

Measuring the Effect of Music Downloads on Music Sales

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Abstract

File sharing may substantially undermine intellectual property rights of digital goods. This paper concentrates on the music industry. I estimate the effect of music downloads on music sales using two data sources: a panel of aggregate music sales by country for 1997-2002 and a European individual level cross section of 15,000 people from October 2001. Using the number of internet and broadband users by country as a measure of users of P2P systems, the panel of aggregate data shows a large impact of downloads on music sales. In the micro-data, a simple comparison of means shows that people who regularly download music online are more likely to buy music. The positive relation persists when controlling for many individual level characteristics. However, simultaneity between tastes for music and peer-to-peer usage makes it difficult to isolate the causal effect of music downloads on music purchases. To break that simultaneity, this paper uses measures of internet sophistication as instruments. The results suggest that, for the group of users of peer-to-peer systems, music downloading reduces the probability of buying music by an average of 30%. Separating music downloaders with and without broadband connection reveals a high reduction in purchases for downloaders with broadband connections.

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I- Introduction

The global music industry was quite successful during the 1990s. According to the International Federation of the Phonographic Industry (IFPI), album sales grew from US\$24.1 billion to US\$38.6 billion during the decade. Those days are over and the industry is now struggling. Sales have been falling for the last three years: global sales dropped 7.1% (to US\$30.9 billion) in 2002, 8.8% in 2001, and another 5.0% in 2000.

This downturn coincides with the proliferation of online music file sharing. In June 1999, Napster was created and made the work of many artists available for free. Its popularity was immediate. According to Mediametrix, a company that provides internet rankings and measurement, Napster was the fastest software adoption in history (CNN, 2000). Given its impact, the Recording Music of America (RIAA) soon filed a motion against Napster in the U.S. District Court of San Francisco for “engaging in or enabling, facilitating or assisting others in the copying, downloading, uploading, transmission, or distribution of copyrighted musical work or sound recordings protected by copyright or state law without the express permission of the rights owners” (US District Court, 2000). Napster was shut down in February 2001. However, many peer-to-peer (P2P) alternatives to swap music over the internet remain available. KaZaA, a Napster successor, holds the new record of most downloaded software with more than 230 million users worldwide (KaZaA, 2003). In all the countries considered by the Yahoo Buzz Index, an index that measure internet search using the Yahoo search engine, KaZaA was the number one search term on the internet in many weeks during 2003.

File sharing has an important online presence. In June 2001, IFPI estimated 3 million simultaneous global users and 500 million files available for copying at any given time. In 2002, the IFPI estimate went up to 5 million simultaneous users and 900 million files (IFPI, January 2003). In 2002, NetPD, a company that provides protection services to copyright owners whose material is being pirated through the internet, reported that 3.6 billion files were downloaded “monthly,” of which around 60% and 70% were music files (The Observer, 2002). Most popular albums are available for online swapping almost immediately after release, and in some cases, such as Oasis and Eminem, even before (IFPI, 2002). Copy protection technology has been ineffective.

The development of broadband facilitates music swapping. A soundtrack that takes more than 12 minutes to download with a dial-up connection can be downloaded in as fast as 20 seconds with a high-speed (household level) connection. Universities have very fast connections and Napster and its successors were banned in many of them because file swapping was consuming much of the available bandwidth. In the case of the University of Illinois at Urbana-Champaign, this amounted to 75% of the total bandwidth (BusinessWeek, 2000).

Online piracy is not exclusive to music. Other digital copyrighted goods, such as movies, software, games, books, etc, are also being pirated. The development of fast connections is extending piracy to digital goods with high content. Some top movies are available to swap online during their opening week in the theaters.

What is the magnitude of the impact of file sharing on music sales? Is file sharing responsible for the drop in sales during the last years? Inside the music industry, it is generally accepted that music sales have been affected by file sharing. But there has not been much empirical work done to measure the extent of this effect.

The question is important because file-sharing technology “has substantially undermined the effective protection offered by copyright” (Romer, 2002). Strong property rights create monopoly distortions but weak property rights may lead to low creation of artistic work or innovation.¹ The balance between these opposing forces has not been much quantified empirically. Knowledge of the actual estimates of the impact of file sharing on sales is an essential part of the information needed in the determination of the strength of property rights of digital goods.

To the best of my knowledge, the only empirical attempt to measure the effect of online file swapping on music sales is the one prepared in the legal battle against Napster.² To measure this effect, the plaintiff hired Soundscan, a company that developed an information system to capture point-of-sale data on music sales in more than 18,000 stores throughout the US. Soundscan compared sales means for the first quarter of years 1997, 1998, 1999 (when Napster was not available) and 2000, of all stores, stores within

1 See Boldrin and Levine (2002) and Klein, Lerner and Murphy (2002) for a discussion of the effect of file sharing on copyright value.

2 Hui and Png (2003) analyze the effect of commercial piracy on music sales with data from the years 1994-1998.

one mile of any college or university, stores within one mile of the top 40 most wired universities and stores near universities that banned Napster use after the first quarter of 2000. From the first quarter of 1999 to the first quarter of 2000, national sales grew 6.6%, sales near all universities dropped 2.6%, sales near most wired schools dropped 6.2% and sales near schools where Napster was banned after the first quarter of 2000 fell 8.1%. However, sales near universities were falling since 1998, at a time when Napster was not available and in which national sales were growing, casting doubts on the conclusion of Soundscan's report (Fine, 2000).

The objective of this paper is to obtain estimates of the causal effect of online file sharing on music sales. I use two databases: aggregate data by countries and data at the individual level. In the aggregate analysis, I combine a panel of aggregate music sales by country for the years 1997-2002 with data on internet and broadband usage by country as a measure of the number of P2P users. Controlling for aggregate level variables, I find that the country level of peer-to-peer users significantly affects the change in music sales pre and post existence of P2P systems.

The turn to the individual level data allows working with a high number of observations and more controls. In the microdata, the main difficulty in the estimation of the effect of downloads on purchases of music is the presence of unobserved heterogeneity in music tastes among individuals. To control for this heterogeneity, it would be ideal to follow individuals through time. In the absence of such a panel data, I use a major European cross section database of 15,000 observations from October 2001. With these data, I attempt to identify the causal effect of downloading MP3 files on the probability of buying music.

Ordinary least squares shows a positive -- though not significant -- relationship between peer-to-peer usage and the probability of purchasing music. However, OLS is biased and inconsistent in the presence of unobserved heterogeneity. People who download music may have a higher taste for music. To overcome this obstacle, my approach is to use instrumental variables techniques. It is required an instrumental variable that is correlated with peer-to-peer systems usage, but is otherwise unrelated to music purchases. In this paper, I employ measures of internet sophistication and prices of broadband as instruments. My estimates indicate that peer-to-peer usage reduces the

probability of buying music by an average of 30 percent. Separating MP3 downloaders with and without broadband shows a very high reduction in purchases among the first group.

Given the dramatic change in the estimated effect in the instrumented regressions, special attention is given to the validity of the instruments and robustness of the results. First step regressions show a positive and significant correlation of the instruments with peer-to-peer usage. I analyze the exogeneity of the instruments by studying how MP3 downloading affects purchases of other goods, and by studying the relationship of the instruments with variables that may signal taste for music and value of time. I analyze the robustness of the results by restricting the analysis to internet users and to individuals who had an internet connection before Napster started -- to control for the possibility that people went online in order to download music.

With the level of people who downloaded MP3s in 2002, and assuming that the purchased *quantity* conditional on purchasing is the same for users and non-users, my individual level estimates imply a reduction of music sales units in the countries considered of around 7.8 percent.

The paper is organized as follows. Section II summarizes the main features of the music industry. Section III presents the empirical analysis with the aggregate data. Section IV describes the micro-data. Section V presents the empirical strategy and results using the micro-data. Section VI discusses the implications of the estimated coefficients for music sales. Finally, section VII concludes.

II- The Music Industry

Global music sales in 2002 were US\$32.2 billion.³ 41% of these sales were made in North America, 34.5% in Europe, 18.6% in Asia -- with Japan representing more than 80% of Asian sales --, 3.1% in Latin America, and 2.7% distributed among Australasia, the Middle East and Africa. Sales are very concentrated in the top markets. The Top 5 countries -- US, Japan, UK, France, and Germany -- represent 76.5% of global sales and

³ This magnitude differs from the one in the introduction because it includes sales of music videos.

the top 10 -- the top 5 above plus Canada, Italy, Spain, Australia, and Mexico -- represent 85% (IFPI, 2002).

Sales are also concentrated in a few companies. The 5 biggest companies -- Universal, Sony, EMI, Warner and BMG -- control more than 70% of the global market of music sales, with the rest of the market share distributed among many independent record labels (indies). These latter labels, in some cases, have an important presence in an individual country, region or continent.

Companies and musicians usually negotiate exclusive multi-year contracts. When producing a new album, artists typically receive an up-front payment and a royalty somewhere between 5% and 13% of the retail price of the record (S&P, 2002).

The compact disc (CD) is the most popular music format, representing 72% of total international units sales. Sales of singles, long plays (LPs) and cassettes (MCs) continue to be replaced by sales of CD albums (IFPI, 2002). Two new formats, DVD Audio and Super Audio CD, are growing but do not yet have an important share. These new formats have higher sound quality (Surround Sound)⁴ and contain some extra content such as video clips, interviews with the artists, etc. The tendency to include more content might have been accelerated by the need to differentiate the product from the illegal online substitute.

There is variability in prices across CDs. While the average price of a CD in the US is US\$14.19 (BusinessWeek, 2003), 28 of the top 50 albums on the Billboard charts cost between US\$17.98 and US\$19.98, and only seven are listed at US\$14.98 or less (Billboard, 2002). There is not much information on music prices for other countries. In 2001, the European Commission opened an investigation to study the higher prices in Europe and the divergence in prices inside the European Union.⁵ In 2003, the average price of a CD in the UK is US\$16.80 (British Phonographic Industry, 2003).

Distribution costs of music represent a very important share of total costs. A CD with a suggested price to consumers of US\$16.98 has a price of US\$10.50 to the retailer

4 "Surround Sound" refers to multiple channels of sound -- as opposed to only two channels -- that are located around the listener, both in front and back.

5 It was found that the major labels were including minimum advertised prices linked to cooperative advertising agreements in Germany (Official Journal of the European Union, 2002). A lawsuit alleging the same practices was filed in the US. The case ended with a settlement in which the companies agreed to refund US\$67.4 million to consumers and discontinue their minimum pricing policies (New York Times, 2002).

(S&P, 2002). This latter figure includes distribution costs from the record company to the retailer.

The distribution channels have been changing. Music stores have been shrinking as a source of sales, and are being replaced by supermarkets, discount stores, department stores and online retail. In the US, music stores' share of sales fell from 62% in 1991 to 42% in 2000 (RIAA). In the UK, supermarkets increased their share of music sales from 11.2% in 1999 to 17.7% in 2001 (IFPI, 2002). Online retail, as a share of total sales, increased from 6% in 2001 to 9% in 2002 in Germany, from 4% to 6% in the UK and remained steady at 3% in the US. Online legitimate delivery became available in 2001 but it is still not an important source of sales.

Digital Music Online

Online delivery is possible in “Motion Picture Expert Group-1 Audio layer 3” format (MP3). This is the same format used in the online sharing of pirate copies. MP3 is a way to compress audio data without significantly compromising sound quality.

Sound recordings are originally represented as waves. When the sounds are digitalized, these waves are sampled many times per second and a file is created. CD quality needs a sampling of 44,100 times per second (44.1KHz). Humans can only hear around 10% of the sounds that are recorded on a CD. The MP3 compression system eliminates sounds that are not perceptible to humans and softer sounds when different sounds are playing simultaneously. There are different qualities of MP3 compression (bitrate of the file). Bitrates of 64Kbps up to 192Kbps are standard on the internet, but only files above 160Kbps have quality comparable to CDs.

A 5 minute soundtrack that would take more than 50 megabytes in CD compression format can be reduced to a file of 5 megabytes without affecting the sound quality. A compressed file of this magnitude takes 12 minutes to download with a dial-up internet connection (56Kbps modem downstream), 1 minute and 20 seconds with a regular DSL or cable connection (512Kbps downstream) and 20 seconds with a fast DSL connection (2000Kbps downstream).⁶

⁶ Universities have T3 connections that are much faster (from 3Mbps to 45Mbps downstream).

People can upload (rip) CDs to their PCs hard drives and listen to music on their computer, compress the files to an MP3 format to reduce the storage memory requirement and to facilitate the sharing of the files over the internet, and also convert the files back to a CD format and “burn” CDs that can be played in a regular player.

The development of these technologies could represent a very significant reduction in costs considering that around 50% of music costs are distribution expenses.

There are many alternatives to get music online. They can be divided into two groups: legitimate and illegitimate (under the current law).

Legitimate companies either own the copyright or make deals with copyright owners to distribute their music. Among the biggest companies are Pressplay, owned by Sony and Universal; AOL MusicNet, owned by the other 3 big labels (EMI, AOL Time Warner and BMG) and by RealNetworks; the recently launched iTunes and the Europe-based OD2, Wippit and Tornado Virtue. Most services offer unlimited “streaming audio”⁷ and “tethered downloads”⁸ for a fixed charge per month of around US\$10 and the possibility to do permanent burnable downloads for around US\$1 a song. Prices of digital tracks in Europe are higher: between US\$1.76 and US\$2.35 a song (Billboard, 2003).

Online legitimate digital delivery has been dominated by piracy. After the shut-down of Napster, illegitimate music online can be found globally on P2P file-sharing services such as KaZaA, Groekster, iMesh, and Gnutella. These services are distributed without charge and allow users to download licensed and unlicensed files, including music, movies, games and software. The amount of music available through these services is higher than on any legitimate site. This is particularly true for some genres. During the last years, there has been a worldwide trend towards sales of domestic repertoire. IFPI attributes this fact, in part, to the wide availability of international repertoire on pirate music services. To check this claim, in the next section, I use changes in domestic and international repertoire shares by country.

⁷ Listen to soundtracks without downloading them to the hard disc.

⁸ It is possible to download a song to the hard disc but it is not possible to burn it into a CD or listen to it in a portable player. Music is no longer available to listen if subscription is ended.

III- Aggregate Data: Empirical Analysis with a Panel of Countries

In this section I combine aggregate country level data from different sources. Data on music sales is from the IFPI. The IFPI publish a panel of sales for 71 countries for years 1997-2002. Music sales data by country is measured in units, decomposed in singles, long plays (LPs), cassettes (MCs) and compact discs (CDs). For years 1997-2001 and some countries, the panel also contains shares of international, domestic and classical repertoire as percentage of total value of music sales. I combine this panel with data on the number of internet users and broadband users by country provided by the International Telecommunication Union (ITU), with a panel of software piracy⁹ by country from the Business Software Alliance (BSA) and with panels of total and per capita GDP and exchange rates¹⁰ from the World Bank and IMF, respectively. Table 1 presents summary statistics.

To estimate the effect of the development of online music piracy on music sales, I analyze how the country level of peer-to-peer users affects the change in music sales pre and post existence of P2P systems. Consider a two period model -- pre and post existence of peer-to-peer systems -- in which the demand for music in country i and period t is determined by

$$S_{it} = a_t + bP2P_{it} + cX_{it} + e_{it} \quad t = 1,2$$

where S is the logarithm of music sales per capita, $P2P$ is the number of peer-to-peer users per capita and X is a group of other controls. I assume that the relationship between the number of $P2P$ and internet users has the following form

$$P2P_{it} = \begin{cases} 0 & \text{if } t = 1 \\ \lambda I_{it} & \text{if } t = 2 \end{cases}$$

9 Software piracy is measured as the percentage of software sales that is lost due to piracy. A demand for new software is estimated using the number of PCs and an estimated ratio of software to PCs in the US market. The supply of software is estimated with shipments data of BSA members companies. Piracy is defined as the difference between software demand and software legally supplied.

10 Units of foreign currency per dollar.

where I is the number of internet users per capita.¹¹ Substituting and taking differences, the change in the logarithm of music sales follows

$$(1) \quad S_{i2} - S_{i1} = (a_2 - a_1) + b\lambda I_{it} + c(X_{i2} - X_{i1}) + (e_{i2} - e_{i1})$$

Table 2 presents estimates of different specifications of equation (1). The dependent variable is the change in the logarithm of the sum of sales in years 2001 and 2002 and the logarithm of the sum of sales in years 1997 and 1998.¹² All but the last columns of Table 2 use units of CDs as the measure of sales. The covariates are the level of internet users in year 2001, the change in the logarithms of year 2001 and 1997 of GDP per capita, of piracy -- to capture changes in commercial piracy -- and of exchange rates -- to capture changes in prices of music --. Dummies for English being the first spoken language -- English is the dominant language in online sites to swap music -- and for continents are also included.^{13 14}

Assigning equal weight to all the countries in the sample, the estimated coefficient implies a reduction in music sales of around 24% at the country mean of per capita internet users. Quantile regression, to reduce the weight of outliers, gives a smaller estimated impact, an implied reduction of music sales of 9% at the mean. However, there is a lot of heterogeneity of economy sizes among the countries in the sample: from Bahrain with sales in 2002 of 0.1 million units of CDs to the US with 803.3 million units. To give a higher weight to markets that represent a higher fraction of the global market, Table 2 also presents a regression weighted by sales of CD units in year 1997. Adjusting for size, the implied estimated impact on sales at the mean is 15%.¹⁵

11 If the proportion of P2P users varies by country ($\lambda_i = \lambda + u_i$), we need u_i to be uncorrelated with I_i .

12 No population growth is implicitly assumed.

13 The "continents" are Africa, Asia, Australasia, Europe, Latin America, Middle East and North America. "English" is the first spoken language in Australia, Canada, Ireland, Jamaica, New Zealand, UK, USA and Zimbabwe (CIA World Factbook).

14 There could be an overestimation of the effect of music downloading if using the internet and music listening are substitutes. However, the level of internet users in 1998 is positively (non-significant) correlated with the change in sales between years 1998 and 1997.

15 Weighting by GDP and by internet users gives a similar estimate. Without including the US, the coefficient weighting by sales of CDs is -0.6505 and is significant at 5%.

As might be expected, changes in GDP per capita are positively correlated with changes in sales. Also, in the weighted regression, changes in piracy and in exchange rates show the expected sign, although the effect of a change in the exchange rates is not significant.¹⁶

Interacting the level of internet users per capita and GDP per capita -- to allow heterogeneity in the impact of piracy for different wealth levels -- reveals that an increase in GDP per capita reduces the marginal impact of piracy on sales. This estimate implies a reduction in sales at the means of internet users and GDP per capita of around 20% and, for example, for the US it implies an explained drop in sales of around 30%.

Contrary to what might be expected, English has a positive impact on sales. This result might suggest that the level of English proficiency required to swap music online is not too high. It might also indicate that the availability of repertoire in English online is not relatively more abundant, or that music swappers listen to music in the English language. It should also be mentioned that the measure of English fluency is rather simple. Many countries -- for which English is not the principal language -- have a high understanding of the language.

The restriction to CDs could be misleading if the trend of substitution of cassettes for CDs is correlated with the country level of internet usage. The last two columns of Table 2 explore this possibility including the share of quantities of CDs over the sum of CDs and MCs for year 1997 as a control variable and using the change in the logarithm of sales of MCs as the dependent variable, respectively.

The relationship between growth of MCs sales and internet usage is not significant and the inclusion of the ratio of sales of CD and MC does not change the negative relationship between sales of CDs and level of internet per capita. The non-significant relationship between the growth of sales of MCs and piracy might be suggesting that online piracy is a closer substitute for CDs than for cassettes. However, the coefficient is larger in absolute value -- but still not significant -- when weighting by number of users of the internet, GDP and sales of MCs.

¹⁶ It was mentioned in section II that, across the countries with information, there is some variation in prices of CDs. If music was a commodity, it would not be possible to identify the effect of changes in prices with the proposed model. I also tried including the change in the logarithm of "prices" of music calculated as the quotient of total music sales in dollars and total unit sales (CD, MCs, LPs and Singles). The coefficient on internet users remains unaltered and the coefficient on prices is also not significant.

It is considerably faster to download music online with a broadband connection. This implies that the number of broadband connection might be a better proxy for the number of P2P users. Table 3 presents regressions using the number of broadband users by country. The first 2 columns drop the countries with missing number of broadband users and the last 2 treat them as real zeros. Including both broadband users and internet users in the regression, the significance of internet users is reduced. However, the correlation between broadband and internet users is high (74%).¹⁷

Using broadband users as a proxy of the degree of piracy, the estimates imply a reduction in music sales of between 6% and 9% at the mean. For the US, these regressions imply a reduction in sales of between 14% and 20%.

During the last years, music sales have experienced a trend toward local repertoire. Globally, domestic repertoire increased from 64.0% in 1997 to 67.5% in 2001. According to the IFPI, one reason behind this trend is the wide availability of international repertoire on pirate music services; especially some top-selling international acts (IFPI, 2002). A differenced impact by repertoire could also be explained by different music tastes between music downloaders and non-downloaders. I use data on domestic and international music shares by country to test this claim. In most cases, the classification of domestic-international is defined on the country of signing. In France and the Middle East, the classification is defined by language. The US is excluded from the regressions because it is the signing location of a high proportion of music acts (US acts represent a high proportion of international repertoire sales in other countries).

I consider how the level of internet users in 2001 affects the change in the logarithms of the shares of international and domestic repertoire in 2001 and the logarithms of the average shares of years 1997 and 1998 of international and domestic music.¹⁸ Table 4 shows results weighted by total number of internet users, total GDP and total dollar value of sales in 1997. The results indicate that, as the music industry claims, there is some evidence that online piracy has a stronger effect on international repertoire. However, the impact is insignificant when weighting by total dollar value of sales. Note

17 The un-weighted estimates are of the same order of magnitude, but the coefficient is only significant when treating the missing observations as real zeros.

18 Note that, as the dependent variable is the change in the logarithm of the shares, the change in the logarithm of the share of one type of repertoire is not equal to the negative of the change in the logarithm of the share of the remaining repertoire.

that data by repertoire is limited to a reduced number of countries (51 countries). Classical repertoire is available for 38 countries. Restricting to these countries, the effect by repertoire is not significant

IV- The Micro-data

The turn to the microdata allows working with a high number of observation and more controls. In this section I use a European consumer mail survey by Forrester from October 2001 called Technographics. Forrester is a business research company specializing in the information economy. The fieldwork for the survey was conducted by the market research company Taylor Nelson Sofrés. The sampling methodology is proprietary but is meant to ensure a representative sample in each country. Analogous US data from Forrester have been used extensively in economic literature related to the internet (Goolsbee, 2000 and 2001; Goolsbee and Brown, 2002; Goolsbee and Klenow, 2002).

The survey includes 22,488 observations and is representative of the total 16-and-older population in 7 European countries: France, Germany, Italy, Netherlands, Spain, Sweden and UK.¹⁹ Three of these countries are among the top 5 music markets and 5 are among the top 10. In 2001, they represented 27.8% of international music sales (IFPI, 2002).

The database contains a discrete $\{0,1\}$ variable of purchases of music during the month prior to the survey for each respondent. This question is broad in the sense that it is not restricted to off-line purchases. For each respondent, it also contains information about access to the internet; purchases of many goods during the last month including, for example: videos, books, software and groceries; ownership of many electronic goods including, for example: portable stereo, Hi-Fi stereo, cellular phone, DVD player, MP3 player, CD writer and game console; and demographic variables: gender, age, work status, education, household size and household income.

¹⁹ The total survey includes 13 European countries. However, music purchases are not available for some countries (Austria, Belgium, Finland, Ireland, Norway and Switzerland). Also, among the countries considered, 7630 individuals have missing values for at least one of the variables.

For people using the internet, the database contains information on the weekly average number of hours spent online; the number of years that they have been going online and using the email; and information about the respondent's internet activity including, for example: check email, use search engines, purchase goods online, publish own web pages, participate in online auctions and download MP3 files. For people with internet connection at home, the database contains information on the type of connection -- DSL, cable, ISDN or dial-up -.

Table 5 presents summary statistics. Across the overall sample (14858 observations), 39.4% bought music during the month prior to the interview, 9.0% regularly download MP3 files and 50.5% have internet access. The percentage of people who bought music is much larger among the group who regularly download MP3 files (55.7%) than among those who do not (37.8%); suggesting that MP3 downloaders have a high taste for music.

Considering only those people who have an internet connection at home (5781 observations), 47.4% bought music during the month prior to the interview and 21.1% regularly download MP3s. Again, the fraction of people who bought music is higher among those who regularly download music (54.9%) than among those who do not regularly download music (45.4%).

Table 6 compares internet users and broadband access by country in Forrester's sample with data on the number of internet users by the International Telecommunication Union (ITU). The ITU does not collect the data by itself but it compiles information from different country level surveys.²⁰ Forrester's data shows a higher number of internet users and broadband users than the data by the ITU.

There is heterogeneity in per-capita music sales among the countries considered. According to the IFPI, in 2001, per-capita CD sales per year in the UK were 4.1 units, 3.2 in Sweden, 2.7 in Germany, 2.4 in France, 2.3 in Netherlands, 2.0 in Spain and 0.8 units in Italy. Average per-capita unit sales per year over the countries considered in the

²⁰ It is not known the date of the year in which the data was collected in each country and the broadness of the measure of internet access -- access at home, overall access, etc --.

sample were 2.47. The micro-data does not contain sales quantities to match to the IFPI data.²¹ Table 5 also reports probabilities of music purchases by country.

V- Empirical Approach: Microdata

The goal of this paper is to estimate the causal effect of peer-to peer usage on music sales. It was shown in the last section that a comparison of means indicates that individuals who regularly download MP3s buy more music. This positive relationship persists -- although is not statistically different from zero -- when controlling for many individual level characteristics.

I consider the following model

$$B_i = b_1 D_i + b_2 X_i + \varepsilon_i$$

where B_i and D_i are discrete $\{0,1\}$ variables indicating the response of having bought music during the month prior to the survey and the response of regularly downloading MP3 files, respectively, X_i is a vector of observed individual characteristics and ε_i represents the error. Column I of Table 7 presents OLS estimates. This regression is done with respondents with and without internet access. Feasible generalized least squares is employed to allow for heteroskedasticity across individuals. Household income was standardized to gross annual euros per year and its logarithm was included in the regression. Age is measured in years. Confidence in English is measured from 1 to 5 with 5 being “very confident”. Education takes values from 1 to 3 for lower, middle and upper. Household size has a cap for 5 or more people in the household. Hours of TV and hours of internet (only for internet users) are the average hours per week and take the values 2, 7, 12, 17, 22, 27 and 30 (with a cap for 30 or more). All the other controls are dummies.²²

21 The micro-data probably include purchases of illegitimate copies of music (commercial piracy).

22 Note that prices are not included in the analysis. However, in this section the coefficient is identified in the cross section, and therefore the controversy about the dynamic of prices might be eluded. Regional differences in level of prices could be accounted for by regional dummies.

The downloaded online product can theoretically be a complement for music in regular formats (CDs, MCs, LPs) as the mean comparison and the OLS regression suggest. Consumers may get to know albums by downloading some tracks from the internet and then deciding whether or not to buy the whole album. Downloading takes time; but this cost could be lower than the cost of getting to know music by going to the store and listening to different albums before purchasing. Also, not having an MP3 player, not being able to burn CDs in order to listen to the downloaded copy on a regular stereo system, or some quality difference between the copy and the original may induce the purchase of the album.

However, radios advertise music and there exists technology to burn good quality CDs from MP3 files in order to listen the downloaded copy in a regular player. The presence of unobserved heterogeneity in music tastes across individuals may obstacle the identification of the causal effect. The approach of this paper is to use instrumental variables techniques. To achieve the goal requires an instrumental variable that is correlated with peer-to-peer systems usage, but is otherwise unrelated to music purchases.

To account for the unobserved heterogeneity, I consider the following model

$$B_i = b_1 D_i + b_2 X_i + \theta_i + v_i$$

where θ_i represents unobserved taste for music and v_i represents the error. If θ_i and D_i are not orthogonal, OLS gives a biased and inconsistent estimate of b_1 . One way to overcome this problem is to find an instrumental variable Z_i that is correlated to D_i but orthogonal to θ_i .

In the database there is information about many uses of the internet and information on the number of years individuals have been using the internet and the email. There is also a dummy variable for individuals who read computer magazines. These variables could be employed as instruments. The idea is that downloading MP3 requires a high degree of internet sophistication. A high number of years using the internet and the email; some uses of the internet, as “publish own web pages”, “participate in online auctions”, “ask for technical support online”; and “read computer

magazines” might signal a high degree of internet sophistication. These variables could be correlated to downloading music but might be otherwise unrelated with an unobserved taste for music.

Column I of Table 8 reports the first step regression of “download MP3” on the proposed instruments. The probability value of an F-test of the global significance of the excluded in the second stage variables is reported at the bottom of Table 8.

In column II of Table 7, “download MP3” is instrumented for with the proposed instruments. The coefficient on “download MP3” is negative and significant. It indicates that downloading MP3s reduces the probability of buying music by 32%.²³ Purchases of music are negatively correlated with age and household size and positively correlated with listening to music while online,²⁴ with being male, with being a student, with the level of confidence in English, with the ownership of a CD writer and a MP3 player and with the ownership of complements of music, such as walkman and Hi-Fi stereo.

The instruments “how long using the internet” and “how long using the email” are not significant in the first step. Even having a high global significance of the instruments -- F-value of 14.7 --²⁵ in the first step regression, to avoid the risk of dealing with weak instruments, column III of Table 7 shows that excluding the non-significant instruments from the analysis does not alter the estimated effect.

To further analyze the robustness of the results, columns V and VI of Table 7 restrict the regressions to people with internet access at home and with internet users more than two years of online experience, respectively. The regression with individuals with more than two years of internet experience is performed to exclude people who acquire an internet connection after Napster started -- to control for the possibility that

23 Estimation of models of limited dependent variables (LDV) with endogenous *continuous* regressors has been discussed extensively in the literature. Newey, (1987) proposes an estimator that can be calculated by applying GLS to estimates of the reduced form coefficients including the least square residuals from the first step as an additional regressor. Another estimator, that according to Newey (1987) is less efficient, was proposed by Rivers and Vuong (1988). This estimator is calculated by running a probit, including the exogenous variables, the endogenous regressor and the residuals from the first step as explanatory variables. Newey’s estimator is presented in column IV of Table 7. However, here the endogenous regressor is a dummy variable. Angrist, (2001) shows different ways of dealing with dichotomous endogenous regressors in models of LDV. Using linear IV is one of the proposed alternatives.

24 This is not necessarily streaming audio by the context in which the question is asked. The question is “Do you ever do any of the following while online?” One of the options is “Listen to music/radio” and there are many other options, such as “Have the TV on,” “Have friends over,” “Read magazines,” etc.

25 A rule of thumb for being concerned about weak instruments in the case of a single endogenous regressor, is to have an F-value lower than 10. Staiger and Stock, (1997).

people went online in order to download music --.²⁶ The negative effect of downloading music remains strong over these groups.

Given that the number of instruments exceeds the number of endogenous variables, it is possible to test for overidentifying restrictions.²⁷ The probability values for this test are reported in the next to last row of Table 7. The support of the exclusion of the instruments from the purchase equation is stronger when restricting the analysis to internet users than when considering the whole population.

Given the dramatic change in the estimated coefficient in the instrumented regressions in comparison with the OLS estimate, special scrutiny of the instruments is necessary.

To overstate the negative effect of downloads on music purchases, the instruments would have to be correlated with a low taste for music. Another possibility is that the instruments are correlated with an unobserved low value of time. Downloading music from an illegitimate site is free of charge. However, there are other costs associated with the process of downloading. An important one is the cost of time involved in this process. The risk is that sophisticated internet users are people with a low value of time, and therefore -- for a given taste for music -- more willing to substitute music purchases for freely downloaded music.

Table 9 presents OLS regressions of goods that may be related to a taste for music or entertainment -- having a Walkman, having a Hi-Fi stereo, having a DVD player and having a game console -- on the instruments. Publishing a web page is positively correlated with having a DVD and a game console but is negatively and significantly correlated with owning a Walkman and a Hi-Fi stereo. Excluding "own a web page" as an instrument (column VII of Table 7), shows a similar estimated impact of downloading MP3 on the probability of purchasing music.²⁸

26 Napster was launched (in the US) 2 years and 4 month before the fielding of the survey. The coefficient is similar but the SE is bigger when restricting to internet users with more than 3 years and more than 4 years of internet experience.

27 The test is computed multiplying N times R2, where N is the number of observations and R2 is the R2 of a regression of the residuals from the second-stage regression on all the instruments (exogenous variables and instruments not included in the second stage regression). This test is distributed χ^2 with degrees of freedom equal to the number of overidentifying restrictions (number of instruments minus 1).

28 The correlation of the other instruments with the considered goods remain stable when excluding "own a web page" from the regressions in Table 9.

Table 9 also reports a OLS regression of the number of hours that they watch television, an activity that may be thought to be negatively correlated with the value of time, on the instruments.²⁹ The number of hours of television watched per week correlates negatively with publish own page and ask for technical support online, suggesting that sophisticated people do not have an especially low value of time.

In order to further analyze the exogeneity of the instruments, I study how purchases of goods that may signal taste for entertainment are affected by MP3 downloading. Table 10 presents instrumental variables regressions of purchases of books, videos and DVDs,³⁰ video games and audio-visual electronics. If the instruments were selecting individuals with low taste for entertainment, it would be expected a negative impact of the predicted values of MP3 downloading on purchases of these goods. None of the regressions show that downloading music reduces the probability of buying entertainment goods. This suggests that the negative effect of downloading music on the probability of buying music is not driven by using instruments that pick individuals with low taste for entertainment.

Having a high speed connection considerably reduces the cost in downloading time. This suggests that the effect of downloading should be higher for downloaders with broadband. The type of connections is not available for all internet users but only for users with internet connection at home. Downloaders with high speed connections represent 20.9% of the total number of downloaders and 4.4% of the total number of internet users with connection at home.

To separate downloaders with high speed and low speed connections, I include “have a broadband connection” and an interaction term of downloading MP3 and having a broadband connection in the regression. Columns II and III of Table 8 present the first step regressions. Standard errors are clustered by region to allow for autocorrelation coming from differences in broadband availability across regions. The instruments are not very powerful in explaining “have a broadband connection”. The second step is presented in column I of Table 11. The results have high standard error but show a high reduction in the probability on purchases of downloaders with high speed connections, a

29 This analysis may not be valid if using the internet and watching television are substitutes.

30 The swapping of films on the internet has some importance now, but was nearly non-existent in 2001. The sharing of films requires fast connections because the files are big (around 600MB).

lower effect on purchases of downloaders with low speed connections and a positive correlation between the probability of purchasing music and having a broadband connection by itself.

As the power of the instruments in predicting “have a broadband connection” is low, I include interactions of prices of broadband by country with measures of internet sophistication and with income as additional instruments. Prices of broadband are from the OECD and for year 2001.³¹ The inclusion of interactions of prices with measures of internet sophistication and income generates additional variation by allowing for heterogeneity in elasticities across individuals with different degrees of sophistication. Note that the inclusion of dummies within countries in the regression impedes to include level of prices of broadband as an additional instrument. However, the regional dummies may account for the level of broadband prices.

Table 8 shows the first step regressions.³² F-tests of the global significance of the additional instruments are, presented in column reported in the next to last row of Table 8. The second step is presented in column II of Table 11. The standard errors are still too high, but lower than in column I. Again, the results show a high reduction in purchases of downloaders with broadband connections.

VI- Effects of online music downloading on music sales

The results in the last section indicate that downloading MP3 files online changes the probability of buying music during the month prior to the survey by an average of 30%. Downloaded music may be shared with people who do not download MP3 and affect their purchases too. In this event, the estimates understate the causal effect of online music downloading on music sales.

31 There is heterogeneity in the proportion of cable or DSL connections among countries. The prices used are weighted averages of prices of cable connection and prices of DSL connection. The weights are the weights of the two types of connections in each country in Forrester’s data, under the assumption that each individual have no choice between cable or DSL.

32 Sophisticated individuals have a higher demand for broadband. For example, among individuals who own a web page, 24% have broadband internet connections. On the other hand, only 9% have broadband among individuals who do not own a web page. Without including the price level in the broadband equation it is not possible to predict if the demand for broadband is more or less elastic to price for sophisticated or non-sophisticated individuals.

The database does not contain quantities of music purchased to calculate what music sales would have been in the absence of music downloading. Another obstacle in calculating the impact on sales comes from the possibility of having downloaders correctly measured. In particular, if Forrester's data overestimate the number of internet users (Table 6), the number of downloaders may also be overestimated. That said, in this section I investigate this counterfactual.

Across the overall population, 9% regularly downloaded music online in 2001.³³ Therefore, if both digital music users and nonusers had the same propensity to buy music, the effect on the music industry would be a reduction in music sales units of 2.7%.

But digital music users have a higher propensity to buy music, indicating that a correction for the heterogeneity in the groups is needed. It was shown in Table 1 that the probability of buying music for the group of people who download music is 50% higher than the probability for nonusers of P2P systems. Also, the proportion of music downloaders who buy music would have been around 30% higher if the possibility to download music did not exist. This suggests that the probability of buying music for downloaders would have been around double the probability of buying for non-downloaders. As there is no data on quantities of music purchased, an assumption about the number of units bought is needed. One conservative assumption is to assume that users and nonusers of P2P systems, reporting that they bought music during the month prior to the survey, bought the same *quantity* of units. With this assumption, the estimated impact on units sold, at the 2001 level of file-sharers, would be a reduction of 4.9%.³⁴ If users of P2P systems not only have higher propensity to buy music, but also have bought more units conditional on buying, this would be an underestimate of the impact.

In year 2002, the IFPI reports a global increase in the number of users from 3 million in 2001 to 5 million (IFPI, January 2003). Assuming that this magnitude is representative of the increase in the European countries, the predicted drop in sales would be around 7.8%.

³³ Legal online digital delivery was nearly nonexistent in 2001.

³⁴ $((0.09*2)/109)*(-0.3)$

VII- Conclusion

This paper uses two different databases and empirical approaches to measure the causal effect of online music piracy on music sales and finds that file-sharing may reduce the probability of purchasing music by an average of 30% and may explain an important reduction in music sales. Separating music downloaders with and without broadband internet connection reveals a very high reduction of purchases for broadband users. Freely downloadable music seems to be a close substitute for off-line commercially purchased music.

The estimates in this paper are important for welfare analysis. Strong property rights create monopoly distortions but weak property rights may lead to low creation of artistic work. The debate about the underproduction-underutilization trade-off has not been very much quantified empirically. Knowledge of the estimates of the impact of piracy on sales is an essential part of the information needed to determine the strength of property rights.

The interest is not exclusive to the music industry. Other digital copyrighted goods, such as movies, software, games, books, etc, are also being swapped online. The development of fast connections will increase the importance of the impact of file sharing on sales of these goods.

Piracy is illegal under the current legal system. The music industry is fighting piracy in court.³⁵ In the US, music piracy has been legally fought on the basis of contributory and vicarious liability (Landes and Lichtman, 2003). Under these doctrines, copyright holders sue parties that in some way contribute or benefit from the infringing conduct, instead of suing individuals. However, the new P2P systems are more sophisticated and difficult to fight legally because they do not require a central server to operate (Varian, 2000) and have alternative legitimate uses. The other difficulty is that these new systems are established in countries with different legal systems (KaZaa is

35 In Canada, royalties are imposed on digital media, recorders and players. Supposedly, however, these are royalties to copyright holders for private copying for personal use only and do not compensate for piracy/unauthorized copying of sound recordings online or elsewhere. In Italy and Germany, blank CD and burners pay between 5% and 10%. A legislation to extend taxes to the 15 EU nations has been passed last year and is pending ratification by the national parliaments. USATODAY, (2002). Another way to combat piracy is to flood the net with decoy files. This alternative seems to be under use given that there are many of these files in P2P systems. Lichtman and Jacobson, (2000).

registered in the South Pacific island nation of Vanuatu, the software distributor is in Australia and the servers are in the Netherlands; Chicago Tribune, 2003).

Recently there has been a change in the legal strategy. The RIAA has been “gathering evidence and preparing lawsuits against individual computer users who are illegally offering to ‘share’ substantial amounts of copyrighted music over peer-to-peer networks”. In Europe, this strategy is less promising. Recently, the European Commission has proposed to the European Parliament an Enforcement Directive with criminal provisions for infringing P2P file-sharing businesses but excluding not-for-profit copyright infringements (Grammy.com, 2003).

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Table 1
Summary Statistics

	Mean	Minimum	Maximum
Sales of units of CDs (2002) (millions)	34.72	0.1	803.3
% of internet users by country (2001)	20.0%	0.3%	59.9%
% of broadband users by country (2002) (52 countries)	3.0%	0.0%	21.3%
% of piracy by country (2001)	54%	25%	92%
GDP per capita by country (2001) (\$)	14883	1899	34320
Number of countries	65	65	65

Table 2
Aggregate Sales-Internet Users as a Proxy for P2P users

	OLS(a)	Quantile(a)	OLS(a)(1)	OLS(a)(1)	OLS(a)(1)	OLS(b)(1)
Internet users per capita-2001	-1.1954*	-0.4620**	-0.7829*	-1.3249*	-0.6394**	-0.1525
	(0.4186)	(0.1929)	(0.2825)	(0.4063)	(0.2829)	(1.1747)
Change in the logarithm of GDP per capita 2001-1997	1.8502**	1.8445*	1.8130*	2.2054*	1.8963*	-0.6978
	(0.7950)	(0.3387)	(0.5937)	(0.6158)	(0.5777)	(2.4690)
Change in the logarithm of piracy 2001-1997	0.3259	0.0291	-0.3680	-0.4166***	-0.3254	2.3070*
	(0.6027)	(0.2648)	(0.2317)	(0.2284)	(0.2258)	(0.9636)
Change in the logarithm of the exchange rate 2001-1997	0.0398	0.0439	-0.0208	-0.0250	-0.0187	0.0455
	(0.0572)	(0.0265)	(0.0203)	(0.0200)	(0.0197)	(0.0847)
English dummy	0.0263	0.2510**	0.2041**	0.1823**	0.1917**	-1.2008*
	(0.3168)	(0.1117)	(0.0837)	(0.0828)	(0.0814)	(0.3481)
Interaction internet users*GDP per capita	na	na	na	0.000020***	na	na
	na	na	na	(0.000011)	na	na
CD units/(CD units+MC units) (year 1997)	na	na	na	na	-0.0019**	na
	na	na	na	na	(0.0009)	na
Other dummies	Continent	Continent	Continent	Continent	Continent	Continent
R2	0.36	0.24	0.52	0.62	0.62	0.68
Number of observations	65	65	65	65	65	65

(a) The dependent variable is the change in logarithms of the sum of CD units sales of years 2001 and 2002 and the logarithm of the sum of sales in years 1997 and 1998.

(b) The dependent variable is the change in logarithms of the sum of MC units sales of years 2001 and 2002 and the logarithm of the sum of sales in years 1997 and 1998.

(1) Weighted by CD units sales 1997.

Standard errors in parentheses. *1% significance. **5% significance. ***10% significance.

Table 3
Aggregate Sales-Broadband Users as a Proxy for P2P users

	Missing observations dropped*		Missing observations treated as zeros	
	OLS(1)	OLS(1)	OLS(1)	OLS(1)
Broadband users per capita-2002	-2.4073*** (1.2460)	-2.8847* (0.9379)	-2.1428*** (1.1686)	-2.8557* (0.8790)
Internet users-2001	-0.2377 (0.4041)	na na	-0.3403 (0.3669)	na na
Change in the logarithm of GDP per capita 2001-1997	2.0128* (0.6289)	2.1451* (0.5826)	1.9860* (0.5885)	2.1929* (0.5439)
Change in the logarithm of piracy 2001-1997	-0.5853** (0.2601)	-0.6010** (0.2567)	-0.5324** (0.2438)	-0.5534** (0.2424)
Change in the logarithm of the exchange rate 2001-1997	-0.0272 (0.0214)	-0.0280 (0.0212)	-0.0232 (0.0199)	-0.0237 (0.0199)
English dummy	0.1350 (0.0938)	0.1256 (0.0917)	0.1452*** (0.0879)	0.1297 (0.0862)
Other dummies	Continent	Continent	Continent	Continent
R2	0.65	0.64	0.62	0.61
Number of observations	52	52	65	65

The dependent variable is the change in logarithms of the sum of CD units sales of years 2001 and 2002 and the logarithm of the sum of sales in years 1997 and 1998.

(1) Weighted by CD units sales 1997.

*Missing number of broadband users.

Standard errors in parentheses.*1% significance. **5% significance. ***10% significance.

Table 4
Sales by Repertoire

	I		II		III	
	International	Domestic	International	Domestic	International	Domestic
Internet users per capita-2001	-0.8841** (0.3430)	0.3850 (0.3081)	-0.9780** (0.4011)	0.2678 (0.3516)	-0.4743 (0.3398)	-0.0692 (0.3425)
Change in the logarithm of GDP per capita 2001-1997	-1.0919 (0.7010)	0.8442 (0.6295)	-1.0058 (0.8022)	0.8222 (0.7033)	-0.2111 (0.7706)	0.7152 (0.7767)
Change in the logarithm of piracy 2001-1997	0.4831 (0.3364)	-0.4940 (0.3021)	0.1541 (0.3779)	-0.0756 (0.3313)	0.0312 (0.2879)	0.1072 (0.2902)
Change in the logarithm of the exchange rate 2001-1997	-0.0006 (0.0241)	-0.0008 (0.0216)	-0.0077 (0.0227)	0.0086 (0.0199)	-0.0181 (0.0226)	0.0177 (0.0227)
English dummy	0.2368 (0.1649)	-0.2561*** (0.1480)	0.2096 (0.1538)	-0.2163 (0.1348)	0.1702*** (0.1004)	-0.1760*** (0.1012)
Other dummies	Continent	Continent	Continent	Continent	Continent	Continent
R2	0.34	0.32	0.26	0.30	0.21	0.29
Number of observations	51	51	51	51	51	51

The dependent variables are the change in the logarithms of the shares of international and domestic music of year 2001 and the averages shares of years 1997 and 1998 of international and domestic music. Shares measured as % of market value.

(I) Weighted by total number of internet users.

(II) Weighted by total GDP 2001.

(III) Weighted by total dollar value of sales 1997.

Standard errors in parentheses.*1% significance. **5% significance. ***10% significance.

Table 5
Summary Statistics

Overall Population	
% of internet users	50.5%
% of people who regularly download MP3	9.0%
% of people who bought music during the last month	39.4%
% of people who bought music during the last month given that they regularly download MP3	55.7%
% of people who bought music during the last month given that they do not regularly download MP3	37.8%
% of people with DSL or cable internet connection	4.3%
Number of observations	14858
Internet Connection At Home	
% of people who regularly download MP3	21.1%
% of people who bought music during the last month	47.4%
% of people who bought music during the last month given that they regularly download MP3	54.9%
% of people who bought music during the last month given that they do not regularly download MP3	45.4%
% of people with DSL or cable internet connection	11.0%
Number of observations	5781
Probability Of Music Purchases	
France	33.1%
Germany	48.5%
Italy	34.3%
Netherlands	30.2%
Spain	27.4%
Sweden	36.7%
UK	53.5%

Table 6
Internet Access

	Forrester (October 2001)			ITU*		
	Access At Home	Overall Access	Broadband	Internet 2001	Internet 2002	Broadband 2002
France	28.4	38.9	2.3	26.3	31.3	2.4
Germany	43.4	55.2	4.8	37.3	42.3	3.9
Italy	40.0	53.0	1.3	26.8	30.1	1.5
Netherlands	59.1	66.8	15.2	49.0	53.0	7.2
Spain	17.7	33.3	1.8	18.2	19.3	1.1 (2001)
Sweden	58.1	67.7	8.0	51.6	57.3	7.8
UK	47.7	59.7	3.8	32.9	40.6	2.3

* International Telecommunication Union.

Table 7
Ordinary Least Squares and Instrumental Variables

	I	II	III	IV	V	VI	VII
	OLS	IV(1)	IV(2)	IV Probit (1) (a)	IV(1) (b)	IV(1) (c)	IV(3)
Download MP3	0.0113 (0.0154)	-0.3263** (0.1272)	-0.3041** (0.1275)	-0.3037* (0.0752)	-0.3428** (0.1332)	-0.4216** (0.1806)	-0.2652** (0.1346)
Age	-0.0033* (0.0003)	-0.0034* (0.0003)	-0.0034* (0.0003)	-0.0047* (0.0004)	-0.0037* (0.0007)	-0.0045* (0.0010)	-0.0034* (0.0003)
Log of income	-0.0022 (0.0070)	-0.0046 (0.0072)	-0.0044 (0.0072)	-0.0044 (0.0092)	-0.0069 (0.0134)	-0.0060 (0.0201)	-0.0041 (0.0071)
No internet access	0.0161 (0.0104)	0.0115 (0.0107)	0.0118 (0.0106)	0.0159 (0.0132)	na na	na na	0.0123 (0.0106)
Listen to music while online	0.0665* (0.0116)	0.1141* (0.0213)	0.1109* (0.0213)	0.1334* (0.0254)	0.1230* (0.0211)	0.1212* (0.0267)	0.1055* (0.0221)
Household size	-0.0144* (0.0039)	-0.0134* (0.0039)	-0.0134* (0.0039)	-0.0149* (0.0048)	-0.0089 (0.0063)	-0.0187** (0.0093)	-0.0136* (0.0039)
Confidence in English	0.0075** (0.0037)	0.0093** (0.0038)	0.0091** (0.0038)	0.0125* (0.0047)	0.0151** (0.0065)	0.0123 (0.0096)	0.0089** (0.0038)
Male	0.0489* (0.0087)	0.0584* (0.0095)	0.0578* (0.0094)	0.0801* (0.0120)	0.0975* (0.0187)	0.1220* (0.0272)	0.0567* (0.0095)
Hours of TV	-0.0003 (0.0004)	-0.0003 (0.0004)	-0.0003 (0.0004)	-0.0003 (0.0005)	-0.0000 (0.0008)	-0.0003 (0.0011)	-0.0003 (0.0004)
Hours of internet	-0.0022* (0.0008)	0.0020 (0.0018)	0.0017 (0.0018)	0.0021 (0.0020)	0.0024 (0.0018)	0.0031 (0.0021)	0.0012 (0.0019)
Student	0.0285 (0.0184)	0.0561* (0.0215)	0.0542** (0.0214)	0.0527** (0.0251)	0.0384 (0.0294)	0.0380 (0.0413)	0.0511** (0.0217)
Work full time	0.0175*** (0.0096)	0.0102 (0.0101)	0.0106 (0.0101)	0.0115 (0.0121)	0.0079 (0.0161)	-0.0120 (0.0236)	0.0115 (0.0101)
Education	-0.0073 (0.0054)	-0.0097*** (0.0055)	-0.0095*** (0.0055)	-0.0094 (0.0069)	-0.0049 (0.0095)	0.0068 (0.0136)	-0.0093*** (0.0055)
Own walkman	0.0767* (0.0088)	0.0784* (0.0089)	0.0783* (0.0089)	0.0869* (0.0104)	0.0764* (0.0146)	0.0738* (0.0206)	0.0781* (0.0088)
Own MP3 player	0.0215 (0.0205)	0.0411*** (0.0223)	0.0398*** (0.0223)	0.0588** (0.0267)	0.0189 (0.0336)	0.0264 (0.0466)	0.0376*** (0.0222)
Own Hi-Fi stereo	0.0670* (0.0093)	0.0636* (0.0094)	0.0638* (0.0094)	0.0927* (0.0125)	0.0278 (0.0216)	0.0160 (0.0322)	0.0642* (0.0094)
Own CD writer	0.0001 (0.0118)	0.0458** (0.0210)	0.0428** (0.0210)	0.0545** (0.0243)	0.0538** (0.0262)	0.0748** (0.0373)	0.0375*** (0.0217)
Other Controls (dummies)	Region (4)- Ownership of goods (5)- Purchases of goods (6)-Read magazines (7).	Region (4)- Ownership of goods (5)- Purchases of goods (6)-Read magazines (7).	Region (4)- Ownership of goods (5)- Purchases of goods (6)-Read magazines (7).	Region (4)- Ownership of goods (5)- Purchases of goods (6)-Read magazines (7).	Region (4)- Ownership of goods (5)- Purchases of goods (6)-Read magazines (7).	Region (4)- Ownership of goods (5)- Purchases of goods (6)-Read magazines (7).	Region (4)- Ownership of goods (5)- Purchases of goods (6)-Read magazines (7).
Overidentifying restrictions test (p-value)	na	0.059	0.092	na	0.311	0.180	0.056
Number of observations	14858	14858	14858	14858	5781	3215	14858

The dependent variable is a dummy variable for buying music during the last month.

(1) Download MP3 instrumented. Instruments: publish own web page, participate in online auctions, ask for technical support online, read computer magazines, how long using internet and how long using email.

(2) Download MP3 instrumented. Instruments: publish own web page, participate in online auctions, ask for technical support online, read computer magazines.

(3) Download MP3 instrumented. Instruments: participate in online auctions, ask for technical support online, read computer magazines, how long using internet and how long using email.

(4) 53 regions within countries.

(5) TV, widescreen TV, dish, cable TV, pay TV, set-top box for TV, VCR, PC, digital assistant, handheld game, WAP, camcorder, printer, digital camera, digital camcorder, web camera, game console, DVD drive, DVD player, scanner and mobile phone.

(6) Books, videos, video games, software, toys, sports goods, clothing, footwear, jewelry, gifts, flowers, event tickets, electronics, groceries, beer, wine or spirits, tobacco, health and beauty.

(7) Women, family, home, cooking, travel, health, sports, motor, men, tv, celebrity, news, business, finance and nature.

(a) Newey (1987) estimator.

(b) Only internet users with connection at home.

(c) Internet users with more than 2 years going online.

Robust standard errors are listed in parentheses. * 1% significance. **5% significance. ***10% significance.

Table 8
First Step Regressions

	I	II	III	IV	V
	OLS(1)	OLS(1)	OLS(2)	OLS(1)	OLS(2)
Publish own web page	0.0662* (0.0225)	0.0531** (0.0237)	0.0468*** (0.0235)	0.0723 (0.0445)	0.0961** (0.0428)
Read computer magazines	0.0680* (0.0111)	0.0737* (0.0150)	0.0010 (0.0095)	0.0556* (0.0188)	0.0065 (0.0181)
Participate in online auctions	0.0472** (0.0205)	0.0556* (0.0152)	0.0164 (0.0185)	0.0585** (0.0276)	0.0946* (0.0308)
Ask for technical support online	0.0479* (0.0144)	0.0509* (0.0153)	-0.0071 (0.0103)	0.1006* (0.0293)	0.0116 (0.0199)
How long using the internet	0.0053 (0.0050)	0.0010 (0.0054)	-0.0076*** (0.0043)	-0.0016 (0.0105)	-0.0110 (0.0077)
How long using email	-0.0024 (0.0047)	0.0060 (0.0059)	-0.0019 (0.0049)	-0.0120 (0.0095)	0.0050 (0.0088)
Price of broadband*Publish own web page	na	na	na	-0.0004 (0.0009)	-0.0011 (0.0006)
Price of broadband*Ask for technical support online	na	na	na	-0.0010**	-0.0004 (0.0003)
Price of broadband*Participate in online auctions	na	na	na	-0.0000 (0.0006)	-0.0019* (0.0006)
Price of broadband*Read computer magazines	na	na	na	0.0003 (0.0003)	-0.0001 (0.0003)
Price of broadband*How long using the email	na	na	na	0.0003**	-0.0001 (0.0001)
Price of broadband*How long using the internet	na	na	na	0.0000 (0.0002)	0.0001 (0.0001)
Price of broadband*Log of income	na	na	na	-0.0001 (0.0002)	0.0005** (0.0002)
Age	-0.0003*** (0.0002)	-0.0020* (0.0004)	0.0004 (0.0004)	-0.0020* (0.0004)	0.0004 (0.0004)
Log of income	-0.0043 (0.0042)	-0.0158 (0.0111)	-0.0228** (0.0089)	-0.0124 (0.0191)	-0.0482* (0.0144)
No internet access	-0.0076 (0.0052)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)	0.0000 (0.0000)
Listen to music while online	0.1357* (0.0094)	0.1163* (0.0163)	-0.0063 (0.0085)	0.1148* (0.0161)	-0.0068 (0.0084)
Household size	0.0038 (0.0024)	0.0090*** (0.0045)	0.0077 (0.0052)	0.0086*** (0.0046)	0.0090*** (0.0051)
Confidence in English	0.0031 (0.0021)	0.0023 (0.0054)	-0.0013 (0.0030)	0.0023 (0.0055)	-0.0020 (0.0028)
Male	0.0197* (0.0047)	0.0522* (0.0114)	0.0000 (0.0116)	0.0521* (0.0114)	-0.0007 (0.0116)
Hours of TV	0.0003 (0.0002)	0.0003 (0.0007)	-0.0007 (0.0005)	0.0004 (0.0007)	-0.0007 (0.0005)
Hours of internet	0.0104* (0.0008)	0.0092* (0.0011)	0.0096* (0.0016)	0.0092* (0.0011)	0.0096* (0.0016)
Student	0.0827* (0.0134)	0.0886* (0.0162)	0.0156 (0.0136)	0.0889* (0.0166)	0.0145 (0.0141)
Work full time	-0.0219* (0.0053)	-0.0337* (0.0089)	-0.0136 (0.0102)	-0.0332* (0.0089)	-0.0140 (0.0104)
Education	-0.0085* (0.0029)	-0.0150* (0.0050)	-0.0071 (0.0057)	-0.0145* (0.0050)	-0.0069 (0.0057)
Own walkman	0.0058 (0.0046)	0.0184 (0.0120)	0.0129 (0.0082)	0.0189 (0.0115)	0.0131 (0.0082)
Own MP3 player	0.0564* (0.0155)	0.1101* (0.0339)	0.0325*** (0.0192)	0.1096* (0.0340)	0.0341*** (0.0195)
Own Hi-Fi stereo	-0.0091** (0.0041)	-0.0068 (0.0156)	0.0160 (0.0122)	-0.0066 (0.0155)	0.0162 (0.0126)
Own CD writer	0.1246* (0.0090)	0.1536* (0.0116)	0.0414* (0.0102)	0.1539* (0.0115)	0.0410* (0.0101)
Other Controls (dummies)	Region (3)-Ownership of goods (4)-Purchases of goods (5)-Read Magazines (6).	Region (3)-Ownership of goods (4)-Purchases of goods (5)-Read Magazines (6).	Region (3)-Ownership of goods (4)-Purchases of goods (5)-Read Magazines (6).	Region (3)-Ownership of goods (4)-Purchases of goods (5)-Read Magazines (6).	Region (3)-Ownership of goods (4)-Purchases of goods (5)-Read Magazines (6).
R2	0.31	0.27	0.17	0.27	0.18
F-test (global test of excluded in the second stage instruments)	14.7	21.15	2.37	14.15	4.52
F-test (global test of the instruments interacted with prices)	na	na	na	4.18	3.24
Number of observations	14858	5781	5781	5781	5781

(1) Dependent variable is a dummy variable for regularly download MP3 files.

(2) Dependent variable is a dummy variable for having broadband.

(3) 53 Regions within countries.

(4) TV, widescreen TV, satellite dish, cable TV, pay TV, set-top box for TV, VCR, PC, digital assistant, handheld game, WAP, camcorder, printer, digital camera, digital camcorder, web camera, game console, DVD drive, DVD player and mobile phone.

(5) Books, videos, video games, software, toys, sports goods, clothing, footwear, jewelry, gifts, flowers, event tickets, electronics, groceries, beer, wine or spirits, tobacco, health and beauty.

(6) Women, family, home, cooking, travel, health, sports, motor, men, tv, celebrity, news, business, finance and nature.

Robust standard errors are listed in parentheses. * 1% significance. **5% significance. ***10% significance. SE clustered by region in columns II, III, IV and V.

Table 9
Correlation of Instruments with Goods that Signal Taste for Entertainment and Value of Time (OLS)

	Walkman	Hi-Fi stereo	DVD	Game Console	Hours of TV
Publish own web page	-0.0455** (0.0223)	-0.0321** (0.0148)	0.0109 (0.0184)	0.0189 (0.0214)	-0.8189** (0.4043)
Read computer magazines	-0.0027 (0.0126)	-0.0079 (0.0085)	0.0133 (0.0097)	-0.0003 (0.0120)	0.1719 (0.2406)
Participate in online auctions	0.0108 (0.0199)	-0.0149 (0.0117)	0.0186 (0.0178)	0.0145 (0.0193)	0.2402 (0.3823)
Ask for technical support online	-0.0044 (0.0153)	0.0132 (0.0091)	0.0197 (0.0124)	-0.0041 (0.0145)	-0.4816*** (0.2812)
How long using the internet	-0.0036 (0.0063)	-0.0086*** (0.0045)	0.0020 (0.0043)	-0.0021 (0.0056)	0.1351 (0.1123)
How long using email	0.0072 (0.0061)	0.0063 (0.0042)	-0.0019 (0.0041)	-0.0123** (0.0055)	-0.3263* (0.1071)
Age	-0.0042* (0.0003)	-0.0039* (0.0003)	-0.0006* (0.0002)	-0.0035* (0.0003)	0.0451* (0.0065)
Log of income	-0.0093 (0.0070)	0.0324* (0.0061)	0.0118* (0.0043)	-0.0217* (0.0060)	-0.5098* (0.1436)
No internet access	-0.0175 (0.0112)	-0.0191** (0.0088)	-0.0057 (0.0069)	0.0076 (0.0096)	0.4374** (0.2084)
Listen to music while online	0.0421* (0.0108)	-0.0008 (0.0070)	0.0160** (0.0079)	0.0006 (0.0101)	-0.3085 (0.2018)
Household size	0.0351* (0.0038)	-0.0016 (0.0030)	-0.0018 (0.0025)	0.0558* (0.0036)	-0.5279* (0.0737)
Confidence in English	0.0221* (0.0037)	0.0040 (0.0031)	-0.0026 (0.0023)	-0.0060*** (0.0031)	-0.1123 (0.0720)
Male	-0.0383* (0.0086)	0.0280* (0.0075)	-0.0100*** (0.0053)	0.0005 (0.0071)	0.7189* (0.1743)
Hours of TV	0.0019* (0.0004)	0.0000 (0.0004)	0.0005** (0.0003)	0.0015* (0.0004)	na na
Hours of internet	-0.0015*** (0.0008)	-0.0003 (0.0005)	-0.0007 (0.0006)	-0.0007 (0.0008)	0.1138* (0.0150)
Student	0.0744* (0.0163)	-0.0331* (0.0122)	-0.0550* (0.0112)	-0.0513* (0.0166)	-0.7717** (0.3266)
Work full time	0.0380* (0.0095)	0.0177** (0.0074)	0.0004 (0.0061)	0.0182** (0.0083)	-1.4793* (0.1821)
Education	0.0161* (0.0053)	0.0129* (0.0045)	-0.0039 (0.0034)	-0.0221* (0.0044)	-0.4420* (0.1032)
Other Controls (dummies)	Region (1)-Ownership of goods (2)-Purchases of goods (3)-Read magazines (4).	Region (1)-Ownership of goods (2)-Purchases of goods (3)-Read magazines (4).	Region (1)-Ownership of goods (2)-Purchases of goods (3)-Read magazines (4).	Region (1)-Ownership of goods (2)-Purchases of goods (3)-Read magazines (4).	Region (1)-Ownership of goods (2)-Purchases of goods (3)-Read magazines (4).
Number of observations	14858	14858	14858	14858	14858

(1) 53 Regions within countries.

(2) TV, widescreen TV, satellite dish, cable TV, pay TV, set-top box for TV, VCR, PC, personal digital assistant, handheld game, WAP, camcorder, printer, digital camera, digital camcorder, web camera, game console, DVD drive, DVD player scanner and mobile phone, Walkman. Hi-Fi stereo, CD writer, MP3 player. Excluded the good under analysis.

(3) Books, videos, video games, software, toys, sports goods, clothing, footwear, jewelry, gifts, flowers, event tickets, electronics, groceries, beer, wine or spirits, tobacco, health and beauty.

(4) Women, family, home, cooking, travel, health, sports, motor, men, tv, celebrity, news, business, finance and nature.

Robust standard errors are listed in parentheses. * 1% significance. **5% significance. ***10% significance.

Table 10
Purchases of Goods that Signal Taste for Entertainment-Instrumental Variables

	Books (1)	Videos-DVDs (1)	Video Games (1)	Audio-visual electronics (1)
Download MP3	0.1033 (0.1205)	0.1606 (0.1039)	0.3634* (0.1043)	0.2234** (0.0981)
Age	0.0027* (0.0004)	-0.0014* (0.0003)	-0.0009* (0.0002)	0.0004*** (0.0002)
Log of income	0.0241* (0.0077)	-0.0052 (0.0055)	-0.0147* (0.0048)	0.0052 (0.0046)
No internet access	-0.0208*** (0.0112)	0.0165** (0.0082)	0.0035 (0.0069)	0.0069 (0.0068)
Listen to music while online	-0.0068 (0.0202)	-0.0250 (0.0171)	-0.0548* (0.0173)	-0.0358** (0.0160)
Household size	-0.0027 (0.0041)	-0.0020 (0.0032)	0.0062** (0.0028)	-0.0002 (0.0027)
Confidence in English	0.0265* (0.0040)	0.0033 (0.0028)	-0.0025 (0.0023)	-0.0036 (0.0025)
Male	-0.0414* (0.0099)	0.0156** (0.0070)	0.0100*** (0.0060)	0.0099 (0.0062)
Hours of TV	-0.0029* (0.0005)	0.0009* (0.0003)	0.0008* (0.0003)	0.0003 (0.0003)
Hours of internet	0.0009 (0.0017)	0.0001 (0.0015)	-0.0029** (0.0014)	-0.0004 (0.0014)
Student	-0.0067 (0.0211)	-0.0484* (0.0166)	-0.0554* (0.0159)	-0.0023 (0.0153)
Work full time	-0.0030 (0.0102)	-0.0023 (0.0077)	-0.0124*** (0.0067)	0.0019 (0.0067)
Education	0.0579* (0.0058)	0.0026 (0.0042)	0.0005 (0.0036)	0.0009 (0.0035)
Own walkman	0.0229** (0.0091)	0.0057 (0.0065)	-0.0062 (0.0054)	0.0126** (0.0055)
Own MP3 player	0.0279 (0.0207)	-0.0086 (0.0186)	-0.0104 (0.0162)	0.0082 (0.0166)
Own Hi-Fi stereo	0.0151 (0.0109)	-0.0070 (0.0066)	-0.0151* (0.0053)	-0.0026 (0.0058)
Own CD writer	-0.0352*** (0.0202)	-0.0435* (0.0167)	-0.0457* (0.0164)	-0.0324** (0.0155)
Other Controls (dummies)	Region (2)- Ownership of goods (3)- Purchases of goods (4)-Read magazines (5).	Region (2)- Ownership of goods (3)- Purchases of goods (4)-Read magazines (5).	Region (2)- Ownership of goods (3)- Purchases of goods (4)-Read magazines (5).	Region (2)- Ownership of goods (3)- Purchases of goods (4)-Read magazines (5).
Number of observations	14858	14858	14858	14858

(1) Download MP3 instrumented. Instruments: publish own web page, participate in online auctions, ask for technical support online, read computer magazines, how long using internet and how long using email.

(2) 53 regions within countries.

(3) TV, widescreen TV, dish, cable TV, pay TV, set-top box for TV, VCR, PC, digital assistant, handheld game, WAP, camcorder, printer, digital camera, digital camcorder, web camera, game console, DVD player and cell phone.

(4) Books, videos, video games, software, toys, sports goods, clothing, footwear, jewelry, gifts, flowers, event tickets, electronics, groceries, beer, wine or spirits, tobacco, health and beauty. Excluded the good under analysis.

(5) Women, family, home, cooking, travel, health, sports, motor, men, tv, celebrity, news, business, finance and nature.

Robust standard errors are listed in parentheses. * 1% significance. **5% significance. ***10% significance.

Table 11
Instrumental Variables-Internet Users with Connection at Home

	I	II
	IV(1)	IV(2)
Download MP3	-0.2396 (0.1926)	-0.1842 (0.1502)
Have broadband	0.2623 (0.3749)	0.4025 (0.2886)
Download MP3*Have broadband	-0.7583 (0.7171)	-0.9679*** (0.5217)
Age	-0.0036* (0.0007)	-0.0035* (0.0007)
Log of income	-0.0058 (0.0128)	-0.0033 (0.0117)
No internet access	0.0000 (0.0000)	0.0000 (0.0000)
Listen to music while online	0.1202* (0.0238)	0.1168* (0.0227)
Household size	-0.0119 (0.0075)	-0.0135*** (0.0072)
Confidence in English	0.0145*** (0.0074)	0.0143*** (0.0074)
Male	0.0905* (0.0191)	0.0868* (0.0198)
Hours of TV	-0.0002 (0.0010)	-0.0002 (0.0010)
Hours of internet	0.0043 (0.0044)	0.0039 (0.0040)
Student	0.0433*** (0.0241)	0.0414*** (0.0242)
Work full time	0.0102 (0.0244)	0.0129 (0.0246)
Education	0.0004 (0.0124)	0.0028 (0.0119)
Own walkman	0.0749* (0.0149)	0.0731* (0.0145)
Own MP3 player	0.0239 (0.0456)	0.0200 (0.0471)
Own Hi-Fi stereo	0.0211 (0.0270)	0.0185 (0.0253)
Own CD writer	0.0593*** (0.0329)	0.0536 (0.0337)
Other Controls (dummies)	Region (3)-Ownership of goods (4)- Purchases of goods (5)-Read magazines (6).	Region (3)-Ownership of goods (4)- Purchases of goods (5)-Read magazines (6).
Overidentifying restrictions test (p-value)	0.23	0.71
Number of observations	5781	5781

The dependent variable is a dummy variable for buying music during the last month.

(1) Download MP3, have broadband and their interaction instrumented. Instruments: publish own web page, participate in online auctions, ask for technical support online, read computer magazines, how long using internet and how long using email.

(2) Download MP3, have broadband and their interaction instrumented. Instruments used in (1) and interactions of prices of broadband with instruments used in (1) and with the logarithm of income.

(3) 53 regions within countries.

(4) TV, widescreen TV, dish, cable TV, pay TV, set-top box for TV, VCR, PC, digital assistant, handheld game, WAP, camcorder, printer, digital camera, digital camcorder, web camera, game console, DVD drive, DVD player, scanner and mobile phone.

(5) Books, videos, video games, software, toys, sports goods, clothing, footwear, jewelry, gifts, flowers, event tickets, electronics, groceries, beer, wine or spirits, tobacco, health and beauty.

(6) Women, family, home, cooking, travel, health, sports, motor, men, tv, celebrity, news, business, finance and nature.

Robust standard errors clustered by region are listed in parentheses. * 1% significance. **5% significance. ***10% significance.