

# Buyers or Pirates? The Microeconomics of Reproducing, Consuming, and Smuggling Information Goods

Stefania Lionetti <sup>1</sup>

## Abstract

*This paper models piracy behaviour of individuals as a consumption choice under uncertainty. Several cases are analysed: (a) with and without heterogeneity of costs; (b) copying for private use and for reselling; (c) in both developed and developing countries; (d) with and without positive externalities. Both income and substitution effects occur in each of these cases: thus policy solutions have to be case specific. (JEL D01, K42)*

## 1. Introduction

Over the last two decades, the swift penetration of the Internet and the increased digitization of information have turned the piracy of information goods (in particular music, movies, and software) into a topic of intense debate. Not surprisingly, economists have recently shown a renewed interest in information goods piracy. Ideas and innovation have become more and more important in our increasingly globalized society, thus growing attention is being focused on intellectual property rights (IPR).

From an ex ante point of view, protecting intellectual property rights preserves the incentive to create information goods, which are inherently public (absent appropriate protection, creators might not be able to recoup their potentially high initial creation costs). On the other hand, from an ex post point of view, protecting IPR encompasses various potential inefficiencies (e.g., protection grants de facto monopoly rights, which generates the standard deadweight losses; also, by inhibiting imitation, protecting IPR might limit the creators' ability to borrow from, or build upon, earlier works, and thereby increase the cost of producing new ideas; see Belleflamme 2002 and 2003). The total effect of piracy on welfare is extremely complicated and not clear: the loss in profit

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<sup>1</sup> Università della Svizzera Italiana and Università degli Studi di Milano; contact info: devocicka@gmail.com

can be compensated for an increase in consumer surplus. Lower profits, however, do reduce the ex ante incentives to provide the good. Bae and Choi (2003) show that, at a lower price, more original copies are sold in the presence of piracy; this is due to the fact that the monopolist faces a flatter linear demand function if pirated copies are available.

Neither the theoretical nor the empirical studies have been able to give a definitive answer to the question posed by Shapiro (1998) on the precise nature of the effect of piracy on the elasticity of demand.

And apparently, the literature lacks of a sound theoretical microeconomic basis about consumer's choice between consuming and smuggling information goods. In this essay I try to model the piracy behaviour of individuals as a consumption choice under uncertainty. The theoretical analysis is intended primarily as an investigation of the main determinants of the piracy behaviour at the individual level.

This research has been initiated to better assess the social and economic effects of illegal commercial copying and how this practice interacts with private noncommercial copying for personal use. Surely there are differences among different demographic groups, different geographic locations, and even different cultures and judicial systems. The phenomena may include such factors as how the difficulty of making an illegal copy affects the frequency of copying; the effect of the availability of illegal copies on the price and the availability of legitimate copies; the consumer's personal sense of the moral or ethical dimensions of the copying behaviour; the degree of law enforcement or legal scrutiny directed at the behaviour; and peer group or other social opprobrium or encouragement (Committee on Intellectual Property Rights and the Emerging Information Infrastructure, National Research Council 2000). We need an improved understanding of what these phenomena are and how they operate in the real world, so that they can be targeted for educational efforts and policy making. Reducing the current state of uncertainty about the impact of these various phenomena will be important to future policy makers and entrepreneurs.

The problem of information goods piracy is complex. Straightforwardly, piracy can cause harm to the economy and to producers of a good in that consumers are enabled by this use of technological innovation to get for free what they have paid for in the past. But probably, the damage caused by piracy also depends on publishers' pricing strategies. Thus it could be the case that strategies used to prevent piracy end up inducing would-be consumers not to buy or use the product at all. As Bensen (1986,

1987) states, lowering prices could be a useful strategy in discouraging piracy, but it would understate the loss in revenue, while raising prices in order to compensate for the consumer's increased surplus due to private copying would overstate the losses due to piracy.

Moreover, piracy has some positive demand-side externalities, such as direct and indirect network externalities (both for interaction for software and for music). Hence, from a supply side point of view, copying can actually result in positive effects for the relevant industry, increasing demand and thereby the profits for the firm that sells the original. For example, by increasing the provision of recorded music, music piracy could induce an increase in CD-player sales, which in turn results in greater consumption of music (Hui and Png 2002). Furthermore, copying greatly facilitates social sharing of information goods (in some ways akin to imitation or "free" advertising of the product), which can also increase the consumer's willingness to pay for these goods. On the negative side, expectations of a future illegal market for copies can also create expectations of future price cuts on the original and thus inhibit current consumption. Takeyama (1994) points out that such expectations may cause reductions in demand and profit for the seller of the original.

The model introduces a specification about different access to technology and different kinds of piracy coming from different countries in order to provide a theoretical framework useful to test (in a successive paper) whether piracy from developing countries is more harmful than piracy from developed world.

As Lesser argues, "Ideally, it would be possible to identify a direct relationship between the forms of intellectual property in place in a country and economic growth" (Lesser 2001). Developing countries, as net importers of technology, want to buy the latest technologies at the lowest possible price, while higher standards of protection of IPR are associated with higher prices of technology. On the other side, as net exporters of capital, and especially from an intellectual property rights perspective, developed nations want to protect as much as possible their investments in the technologies they are exporting, which generate generous income. Thus the question of how much protecting IPRs in developing world is still an open debate, notwithstanding the role exercised by the TRIPs Agreement.

In addition, the study models the behaviour of an Authority in charge of controlling and repressing pirate operators: from a public policy perspective, it may be interesting to understand the extent to which the social interests align with the interests of copyright owners.

The remainder of the essay is organised as follows. In section 2 I discuss the two kinds of literature necessary to understand the construction of the models of copying and smuggling, which are provided in section 3; section 4 concludes.

## ***2. Literature Review***

A primary reason for providing intellectual property protection is to enable the inventor to gain a return from the inventions he or she creates, and therefore provide an incentive for technology to advance. On the other side of the argument, IPR protection gives the rights holder a virtual monopoly over the market for the new product, thus preventing the benefits of the new product to be fully enjoyed by all consumers and distorting consumer choice by monopoly pricing. When the issue is posed in an international context, it becomes extremely complicated; until recently, there has been no universally accepted verdict on the desirability of extending a high level of IPR (typical of developed countries) to developing countries. Given the 1994 signing of the TRIPs agreement and the fact that developing countries continue to apply its provisions, the issue has become even more crucial.

In order to develop the model in this study two different streams of literature have been reviewed. The first approach regards the complex relationship between intellectual property rights and development, through trade or foreign direct investment. These kinds of works are more “traditional,” in the sense that to most economists, the term intellectual property (IP) has been until recently largely synonymous with patents, whose economic effects are studied in the context of innovation, technical progress, and growth. These authors mostly use patents data also because such data are regularly collected and thus many statistics are available.<sup>2</sup>

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<sup>2</sup> On the contrary, due to the difficulty of calculation because of the nature of the product, and the lack of attention in a statistical sense of which copyrights suffer, collecting the data on copyrights that will be used in the empirical paper relative to this theoretical one, has not been an easy task.

## 2.1

**Maskus and Penubarti** (1995) relate international trade flows to the cross-country strength of patent laws. The authors use an augmented version of the general-equilibrium trade model of **Helpman–Krugman** (1985). If international firms were presented with enforceable IPR protection in their export markets, they could either expand trade flows (a market-expansion effect) or restrict them (a market-power effect). The market-power effect would reduce the demand elasticity faced by the foreign firm, and would reduce exports of the patentable product to those in the market with stronger protection of IPR. On the contrary, the market-expansion effect would increase the demand elasticity and induce larger sales. The prediction of the model is that under free trade, bilateral imports are proportional to the exporting country's output. The empirics suggest that stronger patent laws increase bilateral trade flows particularly in large and middle-income countries. **Maskus** (2000) calculated that partial harmonization of patents through TRIPS could increase manufacturing imports into larger developing economies by up to 9 percent, which would generate a subsequent gain in total factor productivity growth. **Deardoff** (1992) analyses the welfare effects of extending patent protection from the country where invention takes place to another country that is only a consumer of the invented products. His analysis is based on some strong assumptions, including: 1) Countries are fixed either as innovators or as purchasers of innovations; 2) Products are freely available without patent protection; 3) Identical linear demand curves for all countries; 4) constant marginal production costs; and 5) monopoly prices imposed under patent protection. Under these specific circumstances it is not optimal to extend patent protection to all countries of the world. Thus, at least the poorest countries should be exempt from the TRIPs requirements. **Diwan and Rodrik's** (1991) analysis allows for different tastes between northern and southern countries. They show that, for goods used in both the north and south, southern countries should act as free-riders and not protect patent rights; however, for goods preferred by southern countries, intellectual property rights should be protected. But, as preferences become more and more similar, the effects become ambiguous. When R&D resources are scarce, they conclude that as long as northern and southern countries have different preferences, both groups have the incentive to provide patent protection. **Helpmann** (1993) analyses the effects of strengthening IPR policies in the southern countries on the growth rate

and welfare in both northern and southern worlds. He models the patent rights issue as a dynamic general equilibrium problem of a two-country world economy where north innovates and south imitates. Rate of innovation is endogenous while imitation rate is exogenous, and all the past innovations receive equal weight in the knowledge spillover specification though the different innovations have taken place at different dates; the tightening of the IPR policy implies the reduction in the rate of imitation. In the steady-state equilibrium, this strengthening of the IPR policy adopted in south lowers the rate of innovation in the north. This policy always lowers the welfare of the south, and lowers the welfare of the north if the rate of imitation is very small. Southern consumers are not benefited by tighter IPR policy owing to resultant higher prices. However, there is a nearly infinite number of possible scenarios to examine so that no general conclusion is possible theoretically. The issue becomes an empirical question. **Grossman and Lai (2004)** propose a theoretical framework for explaining the variation in degrees of patent protection across countries as the outcome of a noncooperative Nash game. They study the incentives governments have to protect intellectual property in a trading world economy. They associate the strength of IPR protection with the length of a country's patents, while holding other patent characteristics constant. Endogenous innovation is ongoing and countries differ in market size and R&D capacity. The authors find that harmonization of patent policies is neither necessary nor sufficient for global efficiency. In a noncooperative equilibrium, countries with larger markets and more human capital will provide stronger patent rights than will those with smaller markets and less human capital<sup>3</sup>.

Theoretical approaches, therefore, show that with patent right enforcement different welfare effects are possible.

There is another type of models that deals with more “innovative” issues, such as the effect of file-sharing on music sales, the effect of piracy on music sales, and the determinants of piracy both in software and in music. Owing to the fact that the advantages and/or disadvantages of IPRs are still a matter of debate, it becomes important to examine what the literature says about the infringements of IPRs, i.e. piracy. Unlike patents, such issues of copyright and the creative industries in which it is

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<sup>3</sup> “Moreover, starting from this equilibrium with stronger patent protection in the North than in the South, an efficient agreement calling for harmonization of patent policies benefits the North quite possibly at the expenses of the South” (Grossman and Lai 2004).

crucially important have until lately attracted little attention. But with the expansion of the Internet, these issues become crucial as an increasing number of digital products and services are copied and distributed without authorization of their legal owners.

If both firms and consumers do lose from piracy, it goes without saying that strategies to prevent piracy should be implemented; but in some studies, the results have been that consumers sometimes gain from piracy, and in such a case there is a lot of room for alternative policy options. The question is one of how producers in fact modify their pricing behaviour in the face of copying; and from these studies it can be shown that the answer depends on the properties of the copying technologies (quality, and the average and marginal cost of copying). More important is the question of whether there is an optimal level of copyright protection, and whether there are also mechanisms to improve profits and welfare.

Typically, the cost of copying can be zero, or it can be much higher, but it cannot be prohibitive, and of course the price of the copied product must be lower than the price of the original. Hinnossar (2002) observes that information goods are characterized by (1) increasing returns to scale on the supply side: a large initial investment, while its marginal cost is close to zero; (2) increasing returns to scale on the demand side for all consumers (network effects); (3) increasing returns to scale on the demand side for each consumer, leading to very high switching costs.

General features characterize the models analysed, and there are different criteria under which each model can be classified (Peitz and Waelbroeck 2003):

**(a) The difference between the original and the copied item** usually regarding quality and price. Bae and Choi (2003), using a vertical product differentiation model with quality degradation for copies, find out the classic trade-off between underprovision (lower profits reduce the ex ante incentives to provide quality and variety) and underutilization of the legal product, already stressed by Arrow (1962).

**(b) The heterogeneity of the consumers**

Chen and Png (2002) model two kinds of consumers: the first one never copies (i.e., has infinite copying costs) and the second one has finite copying costs. Within each group, consumers are heterogeneous in their valuations for the good although originals and copies are identical. The expected utility from illegal copying depends on the

probability of detection. In a single-market scenario model of vertical product differentiation such as that of Mussa-Rosen (1978), the heterogeneity with respect to the copying costs is replaced by heterogeneity with respect to the utility derived from the difference in quality between the original and the copy.

In the literature, the heterogeneity of consumers' valuation can be formulated as one of

(i) high-value and low-value consumers (those who are willing to pay a high premium for the original and those who are essentially not willing to pay for original); for the high-value case, a targeted copyright policy is possible *Broad-based versus targeted copyright enforcement*. A broad-based enforcement policy affects all consumers in the same way, whereas a targeted enforcement policy concentrates on a certain kind of consumer, typically high-value consumers.

or (ii) a continuum of types, with a uniform distribution over an interval single market scenario (Belleflamme 2002; Bae and Choi 2003).

### **(c) Dynamic models versus static models**

Takeyama (1997) examines the possibility that consumption of copies is able to reveal the product quality of originals when they are experience goods, using a two-period model.

### **(d) Single-market scenario versus multimarket scenario**

Shy and Thisse (1999) analyse a duopoly framework. In this model, the benefit from purchasing the original is independent of the network effect (contrary to Takeyama 1994). Under copy protection, there are two types of symmetric equilibria: one equilibrium in which both firms price low in order to sell the good also to some low-value consumers, and another equilibrium in which both firms set prices in order to sell only to the high-value consumers. Belleflamme (2002) also analyses a multimarket scenario in which each firm offers a single product. As long as demands are independent, all results from the single-market framework remain. If fixed costs are sufficiently heterogeneous, some firms do not enter the market; for a particular uniform distribution of these fixed costs across firms, the author shows that the existence of copies reduces welfare if copies are good substitutes for originals and increases welfare if they are bad substitutes.

### **(e) Independence of the decisions**

*Case 1: Consumers are perfectly aware of the characteristics of the pirated item and make independent decisions, allowing for indirect appropriation of rents.*

In this case, the copyright owner can still appropriate some benefits from copying.

For Besen and Kirby (1989) direct appropriation is more advantageous than indirect appropriation depending on the technology of copying and the degree of substitutability between originals and their copies. In their model of small-scale copying they demonstrate that direct appropriation arises when the marginal cost of copying is constant, and indirect appropriation arises when the marginal cost increases with the number of copies.

*Case 2: The presence of network effects*

In this case, consumers are not independent on each other for any given price value. Network effects have the same ratio both in the software/music case (direct for the exchange of files and indirect for complementary products and services) and in the case of books.

Belleflamme (2003) considers interdependent demand in the presence of copying as a result of the consumer's copying technology exhibiting increasing returns to scale. This is typical when a consumer incurs a high initial fixed cost, for example by buying equipment in order to enable him to copy. If the consumers' average cost of copying is sufficiently high, a multiproduct monopolist will either set the unconstrained monopoly price or lower its price so as to deter copying. In contrast, if each single information good is provided by one firm, these firms might have to consider copying as a phenomenon at industry level, and set a high price in order to gain a high margin from those consumers who buy originals. Takeyama (1994) assumes that (1) each user receives only a share of the net utility associated with the original when using an illegal copy; (2) this utility depends positively on the number of users; and (3) the network effect is more pronounced for the original than for the copy. Piracy enlarges the installed base of users, it generates network effects that increase the legitimate users' willingness to pay for the software and, thereby, potentially raises the producer's profits.

I will analyze a static model of consumers' behaviour, in a single market scenario and with different kinds of heterogeneity, keeping the difference in quality between the original and the copied item.

### 3. A General Simple Framework

I consider a scenario where a single consumer's utility depends positively on both the legal quantity of the item and the pirated quantity of the same item. For the sake of simplicity I assume a Cobb-Douglas Utility function. Its properties (homotheticity and additivity) imply that, in this general framework, I am assuming that the propensity of the individual towards the pirated version of the item is independent from his budget. The two regularity conditions (monotonicity and convexity) suffice for the Cobb-Douglas to be well behaved.

Assume that the utility function of the consumer is  $U = A Q_l^\alpha Q_c^\beta$  such that  $Q_l$  represents the legal quantity and  $Q_c$  the copied quantity, and  $\alpha$  and  $\beta$  are the weights that the consumer gives respectively to the legal and the pirated item to capture differences in quality between the two products. The assumption of vertical (quality) differentiation is common (Gayer and Shy, 2001a) and may be justified in several ways.<sup>4</sup>

Assume there are two states of the world and that  $\mu$  is the detection rate in case of consuming the pirated item, so that  $(1-\mu)$  is the probability of not being detected. When detected the consumer has to pay a fine  $f$  (to be specified). Thus the expected penalty  $E[X]$  is equal to  $\mu f$ . The quantity not already consumed  $\tilde{Q}_c \leq Q_c$  is confiscated. The expected utility in log form is

$$E(\log U) = (1-\mu)[A + \alpha \log Q_l + \beta \log Q_c] + \mu[A + \alpha \log Q_l + \beta \log(Q_c) - \beta \log(\tilde{Q}_c)] \quad (3.1)$$

The expected budget constraint, with a lump-sum fine, is

$$I = (1-\mu)p_c Q_c + \mu(p_c Q_c + f) + p Q_l \quad (3.2)$$

where  $I$  stands for lump-sum income, and  $p_c$  and  $p$  are the price of the pirated items and the price of the legitimate one, respectively.

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<sup>4</sup> In a successive paper, when the empirics are implemented, this assumption will be relaxed, at least for part of the tested regressions. I take into account both "handmade" piracy and copied digital products. While for the "handmade" piracy the lower quality of the copied product is obvious, for some products this is not necessarily so. For instance, digital products can be compressed without losing too much quality. However, the original product is often furnished with a set of nondigital components (CD cases, printed booklet with info on the artist, the songs, printed manual software, and so on) that usually the copied item does not have; we consider this feature as another difference in quality between the two kinds of products. For the time being, however, we will maintain that there is a difference in quality generated by the two different technologies of piracy.

First-order conditions are

$$\begin{aligned}\partial L/\partial Q_i &= (1-\mu)\alpha/Q_i + \mu\alpha/Q_i - \lambda p = 0 \rightarrow \lambda = \alpha/pQ_i \\ \partial L/\partial Q_c &= (1-\mu)\beta/Q_c + \mu\beta/Q_c - \lambda p_c = 0 \rightarrow \lambda = \beta/pQ_c\end{aligned}$$

from which we obtain:

$$Q_i = \alpha p_c Q_c / \beta p \quad (3.3)$$

Substituting the value of  $Q_i$  in the budget constraint we obtain

$$Q_c = \beta(I - \mu f) / p_c(\beta + \alpha) \quad (3.4)$$

In logs this expression is equivalent to

$$\log Q_c = \log \beta / (\beta + \alpha) + \log(I - \mu f) - \log p_c$$

Differentiating with respect to  $p_c$  and  $f$ , we obtain

$$\partial \log Q_c / \partial p_c = -1/p_c < 0$$

$$\partial \log Q_c / \partial f = -\mu / (I - \mu f) < 0$$

$$\partial \log Q_c / \partial \mu = -f / (I - \mu f) < 0$$

which implies that the pirated quantity decreases when its price increases and when the penalty and/or the probability of detection increases.

The above general model is very elementary. Still, it has the merit to provide some theoretical underpinnings for the commonly held beliefs ascribed to individuals who consume pirated items. The above results, in other words, represent a sort of popular wisdom about piracy and the effects of repressive policy against piracy.

In what follows I enrich the above basic framework by presenting a behavioural model intended:

(a) to overcome the Cobb-Douglas restrictions, particularly on the budget shares, and on the separability of the arguments;

(b) to introduce some forms of heterogeneity among consumers; the purpose of these specifications is to make the model a better reflection of the real world:

·b<sub>1</sub> by distinguishing between “end-users” pirates and “resellers,” who make pirated copies and smuggle them illegally;

·b<sub>2</sub> by allowing for an individual structure of the cost of copying;

·b<sub>3</sub> by differentiating between consumers from developing countries and consumers from developed countries.

Nonauthorized (pirated) copies can be obtained in two different ways (i.e., there are two possible technologies for the pirate):

- (i) a costless way, e.g., by borrowing originals from friends and family members;
- (ii) a costly way, e.g., by downloading the products from the Internet.

This type of heterogeneity implies that for example using file-sharing technologies, consumers spend a higher effort/cost than he or she would do by borrowing. Justification for this assumption are several: users spend time by looking for and downloading files; the digital copy lacks valuable information such as song lyrics or instructions on how to install the software; the file can be poorly compressed or incomplete; and so on. Thus we can expect that digital copies will play a positive role for copyright owners, reducing the costs of transmitting information to consumers, and a negative role, reducing revenues as a result of copying.

### 3.1 End-user model

I start with the most elementary case in which there is no heterogeneity. To model the behaviour of a pirate who uses the item himself without (re)selling one or many illegal copies he made, I now introduce the following assumptions.

**A1** There is a single profit-maximizing official producer in the market (the item price set by the producer is  $p$ ), who can invest some effort in detecting piracy.

**A2** Potential users can choose among two possible actions: (a) buy the legal product; (b) copy the item.

**A3** The fine for being detected is determined as follows. In the simple version of the model discussed above, the expected penalty  $E[X]$  was simply equal to  $\mu f$ . I now assume a fine that can depend on the pirated quantity either because the *probability of detection* depends on quantity or because the *amount of the fine* depends positively on quantity.

**A4** A general utility function (continuously differentiable and positively dependent on both its arguments) can be defined to be

$$V = V(Q_1, Q_c - \tilde{Q}_c)$$

with  $V'_{Q_c} > 0, V''_{Q_c} \leq 0, V'_{Q_1} > 0, V''_{Q_1} \leq 0$ . This utility is to be maximised under the constraint already defined by (3.2).

First-order conditions generate five cases, each related to different possible forms of both  $\mu$  and  $f$ . The results are summarized in the following table.

Penalty and Probability	First-Order Conditions
<b>1</b> $\mu=0$ or $f=0$	$\text{MRS1} = \frac{V'_{Q_c}}{V'_{Q_1}} = \frac{p_c}{p}$
<b>2</b> $\mu=\text{fix}$ and $f=\text{fix}$	$\text{MRS2} = \frac{V'_{Q_c}}{V'_{Q_1}} = \frac{p_c}{p}$ Lump-sum effect of penalty
<b>3</b> $\mu = \mu(Q_c)$ and $f=\text{fix}$	$\text{MRS3} = \frac{V'_{Q_c}}{V'_{Q_1}} = \frac{p_c}{p} + f \frac{\mu'_{Q_c}}{p} \geq \frac{p_c}{p}$ Distortion
<b>4</b> $\mu=\text{fix}$ and $f=f(Q_c)$	$\text{MRS4} = \frac{V'_{Q_c}}{V'_{Q_1}} = \frac{p_c}{p} + \mu \frac{f'_{Q_c}}{p} \geq \frac{p_c}{p}$ Distortion
<b>5</b> $\mu=\mu(Q_c)$ and $f=f(Q_c)$	$\text{MRS5} = \frac{V'_{Q_c}}{V'_{Q_1}} = \frac{p_c}{p} + \frac{\mu f'_{Q_c} + \mu'_{Q_c} f}{p} \geq \frac{p_c}{p}$ Distortion

Where  $\mu' > 0$  and  $f' > 0$ . Second-order conditions are satisfied. The following relationship among the marginal rates of substitution holds:

$$\text{MRS}_1 = \text{MRS}_2 \text{ (pure income effect)}$$

$$\text{MRS}_2 < \text{MRS}_3 < \text{MRS}_4 < \text{MRS}_5 \text{ (both income and substitution effects)}$$

We can observe that since  $\text{MRS}_1 = \text{MRS}_2$ , the fixed penalty with a given probability is a lump-sum levy, simply implying that the consumer is in a lower utility level, because when  $\mu$  and  $f$  differ from 0 the budget constraint shifts down. In the other

cases, owing to the presence of  $\mu = \mu(Q_c)$  and/or  $f = f(Q_c)$ , there is also a distortion working in the direction of reducing the pirated quantity.

In order to eliminate copies a firm can: lower its price or spend additional resources on developing a technology that increases the probability of detection. While a lower price improves welfare because less effort in copying is needed, increasing the probability of detection is inefficient from a social point of view, and the surplus of copiers is also reduced.

Both the copyright industry and the government could be in charge of affecting  $\mu$  and  $f$ . However, at this level of the analysis, it is very difficult to distinguish between the influences of the two actors. Detection by the industry raise the social cost of copying, thus raising the price of the original product (in this case, enforcing copyright protection could decrease the demand for the originals). Detection by the government (beyond the laws and the enforcement mechanism) would instead consist in tax on copies and recording equipments, subsidies to the original, and penalties in case of copyright violations (Chen and Png 2002).

### ***3.1.1 End-user model with cost heterogeneity***

So far the cost of copying the item has not been explicitly considered, and the decision of buying versus copying has been seen as affected only by prices and a (fixed) probability of detection.

In order to incorporate the cost of copying I introduce the following additional assumption.

**A5** The distribution of the potential user's copying cost is  $\Phi(c)$ , where  $C$  is the user's copying cost assumed to be a random variable with a probability distribution function over a support  $[0, \infty]$  and a hazard rate  $\Phi'(c)/[1 - \Phi(c)]$  that is monotonically decreasing.

Thus the consumer net benefit of buying the legal item is:

$$V(Q_i, Q_c - \tilde{Q}_c) - p \quad (3.1.1)$$

The net benefit of copying is:

$$(1 - \delta)V(\bullet) - E[X] - c_i \quad (3.1.1.2)$$

where  $\delta \in (0, I)$  represents the difference in quality between the pirated and the original item. Comparing the two net benefits, we can derive the condition under which it is more convenient for the consumer to buy the product:<sup>5</sup>

$$c_i \geq p - E[X] - \delta V(\bullet) \equiv c_1 \quad (3.1.1.3)$$

which means that he or she buys the legal item if the cost of copying exceeds the legal price net of the expected penalty and the reduction in value.

If  $c_i < c_1$ , the potential consumer chooses to copy. Accordingly, the expected utility is

$$\begin{aligned} E[V] &= \underbrace{\mu \int_0^{c_1} V(\bullet)\phi(c)dc}_{\text{copying and detected}} + \underbrace{(1-\mu) \int_0^{c_1} V(\bullet)\phi(c)dc}_{\text{copying and not detected}} \\ &\quad + \underbrace{\int_{c_1}^{\infty} V(\bullet)\phi(c)dc}_{\text{buying}} \quad (3.1.1.4) \\ &= \int_0^{\infty} V(\bullet)\phi(c)dc \end{aligned}$$

Using this version of the expected utility I can repeat the above maximization exercise for different definitions of the expected penalty. To do this I modify the budget constraint as follows:

$$I = (1-\mu)p_c Q_c + \mu(p_c Q_c + f) + p Q_l + Q_c \int_0^{c_1} c\phi(c)dc ,$$

where the last term is the expected value of the cost of copying the entire quantity  $Q_c$ . Results are reported in the following table.

Penalty and Probability	First-Order Conditions
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<sup>5</sup> If we allow for a corner solution, specifically  $U(0, 0) > 0$ , we are allowing for another state of the world: not using the product. In this case, defined  $r \equiv \left\{ \begin{array}{l} \min[V(\bullet) - p] \text{ if } (p < c_i) \\ \min[V(\bullet) - c_i] \text{ if } (c_i < p) \end{array} \right\}$  as the utility reserve value for which the consumer is indifferent between buying and not using the product, there will be another cut-off value  $c_2$  for which  $p - E(X) - \delta V(\bullet) < c_2 \leq r$ . The theory does not support this alternative, but this is a case that in reality could happen, as well as the case in which the consumer uses both legal and pirated products.

<p><b>1</b> <math>\mu=0</math> or <math>f=0</math></p>	$\frac{E[V'_{Q_c}]}{E[V'_{Q_1}]} = \frac{p_c + \int_0^{c_1} c\phi(c)dc}{p}$ $= \frac{p_c}{p} + \frac{E[c c \leq c_1]}{p}$
<p><b>2</b> <math>\mu=fix</math> and <math>f=fix</math></p>	$\frac{E[V'_{Q_c}]}{E[V'_{Q_1}]} = \frac{p_c + \int_0^{c_1} c\phi(c)dc}{p}$ $= \frac{p_c}{p} + \frac{E[c c \leq c_1]}{p}$ <p>Lump-sum effect</p>
<p><b>3</b> <math>\mu = \mu(Q_c)</math> and <math>f=fix</math></p>	$\frac{E[V'_{Q_c}]}{E[V'_{Q_1}]} = \frac{p_c - \mu'_{Q_c} f + \int_0^{c_1} c\phi(c)dc}{p}$ $= \frac{p_c}{p} - \frac{\mu'_{Q_c} f}{p} + \frac{E[c c \leq c_1]}{p}$ <p>Distortion</p>
<p><b>4</b> <math>\mu=fix</math> and <math>f=f(Q_c)</math></p>	$\frac{E[V'_{Q_c}]}{E[V'_{Q_1}]} = \frac{p_c - \mu f'_{Q_c} + \int_0^{c_1} c\phi(c)dc}{p}$ $= \frac{p_c}{p} - \frac{\mu f'_{Q_c}}{p} + \frac{E[c c \leq c_1]}{p}$ <p>Distortion</p>
<p><b>5</b> <math>\mu = \mu(Q_c)</math> and <math>f=f(Q_c)</math></p>	$\frac{E[V'_{Q_c}]}{E[V'_{Q_1}]} = \frac{p_c - \mu f'_{Q_c} + \mu'_{Q_c} f + \int_0^{c_1} c\phi(c)dc}{p}$ $= \frac{p_c}{p} - \frac{\mu f'_{Q_c} - \mu'_{Q_c} f}{p} + \frac{E[c c \leq c_1]}{p}$ <p>Distortion</p>

In this way distortion becomes higher, being the F.O.C. dependent on the expected conditioned value of costs. Comparing this case with the previous one (without heterogeneity), we find that in this case, the intercept of the budget constraint shifts more the higher is the expected value that the consumer will copy. In this way, the consumer's utility is reduced in any of the five cases. Detection policies become more

incisive as copying becomes more expensive. Moreover, the cheaper the legal price, the more inconvenient is copying. These conclusions are obvious, but the purpose of this paper is exactly giving an economic rationale to common behaviour.

The cost structure plays an important role in determining whether the original and pirated good are good or bad substitutes. It is partly determined by the copyright enforcement policy of the copyright owner. A broad-based enforcement policy affects all consumers in the same way. As an alternative, a targeted enforcement policy concentrates on high value consumers (Harbaugh and Khemka 2001). The cost structure of copying has to include both the opportunity cost of alternative uses, and the search and information costs of how to copy the product.

### ***3.1.2 Consumers coming from different worlds***

Another specification can be introduced, in order to distinguish consumers from developing and developed countries.

There are two criteria to distinguish between developed and developing countries: the possibility of a generic access to the technology, and the different kinds of piracy. We assume that: (1) living in a developed country makes the access to the technology easier; and (2) at least as far as the very low-income countries are concerned, the “handmade” piracy is more common in the developing world, while developed countries are more used to more “sophisticated” downloading piracy. Thus the structure of the costs of copying is the following:

$$C = \begin{cases} F_l + C_i(Q_c) & \text{if the } i\text{th consumer lives in a developed country} \\ F_h + C_i(Q_c) & \text{if the } i\text{th consumer lives in a developing country} \end{cases}$$

where  $F_l$  and  $F_h$  stand for low fixed costs and high fixed costs, respectively. Costs include a common part depending on the copied quantity and an idiosyncratic part specific to belonging to a developing or developed country.

Moreover, to make things more realistic, we assume that the fine depends on the pirated quantity, and because of the different structure of the copyright regimes in the developing and the developed worlds, that  $X_h(Q_c) = \text{high}$  for developed countries and  $X_l(Q_c) = \text{low}$  for developing countries.

These specifications do not alter the previous results, but they reflect the various costs and IPR structures actually faced by consumers in a developing or developed country.

### 3.1.3 The market demand of the end-user pirate

The properties of the market demand of an end-user consumer can be discussed as follows. Solving (3.1.1.3) for  $V$  gives the valuation consistent with the decision not to copy, i.e.:

$$V(\bullet) = \frac{p - c_i - E[X]}{\delta} \equiv v_1 \quad (3.2.1a)$$

Then, the unit expected demand for copying (choosing the pirated product) will be:

$$Q_c = \int_0^{v_1} d\Phi(v) = \Phi(v_1) \quad (3.2.1b)$$

And the unit expected demand for buying the original will be

$$Q_l = \int_{v_1}^{\infty} d\Phi(v) = 1 - \Phi(v_1) \quad (3.2.2)$$

Differentiating, we can derive that

$$\frac{\partial Q_c}{\partial p} = -\frac{\phi(p)}{\delta} < 0 \quad (3.2.3)$$

$$\frac{\partial Q_c}{\partial E[X]} = \frac{\phi(p)}{\delta} > 0 \quad (3.2.4)$$

(3.2.3) is the usual assumption of any no-Giffen good: the demand for the legal item decreases as its price increases; and it increases as the expected penalty increases. This implies that, from the producer side (the monopolist), if piracy is a real threat (i.e., it reduces profit), three strategies can be adopted: (1) not react at all; (2) deter piracy by (a) lowering the price of the legal product which in turn increases social welfare, or (b) spending additional resources on a technology that increases the probability of detection, which raises the price of the legal product and lowers social welfare; or, (3) accommodate. Probably, as Johnson (1985) states, the answer crucially depends on the properties of the copying technology: that is, on the relative importance of the average and marginal costs of copying, and on the relative quality of copies. Thus it is evident how crucial the cost structure is.

In addition:

$$\frac{\partial Q_c}{\partial p} = \frac{\phi(p)}{\delta} > 0 \quad (3.2.5)$$

the demand for the pirated item increases as the price of the legal item increases, while

$$\frac{\partial Q_c}{\partial E[X]} = -\frac{\phi(p)}{\delta} < 0 \quad (3.2.6)$$

This is an important result that shows that both the pirated quantity and the legal quantity depend on the same set of factors, and thus regressing the legal quantity directly on the pirated quantity would be a mistake<sup>6</sup>.

### 3.2 Introducing reselling

In this model the resellers sell the copied item and bear the costs of copying as well as the risks of paying the fine. It is assumed that the resellers bear the costs associated with copying and selling the pirated item (i.e., these are not shifted onto final consumers). The price to customers of the pirated product is  $p_c$ . With the probability  $\mu$  the reseller will pay a fine  $f$  for being caught. So the reseller's expected profit is  $p_c - \mu f - c_i$  for each unit copied and sold. If we assume free entry and exit in the black market and perfect competition among smugglers,<sup>7</sup> in the long run profit will be zero. So  $p_c = \mu f + c_i = E[X] + c_i$ . For the final user, the net benefit of buying the item legally is, once again,  $V(Q_l, Q_c - \tilde{Q}_c) - p$ , and the net benefit of buying the pirated one from the reseller is

$$(1 - \delta)V(Q_l, Q_c - \tilde{Q}_c) - p_c \quad (3.3.1)$$

The condition for the final user to buy the legitimate product or the pirated item from a smuggler will be the same as the previous ones, respectively. Also, the demand for the legal and pirated item will be equivalent to equations (3.2.1b) and (3.2.2), and the comparative static relationships will remain the same.

A different result is obtained if we assume that the fine is paid not only by the smuggler but also by the customer. To formalise this, call  $\mu f_c$  the expected penalty for the customer. Then, equation (3.3.1) becomes

$$(1 - \delta)V(Q_l, Q_c - \tilde{Q}_c) - p_c - E[f_c]$$

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<sup>6</sup> In fact in a successive empirical paper, in order to test for the effect of piracy on the demand for the legal quantity I used instrumental variables.

<sup>7</sup> Hui and Png (2002) assert that even including some modifications to the hypothesis, such as the resellers enjoying a monopoly by specifying a constant profit margin, or different penalties for the reseller and the end-user, the substantial results of this analysis do not change.

The cut-off value for not buying from a smuggler is

$$\frac{p - p_c - E[f_c]}{\delta} \leq V(\bullet) \equiv v_1 \quad (3.3.2)$$

which can be rewritten, using for the smuggler the zero-profit condition, as

$$\frac{p - c_i - E[f] - E[f_c]}{\delta} \leq V(\bullet) \equiv \hat{v}_1 < v_1 \quad (3.3.3)$$

This implies

$$\hat{Q}_l = \int_{\hat{v}_1}^{\infty} d\Phi(v) = 1 - \Phi(\hat{v}_1) > Q_l \quad (3.3.4)$$

### 3.3 Introducing positive externalities

Some models (e.g., Hui and Png 2002) specify the benefit of copying by means of a term that captures so-called “positive externalities” of copying:  $e(Q_l, Q_c)$ , where the function  $e$  is increasing in each of its arguments,  $Q_l$  and  $Q_c$ . The idea is simply that the increased consumption due to copying makes the consumer more aware and fond of the product, thus making it more likely that he or she will buy the legal version of it.<sup>8</sup>

If an end-user buys the product, she enjoys a net benefit of

$$V(Q_l, Q_c - \tilde{Q}_c) + e(Q_l, Q_c) - p \quad (3.4.1)$$

If she copies, her net benefit is

$$(1 - \delta)V(Q_l, Q_c - \tilde{Q}_c) - E[X] - c + (1 - \lambda)e(Q_l, Q_c), \quad (3.4.2)$$

where  $\lambda$  denotes the proportionate reduction in the positive influences for the user of a pirated item (*as she may be inhibited in “openly” showing or sharing with others*) (Hui and Png 2002).

The indifference between buying and copying the item is given by a cut-off value of costs:

$$c_i \geq p - E[X] - \delta V(\bullet) - \lambda e(Q_l, Q_c) \equiv c_1 \quad (3.4.3)$$

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<sup>8</sup> Alternatively, the demand for music may increase because it is freely available, but how can record companies capture any value from a free good? The answer is by reaping profits from complements, those activities and goods that become more valuable when music is free. A cursory analysis suggests a broad range of such complements: music concerts, artist merchandise, mp3 players, storage devices, personal computers, high-speed Internet access, and so on. For example, in 2001, unit sales of blank CDs (1.1 billion) exceeded sales of pre-recorded CDs (968 million) for the first time.

The function  $e$  is increasing in each of its arguments,  $Q_l$  and  $Q_c$ , which implies that

$$\partial c_1 / \partial Q_c < 0, \text{ and}$$

$$Q_l = \int_{c_1}^{\infty} d\Phi(v) = 1 - \Phi(c_1) \rightarrow \partial v Q_l / \partial Q_c > 0 \quad (3.4.4)$$

The sign of this last derivative depends on the distribution of the consumer's utility  $\Phi(v)$ , and on the relative magnitude of  $\delta$  and  $\lambda$ . Supposing that  $\Phi$  is linear ( $v$  is uniformly distributed), it can be shown that

$$\text{if } \delta > \lambda, \text{ then } \partial Q_l / \partial Q_c > 0,$$

$$\text{if } \delta = \lambda, \text{ then } \partial Q_l / \partial Q_c = 0,$$

$$\text{while if } \delta < \lambda, \text{ then } \partial Q_l / \partial Q_c < 0.$$

As the previous analysis showed, the extent of piracy is endogenous, in the sense that it depends on the price of the legitimate item and on the expected penalty.

#### **4. Conclusions**

With the widespread growth of the Internet, increasing numbers of digital products and services have been copied and distributed without the authorization of the legal owners, thus highlighting issues of intellectual property rights, especially in those creative industries for which copyright is essential. The research presented here has been initiated to better assess the social and economic effects of illegal commercial copying and how these effects interact with private noncommercial copying for personal use.

As we have seen, theoretical approaches show that with increasing enforcement of patent rights, prices rise in developing countries, leading to different welfare effects. I have constructed various models in order to make piracy modelling a better reflection of the real world. I have analysed several cases: (a) with and without heterogeneity of costs (detection policies become more incisive as copying becomes more expensive; moreover, the cheaper the legal price, the more inconvenient it is to copy); (b) copying for private use vs. copying for reselling; (c) copying in a developed vs. a developing country; (d) copying with vs. without positive externalities. Both income and substitution effects occur in each of these cases: thus policy solutions have to be case specific.

As we have seen, the cost structure plays an important role in determining if the original and pirated good are good or bad substitutes. It is partly determined by the copyright enforcement policy of the copyright owner. The cost structure of copying

must include both the opportunity costs of alternative uses, and the search and information costs of how to copy the product.

Overall, the model presents two useful characteristics:

(1) It takes into account both the piracy variable and a variable for the expected penalty. This characteristic permits to consider a more realistic version of the world that includes both piracy and the law on intellectual property rights that can be considered as a proxy of the expected penalty.

(2) One of its results is that the demand for the legal item increases as the expected penalty increases. An important result coming from this model and its variations is that the extent of piracy is endogenous, in the sense that it depends on the price of the legitimate item and on the expected penalty. The result is important especially in case of empirical studies, because it demonstrates that both the demand of legal products and the demand of pirated products depend on the same set of factors.

## References

- Almeida, Paulo (1990). "The new intellectual property regime and its economic impact on developing countries." In Giorgio Sacerdoti (ed.), *Liberalization of Services and Intellectual Property in the Uruguay Round of GATT*. University Press, Fribourg.
- Anand, Bharat, and Alexander Galetovic (2003). "Strategies that work when property rights don't." UCLA, Levine's working paper archive 6188970000000005178.
- Arrow, K. (1962). "Economic Welfare and the Allocation of Resources for Inventions." In R. Nelson (ed.), *The Rate and Direction of Inventive Activity*. Princeton University Press, Princeton.
- Belleflamme, P. (2002). "Pricing Information Goods in the Presence of Copying." Unpublished *mimeo*, Queen Mary University of London.
- Belleflamme, P. (2003). "Oligopolistic Pricing of Piratable Information Goods." Unpublished *mimeo*, CORE, Louvain-la-Neuve.
- Besen, S. M., and S.N. Kirby (1989). "Private Copying, Appropriability, and Optimal Copying Royalties." *Journal of Law and Economics* 32: 255–280.
- Braga, Carlos, A. Primo, and Carsten Fink (1998). "How stronger protection of intellectual property rights affects international trade flows." Available at [www.worldbank.org/html/dec/publications/Workpapers/wps2000series/wps2051/wps2051.pdf/](http://www.worldbank.org/html/dec/publications/Workpapers/wps2000series/wps2051/wps2051.pdf/).
- Braga, C. A. Primo (1995). "Trade-Related Intellectual Property Issues: The Uruguay Round Agreement and Its Economic Implications." Chap. 12 (pp. 381–412) in W. Martin and L.A. Winters (eds.), *The Uruguay Round and Developing Economies*. Washington, D.C.: World Bank, Discussion Paper 307.
- Chen, Y., and I. Png (2002). "Information Goods Pricing and Copyright Enforcement: Welfare Analysis." Forthcoming in *Information Systems Research*.
- Chin, Judith C., and Gene Grossman (1990). "Intellectual Property Rights and North-South Trade." In R. W. Jones and A. O. Krueger (eds.), *The Political Economy of International Trade*, pp. 90–107. Blackwell, Oxford, and Cambridge, Mass.
- Committee on Intellectual Property Rights and the Emerging Information Infrastructure, National Research Council, (2000) "The Digital Dilemma: Intellectual property in the Information age" *National Academy Press*, Washington, D.C..
- Deardorff, Alan V. (1990). "Should Patent Protection Be Extended to All Developing Countries?" *World Economy* 13(4): 497–508.

- Deardorff, Alan V. (1992). "Welfare Effects of Global Patent Protection." *Economica* 59: 35–51.
- Diwan I., and D. Rodrik (1990). "Patents, appropriate technology and north–south trade." *J. Internat Economics* 30: 27–47.
- Dollar, D., and A. Kraay (2000). "Growth *Is* Good for the Poor." World Bank. Available at [www.worldbank.org/research/growth/absdollakray/](http://www.worldbank.org/research/growth/absdollakray/).
- Grossman, G., and E. Lai (2003). "International Protection of Intellectual Property." Unpublished manuscript.
- Harbaugh, R., and R. Khemka (2001). "Does copyright enforcement encourage piracy?" Claremont colleges working paper 2001-14.
- Helpman, Elhanan (1993). "Innovation, imitation, and intellectual property rights." *Econometrica* 61(4): 1247–1280.
- Johnson, W. (1985). "The Economics of Copying." *Journal of Political Economy* 93: 158–174.
- Marron, D. B., and D. G. Steel (2000). "Which Countries Protect Intellectual Property? The Case of Software Piracy." *Economic Inquiry* 38(2): 159–175.
- Maskus, K. E., and D. E. Konan (1994). "Trade-Related Intellectual Property Rights: Issues and Exploratory Results." In Deardorff and Stern (eds.), *Analytical and Negotiating Issues in the Global Trading System*, pp. 401–446. University of Michigan Press, Ann Arbor.
- Maskus, Keith E., and John S. Wilson (2001). *Quantifying the Impact of Technical Barriers to Trade: Can It Be Done?* University of Michigan Press, Ann Arbor.
- Maskus, K. E., and M. Penunbarti (1995). "How Trade-Related Are Intellectual Property Rights?" *Journal of International Economics* 39: 227–48.
- Mussa, M., and S. Rosen (1978). "Monopoly and Product Quality." *Journal of Economic Theory* 18: 301–317.
- Novos, I. E., and M. Waldman (1984). "The Effects of Increased Copyright Protection: An Analytic Approach." *Journal of Political Economy* 92, 236–246.
- Peitz and Waelbroeck (2004) "Piracy of Digital Products : A Critical Review of the Economics Literature", CESifo Working Paper Series No. 1122
- Romer, P. (1992). "True strategies for economic development—Using ideas and producing ideas." In *Proceedings of the World Bank Annual Conference on Development Economics*. Washington, D.C.: World Bank.

- Salant, S.W. (1987) "Treble Damage Awards in Private Lawsuits for Price Fixing" *Journal of Political Economy* 95, 1326-36.
- Shapiro, Carl (1988). "Economic Effects of Home Copying." Unpublished mimeo. Princeton University, Princeton.
- Shy, O., and J. Thisse (1999). "A Strategic Approach to Software Protection." *Journal of Economics and Management Strategy* 8: 163–190.
- Takeyama, L. N. (1997). "The Welfare Implications of Unauthorized Reproduction of Intellectual Property in the Presence of Demand Network Externalities." *Journal of Industrial Economics* 42: 155-166.
- Takeyama, L. N. (1997). "The Intertemporal Consequences of Unauthorized Reproduction of Intellectual Property." *Journal of Law and Economics* 40: 511–522.
- Van Wijk, Jeroen, and Gerd Junne (1992). "Intellectual Property Protection of Advanced Technology. Changes in the global technology system: implications and options for developing countries." United Nations University-INTECH, Maastricht.