)Q'(r^{**}) = 1$. A comparison of this expression with the equation that defines r_{NC}^2 in footnote 14 yields that the monopolist underinvests in quality.

tuition if students value the ability to make copies at the university library. And it can also be applied to public libraries if taxpayers who use the library value copying and are thus willing to pay higher taxes to support the library when copying is possible.

But in many other real world markets the indirect appropriability argument seems weak. For example, if one wants to download music from the web there are frequently both legal and illegal sites from which the music can be downloaded for free. So there are revenues associated with these sites from advertising, etc., but the revenue generated per download seems to be quite limited since there is no actual charge. And the reason there is no actual charge is basically the argument of Section IV. There are multiple sites on the web at which copies can be made so, if one site included a substantial charge, individuals interested in downloading could simply switch to a site with no charge.

Of course, there are numerous examples such as the iTunes Store of firms that sell legal music on the web so this substitution argument does not stop a positive price in all cases. Some customers prefer to purchase music legally and the iTunes Store, in particular, also has the advantage of being especially well designed and easy to use. But even in the iTunes case the availability of free downloads seems to substantially limit the price that iTunes can charge. For example, the iTunes Store charges about \$10 for an album, but based on album prices in the early 90s before free downloads became important one would have predicted album prices much higher than \$10. Although it is worth pointing out that iTunes's costs are significantly lower because no physical good is produced and shipped. And it is also worth noting that the fact that iTunes charges a positive price is not evidence for indirect appropriability since the iTunes Store sells original units not copies.

One final point is that there is probably another factor limiting indirect appropriability in many markets not captured in the earlier analyses. As discussed by Liebowitz in his analysis of libraries and copying, the indirect appropriability argument requires the sellers of original units to be able to price discriminate when only a small subset of buyers (the libraries in his argument) receive substantial revenues from selling copies or more generally making copies available. In the case of libraries this type of price discrimination is feasible. In the case of music on the web this type of price discrimination does not seem feasible. So, even if these free legal and illegal sites make some profits from advertising, etc., it is unclear that these profits translate into higher revenues and profits for the music publishers.

VII. CONCLUSION

In durable goods markets a consumer's willingness to pay for a new unit will typically reflect the expected price the good will sell for on the secondhand market in the future. This, in turn, significantly contributes to the quality, durability, and variety of durable goods that are available in the market. Suppose markets for copying worked like durable goods markets in the sense that a consumer's willingness to pay for a copy had a substantial component that reflected expected future profits the consumer would derive from the sale of copies. Then illegal copying would likely not have significant negative effects on the quality and variety of creative works. This is the indirect appropriability argument.

But casual observation of most real world markets where copying is present suggests that few profits are involved in the sale of illegal copies and so the indirect appropriability argument seems of limited relevance in most of these markets.

In this paper I have explored a series of simple related models to demonstrate the factors that limit indirect appropriability. I focused on two factors. First, competition between either the seller of a creative work and those selling copies or only among those selling copies limits indirect appropriability. The argument is that such competition will drive the copy price down to marginal cost in which case no profits are associated with the sale of copies and so copying will hurt rather than help the incentive for the creation of new works.

Second, substitutability between new units and copies also limits indirect appropriability. A high valuation consumer's willingness to pay for a new unit depends on whether copies are available and the price the copy sells for. The result is that, if there is a constant inflow of high valuation consumers into the market, the availability of copies reduces willingness to pay of high valuation consumers who enter the market later after copies are available which, in turn, also limits the effects of indirect appropriability.

Overall, the indirect appropriability argument is an important insight and does help explain behavior in some markets where copying is important such as in the case of libraries. But there are a number of factors present in many if not most real world markets where copying is important that limit the importance of indirect appropriability for these markets.

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