

THE EMERGENCE OF COPYING TECHNOLOGIES:

WHAT HAVE WE LEARNED

by

Ian E. Novos  
Department of Economics  
University of Southern California

and

Michael Waldman  
Department of Economics  
UCLA  
Los Angeles, CA 90024

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## ABSTRACT

The last few decades have seen dramatic advancements in the technology of copying and the diffusion of copying technology to the general public. In this paper we survey some of the recent academic literature which deals with markets where copying is an issue. In particular, our survey concentrates on two topics: (i) what is the effect of varying the extent of property rights enforcement by the government; and (ii) what are possible responses by producers of originals to the ability of consumers to produce copies?

## I. Introduction

The last few decades have seen dramatic advancements in the technology of copying and the diffusion of copying technology to the general public. For example, the original Xerox machine was introduced in 1959 and today the photocopying machine is an integral component of the office environment. Similar advances have also increased the ability of consumers to copy both video and audio products. This increased access of consumers to copying technology has led to substantial public policy debate. The debate centers around possible deleterious effects that copying might have on the supply of originals, and in turn, remedies that might help ameliorate these effects.

This increased interest in copying from a public policy standpoint has stimulated much additional research in this area.<sup>1</sup> In this paper we will survey some of the recent academic literature with two particular topics in mind: (i) what is the effect of varying the extent of property rights enforcement by the government; and (ii) what are possible responses by producers of originals to the ability of consumers to produce copies? The outline for the paper is as follows. In Section II we first describe the two social welfare losses which can arise in a market where copying is possible, and then present the traditional viewpoint for how these losses vary with the extent of property rights enforcement by the government. In Section III we show how the analyses contained in a number of recent studies throw doubt on this traditional viewpoint. In particular, we show that varying the extent of property rights enforcement has effects which the traditional analysis ignores, with the result being that the social welfare losses mentioned above can

move in ways not previously recognized. Section IV considers possible market responses to the ability of consumers to produce copies. Among others, we consider the role of price discrimination and complementary products when copying is possible. Finally, in Section V we present some concluding remarks.

## II. The Traditional Viewpoint

Consider a market wherein copying is an issue, e.g., the market for computer software sold in the form of computer disks. There are two social welfare losses associated with this type of market. First, given the ability of consumers to produce copies, some consumers will be able to get access to the good without paying the original producer. This potential for free riding suggests that from a societal standpoint either quality or variety will be too low because the incentive to produce is inadequate. This loss has come to be known as the social welfare loss due to underproduction. It is similar to the loss that occurs in the classic public goods case (see e.g., Samuelson (1954)).

Besides having the property of being copyable, goods of this type typically display another important characteristic. That is, production is typically characterized by decreasing average costs with the resulting price exceeding the marginal cost of production. Hence, the second social welfare loss is similar to the standard monopoly type loss which results when price exceeds marginal cost. This loss has come to be known as the social welfare loss due to underutilization.

There are many policies available to the government which allow the government to affect the magnitude of these two losses. One way to look

at a number of these various policies is simply to say that the government can vary the extent to which property rights are enforced. That is, it can vary how difficult it is for a consumer to get a copy of the good without paying the original producer.

When looked at in this way, the following question immediately arises. As the government varies the extent of property rights enforcement, what is the effect on the two social welfare losses referred to previously? The traditional view on this subject is to regard the problem as being analogous to the problem of patents.<sup>2</sup> This view suggests that as the government increases property rights enforcement the following two things will occur: (i) there will be a decrease in the social welfare loss due to underproduction; and (ii) there will be an increase in the social welfare loss due to underutilization. The logic for these predictions is as follows. As indicated above, an increase in property rights enforcement means that it is more difficult for a consumer to acquire a copy of the good without paying the original producer. Hence, an increase in enforcement will have the following two effects. First, because of the increased cost of copying, some consumers who were previously copying the good will now purchase the good from the original producer (a decrease in the underproduction loss). Second, other consumers who were previously copying will also find that it is not worthwhile to copy, but rather than acquire the good from the original producer they simply wind up not getting the good in any manner (an increase in the underutilization loss).

Taking this viewpoint, the implications for public policy of the

emergence of new copying technologies is straightforward. In setting the level of property rights enforcement the government faces a trade-off between the underproduction and underutilization losses. The new copying technologies have increased the underproduction loss and decreased the underutilization loss. Hence, the trade-off now suggests that property rights enforcement should be increased.

### III. Implications of Some Recent Analyses

As indicated in the previous section, the traditional viewpoint is that an increase in property rights enforcement has straightforward implications for the social welfare losses due to underproduction and underutilization. Some recent analyses suggest this is incorrect, and that instead the implications of such an increase are actually quite complex. In this section we review some of the arguments contained in these recent papers and, in particular, we show why the problem of setting the optimal level of property rights enforcement should not be viewed as a simple trade-off between the underproduction and underutilization losses.

Consider first the social welfare loss due to underutilization. This is the loss due to the original producer pricing above the marginal cost of production. In considering this loss, the traditional analysis views the problem as being analogous to the simple monopoly problem. That is, because the price is above the marginal cost of production, some consumers who should obtain the good don't. Further, an increase in property rights enforcement will typically result in fewer individuals getting access to the good. Hence, an increase in property rights

enforcement will increase the underutilization loss.

As pointed out in Novos and Waldman (1984) and Johnson (1985), when copying is an issue the underutilization loss is not simply the loss due to consumers who should get access to the good but don't. In particular, there is a second component of the underutilization loss which consists of the excess costs consumers spend on copying. For example, suppose an individual considers as perfect substitutes a brand new album which he can buy in a record store, and a recording of the same album that he can make if he borrows the album from a friend. Further, suppose the price of a new album is \$8, while the marginal cost of production for the manufacturer is only \$2. In this case our individual will make a copy rather than purchase from the original manufacturer as long as he can make a copy for an expenditure in real resources of less than \$8 (note: by expenditure in real resources we mean the time costs involved in making a copy plus any material costs he might incur). Obviously, this means that even if our individual gets access to the album by copying, there is a potential for an underutilization loss of up to \$6 in real resources.

Once this second component of the underutilization loss is taken into account, an increase in property rights enforcement will no longer necessarily increase the underutilization loss. To see this consider the following. If there is an increase in property rights enforcement, the underutilization loss is actually affected in three different ways.<sup>3</sup> The first of these ways is simply the effect identified in the traditional analysis. That is, some consumers who were previously copying the good will find that it is both not worthwhile to copy, and

not worthwhile to acquire the good from the original producer. As before, this effect suggests that an increase in property rights enforcement will tend to increase the underutilization loss. A second way that the underutilization loss is affected is through consumers who were previously copying the good and who continue to copy. Increasing property rights enforcement means that it is costlier to acquire a copy. Hence, for these consumers any excess expenditures on copying will now be larger, which means there is again a suggestion that an increase in property rights enforcement will tend to increase the underutilization loss. The final way that the underutilization loss is affected is through consumers who were previously copying the good, but who now purchase the good from the original producer. The consumers who switch in this way must be those for whom expenditures on copying are near the price being charged by the original producer. Hence, when these consumers switch over to the purchasing of originals, there is a decrease in the amount of real resources which are being consumed. In other words, this third factor suggests that an increase in property rights enforcement would actually decrease the underutilization loss.

What we have, therefore, is that two factors suggest a positive relationship between property rights enforcement and the size of the underutilization loss, while a third factor suggests that there should be a negative relationship. In our original paper we worked through a simple specification where the third factor was dominant, and hence, an increase in property rights enforcement caused a decrease in the underutilization loss. More generally, it is easy to demonstrate that any of the factors can be dominant, and thus, when costs of copying are



taken into account the prediction is that there is an ambiguous relationship between property rights enforcement and the size of the underutilization loss.

We now turn our attention to the social welfare loss due to underproduction. This is the loss due to the consumers who get access to the good without paying the original producer. In considering this loss, the traditional analysis has viewed the problem as being analogous to the case of a pure public good. Because some consumers get access to the good without paying the original producer, the free rider problem suggests that either quality or variety will be too low because the incentive to produce is inadequate. We also know that an increase in property rights enforcement will tend to decrease the number of copiers. Hence, an increase in property rights enforcement will decrease the underproduction loss.

As pointed out by Liebowitz (1985), the analogy with the case of a pure public good misses an important aspect of the problem.<sup>4</sup> In particular, it misses the possibility that copies of the good are sold rather than given away. Once this aspect of the problem is taken into account, the above conclusion concerning how property rights enforcement affects the underproduction loss can actually be reversed. To see this suppose there is an increase in property rights enforcement when copies are being sold at a profit. This increase will cut down on the number of copies being sold. In turn, this may well lower the valuation that buyers of originals have for originals, since the profit such buyers can now derive from sales of copies will be reduced. Hence, an increase in property rights enforcement may actually lower the demand for originals,

which in turn implies an increase in the underproduction loss rather than the decrease predicted by the traditional analysis.

The general applicability of the above argument is not at all clear, however, because the argument is predicated on the existence of market power in the market for copies. That is, suppose there are a large enough number of agents selling copies such that the market for copies is best thought of as being perfectly competitive. The subsequent zero profit constraint implies that the above reasoning will no longer be valid. The logic is as follows. An increase in property rights enforcement will still cut down on the number of copies being sold. However, this will not lower the valuation that buyers of originals have for originals, because the zero profit constraint implies that the profitability of selling copies will be unchanged. Hence, the above argument only suggests that an increase in property rights enforcement can increase the underproduction loss if there is market power in the market for copies.

In looking at actual markets where copying is an issue, it is somewhat difficult to believe that market power is significant. Thus, one is left with the impression that the above idea which Liebowitz refers to as "indirect appropriability" is somewhat narrow in terms of applicability. Note, however, this is not a criticism of Liebowitz's initial paper, since there the concept was applied to a market setting where a type of "market power" is quite plausible. In particular, Liebowitz originally applied the idea to the market for academic journals, where copying typically takes place at libraries. Because of transportation and time costs, it is easy to believe that consumers who

copy at libraries do not consider different libraries as perfect substitutes, i.e., in some sense each library has market power. Given this, the above argument seems to be correct for this case. An increase in property rights enforcement increases the cost of acquiring a copy, which in turn implies a decrease in the valuation that consumers place on library services. If the objective function of a library is to maximize the welfare of its patrons, the above implies that an increase in property rights enforcement will decrease the demand for originals by libraries. Finally, this decrease in demand for originals means that an increase in property rights enforcement can actually decrease the quality and variety of journals produced.

There is a second reason for why property rights enforcement and the loss due to underproduction may be negatively related. The reason is that a purchaser of originals may value copies he makes for his own use. For example, consider the case of a buyer of cable television who makes copies of telecasts either so that he can watch the telecast at a time which is more convenient than the original telecast time, or because he wants to add the telecast to a permanent collection. In either case, it is possible to imagine that an increase in the cost of copying could actually lower the valuation that the individual has for cable TV. Hence, we have another reason for why property rights enforcement and the loss due to underproduction may be negatively related.

Overall, therefore, we see that the implications of an increase in property rights enforcement are quite complex. First, because of the excess costs consumers spend on copying, it is possible for such an

increase to have either a positive or negative effect on the social welfare loss due to underutilization. Second, because restrictions on copying can actually lower the valuation consumers place on originals, we get a similar conclusion for the social welfare loss due to underproduction. Hence, it is clear that choosing the socially optimal level of property rights enforcement should not be viewed as a simple trade-off between the underproduction and underutilization losses.

#### IV. Market Responses

In the previous section we considered some of the implications of the government varying the level of property rights enforcement. Of course, the government is not the only agent in the economy which can respond to the ability of consumers to produce copies. In particular, producers of originals will also frequently respond to this ability. In this section we consider some of these market responses.

One market response arises in the context of the problem of indirect appropriability considered in the previous section. One thing a producer of originals would obviously like to do is price discriminate, i.e., charge a higher price to consumers who place a higher valuation on originals. Indirect appropriability referred to the idea that the valuation for originals will partially depend on the profit that can be derived from the sale of copies. This would suggest the following as a potential market response to the ability of consumers to produce copies. That is, producers of originals could price discriminate by charging a higher price to consumers who derive a large profit from the sale of copies.<sup>5</sup>

In general, the above market response is probably limited in terms of applicability for two reasons. First, as pointed out in the previous section, indirect appropriability only arises if some sellers of copies possess market power, and it would seem that in most such markets there is not significant market power on the part of sellers of copies. Second, to the extent that market power exists, problems can arise either in terms of preventing resale or in terms of identifying who the sellers with market power are. However, the setting initially considered by Liebowitz, i.e., the market for academic journals, does seem to be a setting where this type of market response is significant. As pointed out earlier, this would seem to be a setting where "sellers" of copies do typically possess market power of a sort. In addition, identifying who the appropriate sellers are and preventing resale would also seem to be problems which can be overcome in this environment. Hence, although we would not expect price discrimination to be a general response to the problem of copying, it does seem to be a potential market response in at least some environments.

A second type of market response can occur when the environment contains a good which is complementary to the good which can be copied. For example, suppose that two goods are perfect complements - they can only be used jointly - and consumers have the ability to make copies of one of the two goods. In this case a manufacturer can tie the sale of the two goods together and in this way avoid any problems associated with copying. A simple illustration of this occurs with almost any good that comes with instructions. That is, instructions can be copied and thus, if a manufacturer tried to sell instructions separately from the

product to which the instructions pertain, problems of underproduction and underutilization would arise. Manufacturers typically avoid these problems by providing instructions "free" with the purchase of the product.<sup>6</sup>

Of course, goods can be complementary to such a limited extent that bundling them together is not feasible. However, if two goods are complementary, even if they are not sold as a package, there is still reason to believe that some of the losses due to underproduction and underutilization may be avoided. To see this consider the following.<sup>7</sup> It is well known that when two separate firms produce complementary products, each firm does not internalize how its own price and quality decisions affect the profitability of the other firm. Hence, there is an incentive for a single firm to produce both goods since this will increase aggregate profits.<sup>8</sup>

Now consider what happens when a single firm produces complementary products, where the goods are not sold as a package, and one of the products is copiable. For example, suppose a single firm produces both computers and computer software. In such an environment there are two important factors affecting the underproduction and underutilization losses. The underproduction loss arises because those who copy do not pay the actual producer of the software. However, since in this case copiers must buy the computer from the same firm, there exists an avenue by which the producers of software can internalize some of the societal benefits enjoyed by copiers. This is the first factor present, and it suggests that having the same firm produce both goods should result in a reduction in the size of the underproduction loss. On the other hand,

when a single firm produces both goods, the firm will likely have an incentive to increase the price of the computer and decrease the price of software. Such behavior would tend to increase profits because of the subsequent decrease in the number of copiers. This is the second factor present, and it suggests that having the same firm produce both goods should result in a reduction in both the underproduction and underutilization losses.

The above suggests that when the environment contains a good which is complementary to the good which can be copied, avenues are open to the manufacturer which should allow parts of the underproduction and underutilization losses to be avoided. One thing to note, however, is that the above argument only makes sense if the seller of the complementary good has some market power. The logic here is that in the absence of market power any change in the production or pricing of the copiable good will be reflected in the industry demand for the complementary good, rather than the demand for the product of any particular firm. Hence, if a manufacturer produced both goods, but had no market power in the market for the complementary good, neither of the previously mentioned factors which help reduce the underproduction and underutilization losses would be present. If we now go back to our example of computers and computer software, this suggests that IBM may well behave in a manner which will tend to reduce the underproduction and underutilization losses, while we would not expect such behavior from a firm like Kaypro Computers.

The final market response we will consider is simply that producers of originals can try to make their products more difficult to copy.

A straightforward example of this occurs with computer software. That is, producers of computer software frequently "copy protect" their disks - the purpose being that this cuts down on the number of illegal copies produced. More exotically, a type of paper is now being developed which is not copiable through the use of standard photocopying technology. It works by being reflective, i.e., the paper cannot be copied because the flash of the photocopying machine is reflected back at the lens of the machine. Producers of photocopyable products may soon have the option of using this type of paper, and by doing so avoid the problems which arise when consumers have the ability to easily produce copies.

Since the result of this market response is that it is more difficult for consumers to produce copies, the response would seem to be analogous to an increase in property rights enforcement by the government. Hence, from the previous section we can conclude that when a firm responds in this way, there can be either a positive or negative effect on the welfare loss due to underutilization. One might also be tempted to draw a similar conclusion concerning the loss due to underproduction. This, however, would be incorrect. A firm would not make its product more difficult to copy unless on net this resulted in an increase in the demand for originals. Hence, if this market response were to be employed, one could be quite certain that the result would be a decrease in the loss due to underproduction.

Overall, we see that there are a number of different ways that the market may respond to the ability of consumers to produce copies. First, producers of originals may attempt to price discriminate by charging a higher price to consumers who derive a large profit from the



sale of copies. Second, if a complementary good exists which is not copiable, the market may respond by tying the two goods together, or at least by having the same firm produce both goods. Either way we would expect a reduction in both the underproduction and underutilization losses. Third, producers of originals may directly alter their products in a manner which makes copying more difficult.

#### V. Conclusion

In this paper we have considered both the effects of property rights enforcement by the government when copying is an issue, and the types of market responses which could arise in such an environment. The question now arises as to what conclusions can be drawn concerning public policy. In Section III we showed that, in terms of both the underproduction loss and underutilization loss, an increase in property rights enforcement can cause a movement in either a positive or negative direction. Hence, the choice of an optimal level of property rights enforcement should not be viewed as a simple trade-off between these two losses. One might ask, therefore, is there some alternative perspective from which one might judge public policy proposals? We feel that the discussion in Section IV suggests one such alternative.

In Section IV we discussed potential market responses to the ability of consumers to produce copies. We feel that in many cases property rights enforcement by the government serves as a substitute for these private methods of responding, and therefore, that the appropriate policy for the government is to enforce property rights when public enforcement is cheaper than private enforcement. For example, suppose

there is a product for which at some cost the government can stop copying by consumers. If, however, the government does not eliminate copying, then the producer will alter the product in a way which makes copying impossible. From a public policy standpoint, it is clear the government should prohibit copying if its costs of doing so are lower than the producer's cost of altering his product.

In some sense, our suggestion simply makes explicit a perspective on the problem which frequently is an important factor even if only by default. Consider the case of computer software. The government's cost of limiting copying by individuals is obviously prohibitive. Hence, following the above rule, the government has implicitly decided that if copying is to be limited in this sub-market, it must occur through software manufacturers copy protecting their disks. Our suggestion is that this perspective on the problem, which is obvious when governmental costs of enforcement are prohibitive, should be taken into account even when costs are much lower.

Footnotes

<sup>1</sup>Examples include Besen (1986), Johnson (1985), Liebowitz (1985), and Novos and Waldman (1984).

<sup>2</sup>See Hirshleifer and Riley (1979) for a clear statement of this viewpoint, and Arrow (1962) for a related discussion. See also Ploman and Hamilton (1980) for a discussion by noneconomists in which a similar viewpoint is expressed.

<sup>3</sup>In this discussion we are assuming that the government enforces property rights by directly restricting copying, rather than by taxing the copying activity. If the government operates through taxes, then the argument is somewhat more complex. However, the conclusion would remain unchanged, i.e., an increase in property rights enforcement by the government could lower the underutilization loss.

<sup>4</sup>See also Besen (1986).

<sup>5</sup>Relatedly, one could also imagine firms following this strategy because they would like to eliminate copying.

<sup>6</sup>See Burstein (1984) for an interesting discussion along these lines.

<sup>7</sup>The following discussion is taken from Novos and Waldman (1986).

<sup>8</sup>For a discussion of the pricing of complementary goods see Telser (1979).

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