Digital goods and the effects of copying: an empirical study of the music market

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Abstract

Digital goods, streams of information stored in bits with economic value, have transformed the way many economic agents interact in markets and specially those in the cultural sector. The non-rival nature of its consumption has had a significant impact in different industries, specially the music industry: record labels have witnessed in the last decade a proliferation of the means to circumvent copyright in protected materials. This paper aims at assessing the impact of piracy on legal demand. Unlike previous studies we address the issue from a wider perspective, considering both physical and online piracy. Our findings show that there is a substitution effect between copies and originals, and that there is no significant positive effect of piracy on legal demand, which rules out the possibility of network effects or sampling effects much discussed in the literature on piracy. Moreover we find that lost sales amount to a 131% of the legal market on the average, even though there is a wide variation between countries.

Keywords: copyright, information goods, substitution effect, demand for phonographic recordings, music industry, piracy.

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1 Introduction

The cultural industry is mostly based on information goods delivered as digital goods. Even though this adds value to the product itself, it also increases its non-rival nature as digital goods are easily copied or delivered through the Internet. As copying technologies and storage media become widespread, duplication costs fall. In addition to it, the feasibility of an almost costless exchange of digital goods brought about the Internet seriously weakens the enforcement of intellectual property rights (IPR) of digital goods.

The music industry is a good example. The 1990s was a period characterized for increasing overall revenue in the sector. This trend breaks down in 1999 as global sales of recorded music fall since. According to the report *The Music Industry in Numbers*, (IFPI, 2004), the retail value of music sales in 1999 was of 38,228 US dollars, while in 2003 it was of 32,036 US dollars, both measured at the average exchange rate of 2003. This yields an average cut of 16.20% in revenue between these years. No doubt this sharp decline amounts to a large extent to the ability of users to copy and distribute copyright protected materials, a phenomenon commonly labeled as piracy .

This paper aims at empirically testing the impact of piracy, both physical and online, on the music industry. To this end we follow a cross-section econometric approach in order to assess the effects of piracy on the demand side of the market. We estimate alternative specifications for a demand function which allows us to test a controversial theoretical claim: that loose copyright enforcement standards may have positive effects on legal demand. Our main conclusion is that both physical and online piracy substitute legal demand, hence reducing consumption of original recordings. Second we find no evidence, so far, of any positive impact of either file-sharing or physical piracy on demand. Finally, when it comes to assess the economic impact of piracy, we find that average losses amount to a 131% of the legal market, although these are subject to a high variability.

The paper is structured as follows. Section 2 is focused on the theoretical and empirical background. We briefly discuss the economic approach to copyright and its enforcement and infringement in digital goods, from the perspective of the music market. Next we link our paper with the recent empirical literature. Section 3 follows with the empirical analysis of the music market. In it we estimate a demand function; we try alternative specifications in order to verify most theoretical claims. Finally section 4 closes by discussing our main results.

2 Economics of copyright

Copyright as the power of an author to restrict the diffusion of her work, provides the institutional framework for the music market, as Towse (1999) puts it. Authors', performers, and even session musicians or singers[1] are under the umbrella of the copyright which protects their basic rights which they license or sell to a firm (publisher and/or record company) that will market the product. Copyright is usually justified on grounds of the inefficiency of market outcomes: unless artists are granted with some monopoly in the replication of their work, there will be an undersupply of artistic production. We find two non competing arguments that stress this point. Both the creative process of composing music, as an information good, and its distribution as a digital good reinforce the basic weakness of phonographic recordings: the limited appropriability of the proceeds of a work by the rights holder.

First, the production of the creative work has some peculiarities that prevent economic forces to send correct signals to authors. As it has been mentioned in the literature —see for instance Landes and Posner (1989) — the creation process implies high initial costs, which some authors identify as fixed costs but that in some instances can be considered sunk costs. On the other side marginal costs for the replication of the original are low, at least when compared to those of the creative process. Market competition will push down prices towards marginal costs which may reduce incentives for creative work. By granting the artist with the monopoly of its work, copyright fosters artistic production.

Second, due to the nature of the product sold in the music market, phonographic recordings suffer from the same problem at a different level. Record labels distribute the final music recording as a digital good. This reinforces the previous problem as replication of digital goods is easy and cheap. If recordings can be easily duplicated and massively distributed through networks at an almost zero marginal cost, there will be no economic rent for the licensing firm. Again, market competition will drive down prices towards marginal costs and initial investments —promotion, recording expenses, session musicians etc.— will never be recovered. Weren't it for the copyright, firms will not have incentives to buy the rights from authors to record and release music albums.

All in all copyright infringement weakens incentives both for authors and record firms as copies compete with original recordings. Based on these, we may conclude with a negative impact of piracy on demand. As copies are substitutes for the original product, piracy reduces legal demand through this *substitution effect*.

[1] Without loss of generality, from now on we will refer to them as artists, without distinguishing the different parties that enter in the creative process of recording an album. Towse (1999) describes in depth the industry from an institutional perspective, giving interesting insights to the different contractual arrangements in the music markets.

Even though the case for copyright seems solidly grounded, some authors have challenged it on the basis of economic arguments, pointing out that copying and file-sharing may not introduce negative incentives to artists. Some authors, for instance Boldrin and Levine (2002, 2005), resort to the concept of *indirect appropriability* –initially proposed by Liebowitz (1985)–, which refers to the ability of a seller to capture the increase in value of an original due to the possibility of copying. They not only deem the concept of copyright as unnecessary for sustaining artistic production, but also consider it is damaging innovation.

Apart from the indirect appropriability argument, there have been additional ones supporting, at least partially, the case against copyright. The first is known as *sampling effect* or *exposure effect*, which basically refers to the increase in the legal demand for those downloading or copying. The argument goes as follows: as individuals get —illegally— exposed to more music, they will be better informed and finally may shift and become legal buyers of some artists. To some extent sampling allow users to shape their music tastes.

A second positive effect of piracy, *network effects*, has been well known in other fields. The underlying logic is that the number of consumers of a product increases its value. Hence the more consumers a product has, no matter whether they buy it or copy it, the more each consumer values it. This, in turn, benefits sellers that may exploit this higher willingness to pay.

Whether the negative effects of copying outweigh the positive ones is a matter of empirical research. Applied works investigating the issue of piracy can be grouped in two, depending on the object of their research. First, those that try to single out the determinants of piracy and that usually resort to some type of regression of the piracy rate over different explanatory variables. Second, those that try to assess the economic impact of piracy in the recording industry. Within this last group there is a wider variety of research methods.

Within the first group we find Holm (2003), Papadoulos (2003, 2004), or Proserpio et al. (2005). All these single out economic, social and institutional factors that explain the piracy rate.

If we shift to the second group of works, testing for the economic impact of piracy on the legal market, we find a major drawback: data on overall music piracy are not easily available. While the *International Federation of the Phonographic Industry* (IFPI) estimates and compiles data on physical piracy, online piracy is not observed. Therefore researchers trying to measure the impact of piracy at a macro level have resorted to either directly test for the influence of physical piracy, as the work by Hui and Png (2003), or to indirectly use other data available to measure the impact of file sharing, as Zentner (2004), Peitz and Waelbroeck (2004), Liebowitz (2005) or Oberholzer and Strumpf (2004). Except for the latter, all authors find that piracy reduces expenditure in the legal market. At a micro level

Rob and Waldfogel (2004) undertakes a survey to measure the effect of downloading on sales showing a net negative effect. Nevertheless their results are only valid for their sample and may not be generalized for the overall population.

3 Empirical analysis

Our empirical work belongs with the second line of research, i.e. the one trying to assess impact of piracy on the industry. We start by defining average legal and illegal demand in the market for phonographic recordings as

$$q_L^D = f(p, z, y, X, q_I^D) \quad (1)$$

$$q_I^D = h(p, z, y, X, q_L^D), \quad (2)$$

respectively. The factors that influence both q_L^D and q_I^D are the price of the original recording, p, the opportunity cost of the copy, z, the income y, and a set of other meaningful variables X. Note that z should include not only explicit costs, as the price in the black market for a copy or the cost of the media, but the opportunity cost of copying which we assume that depends on institutional and technological factors. The former determine the extent by which IPR are enforced, while technology determines the barriers for music copying and sharing. Let us call z_1 for institutional and z_2 for technological barriers respectively.

Expressions (1) and (2) allow for the expected substitution effects between the original and the copy through prices. Other things equal, cuts in z_2, for instance as copying technologies become available, will affect not only the illegal but also the legal market as consumers respond to this change in relative prices. For the same reason, changes in p trigger modifications both in $q_L^D$and in q_L^D.

Finally we include q_I^D in expression (1) and q_L^D in expression (2) to account for potential reciprocal positive external effects between both markets.

3.1 Data

Given the nature of our analysis we need to compile information about the phonographic industry: data on legal and illegal demand and average prices for music recordings will be used. We also need data on the illegal market costs, which we will relate to institutional as well as technological factors. Finally we will use other general data such as per capita GDP or hardware availability.

3.1.1 Music industry data

We resort to the 2003 data available for a sample of 60 countries included in the annual report *The Music Industry in Numbers*, (IFPI, 2004), compiled and published by the *International Federation of the Phonographic Industry* (IFPI). It includes data on the music industry such as volume of sales by value and by units of a standardized CD.[2] It allows us to get the average price of the standard album in each country as the quotient between the two.

IFPI also publishes data on estimated physical piracy level. However the use of such data is of limited value as file sharing may be a second source of market distortion. To our best knowledge there are no estimates for the share of the overall market that accounts for online piracy. We will therefore take physical piracy levels and will try to overcome the problem of online piracy by estimating a reduced-form version of the model.

We complete the physical piracy rates with data from the special 301 report on global copyright protection and enforcement by *International Intellectual Property Alliance*. We use data available for the 2004 report, (IIPA, 2004). Additionally, when needed, we use data published in the *Global Software Piracy Study* by the *Business Software Alliance* on piracy levels in the software industry.

3.1.2 Institutional environment: the enforcement of rights

One of the central issues in our analysis is to determine the opportunity cost that individuals face when copying as it will set the relative prices of originals and will help us determine the magnitude of the substitution effect. We will try to capture this by means of two variables. First, we consider that the institutional setup in every country is a central variable in our study. It may help explaining the enforcement of IPR which in turn explains the expected costs and ease of breaking copyrights to mention some. Second we know that certain technological requisites must be met for online file-sharing to emerge. Broadband connections in a given country may explain the growth in online piracy, as it may be a proxy for the technological cost of downloading copyright protected materials.

Let us first start with the institutional framework. Other things equal, the more protected IPR are, the less the share of the illegal market. So enforcement of IPR plays the role of z_1 in our model. In order to capture it we use as a proxy an index on the enforcement of contracts based on the updated data originated by the work of Djankov et al. (2003). Data are updated on an annual basis in the *Doing Business Project* website (http://www.doingbusiness.org), supported by the World Bank group. The efficiency in enforcement of contracts is measured

[2]IFPI figures on sales aggregate the different media that the industry supplies into one measure: a standard album.

by following the evolution of a payment dispute. The index is composed of three items: time until resolution, cost as a percentage of the debt, and number of procedures involved from the moment the plaintiff files the lawsuit until actual payment. We averaged over the three indices for each country leading to a unique ratio that allow to quantify enforcement of contracts for each country.

Apart from this, the *World Bank* supports a broader project on governance and institutional quality which aims at providing, compiling and making publicly available governance indicators.[3] Within this work we relied on some of the results of Kaufmann (2004),[4] and Kaufmann et al. (2005).[5] The former aims at building a set of corporate corruption and ethics indices by using the 2004 survey of enterprises by the *World Economic Forum*. The latter is a set of perception based governance indicators built by combining information from different sources, including surveys of enterprises, citizens and experts. This is an ongoing project spanning from 1996 to 2004 on even years. We also used the data for 2004. In both cases we rested on the assumption that institutional changes take time; if this is the case, 2004 data may be a good proxy for 2003. In fact Kaufmann et al. (2005) show this point: there is no clear trend, at least in the short run, for most of the indicators they build. The 95% confidence interval for the governance estimates overlapped in most observations for two consecutive years.

3.1.3 Technological constraints and other relevant data

With regards to z_2, i.e. technological availability, we resort to data published in the annual report by IFPI. This includes data on hardware availability: digital recorders, digital players, compact disc players and broadband connections. We also used data on users (as percentage of total population) connected to P2P networks compiled in the report on *Digital Broadband Content*, (OECD, 2005). Some of this variables had missing observations which we considered as zero. For instance data on broadband connections were missed for some countries in the sample, those with a lower development level. This suggests that Internet broadband connections are not deployed in these countries, which is a rather reasonable assumption.[6]

[3] See http://www1.worldbank.org/publicsector/index.htm.

[4] The author defines seven indices: public sector ethics (PSEI), judicial and legal effectiveness (JLEI), corporate governance (CGI), corporate illegal corruption index (CICI), corporate legal corruption (CLCI) and corporate ethics (CEI).

[5] The authors include six dimensions of governance: voice and accountability (VAI), political stability and absence of violence (PSAVI), government effectiveness (GEI), regulatory quality (RQI), rule of law (RLI), and control of corruption (CCI).

[6] We find this problem in the percentage of digital music players, broadband connections and to a lesser extent in percentage of DVD players and CD players.

Finally we used per capita GDP data and average US dollar exchange rate available from *IMF World Economic Outlook*.

3.2 Model specification

We start by specifying expression (1). We define legal demand equation as a function of income (y), price (p), cost of copying ($z_1$and z_2), illegal market demand (q_P^D), other technological variables (x), and an error term (u) as follows:

$$q_{_L}^D = \alpha_0 + \alpha_1 y + \alpha_2 p + \alpha_3 z_1 + \alpha_4 z_2 + \alpha_5 q_I^D + \alpha_6 x + u. \tag{3}$$

As already mentioned the pirate market for phonographic recordings is composed of two segmented markets. First the physical market in which counterfeited physical products are exchanged. IFPI data on piracy cover this market. Second the online market. It allows users of networks, basically P2P networks, to exchange the core product of music recordings.

It should be noted that the opportunity cost that consumers face in both markets for copies do actually differ. Institutional setup, the extent of IPR protection and enforcement, affects both physical and online piracy. However online piracy bears a premium due to technological constraints. We proxy the cost of file-sharing with broadband connections deployment, which is a requisite for massive online piracy. Therefore we link the cost of physical piracy with z_1, while online piracy depends on both z_1 and z_2.

Finally α_5 accounts for the potential positive effects of piracy in the market for originals, while α_6 refers to the influence of technological variables on demand.

Next, define q_P^D as physical piracy demand and q_O^Das online piracy. Then

$$q_I^D \;\; = \;\; q_P^D + q_O^D \tag{4}$$

While IFPI produces data for physical piracy, data for online piracy are not extensively available. Hence q_P^D is observable, while q_O^D is not. Due to this fact, researchers have attempted to estimate the costs of online markets without explicitly resorting to quantities.[7] We use an alternative approach. Consider that the model explaining online piracy is nested within the following expression

$$q_O^D \;\; = \;\; \beta_0 + \beta_1 y + \beta_2 p + \beta_3 z_1 + \beta_4 z_2 + \beta_5 q_L^D + \beta_6 x + \epsilon. \tag{5}$$

Then, combining expressions (3), (4) and (5), we get a semi-reduced form for legal demand:

$$q_L^D = \psi_0 + \psi_1 y + \psi_2 p + \psi_3 z_1 + \psi_4 z_2 + \psi_5 q_P^D + \psi_6 x + \eta. \tag{6}$$

[7] As is the case of Rob and Waldfogel (2004), Oberholzer and Strumpf (2004), Zentner (2004) or Peitz and Waelbroeck (2004).

Given our data set, expression (6) can be empirically estimated. However it should be noted that, unless we impose further restrictions on the parameters, we will not be able to estimate the structural parameters of equation (3). Later we will discuss this issue.

With regards to the parameters in (6) we expect that $\psi_1 > 0$ and $\psi_2 < 0$. As z_1 is measured as an index of contract enforcement taking values in the support [0,1], with larger values meaning more enforcement, we expect that $\psi_3 > 0$. Similarly, z_2 is measured by the percentage of households with broadband connections, so the cost of downloading decreases with z_2 and therefore $\psi_4 < 0$. Finally, shall there be any positive impact of piracy on legal demand, we should find that $\psi_5 > 0$.

3.3 Estimation results

Table 1 shows the estimation expression (6). Legal demand is measured in per capita terms; so is income (Per capita GDP) and physical piracy (Illegal). Price is the average price for a standardized album; the cost of substitutive goods, i.e copies of the original, is given by Enforcement and Broadband (z_1 and z_2 respectively). Apart from these, we used as technological variables the percentage of households with a CD player (CD), the percentage of households with a DVD player (DVD), the percentage of households with a digital music player (DP), and the percentage of the total population using peer-to-peer networks (P2P). We take logarithms of all variables except for those in percentages.

The first two columns summarize the main results of the ordinary least squares (OLS) estimation. Results are those expected for most variables.[8] However we cannot rely on OLS as these may yield inconsistent estimates. It is highly unlikely for the price and the per capita physical pirate demand to be exogenous to the model. Therefore they may be correlated with the error term in (6) and least squares would fail to yield consistent estimates. As an alternative, instrumental variables (IV) may be adequate.

The problem with IV is the need to find instruments that being correlated with p and q_P^D, are uncorrelated with the error term. Illegal physical demand may be correlated with software piracy data (SOFTWARE). The local repertoire as a fraction of overall sales (LOCAL) may also be an instrument for illegal demand, as piracy rates are biased towards best selling international albums.

For the price, we assume that firms are price-setters and their monopoly power is de-

[8] Apart from the point estimates and their standard deviations, we include in it the size of the sample, and the adjusted R^2 and the *Akaike Information Criterion* (AIC) as measures of the goodness of fit. Finally we include the *Breusch-Pagan test* for heteroscedasticity. We assume that the source of heteroscedasticity is income levels, and used per capita GPD and its square as the explanatory variables of the standardized square of the residuals of the estimated regression.

termined by the extent of IPR protection. This has to be correlated with institutional factors. Therefore we choose a subset of the institutional indicators previously described: Rule of Law, Regulatory Quality, Judicial and Legal Effectiveness, Public Sector Ethics and Corporate Governance.

With these, we estimate expression (6) by two stages least squares (2SLS). Results are in Table 1, columns 3–5. Given that our model is overidentified, i.e. the number of instruments is larger than that of endogenous explanatory variables, we also include the *Sargan test* for instruments validity.

The third column in Table 1 shows the estimation of the unrestricted model. Qualitative results do not significantly differ from those by OLS. However instruments may not be valid at a 10% significance level. Moreover some variables are not significant so we drop these except for the illegal demand. Column 4 shows the result. As per the outcome of the Breusch-Pagan test, it seems that all estimations from column 1–4 to be affected by heteroscedasticity. This may be suggestive of the presence of outliers. We found that both Venezuela and China were likely to be such outliers.[9] Column 5 shows the outcome once we drop these observations. It seems that heteroscedasticity is no longer an issue. Moreover we could not reject the hypothesis of normality of residuals in this last specification. Therefore we choose it as our benchmark model.

First, and after accounting for differences in income between countries summarized in the influence of per capita GDP, key price variables (p, z_1 and z_2) seem to play a significant role in explaining overall demand. Results are those expected and are quite robust for different specifications and estimation methods.

The estimate for the influence of price on demand is negative. All columns in Table 1, lead to a negative and significant (at least to a 10% significance) estimate for ψ_2. Depending on the estimation method and on the inclusion or exclusion of outliers, a one unit increase in price leads to a decrease in legal music demand ranging from 0.5058 to 0.7554. This last estimate implies that a one unit standard deviation in price leads to a decrease in per capita legal demand of around a 57%.[10] It is worth noting that we should not consider the estimated parameter as the price elasticity, as we have estimated the semi-reduced form parameter ψ_2, and not the corresponding structural one α_2.

With regards to the cost of copying, we also get the expected results. Enforcement is significant and positive: legal systems that score better when enforcing rights create disin-

[9] We run a regression including a dummy for each outlier, and could not reject the significance of these.

[10] We get this result by multiplying the parameter by the sample standard deviation of price, $\Delta q_L^D = \hat{\beta}\Delta x$. Being $\hat{\beta}$ the estimated parameter and Δx the one unit standard deviation of the explanatory variable the effect of which we want to quantify. As q_L^D is the logarithm of legal demand, its variation Δq_L^D, yields an approximation for its change rate.

centives for consumers in illegal markets. In fact we get an estimate of 2.0700($\pm$1.0471), which explains the cost of both online and physical piracy. Not surprisingly, better enforcement means increasing legal sales: a one unit standard deviation increase in this factor leads to an increase in music sales of around a 27%.

With respect to the cost of online piracy, measured as the availability of broadband connections, we get quite a clear cut result with an estimated parameter of -1.1415 ($\pm$0.73). A one standard deviation increase in the proportion of households with broadband connections decreases per capita legal demand by a 19%.

If we compare these results with the sample average of legal demand, of approximately 0.63 units, a one unit standard deviation in price, enforcement and broadband yields a variation of legal demand of -0.27, 0.19 and -0.10 units respectively. All in all, it seems that we can conclude with a negatively sloped demand for original recordings. The market for music exhibits a clear substitution effect with alternative ways of consumers' access to music .

Second, the parameter affecting illegal demand has always been positive on all the regressions we run. This could lead to the wrong suggestion of a positive impact of piracy on music demand as results show that, apart from column 3, no estimate is significant as per the standard t-test. And even when it is significant, the presence of heteroscedasticity and the fact that the set of instruments may not be significant are indicative of some specification problem. Therefore we cannot conclude with any kind of positive effect of piracy on legal demand. In fact we may also conclude it being negative as a 95% interval for the estimation yields (-0.1200, 0.2660).

Shall we accept that ψ_5 is not different from zero, then the meaning of the estimations changes. For it implies that $\alpha_5 = 0$, hence no network or sampling effect can be claimed. Moreover the estimates become elasticities and they can be directly interpreted as such. We run a restricted regression setting $\alpha_5 = 0$; results are in Table 2 in which we dropped all non significant variables. In this case we estimate the structural model: column 1 takes the whole sample, while in column 2 we dropped the outliers. Estimates are quiet robust. Only price elasticity and enforcement experience an increase of around a 4%–5%. Price elasticity now is close to unit, and the 95% confidence interval is the support (-1.2510, -0.3229).

Returning to Table 1, the effect of hardware variables is not conclusive. We shall expect CD to increase demand, as legal music and CD players are complements, while P2P users reduce it, as users of P2P networks basically exchange copyright protected materials. However no estimation yields a significant estimate for both variables, hence we drop them.

Results for DVD and DP seem counterintuitive at a first glance. Some may see the irruption of the DVD format as a threat to the music industry as they generalize an alternative

leisure activity to music. This should imply a negative estimate for its parameter. However we get, in a quite robust fashion, a positive estimate. The last estimate in column 5 indicates that a one unit standard deviation increase in DVD players ownership increased legal demand by a 17%.

Counterintuitive as it may seem, there may be a possible explanation for this positive effect of DVD ownership on legal music. As a way to cut losses due to piracy, phonographic firms are trying to price-discriminate by including additional features in their releases. These usually come as DVD that may contain live recordings, music videos or other materials as the making of the album. For some people these additional features will be meaningless, but for hardcore fans this is an incentive for buying the original. Moreover, while downloading a CD track may take a few minutes, DVDs are hard to download and it may even take days and its download heavily depends on the sources available —those sharing the DVD being connected to the network during the download. Hence the costs of downloading a video are large enough to prevent generalized online sharing. In this case, as DVD players become more popular, this strategy may appeal to the upper segment of the demand. If this is so, DVD players ownership may have a positive impact on legal demand.

If portability of music fosters its consumption, then DP, the epitome of portability nowadays, need have a positive impact on it. However consumption may be legal or not. In fact most authors, as Peitz and Waelbroeck (2004), relate DP to illegal downloads. However recent events, as the success of *iTunes* —the online music shop for the Apple's *iPod* DP—, suggest that these can also boost legal demand. Our estimates suggest that DP play a positive role in determining legal demand. However this positive role must be weighted by the fact that DP are less than generalized in our sample. With an average penetration rate of 5.77%, the net effect on legal sales is an increase of 0.06 units, a 10%, in the average observation.

4 Discussion and conclusions

The previous pages have tried to assess the impact of piracy, both physical and online, on the legal market for music recordings. Our aim was twofold. First whether we can test and measure the substitution effect between different forms of piracy and the legal market. Second, whether there was a positive effect of piracy on demand. We think our work has answered both, even though our quantitative results may suffer from the limited sample size that prevents us of putting too much emphasis on specific results.

Our findings clearly support a substitution effect: changes in relative prices shift legal demand hence affecting firms revenue. While prices in the legal market are transparent, it

is not straightforward to define a price for the illegal market. Because copying may mean different things, there is no clear price for a copy, let alone a database of consistent and extensive figures. We can however resort to the cost individuals face in these markets. And there are two barriers for entering this market: institutional and technological. Institutional barriers refer to the set of norms that prevent individuals from copying. We have considered enforcement of contracts as a proxy of the enforcement of IPR, which reflects the working of the legal system enforcing rights. Technological barriers are related to the (lack of) accessibility of individuals to means of copying and delivering digital contents that infringe copyright. We think that, mainly, the percentage of households with broadband connection is a good proxy. The more broadband connections, the lower the cost for consumers in terms of resources (specially time but not only) devoted to copy. Our results show that both variables are significant and its estimates are robust for alternative specifications.

We also conclude that data do not support the hypothesis of a positive impact of piracy on demand. Although most estimations yielded a positive parameter, the evidence so far rejects it being significant. But just because we do not find any positive effect of piracy on legal demand, we cannot conclude that each copy crowds out a legal sale. In fact we do not know the extent by which a copy shifts sales. We know it does by the substitution effect, that is the indirect effect through relative prices. In order to assess the impact of piracy on the industry we have to calculate how illegal demand shifts legal demand.

We may be tempted to yield an approximate measure of the crowd-out effect by using estimation results and calculating the magnitude of substitution effect. The argument goes as follows: if z_1 and z_2 reflect the opportunity cost of copying, we may indirectly calculate the effect of piracy on demand by measuring each country's lost sales due to these two factors. Then the crowding-out effect is given by dividing lost sales by illegal demand.

We undertook such calculation and arrived to the following conclusion: on average, each copy reduced legal sales by a 2.18 units. However this calculation is misleading. As we use only physical piracy, overall piracy is understated. And its effect on sales is overstated. Then the crowding-out effect is upwards biased.

However we can take a different approach. Instead of trying to measure the effect of the illegal market on lost sales we can actually measure lost sales as a percentage of legal sales. This yields a measure of the share of the legal market lost due to piracy. And in doing this exercise we are not subject to the previous bias, as we are not making any assumption about the extent of the illegal market. Table 6 shows the results. In it column 2 (labeled as Loss) takes into account the effect of z_1 and z_2 (Broadband and Enforcement); on the other hand column 3 (Loss*) also includes the positive (but otherwise not significant) effect of physical piracy. We also include the crowding-out effect for comparison purposes although,

as previously mentioned, its value is significantly flawed.

Taking the second column —the one labeled Loss*—, lost sales due to piracy are worth a 131% of the legal market on average. Which is a rough average and assumes equal weighting of all observations. However we should expect this impact be much lower if we weight each country by its global market share. This significantly reduces the above outcome to around a 30% of the legal global market. In any case, there are significant differences between countries, with the estimate ranging from just a 11% of the value of the legal market in the United Kingdom, to around a 1700% in the case of Peru. In between there are countries in which lost sales are a fraction of the legal market —for instance Spain where estimates losses are a 36%, or the United States with a 17%— and countries in which lost sales are larger than the legal market —for instance Argentina in which losses are a 143%.

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Table 1. Estimation Results. Dependent variable: per capita legal demand for a standardized music album

	Estimation Method				
Variable	*OLS*[a]	*OLS*[a]	*2SLS*[b]	*2SLS*[a,b]	*2SLS*[b]
Constant	-8.9631 ***	-9.1701 ***	-8.3432 ***	-8.8216 ***	-8.6893 ***
	(1,1348)	(0.9789)	(1.1414)	(1.0860)	(0.7844)
Per capita GDP	0.9093 ***	0,9333 ***	0.8729 ***	0.9363 ***	0.9360 ***
	(0.1264)	(0.1109)	(0.1787)	(0.1584)	(0.1266)
Ilegal	0.1288	0.1175	0.2550 *	0.1853	0.0710
	(0.1035)	(0.0962)	(0.1346)	(0.1364)	(0.0948)
Price	-0.6893 ***	-0.7129 ***	-0.5058 *	-0.6200 *	-0.7554 ***
	(0.1955)	(0.1845)	(0.2916)	(0.3260)	(0.2191)
Enforcement	2.3914 **	2.4517 **	1.7878 **	1.9104 **	2.0700 ***
	(0.9522)	(0.9243)	(0.6897)	(0.8702)	(0.5197)
Broadband	-1.0408 ***	-1.0745 ***	-0.9223 *	-1.0853 ***	-1.1415 ***
	(0.3047)	(0.2912)	(0.5115)	(0.3346)	(0.3623)
DVD	0.8646 *	1.2479 ***	0.6759	1.0631 ***	0.8677 **
	(0.4688)	(0.3584)	(0.6812)	(0.3849)	(0.3755)
CD	0.0575		0.0237		
	(0.1612)		(0.1535)		
DP	0.9417 **	0.9949 *	1.0204 *	1.0330 **	0.8227 *
	(0.4294)	(0.4976)	(0.0991)	(0.4845)	(0.4484)
P2P	0.3312		0.5290		
	(0.3482)		(0.4312)		
N	60	60	54	54	52
Adjusted R^2	0.7850	0.7915	0.8502	0.8526	0.8991
AIC	110.247	106.745	73.4145	70.9563	38.4219
Breusch-Pagan Test	13.6038	13.4644	5.3733	6.7395	1.3743
	(0.0011)	(0.0012)	(0.0681)	(0.0343)	(0.5030)
Sargan Test			9.4266	8.9089	7.2467
			(0.0932)	(0.1127)	(0.2029)

Significance levels: ***1%,**5%,*10%

[a] Heteroscedasticity robust standard deviations.

[b] Instruments: LOCAL, SOFTWARE, RQI, RLI, PSEI, JLEI and CGI.

Table 2. Estimation Results. Dependent variable:
per capita legal demand for a standardized music album

	Estimation Method	
Variable	***2SLS***[a]	***2SLS***[a]
Constant	-9.9319 ***	-8.6785 ***
	(2.0518)	(0.9173)
Per capita GDP	1.1050 ***	0.9258 ***
	(0.3336)	(0.1591)
Price	-0.8946 *	-0.9258 ***
	(0.4745)	(0.2303)
Enforcement	1.9746 **	2.1808 ***
	(0.8685)	(0.5390)
Broadband	-1.2704 ***	-1.1405 ***
	(0.3865)	(0.3811)
DVD	0.5908	0.7930 **
	(0.4299)	(0.3784)
DP	0.6196 *	0.7091
	(0.3546)	(0.4282)
N	54	52
Adjusted R^2	0.8342	0.8940
AIC	76.5298	72.7532
Breusch-Pagan Test	13.3109	3.3609
	(0.0012)	(0.8137)
Sargan Test	8.8906	7.2690
	(0.1135)	(0.2013)

Significance levels: ***1%,**5%,*10%
[a] Instruments: LOCAL, SOFTWARE, RQI, RLI, PSEI, JLEI and CGI.

Table 3. Assessment of the impact of piracy. Point estimate for decrease in legal demand as a share of total sales (***Loss*** and ***L****) and measure of the crowding-out effect (***Crowd-out***).

Country	Loss	Loss*	Crowd-out	Country	Loss	Loss*	Crowd-out
Argentina	1,55	1,43	1,27	Lebanon	1,10	1,08	0,46
Australia	0,20	0,18	2,45	Malaysia	2,12	1,89	2,31
Austria	0,26	0,22	4,12	Mexico	0,81	0,80	0,51
Belgium	0,25	0,23	1,69	Netherlands	0,27	0,25	1,65
Brazil	1,44	1,34	1,24	New Zealand	0,36	0,32	4,22
Bulgaria	2,98	2,88	0,72	Norway	0,21	0,18	3,43
Canada	0,22	0,18	5,88	Pakistan	1,43	1,52	0,17
Chile	1,47	1,33	1,99	Peru	17,05	17,28	0,35
China				Philippines	4,74	3,86	5,79
Colombia	2,18	2,05	0,88	Poland	1,03	0,94	1,15
Croatia	1,33	1,21	2,02	Portugal	0,36	0,36	0,66
Czech Republic	1,44	1,28	2,72	Romania	0,60	0,65	0,16
Denmark	0,29	0,24	7,65	Russia	0,64	0,66	0,37
Ecuador	5,07	5,26	0,28	Saudi Arabia	2,27	1,95	2,93
Egypt	3,21	2,71	3,31	Singapore	0,35	0,32	1,29
Estonia	0,98	0,98	0,65	Slovakia	1,57	1,44	1,44
Finland	0,23	0,21	1,21	Slovenia	0,58	0,50	2,64
France	0,25	0,22	5,17	South Africa	1,37	1,17	4,97
Germany	0,23	0,20	4,74	South Korea	0,67	0,57	2,27
Greece	1,08	1,05	0,97	Spain	0,38	0,36	1,09
Hong Kong	0,18	0,17	0,40	Sweden	0,17	0,15	2,78
Hungary	1,19	1,06	2,48	Switzerland	0,16	0,14	2,65
India	2,47	2,10	3,14	Taiwan	0,52	0,50	0,69
Indonesia	1,29	1,30	0,19	Thailand	0,90	0,84	1,21
Ireland	0,30	0,26	4,85	Turkey	1,11	1,15	0,38
Israel	0,45	0,47	0,27	Ukraine	1,55	1,56	0,52
Italy	0,43	0,39	1,38	United Kingdom	0,13	0,11	5,56
Japan	0,27	0,22	7,07	Uruguay	4,27	3,70	2,47
Kuwait	0,45	0,46	0,37	USA	0,19	0,17	3,17
Latvia	2,07	2,10	0,52	Venezuela			

Table 4. Descriptive statistics for the data used in the estimation. All variables (except those in percentages) in logarithms.

Variable	*Mean*	*Standard Deviation*
Per capita Legal demand	-0.4595	1.1377
Per capita GDP	8.9619	1.2715
Per capita Ilegal Physical Demand	-1.1845	1.0594
Price	1.9737	0.7412
Enforcement	0.6918	0.1290
Broadband	0.1051	0.1661
DVD	0.1662	0.1940
DP	0.0577	0.1197
CD	0.6587	0.7622
P2P	0.1202	0.2338
D1	0.4154	0.2167
D2	0.3428	0.1333
D3	0.4544	0.2833
D4	0.4860	0.3667
Price (Low Piracy)	0.5952	1.1212
Price (Medium Piracy)	0.8940	1.1084
Price (High Piracy)	0.4844	0.7841