The Economics of Copyright Levies on Hardware*

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Abstract

We provide an economic analysis of the static and dynamic effects of copyright levies on hardware used to access content. An immediate effect of such a levy is to decrease consumption of content. In a competitive environment, the net revenue of content providers increases with the levy only if the share of the levy they receive exceeds the share of consumers using licensed content, a condition that does not seem to be satisfied in reality. We extend the basic model to allow for differentiated content providers and show that in a dynamic setting of reputation building, less “reputable” content providers suffer more from levies on hardware. Finally, we allow for market power by content providers and show that high levels of levies will deter content providers from adopting subscription systems. This may happen despite the fact that subscription systems may bring back into licensed consumption “pirates” and benefit licensed consumers.

1 Introduction

Copyright levies on hardware are slowly making their way in the United States and Canada as well as in Europe. Interestingly, in the U.S. royalties apply to stand-alone CD recorders but not to CD burners with computers (as well as to blank CDs labeled and sold for

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music alone, but not to blank computer CDs, though they can also be used to burn music from a computer to CD). 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 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 level of $13 (plus VAT) on computers, but the pressure of the European Commission to generalize this to other countries is increasing. Our paper aims at showing that, contrary to copyright levies on blank CDs and similar devices, levies on hardware are very likely to have negative effects both on producers of hardware and on copyright holders.

In the presence of market externalities – a typical example is the control of pollution – 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 which 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 contracting possibilities between the polluter and the victims of the pollution are weak, a Pigouvian tax imposed on the producer of the externality is a substitute for a market for rights and will also induce the firm and the other agents to internalize the externality (negative or positive), and reduce the level of over- or under-consumption.\footnote{As noted by Pigou himself, the “right” level of the tax may be difficult to determine by a regulator.} By taxing a producer, his level of production and, therefore, the level of pollution will decrease. The proceeds from taxation could then be given to those agents who bear the cost of pollution or used for other means. Note that the tax is \textit{targeted} to 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 does not bring revenues to the content provider that he 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 contrary to the traditional example of pollution by a productive firm, pollution is here exerted by consumers rather than by the producer. Therefore, for a Pigouvian tax to be effective in curbing this type of 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 copying, making them more expensive by taxing will reduce the level of copying and make sellers of artistic content (whether intellectual property right holders, artists, or producers, such as studios or CD producers) better off.  

An early objective of levies was to compensate content providers for copying by consumers. Even if copying falls within the licensing terms of the sale, e.g., private copying allowed by the license, content providers may feel that this reduces 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). 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).

While the objectives are relatively clear, it remains to show that levies indeed serve as a compensatory instrument for copying, that is, effectively increase the revenues of content providers. After all, if consumers pay more for copying, their indirect utility decreases and they are more reluctant to buy content to begin with.

The parallel with Pigouvian taxes is useful because we will show that when levies are targeted the objective of increasing the revenues of content providers is often met.

Because levies increase the price of copying (including that made outside the terms of the license), a direct effect of taxation is to curb both licensed copying and piracy; this increases the revenue of content providers as long as consumers substitute original content for copies. However, an indirect effect of taxation is to decrease the indirect utility from

\[\text{footnote}{2}\text{We will not distinguish between these roles and use ‘content providers’ from now on.}\]

\[\text{footnote}{3}\text{For a review of copyright levies, see for instance Oksanen and Välimäki (2005).}\]
using content and this may lead to a decrease in demand for the hardware needed to access and play content. There will thus be less consumers purchasing content, but consumers who purchase content tend to buy more legal content. Under general specifications, the positive effect dominates and content providers will be better off with the levy.

By contrast, 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 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.

This effect is discussed in Section 2 of the paper. We highlight a simple relationship between the share of levies that content providers retain (the “retention rate”) and the propensity of consumers to use copies rather than original content to characterize situations where the revenue of content providers decreases with higher levels of the levy. This relationship seems comforted by available data. What is important for this result is that the demand for hardware is elastic; we also assume that content providers are price-takers.

In Section 3, we allow for market power by content providers and specialize the previous model to situations where consumers are either reluctant to (or have strong preference for) using copied content outside the licensing agreement (“pirates”). Under linear pricing, if the share of pirates’ is small enough, monopoly pricing by content providers leads to segmentation: pirates do not buy legal content and the price of legal content is decreasing in the level of a levy. Independently of the retention rate, if content providers can set the price of content and retain all the levies, their profits are increasing with the levy. By contrast, if a subscription system is put in place, and content providers fully retain the tax proceeds, their profit level is independent of the level of the tax. It follows that the difference of profits between a subscription system and a uniform price is decreasing in the level of the levy; in turn, this implies that a subscription system is less likely to be adopted with higher levies. We show that this result holds, independently of the retention rate. Hence even if levies on hardware have the ‘right’ static effect to increase the revenues of
content providers, they have detrimental consequences from a dynamic perspective since welfare improving business models such as subscription services are less likely to be adopted.

2 Levies in a Competitive Setting

We consider an industry with competitive firms enjoying constant returns to scale: the supply of hardware producers and of content providers is inelastic. Consumers need a piece of hardware (computer, mobile phone, MP3 player) in order to access content. Let \( h \) be its price. A consumer can buy content from the content provider (we denote this as “licensed” content) or use copies, either obtained by copying a licensed content within the terms of the license agreement or by copying content on the internet. Licensed content costs \( p \), a copy costs \( r \) (\( r \) includes the cost of using another interface to convert music or videos; cost of tapes; opportunity cost of time; disutility of engaging in “illegal activity” in the case of piracy; perceived or actual difference of quality between original and copies). \( r \) is a random variable from the point of view of consumers at the time they purchase the hardware, but becomes known afterwards; it has distribution \( F \) on \([0, 1]\).\(^4\)

Consumers

Consumers have total income \( I \) to spend on leisure, including hardware needed to access digital content. They can consume content by either purchasing from content providers or by using shared content (through own copying or P2P networks for instance); if there is some residual income, they can use it for other leisure goods (go to theater, etc.) Let \( l \) and \( s \) be the number of units of licensed and copied content and \( m \) the residual income after purchasing hardware and content. The consumer has utility \( u(l + s) + m \).\(^5\)

A consumer who purchased hardware at price \( h \), has residual income \( I - h \) to spend on content or other goods. His problem is then to choose \( l, s, D \), where \( D \) is the total expense

\(^4\)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.

\(^5\)Though shared content is often of lower quality, in this specification, a unit of shared content is a perfect substitute for a unit of legal content. Utility functions \( u(l + \phi s) \) where \( \phi \) is the quality of shared content will hardly change our results: instead of condition \( r < p \) for legal purchases, the condition will be \( r/\phi < p \).
on content (both legal and shared), solution of:

\[
\max_{l,s,D} u(l + s) + I - h - D
\]

\[
p l + r s \leq D
\]

\[
D \leq I - h.
\]

Let us define the function \( x^*(q) \) to be the maximum level of content a consumer will buy when the price of content is \( q \):

\[
u'(x^*(q)) = q.
\]  

(1)

An unconstrained consumer is a consumer for whom \( D < I - h \) in the optimum. If \( p < r \), he buys \( x^*(p) \) units of licensed content only, and if \( p > r \) he buys no licensed content and uses \( x^*(r) \) units of shared content only. Letting \( p \wedge r \equiv \min\{p, r\} \), a consumer is unconstrained when \( I - h > (p \wedge r)x^*(p \wedge r) \).

If \( I - h < (p \wedge r)x^*(p \wedge r) \), the consumer is constrained and will spend all his residual income \( D = I - h \) on content: when \( p < r \) the consumer demands \( (I - h)/p \) of licensed content and when \( p > r \) he demands \( (I - h)/r \) of shared content.

**Lemma 1.** For given prices \( p, h \) and income \( I \), the expected demand for licensed \((L)\) and copied \((C)\) contents are

(i) \( L(p, h) = (1 - F(p))x^*(p), \ C(p, h) = \int_{0}^{p} x^*(r)dF(r), \) if the consumer is unconstrained

(ii) \( L(p, h) = (1 - F(p)) \frac{I - h}{p}, \ C(p, h) = \int_{0}^{p} \frac{I - h}{r}dF(r), \) if he is constrained.

The revenue \( R(p, h) \) from the sale of licensed content is therefore \( R(p, h) = (1 - F(p))px^*(p) \) for unconstrained consumers, and \( R(p, h) = (1 - F(p))(I - h) \) for constrained ones.

The term \( F(p) \) illustrates the substitution effect between copied and licensed content while \( I - h \) illustrates an income effect: as \( h \) increases, less income is available to purchase shared and licensed contents and therefore while there is less copied content there is also less licensed content purchased and therefore less revenues for content providers.

It then follows that a copyright levy on copied content will increase the revenue of content providers but that a levy on hardware will decrease this revenue. Indeed a levy \( \tau \) on copied content has the effect of making licensed content more attractive and consumers buy it as long as \( r + \tau > p \). This happens with probability \( 1 - F(p - \tau) \) which is increasing
in \( \tau \). By contrast, a levy on hardware implies that consumers are more often constrained and therefore consume less copied \textit{and} licensed content.

However, part of the logic of copyright levies is to use their proceeds to compensate content providers for lost revenues on copied content. This transfer reinforces the direct positive effect of a levy on copied content. However, the transfer can compensate for the direct negative effect of the levy on hardware only if a large enough share of the proceeds is distributed to content providers.

We now show that in practice, this share is not large enough. We consider first the case of homogeneous consumers, who all have the same utility function and income, and restrict attention to constrained consumers. This assumption is likely in the case of young consumers who are still depending on their parents for their income; they are also those who are most likely to download and share content. We then turn to more general cases.

\subsection{Homogenous Consumers}

We suppose that all consumers have the same income \( I \) and make the reasonable assumption that they are income constrained: \( h \leq I < h + px^*(p) \). Consider a levy on hardware of \( t \) and let \( \rho \) be the retention rate of proceeds by content providers. The price of hardware is \((1 + t)h\) and the total expected revenue (gross of the levy proceeds) of content providers is:

\[
(1 - F(p))(I - h - t) + \rho t = (1 - F(p))(I - h) + t(\rho - 1 + F(p)).
\]

Therefore

\textbf{Proposition 1.} Suppose that all consumers have income \( I \in (h, h + px^*(p)) \). A levy on hardware increases the total revenue to the content providers if and only if

\[
\rho > 1 - F(p),
\]

where \( 1 - F(p) \) is the probability that a consumer will buy licensed content rather than copied content, and \( \rho \) is the retention rate. We now try to assess the approximate values of \( F(p) \) and \( \rho \), and show that the inequality in Proposition 1 is unlikely to hold, hence that it is unlikely that content providers can be compensated if a levy on hardware is imposed.
Assessing a lower-bound for $1 - F(p)$

A general difficulty in assessing empirically the propensity of agents to share content is the need to control for a change of consumers’ habits in particular the fact that a larger share of music consumption is now done 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, and may therefore influence the desire of content providers to supply on the internet, as well as their pricing strategies.\footnote{Data from the Recording Industry Association of America are consistent with the two effects (change of consumer habits and cannibalization by the online market). While online content shipments represented a negligible percentage of total shipments in 2003, they continuously increased and represent 83% of total shipments in 2009, though there is a small decline in 2009. However, revenues from digital shipments went from 0% in 2003 to only 40% of the total value in 2009 and this total value was relatively stable until 2005, with a regular decline since then.\textsuperscript{6}}

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 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 in the period 2003-2009 they had weak control on online distribution.

Furthermore, there is some evidence (Futuressource, 2010) that in 2009, streaming music downloads (available through online radios specialized in musical genres, YouTube, \footnote{See Herings, Peeter and Yang (2009) for a dynamic model of pricing that takes into account this cannibalization effect.}
Facebook or Myspace, including paid services such as Rhapsody, or Napster) exceeded music downloads. The greater availability of “free” music through streaming should lead also to a lower consumption of other types of content (whether traditional CDs or pay-per-view online content). Note that as illustrated by the RIAA (2010) data, despite this cannibalization, 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 consume licensed content rather than copy from other sources they may resort to use 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. Some evidence that lack of supply is correlated with piracy (or P2P downloads) is provided by Danaher et al. (2010). The authors 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.

- 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 likely to overemphasize its effect. Nevertheless, even if we do not take account of the previous effects, different estimates described below suggest that a reasonable lower bound for $1 - F(p)$ is 80%.

Zentner (2006) uses a European consumer mail cross-sectional survey of 15,000 observations from October 2001, 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, which is cheaper than “going to the store

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8See also the theoretical model by Peitz and Waelbroeck (2004) who show that for a large set of parameter
and listening to the album before purchasing.” Rob and Waldfogel (2004) note that (college student) downloaders are obviously better off. This may of course harm firms, only if “downloading tends to occur for albums that consumers value highly and would otherwise have purchased.” Otherwise, no harm is done. 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 on the US market accounts for less than 25% of the decline. The conclusions obtained by Oberhizer and Koleman (2007) are not based on consumer surveys, but on a sample of 1.75 million file transfers in 2002. They confirm the previous result by stating that “on the basis of all specifications in the paper, even our last precise results, 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 that of 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.

There is also the issue of welfare. Using the sample that was mentioned earlier, Rob and Waldfogel (2004) show that those students who download reduce their music expenditure by $25 and increase their consumer surplus by $75. The decrease in deadweight loss of some $50 is “nearly double the reduction in industry revenue.”

One may argue that these studies are based on ten years-old data. IFPI (2010) data summarized in Appendix 5.2 show the rate of decline of sales (of CDs, music videos, online downloads) in various countries. 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 previous studies cited.

values of their model, consumers use downloading to make more informed purchasing decisions, but also buy, though they could consume the download for free.

9 Most estimates of the relevant parameters are not statistically different from zero.

10 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 therefore tend to exaggerate the rate of decline of sales and therefore provide the most pessimistic scenario for $1 - F(p)$. 
The loss in legal sales is larger than 20% over the four years in some countries and may suggests that the lower bound on $1 - F(p)$ could be less than 80%, but this decline in sales is due to piracy, cannibalization and other factors as suggested by Rob and Waldfogel (2004), Peitz and Waelbroeck (2004), and Oberhizer and Koleman (2007), and not to piracy alone. The empirical literature therefore suggests that $1 - F(p) \geq 80\%$ is consistent with stylized facts. 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.

**Comparing $1 - F(p)$ and $\rho$.**

Therefore, in the most optimistic scenario the retention rate $\rho$ is smaller than 80% and since under the most pessimistic scenario $1 - F(p) \geq 80\%$, a levy will lead to a decrease in the total revenues accruing to content providers when consumers are constrained, as suggested in Proposition 1. While this result illustrates that levies may fail to achieve their goal of compensating content providers for piracy or sharing on the internet, a general argument should take into account the heterogeneity in available income for leisure by consumers.

In particular, if given the levy $t$, consumers have retained income $I \geq h + t + px^*(p)$, their consumption behavior is unchanged by the levy and as long as the levy is not too large, they will continue to buy the hardware. It follows that under this assumption, content providers are strictly better off imposing the levy on these consumers since their revenue increases by $pt$. However, as we have just seen, a levy on constrained consumers is likely to decrease their revenues. An additional effect brought by levies when consumers are not homogenous is to make income constrained some consumers who were not initially constrained; this effect will exacerbates the negative effect of the levy. We turn to this general case below.
2.2 Heterogenous Consumers

Let $G(I)$ be the distribution of income in the population, and make the usual assumption that this distribution has an increasing hazard rate:

$$\frac{g(I)}{1 - G(I)} \text{ is increasing in } I. \quad (2)$$

Let $v(I, h, p)$ be the expected (with respect to $r$) indirect utility of a consumer with income $I$ facing prices $h, p$ for hardware and legal consumption respectively. To simplify, we consider a log-utility for consumption. In this case consumers spend the same income on legal or copied content. They spend 1 if they are unconstrained ($I \geq h + 1$) and $I - h$ otherwise. With the log specification, the indirect utility of consumers is

$$v(I, h, p) = \begin{cases} 
- (1 - F(p)) \log(p) - \int_0^p \log(r) dF(r) + I - h - 1 & \text{if } I \geq h + 1 \\
- (1 - F(p)) \log(p) - \int_0^p \log(r) dF(r) + \log(I - h) & \text{if } I < h + 1 
\end{cases}$$

for unconstrained (high income) and constrained (low income) consumers, respectively. Clearly, $v(I, h, p)$ is increasing in $I$ and decreasing in $h, p$.

For unconstrained consumers, the marginal indirect utility from income is equal to 1. It is strictly larger than 1 for constrained consumers since a higher income loosens their budget constraint. High income consumers buy the hardware only if

$$- (1 - F(p)) \log(p) - \int_0^p \log(r) dF(r) \geq 1 + h \quad (3)$$

and, to avoid trivialities, we will restrict attention to environments were this condition holds strictly (otherwise no consumer buys hardware).

Given (3), unconstrained consumers always purchase hardware but constrained consumers purchase hardware only if $v(I, h, p) \geq I$. A consumer who is indifferent between purchasing and not hardware has income $I$ solving

$$I - \log(I - h) = -(1 - F(p)) \log(p) - \int_0^p \log(r) dF(r) \quad (4)$$

11 This condition is satisfied for most of the usual distributions like the uniform, or the normal.
12 This is a well known property of the log utility: the unconstrained optimum when the price is $q$ solves $\log'(x) = q$ implying $xq = 1$ for any $q$. 
Since the function $I - \log(I - h)$ is strictly decreasing in $I$ when $I - h < 1$, there exists a unique solution to (4), that we denote by $I(h, p)$. It is immediate that this cutoff level is increasing in $h, p$, therefore illustrating why an increase in levies (i.e., a higher after levy price of hardware) leads to a decrease in sales of content.

The question is whether this decrease in revenues through lower sales is compensated by the tax revenues to content providers. The tax proceeds are

$$T(t) = t[1 - G(I(h + t, p))]$$

(5)

It is possible to show (see Appendix 5.1) that this function is concave in $t$ achieving a maximum at a finite value $t^*$. This “Laffer curve” effect has some interesting consequences.

- Any levy that leads to a total tax greater 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) are, the less effective levies are for generating additional revenues for content providers.

- Looking beyond this market, levies decrease the initial levy revenues. Indeed, if the initial rate is $t_0$, then with levies of $t - t_0$ the receipts are $t_0(1 - G(h + t))$ which are strictly lower than the tax revenues before the levies $t_0(1 - G(I(h + t_0)))$. 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 proceeds for other social uses.

It follows that if all consumers are initially constrained, the condition in Proposition 1 is sufficient for a levy on hardware not to raise the revenue of content providers. In other words, heterogeneity in income between constrained consumers makes it more likely that levies do not increase the total revenue of content providers.

**Proposition 2.** Suppose that all consumers are budget constrained, that is that $G(1 + h) = 1$. Then:

(i) If $t > t^*$, total revenues of content providers are decreasing in $t$ for any $\rho$.

(ii) If $t < t^*$, there exists $\rho^* > 1 - F(p)$, such that a tax on hardware will strictly decrease the revenue available to content providers whenever $\rho < \rho^*$. 
The proof is given in Appendix 5.1.

If some consumers are unconstrained in the absence of levies \((G(1 + h) < 1)\), the cutoff value of \(\rho^*\) will decrease, as the measure of unconstrained consumers increases. Indeed, in general,

\[
R(t) = (1 - F(p)) \left[ 1 - G(1 + h + t) + \int_{I(h+t,p)}^{1+h+t} (I - h - t)dG(I) \right]
\]

and therefore

\[
R'(t) = (1 - F(p)) \left[ G(I(h + t, p) - G(1 + h + t) - \frac{\partial I(h + t, p)}{\partial h} (I(h + t, p) - h - t)g(I(t))) \right]
\]

which is greater than the marginal revenue from sales when all consumers are constrained since \(G(1 + h + t) < 1\). By contrast, the marginal tax \(T'(t)\) is the same as in the previous case. Now, if \(\rho = 1 - F(p)\),

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

and therefore as \(G(1 + h + t)\) decreases (that is, as the measure of unconstrained consumers increases), this expression will increase, implying that the retention rate consistent with a positive effect of levies on total revenues of content providers is decreasing.

3 Extensions

3.1 Heterogeneity Among Content Providers

Until now we have assumed that all content providers (artists) want to maximize their (static) revenue. However, as is well documented, artists have a variety of objectives when they distribute their work. In particular, while established artists may indeed care mainly about their revenue, less established artists benefit first from establishing their reputation, even if this requires for their work to be made available at a discount (see for instance [Legros 2006]). Sales enhance reputation which has long term benefits since higher reputation increases future sales and revenues. Hence, new entrants on the market may rationally 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 reputation can be high ($H$) or low ($L$) and that the probability $\sigma(x, k)$ of increasing future reputation is a function of today’s sales $x$ and today’s reputation $k$. To simplify, assume that high reputation artists keep their reputation ($\sigma(x, H) = 1$) and low reputation artists have a positive probability not to change their future reputation ($\sigma(x, L) < 1$). Given these assumptions, we can simply denote by $\sigma(x)$ the probability that a low reputation artist increases his future reputation when he sells $x$ units of content.\textsuperscript{13} 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.

Suppose that the price $p$ does not change over time\textsuperscript{14} and that lifetime utility is discounted at the rate $\delta$ for each type of artist. Define $R(t) = px(t)$ and let $V(k, t)$ be the lifetime expected utility of an artist with reputation $k$ today when the levy proceeds are $T(t)$.

For H-artists, we have

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

or

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

For L-artists we have

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

if becomes $H$

$$\text{if stays } L$$

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

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

\textsuperscript{13}The qualitative results are unchanged as long as $\sigma(x, H) > \sigma(x, L)$.

\textsuperscript{14}This is a reasonable assumption for recorded music or movies (CDs, or online downloads).
Direct computation shows that

\[
\frac{\partial V(L, t)}{\partial t} = A(t) \frac{\partial V(H, t)}{\partial t} + B(t)x'(t)\sigma'((1 - \beta)x(t)) V(H, t)
\]  

(6)

where

\[
A(t) = \frac{1 - \beta(1 - \delta) + \delta \sigma((1 - \beta)x(t))}{1 - \delta + \delta \sigma((1 - \beta)x(t))}; \quad B(t) = \frac{\delta(1 - \delta)(1 - \beta)(2\beta - 1)}{(1 - \delta + \delta \sigma((1 - \beta)x(t)))^2}.
\]

Since 1/2 < \beta < 1 and \delta < 1, \(A(t)\) and \(B(t)\) are positive. Because \(x'(t) < 0\) while \(q' > 0\), the coefficient of \(V(H, t)\) in (6) 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 \(\rho^*\) 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 retention rates less than \(\rho^{**}\).

If \(\partial V(H, t)/\partial t < 0\), all artists will suffer, H-artists because they have less revenue (the retention 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.

### 3.2 Levies and Subscription Systems

While there are many experiments of business models for online distribution (subscription or streaming services, for example), the pay-per download model is still dominant. Online distribution requires investments by different stakeholders, including hardware providers. Because these investments are often complementary to the emergence of new business models, these are likely to emerge when their added value exceeds the investment cost.

We now consider the possibility for content providers and the hardware manufacturer to develop a subscription service, that is a two-part tariff (TPT) where the consumer pays a fixed price \(S\) for access to a platform and then a pay-per-download price \(p\) for each track, which can be as low as zero if access is free once the fixed fee \(S\) has been paid.

We will assume that a fixed investment is needed to implement a TPT. It follows that a TPT will be used only if the increase in profits with respect to charging a linear price for content is greater than the investment: the larger the difference in profits, the more
likely will the adoption of TPT be. We show that adoption of a TPT is less likely when the copyright levy on hardware \( t \) increases.

There are different reasons for which it is costly to put in place a two-part tariff.

- Traditionally, we observe two-part tariffs in settings where access is restricted. This was the case for the first Disneyland attraction park, or for telecom operators, and is no accident: since the unit price is (often) close to cost, if consumers can buy the good without paying the access fee, the benefit of this system for the operator is moot. For Disneyland, the access problem is easily solved: put a wall around the park and booths at the few access points. For the telecom operator, access is restricted to those owning a sim card, as long as these cards cannot be falsified too easily. On the fixed internet, creating walls around platforms is often difficult, and it is also difficult to prevent users to share with other consumers their content obtained at a low price. For mobile internet, creating such walls is easier if the platform for content is part of the hardware. Hence the cost \( K \) of TPT could be related to the cost of securing the system.

- Two part tariffs like subscription systems may also require additional contracting between distributors and content providers. These legal costs are often non trivial since rights have to be secured for different countries.

Since TPTs have little role to play in a competitive world, we introduce market power by content providers. To illustrate our purpose and give the best chances for a TPT to arise, we also consider a special case of the model.

We assume that the distribution \( F \) introduced earlier has two atoms at 0, 1. Hence, consumers come in two types: “official” consumers who choose to consume licensed content independently of the price \( p \) (as long as they have sufficient income); “pirates” who choose to copy content for any price \( p > 0 \) but may be induced to buy legal content if \( p \leq r \). The measure of official consumers is \( \alpha \in [0,1] \). If official consumers are homogenous, either they all buy or none will buy the hardware; the “demand” for hardware is therefore not continuous in its after-tax price.

Let \( p^M \) be the price maximizing

\[
\pi(p) \equiv px^*(p)
\]

and to avoid trivialities, assume that \( p^M > r \). Let us denote by \( v(p) \) the indirect utility of
an unconstrained consumer facing price $p$:

$$v(p) = u(x^*(p)) - \pi(p).$$

This function is decreasing and convex in $p$.

Consistent with our previous analysis in the competitive case, we say that a consumer is constrained at price $p$ when he cannot afford to purchase $x^*(p)$, that is when $I < h + t + \pi(p)$. There are two cases of interest corresponding to situations where consumers are constrained or not at the monopoly price $p^M$. It turns out that the case of unconstrained consumers is simpler than the alternative and for this reason we start the analysis by this case.

**Unconstrained Consumers at $p^M$**

Consumers are unconstrained if $p^M x^*(p^M) < I - h - t$. Then they are also unconstrained at any $p < p^M$ since $px^*(p)$ is increasing in $p < p^M$. If consumers buy the hardware and are then able to consume $x^*(p^M)$ it must be the case that

$$v(p^M) > h + t$$

and to simplify we will assume that this condition holds. The monopolist can choose either to set a price $p^M$ and sell to official consumers only, or to set a price $r$ and sell to all consumers. His total revenue is therefore

$$\Pi^{linear}(t) = \max \{ \alpha \pi(p^M), \pi(r) \} + \rho t$$

Consider now a TPT $(S, p)$, where $S$ is the subscription price and $p$ the price per-download. In order to give the best chance to a subscription service emerging, we will assume that content providers are able to extract as much surplus as they want from consumers. As is well known, the optimal TPT is of the form $(S, 0)$, since by decreasing the unit price, consumer surplus increases and, therefore, more surplus can be extracted from them.

Content providers sell to official consumers if $u(x^*(0)) - h - t - S \geq 0$ and if $S \leq I - h - t$.

---

15 Since by assumption all consumers have sufficient income to buy the optimal quantity at the monopoly price, there is no benefit for content providers to offer menus of subscription services, with $S$ larger when $p$ is smaller. In general, with heterogenous consumers such menus may be optimal.

16 This would not be the case if there was competition in the provision of content for instance.
Hence, the latter subscribe if $S$ is smaller than the bound

$$S^0 = \min \{ u(x^*(0)), I \} - h - t.$$ 

Pirates subscribe if $S \leq S^0$ and if they prefer to subscribe than to pay instead $r$ per unit of content, that is when $v(0) - S \geq v(r)$. Therefore pirates subscribe when $S$ is smaller than the bound

$$S^p = \min \{ v(0) - v(r), S^0 \}.$$ 

Clearly $S^p \leq S^0$, and therefore the monopolist will attract all consumers when $S^p = S^0$ since then $S^p \geq \alpha S^0$. He attracts only official consumers when $S^0 > \alpha S^0 > v(0) - v(r)$.

In either case, since the pre-tax revenues $\alpha S^0$ or $S^p$ are decreasing in the level of the levy while the pre-tax profit under linear pricing $\max \{ \alpha \pi(p^M), \pi(r) \}$ is independent of the level of the levy, it follows that the difference in profits under TPT and uniform price is a decreasing function of the levy.

**Proposition 3.** Suppose that consumers are not constrained at $p^M$ and let $t(I) \equiv \min \{ u(x^*(0)), I \} - \max \{ \alpha \pi(p^M), \pi(r) \} - h$. Then:

(i) for any positive level of investment $K$, there exists a cutoff level of tax $\tau(K, I) < t(I)$ such that a TPT will be implemented;

(ii) a TPT will increase the after tax profit of the monopoly if, and only if, $t < \tau(K, I)$;

(iii) $\tau(K, I)$ is decreasing in the level of investment $K$.

**Proof.** (i) is proven in the text. (ii) follows (i). For (iii), $\tau(K, I)$ is decreasing in $K$ since the difference in profits between a TPT and a uniform price is a decreasing function of the levy.

**Constrained Consumers at $p^M$**

Consumers are constrained if $p^M x^*(p^M) > I - h - t$. At price $p^M$, constrained consumers will choose to consume a quantity $x$ such that $p^M x = I - h - t$, since the function $u(x) - p^M x$ is concave and increasing in $x \leq x^*(p^M)$. Hence, the monopolist will be able to extract all the residual income from these consumers.

In order to attract “pirates,” the price must be lower than $r$. If $\pi(r) > I - h - t$, consumers are constrained even at price $r$ and therefore will spend all their income on content. In this case, assuming that all consumers have the same income, it is optimal for the monopolist to set a low price (of $r$ for instance) since he will extract the maximum...
revenue from consumers. Since with linear pricing, the monopolist extracts all the surplus from consumers, he will not choose to implement a TPT in order to save \( K \).

If however \( \pi(r) < I - h - t \) (this is consistent with \( \pi(p^M) \leq I - h - t \) since the function \( \pi(p) \) is increasing for \( p < p^M \), then consumers are not constrained at price \( r \) and will therefore consume \( x^*(r) \) units yielding a total revenue to the monopoly of \( \pi(r) \). By setting a higher price (for instance \( p^M \)), the monopoly is able to extract all the residual income from “legal” consumers but does not sell to pirates. If \( \alpha \) is “large enough”, he will not sell to pirates. However, as shown in Proposition 4, subscription systems will fail to be adopted if the levy is too large.

**Proposition 4.** Suppose that consumers are constrained at \( p^M \). Then:

(i) If \( \pi(r) > I - h - t \), a TPT cannot improve on the monopoly’s profits and will therefore not be adopted whatever the value of \( t \);

(ii) If \( \pi(r) \leq I - h - t \), the difference \( \Pi^{TPT}(t) - \Pi^{linear}(t) \) is a decreasing function of \( t \) whenever \( t \geq \min\{v(0), I\} - h - v(0) + v(r) \). It follows that there exists \( \tau(K, I) \) such that a TPT is adopted only if \( t \) is less than \( \tau(K, t) \).

**Proof.** The condition \( t \geq \min\{v(0), I\} - h - v(0) + v(r) \) insures that the difference in profits between a TPT and a uniform price is decreasing in \( t \). Further details of the proof are given in Appendix 5.1.

\[ \square \]

**4 Conclusion**

Contrary to levies on tapes, cassettes or CDs, levies on hardware like MP3 players are not targeted and do not insure that content providers will increase their revenue. In particular, when consumers are budget constrained, 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 tax revenue can compensate for this decrease only if the retention rate of the tax revenue 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 entering artists or prevent the emergence of new business models, though these could be in the interest of consumers. We consider in particular the possibility of subscription services that we model as two-part tariffs. As we show, two-part tariffs can lead pirates to re-enter the legal sphere.
if the unit price is low enough. However, if the profit of content providers is increasing in the level of the levy when they use linear prices, subscription systems will be implemented only when the levy is small.

4.1 Proofs

Proof of Concavity of $T(t)$

Lemma 2 (Laffer curve). Suppose that the hazard rate $\frac{g}{1-G}$ is increasing. Then the tax proceeds $T(t)$ is a concave function of $t$, with a maximum at $t^*$ solution of:

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

Proof. Using the definition of $I(h, p)$ in (4), the variation of the tax proceeds is

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

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

The function $\frac{t}{1 - I(h + t, p) + h + t}$ has a variation proportional to

$$1 - I(h + t, p) + h + \frac{t}{1 - I(h + t, p) + h + t}$$

which is positive since by construction $I(t) < 1 + h + t$. By (2), 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 $t$.  \qed

Proof of Proposition 2

Part (i) is obvious from Lemma 2. We prove (ii). Assume that $t < t^*$ and that $G(1+h) = 1$, revenue from sales of legal content is

$$R(t) = (1 - F(p)) \int_{I(h+t,p)}^{1+h} (I - h - t) dG(I)$$
and the marginal effect of the levy is
\[
R'(t) = (1 - F(p)) \left[ G(I(h + t, p)) - 1 - \frac{\partial I(h + t, p)}{\partial h}(I(h + t, p) - h - t)g(I(h + t, p)) \right]
\]
If \( \rho \leq 1 - F(p) \),
\[
R'(t) + \rho T'(t) \leq -(1 - F(p)) \frac{\partial I(h + t, p)}{\partial h}(I(h + t, p) - h)g(I(h + t, p)) < 0
\]
hence there exists \( \rho^* > 1 - F(p) \) with the desired properties.

**Proof of Proposition 4**

(i) is immediate since the monopoly extracts already the maximum consumer surplus under uniform price when \( \pi(r) \geq I - h - r \).

(ii) From the previous discussion,
\[
\Pi^{\text{linear}}(t) = \begin{cases} 
I - h - (1 - \rho)t & \text{if } \pi(r) > I - h - t \\
\max\{\pi(r), \alpha(I - h - t)\} + \rho t & \text{if } \pi(r) \leq I - h - t
\end{cases}
\]
From our previous discussion, the profit under TPT is
\[
\Pi^{TPT}(t) = \begin{cases} 
S^0 + \rho t & \text{if } S^0 \leq v(0) - v(r) \\
\alpha S^0 + \rho t & \text{if } \alpha S^0 \geq v(0) - v(r) \\
v(0) - v(r) + \rho t & \text{if } \alpha S^0 < v(0) - v(r) < S^0
\end{cases}
\]
Recall that \( S^0 = \min\{u(x^*(0)), I \} - h - t \). When \( \pi(r) \leq I - h - r \), whenever the condition
\[
t \geq \min\{v(0), I\} - h - v(0) + v(r)
\]
holds, we have \( S^0 = \min\{v(0), I\} - h - t \geq v(0) - v(r) \). It follows that the pre-tax profit
under a TPT is $\Pi^{\text{TPT}} = \min\{v(0), I\} - h - t$ since $\alpha S^0 < S^0 = S^P$. Therefore,

$$\Pi^{\text{TPT}}(t) - \Pi^{\text{linear}}(t) = \min\{v(0), I\} - h - t - \max\{\pi(r), \alpha(I - h - t)\}$$

and the variation with respect to $t$ is either equal to $-1$ or $-1 + \alpha$ depending on whether $\alpha(I - h - t)$ is smaller or greater than $\pi(r)$. In either case the variation is negative. The rest of the proof follows the lines of that of proposition 3.

### 4.2 Data

Table A.1 that follows contains information for the main countries (and important music markets) in Europe, North America, Japan, Australia, South America and Africa) aimed at supporting some of the claims used in the paper. It is based on the following documents and sources: IFPI (2010) for sales from 2005 to 2009, as well as the number of Internet users, Portable Players and Median Age. For the years 2000 to 2004 we used IFPI reports on annual world sales.

Sales and growth rates are constructed as follows. For the period 2005-2009, sales are obtained by adding “Physical CDs,” “Physical DVDs,” “Physical ‘Other,” “Digital Singles” (to make these comparable to CDs, their number is divided by 10, assuming that CDs contain on average ten tracks), and “Digital Albums.” To give an idea of the dimension of the market, sales for 2009 are reproduced in column (2), and the annual growth rate 2005-2009 in column (4). For the period 2000-2004, the information available is somewhat different, given that new products were introduced later. Total sales are therefore obtained by adding “Physical CDs,” and “Physical DVDs” only. At the time, the number of singles sold was negligible, and we did not take them into account. The annual growth rate for that period is thus calculated on a different basis; it is reproduced in column (3) of the table.

Most growth rates over the two periods are negative, as expected. Eastern European countries such as Bulgaria, Croatia, the Czech Republic, Hungary, Russia, Slovakia as well as Turkey experience positive growth rates during at least one of the two sub-periods. This is also the case for South Africa. It may also be so in other emerging African and Asian countries, but their markets are still very small.

Columns (5) to (7) contain information that may be linked to the previous numbers, since the number of internet users and portable players, as well as the median age of the population may have an effect on sales.
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<th>Sales 2009 (million eq. albums)</th>
<th>Annual Growth Rate 2000-2004</th>
<th>Annual Growth Rate 2005-2009</th>
<th>Internet Users (millions)</th>
<th>Portable Players (millions)</th>
<th>Median Age (years)</th>
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Source: IFPI Reports. See text.
References


