THE ECONOMICS OF COPYRIGHT LEVIES ON HARDWARE

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ABSTRACT. The fight against illegal music downloading has taken many forms. Beside legal prosecution (Hadopi in France, for example), many countries have chosen to tax blank tapes and CDs, both to reduce their use for illegal copying, but also to redistribute the proceeds to content providers. This has become less effective, since now illegal copying is stored on hardware devices, such as smartphones, computers, MP3 players, and external hard disks. We provide an economic analysis of the effects of copyright levies on hardware used to access original content. A first effect is to decrease the consumption of *both* illegal and legal content. We show that in a static model, content providers can hardly be compensated, and therefore are made worse off by the levy. We also consider a dynamic model where current sales contribute to the reputation of the content provider, and to his future revenues. A levy on hardware tends to penalise 'young' content providers in terms of reputation acquisition.

1. INTRODUCTION

The fight against illegal music downloading has taken many forms. Beside legal prosecution (for example Hadopi in France), many countries have chosen to tax blank tapes and CDs, both to reduce their use for illegal copying, but also to redistribute the proceeds to content providers. This has become less effective, since now illegal copying is stored on hardware devices, such as smartphones, computers, iPads, and external hard disks. Some recent computers no longer include a CD or DVD player. Therefore one can make the case that copyright taxes should be levied on hardware as well. Such levies have been discussed in the United States, Canada and Europe.

In the United States, royalties apply to stand-alone CD recorders but not to CD burners with computers (as well as to blank CDs labeled and sold for music alone, but not to blank computer CDs, though they can also be used to burn music from a computer to CDs). In 1998, when the RIO PMP300 MP3 digital audio player was launched, the Recording Industry Association of America (RIAA) filed an application to try to prevent its sale because it was violating the 1992 Audio Home Recording Act. Judge Collins of the Central District Court of California denied the

RIAA application, and therefore MP3 players are considered as computer peripherals and are not subject to copyright levies. In 2005 and 2007, Canada extended blank audio recording media levies to MP3 players and on memory components of digital audio recorders. A European Union Directive on levies issued in 2001 is quite severe, but not prescriptive, and most European countries are discussing the issue with manufacturers. For the time being, only Germany, imposes a copyright levy of $13 (plus VAT) on computers. But the situation is evolving. In May 2013, a French tribunal sentenced Apple to pay a fine to Copie France, the society which collects levies on private copies produced by high tech devices such as iPads.

In this paper, we show that, contrary to copyright levies on blank CDs and similar devices, levies on hardware are very likely to have negative effects not only on producers of hardware, but also on copyright holders, especially if the part of the copyright levy that is redistributed to them is small, as seems to be the case in markets for music.

In the presence of market externalities, a market for rights can force the firm which generates the negative externality to internalize the social cost of its activity. For instance, by giving rights to polluters and letting them negotiate with individuals hurt by the externality, a "price for pollution" will emerge and the final level of production by the firm will equate the marginal cost (pollution abatement) and the marginal benefit (reduced pollution) of the activity. If the rights are given to consumers, it is the firm that will pay in order to have the right to produce and pollute. The market solution presumes efficient bargaining, well defined property rights and also the possibility to enforce the outcome of the bargaining. If, however, contracting possibilities are weak, a Pigouvian tax (the level of which may be difficult to determine) imposed on the firm is a substitute. It will induce the firm and the other agents to internalize the externality (negative or positive), and reduce the level of over- or under-consumption. By taxing the firm, its level of production and, therefore, of pollution will decrease. The proceeds from taxation could then be redistributed to those agents who bear the cost of pollution (or used for other means). Note that the tax is *targeted* against the creator of the externality.

It is tempting to view copyright infringement as a type of pollution. When a consumer buys (artistic or any type of) content, there is a probability that it will be given for free – through copying and sharing – to other consumers. This additional consumption fails to bring revenues to content providers (intellectual property right holders, artists, or producers, such as studios or CD producers)[1] that they could have had if individuals were not able to copy: hence the purchase of content creates as a byproduct a "pollution" generated by sharing and copying. Note that here pollution is exerted by consumers rather than by the producer. Therefore, for a

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[1] We will not distinguish between these roles and use the term 'content providers' in what follows.

Pigouvian tax to be effective in curbing this pollution, it is necessary that consumers be taxed when they engage in copying and sharing. This logic has led to the imposition of copyright levies on blank tapes and later on CDs or flash drives. Since these are the supports on which consumers will produce copies, making them more expensive by taxing will reduce the level of copying and make sellers of artistic content better off.[2]

One of the early objectives of levies on supports was to compensate content providers for copying by consumers. Even if copying falls within the licensing terms of the sale such as private copying allowed by the license, content providers may feel that this increases their sales and therefore welcome this type of taxation. More recently, digital distribution has also magnified the practice of copying outside the terms of the license agreement, and levies also play the role of compensating content providers for this "illegal" or "unlicensed" copying (piracy).[3] While the objectives are relatively clear, one still has to show that levies indeed serve as a compensatory instrument for copying, that is, effectively increase the revenues of content providers.

Because the levy on supports is targeted against copying, a direct effect of taxation is to curb copying and piracy; this increases the revenue of content providers as long as consumers substitute original content for copies. An indirect effect of taxation is to decrease the indirect utility from using content (since consumers will be less able to share it with others). There may thus be fewer consumers purchasing content, but consumers who purchase content tend to buy more legal content. One expects the direct effect to dominate and content providers to be better off with the levy.

As already discussed, this type of taxation has become less effective, since now illegal copying is stored on hardware devices, such as smartphones, computers, MP3 players, and external hard disks, which are also used to access and store content obtained legally. Therefore, levies on MP3 players, computers or other hardware are *not targeted*: not all consumers who are taxed do copy and, in addition, the levy does not modify the relative prices of original content and copies *once* the hardware has been purchased. Hence the effect of the levy on individual copying behavior is likely to be second order, implying that the substitution towards original content is small; in fact since the income available for purchasing content is lower, the quantities of *both* original and copied contents decrease. In addition to the decrease in indirect utility – which is more pronounced than for a tax on copies – there is also a direct effect on the purchase of hardware which is likely to be

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[2]For a review of copyright levies, see for instance Oksanen and Välimäki (2005).

[3]In our model, we will not distinguish between the two since taxes will influence both the desire of consumers to make copies within *or* outside the license agreement (e.g., by downloading from P2P networks).

first order. Hence, contrary to a levy on supports, the negative effects of levies on hardware often dominate their positive effects. Revenues of content providers are therefore likely to decrease.

The economic literature on the economic effects of copying is quite extensive (see Legros, 2006 for a survey). The early literature (Novos and Walman, 1984; Johnson, 1985) assumed that the benefits that copying brings to consumers cannot be appropriated by the sellers, and highlights the role of supply elasticity for understanding the welfare consequences of copying. The literature has then articulated the idea that the providers may recoup part of the lost volume due to copying activity in the price of the initial units (Liebowitz,1985; Besen, 1986 and others). Levies on magnetic supports like CDs or on hardware may lead to indirect appropriability of the benefits enjoyed by consumers who copy, legally or not, original content.

The advent of the internet has led to a renewal of interest in the issue on how content providers could recoup some of the losses due to copying or curb piracy. There are significant policy (e.g., Oxera Consulting, 2011; Kretschmer, 2011; Kim, 2012) and legal (e.g., Mehra, 2008; Huang and Png, 2010) dimensions to the question of levies of hardware. Most relevant for us is the paper by Gayer and Shy (2003) who analyze the welfare consequences of a tax on sales of hardware that is chosen by software providers. Kinokuni (2005) extends this model by assuming general bargaining positions of hardware and software providers. In both papers, legal and copied software are vertically differentiated and firms are price makers and the issue is whether there is a gap between the "optimal" tax rate for hardware or software producers and the "total surplus" efficient tax rate. In particular, there always exist a tax rate that would eliminate piracy in these models. By contrast we assume horizontal differentiation and assume competitive pricing by hardware producers, and a tax can never completely eliminate piracy or copying in our model. The dynamic effects of levies, which is the object of our last section is novel to the literature.

Section 2 of the paper describes a basic static model in which a levy on hardware will reduce the available income available to consumers for content and will lead to a decrease of *both* "legal" and "shared" content, decreasing the revenues from the sale of content. We provide a simple sufficient condition for content providers to end up worse off with the levy even if they collect tax revenues. This condition is likely to be satisfied for two reasons. First, the revenue from the levy is subject to a Laffer curve effect: the tax revenue function is concave and is decreasing after a certain level. Hence, in economies with high existing taxes (like VAT or state and federal taxes), the revenue generated specifically by the levy on hardware is likely to be small. Second, in practice, content providers obtain only a small percentage

(that we call "recouping rate") of the levy's revenue, making it difficult for the levy to yield them revenues sufficient to compensate for the decrease in sales.

Section 3 explores the dynamic effects of levies on hardware by considering situations where current sales may improve the reputation of content providers, and eventually future sales. We show that levies on hardware may be detrimental to the long run income of content providers, especially "young" ones. Section 4 concludes.

2. The Positive and Normative Implications of Levies in a Static Model

We consider an industry with competitive firms enjoying constant returns to scale: the supply of hardware producers and of content providers is inelastic. Consumers have income I which has distribution G; we assume without much loss of generality that G has an increasing hazard rate:[4]

$$\frac{g(I)}{1 - G(I)} \text{ is increasing in } I. \tag{1}$$

Consumers spend their income on a variety of goods, including a piece of hardware (computer, mobile phone, MP3 player) at price h needed to access digital content that can be bought from the content provider at price p ("licensed" content denoted l) or copied at price r ("shared content" denoted s) within the terms of the license agreement or from sharing platforms on the internet. While p is set by content providers, the price r for shared content includes many components such as the cost of using another piece of software to convert music or videos, the cost of tapes or digital recording devices, the opportunity cost of time, the disutility of engaging in "illegal activity" in the case of piracy, or finally the perceived or actual difference of quality between original and copies. Hence even if the "commercial" cost of copying is zero for the consumer, r may be positive because of these other aspects. For instance, being away from one's computer may increase the access to "free" copying.

From the point of view of consumers, r is a random variable at the time they purchase the hardware, but becomes known afterwards; it has distribution F on $[0, 1]$.[5]

The utility of a consumer with income I who buys the hardware and digital content is $\theta \log(l + s) + (1 - \theta) \log(I - h - pl - rs)$ where $\theta \in [0, 1]$ is an index of the taste that the consumer has for digital music. One would expect for instance young consumers to have a high value of θ; $1 - \theta$ could be interpreted as the taste

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[4]Most common distributions have this property, like the uniform or the normal distribution.

[5]For instance, on P2P networks, the consumer may not find the song he is looking for and will have to settle for other songs that are less preferred; quality wise, some bits in the song may be distorted during the download.

for "non-digital" access to content, e.g., radio or TV listening, concert attendance, etc. The log specification implies that, for given θ, consumers spend independently of prices p, a fixed proportion r of their income on content.[6] Indeed, assume that a consumer has purchased the hardware. If at a point in time $p < r$, she will buy legal content only, and the first order optimality condition is:

$$\frac{\theta}{l} - \frac{(1-\theta)p}{I - h - pl} = 0 \Rightarrow pl = \theta(I - h) \tag{2}$$

while if $r < p$, she will buy shared content only, and spend:

$$rs = \theta(I - h). \tag{3}$$

The utility of buying legal content is $\theta \log(\theta(I - h)/p) + (1 - \theta) \log((1 - \theta)(I - h))$ and that of buying shared content is $\theta \log(\theta(I-h)/r) + (1-\theta) \log((1-\theta)(I-h))$; the probability for buying legal content over the lifetime of the hardware is therefore $1 - F(p)$, and one can interpret $F(p)$ as the (expected) proportion of legal content that the consumer will purchase.[7]

Therefore the expected utility of a consumer buying the hardware before r is realized is:

$$v(I, h, p) \equiv \log(I - h) + A(\theta) - \theta \left[(1 - F(p)) \log(p) + \int_0^p \log(r) dF(r) \right], \tag{4}$$

where:

$$A(\theta) \equiv \theta \log(\theta) + (1 - \theta) \log(1 - \theta).[8] \tag{5}$$

In order to be willing to buy the hardware, it is necessary that $v(I, h, p)$ be greater than $(1-\theta) \log(I)$, the utility of the consumer if she does not buy hardware and content. We prove the following result.

Proposition 1. *There exists a unique $I(h, p)$ such that a consumer buys the hardware if, and only if, her income is higher than $I(h, p)$.*

Proof: See Appendix.

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[6]This specification implies that when consumers *do not buy the hardware* their utility is $(1 - \theta) \log(I)$, and higher taste for digital content decreases the utility of not having access to it when consuming other goods. Alternatively, one could use a utility function $\theta \log(l + s) + \log(I - h - pl - rs)$; this would not affect our qualitative results however. Similarly, the perfect substitution between legal and shared content is without loss of generality: once the hardware is bought, the rate of substitution between the two will reflect their relative prices, and is likely not to be affected in a first order way, making the substitution away from shared content in favor of legal content unlikely.

[7]Hence each consumer purchases either legal or copied content, even if from an ex-ante point of view she has a probability $F(p) < 1$ of using copied content. A dynamic model of purchases, e.g., continuous time with purchase of one unit at a point in time, would generate mixed purchases over the lifetime of the hardware.

[8]$A(\theta)$ is a negative, convex, symmetric function satisfying and $A(0) = A(1) = 0$ with a minimum value of $-\log(2)$ achieved at $\theta = 1/2$.

Because consumers spend the same percentage of income whether or not they purchase legal content, $F(p)$ — the propensity for consumers to use shared content — is also the probability that content providers will not obtain the revenue $\theta(I - h)$ from the consumer. Note that if shared content did not exist, a consumer will spend $\theta(I - h)$ on legal content with probability one. We are therefore in a world where $F(p)$ captures the propensity of consumers to use shared content *instead* of legal content.[9]

Levies on hardware may be one way to compensate content providers for this loss.[10] Letting t be the levy, the expected revenues from sales of legal contents are now $(1 - F(p))(I - h - t)/p$ while the revenue is:

$$T(t) = t[1 - G(I(h + t, p))]. \tag{6}$$

Increasing the levy brings more revenue as long as consumers are willing to buy the hardware at the higher price $h + t$. Proposition 1 tells us that consumers with income in the interval $[I(h, p), I(h + t, p))$ will stop buying the hardware. Because the distribution of income is log-concave, we can show that the revenue is a concave function of t, and is actually decreasing in t for high enough levies. Hence, there is Laffer curve effect for levies on hardware:

Proposition 2 (Laffer curve). *The revenue function $T(t)$ is a concave function of t, with a maximum at t^*, solution of:*

$$\frac{g(I(h + t^*, p))}{1 - G(h + I(h + t^*, p)))} = \frac{(1 - \theta)I + \theta(h + t^*)}{It^*}$$

Proof: See Appendix.

This "Laffer curve" effect has some interesting consequences.

- Any levy larger than t^* is inefficient from the point of view of content providers. It follows that the higher the initial taxes (VAT or sales tax, tax on profits of the hardware manufacturer), the less effective levies are for generating additional revenues for content providers.
- Looking beyond this market, levies decrease the initial tax revenues. Indeed, if the initial rate is t_0, then with levies of $t - t_0$ the receipts are $t_0(1 - G(h + t, p)))$ which are strictly smaller than $t_0(1 - G(I(h + t_0, p)))$.

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[9]As we discuss below, the demand for shared content may also come from a lack of supply in the "legal" market, in which case the price of this content in the legal market is infinite. A generalization of the model in this direction is straightforward.

[10]Note that consumers may view the levy as a tax on *any type of copying* which may blur the perception between legal and illegal copying, effectively decreasing the opportunity cost of copying. In the notation of the model, this type of misperception by consumers would imply a first order stochastic shift in the distribution F. The legislator has been sometimes very explicit that levies *do not allow* for any type of copying, Spain being a case in point. For simplicity we ignore this potential effect and assume that the levy has no effect on F.

There is therefore a negative externality on agents who do not consume online content: part of the social cost of the levy is the reduction in available tax revenues for other social uses.

We can now turn to our initial question and ask whether content providers are better off after a levy on hardware in imposed. Let ρ represent the recouping rate, that is the proportion of the revenue that actually ends up in the hands of content providers.

The total revenue from the sales of (legal) content is $(1 - F(p))\theta(I - h - t)$ while the revenue accruing to content providers from the levy is $\rho T(t)$.[11] The variation of the sum of these two sources of revenue is negative when:

$$-\theta(1 - F(p)) + \rho T'(t) < 0. \tag{7}$$

By concavity of $T(t)$, $T'(t) \leq T'(0) = 1 - G(I(h, p)$, and therefore the left hand side of the previous equation is bounded above by $-\theta(1 - F(p)) + \rho(1 - G(I(h, p))$. It follows that a sufficient condition for content providers to be worse with *any* levy is that (7) holds at $t = 0$:

Proposition 3. *Content providers are worse off with an increase in the levy if:*

$$\theta(1 - F(p)) > \rho(1 - G(I(h, p))). \tag{8}$$

This condition is most likely to be satisfied the more important digital content is for consumers (higher θ); the lower the recouping rate ρ, the lower the propensity $F(p)$ for consumers to use shared content *at the expense of legal content*. We now assess the approximate values of $F(p)$ and ρ from available data, and argue that $1 - F(p)$ is larger than ρ, implying that the inequality in Proposition 3 is likely to hold when θ, the taste for digital content is of a similar degree of magnitude as the measure of agents who purchase hardware.

Evaluating ρ. Two pieces of evidence suggest that the recouping rate is small:

- First, there is evidence that a significant part of the levies collected and distributed to collecting agencies is not distributed to content providers. Collecting societies have to be compensated for their operational costs; there are bureaucratic complexities, such as the transfer of levies across different collecting agencies, each of which is compensated for its intervention; some IPR holders are never compensated because they cannot be traced (so-called "orphans").[12] The 2009 report of the oversight committee

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[11]Assuming that the price of content is not affected by the level of the levy is appropriate if prices are decided ex-post, after consumers have purchased the hardware.

[12]Sometimes the failure of distributing royalties to authors is due to the impossibility of locating them. A funny anecdote that happened in the 1990s is that of ADAMI (*Administration des droits de artistes et des musiciens interprètes*), a collecting agency in charge of transferring to authors

of French collecting agencies indicates that only 80% of collected levies are finally distributed to artists. The report also shows that "residual income" (non-redistributed income) is increasing over time. In 2008, the total inflow was 1,259 millions of Euros but the total available revenue was 3,224 millions Euros. Hence the annual inflow of levies represents only some 40% of the total annual and accumulated income, which suggests that societies tend to accumulate income instead of distributing it.

- Second, as noted above, copyright levies are imposed on top of existing taxes, like the VAT in many European countries, or state and federal taxes in the US. Hence the t we have used above includes not only the levy on hardware t_l but also these other taxes t_0. If ρ is the share of the total proceeds from the levy flowing to the content providers for the reasons explained in the first remark above, content providers obtain:

$$\rho t_l(1 - G(h + t_0 + t_l)).$$

It follows that the net profit from the levy is:

$$\theta(1 - F(p)(I - h - t_0 - t_l) + \rho t_l(1 - G(h + t_0 + t_l)),$$

implying that an increase is not beneficial to the content providers when:

$$\theta(1 - F(p)) > \rho\left[1 - G(h + t_0 + t_l) - t_l g(h + t_0 + t_l)\right]$$

By continuity of the distribution function G, there exists $\rho_0 < 1$ such that:

$$\rho_0(1 - G(h + t_0 + t_l)) = 1 - G(h + t_0 + t_l) - t_l g(h + t_0 + t_l),$$

and therefore a necessary condition for content providers to be worse off with an increase in the levy t_l is:

$$\theta(1 - F(p) > (\rho\rho_0)r(1 - G(h + t_0 + t_l)),$$

implying that this second effect yields an effective recouping rate for the content providers less than ρ.

Combining these two observations, in the most optimistic scenario, out of a total tax of t on hardware (including VAT in particular), the recouping rate on tax proceeds on levies on hardware is lower than 80%.

Evaluating $F(p)$. The general difficulty in assessing empirically the propensity of agents to share content is linked to understanding how and why consumer habits have changed, and in particular the fact that a larger share of music consumption

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royalties on the sale of audio and video cassettes, which was unable to transfer the royalties due to Charles Bronson and Sean Connery because it could not find their addresses.

goes through the internet or MP3 players, and that "single" tracks online consumption is preferred to the usual "bundled" tracks available on CDs. This effect will naturally lead to a cannibalization of CD sales. Data from the Recording Industry Association of America (RIIA) show that online content shipments represented a negligible percentage of total shipments in 2003, but represent 83% of total shipments in 2009. However, revenues from digital shipments went from 0% in 2003 to only 40% of the total value in 2009.[13]

Note that even if there is no piracy, the emergence of a new distribution channel on which competition between providers is more severe – because the costs of distribution are lower, entry is easier, and consumers have lower search costs – should increase the volume of transactions *and* reduce the revenues and profits of incumbent firms. But obviously cannibalization can occur in the absence of competition also. A new distribution channel will cannibalize the old one, even if there is only one firm in the market. According to RIAA's data, this happened between 1973 and 1992, when the introduction of CDs (single or multiple tracks) cannibalized the market for LPs and cassettes; interestingly, and contrary to the recent trend where the growth in internet distribution led to an increase in volume but a decrease in the value of shipments, the period 1973-1992 was characterized by a regular increase in this value. The difference between the two episodes of cannibalization is that between 1973 and 1992, majors controlled most of the markets for distribution (CDs and cassettes) while between 2003 and 2009, they had weak control on online distribution, and had to face many small entrants.

The greater availability of "free" music through streaming probably also led to a lower consumption of other types of content. Note that as illustrated by the RIAA data, despite this canibalization, there is a continuous increase in the volume of online downloads for single tracks, a segment on which piracy should a priori be the more active.

Finally, even if consumers prefer to consuming legal content rather than copying from other sources they may resort to using P2P networks to access content that is not available through legal means rather than go and buy physical CDs or DVDs. Hence, *given the change in consumption habits of consumers* piracy is influenced by the size of the stock of content made legally available on the online market. The lack of supply may lead to more piracy, as suggested by Danaher et al. (2010), who use as a natural experiment the removal of NBC content from Apple's iTunes store in December 2007, and its restoration in September 2008. Their findings support both the "change of habits" and the "supply" effects.

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[13]It is not clear how RIAA statistics account for the fact that there are several tracks on CDs, but that very often, downloads are singles. If they assume that a CD and a download of a single count both for one unit, this may explain why in volume, the total market does hardly decrease, while its value is falling.

- NBC's decision to remove its content from iTunes in December 2007 is very likely to have caused a 11.2% increase in the demand for pirated content. There is also a small but significant decrease in piracy *after* the NBC content was restored on iTunes' store in September 2008. This suggests that there is indeed a supply effect for piracy: a decrease in online legal content seems to lead to more piracy.

- *A contrario*, the paper finds no effect on demand for NBC's DVD content at Amazon.com for the two events in 2007 and 2008. This seems to imply that there is little substitution between online content and traditional content (DVDs) and reinforces the idea of a change in consumption habits of consumers.

The use of a change in sales as an indicator of piracy activity is therefore likely to over-emphasize the volume of piracy. This is also confirmed by a certain number surveys.

Zentner (2006) uses a European consumer mail cross-section survey of 15,000 observations, and finds that music downloading reduces the probability of buying music by 30%. But he observes that 56% of those who regularly download files also *buy* music. This percentage is much larger than among those who do not download. These consumers use downloading to sample,[14] which is cheaper than "going to the store and listening to the album before purchasing."

Rob and Waldfogel (2004) note that downloads will harm firms, only if "downloading tends to occur for albums that consumers value highly and would otherwise have purchased." Their empirical results show that downloaded albums tend to be low valued, and would probably not have been bought. If this is so, the loss for firms is limited. Peitz and Waelbroeck (2004) find that internet piracy in 2002 in the US accounts for less than 25% of the decline of sales.

The conclusions obtained by Oberholzer-Gee and Strumpf (2007), based on a sample of 1.75 million file transfers in 2002 confirm the previous result by stating that "on the basis of all specifications in the paper, even our least precise results,[15] we can reject the hypothesis that file sharing cost the industry more that 24.1 million albums annually (3 percent of sales and less than one-third of the observed decline in 2002)." They also reject the null hypothesis that peer-to-peer exchanges displaced more than 10% of the 2002 decline. Their conclusion rejoins Rob and Waldfogel (2006) by suggesting that most downloaders are likely to be individuals who would not have bought music if downloading had not existed.

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[14]See also Peitz and Waelbroeck (2006) who show that for a large set of parameter values of their model, consumers use downloading to make more informed purchasing decisions, but also buy, though they could consume the download for free.

[15]Most estimates of the relevant parameters are not statistically different from zero.

One may argue that these studies are based on ten year-old data. We have used IFPI (2010) data to compute the rate of decline of sales (of CDs, music videos, online downloads) in various countries.[16] In Western Europe, the annual growth of total sales over the period 2005-2009 range from -13.9% (for Italy) to -0.7% (for Germany). In Eastern European countries (Croatia, Czech Republic, Poland, Slovakia), the rate of growth is positive. The rates for Canada and the US are respectively -7.1% and -10.9%. These ranges are similar to those of the period 2000-2004, used in the studies cited above.

The empirical literature therefore suggests that $1 - F(p) \geq 80\%$ is consistent with stylized facts, showing that less then 20% of the drop in sales is the result of piracy. Moreover, even if the loss were due to piracy only, it is generated by the whole *outstanding stock* of hardware, which is much larger than annual sales. The levy on hardware will only concern additional sales and the supposed additional piracy that these new purchases will generate will at best be much smaller, say 1/4 of the loss generated by the old stock, assuming that the average life of a piece of hardware is 4 years. Hence, we should rather base our rough estimate of the upper bound of $1 - F(p)$ on the annual decrease of sales, which goes in the same direction as the studies discussed earlier.

To sum up, evidence suggests that $\rho < 80\% < 1 - F(p)$. Hence a levy will lead to a decrease in the total revenues accruing to content providers if θ is not too small with respect to $1 - G(I(h, p))$,[17] that is if the proportion of consumers who purchase hardware is less than θ. In that case, inequality (8) which shows that content providers may be worse off, is satisfied.

3. A DYNAMIC EFFECT OF LEVIES WITH HETEROGENEOUS CONTENT PROVIDERS

It is well documented that artists have a variety of objectives when they distribute their work. In particular, while established artists may indeed care mainly about their revenue,[18] less established artists benefit first from establishing their reputation, even if this requires for their work to be made available at a discount.[19] Sales enhance reputation which has long term benefits since higher reputation increases future sales and revenues. Hence, new entrants on the market may rationally

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[16]In order to have a meaningful comparison with CDs in which many tracks are bundled, and contrary to what RIAA seems to be doing, we divide the number of single track downloads by 10. This may be largely exaggerated, since the eight or ten tracks that are bundled in a CD may not all be of interest to the consumer, who may be forced to buy an expensive CD, and be interested in one track only. The division by 10 will tend to exaggerate the rate of decline of sales and therefore provide the most pessimistic scenario for $1 - F(p)$. Details about the computation of these rates are available from the authors upon request.

[17]Or $1 - G(I(h + t_0, p))$ if there are other taxes t_0 like VAT.

[18]Though even that is not always true, as is shown by Courty and Pagliero (2014).

[19]See for instance Legros (2006).

favor increased sales rather than higher revenues in order to maximize their lifetime earnings.

We illustrate this idea by introducing the possibility for artists to build their reputation through sales. Suppose that k, the current reputation of an artist can be high (H) or low (L) and that the probability $q(x, k)$ of increasing future reputation is a function of current sales x and current reputation k. To simplify the exposition we will assume that high reputation artists keep their reputation for any value of x but that low reputation artists have a positive probability not to change their future reputation and a probability $q(x)$ of getting a high reputation that is increasing in sales x.[20] Assume that each consumer buys from H- and L-artists in proportions $\beta, 1 - \beta$ where $\beta > 1/2$ and that the proceeds from the levy are distributed using these proportions. One interpretation of β is the "stickiness" of demand for high reputation artists, and $1 - \beta$ is the desire of consumers to experiment. In general, β is likely to be endogenous to the technology, for instance with streaming, internet radios, but whether this will increase or decrease over time its value is unclear.[21]

Finally, assume that the price p of legal content does not change over time, hence adopting the same competitive view as in the previous section,[22] and that lifetime utility is discounted at the rate $\delta < 1$ for each type of artist. Define $R(t) = px(t)$ and let $V(k, t)$ be the lifetime expected utility of an artist with current reputation k when the levy revenues are $T(t)$.

For H-artists, we have:

$$V(H, t) = \beta[R(t) + \rho T(t)] + \delta V(H, t),$$

or

$$V(H, t) = \frac{\beta}{1 - \delta}[R(t) + \rho T(t)].$$

L-artists have a probability $q\left((1 - \beta)x(t)\right)V(L, t))$ of increasing their reputation to H, and therefore:

$$
\begin{aligned}
V(L, t) \;=\; & (1 - \beta)[R(t) + \rho T(t)] \\
& + \delta\left\{q\left((1 - \beta)x(t)\right)V(H, t) + (1 - q\left((1 - \beta)x(t)\right)V(L, t))\right\}
\end{aligned}
$$

Replacing $V(H, t)$ by its value leads to

$$V(L, t) = \frac{1 - \beta + \frac{\delta\beta}{1 - \delta}q\left((1 - \beta)x(t)\right)}{1 - \delta + \delta q\left((1 - \beta)x(t)\right)}[R(t) + \rho T(t)]$$

---

[20]The qualitative results are unchanged as long as high reputation artists have a larger probability of staying in high reputation than low reputation artists have to 'jump' to a high reputation status, that is as long as $q(x, H) > q(x, L)$ for any x.

[21]For instance, internet radios may increase the exposure to new artists but also enable the consumer to focus on specific "playlists".

[22]This is a reasonable assumption for recorded music or movies (CDs, or online downloads).

Direct computation shows that

$$\frac{\partial V(L,t)}{\partial t} = A(t)\frac{\partial V(H,t)}{\partial t} + B(t)x'(t)q'\left((1-\beta)x(t)\right)V(H,t)$$

where

$$A(t) = \frac{\frac{1-\beta}{\beta}(1-\delta) + \delta q\left((1-\beta)x(t)\right)}{1 - \delta + \delta q\left((1-\beta)x(t)\right)}; \quad B(t) = \frac{\delta(1-\delta)(1-\beta)(2\beta-1)}{\left(1 - \delta + \delta q\left((1-\beta)x(t)\right)\right)^2}.$$

Since $1/2 < \beta < 1$ and $\delta < 1$, $A(t)$ and $B(t)$ are positive. Because sales are decreasing in the levy, $x'(t) < 0$, and by assumption $q'(x) > 0$. Therefore, the coefficient of $V(H,t)$ in (??) is negative. Hence, even if high reputation artists gain from the levy (that is $\partial V(H,t)/\partial t$ is positive), L-artists may suffer. Indeed, since $R'(t) < 0$, there exists ρ^* such that $\partial V(H,t)/\partial t = 0$ when $\rho = \rho^*$, and in this case $\partial V(L,t)/\partial t < 0$. Hence, by continuity, there exist $\rho^{**} > \rho^*$ such that $\partial V(L,t)/\partial t < 0$ for all recouping rates less than ρ^{**}.

If $\partial V(H,t)/\partial t < 0$, *all* artists will suffer, H-artists because they have less revenue (the recouping rate is too small for instance to compensate for the decrease in revenues from sales) and L-artists because they sell less content (since there is less hardware sold and the income available for purchasing content decreases) and hence have a lower reputation benefit.

4. Conclusions

Contrary to levies on tapes, cassettes or CDs, levies on hardware are not targeted and do not ensure that content providers will see their revenue increase. In particular, levies on hardware lead to a decrease in the consumption of hardware, which in turn leads to a decrease in the sales of content. The revenue of the levy can compensate for this decrease only if the recouping rate by content providers is larger than the propensity of consumers to buy legal content, a condition that seems empirically violated. Moreover, even if it is the case that content providers benefit from levies on hardware, these levies generate dynamic effects that may discriminate against aspiring artists and ultimately hurt the supply of new content.

Appendix A. Appendix

Proof of Proposition 1. Fix θ and denote

$$C(p) \equiv A(\theta) - \theta\left((1 - F(p))\log(p) + \int_0^p \log(r)dF(r)\right).$$

Solving $v(I,h,p) \geq (1-\theta)\log(I)$ is then equivalent to solving:

$$\log(I-h) - (1-\theta)\log(I) \geq -C(p) \tag{9}$$

$$\Leftrightarrow \frac{I-h}{I^{1-\theta}} \geq \exp(-C(p)). \tag{10}$$

The left hand side has variation proportional to $I - (1-\theta)(I-h)$ and is therefore increasing with I. If follows that there exists a unique value $I(h,p)$ such that $v(I,h,p) = (1-\theta)\log(I)$ and consumers with income higher than $I(h,p)$ buy the hardware.

Proof of Proposition 2. The variation of the tax proceeds is

$$T'(t) = 1 - G(I(h+t,p)) - t\frac{\partial I(h+t,p)}{\partial t}g(I(h+t,p))$$

$$= (1 - G(I(h+t,p)))\left[1 - t\frac{\partial I(h+t,p)}{\partial t}\frac{g(I(h+t,p))}{1 - G(I(h+t,p))}\right].$$

$I(h+t,p)$ solves (9) with an equality and therefore:

$$\frac{\partial I(h+t,p)}{\partial t} = \left[1 - \theta\frac{I-h-t}{I}\right]^{-1}$$

which is positive since θ and $(I-h-t)/I$ are both less than 1. Hence by (1), it follows that the term in brackets in the previous expression for $T'(t)$ is decreasing in t. Since $1 - G(I(h+t,p))$ is also decreasing in t, it follows that the tax proceeds function $T(t)$ is concave in t.

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