

8-2009

The Impact of DRM Technology in the P2P Age

Ying Xin

Clemson University, dasidaniya@hotmail.com

Follow this and additional works at: https://tigerprints.clemson.edu/all_theses

 Part of the [Economics Commons](#)

Recommended Citation

Xin, Ying, "The Impact of DRM Technology in the P2P Age" (2009). *All Theses*. 667.

https://tigerprints.clemson.edu/all_theses/667

This Thesis is brought to you for free and open access by the Theses at TigerPrints. It has been accepted for inclusion in All Theses by an authorized administrator of TigerPrints. For more information, please contact kokeefe@clemson.edu.

The Impact of DRM Technology in the P2P Age

A Thesis

Presented to

**The Graduate School of
Clemson University**

In Partial Fulfillment

Of the Requirements for the Degree

Master of Arts

Economics

by

Ying Xin

August 2009

Accepted by:

Dr. Michael Maloney, Committee Chair

Dr. Raymond Sauer

Dr. Curtis Simon

ABSTRACT

The innovation of P2P technology in digital world challenges the present copyright institutions and retailers. People are declined to look for the protection from the traditional law in digital circumstance. As the trend of extending copyright protection term across the world, most intellectual property institutions implement new technologies to deal with such situation. This paper uses a panel of country-level data to investigate the extent to which this is a consequence of the extension of copyright protection. Utilizing the economic model, the analysis suggests that the economic effects of implementing DRM technology are generally negative, albeit uncertain. The available evidence suggests the implementation of the technologies like DRM (Digital Rights Management) in copyright protection is likely to have little significant effects on music sales. The key factors that may have impact on music sales include Population, GDP, Internet Penetration and Domestic Piracy. Confronting the impact of new technological innovation, there might be temporarily declination in music industry and confusion in digital property protection system, but a balancing situation will finally be reached.

Key Words: File sharing, P2P, DRM, Digital music

TABLE OF CONTENTS

| | Page |
|---|------|
| TITLE PAGE | i |
| ABSTRACT | ii |
| LIST OF TABLES | iii |
| LIST OF FIGURES..... | iv |
| CHAPTER | |
| 1. INTRODUCTION | 1 |
| 2. DRM TECHNOLOGY IN RECORDING INDUSTRY | 4 |
| 3. LITERATURE REVIEW | 8 |
| 4. DATA..... | 12 |
| 5. MODEL | 15 |
| 6. RESULTS | 18 |
| 7. DISCUSSION..... | 21 |
| 8. CONCLUSION..... | 24 |

Table of Contents (Continued)

| | |
|----------------------------------|----|
| APPENDICES | 33 |
| A: Variables Description | 34 |
| B: DRM Implémentation Date | 36 |
| REFERENCES | 37 |

LIST OF TABLES

| TABLE | Page |
|---|------|
| 6.1 Summary Statistics..... | 25 |
| 6.2 Summary Statistics by country | 26 |
| 6.3 Correlations of Variables | 31 |
| 6.4 Regressions of Unit Sales and Price | 32 |

LIST OF FIGURES

| FIGURE | Page |
|--|------|
| 2.1 Average Global CD Price | 6 |
| 2.2 Global Pirate Music and DRM penetration | 7 |
| 4.1 Global Music Sales in value | 13 |
| 4.2 Percentage of main formats Music Unit Sales..... | 14 |

Chapter 1

I. Introduction

As Steve Moore said in <The Truth about Music Business>:

“The future is uncertain...”¹

There's probably no issue in the entertainment industry that causes more dispute today than digital property rights. This is the realm of copyright law dealing with materials that have been developed with newer digital technologies. With the invention of newer and faster technologies, especially computers, anyone can copy CDs that they have legally acquired and then burn copies to give to others. With the use of convenient Internet connections at home with computer, almost anyone can copy, distribute, and share files with impunity, and the music industry is facing much bigger challenges. Recording company even claims: “the unabated Internet piracy could mean the end of the industry as a whole.”²

Contrary to traditional form of recording products, digital music on file-sharing networks can be separated from their physical support, compressed and exchanged on the internet in a short time, that is, substantially faster than by renting a CD in a media library or than by borrowing from friends. Facing such a threat, record companies have begun to sue Internet users who share copyrighted files illegally on Peer-to-peer (P2P) networks

¹ See Steeve Moore, The Truth about Music Business, June 2002, Chapter 6.

² See www.riaa.org, RIAA Key stats Facts 2006

freely without the authorization of copyright holders.

At the same time, technology companies are developing technological measures of protection, one of which known as Digital Rights Management (DRM), to control the uses of music in digital format. A paradox is born then. On the one hand, new technologies of information and communication increase the value of information goods for consumers who can download songs anywhere at anytime. On the other hand, new Copyrights Management technologies can restrict and even lock the use of digital music licensed to consumers. At its core, DRM technology allows a copyright holder to define a set of rules attached to a product in a digital format that control consumer access and manipulation of that product. Various rules control the ability to copy, archive, and distribute digital works.³ The goal of this paper is to understand the reasons of the paradox and to analyze the economic effects of the new technologies bringing in the record industry. In determining the effects of DRM, the analysis will rest firmly on the relationship between DRM technology and the music sales in main formats. The hope is to suggest whether music sales fact in the realm of copyright protection should support or impede music industry investment in the development of DRM technologies.

Several points should be noted at the outset. First, this paper will focus its analysis solely on music, excluding all other types of copyrighted properties produced and distributed in digital formats. The reason is that many studies on DRM have based their analysis on improper or overly simplistic assumptions about all kinds of intellectual

³ See the Berkman Center for Internet & Society at Harvard Law School, Copyright and Digital Media in a Post-Napster World, August 2003, at <http://cyber.law.harvard.edu/home/uploads/254/2003-05.pdf>.

properties. Focusing on music exclusively will provide concrete examples that refute those assumptions. Moreover, the recording industry is on the front line of the war against copyright piracy and online file sharing, the very behavior DRM is intended to stop. Second, this paper will be rather speculative in its description of the music industry's implementation of DRM technology. Though various methods of DRM implementation currently exist, DRM technology has not yet provided all of the technological protections. Thus, in looking toward the DRM solutions future effects, one necessarily must speculate as to the nature of its implementation.

The paper is organized as follows. Section II will introduce the rise and the development of digital technology in the global recording industry. Section III provides an overview of the empirical literature examining the effects of DRM technology and file sharing in recording industry. Section IV describes the data for empirical analysis. Next I'll describe the econometric approach and its purpose in Section V. Section VI shows the results according to the designed approach, and Section VII discusses the implications of this study. The final section presents the conclusion.

Chapter Two

II DRM Technology in Recording Industry

In the digital media realm, digital rights management (DRM) systems are used by content-holders to control the access to and use of music or other forms of digital content. DRM technology essentially allows content-holders to set and improve rules about what users can and cannot do with digital content either from the Internet or on physical media such as CDs or DVDs. The initial rationale for DRM was mainly to stop large-scale copyright infringement over peer-to-peer networks. However, other justifications like price discrimination and system innovation have been identified recently.⁴

While DRM is most commonly used by the entertainment industry (*e.g.* film and recording), it has found use in other situations as well. Many online music stores, such as Apple's iTunes Store, as well as certain e-book publishers, have imposed DRM on their customers.⁵ In recent years, a large number of television companies have imposed DRM systems on consumer's electronic devices, to control access to the free broadcast content of their shows.

Traditional DRM schemes regulate the interoperability between digital products and services.⁶ In order to serve its purposes, it is also designed to create a certain degree of incompatibility. Depending on the result of DRM schemes, the certain level of

⁴ See Ed Felten, DRM Wars: the Next Generation, <http://www.freedom-to-tinker.com/?p=1501>.

⁵ See www.noteburner.com, <http://www.noteburner.com/protected-wma-mp3/convert-protected-wma-file-to-mp3>

⁶ See Ed Felten, DRM Wars: the Next Generation, <http://www.freedom-to-tinker.com/?p=1502>.

interoperability may lead to a positive or negative result.

DRM systems allow digital music consumers to transfer their music collection from different devices, or to change between different vendors. On the contrary, it is more difficult to change platforms in non-interoperable DRM systems. DRM system is designed to reduce prices and to stimulate product and service innovation⁷. Additionally, higher levels of DRM interoperability would increase potential competition by reducing entry barriers of the market for new players. As a result, higher levels of DRM interoperability might lead to higher consumption and thus let companies to enter the music market with innovative products and services to improve their market share through product differentiation.

However, the basic purpose of Implementing DRM system doesn't go well as it is expected. Figure 2.1 show the average price of CDs of Top 7 music consumption countries in music market from 2001 to 2007, we can see that the price of CDs in these countries are not simply declining after implementing DRM technology. The prices would temporarily rise after DRM implementation and then fall down. And the average CD prices in Germany, France and Japan are still increasing after 2007, which is beyond the prediction of DRM investors. As I mentioned before, DRM system is designed to reduce music price, but from this figure we cannot say the results satisfy the music industry.

⁷ See the argument of Bomsel & Geffroy, *supra* note 30, that DRM incompatibility may represent a form of "moral hazard," resulting in a failure to maximize welfare. For a discussion of potentially detrimental effects on innovation if intellectual property rights are used principally as strategic weapons which arguably is facilitated in the age of new technologies, see: Strategic Behaviors and Competition, available at <http://papers.ssrn.com/sol3/papers.cfm?abstractid=586483>.

The effect of DRM technology on the piracy issues in global recording market seems also not very significant. We can see from Figure 1, as the share of DRM penetration increases, the units of pirate CDs and digital music are still growing until the period after 2006 when several online music companies decided to sell DRM-free music products. However, we could not draw conclusions based on this trend that DRM technology has little effects on piracy issues in music industry, there might be other factors working on this result.

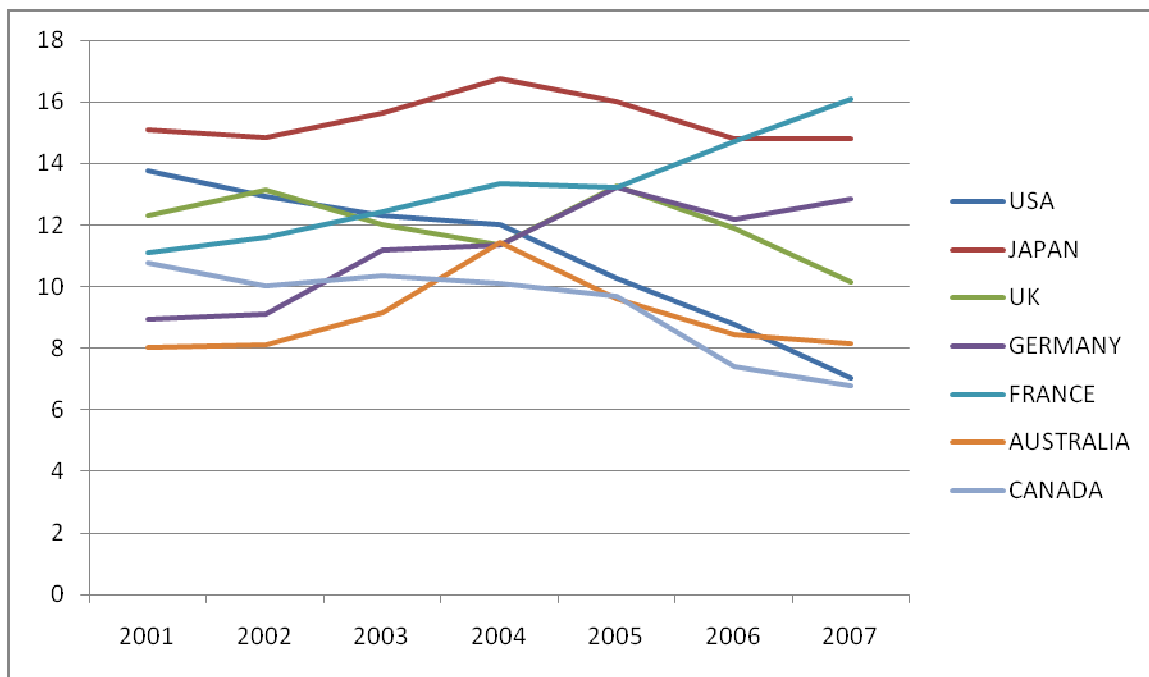


Figure 2.1 Average CD Price of Top 7 Music Consumption Countries 2001 -2007

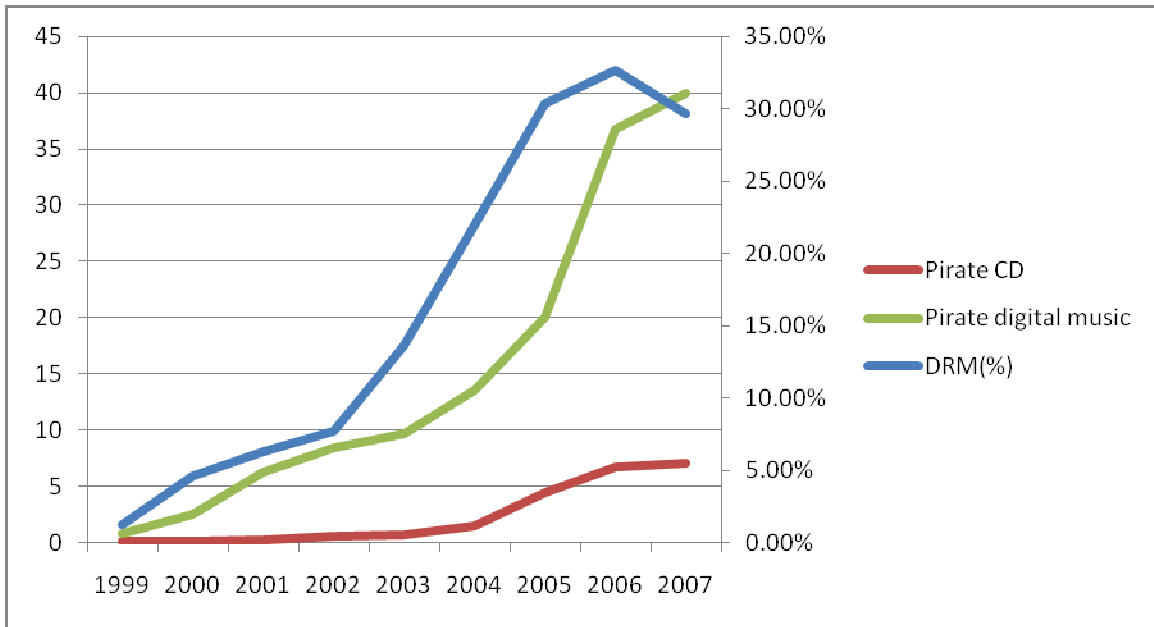


Figure 2.2 Global Pirate Music and DRM penetration (in billion units)

Chapter Three

III. Literature

Piracy is always the greatest pain for the recording industry: The Economist (2003) predicts that file sharing systems would cause the music industry about 15.4 billion dollars potential revenues in 2010. Despite the disappearing of 'free' online file-sharing company Napster, and any other company that would supply similar service online, it's said that Internet song swapping is going to stay (Lyman 2002).

The new versions of P2P networks will be able to guard the identity of the users, which is also its selling point. After years of struggling, the music business has made big moves in dealing with piracy. The major labels began to license music products to several legal download services, starting with the iTunes site Apple Computer Inc in April 2003. Musicmatch Downloads and the RealPlayer Music Store are never far behind for any chance of online music trade. The big retailers Wal-Mart Stores, Virgin Group, and Amazon.com launched their own online stores after (Business Week 2004 b). The online availability becomes wider, but the threat of legal actions is convincing music fans.

Network effects have been used to justify non-protection in a monopoly (Conner and Rumelt 1991) and duopoly environment (Shy and Thisse 1999). The ideas of these papers are: The more consumers are using the same product, the higher utility they hold. Hence, a higher price can be imposed on the legal buyers, if the firm 'allows' the good to be pirated. The members of the network could be legal or illegal software users, and the utility to all consumers increases with the size of the network. If the NE benefits are high

enough, then zero protection may be optimal. In the other papers focus on network externalities (Conner and Rumelt 1991; Shy and Thisse 1999), protection may be optimal if NE is high enough. In the work cited above, protection increases the cost of pirating by raising the cost of breaking these protections.

The reduced utility that a consumer gets from consuming a DRM protected good is related to indirect appropriability (Liebowitz 1985) and shared information goods pricing (Bakos et. al 1999). About the concept of indirect appropriability, take libraries for example, many users may want to pay for one journal, thus the author can charge a library a higher price to any individual who purchases the journal. A similar method is used for the pricing of shared information goods by Bakos et.al. (1999). DRM restricts the number of copies available and the types of devices as music players. As a result, consumers may get a lower utility from the music protected through DRM.

Pirated copies could be used to evaluate originals when its quality is unknown before (Chellappa and Shivendu 2003, Takeyama 2003). The value provided by the pirated copy could help the sales of the original version, if the net surplus from the original exceeds its value. The 'harm' from unauthorized shared information goods may be overstated, because the information value of the copy is counted for all (Takeyama 2003). Chellappa and Shivendu (2003) find that losses due to piracy are more severe for digital goods that do not live up to their hype. Empirical studies are turned to the impact of piracy on music sales. For example Hui and Png (2003), using a data set for sale of music CDs worldwide, find that demand for music CDs declined with piracy. This indicates that the negative effects of piracy outweigh the positive sides. Another study

(Oberholzer-Gee and Strumpf 2004) finds that Internet music piracy won't do harm to legal CD sales, it may even boost some types of music sales. The main rationale is that the consumers who download music on the file-sharing network are usually college students, who prefer not to buy a CD otherwise. By the P2P network, they can evaluate music free and then decide to buy the CD if they like it. Thus, the file-sharing network could stimulate demand.

A recent paper (Chen and Png 2003), studies the problem of a social planner who has three policy choices: to tax the copying medium, to subsidize legal sales and to fine offenders. Providing subsidies to users is found to be welfare maximizing, compared to taxing the copying medium, or penalizing copiers. Gopal and Sanders (1997), distinguish between preventive and deterrent measures to fight software piracy and show in a setting with club formation that using deterrent measures is optimal. The intuition is related to club formation: the firm cannot extract a higher price from each individual, part of the club, using preventive controls. The reverse is true for deterrent measures. Novos and Waldman (1984) look at the classic trade-off problem in copyright literature - the incentives of the copyright holders vs. efficient consumption of the good - from an alternate perspective. They measure 'production efficiency' in terms of the quality of the good rather than the more traditional quantity of goods produced by creators. They study the impact of piracy on the quality choices by a firm, and find that quality choices are below the socially optimal level in the presence of piracy. Additionally under certain conditions, the quality choice increases with the level of protection used by the firm.

A recent working paper (Sundararajan 2003) considers the detrimental impact of

DRM protection on the quality of the product. The paper finds that a seller's choice of optimal level of protection when she can price discriminate, would always be less than the protection level that maximizes the quality difference between its own product and the pirated good. Additionally it finds that if the DRM technology weakens with time (which is to be expected if hackers have more time to overcome DRM), then the optimal strategy may involve either increasing or decreasing the level of protection, depending on whether the marginal reduction in piracy is increasingly less, or more vulnerable to hacking.

Chapter Four

IV. Data

In this study, I focus on a sample of music sales in 15 countries from year 2001 to 2007 according to IFPI, RIAA reports and other digital commerce research organizations.⁸ The 15 countries in the later empirical analysis represent countries with the largest markets in the recording industry (in value), accounting for more than 90% of the world market value.⁹ Data on music sales and DRM usage have been obtained from RIAJ. The data are representative of main commercially relevant forms of music on sale, allowing me to draw meaningful inferences about DRM technology impact on overall music sales. Data on population, Domestic piracy, GDP, and Internet access were drawn from the Census Bureau's yearbook from 2001 to 2007. Annual music statistics from RIAA offers data of variable music sales and changes, including digital music sales from Internet.

Although these years were chosen mainly because of data availability, they are also very good for conceptual reasons. It does not seem relevant to look at data prior to 2001 since DRM management technology, a prerequisite for large-scale Internet piracy,

⁸ These institutions include RIAJ (Recording Industry Association in Japan), BPI (British Phonographic Industry), US Bureau of the Census, WIPO (World Intellectual Property Organization) and business research companies like Forrester, Soundscan.

⁹ The countries are USA, Japan, UK, Germany, France, Italy, Spain, Netherland, Belgium, Sweden, Denmark, Austria, Australia, Canada, and Taiwan. Although China is listed as one of the top 10 digital markets in the world (IFPI 2007 report), ranked 10th with 1.96% of the world sales, it is an outlier with poor Internet piracy though the Internet penetration rate is high, and Chinese GDP is a poor measure of disposable income across the population.

only appeared apparently in the second half of 2001. The year 2001 and 2002 represents the Pre-DRM period, while file sharing had already become entrenched since 2000, and DRM systems have not greatly been developed and implemented in music realm. The time starts from 2003 marked an after-DRM period, as most of the countries in my database started to implement DRM system or similar technology in recording industry.¹⁰ Since my model will be estimated based on the changes during DRM technology is applied, it would be estimating the effects that coincide with the rise of file sharing.

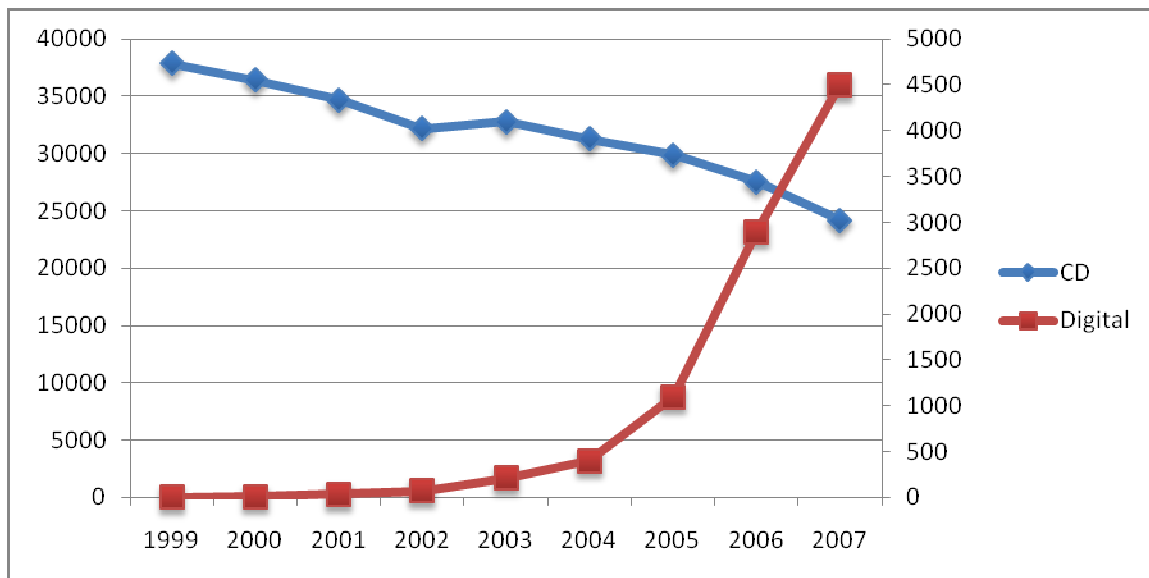


Figure 4.1 Global Music Sales in value (in million US\$)

¹⁰ See Appendix 2, The Timeline of DRM technology in the world.

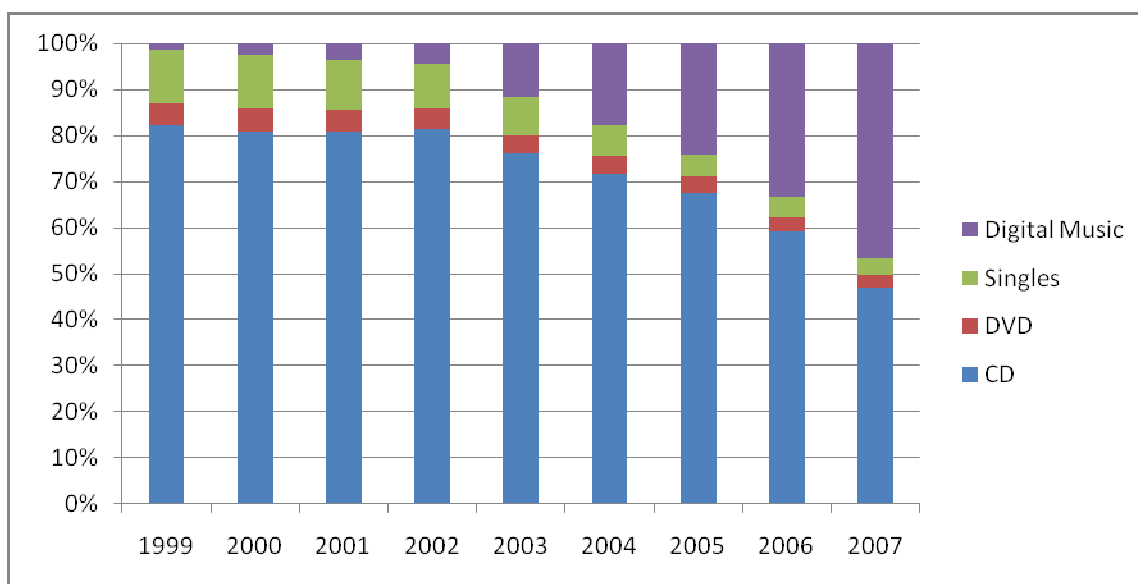


Figure 4.2 Percentage of main formats of Music Unit Sales (in millions)

One of the good properties of those years is that CDs are the clearly dominant medium for recorded music. Measuring the changes in CD sales will give a good picture on how various factors affect the music industry. Also, CD sales are not trending over the years studied. This is desirable because it means the model will not register misleading correlations between CDs and variables like income and population that have a strong time trend. Besides, the Downloaded music from online shops also plays an important role in the recording industry after the development of file sharing. Figure 1 and 2 shows that the numbers of CD sales and digital sales become almost the same in 2006, and the digital share of the total music market has risen from only two per cent in 2000 to around 48.6 percent in 2007,¹¹ so counting digital music sales should make the DRM effect analysis more reliable.

¹¹ See Digital Music Report 2008, P6, IFPI

Chapter Five

IV. Model

To estimate the shifting effect of DRM on music sales, I focus on demand shifters, and particularly on factors related to file sharing and DRM technology. To frame what follows, I begin by using OLS estimation and time series model as means of highlighting the issues involved with estimating the effect of DRM on music sales. The simplest model of the relationship between sales and file sharing with DRM is a model of equation (1). V is music sales (Singles, DVDs, CDs, Digital music, etc), *Internet Penetration* is the number of people with home Internet connection in percentage of the total number of households, *DRM Penetration* is the number of DRM technology used on recording products by recording companies in percentage. The control variables should include GDP, Population, Domestic Piracy rate, etc.¹² The dependent variable is Aggregate Music Sales, given in total units of pre-recorded music sales.

$$V = F(DRM, Internet, GDP, Population, Piracy...) \quad (1)$$

Besides, the availability of file sharing is the same for all countries although the quality of MP3 files may differ if the ownership of CD writers and MP3 players differs. Since I have no information on these latter factors we assume that the quality of MP3 files is the same for all countries. In the analysis below, I assume that any behavioral difference across countries is random.

To estimate the effect of DRM technology on music sales, I analyze whether

¹² See Appendix 1

countries with a higher DRM penetration rate have obtained lower drops in music sales during the period it is implemented. The following equation is used to estimate the model, in which the demand for music in country i and year t is determined by:

$$\log(V)_{it} = \alpha_i + \beta(DRM)_{it} + \delta \log(X)_{it} + \varepsilon_{it} \quad (2)$$

where $\log(V)_{it}$ denote music sales in log units in country i , $i=1,2,\dots,n$, at time t . α_i represents a vector of constants, X is a group of other controls (Population, GDP, Domestic Piracy rate). Finally, ε_{it} is an unobservable variable with mean 0 and variance σ^2 .

The summary statistics are shown in Table 6.1. It presents summary statistics for the 15 countries by year. There are less than 105 observations listed per year because empty cells for any variable were taken to indicate imprecision in the data and led to the elimination of the country.¹³

Though DRM technology is not implemented in the same year for all countries, but we can see the usage of it in 2007 is twice of that in 2003. The share of Internet users doubled from 2001 through 2007, reaching a level of just over 67% in 2007. Downloaded music sales rose from 2001 to 2007 and increased significantly, while the greatest increasing range for the digital music sales is over 300%. However, the decline in CD sales is getting bigger every year, especially the last three years. Singles sales also fall as well as CD's, but the range of change is not big. DVD sales keep waving up and down

¹³ The data for DRM penetration were missing in the first two years because most countries in the database implemented this technology in the early or late half of 2003, only USA and Japan begun to use such systems before 2001. Besides, many of the data for downloaded music unit sales were also missing before 2003.

and don't have a stable trend. As expected, demographic variables such as the population of each country, or domestic piracy rate changed very little over this short interval.

Based on the results of summary statistics, the impact of DRM technology on CD, DVD, Singles and digital music is not significant to observe. Therefore, it should be clearer if we focus on DRM impact on the total music sales and related factors. For this purpose, I amended the dependent variable into two forms to estimate the effects of DRM technology:

- (1) Unit Sales. It's defined as the sum of four formats of music unit sales in each year by country:

$$U = CD + DVD + Singles + Digital Music$$

- (2) Price of Unit Sales. It's defined as the average price for four formats of music:

$$P = V/U$$

Besides, I add two control variables Year and DRM dummy¹⁴ into the equation (2) to get a fixed effect, since the database contains data in both years and countries. Inserting these new variables into equation (2), we get equation (3) and (4):

$$\log(P)_{it} = \alpha_t + \beta(DRM)_{it} + \delta \log(X)_{it} + \gamma Year + \phi D + \varepsilon_{it} \quad (3)$$

$$\log(U)_{it} = \alpha_t + \beta(DRM)_{it} + \delta \log(X)_{it} + \gamma Year + \phi D + \varepsilon_{it} \quad (4)$$

The summary statistics of new variables are listed in Table 6.2, which is sorted by

¹⁴ This dummy variable is defined as "if a country has implemented DRM technology more than 4 years, then D=1, if the period is less than or equal to 4 years, then D=0". This dummy variable is set to estimate the impact of the length of DRM implementation on music sales for country.

country.

Chapter Six

VI. Results

First, I investigate in the correlations of all variables and the results are shown in Table 6.3. The first row of Table 6.3 shows a Year trend of other variables: GDP per capita, Internet Penetration and DRM dummy are positive correlated to Year significantly, which means the number of these three variables will be higher as years pass by. Though Population and Total unit sales variable are also positive correlated with Year, the results are not significant at all; on the contrary, Total music sales in value, DRM penetration rate and Price are all negatively correlated with Year, though not significantly. The number of these three variables might decline in the future based on these results.

For the purpose of this paper, I also focus on the relationship between music sales and DRM Penetration. From this table, we can see from the last three columns that DRM Penetration has positive correlations with both Total music sales in value and Total unit sales significantly, so it gives us a simple idea about the impact of DRM technology in the music industry that it probably can increase the music sales as expected. It is also not hard to observe that the correlation between DRM Penetration and D (DRM dummy) is not very significant. It might be because they are both indicators to estimate the impact of DRM, and it is easy to generate a repeated effect in the regression. Moreover, the Domestic Piracy variable is not significantly correlated to both DRM Penetration and D,

so I decide to drop these three variables separately in the regression model.

Table 6.4 is the results of running regression on equation (3) and (4) with different dependent variables and control variables. The dependent variable of the first columns is P, the price of total music sales. In Column 1, I dropped the DRM Penetration variable and the result shows that the relationship between Price and DRM dummy is negative but not significant, while the effects of Population and GDP are both significant. Column 2 represents a regression without DRM dummy variable, and the result is similar to Column 1 except the Internet Penetration also has a negative and significant relationship with Price. In Column 3 and 4, I run the same regressions as the first column but dropped Domestic Piracy at the same time, as we can see, the Year control variable becomes negative significant in these regressions. To sum up, DRM Penetration, DRM dummy variable and Domestic Piracy show insignificant relationship with the Price of total music sales. At the same time, a higher value of Price of total music sales is related to higher rate of GDP per capita in a country, countries with larger population or higher Internet Penetration have lower value of Price of total music sales. Besides, the Price may also drop as years pass by.

Then I redo the same regressions as in the first four columns except the dependent variable is the Unit music sales (U). On one hand, the results of Colum 5 and 6 show that higher domestic piracy rate is related to a lower number of Unit Sales when the DRM Penetration variable or the DRM dummy is dropped, and a higher population in a country is highly related to a higher number of the Unit Sales. However, the GDP variable isn't related to the Unit Sales in these two columns. The possible reason might be because the

GDP variable and Domestic Piracy variable is highly correlated, making it difficult to identify this effect. The sign of their coefficient suggests that an increase in GDP reduces the marginal impact of piracy on sales. On the other hand, Column 7 and 8 also dropped domestic piracy. The DRM Penetration and DRM dummy variable are still have no significant relationship with the Unit Sales; the Population, GDP and Internet Penetration are all positive and significantly related to the Unit Sales, while the Year variable has a negative and significant relationship with the sum sales.

The symbol of the estimation on Internet penetration is switching from negative to positive between the first four columns and the last four columns. The possible reason for this is because music consumers can hear or purchase music products in more and more channels with the convenience of fast internet connection, so it boosts the unit sales, while the increasing competitions force the music price to decline.

According to the regression results, we can hardly find any significant relationship between DRM technology and the music sales as expected, while the key indicators related to music sales are Population, GDP per capita, Domestic Piracy rate and Internet Penetration.

Of course, models such as these are likely to provide unreliable results. The number of observations per year is too small for a reliable result, and there are many differences across countries that are not taken into account in these regressions, possibly leading to an omitted variables bias.

Chapter Seven

VII. Discussion

According to the results of empirical analysis, we could not find significant effect of DRM technology on music sales, and there are many possible reasons for such effect. On one hand, although the recent DRM systems are proved to be highly effective in piracy issues for physical format music like CD or DVD, but technically it may also cause consumer's computer system crashes and creating security risks. Some of the DRM systems may even be designed for recording companies to get customers' information through its software. Besides, the interoperability problems trouble consumers who purchase physical music products with a DRM system -- the music cannot be played unless on a standard player. To solve the interoperability problems, security risks and other troubles, recording companies need to exploit new DRM technologies with better interoperability year by year, and the costs of such systems rise without an end. This part of technology costs will indirectly be imposed on customers using DRM systems, which will cause losses both to consumer surplus and social welfare.

On the other hand, the online music market also suffers disadvantages from DRM technology, where DRM interoperability issues are among its core problems. Utilization of DRM technology would cause price discrimination. For example, a typical CD, which usually contains an entire album and includes packaging that is conveniently ported from one device to another, is priced much higher than a downloaded track from iTunes, which contains only a single song without packaging that is less convenient for porting. One can

imagine that producers will apparently implement DRM to charge different prices based on the frequency of the consumer would like to listen to a song or the complete album, and the user wishes to port the music from one device to another. While an economic analysis results in a “non liquet,” important values of a society call for a high level of DRM interoperability. The possible drawbacks of an interoperable DRM system do not outweigh its benefits. There exists only little evidence that higher levels of DRM interoperability will compromise security and user privacy, and some of the drawbacks are more closely related to the use of DRM as such rather than to the degree of interoperability. Finally, the negative impact of increased DRM interoperability on security becomes less persuasive in an environment in which DRM is used less and less to prevent piracy.

Although I have listed quantities of drawbacks of DRM technology in music industry, the idea still exists that the birth of DRM technology has reasons to exist in the whole industry, if going to a wider audience I am certain there is a real blind spot where it comes to DRM. To most people, the fact that the music is locked up or tied to a particular system is not something that consumers are aware of. That is the problem. Outside of a small circle of professional users, there isn't a real understanding of what DRM is, which means that as a whole, consumers don't really care about the issues.

So, what effects would no DRM on music have? I think that while the music industry would fuss about losses due to piracy and there are losses indeed, I'm certain that these are small and akin to the kind of shoplifting losses that any bricks-and-mortar store has to suffer – the true effect would be pretty small. Away with DRM would remove the

ripping the CD step out of the piracy workflow, but that is no major debate for any determined pirate. Again, to the consumers who like listening to music, I think that the effects would be negligible. It would be harder to lose music because of a system crash and easier to share music between different devices without DRM, but I do not see this turning everyone into a pirate. I wish that the recording industry would have more respect for the customers than to think that everyone is a potential thief.

Chapter Eight

VIII. Conclusion

Having examined the empirical and theoretical effects of DRM implementation on the music industry, we are left with a rather uncertain future. DRM may indeed tend to increase competition and diversity in the music industry. However, it is also quite possible that DRM implementation could not affect the trend of music sales significantly in the music industry. In this study, countries with higher DRM penetration are not shown to have higher increase or reductions in music sales. The key indicators for music sales are Population, GDP, Domestic Piracy rate and Internet Penetration.

This empirical analysis combines a panel country-level data of total music sales in the past seven years. One problem with this approach is that many country-year observations on DRM penetration and music sales are missing. In addition, the same level of domestic piracy is often reported for different years -- especially for the most recent years. An update of this alternative identification strategy using more years might be desirable.

Furthermore, interest in this topic is not exclusive to the music industry. Other digital copyrighted goods are also being swapped online (movies, software, games and books). The development of fast and convenient connections will very likely increase the importance of the impact of new protection technology on sales of these goods. More empirical studies are necessary to investigate the use of DRM technology in the future.

Table 6.1 Summary Statistics

| | Obs. | Mean | Min | Max | Std. Dev |
|-----------------------------------|------|----------|----------|----------|----------|
| Total music sales (\$) | 105 | 1873.02 | 67.00 | 13740.00 | 3069.04 |
| Single sales (in millions) | 104 | 24.55 | 0.02 | 104.50 | 28.45 |
| CD sales (in millions) | 105 | 101.76 | 53.66 | 881.90 | 182.04 |
| DVD sales (in millions) | 104 | 4.53 | 0.01 | 29.00 | 6.69 |
| Digital Music sales (in millions) | 80 | 32.27 | 0.37 | 868.40 | 110.21 |
| Total Unit Sales (in millions) | 105 | 163.12 | 12.41 | 1472.11 | 282.06 |
| Price (\$) | 105 | 11.13 | 2.64 | 29.94 | 3.78 |
| Population (in millions) | 105 | 56.46 | 5.32 | 303.80 | 71.89 |
| GDP per capita (\$) | 105 | 31624.88 | 13022.00 | 56975.00 | 9200.44 |
| Internet Penetration (%) | 105 | 57.14 | 17.97 | 86.76 | 15.15 |
| DRM Penetration (%) | 77 | 17.96 | 1.25 | 52.10 | 15.77 |
| Domestic Piracy (%) | 105 | 10.44 | 3.70 | 30.80 | 8.21 |

Source: IFPI report 2001-2007, Yearbook of Bureau of the Census.

Table 6.2 Summary Statistics by Country

| Country | Variable | N | Mean | Min | Max | Std Dev |
|---------|--------------------------|---|----------|----------|----------|---------|
| USA | Unit Sales | 7 | 1139.15 | 962.53 | 1472.11 | 201.97 |
| | Price | 7 | 11.01 | 7.04 | 13.75 | 2.42 |
| | Population | 7 | 294.39 | 283.23 | 303.80 | 7.50 |
| | GDP per capita | 7 | 39887.00 | 35289.00 | 45429.00 | 3851.40 |
| | Internet Penetration (%) | 7 | 63.99 | 49.76 | 71.24 | 7.53 |
| | DRM Penetration (%) | 7 | 42.96 | 35.27 | 52.10 | 6.01 |
| | Domestic Piracy (%) | 7 | 4.22 | 4.00 | 4.50 | 0.17 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| JAPAN | Unit Sales | 7 | 309.95 | 282.18 | 348.74 | 19.85 |
| | Price | 7 | 15.43 | 14.79 | 16.77 | 0.75 |
| | Population | 7 | 127.40 | 126.92 | 127.80 | 0.28 |
| | GDP per capita | 7 | 33686.86 | 30726.00 | 36006.00 | 1849.60 |
| | Internet Penetration (%) | 7 | 56.99 | 38.42 | 68.85 | 12.37 |
| | DRM Penetration (%) | 7 | 42.22 | 4.30 | 4.80 | 0.19 |
| | Domestic Piracy (%) | 7 | 4.57 | 4.30 | 4.80 | 0.19 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| UK | Unit Sales | 7 | 274.04 | 255.80 | 301.73 | 14.78 |
| | Price | 7 | 12.01 | 10.14 | 13.27 | 1.07 |
| | Population | 7 | 59.96 | 59.30 | 60.90 | 0.70 |
| | GDP per capita | 7 | 34520.00 | 24520.00 | 45607.00 | 7539.34 |
| | Internet Penetration (%) | 7 | 60.79 | 33.63 | 79.90 | 14.05 |
| | DRM Penetration (%) | 7 | 13.73 | 0.00 | 33.59 | 12.07 |
| | Domestic Piracy (%) | 7 | 6.60 | 5.50 | 7.40 | 0.68 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| GERMANY | Unit Sales | 7 | 189.67 | 162.20 | 235.30 | 28.05 |
| | Price | 7 | 11.26 | 8.95 | 13.23 | 1.69 |
| | Population | 7 | 79.11 | 60.10 | 82.50 | 8.30 |

| | | | | | | |
|-----------|--------------------------|---|----------|----------|----------|---------|
| | GDP per capita | 7 | 31313.57 | 22890.00 | 40182.00 | 6117.30 |
| | Internet Penetration (%) | 7 | 60.96 | 49.00 | 75.73 | 9.60 |
| | DRM Penetration (%) | 7 | 14.89 | 0.00 | 34.46 | 12.83 |
| | Domestic Piracy (%) | 7 | 4.41 | 4.00 | 4.70 | 0.23 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| FRANCE | Unit Sales | 7 | 142.62 | 91.30 | 171.40 | 29.70 |
| | Price | 7 | 13.21 | 11.08 | 16.11 | 1.75 |
| | Population | 7 | 64.29 | 59.24 | 82.50 | 8.25 |
| | GDP per capita | 7 | 32161.43 | 22463.00 | 41508.00 | 6923.38 |
| | Internet Penetration (%) | 7 | 39.52 | 26.99 | 51.21 | 9.21 |
| | DRM Penetration (%) | 7 | 16.42 | 0.00 | 36.20 | 15.37 |
| | Domestic Piracy (%) | 7 | 6.52 | 6.20 | 6.80 | 0.20 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| CANADA | Unit Sales | 7 | 71.38 | 58.70 | 90.10 | 11.51 |
| | Price | 7 | 9.31 | 6.77 | 10.78 | 1.55 |
| | Population | 7 | 32.10 | 30.75 | 33.40 | 1.11 |
| | GDP per capita | 7 | 25960.00 | 14199.00 | 38974.00 | 7705.63 |
| | Internet Penetration (%) | 7 | 61.45 | 0.00 | 29.70 | 9.63 |
| | DRM Penetration (%) | 7 | 13.28 | 0.00 | 29.70 | 13.10 |
| | Domestic Piracy (%) | 7 | 5.38 | 4.90 | 6.20 | 0.50 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| AUSTRALIA | Unit Sales | 7 | 66.83 | 61.70 | 73.47 | 4.13 |
| | Price | 7 | 8.98 | 8.02 | 11.43 | 1.23 |
| | Population | 7 | 19.88 | 19.13 | 20.60 | 0.54 |
| | GDP per capita | 7 | 27400.57 | 19103.00 | 37083.00 | 7502.32 |
| | Internet Penetration (%) | 7 | 60.47 | 53.00 | 70.50 | 5.55 |
| | DRM Penetration (%) | 7 | 8.96 | 0.00 | 21.06 | 9.72 |
| | Domestic Piracy (%) | 7 | 4.47 | 4.10 | 4.80 | 0.25 |
| | DRM Dummy | 7 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |

| | | | | | | |
|------------|--------------------------|---|----------|----------|----------|---------|
| ITALY | Unit Sales | 7 | 45.80 | 42.33 | 51.78 | 3.36 |
| | Price | 7 | 12.77 | 9.52 | 15.29 | 1.90 |
| | Population | 7 | 57.76 | 57.30 | 58.40 | 0.43 |
| | GDP per capita | 7 | 27783.00 | 19289.00 | 35945.00 | 6001.14 |
| | Internet Penetration (%) | 7 | 42.57 | 26.99 | 52.91 | 9.35 |
| | DRM Penetration (%) | 7 | 14.21 | 0.00 | 27.70 | 12.43 |
| | Domestic Piracy (%) | 7 | 27.47 | 25.00 | 30.80 | 2.12 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| NETHERLAND | Unit Sales | 7 | 32.87 | 21.40 | 38.23 | 5.56 |
| | Price | 7 | 12.11 | 10.69 | 13.28 | 3.43 |
| | Population | 7 | 14.97 | 7.20 | 16.60 | 3.43 |
| | GDP per capita | 7 | 35731.86 | 25013.00 | 47312.00 | 7815.27 |
| | Internet Penetration (%) | 7 | 70.38 | 49.43 | 96.76 | 13.06 |
| | DRM Penetration (%) | 7 | 12.07 | 0.00 | 32.70 | 13.30 |
| | Domestic Piracy (%) | 7 | 14.61 | 14.00 | 15.70 | 0.61 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| SPAIN | Unit Sales | 7 | 51.09 | 34.72 | 73.53 | 15.16 |
| | Price | 7 | 10.56 | 8.33 | 12.89 | 1.82 |
| | Population | 7 | 41.71 | 39.91 | 45.20 | 2.17 |
| | GDP per capita | 7 | 23393.00 | 14781.00 | 32479.00 | 6386.10 |
| | Internet Penetration (%) | 7 | 37.95 | 17.97 | 58.69 | 14.68 |
| | DRM Penetration (%) | 7 | 16.18 | 0.00 | 36.90 | 15.65 |
| | Domestic Piracy (%) | 7 | 23.84 | 21.50 | 25.40 | 1.50 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| AUSTRIA | Unit Sales | 7 | 15.41 | 12.50 | 18.90 | 2.32 |
| | Price | 7 | 18.57 | 13.39 | 29.63 | 5.63 |
| | Population | 7 | 8.00 | 7.20 | 8.20 | 0.36 |
| | GDP per capita | 7 | 32799.00 | 23768.00 | 39439.00 | 6101.29 |
| | Internet Penetration (%) | 7 | 49.11 | 37.00 | 61.00 | 9.99 |
| | DRM Penetration (%) | 7 | 15.90 | 0.00 | 40.10 | 15.52 |

| | | | | | | |
|---------|--------------------------|---|----------|----------|----------|---------|
| | Domestic Piracy (%) | 7 | 4.08 | 3.70 | 4.50 | 0.37 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| BELGIUM | Unit Sales | 7 | 30.32 | 23.90 | 38.80 | 5.93 |
| | Price | 7 | 8.94 | 5.96 | 11.45 | 1.73 |
| | Population | 7 | 10.37 | 10.25 | 10.70 | 0.15 |
| | GDP per capita | 7 | 32552.00 | 22373.00 | 43871.00 | 7597.73 |
| | Internet Penetration (%) | 7 | 52.46 | 30.97 | 67.00 | 11.87 |
| | DRM Penetration (%) | 7 | 18.40 | 0.00 | 42.00 | 16.82 |
| | Domestic Piracy (%) | 7 | 10.10 | 9.10 | 11.80 | 1.09 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| SWEDEN | Unit Sales | 7 | 33.54 | 29.56 | 37.18 | 3.22 |
| | Price | 7 | 7.44 | 5.54 | 9.25 | 1.34 |
| | Population | 7 | 8.92 | 8.83 | 9.00 | 0.08 |
| | GDP per capita | 7 | 37292.86 | 25299.00 | 49821.00 | 8655.36 |
| | Internet Penetration (%) | 7 | 78.52 | 51.58 | 86.00 | 11.49 |
| | DRM Penetration (%) | 7 | 8.18 | 0.00 | 39.90 | 0.38 |
| | Domestic Piracy (%) | 7 | 8.18 | 7.60 | 8.70 | 0.38 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| DENMARK | Unit Sales | 7 | 21.27 | 12.41 | 29.52 | 6.19 |
| | Price | 7 | 9.03 | 5.74 | 13.47 | 2.92 |
| | Population | 7 | 5.40 | 5.32 | 5.50 | 0.07 |
| | GDP per capita | 7 | 43141.14 | 29950.00 | 56975.00 | 9810.93 |
| | Internet Penetration (%) | 7 | 71.58 | 42.91 | 84.90 | 14.35 |
| | DRM Penetration (%) | 7 | 16.31 | 0.00 | 34.20 | 14.15 |
| | Domestic Piracy (%) | 7 | 6.25 | 6.00 | 6.60 | 0.23 |
| | DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| | Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |
| TAIWAN | Unit Sales | 7 | 22.67 | 15.20 | 28.38 | 4.73 |
| | Price | 7 | 5.89 | 2.63 | 12.38 | 3.40 |
| | Population | 7 | 22.62 | 22.28 | 22.90 | 0.27 |

| | | | | | |
|--------------------------|---|----------|----------|----------|---------|
| GDP per capita | 7 | 16748.43 | 13022.00 | 34998.00 | 8066.75 |
| Internet Penetration (%) | 7 | 53.68 | 34.90 | 65.70 | 10.46 |
| DRM Penetration (%) | 7 | 21.41 | 0.00 | 20.63 | 7.87 |
| Domestic Piracy (%) | 7 | 25.78 | 21.40 | 28.13 | 2.61 |
| DRM Dummy | 7 | 1.00 | 1.00 | 1.00 | 0.00 |
| Year | 7 | 2004.00 | 2001.00 | 2007.00 | 2.16 |

Source: IFPI report 2001-2007, Yearbook of Census Bureau.

Table 6.3 Correlations of Variables

| | YEAR | Total Music sale (\$) | Total Unit Sales | Price | Population | GDP per capita | Internet Penetration | DRM Penetration | Domestic Piracy | DRM Dummy |
|-----------------------|---------|-----------------------|------------------|---------------|--------------|-------------------|----------------------|-------------------|-----------------|--------------|
| YEAR | 1.000 | -0.033 | 0.042 | -0.074 | 0.013 | 0.608 | 0.603 | 0.659 | -0.076 | 0.000 |
| | | 0.740 | 0.673 | 0.456 | 0.894 | <. 0001 | <. 0001 | <. 0001 | 0.441 | 1.000 |
| Total Music sale (\$) | -0.033 | 1.000 | 0.914 | -0.375 | 0.971 | 0.253 | 0.077 | 0.522 | -0.335 | 0.245 |
| | 0.740 | | <. 0001 | 0.093 | <. 0001 | 0.009 | 0.433 | <. 0001 | 0.001 | 0.016 |
| Total Unit sales | 0.042 | 0.914 | 1.000 | -0.261 | 0.921 | 0.263 | 0.130 | 0.455 | -0.237 | 0.164 |
| | 0.673 | <. 0001 | | 0.007 | <. 0001 | 0.007 | 0.187 | <. 0001 | 0.015 | 0.095 |
| Price | -0.074 | -0.375 | -0.261 | 1.000 | -0.457 | 0.185 | 0.083 | -0.196 | -0.198 | 0.040 |
| | 0.456 | <. 0001 | 0.007 | | <. 0001 | 0.059 | 0.397 | 0.045 | 0.042 | 0.684 |
| Population | 0.013 | 0.971 | 0.921 | -0.457 | 1.000 | 0.200 | 0.020 | 0.532 | -0.224 | 0.261 |
| | 0.894 | <. 0001 | <. 0001 | <. 0001 | | 0.041 | 0.840 | <. 0001 | 0.022 | 0.007 |
| GDP per capita | 0.608 | 0.253 | 0.263 | 0.185 | 0.200 | 1.000 | 0.685 | 0.649 | -0.471 | 0.273 |
| | <. 0001 | 0.009 | 0.007 | 0.059 | 0.041 | | <. 0001 | <. 0001 | <. 0001 | 0.005 |
| Internet Penetration | 0.603 | 0.077 | 0.113 | -0.242 | 0.020 | 0.685 | 1.000 | 0.438 | -0.374 | -0.145 |
| | <. 0001 | 0.433 | 0.252 | 0.130 | 0.840 | <. 0001 | | <. 0001 | <. 0001 | 0.140 |
| DRM Penetration | 0.659 | 0.522 | 0.455 | -0.196 | 0.532 | 0.649 | 0.438 | 1.000 | -0.286 | 0.281 |
| | <. 0001 | <. 0001 | <. 0001 | 0.045 | <. 0001 | <. 0001 | <. 0001 | | 0.003 | 0.004 |
| Domestic Piracy | -0.076 | -0.335 | -0.237 | -0.198 | -0.224 | -0.471 | -0.374 | -0.286 | 1.000 | -0.277 |
| | 0.441 | 0.001 | 0.015 | 0.042 | 0.022 | <. 0001 | <. 0001 | 0.003 | | 0.004 |
| DRM Dummy | 0.000 | 0.245 | 0.164 | 0.040 | 0.261 | 0.273 | -0.145 | 0.281 | -0.277 | 1.000 |
| | 1.000 | 0.016 | 0.095 | 0.684 | 0.007 | 0.005 | 0.140 | 0.004 | 0.004 | |

Table 6.4 Regressions of Unit Sales and Price

| | Price | | | | Unit Sales | | | |
|--------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| | Reg1 | Reg2 | Reg3 | Reg4 | Reg5 | Reg6 | Reg7 | Reg8 |
| Log of Population | 0.048 | 0.040 | 0.052 | 0.043 | 0.985 | 0.997 | 1.009 | 1.013 |
| | 0.027 ^c | 0.033 | 0.028 ^c | 0.033 | 0.028 ^a | 0.034 ^a | 0.038 ^a | 0.045 ^a |
| Log of GDP per capita | 0.674 | 0.639 | 0.749 | 0.720 | 0.206 | 0.235 | 0.654 | 0.753 |
| | 0.147 ^a | 0.144 ^a | 0.140 ^a | 0.133 ^a | 0.153 | 0.149 | 0.191 ^a | 0.183 ^a |
| Internet Penetration (%) | -0.014 | -0.013 | -0.012 | -0.013 | 0.011 | 0.011 | 0.019 | 0.017 |
| | 0.003 ^a | 0.003 ^a | 0.003 ^a | 0.003 ^a | 0.003 ^b | 0.003 ^a | 0.004 ^a | 0.004 ^a |
| Domestic Piracy (%) | -0.007 | -0.006 | na | na | -0.041 | -0.041 | na | na |
| | 0.004 | 0.004 | na | na | 0.004 ^a | 0.005 ^a | na | na |
| DRM Penetration (%) | na | 0.001 | na | 0.002 | na | -0.002 | na | 0.001 |
| | na | 0.003 | na | 0.003 | na | 0.003 | na | 0.005 |
| DRM Dummy | -0.020 | na | 0.003 | na | -0.010 | na | 0.129 | na |
| | 0.089 | na | 0.088 | na | 0.092 | na | 0.120 | na |
| Year | -0.032 | -0.038 | -0.044 | -0.050 | -0.081 | -0.073 | -0.145 | -0.149 |
| | 0.020 | 0.024 | 0.019 ^b | 0.022 ^b | 0.02 ^a | 0.024 ^a | 0.026 ^a | 0.030 ^a |
| R ² | 0.937 | 0.938 | 0.911 | 0.927 | 0.937 | 0.937 | 0.889 | 0.888 |
| Adj. R ² | 0.933 | 0.933 | 0.913 | 0.923 | 0.933 | 0.933 | 0.884 | 0.882 |
| Number of Obs. | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 |

Reg1 to reg4: the dependent variable is log of Price of total music sales.

Reg5 to reg8: the dependent variable is log of unit sales.

Robust standard errors in parentheses: a 1% significance, b 5%significance, and c 10%significance.

APPENDICES

Appendix A

Variables Description

- Aggregate Music Sales: CD, DVD, Single sales are counted in million units based on the RIAA Yearbook.
- DRM Penetration: defined as the share of DRM technology implemented on recorded music products. This statistic is estimated in IFPI annual report. Internet Penetration may capture the substitution with the interaction of digital technology and record companies.
- Digital music sales: defined as the number of music files downloaded in MP3 format from the Internet at least once. This variable serves as a proxy for online end-user piracy but does not completely capture the intensity of the downloading activity: ideally, this number should be obtained by year, but before 2003, legal downloads were almost inexistent. Online music stores backed by major technology and retail company only appeared in the second quarter of 2003. Only the data of USA and Japan can be found in RIAA and RIAJ's yearbook.
- Population: defined as the number of individuals on recorded in each country, collected from Census Bureau of USA.
- GDP (in constant US dollars per capita) captures the economic environment. GDP data are from the Census Bureau except for Taiwan for which we gathered compatible information from the Economist Intelligence Service
- Domestic Piracy: defined as the percentage of pirate music products and illegal

infringements in the total sales of recorded industry. It includes physical piracy and Internet piracy; the data are estimated by IFPI anti-piracy research center.

- Internet Penetration: defined as the number of people with home Internet connection in percentage of the total number of households. Internet Penetration partly captures the substitution with new forms of online activities, such online games as well as audio streaming and legal downloads from commercial Internet sites. It may also partly capture the intensity of the downloading activity because Internet access makes music downloads less time-consuming.

Appendix B

DRM implementation Date

| Country | Implemented. | Date |
|--------------------|--------------|------------|
| USA | Yes | 5/14/1998 |
| JAPAN [□] | Yes | 1/25/1999 |
| UK | Yes | 10/31/2003 |
| GERMANY | Yes | 9/13/2003 |
| FRANCE | Yes | 4/25/2003 |
| CANADA | Yes | 3/10/2003 |
| AUSTRALIA | Yes | 1/19/2004 |
| ITALY | Yes | 4/9/2003 |
| NETHERLANDS | Yes | 9/1/2004 |
| SPAIN | Yes | 8/22/2003 |
| AUSTRIA | Yes | 7/1/2003 |
| BELGIUM | Yes | 1/15/2002 |
| SWEDEN | Yes | 11/9/2003 |
| DENMARK | Yes | 12/22/2002 |
| TAIWAN | Yes | 9/1/2004 |

* The EUCD has not yet formally implemented DRM. Nevertheless, present legislation transposes the directive's provisions at least in part.

* Japan has actually run a very similar system since the early half of 1993, but Sony was the first company implementing DRM technology officially in 1999, so it is believed as the same as DRM penetration in the database.

Work Cited

- Arrow Kenneth J.** (1962), “Economic Welfare and the Allocation of Resources for Invention”, in R. Nelson (ed.), *the Rate and Direction of Inventive Activity*, Princeton, NJ: Princeton University Press.
- Bakos Yannis, Erik Brynjolfsson, and Douglas Lichtman.** (1999). “Shared Information Goods.” *Journal of Law and Econ*, 42, no. 1, pt. 1 (April): 117–56.
- Blackburn D.** (2004), “Online Piracy and Recorded Music Sales”, working paper, Department of Economics, Harvard University.
- Business Week**, (2004), "Downloads: The next generation", Issue 3870, pp. 64.
- Business Week**, (2004), "E-Tune Shopping", Issue 3876, pp. 108.
- Chen, Y.N. and Png, I.** (2003), “Information goods pricing and copyright enforcement: welfare analysis”, *Information Systems Research*, 14(1), pp.107-123.
- Conner, K.R. and Rumelt, R.P.** (1991), “Software piracy: an analysis of software protection strategies”, *Management Science*, 37(2), pp.125-139.
- Economist**, (2003a) "In a Spin", *The Economist*, Vol 366, Iss 8313, pp. 67.
- Economist**, (2003b) "Upbeat", *The Economist*, Vol 369, Iss 8348, pp. 76.
- Gopal, R.D and Sanders, G.L.** (1997), "Preventive and deterrent controls for software piracy", *Journal of Management Information Systems* 13, pp. 29-48.
- Hal R. Varian**, (2005), “Copying and Copyright”, *the Journal of Economic Perspectives*, Vol. 19. No. 2, pp. 121-138
- Hong Seung-Hyun**, (2004), “The Effect Of Digital Technology On The Sales Of Copyrighted Goods: Evidence From Napster”, Working Paper, Department of Economics, Stanford University.
- Ian E. Novos and Michael Waldman**, (1984), “The Effects of Increased Copyright Protection: An Analytic Approach”, *the Journal of Political Economy*, Vol. 92, no. 2, pp. 236-246.
- International Federation of the Phonographic Industry (IFPI)**, “The Recording Industry in Numbers”, October 2002.
- : “The Recording Industry World Sales”, April 2003.

IFPI Digital Music Report, 2000-2008, IFPI

Kai-Lung Hui and Png Ivan (2003), "Piracy And The Legitimate Demand For Recorded Music", *Contributions to Economic Analysis & Policy*, Vol 2, Issue 1, Article 11.

Karagiannis Thomas, Andre Broido, Nevil Brownlee, kc claffy, and Michalis Faloutsos. (2004), "Is P2P Dying or Just Hiding?" Paper presented at Globe.com, Dallas. ([Http://www.caida.org/outreach/papers/2004/p2p-dying/](http://www.caida.org/outreach/papers/2004/p2p-dying/))

Klein, Benjamin, Andres V. Lerner, and Kevin M. Murphy. (2002). "The Economics of Copyright 'Fair Use' in a Networked World." *A.E.R. Papers and Proc.* 92 (May): 205–8.

Liebowitz Stan J. (2003), "Will MP3 Downloads Annihilate The Record Industry? The Evidence So Far", in G. Libecap (ed.), *Advances in the Study of Entrepreneurship, Innovation and Economic Growth*, JAI Press, pp. 229-60.

Liebowitz Stan J. (2006), "Testing File-Sharing's Impact by Examining Record Sales in Cities". working paper, University of Texas at Dallas.

Lyman J. (2002), "The future of online file sharing", News Factor Network.

Michael O'Hare. (1985), "Copyright: When Is Monopoly Efficient?", *Journal of Policy Analysis and Management*. Vol. 4. No. 3, pp. 407-418

Musick Nathan. 2004. "Copyright Issues in Digital Media." Congressional Office.

Novos and Waldman. (1984) "The effect of increased copyright protection: an analytical approach", *Journal of Political Economics*, 92(2), pp.236-246.

Oberholzer, Felix and Strumpf, Koleman (2007), "The Effect of File Sharing on Record Sales. An Empirical Analysis", *Journal of Political Economy*, vol. 115, no. 1.

Patrick Burkart and Tom McCourt, (2006), "Digital Music Wars---Ownership and Control of The Celestial Jukebox", chapter 3 Jukebox Contested

Peitz Martin and Waelbroeck Patrick (2004), "The Effect of Internet Piracy on Music Sales: Cross Section Evidence". *Review of Economic Research on Copyright Issues*, 1 (2), 71-79.

Plant Arnold. (1934). "The Economic Aspects of Copyright." *Economica*. 1:2, pp. 167-95. Washington, D.C U.S. Copyright Office.

Posner Richard A. (2005). "Intellectual Property: The Law and Economics Approach." *J. Econ. Perspectives* 19 (spring): 57–73.

Rob Rafael and Waldfogel Joel (2006), "Piracy on the High C's: Music Downloading, Sales Displacement, And Social Welfare in a Sample of College Students", 2004, forthcoming *Journal of Law and Economics*.

Recording Industry Association of America's Consumer Profile, 2000-2008, RIAA

Shy, O. and Thisse, J.F., "A strategic approach to software protection", *Journal of Economics and Management Strategy*, 8(2), 1999, pp. 163-190

Steve Moore, B.A J.D. (2005), "The Truth about Music Business--A Grassroots Business and Legal Guide", Chapter 8.

Sundararajan A. (2003), "Managing Digital Piracy: Pricing protection and Welfare", working paper, Stern School of Business.

Takeyama Lisa N. (1994). "The Welfare Implications of Unauthorized Reproduction of Intellectual Property in the Presence of Demand Network Externalities." *J. Indus. Econ.* 42 (June): 155–66.

U.S. Copyright Office (2003), *Copyright Basics*. Washington, D.C, U.S. Available at (<http://www.copyright.gov>).

Zentner A. (2006), "Measuring the Effect of Music Downloads on Music Purchases", *Journal of Law and Economics*.