The iPod/iTunes tying case

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The iTunes Music Store uses an incompatible DRM system to prevent copyrighted music from being shared unauthorized. This practice is currently not abusive because iPod's rivals are not foreclosed to a substantial share of the market for portable digital music players. Nevertheless, the number of consumers using both online music stores and digital music players is increasing. Consequently, an abusive practice is likely to be found in the future. Despite Apple's claim that it prefers to abandon DRM, tying profits are shown to be higher due to rivalling music players. The preference for abandoning DRM arises from positive externalities of piracy, which compensate losses in profits if Apple cannot tie the iTunes Music Store and iPod. Whereas welfare is highest in this scenario, this equilibrium only arises if music labels allow Apple to remove DRM restrictions.

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1. Introduction

Technological improvements have led to new business models in the music industry. For example, the rise of broadband connections changed the distribution of music, enabling Internet sales. Moreover, storage devices changed from carriers with small capacity to hard drives with larger memories. These developments gave major technology companies the opportunity to obtain a profound position in the music industry by creating portable music players, such as Apple's iPod, and online music stores, for example the iTunes Music Store. To protect intellectual property rights of artists and record labels, online music was equipped with Digital Rights Management systems (DRMs); unfortunately, due to DRMs music from one store became incompatible with competing technologies.

Hence, in several European countries, consumer protection agencies have raised concerns about Apple's practice of tying its music store and the iPod. They claim it is not possible to play songs downloaded from the iTunes Music Store on other music players than iPods or play music from other online music retailers on an iPod. Currently, seven European consumer protection agencies are investigating whether Apple is abusing a dominant position by tying iPod and iTunes.[1] Moreover, the EU commissioner of consumer affairs, Ms. Kuneva, criticised Apple for tying the iTunes Music Store to the iPod.[2]

As a reaction to these criticisms, Apple and record label EMI recently announced that existing locks will be taken away from EMI's music sold through the iTunes Music Store, enabling the music to be played on any device.[3] This raises the question what has induced Apple to tie the iPod and iTunes Music Store: profitability considerations or restrictions imposed by record labels. If tying is not profitable for Apple, the firm would perform better by selling interoperable music and the claim that Apple abuses its dominant position would be difficult to defend since an external factor forces the company to tie its goods.

These recent developments show the need for objective investigation of the desirability of Apple's practice. Whereas consumer protection agencies reply to the need for investigation, these agencies act in the interest of the consumer and will try to prove abuse of a dominant position. Investigation undertaken by representatives of Apple or other companies with interests in the industry would also give subjective interpretations of the facts. As a result, investigations by objective parties without a stake in the final conclusion are needed.

[1] Businessweek.com, January 2007. *Europe vs. Apple: facing the Music.* http://www.businessweek.com/globalbiz/content/jan2007/gb20070131_492654.htm

[2] Businessweek.com, March 2007. *EU Commissioner Blasts Apple's iTunes.* http://www.businessweek.com/globalbiz/content/mar2007/gb20070312_106270.htm

[3] BBC News, April 2007. *EMI takes locks off music tracks.* http://news.bbc.co.uk/1/hi/technology/6516189.stm

Economic theory, specifically industrial organization and competition policy, can contribute to an objective statement about the desirability of Apple's practices by modelling the effect on consumer surplus and aggregate welfare.

Therefore, the purpose of this thesis is to objectively contribute to the literature on the issue. Specifically, the iPod-iTunes connection will be explored by the application of economic theory. Firstly, it will be investigated whether Apple abuses a dominant position. Moreover, alleged abuses of dominant positions can be detrimental for consumer surplus, but do not necessarily have to be detrimental to welfare (the aggregate of consumer and producer surplus); instead, efficiency reasons for tying practices can exist. As a result, abandoning tying practices could well have negative effects on aggregate welfare. Since the goal of policy makers is to maximize welfare, potential anti-competitive effects have to be weighted against efficiency reasons behind the practice. This will be done by analysing the effect on both consumer surplus and aggregate welfare. Furthermore, in light of the recent announcement that Apple is going to sell EMI's music interoperable, it will be analysed whether Apple behaves rational by tying the iPod and iTunes Music Store or whether it would be more profitable to sell the music without restrictions.

A first element of investigating whether Apple abuses a dominant position is defining the market in which the alleged abuse occurs; thereafter, Apple's market power will be assessed. If Apple holds a dominant position, it can be analysed whether Apple abuses this position; this is the case if tying leads to foreclosure of competitors to Apple its customers.

Regarding the effects on profits, consumer surplus and welfare, two models developed in Whinston (1990) are used, describing conditions under which a firm ties its products. Firstly, Whinston analyses the behaviour of a firm operating in both a monopolised and an oligopolistic market in which complementary goods are supplied. Applied to the case of Apple, the iPod is supplied in the monopolised market and the iTunes Music Store operates in the oligopolistic market. In this basic model, a firm will never find it worthwhile to tie its goods in order to reduce competition in the market. In fact, a firm can increase its profits by selling goods separately because it can benefit from increased sales of its monopolized product through its rival's presence.

One shortcoming of this model is that it assumes a monopolised market, which does not fit reality in the iPod-iTunes connection. In fact, after extension of the model with the existence of an inferior, competitively supplied product in the monopolised market, foreclosing competitors by tying and excluding them from the market can be profitable. It will be

analysed whether this is the case for the iPod/iTunes combination. Moreover, in Whinston (1990) the effect of foreclosure on consumer surplus is negative whereas the effect on aggregate welfare is ambiguous. This direction of welfare is a third issue of interest.

Summarizing, the main questions of this paper are: Does Apple abuse a dominant position by tying the iPod and iTunes Music Store, is this practice profitable for Apple and how does it affect consumer surplus and aggregate welfare?

This thesis is structured as following: firstly, I will provide the reader with some basic knowledge about music piracy and DRM. Subsequently, I will analyse whether Apple abuses a dominant position by defining the relevant product and geographical markets, assessing Apple's market power and analyzing whether the firm abuses its power. This will be followed by an analysis of the profitability and effect on welfare of tying.

A number of solutions to the problem of incompatible DRM systems have been proposed by consumer organizations and Apple's executive director Steve Jobs.[4] The different DRM systems could be made inter-operable, one standard in DRM could be developed or DRM could be abandoned in its totality. These options can solve part of the problem but they also have their own drawbacks. Hence, in Section 7 the desirability of these alternatives will be analyzed.

It will be concluded that nowadays Apple cannot be accused of abusing a dominant position in legal terms, since the number of consumers affected by the tying practice do not add up to a substantial part of the market for music players. Nevertheless, this group of consumers is growing in importance, worsening the problem and increasing the probability of a conviction. Furthermore, a microeconomic analysis points out that for the group of consumers affected by the practice, consumer surplus and welfare are decreased as a result of tying but Apple's profits are increased, particularly if the iPod faces strong competition and preferences for online music stores are homogeneous. For this reason, a solution is not likely to arise unless external parties, for example competition authorities or record labels, take measures.

In the future, the loss in welfare is likely to be even higher because DRM is likely to suppress piracy, which has positive externalities on music sales and demand for portable digital music players. Two alternatives, then, are possible: either the status quo is retained, with incompatible DRMs, or record labels allow retailers of digital online music to abandon DRMs.

[4] Jobs, S., February 2007 in an open letter with the title *Thoughts on Music,* available on www.apple.com

2. File-sharing, piracy, DRM & their influences on the music industry

The music industry has been significantly influenced by the development of peer-to-peer (P2P) networks such as Napster and Kazaa, which allow Internet users to share copyrighted files without authorization of copyright owners (e.g., artists and record labels). Uploading and downloading involved in P2P applications is costly, however. Uploading files creates legal risks, moral concerns and large uses of computers' resources. Downloading files is time-consuming; many files are incomplete, erroneously named, of bad technical quality and in general, only mainstream files can be found easily. Moreover, computers become more vulnerable to worm viruses which forces consumers to invest in anti-virus programs. On the other hand, use of file-sharing technologies can be associated with benefits: users can access and sample music freely and obtain single tracks instead of the complete album.

Since costs are considerably high and often outweigh the benefits, P2P networks are mainly used by consumers with low opportunity costs. In fact, file-sharing is popular among Internet users aged 24 or less, not representing a significant percentage of the population with large purchasing power. Moreover, the majority of music consumers do not use P2P applications, the probability of having downloaded music decreases with the income of the household and since 2003 the number of P2P users has declined significantly, particularly after legal measures were adopted in order to address such illegal actions (Peitz and Waelbroeck, 2004).

Nevertheless, the major record companies are concerned about P2P networks and claim that music piracy affects CD sales, which account for the overwhelming majority of their revenues. For this reason, these labels require that their music sold online must be protected from illegal distribution through P2P applications. The solution devised by online distributors was to create or purchase Digital Rights Management (DRM) systems, which are able to detect, monitor and control the use of copyrighted material. Thus, DRMs allow digital music stores to offer consumers a way to obtain legal online music, for which the market has grown tremendously from 2004 on.

DRM technology, however, requires considerable and constant investments, which can be supported only by large firms with great competence and financial resources. Because DRMs are an essential asset in the online distribution value chain, the online music market is very likely to be monopolized. Apple, responsible for the development of the DRM technology FairPlay, is leader in this business (Brousseau, et al., 2005). A second player is Microsoft with its JANUS. These two systems are incompatible, which has led to the claim that Apple ties its goods and abuses a dominant position.

3. Definition of the relevant market

In order to investigate whether Apple abuses a dominant position, the relevant market in which this dominant position exists has to be defined. This market should reflect the set of products or regions that exercise some competitive constraint on each other (Motta, 2004), which requires absence of demand and supply substitutability from outside the market. The latter is discussed in Section 4 in the context of entry barriers, whereas demand substitutability is discussed below.

It would be useful to define the market by looking at the profitability of small but significant and non-transitory price increases, referred to as the SSNIP-test. If a hypothetical monopolist could profitably increase its price by a small percentage of for example 5%, it would face no competitive constraints and the hypothetical monopolist would comprise the relevant market. Contrarily, if the hypothetical monopolist cannot profitably increase its price, it faces competitive constraints from products or regions not included in the test and the market definition should be expanded (Motta, 2004). The test should be repeated until the outcome is positive.

Unfortunately, the SSNIP-test is difficult to apply in the music industry since public industry information is not easily accessible. Therefore, the market definition is based on demand characteristics. If products are assumed to be a competitive threat to Apple's product because of similarity in demand characteristics, the product has to be included in the relevant market. The outcome of a SSNIP-test would be similar, since this analysis of demand substitutability is still based on the concept of competitive constraints.

In the following, the relevant market for the iPod and the iTunes Music Store will be defined. As will be shown, the relevant national market for iPods consists of portable digital music players. The iTunes Music Store faces competition from other retailers of mainstream digital single songs operating nationally and possibly from music distributed globally in illegal ways.

3.2 Market definition for iPods

The market definition for the iPod is based on an analysis of the French competition authority, which investigated possible competitive constraints of several forms of portable music players on Apple's iPod after VirginMega complained to be foreclosed of Apple's customers.[5]

Firstly, players with hard drives such as the iPod exist, which can store a large stock of near-CD-quality music (with a capacity of 1.5 GB or higher). These devices can play DRM

[5] Conseil de La Concurrence. (2004). *Décision n° 04-D-54 du 9 novembre 2004 relative à des pratiques mises en oeuvre par la société Apple Computer, Inc. dans les secteurs du téléchargement de musique sur Internet et des baladeurs numériques.* http://www.conseil-concurrence.fr/pdf/avis/04d54.pdf

protected music. Secondly, flash based players, often part of USB keys, exist. The iPod nano and shuffle are examples of these players which stock a smaller amount of digital music. However, recent developments increased capacity of some players up to 8 GB.[6] Finally, CD and minidisc players exist. The latter require carrying external physical support (e.g. a CD or minidisc). Since an important demand characteristic for portable players is the ability to play music without carrying such a storage device, CD and minidisc players are not competitive threats to the iPod. Instead, the analysis should focus on devices playing digital music. Moreover, in 2006 digital portable audio players added up to 88% of total sales; this leaves at most 12% for audio players using external carriers.[7] Thus, their share in total sales is low.

Another important demand characteristic is size. According to Jupiter Research, 77% of consumers point out that they are looking for a music player which is able to store a large stock of songs (one thousand songs or more, which is 4 GB). Since recent enlargements of flash based players enable consumers to substitute hard drive players, these players have become a competitive constraint for iPods and other hard drive music players.[8]

Not discussed in the discussion of the French competition authority are music phones, which are also increasingly equipped with large memories. Nevertheless, music players are not substituted with these phones to a large extent yet. Therefore, the definition of the relevant product market for iPods is "the market for portable digital music players".

3.3 Market definition for the iTunes Music Store

Music can only be transferred to an iPod through the program iTunes with the built-in iTunes Music Store. This store sells online digital music secured by Apple's DRM system FairPlay. Since the iPod only plays FairPlay secured music and non-DRM secured music, this section focuses on which sources of music have to be included in the relevant market. Four options to transfer music to an iPod exist: (1) download DRM-secured music from the iTunes Music Store and transfer it to an iPod, (2) download music from other online retailers of DRM-secured music to a computer, copy the music to a CD and copy this to an iPod via a computer, (3) buy a CD from a CD retailer, copy the music to an iPod via a computer and (4) get the music via piracy, for example by peer-to-peer file sharing and unauthorized CD copying.[9] In the following, it will be analysed whether options (2), (3) and (4) should be included in the relevant market for the iTunes Music Store.

[6] At the time of the analysis of the Conseil de la Concurrence's, the maximum was 258 MB; therefore, these players were excluded from the relevant market.
[7] Mintel International Group Ltd, June 2006. *MP3 players and other portable audio players*
[8] Note that some flash based players cannot be included in the relevant market due to their smaller than 4GB memory, for example the iPod shuffle (maximum of 1GB) and the smallest iPod nano of 2GB.
[9] Reckon LLP: Regulation and Competition Economics, 2004. *iTunes, DRM and Competition Law*. http://www.reckon.co.uk/ReckoniTunesSep2004.pdf

CD sales will not be included in the market definition. Peitz and Waelbroeck (2004) conclude that empirical results so far do not give a clear indication whether the rise in downloads has a significant effect on the decline in CD sales. In this line of thought, the European Commission decided in several cases that 'there is an emerging but separate market for the online delivery of music'. [10] The Commission argues that significant differences exist on the demand side between the distribution of recorded music via physical carrier (e.g., CDs) and its online sale. One of these differences is that CD consumers often buy an album, whereas online purchasers mostly wish to create their personalised album with selected tracks from several albums. As a result, online customers will purchase only a few songs from one album. Secondly, online music does not have to be bought from a store; the customer can simply order the music and get it delivered immediately on his computer, whereas customers buying CDs need to visit a store to obtain the music or order CDs in online stores and wait before these are delivered. Finally, the online consumer needs special software such as iTunes and Windows Media Player to play digital music, which is not required for CDs. Because of these differences, it can be concluded that digital music and CDs do not impose effective competitive constraints on each other and the goods are supplied in separated product markets.

Contrarily, the impact of piracy is more ambiguous. It can be argued that piracy should be excluded from the relevant market. As mentioned before, because many costs are involved in downloading and uploading files in P2P networks, mainly consumers with a low opportunity cost of spending time online, especially teenagers and college students, use P2P services. From the empirical data it can be inferred that these low purchasing power consumers would not have been important consumers of legal music distributors if P2P networks had been absent. In fact, the effects of P2P networks and piracy on the performance of CD sales are not entirely clear. On average CD sales have decreased since 2000 but this trend differs across countries. For instance, CD sales increased in France and UK between 1999 and 2003, even tough this was a period that Napster, Kazaa and the likes were making great success (Peitz and Waelbroeck, 2004). One explanation for these CD sales increases is that the teenagers and college students using P2P services were not important consumers in the CD retail market, which could be generalized to the online music retail market.

Furthermore, piracy is argued to have positive externalities on the sales of music due to network effects and the transfer of information. Network effects represent the observation that if more people are listening to the same music, this music becomes valued higher. Also, it is easier to obtain information on the genre or style of an album or song if it is available in free

[10] European Commission, October 2000 (*Case No COMP/M.1845 — AOL/Time Warner)* and July 2004 (*Case No COMP/M.3333 – Sony/BMG).*

format. These functions of illegal music have a positive influence on demand for CDs which again could be generalized to demand for online digital music (Peitz and Waelbroeck, 2004).

Nevertheless, because it was argued above that demand characteristics for CDs and online music are significantly different, demand characteristics for legal online DRM secured music and music obtained via piracy might be more similar. Due to differences in the number of songs purchased, speed of delivery and the fact that DRM secured music requires special software, CDs are not considered to have competitive constraints on legal online DRM secured music. Yet, users of P2P networks often download single tracks instead of an entire album. Furthermore, music obtained via a P2P network is delivered immediately, whereas the consumer of CDs needs to go to a store or order the CD online and wait until it is delivered by post. Finally, playing the music downloaded from a P2P network requires software supporting the digital format in which the music is downloaded. Thus, DRM secured music and music obtained through piracy show similarities in demand characteristics; these similarities combined with the benefits delivered by the free nature of illegally shared music might well offset the costs involved in uploading and downloading via P2P networks.

Moreover, the price structure in the market for mainstream digital music suggests a threat of piracy. In Table 1, an overview of prices in this market is given. Prices are almost identical, but large differences in market shares do not reflect this price similarity. The biggest player is iTunes with a market share of 70% in the period between December 2003 and July 2004. With such a dominant position, one would expect that the iTunes Music Store is able to raise prices, whilst competitors undercut these prices in order to increase their market share (Fisher, 2006). Table 1 illustrates that this does not happen, suggesting existence of other competitive constraints; specifically, piracy might prevent the iTunes Music Store from increasing its prices. Therefore, illegally downloaded music might be included in the relevant market.

Service	Catalogue Size	Price per song
Real Rhapsody	1.7 Million	$0.99
Napster Light Store	1.5 Million	$0.99
Walmart.com	2 Million	$0.88
iTunes	2 Million	$0.99
Yahoo! Musicmatch	Unknown	$0.99

Table 1 - Firms competing in the mainstream digital singles retail market (Fisher, 2006)

Also, online retailers of music content secured by other DRMs than iTunes' FairPlay have to be included. These retailers face similar demand characteristics as the iTunes Music Store, namely a demand for quick delivery of single songs which can be sampled by the consumer from different albums and requires special software to play the music.

This seems paradoxical, since music from these retailers cannot be played on the iPod. Effective DRMs prevent the music being interoperable with Apple's music player. Brousseau et al (2005) cope with this observation by arguing that DRM systems can be easily circumvented by burning the music to audio CDs. However, there are some fallacies in their argument. Notably, this process does not only take much time, it also requires knowledge on how to burn music to CDs and software designed for creating audio CDs; finally, transferring the music is accompanied with quality loss. As a result, the absence of competitive constraints from other online DRM-secured music stores is artificial. Therefore, these music stores are included in the relevant market. In fact, incompatibility of the iPod with other music stores than iTunes has led to this research.

3.4 Geographical market definition

As will be explained in the following, the geographical scope of the market can be considered national for both music players and legal online music as a result of transport costs, language barriers, search costs and the national character of online stores, as reflected by price differences between countries. The scope of illegal downloads is global.

Firstly, transport costs influence the geographical scope of the market for digital music players; that is, consumers are not expected to cross borders in order to get a music player for a lower price than available in the home country. If they did, transport costs add up to a large share of total costs of the music player, which would likely offset the price difference between countries. Thus, consumers buying music players from physical stores face relatively high transport costs and as a consequence they will buy in their own country.

Moreover, language barriers might prevent consumers from shopping in other countries, especially in the European region with many official languages in a relatively small area. Because it is difficult to understand important product information stated in a foreign language, consumers facing national online stores using the language of the associated country are inhibited in purchasing abroad. This notion requires some elaboration.

Although most providers are worldwide operating multinationals, consumers purchasing online products are usually directed to national websites, with built-in national stores for both music players and digital music. For example, Emusic.com has different sites for US, UK and European consumers, Napster states on its website that only US residents can play full length songs, consumers of Yahoo! Music Unlimited outside associated countries cannot use all services and Apple customers are directed to national online stores. These national stores sometimes require use of a credit card registered in the online store's country and discounts

often are given on a national basis (for example, Apple gives discounts to students from educational institutions within the store's country), thereby preventing consumers from purchasing widespread outside their own country.

Furthermore, consumers do not receive information about foreign prices. Retrieving this kind of information takes time. Hence, search costs cannot be ignored and the number of consumers with knowledge about where to buy cheapest products will be unsubstantial.

Moreover, no single geographical market exists if a company is able to price discriminate within its area of operations.[11] Thus, if prices are different from area to area, these areas cannot be aggregated to find the relevant geographical scope. Apple, in fact, does price discriminate between different countries.[12] For example, a 2 GB iPod Nano costs €149 in the Dutch online store, whereas the same product costs €159 in neighbouring country Belgium. If the market had been multinational, Belgium consumers would access the Dutch online store and due to decreased demand, Belgium prices would converge to the Dutch price. This has not been observed, indicating national markets.

Also in the market for online digital music price differences exist, demonstrating price discrimination and thus national markets. For example, British online shoppers have been paying €1.17 during 2006, compared to the €0.99 paid by consumers in the Euro zone.[13] Price discrimination within the EU is not allowed; yet, the music industry is accustomed to national licenses. As a consequence, online digital music retailers are restricted in their distribution to consumers residing in licensed countries.[14] Clearly, the market for legal online digital music is national.

Contrarily, illegal downloads are global. The same peer-to-peer networks are being used all over the world, that is, free downloading has a borderless character.

Summarizing, the relevant markets for iPod and the iTunes Music Store comprise respectively digital music players and legal online digital single songs, both with a national scope. Music obtained globally through piracy also might be included in the market definition for online music.

[11] Europe Economics, 2002. *Market definition in the media sector: Economic issues.* European Commission, Competition DG: Information, communication and multimedia; Media and music publishing.
[12] CommSec, 2007. *The CommSec iPod index: Global comparisons.* www.comsec.au/public/news.aspx?id=809
[13] EU Business, April 2007. *EU competition watchdog bites Apple over iTunes prices* www.eubusiness.com
[14] As noted in the investigation of the Conseil de la Concurrence, 2004.

4. Assessment of market power

In the following, the market power of iPod and the iTunes Music Store is assessed. Whereas an analysis focused on national markets in Europe would be interesting in the light of the recent accusations by European consumer protection agencies, industry data for European markets are difficult to access. Furthermore, no significant differences in European and American markets are expected since suppliers of portable digital music players and online digital music operate globally; their politics do not differ across countries and Apple also received complaints from American consumers. Thus, although markets have a national scope, this analysis focuses on the United States and the outcome can be generalized to national European markets.

Market power is defined as the ability of a firm to raise prices above its marginal cost (Motta, 2005). A theoretical measure following from this definition is the Lerner index, which gives the firm's mark-up over price ratio. Problems with this approach are two-fold: marginal costs are hard to measure and high costs can be inherent to monopoly power. Thus, the traditional approach of indirectly assessing market power by looking at market shares will be used. A company is said to have a dominant position if its share is above a threshold of 50%. If this criterion is satisfied, the company is said to be able to influence the market. Other criteria for are entry barriers, reflecting supply substitutability, and a sustainable situation.

Portable digital music players

The relevant market for the iPod is defined as the market for portable digital music players. Apple's device has a leading position in this market; despite 'the upcoming introduction of Microsoft's new mp3-player Zune, the return of closed-loop digital music service-device combinations and music phones on the horizon', it is forecasted that the iPod should not lose significant market share in the next 12 to 18 months.[15] This indicates both Apple's ability to influence the market and the sustainability of this situation. Moreover, iPod's market share was 72% in the US mp3-player market for 2005[16], which is higher than the threshold of 50%.

A third criterion concerns existence of entry barriers. Interestingly, Apple prevents supply substitutability if the company forecloses the market. In that scenario competitors are inhibited in their operations due to Apple's tying practices as discussed in Section 5.

[15] Jupiter Research, October 2006. *US Portable Music Device Forecast, 2006 to 2011*. http://www.jupiterresearch.com/bin/item.pl/research:concept/105/id=98101/
[16] CNNMoney.com, March 2006. *Apple's remarkable comeback story.* http://money.cnn.com/2006/03/29/technology/apple_anniversary/?cnn=yes

Online digital single songs

If the relevant market for the iTunes Music Store consists of legal online digital music only, Apple has a dominant position in the US market. It is claimed that Apple's iTunes is leader in the global online market of DRM-secured music.[17] Moreover, the French competition authority decided that Apple has a potential dominant position on the market of online music download platforms.[18] USAToday.com also reports a dominant position; in the period January to May 2006 the iTunes Music Store was the biggest player in the downloadable music industry with a market share of 67%.[19] Finally, Figure 1 shows sales data for the US mainstream digital singles retail market for the period between December 2003 and July 2004 (Fisher, 2006). Again Apple's large market share (70% in this figure) becomes clear. This clearly indicates Apple's ability to influence the market.

Apple's dominance in the market for legal downloads of digital music is not only due to iTunes' high market shares, but also because entry barriers in this market are high. Firstly, this is the result of high negotiation costs with record labels. These labels negotiate on a national basis for licenses on their recorded music. Secondly, developing DRMs requires considerable resources; a small player will not be able to incur these costs. Finally, new players are in a disadvantaged position because standing firms have obtained knowledge about consumer behaviour through their DRMs.

Whereas the iTunes Music Store seems to fulfil the three necessary criteria in order to conclude that a firm has a dominant position in the market for online downloads, this picture changes if piracy is included in the relevant market. As pointed out in Section 3.3, illegal music might be considered a competitive threat for legal retailers of downloadable music. If the total amount of illegal downloads is taken into account in determining the total sales volume of the digital music market, Apple's position cannot be considered dominant.

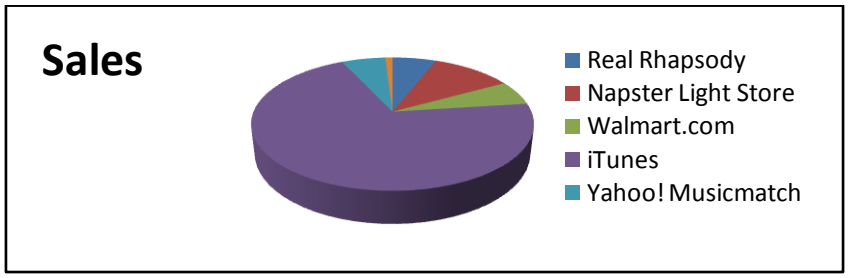

Figure 1 - Sales in the mainstream digital singles retail market (Fisher, 2006)

[17] International Federation of the Phonographic Industry (IFPI), January 2007. *Digital Music Report 2007.* Available on www.ifpi.org

[18] See the investigation of Conseil de La Concurrence, 2004.

[19] USAToday.com, July 2006. *EMusic's pitch: Download Song – and own it*. http://www.usatoday.com/tech/products/services/2006-07-30-emusic_x.htm.

5. Abuse of a dominant position: does foreclosure occur?

In order to explore whether a dominant position is abused, one should investigate whether a firm undertakes exclusionary practices, 'carried out by an incumbent with the aim of deterring entry or forcing the exit of rivals' (Motta, 2005; p. 411). Companies are able to raise entry barriers or force competitors out of the market through tying, defined as 'the sale of one product (the tying product) conditional upon the purchase of another distinct product (the tied product) in which only the tied product can be sold separately'.[20] Tying is a common practice used throughout businesses and it is only abusive if the following four criteria are satisfied: the company concerned is dominant in the tying market; the tying and tied goods are two distinct products; the tying practice is likely to have a market distorting foreclosure effect; and the tying practice is not justified objectively or by efficiencies. These criteria will be applied below to the iPod/iTunes tying case.

First of all, Apple has to be found dominant in the tying market, which is the market for online digital music because music from the iTunes Music Store can only be accessed by iTunes and the iPod, whereas use of the iPod is not conditional upon the purchase of iTunes Music. Consumers play music obtained from other sources on an iPod; in fact, on average only three percent of the music on an iPod is purchased in the iTunes Music Store.[21] In Section 4 it was concluded that Apple indeed has a dominant position if this market only includes legal music. Dominance in the tied market may reinforce the effect of tying and make an abuse more likely to be found. Hence, the problem is exaggerated due to dominance in the market for music players. Contrarily, if piracy is included no dominant position can be found and Apple's tying practices are not abusive.

Secondly, abusive tying practices require that the tying and tied goods are two distinct products. Demand characteristics should be different and consumers would not have purchased the products simultaneously if no tying occurred. This criterion is met; online digital music and music players are complementary to some extent, but not fully related. In the absence of DRM restrictions, some consumers might purchase music without purchasing an iPod and nowadays, consumers already purchase iPods without simultaneously consuming online digital music (for instance, they use CDs).

Moreover, abusive tying practices are likely to have market distorting foreclosure effects. This requires some elaboration. A company that is dominant in the tying market can foreclose the tied market, because tying practices reduce the number of potential customers for

[20] European Commission DG Competition, 2005. *Discussion paper on the application of Article 82 of the Treaty to exclusionary abuses*, p. 54

[21] Jobs, S., February 2007. *Thoughts on music*. http://www.apple.com/hotnews/thoughtsonmusic/

competitors within this industry. Moreover, horizontal foreclosure might occur since the tying market is indirectly foreclosed; namely, the reduced demand in the tied market as a result of tying leads to a reduction in the number of customers in the tying market. Investigation of this third criterion should analyse which customers are 'tied' in the sense that competitors to the dominant company cannot compete for their business and establish whether these customers add up to a sufficient part of the tied market.[22]

Apple's competitors cannot compete for its business if DRMs effectively prevent iTunes Music Store customers from using music on other music players than the iPod. DRMs are not likely to be circumvented, as argued in Section 3.3, due to the knowledge, time and software required to burn audio CDs and quality losses accompanied with transforming music. Nevertheless, only consumers purchasing both online digital music and players are affected by the tying practice. Nowadays, the fraction of DRM secured digital music in total music on digital music players is small; as noted before, on average three percent of all songs on an iPod come from the iTunes Music Store. The other 97% is obtained through other sources, mainly CDs. In the future, however, the significance of digital music is likely to increase because its fixed costs are significantly lower than CDs and broadband penetration facilitates downloading from online music stores (Peitz and Waelbroeck, 2004).[23] Thus, whereas nowadays Apple's tying practices are not foreclosing, competing producers will be increasingly foreclosed to Apple's customers using the iTunes Music Store in the future.

If the three criteria above were satisfied, a final criterion would require the tying practice not to be justified objectively or by efficiencies. In this respect, the question whether record labels force Apple to use an incompatible DRM is important. Whereas record labels require companies to develop a DRM, they do not call for incompatible systems. In Section 7 alternatives to an incompatible DRM, favoured by record labels, will be discussed. Apple prefers to use an incompatible DRM.[24] This indicates that incentives for tying might exist as discussed in the next section. For now, it suffices to conclude that the fourth criterion is met.

Summarizing, Apple's practices can be considered abusive if the threat of piracy is ignored and the legal online music market grows in importance. Possibly, Apple started a lobby at the record labels in order to remove DRMs due to a fear for penalties. In the next section, profit and welfare implications of foreclosing competitors to the currently small but increasing number of consumers purchasing both online music as well as music players are analysed.

[22] See the discussion paper of the EC DG Competition, 2005.
[23] Also pointed out by Soleil Media Team, 2005. *Music Industry Review: Best Questions Answered.*
[24] Jobs, S., February 2007. *Thoughts on music*.

6. Two models – profitability of tying and welfare implications

Whereas the legal considerations above have been based on economic theory, this theory has not been used directly in the analysis. In this section, it will be observed that the outcome based on economic theory is not similar to an outcome based on application of law. Specifically, a model by Whinston (1990) is used to analyse whether it is profitable for Apple to tie its products and what implications tying has for welfare. Firstly, a basic model shows that in the absence of competition in the market for digital music players, it is not profitable for Apple to tie its products; instead, it could make greater profits if it sold its goods independently. Thereafter, the assumption of a monopolised market for digital music players is relaxed and the effects on the profitability of tying and associated welfare are analysed. In this scenario, a different situation arises. Finally, implications of relaxing other important assumptions are given in Section 6.3.

6.1 The basic model

Consider a situation in which firm 1 (Apple) and firm 2 (a competitor) can be active. Firm 1 monopolises the market for good A (portable digital music players) and supplies a complementary good $B1$ in market B (the online digital music market), facing competition from firm 2 that produces good $B2$. These firms face a 2-stage game.[25] In the first stage, firm 1 commits to either tie goods A and $B1$ by implementing an incompatible DRM or sell the goods independently by making good A interoperable with good $B2$ (this implies a compatible DRM or no system at all). The commitment to tying is irreversible and hence credible. In the second stage, both firms set their prices.

Furthermore, assume a one-to-one relationship between goods A and B, that is, a system consists of one unit each. Good A is essential to good B, since the two products are complementary. Thus, good B does not have any value if the good is not purchased simultaneously with good A. Applied to the Apple-case, this means that music downloaded from an online music store does not have any value if it is not used in combination with a portable digital music player; as a result, if Apple ties the iPod and iTunes Music Store through an effective DRM, only music from the iTunes Music Store has value. Moreover, consumers are distributed uniformly on $[0,1]$ with mass 1 and they demand at most one unit of the system. For a consumer, the utility $U_{A,Bi}$ derived from purchasing a system A/Bi is:

$$U_{A,Bi} = \theta - t|x - x_i| - p_A - p_{Bi}$$

[25] In Whinston's original model, the game consists of an extra stage, namely the entrance decision of firm 2. Since Apple's competitors have entered, this stage is considered irrelevant and is left out of the analysis.

In this utility function, θ represents the maximum valuation for a system, t the disutility from purchasing good Bi or heterogeneity in preferences for online music stores, x the location of the consumer and x_i the location of good Bi. Specifically, $x_1 = 0$ and $x_2 = 1$. Thus, some consumers prefer to buy in the iTunes Music Store whereas others prefer to use competing stores. Utility of purchasing a system A/Bi is negatively related with prices for good A (p_A) and Bi (p_{Bi}). Finally, demand for good Bi is positively related with prices for good $Bj, j \neq i$.

To simplify the analysis, fixed costs are assumed to be zero for firm 1 and $F_2 \geq 0$ for firm 2. This implies that Apple does not have to incur large investments, whereas competitors should invest in either their online music stores (for example, negotiations with record labels and development of a sound DRM) or the development of their portable digital music players. It is assumed that fixed costs are lower than firm 2 its gross profits; as a consequence, the firm is always active if it can sell its products. Furthermore, marginal costs for good $A, B1$ and $B2$ are respectively $c_A \geq 0$ and $c_{B1} = c_{B2} = c_B \geq 0$. Finally, all consumers buy a system.

Below, in the context of this model an answer is given to the questions whether Apple voluntarily ties the iPod and iTunes Music Store and what the effect of tying is on welfare.

Firstly, profits under tying are analysed. In this situation firm 2 cannot be active since consumers do not derive utility from a product that is incompatible with good A. If DRMs effectively prevent the consumer from playing music purchased in other online stores on an iPod, only the iTunes Music Store is able to deliver value. As a consequence, consumers will not buy good $B2$. If all consumers buy an iPod/iTunes Music system, firm 1 will charge a monopoly price of $\tilde{p}_m^* = \theta - t$ and monopoly profits equal $\tilde{\pi}_m^* = \theta - t - c_A - c_B$ (see Appendix A).

If Apple decides not to tie its products, music from stores competing with the iTunes Music Store has value since it can be played on an iPod. Hence, utility is obtained from good $B2$ due to compatibility with good A and firm 1 faces competitive constraints from good $B2$; as a result, it cannot charge a price on good $B1$ as high as it could have charged under tying. Yet, despite these constraints, entrance of firm 2 is beneficial for firm 1 as is explained below.

Suppose firm 1 prices good B and A at respectively $\hat{p}_{B1} = c_B - \varepsilon$ and $\hat{p}_A = \tilde{p}_m^* - \hat{p}_{B1}$. The parameter ε is positive and renders $B1$ to be priced below marginal costs. Losses are recuperated by sales of good A. In contrast with the tying game, not all consumers purchase system $A/B1$; depending on their preferences, some will choose system $A/B2$. Under full market coverage, firm 2 sets a price $p_{B2}^* = \frac{t+2c_B-\varepsilon}{2}$ and makes profits $\pi_2^* = \frac{(t-\varepsilon)^2}{8t} - F_2$. Firm

1 sets prices $\hat{p}_{A1}^{*} = \theta - t - c_B + \varepsilon$ and $\hat{p}_{B1}^{*} = c_B - \varepsilon$. It does not only generate profits by selling system $A/B1$; due to complementarity, firm 2 its customers also buy product A on which firm 1 generates profits.

As a consequence, profits under independent pricing (to be found in Table 2) exceed monopoly profits since $\varepsilon\frac{t-\varepsilon}{4t}$ is larger than zero ($t > \varepsilon$) (see Appendix A). Hence, despite competition from firm 2, firm 1 never ties its goods. In equilibrium, firm 1 sells its goods independently because increased sales in market B increase demand for the complementary good A.

	Profit firm 1	Profit firm 2
Tying	$\hat{\pi}_m^* = \theta - t - c_A - c_B$	0
Independent pricing	$\hat{\pi}_1^* = \hat{\pi}_m^* + \varepsilon\frac{t-\varepsilon}{4t}$	$\pi_2^* = \frac{(t-\varepsilon)^2}{8t} - F_2$

Table 2 – Profits for firm 1 and 2 in the basic model

Not only the comparison above shows what equilibrium arises; also the pricing structure indicates that firm 1 can not perform better than under independent pricing. Firm 1 obtains its surplus through sales of good A; no profit is generated by selling good B. Thus, profits do not depend on the store where good B is being sold. In fact, good $B1$ is priced slightly below its cost and losses are recuperated with the profit margin on good A. Therefore it is profitable for firm 1 if the other firm takes over part of its market share for good B, as long as the existence of firm 2 creates an increased demand for the profitable good A.

If the market had not been served fully, the beneficial effects of competition in the market for good B had even been stronger because consumers with strong preferences for good $B2$, not willing to buy system $A/B1$, have a higher valuation for a system $A/B2$ which is more likely to exceed prices, ensuring that they buy the system. As a result, demand for product A is higher and profits generated by firm 1 rise. Thus, firm 1 will sell its goods independently.

This can also be observed in the iTunes/iPod-case. According to Steve Jobs, Apple's CEO, "there is no way to make money on online music stores; for every 99¢ Apple gets from your credit card, 65¢ goes to the music label and another 25¢ is spent on distribution costs." At most, Jobs is left with a ten percent margin. On the question why Apple still sells online music, Jobs answers grinning: "Because we are selling iPods". Low margins and prices in the iTunes Music Store stimulate demand for both iTunes Music and complementary iPods. On the latter, high surpluses are generated: each $499 iPod returns as much as $175 in profit.[26]

[26] Time Magazine, 2003. *The 99c Solution.* http://www.time.com/time/2003/inventions/invmusic.html

It has been shown that independent pricing is the preferred outcome for Apple. It might be interesting to see whether all parties have a stake in this outcome; that is, whether producer surplus, consumer surplus and aggregate welfare are highest under independent pricing.

	Producer Surplus	Consumer Surplus
Tying	$\widetilde{PS} = \theta - t - c_A - c_B$	$\widetilde{CS} = \frac{1}{2}t$
Independent pricing	$\widehat{PS} = \widetilde{PS} + \frac{t^2 - \varepsilon^2}{8t} - F_2$	$\widehat{CS} = \widetilde{CS} + \frac{(t+3\varepsilon)(t-\varepsilon)}{16t}$

Table 3 – Producer and consumer surplus in the basic model

Producer surplus exists of profits generated by both firm 1 and firm 2. In Table 3, an overview of the surplus is given for both tying and independent pricing in which all consumers buy a system. In the tying game, producer surplus totals firm 1 its monopoly profits. If the goods are sold independently, firm 2 its profits have to be taken into account as well. The arising producer surplus is larger than surplus under tying because entrance of firm 2 implies $\frac{t^2-\varepsilon^2}{8t} > F_2$ (see Appendix A).

The same reasoning can be applied if the market is not fully served; again, producer surplus is highest under independent pricing. Whereas its profits would have been higher if all consumers had purchased a system, firm 1 still benefits from existence of firm 2 in a situation of partial market coverage. That is, those consumers who had not purchased a system under tying because of their strong distaste for good $B1$ will buy a system including component A if they can use component $B2$ instead. This raises firm 1 its profits compared to tying. Moreover, firm 2 only enters in case profits under independent pricing are nonnegative; as a result, in a partial covered market firm 2 its surplus is larger under independent pricing than under tying.

Besides producer surplus, welfare consists of consumer surplus. This is the aggregate utility of all consumers and it represents the total amount of consumers willing to pay minus what they actually pay (Sydsaeter and Hammond, 2002). In table 3, an overview of consumer surplus in both situations with full market coverage can be found. In the situation of independent pricing this surplus is higher than in the tying game since $\frac{(t+3\varepsilon)(t-\varepsilon)}{16t} > 0$ (see Appendix A). Thus, consumers are better off if firm 1 decides to price its goods independently.

In the partial market coverage situation, the same result holds. If consumers can use component Bi of their preference, their valuation minus price will be higher than if they are forced to use component $B1$. Moreover, a larger amount of consumers will purchase a system

and have a positive surplus, since some consumers will only purchase a system if they can use component $B2$ (consumers located near $x = 1$).

Finally, total welfare can be derived by summing consumer surplus and total firm profits. Welfare under independent pricing is higher than welfare if firm 1 ties and is a monopolist, because $\frac{(t-\varepsilon)(5\varepsilon+3t)}{16t} > F_2$ (see Appendix A). Thus, if firm 1 sells its goods independently, welfare is improved compared to a situation of tying. As discussed above, the same holds for partial market coverage; compared to tying, both consumer surplus and producer surplus are higher in the situation of independent pricing.

It follows that in the independent pricing game welfare is maximised. No party is worse off under independent pricing compared to tying; firm 1 and firm 2 as well as the consumers retrieve a higher surplus in the independent pricing outcome. For this reason, in equilibrium maximum welfare is achieved.

A firm will not exclude its competitors by tying; selling its products independently and entrance of a competitor is more profitable. The reason for this paradoxical conclusion is that increased sales in the competitive market increases demand for the monopolized good. As a result, pricing products independently becomes a profitable alternative, preferred above tying the goods. Hence, a firm would not tie its products in order to foreclose its competitors; instead, other motives for tying should exist. This conclusion could be applied to the iPod/iTunes-case. Apple generates revenues with its iPod. Thus, it would be irrational of the company to foreclose its competitors in the online music retail market, since interoperability with competitors' music could well increase demand for the complementary and profitable iPod.

Behaviour in line with this analysis has been observed. For example, Steve Jobs claims that record labels effectively force Apple to tie its products. Moreover, Apple and EMI's recent announcement that digital music is going to be sold without DRM restrictions in the future might demonstrate higher profitability if the iTunes Music Store had been compatible with all portable digital music players. For this reason, the company might have lobbied at the record labels for a removal of DRM restrictions. Since Apple has considerable market power in the market for portable digital music players, it would not have to generate a surplus on sales in the iTunes Music Store. Instead, it raises profits by selling iPods, which are demanded in larger quantities if a competitor enters the market for online digital music stores.

6.2 An inferior, competitively supplied component A

Introduction

As long as the basic model is applicable, Apple would not tie voluntarily. This implies that an external factor forces Apple to behave anticompetitive. For example, record labels, trying to protect their sales from music piracy, force online music stores to lock the music with a sound DRM. Otherwise, Apple would have obtained higher profits by making the iPod compatible with other online music stores.

Nevertheless, interoperable DRMs can be designed in which music and players are sold independently. This raises the question why Apple still decides to tie. The answer will be given below by relaxing an important assumption of the model described above, namely that the market for music players is monopolised. The basic model ignores competitive threats from suppliers of portable digital music players. As described in the Section 4, this is not in line with reality; although it has been argued that Apple is dominant in this market, the iPod does not have a market share of 100% and hence faces competition.

Whinston (1990) shows that relaxing the assumption of a monopolised market A changes the outcome of the basic model described above. If an inferior, competitively supplied component A exists, the firm with the higher valued product can profitably bundle products since this will foreclose its competitors. If Apple faces competition in the market for music players, it can protect its margins on the iPod by tying it to the iTunes Music Store. In the following, this will be portrayed by describing an extended model taking an inferior supplied component A into account. As before, both bundling and independent pricing situations are analysed; subsequently, equilibrium and its associated welfare implications are derived.

Consider the same model as described above with two goods, A (music players) and B (online digital music), and two firms, 1 (Apple) and 2 (a competitor). Again, both firms potentially serve market B. However, firm 1 does not monopolize market A anymore; firm 2 can supply the market with good $A2$ (in order to distinguish between both firms' good A, from now on the notation Ai will be used to refer to firm i's good A). Systems comprising product $A2$ are valued $\gamma - c_A$ lower than systems with good $A1$ ($\gamma > c_A$). Heterogeneous preferences exist in market B; the valuation for a system with good $A1$ containing good Bi is:

$$v_{A1/Bi} = \theta - t|x - x_i|$$

Again, θ is the maximum valuation for a system, t the disutility for good B_i of a consumer x and x_i the location of good B_i ($x_1 = 0$ and $x_2 = 1$). Marginal costs are $c_{A1} = c_{A2} \equiv c_A \geq 0$

and $c_{B1} = c_{B2} \equiv c_B \geq 0$. Firm 1 faces no fixed costs and firm 2 incurs $F_2 \geq 0$ (again, profits are assumed to exceed fixed costs; firm 2 enters) and the game consists of two stages. Firstly, firm 1 decides whether to tie good $A1$ and $B1$ or sell the goods independently. Thereafter, both firms set prices. Firm 2 follows firm 1 in its tying decision as firm 1; both firms either tie the DRMs or sell the music and player independently.

In this extended model, the outcome of the basic model changes in the respect that firm 1 is likely to tie since profits are highest under tying. In this situation, firm 2 is foreclosed to the market and its profits under independent pricing had been higher. Consumer surplus and welfare are always highest in the independent pricing game. A detailed technical discussion can be found in Appendix B.

Independent pricing, tying and the equilibrium

Similar to the basic model described above, all consumers are assumed to buy a system. Under independent pricing, firm 1 is able to make all component A sales due to its higher valuation. Specifically, if firm 1 prices good 1 at $\hat{p}_{A1} \leq \gamma$, all consumers will choose product $A1$. Consumers' choice regarding good B depends on their preferences; if half of the consumers buy $B1$ and the other half purchase $B2$, good $A1$ is priced at $\hat{p}_{A1} = \gamma$ and the optimal price for both $B1$ and $B2$ is $\hat{p}^*_{B1} = \hat{p}^*_{B2} = c_B + t$. This implies that both firms set a mark-up on the costs of good B equal to the degree of heterogeneity t. Profits are given in Table 4.

Contrarily, if firm 1 ties its products, consumers cannot use product $B2$ in combination with good $A1$ any longer. Hence, consumers have to choose either system $A1/B1$ or $A2/B2$. Firm 1 maximises profits if its system is priced at $\tilde{p}^*_1 = t + c_A + c_B + \frac{1}{3}\gamma$ Firm 2 its optimal price is $\tilde{p}^*_2 = t + c_A + c_B - \frac{1}{3}\gamma$. Tying profits $\tilde{\pi}^*_1$ and $\tilde{\pi}^*_2$ are given in Table 4.

	Profit firm 1	Profit firm 2
Independent pricing	$\hat{\pi}^*_1 = \frac{1}{2}t + \gamma - c_A$	$\hat{\pi}^*_2 = \frac{1}{2}t - F_2$
Tying	$\tilde{\pi}^*_1 = \frac{1}{2}t + \frac{\gamma}{3} + \frac{\gamma^2}{18t}$	$\tilde{\pi}^*_2 = \frac{1}{2}t - \frac{\gamma}{3} + \frac{\gamma^2}{18t} - F_2$

Table 4 – Profits for firm 1 and firm 2 in the extended model

Apple's competitor makes lower profits under tying as its music player becomes more inferior; that is, if consumers' valuation for the music player becomes lower compared to the iPod. This implies that the extra valuation for iPods has a maximum: $\gamma \leq 3t$. Likewise, the minimum degree of heterogeneity in preferences for online music stores is $t \geq \frac{1}{3}\gamma$ (see

Appendix B). For higher degrees of inferiority, competitive threats are nonexistent and the basic model applies. In Figure 2, profits for firm 2 under both independent pricing and tying have been drawn within the range $\gamma/c_A \in [1\,,2]$[27], using the minimum degree of heterogeneity in preferences for music stores if $\gamma = \frac{3}{2}c_A$[28] (curve 1 under tying) and $\gamma = 2c_A$ (curve 2 under tying). Under independent pricing, firm 2 its profits are unaffected by γ because it does not sell music players in this situation.

A numerical example, using $t = \frac{1}{2}c_A$ and marginal costs $c_A = 325$, shows that firm 2 makes profits under independent pricing equal to $\hat{\pi}_2 = 81\frac{1}{4}$. Contrarily, tying profits decrease if inferiority increases, as can be seen from the figure. For example, if $\gamma = \frac{3}{2}c_A$ and heterogeneity in preferences for music stores is $t = \frac{1}{2}c_A$, no profits are left for firm 2; that is $\tilde{\pi}_2 = 0$. More generally, in Appendix B it is shown that profits are always lowest under tying, independent of the degree of heterogeneity. Hence, Apple's competitor cannot recuperate fixed costs under tying and is likely to be forced out of the market in the long run.

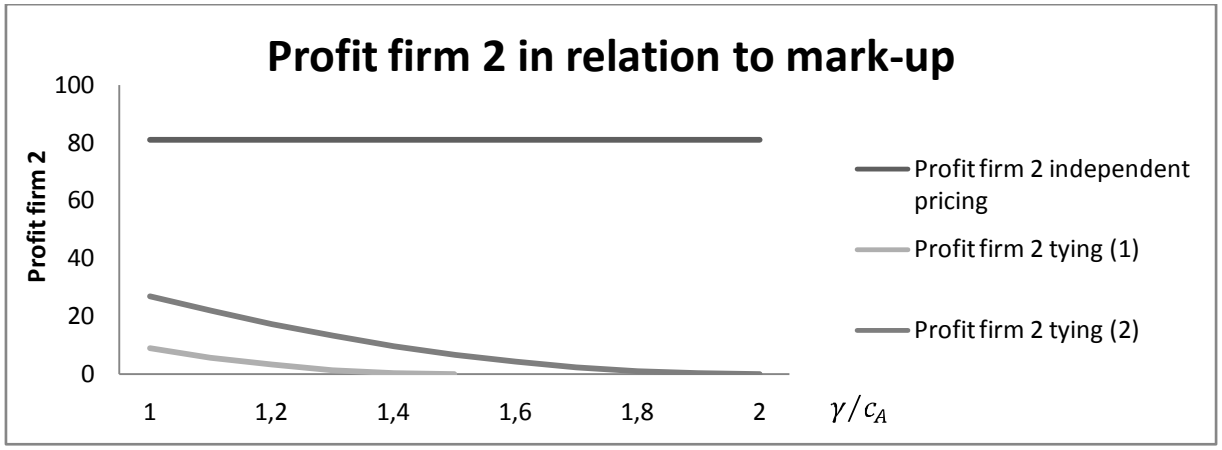

Figure 2 - Values of $\pi_{\hat{E}} + F_2 = \frac{1}{2}t$ and $\pi_{\tilde{E}} + F_2 = \frac{1}{2}t - \frac{\gamma}{3} + \frac{\gamma^2}{18t}$; (1) $t = \frac{1}{2}c_A$ and (2) $t = \frac{2}{3}c_A$

Conversely, firm 1 is likely to make highest profits in the tying game. The difference between profits under independent pricing and tying has been illustrated in Figure 3 for different degrees of heterogeneity in market B within the range $\gamma/c_A \in [1\,,2]$. The dark line, subject to extremely high degrees of heterogeneity in preferences for digital music stores, shows that tying is always more profitable than independent pricing if the mark-up on or superiority of good $A1\ \frac{\gamma}{c_A} \leq \frac{3}{2}$ (see Appendix B). Currently, the mark-up of an iPod is around this maximum

[27] $\frac{\gamma}{c_A} \geq 1$ because $\gamma \geq c_A$; $\frac{\gamma}{c_A} \leq 2$ because in section 6.2 it was noted that each $499 iPod returns $175 in profits, indicating the mark-up $\frac{\gamma}{c_A} = \frac{499}{499-175} \approx 1{,}5$. A margin around this mark-up has been used.

[28] These values reflect the values derived in the footnote above.

value (see footnote 27). Because heterogeneity in preferences for online music is lower than indefinite, tying is even more likely to arise as reflected by the brighter curve.

Continuing the numerical example started above, using $\frac{\gamma}{c_A} = \frac{3}{2}$, $t = \frac{1}{2}c_A$ and $c_A = 325$, also leads to the conclusion that firm 1 is likely to tie its goods: firm 1 makes profits equal to $\hat{\pi}_1 = \frac{3}{4}c_A = 243\frac{3}{4}$ under independent pricing, which is lower than its profits under tying: $\tilde{\pi}_1 = c_A = 325$. The difference $\hat{\pi}_1 - \tilde{\pi}_1 = -81\frac{1}{4}$ follows from the figure below.

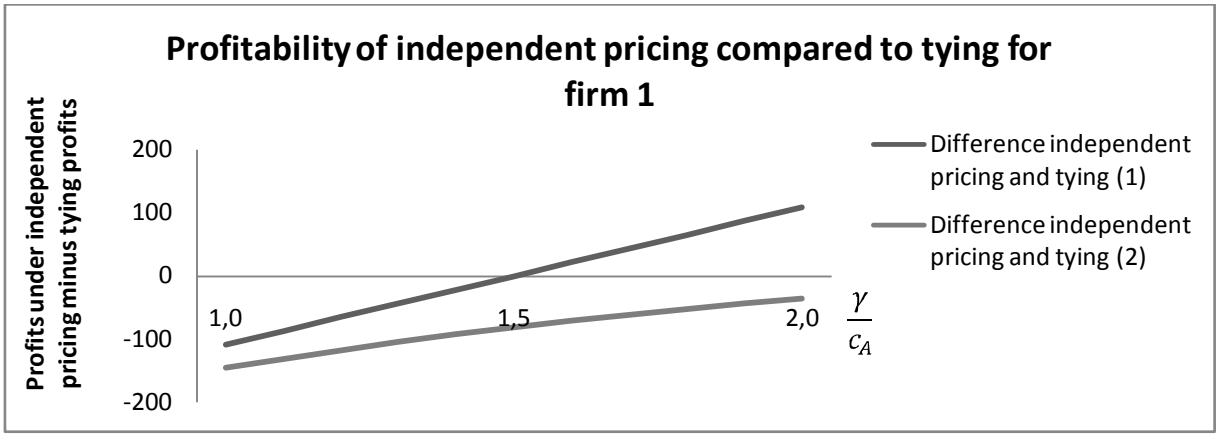

Figure 3 – Values of $\pi_{\hat{E}} - \pi_{\tilde{E}} = \frac{2}{3}\gamma - \frac{\gamma^2}{18t} - c_A$ for (1) $t = \infty$ and (2) $t = \frac{1}{2}c_A$

Hence, Apple ties its goods. In the numerical example used above, the gains from tying for firm 1 (equal to $81\frac{1}{4}$) exactly offset the losses incurred by firm 2. This is only the case for the example used above; that is, firm 1 might generate higher gains from tying than the losses incurred by firm 2. If this is the case, efficiency reasons for tying exist. Nevertheless, firm 2 makes lower profits than it would have done in the independent pricing game. As a result, it might not be able to recuperate fixed costs and will have to exit in the long run.

Welfare

Whereas tying is likely to be the most profitable option for firm 1, profits generated by firm 2 are decreased due to tying. Nevertheless, it could be hypothesised that due to efficiency reasons producer surplus is still highest under tying. In order to give information about the desirability of tying, information on consumer surplus, always lowest under tying, is also required. If the firm 1 its gain from tying is not fully offset by the loss in consumer surplus, tying does not harm aggregate welfare and might be considered justified for efficiency reasons. Below, it is shown that this is not the case for the iPod-iTunes connection.

	Consumer surplus	Aggregate welfare
Independent pricing minus tying	$2t - \frac{1}{2}(\gamma - c_A) + \gamma(\frac{6c_A - \gamma}{36t})$	$2t + \frac{1}{2}(\gamma - c_A) + \gamma\left(\frac{6c_A - 5\gamma}{36t}\right)$

Table 5 – Difference between independent pricing and tying for consumer surplus and welfare

In table 5, the difference between consumer surplus under independent pricing and welfare is given. This value is always positive, that is, consumer surplus is always highest under independent pricing as can be seen in Figure 5 and is derived in Appendix B. Figure 5 is subjective to the data from the numerical example used in the equilibrium section above. Again, marginal costs for good A equal $c_A = 325$; assume the extra valuation for an iPod compared to its competitors is $\gamma = \frac{3}{2}c_A$ and the degree of heterogeneity in preferences for music stores is $t = \frac{1}{2}c_A$. Consumer surplus is higher under independent pricing than tying since $\widehat{CS} - \widetilde{CS} = \frac{9}{8}c_A = 365\frac{5}{8}$.

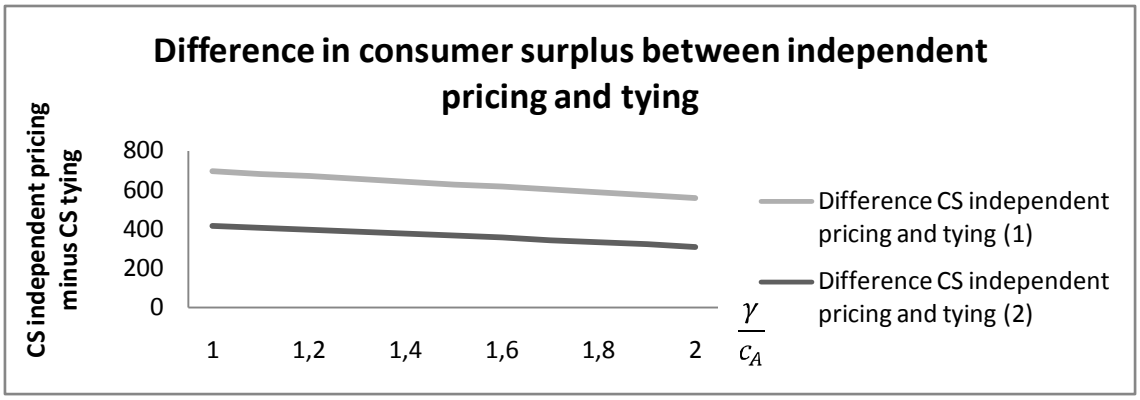

Figure 4 – $\widehat{CS} - \widetilde{CS} = 2t + \frac{1}{2}(\gamma - c_A) + \gamma(\frac{6c_A - \gamma}{36t})$ for $\frac{\gamma}{c_A} \in [1, 2]$; (1) $t = c_A$ and (2) $t = \frac{1}{2}c_A$

Finally, welfare is found to be highest under independent pricing (see Appendix B). Thus, efficiencies arising from tying are offset by both losses in firm 2 its profits and consumer surplus. This is illustrated in Figure 6. In Appendix B, it is shown that the minimum value of the difference between welfare under independent pricing and tying is positive, implying that welfare is highest under independent pricing. This can also be derived from the numerical example used throughout this section with marginal costs of $c_A = 325$, extra valuation for an iPod compared to its competitors of $\gamma = \frac{3}{2}c_A$ and a degree of heterogeneity in preferences for music stores of $t = \frac{1}{2}c_A$; $\widehat{W} - \widetilde{W} = \frac{9}{8}c_A = 365\frac{5}{8}$ which can be seen from the figure below.

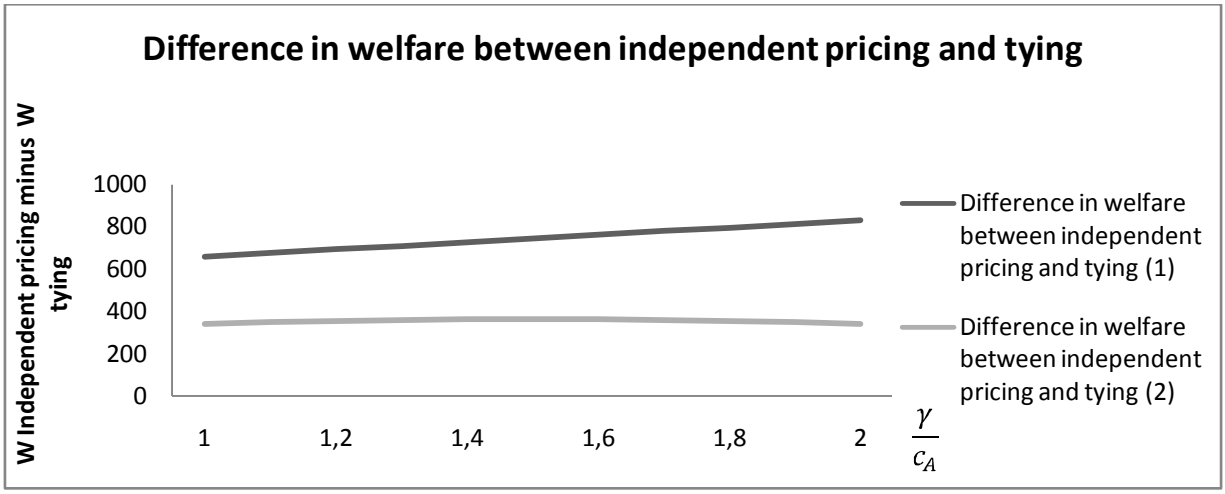

Figure 5 – $\widehat{W} - \widetilde{W} = 2t + \frac{1}{2}(\gamma - c_A) + \gamma\left(\frac{6c_A - 5\gamma}{36t}\right)$ for $\frac{\gamma}{c_A} \in [1,2]$; (1) $t = c_A$ and (2) $t = \frac{1}{3}c_A$

Conclusion extended model

Below, the main results of previous sections are summarized and their implications will be discussed. Firstly, it is explained why tying increases Apple's profits. Yet, this increase in Apple's profits is offset by a loss in profits for firm 2 and consumer surplus. As a consequence, welfare is highest under independent pricing.

	Profit firm 1	Profit firm 2	Consumer Surplus	Aggregate Welfare
Difference between independent pricing and tying	(−)	(+)	(+)	(+)
Influence of mark-up	(+)	(+)	(−)	(+)
Influence of heterogeneity	(+)	(+)	(+)	(+)

Table 6 – Losers of tying, represented by the difference in profit and surplus between independent pricing and tying; influence of mark-up and heterogeneity on this difference. Assumption: $c_A \leq \gamma \leq 2c_A$

In Table 6, the signs of differences in profits, consumer surplus and welfare between independent pricing and tying are given. Compared to independent pricing, tying is likely to be most profitable for Apple. This contrasts the result of the basic model, in which profits were always highest under independent pricing. The change in outcome arises from the absence of a competitive threat in the market for iPods in the basic model, which allowed Apple to price iPods as high as consumers' valuation. However, in the extended model presence of a competitor in the market for music players disables Apple to price the iPod as high as in the basic model. By tying, Apple forecloses competitors to its customers, increases sales and raises its profits.

The tying equilibrium is most likely to arise for homogeneous preferences for online music and low mark-ups on or small superiority of the iPod. The first observation can be explained by the notion that consumers indifferent between music from the iTunes Music Store and its competitors are willing to pay the same amount for a system under tying as they would have

had under independent pricing. In fact, despite their relative preference for another music store than iTunes, under tying they will choose the iPod/iTunes combination because competing systems are inferior. This would increase demand and profits on Apple's products under tying.

Furthermore, tying is more likely the lower inferiority of competing music players to the iPod is. Higher inferiority implies that Apple faces less competitive constraints in the market for iPods. As a consequence, constraints in pricing the iPod are weak and Apple is able to extract higher surpluses on the music player under independent pricing. For a superior iPod, the same reasoning as in the basic model applies: extra sales in the online music market induce higher demand for the complementary iPod, enabling Apple to sell this highly profitable good (note that the degree of inferiority of competitors simultaneously represents the profit margin on an iPod).

One of the main questions to be answered is whether Apple is forced by record labels to tie the iPod and iTunes Music Store, but had preferred to sell the goods independently. From the analysis above it can be concluded that if the online music market is homogeneous and the iPod is not considerable superior to other music players, developing an incompatible DRM and tying the iPod and iTunes Music Store is profitable for Apple. Hence, the extra valuation for an iPod compared to its competitors and the heterogeneity of music stores have to be analysed.

Concerning the extra valuation for an iPod, the conclusion seems to be obvious at first sight but appears to be less straightforward after comparing prices for different music players. The introduction of the iPod with its great design and good marketing has been a success. It is argued that people are willing to pay more for an iPod than for a competitor's device. Nevertheless, the iPod has received strong competition in the last few years. A Sony 8 GB mp3 player costs €299.99, whereas a 30GB iPod is lower priced at €269.00.[29] Apparently, rivals are not that inferior and Apple has to price its goods competitively because of competitive threats.

Moreover, heterogeneity is low in the online music market. The mainstream online music stores do not provide different catalogues and they operate similar. Preferences for one store or the other mainly arise from compatibility of the music with the consumer its music player; not from other store characteristics. Therefore, differences in demand are due to tying practices and demand had been homogeneous if no DRM or interoperable systems were used.

[29] http://store.apple.com/Apple/WebObjects/nlstore/ and https://shop.sonystyle-europe.com/

The low inferiority of iPod's competitors and homogeneity in preferences for online music indicate that tying is most profitable for Apple. Interestingly, this is not in line with the announcement that music recorded by EMI will be sold DRM-free through the iTunes Music Store. Possibly, Apple anticipates fines from competition authorities and reputational damage and lobbied for this reason at EMI to remove DRM restrictions.

Whereas tying appears to be beneficial for Apple in most situations, this is not the case for other parties, such as its competitors and consumers. In Table 6 it is shown that tying harms competitors, as reflected by the positive difference in profits between independent pricing and tying. This effect becomes stronger the more inferior the competitor's music player is and the more heterogeneous different music stores are. Firstly, if a competitor is able to supply the market with a good music player, it faces a large demand under tying. As a result, profits under tying are just slightly below profits under independent pricing; yet, if its music player is inferior, a competitor faces lowered demand and profits under tying, whereas profits under independent pricing had not been affected. Furthermore, compared to tying, competitors would have been able to extract higher surpluses from consumers under independent pricing if preferences for music were heterogeneous. Under tying, consumers with strong preferences purchasing a system at Apple's competitor have to be compensated for the inferior music player. As a result, part of the mark-up which would have been earned under independent pricing (the degree of heterogeneity) is lost. For this reason, profits are lower under tying.

Another losing party is the consumer; this party has highest surplus under independent pricing. If a consumer can use the music player valued most (the iPod) in combination with the preferred music, which differs among consumers due to heterogeneity, surplus is highest. Those who had chosen the iPod/iTunes system under independent pricing are not harmed; however, consumers more inclined to purchase music from other sources in the independent pricing game will receive a lower surplus if Apple ties because their valuation for an iPod/iTunes system is lower than for an iPod/competing music store system.

Finally, welfare is highest under independent pricing. Apple's extra profits generated by tying are likely to be offset with losses incurred by competitors; moreover, the decrease in consumer surplus renders welfare under tying lower than under independent pricing. Welfare, thus, is maximized under independent pricing.

This conclusion indicates that the outcome of a legal investigation is not necessarily in line with the conclusion from a microeconomic analysis; in Sections 3 to 5, using a legal focus, no present abuse of a dominant position was found because competitors are not foreclosed to a

substantial number of consumers. Tying is only becoming a problem in the future since the importance of legal online downloading is growing in importance. Contrarily, the economic analysis undertaken in this section, focusing solely on the group of consumers affected by Apple's tying practices, shows that a suboptimal situation already has arisen.

Shortcomings of the economic analysis above could be the exclusion of other important factors and assumptions not congruent with reality; in the next section, these issues are taken into account and it is concluded that the outcome derived in this section still holds; that is, Apple has an incentive to use an incompatible DRM and welfare would be higher if the iPod and iTunes were sold independently.

6.3 Discussion

Based on the extended model, it is concluded that Apple is likely to prefer tying the iPod and iTunes Music Store, especially for low inferiority of competing music players and homogeneous preferences for music. Moreover, welfare is always highest under independent pricing. In this section, some assumptions used in the analysis above will be relaxed and extra issues will be taken into account. It is shown that the conclusions derived above still hold.

Firstly, full market coverage is assumed throughout the analysis. It can be questioned whether the outcome of the analysis is similar for partial market coverage; that is, how the difference in Apple's profits and aggregate welfare between independent pricing and tying change if not all consumers buy a system. Due to lower demand, both firms as well as consumers generate lower surplus. Nevertheless, in both tying and independent pricing demand would be lower; hence, profits and welfare would be reduced with the same amount in both scenarios. Tying is likely to be beneficial for firm 1 whereas welfare remains highest under independent pricing.

Secondly, only two firms were taken into account in the analysis above whereas more firms are operating in the business. As a result, market shares will be lower than assumed and fixed costs have to be incurred more often. This will not change the outcome that tying is most likely to arise and welfare would be highest under independent pricing. Fixed costs are irrelevant since these have to be incurred in both situations. Moreover, profits will be lower due to smaller market shares but again, this is the case for both independent pricing and tying. Tying is even more likely to arise for low mark-ups since Apple faces more competition.

Furthermore, a one-to-one relationship is assumed whereas in reality consumers are likely to purchase more than one song per iPod.[30] Relaxing this assumption of a one-to-one relationship reinforces the conclusion that Apple makes highest profits and welfare is lowest under tying. Firstly, due to homogeneity in preferences for music, music stores play an unsubstantial role in the decision for a system; first, consumers decide which music player to purchase, followed by a decision on the music store. Because the iPod is valued higher, more consumers choose the Apple system and the iTunes Music Store than they would have done under independent pricing. Consequentially, the positive effect of an increased frequency in music purchases on profits is more profound under tying. Hence, the conclusion that Apple has a stake in tying its goods is reinforced. Furthermore, a similar argumentation applies to the effect on welfare: under tying, the iTunes Music Store has more customers, even those consumers with a preference for competing music stores; the increased frequency of

[30] In fact, as argued by Steve Jobs in Thoughts on Music, three percent of 1000 songs – adding up to 30 songs – per iPod has been purchased in the iTunes Music Store.

purchasing music makes the negative effect of purchasing music in another store than preferred more profound and welfare under tying is lower compared to independent pricing.

Besides assuming a one-to-one relationship, goods were considered to be strictly complementary. Songs form the iTunes Music Store would not have any value if they could not be used in combination with a music player. This is the case for some consumers, specifically for those consumers purchasing both online music and music players on which Section 6 has focused. As discussed in Section 5, this group of consumers does not add up to a substantial part of the market for music players yet; nevertheless, it is growing in importance due to increased online penetration. Furthermore, the analysis in Section 6 focuses on the effects of tying, which is only relevant for the group of consumers perceiving the goods strictly complementary. Whereas the magnitude of this effect might change if total iPod sales are taken into account, the direction of this effect will not change since consumers purchasing only either a music player or online digital music are not affected by Apple's tying decision.

Moreover, firm 2 is expected to display similar behaviour as firm 1; that is, if Apple decides to develop an incompatible DRM, competitors also use non-interoperable DRMs; if Apple enables consumers to use music from other stores on the iPod, rivals allow consumers to play iTunes Music Store content on their music players. A problem with this assumption might be that relaxation implies a change of outcome; that is, Apple can make highest profits in the independent pricing game. In the tying game, a competing music store could decide to make its music compatible with the iPod. As a result, the firm would be able to extract surplus from those consumers with a preference for the competing music store and Apple would face lowered profits, since it loses demand for the iTunes Music Store. In order to extract highest surplus on the music player, it would be more profitable to price independently; as a result, the outcome would change. Nevertheless, the assumption of similar behaviour is congruent with reality. Whereas music from some music stores, for example Emusic, is sold without restrictions, most online retailers use a system which is incompatible with other DRMs. Currently, two major DRM technologies exist, namely Microsoft (JANUS, used by Napster, Real Networks and Yahoo!) and Apple (FairPlay, encrypted in the iTunes Music Store).[31] These systems are incompatible with each other. Hence, the assumption that all firms are either tying or independent pricing seems reasonable.

Also disputable could be the maximum mark-up on the iPod assumed, that is $\gamma \geq 3t$. Below this maximum, a negative relationship between the inferiority of competing music players and rivals' profits exist. If this assumption does not hold, the superiority of the iPod is too strong

[31] Soleil Media Team, May 2005. *Music Industry Review: Best Questions Answered*.

to suffer from competitive threats and the basic model would apply. Since competing music players are not considered that inferior, the maximum mark-up should not be problematic for the analysis.

Related to this issue is the assumption that the iPod is priced at most two times marginal costs; $\gamma \leq 2c_A$. This value is derived using the mark-up rule (Katz and Rosen, 2004):

$$\gamma = zc_A(q) = \frac{1}{1-\frac{q_i}{q}*\frac{1}{\epsilon(q)}}c_A(q);\ x = \frac{1}{1-\frac{q_i}{q}*\frac{1}{\epsilon(q)}} \leq 2;\quad \frac{q_i}{q} * \frac{1}{\epsilon(q)} \leq \frac{1}{2}$$

In this rule, γ is the price of an iPod, z the mark-up or superiority of the iPod, c_A marginal costs given quantity q and $\varepsilon = -(dq/q)/(dp/p)$ represents the price elasticity of demand. The mark-up of $z \leq 2$ applies to a monopolist (a market share of $q_i/q = 1$) with a price elasticity of $\varepsilon \geq 2$ and to firms with lower market shares and higher price elasticity as long as the condition above is satisfied. This means that in order to have a realistic assumption, Apple, with a market share of at most 80% in the market for music players, needs an elasticity of $\varepsilon(q) \geq 1.6$. If the price was increased with one percent, demand should decrease with 1.6%. This can be considered reasonable for music players which are not a basic need.

Moreover, Apple is assumed not to face fixed costs. Relaxing this assumption does not change the outcome if these are low enough to allow Apple to be active, which is the case in reality. Fixed costs lower profits under both tying and independent pricing, but if costs are the same for both situations the effect on profits and welfare is irrelevant in the comparison. More interestingly, it could be argued that fixed costs are lowest in the absence of a DRM because no DRM development costs had to be incurred. Accordingly, profits in the situation where DRM is abandoned would be higher than where DRMs exist. In that case, it could be argued that Apple would not have implanted DRM restrictions voluntarily. Nevertheless, tying is attributed to incompatibility and does not arise from interoperable DRMs. Major music labels do not require incompatible systems; thus, Apple ties the goods voluntarily because this enables foreclosure of the market to competitors and raising its own profits. In Section 7, the interoperable possibilities which Apple does not advocate will be discussed more into detail. Furthermore, it can be questioned how large costs for DRM development are compared to total profits generated. Fixed costs associated with DRMs are not expected to be a large share of total revenues for large players such as Apple and the likes. For this reason, the effect of fixed costs will not be tremendous.

A final issue concerns illegal distribution of digital music. DRMs have been introduced to fight the threat of music piracy, which has not been taken into account yet. Nevertheless, in Section 3.3 it was argued that piracy is possibly part of the market for digital online music. If

this is the case, the results might change. The outcome depends on two factors: whether DRM effectively reduces the extent to which illegal downloading takes place and whether illegal music is a complement, a substitute or unrelated to legal online music.

First of all, assume DRM not to be effective. In 2006, despite DRM restrictions on digital music sold through online stores, networks like Limewire and BitTorrent continued to be massive carriers of copyright theft.[32] It could be argued that tying is not effective and consumers circumvent DRM. For example, consumers would be able to remove DRM from purchased digital music, share it illegally and use the music on players which were incompatible before DRM removal. Hence, DRM would not restrict consumers; all music players and stores were interoperable and tying would not be different from independent pricing.

Nevertheless, as argued in Section 3.3, tying in fact is effective because transforming DRM secured music into interoperable formats requires time, knowledge and specialised software to burn audio CDs, and is accompanied with quality loss. For this reason, consumers will not be inclined to circumvent DRM. Nowadays, the main sources for unauthorised music are CDs sold without DRM restrictions. However, CD sales are becoming less important as online penetration continues. Moreover, in any one year, 60% of music sales are current releases.[33] These observations imply that in the future the majority of music sales will not be available illegaly. As a result, DRMs become effective and comparing independent pricing with tying is relevant. The outcome, then, depends on whether piracy is substitutable, unrelated or complementary to legal online music.

If illegal file sharing is a competitive threat to legal online music due to similarity in demand characteristics (see Section 3.3), producers would not be able to profitably sell online music under independent pricing; producer surplus would be lowest under independent pricing since tying reduces threats of piracy. Whereas consumer surplus is higher due to greater quantities and lower prices, a third player should be taken into account in order to determine the effect on aggregate welfare: the artists and record labels owning the intellectual property rights. Peitz and Waelbroeck (2004) point out that illegal file sharing reduces the ability to appropriate revenues from intellectual property rights. In the traditional business model of the music industry, this would decrease incentives to create music due to large sunk costs. Thus, in the absence of DRM, the quantity supplied would be beyond the allocative efficient outcome as a result of low prices and negative externalities arising from piracy. Nevertheless,

[32] International Federation of the Phonographic Industry (IFPI), January 2007. *Digital Music Report*
[33] Soleil Media Team, May 2005. *Music Industry Review: Best Questions Answered.*

the upsurge of the online music industry led to a new business model in which variable costs are more important relative to fixed costs. For this reason, acts with smaller audiences can succeed and the problem of music piracy seems to be less severe.

In fact, positive externalities or complementarity of piracy might exist. Free copies of music deliver network externalities and have an information function. If an increasing number of people listen to the same music due to the free format of copies, consumers are likely to value the music higher. Furthermore, digital copies provide information on the genre and style of music. These factors increase demand for legal music and thereby benefit the copyright owner as reflected in the recent trend of publishing free available video clips on sites such as YouTube and MySpace. This has increased popularity and stimulated demand for this music.

Even if piracy is not considered complementary, it is not likely to be problematic because in that case it is unrelated to demand for online music. Mainly consumers with low opportunity cost and low purchasing power are using illegal music. They would not have added up to a substantial number of customers in the legal online music market if they had not had the possibility of illegal file-sharing. In fact, the legal online music market can be expected to grow in importance because consumers familiar with illegal digital music are aging, gaining in purchasing power and hence likely to shift to legal sources for music. Furthermore, due to online penetration, consumers characterised by high purchasing power are becoming acquainted with digital music. Their importance in the legal online music market is rising.

Finally, increased availability of digital music, including illegal music, increases demand for digital music players. Due to complementarity between music and players, suppressing piracy through DRM would lower profitability because it reduces the availability of music and thereby demand for music players, on which highest surpluses are generated. In this sense, it is paradoxical for an online digital music retailer also active in the market for digital music players to develop a sound DRM; it is forced to develop such a DRM, but thereby harms sales of music players. This might flatten the positive effect on Apple's profits of tying.

It has been shown that all parties are likely to be better off under independent pricing if DRMs effectively suppress piracy and illegal file sharing delivers no or positive externalities; both consumers and producers are able to generate higher surpluses in the context of the new business model. Welfare, then, is likely to be highest under independent pricing.

Whereas in the discussion above independent pricing has been considered DRM-free and tying a situation with incompatible DRMs, solutions in between are possible as discussed in the next section.

7. Solutions: increasing welfare?

Three alternatives to the current situation have been proposed, namely (1) the different DRM systems could be made interoperable, (2) one standard in DRM could be developed or (3) DRM could be abandoned in its totality.[34] Note that these solutions imply independent pricing since no effective tying occurs; analysing the effect on welfare requires comparing independent pricing and tying as performed in Section 6.2. Moving from a situation of tying to independent pricing was shown to increase welfare, notably if competing music players closely resemble the iPod and the different music stores are homogeneous. Nevertheless, extra considerations apply to the specific solutions which are discussed below.

The first option, making the different DRM systems interoperable, has a positive effect on welfare. From a static perspective, fixed costs would be higher under independent pricing than tying due to coordination efforts directed to interoperability. This would have a detrimental effect on producer surplus. Nevertheless, it can be argued that extra coordination costs will not be substantial, compared to total costs, and likely to be compensated by gains in aggregate welfare under independent pricing.

Moreover, from a dynamic perspective, this solution is likely to increase welfare due to innovation arising from competitive forces (Motta, 2004). Interoperability of the different DRMs would facilitate entrance of new players in the market for music players since no foreclosure occurred. The resulting competitive forces stimulate companies to innovate and reduce fixed costs. Furthermore, network effects exist in the market. That is, consumers derive utility from the total number of consumers using the same DRM format (since this facilitates sharing music and increases the availability of complementary software). This might elicit a standards war with low prices and introductory offers by which competitors are trying to tip the market in their favour (Motta, 2004). As a result, static increases in fixed costs will be offset by a dynamic increase in innovation, lowering fixed costs and prices. For this reason, moving to interoperable DRMs might be a good solution to the problem.

The second option, developing one standard in DRM, would also imply independent pricing. Nevertheless, one DRM instead of different interoperable DRMs would be developed. Again, both static and dynamic effects can arise. From a static point of view, it can be concluded that fixed costs would be lower under independent pricing due to savings in DRM development costs. Moreover, welfare under independent pricing is highest due to increased consumer

[34] Jobs, S. (2007). *Thoughts on music*. http://www.apple.com/hotnews/thoughtsonmusic/

surplus and profitability of firm 2, but a reduction in fixed costs will not contribute tremendously to this observation.

From a dynamic point of view, both negative and positive effects of the solution can be observed. On the one hand, one standard in DRM decreases competition. As a result, incentives for innovation prevalent for interoperable DRMs are nonexistent. Furthermore, if FairPlay and JANUS are forced to adopt one standard, investments of at least one standard might not be recuperated as much as if both systems had remained into existence. This will not remain unnoticed in other industries, inhibiting innovation. On the other hand, an implication of the existence of network effects is that consumers obtain benefits from more consumers using the same system; complementary products using the same DRM standard can be developed. This enables consumers to benefit more from one standard than from different standards (Motta, 2004). Thus, this solution has both disadvantages and advantages and is not as beneficial as the alternative in which several DRMs become interoperable.

Finally, DRM could be abandoned in its totality. With regard to this solution, some of the arguments pointed out above can be used again. Notably, increased competition due to removal of entry barriers causes prices to be lower, quantities to be higher and innovation to be likely. These beneficial effects on welfare might be partly or fully offset by dynamic effects, since the *ex post* decision to abandon DRMs in which companies have made considerable investments discourages companies to invest in the future.

Moreover, it could be argued that in this analysis the positive and negative externalities of the free and illegal distribution of music should be taken into account. In Section 6.3 it was concluded that the existence of piracy, effectively suppressed by DRMs and only possible if DRM is abandoned, is likely to reinforce the welfare improving effect of independent pricing. This is the result of increased quantities, lower prices, an increase in demand for digital music players due to availability of complementary digital music and benefits for artists, record labels and online music stores from positive externalities of free available music. For this reason, Apple might benefit from this solution as well.

Since the effects of illegal music sharing seem to be positive, this analysis tends to favour abandoning DRM in its totality as the optimal solution to the problem. The other solutions proposed do not internalise the positive effects arising from the distribution of free copies, whereas the same effects concerning competition and innovation hold.

8. Conclusion

Summarizing, online music stores use DRM technology to prevent copyrighted music from being shared unauthorized. Different systems are incompatible, foreclosing rivals of the tied iPod to customers of the iTunes Music Store. In order to establish whether this practice is abusive, a dominant position should be established in the market of the iTunes Music Store. This store is found to have a dominant position if it faces competition from legal online digital music stores. However, despite exclusion of illegal downloads from the relevant market, tying is currently not abusive because portable music players and online digital music are not strictly complementary and hence iPod's competitors are not foreclosed to a substantial number of consumers. Nevertheless, the online music market is growing in importance and the number of consumers using both online music stores and a portable digital music player increases. For this reason, an abusive practice is likely to be found in the future as long as piracy is not considered a substitute to digital music. This problem is exaggerated by the dominant position of iPod in the market for portable music players.

Whereas the legal analysis does not require action yet, on the basis of a microeconomic analysis it was concluded that Apple increases its profits through tying and that welfare is not optimised. Although under absence of competing music players Apple would have preferred to sell goods independently, in the presence of a competitive threat it is profitable for the firm to tie because the iPod is not superior to its competition and preferences for music stores are homogeneous. For consumers and rivals, this practice is detrimental; gains in Apple's profits are fully offset by their decreased surplus. Hence, aggregate welfare would be highest if goods had not been tied. Relaxing some assumptions made to simplify the analysis did not change the main results.

Piracy, however, might change the outcome. DRM is not only becoming more effective in foreclosing competitors to the iTunes Music Store customers, it is also increasingly able to suppress illegal file sharing. The latter phenomenon has positive externalities in the new business model for music distribution and is not a substitute for legal online music for the majority of consumers with purchasing power. As a result, DRM limits sales and independent pricing by abandoning DRM would flatten out Apple's profitability of tying compared to independent pricing and improve welfare.

It can be questioned why, if this is the case, Apple does not price independently. The problem is two-fold: either profits are not high enough for Apple after abandoning DRMs to lobby at the record labels, or music labels do not see the positive externalities from illegal file sharing and require the music to be sold with DRM restrictions. DRMs in the combination of

independent pricing have detrimental effects to Apple its profits, as was shown by describing two alternatives besides abandoning DRM and retaining the status quo: making DRMs interoperable or adopting one standard. These are not likely to arise because Apple does not have a stake in these options: the firm does not receive benefits from either tying through foreclosing its rivals or increased sales in the context of piracy.

Instead, Apple advocates abandoning DRM in its totality. Possibly, the firm realises its tying activities are not sustainable since competition authorities will take measures in the future. Reasons for this are both increasing complementarity instead of threats of piracy as well as importance of the online digital music market. Although its profits might still be highest under tying where the firm effectively reduces competitive threats, abandoning DRM in its totality delivers benefits due to positive externalities of free music and therefore this is its second-best solution.

This solution of abandoning DRM in its totality is likely to benefit all parties and therefore would be a perfect equilibrium. First of all, the consumers are winners; their use of music is not restricted by DRM technology, competition leads to higher quantities for lower prices and the availability of free music delivers positive externalities. Also competitors are benefited by this solution. They are not foreclosed anymore and can serve the market for online digital music. Record labels would face an increased demand for music and Apple an increased demand for both online music and music players due to the positive externalities of free music.

Concluding, in the current situation of incompatible DRMs, rivals and consumers are losing more than Apple is winning. Aggregate welfare would be highest if a DRM-free system was adopted, but before this solution will be adopted, music labels have to become convinced of the positive externalities of music piracy. For this reason, maximising welfare in the music industry is a long way to go.

References

Brousseau, E., Deffains, B., Ghosh, S., Harnay, S., Helg, R., Khong, D., Marciano, A., Nicita, A., Porrini, D., Pagano, U., Ramello, G.B., Scherer, F.M. and Silva, F. (2005). *DRMs and competition - a new strategic stake: Paper presented at Workshop on the Law and Economics of Intellectual Property and Information Technology*. Università Carlo Cattaneo Castellanza, LIUC

Fisher, N. (2006). *Apple's iTunes Music Store and the Mainstream Digital Music Retail Market.* www.prism.gatech.edu/~mm284/DRM.pdf

Katz, M.L. and Rosen, H.S. (2005). Chapter 13 Monopoly. In M.L. Katz and H.S. Rosen, *Microeconomics* (pp. 409-450). Boston: McGrawHill.

Motta, M. (2004). *Competition Policy: Theory and Practice*. New York: Cambridge University Press.

Peitz, M., and Waelbroeck, P. (2004). *An Economist's Guide to Digital Music*. CESifo Working Paper: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=628961

Sydsaeter, K., and Hammond, P. (2002). Chapter 9 Integration. In K. Sydsaeter, and P. Hammond, *Essential Mathematics for Economic Analysis* (pp. 305-348). Harlow, Essex: Prentice-Hall, Inc.

Whinston, M. (1990). Tying, Foreclosure, and Exclusion. *The American Economic Review (80)*, 837-859.

Appendix A – The basic model

Tying

Consumers obtain utility from purchasing an iPod/iTunes Music system equal to:

(1) $U_{A,B1} = \theta - tx - \tilde{p}_m$

They only purchase a system if $U_{A,B1} \geq 0$. If $\tilde{p}_m \leq \theta - t$, the full market is covered since even the consumer with the lowest preference for good $B1$ (located at $x = 1$) obtains a utility equal to or higher than zero according to equation (1). As a result, demand equals $\tilde{q}_m = 1$.

If $\tilde{p}_m > \theta - t$, some consumers do not purchase a system and demand equals $\tilde{q}_m = \frac{\theta - \tilde{p}_m}{t}$

Profits for firm 1 are defined as:

(2) $\tilde{\pi}_m = (\tilde{p}_m - c_A - c_B)\, q_m$

If the market is partially covered, (2) can be rewritten as $\tilde{\pi}_m = (\tilde{p}_m - c_A - c_B)\frac{\theta - \tilde{p}_m}{t}$. The first order condition of (2) for price gives the optimal monopoly price in the case of partial market coverage:

(3) $\tilde{p}_m = \frac{\theta + c_A + c_B}{2}$.

Since full market coverage exists if $\tilde{p}_m \leq \theta - t$, substituting (3) in this inequality gives the condition under which all consumers buy:

$\frac{\theta + c_A + c_B}{2} \leq \theta - t$

Rewriting gives the condition under which full market coverage exists:

(4) $\theta \geq 2t + c_A + c_B$

Demand and price in this situation are respectively:

(5) $\tilde{q}_m = 1$ and (6) $\tilde{p}_m^* = \theta - t$

Substituting (5) and (6) in (2), gives the optimal profit:

(7) $\tilde{\pi}_m^* = \theta - t - c_A - c_B$

Independent pricing

Assume firm 1 sets prices as following, irrespective of firm 2's entry decision:

(8) $\hat{p}_A = \tilde{p}_m^* - \hat{p}_{B1}$ and (9) $\hat{p}_{B1} = c_B - \varepsilon$

Consumers choose system $A/B1$ if the valuation net of prices for system $A/B1$ is higher than the valuation net of prices for system $A/B2$, represented by:

$U_{A/B1} = \theta - tx - \hat{p}_A - \hat{p}_{B1} \geq \theta - t(1 - x) - \hat{p}_A - p_{B2} = U_{A/B2}$

From this inequality the indifferent consumer can be derived:

(10) $x_{12} = \frac{t-\hat{p}_{B1}+p_{B2}}{2t}$

Firm 2 enters if $\pi_2 \geq 0$. If condition (4) is satisfied, all consumers buy. Demand for goods A, $B1$ and $B2$ are respectively $q_A = 1,\ q_{B1} = x_{12}$ and $q_{B2} = (1 - x_{12})$. Firm 2's profits are:

(11) $\pi_2 = (p_{B2} - c_B)(1 - x_{12}) - F_2 = (p_{B2} - c_B)\frac{t+\hat{p}_{B1}-p_{B2}}{2t} - F_2.$

The first order condition of (11) for p_{B2}, combined with (9), yields firm 2's reaction curve:

(12) $p^*_{B2} = \frac{t+\hat{p}_{B1}+c_B}{2} = \frac{t+2c_B-\varepsilon}{2}$

Substituting (9) and (12) in (11) gives firm 2's optimal profit:

(13) $\pi^*_2 = \frac{(t-\varepsilon)^2}{8t} - F_2.$

After rewriting and substitution of (8), firm 1's profits are:

$\hat{\pi}_1 = (\tilde{p}^*_m - c_A - c_B)x_{12} + (\tilde{p}^*_m - \hat{p}_{B1} - c_A)(1 - x_{12}).$

The indifferent consumer given in (10) can be rewritten by substituting prices in (9) and (12):

(14) $x_{12} = \frac{3t+\varepsilon}{4t}$

Substituting (6), (9), (10) and (14) into firm 1's profits gives its optimal profits:

(15) $\hat{\pi}^*_1 = (\theta - t - c_A - c_B) + \varepsilon\frac{t-\varepsilon}{4t}$

Welfare

Producer surplus

Producer surplus exists of profits generated by both firm 1 and firm 2.

If firm 2 does not enter, producer surplus is made up of (7). Because full market coverage is assumed, condition (4) holds. Substitution of (4) in (7) gives:

(16) $PS \geq t.$

If the products are sold independently and firm 2 enters, producer surplus consists of (13) and (15). Summing these profits gives producer surplus in this situation:

$PS = (\theta - t - c_A - c_B) + \frac{(\varepsilon+t)(t-\varepsilon)}{8t} - F_2.$

Because it is assumed that condition (4) is satisfied, this can be rewritten as

(17) $PS \geq t + \frac{(\varepsilon+t)(t-\varepsilon)}{8t} - F_2.$

Producer surplus in (17) is larger than in (16) if:

$\frac{(\varepsilon+t)(t-\varepsilon)}{8t} = \frac{t^2-\varepsilon^2}{8t} > F_2.$

Because firm 2 only enters if it makes nonnegative profits (that is, profits in (13) are at least zero), maximum fixed costs are known:

$F_2 \leq \frac{(t-\varepsilon)^2}{8t} = \frac{t^2-2\varepsilon t+\varepsilon^2}{8t}$

Maximum fixed costs are smaller than $\frac{t^2-\varepsilon^2}{8t}$ because $t^2 - 2\varepsilon t + \varepsilon^2 < t^2 - \varepsilon^2$; note that this implies $2\varepsilon(\varepsilon - t) < 0$ which is true since ε is assumed to be only a small fraction of marginal costs for good B. Therefore, the following condition implies that producer surplus under independent pricing and entrance of firm 2 is larger than when firm 2 stays out:

(18) $\frac{(\varepsilon+t)(t-\varepsilon)}{8t} > \frac{(t-\varepsilon)^2}{8t} \geq F_2$

Consumer surplus

Consumer surplus (CS) can be found by the definite integral of the demand function with respect to quantity for the total amount of consumers purchasing a system.

If firm 2 does not enter, consumer surplus is:

$CS = \int_0^{\tilde{q}_m}(\theta - tx - \tilde{p}_m)\,dx$

As long as condition (4) holds, all consumers buy a system and $\tilde{q}_m = 1$. Substituting (6) gives total consumer surplus:

(19) $CS = \int_0^1(\theta - tx - \theta + t)\,dx = t - \frac{t}{2} = \frac{1}{2}t.$

Under independent pricing, some consumers buy system $A/B1$ whereas some consumers choose system$A/B2$. Together, these consumers realize a surplus of:

$\int_0^{x_{12}}(\theta - tx - \hat{p}_A - \hat{p}_{B1})\,dx + \int_{x_{12}}^1[\theta - t(1-x) - \hat{p}_A - \hat{p}_{B2}]\,dx.$

Substituting prices given by (8), (9) and (12) gives:

$CS = \int_0^{x_{12}}[t(1-x)]dx + \int_{x_{12}}^1\left(tx - \frac{t-\varepsilon}{2}\right)dx = tx_{12}\left(1 - \frac{x_{12}}{2}\right) + \frac{t}{2} - \frac{t-\epsilon}{2} - \frac{t{x_{12}}^2}{2} + \frac{t-\epsilon}{2}x_{12}$

$= tx_{12}\left(1 - \frac{x_{12}}{2}\right) + \frac{\varepsilon}{2} - \frac{x_{12}(tx_{12}-t+\varepsilon)}{2}$

Substituting the indifferent consumer given in (14) into this equation gives consumer surplus:

(20) $CS = \frac{(3t+\varepsilon)(5t-\epsilon)}{32t} + \frac{\varepsilon}{2} - \frac{(3t+\varepsilon)(5\varepsilon-t)}{32t} = \frac{9t^2-6t\varepsilon-3\varepsilon^2}{16t} + \frac{\varepsilon}{2} = \frac{1}{2}t + \frac{(t+3\varepsilon)(t-\varepsilon)}{16t}$

Consumer surplus is larger under independent pricing than under tying if (20) exceeds (19) or:

$\frac{(t+3\varepsilon)(t-\varepsilon)}{16t} > 0$

This condition is satisfied because $t > \varepsilon$.

Aggregate welfare

Aggregate welfare consists of consumer surplus and total firm profits.

If firm 2 does not enter and condition (4) holds, aggregate welfare is the sum of (15) and (19):

(21) $W = (\theta - t - c_A - c_B) + \frac{1}{2}t \geq \frac{3}{2}t$

If firm 1 decides to price its products independently and firm 2 enters, aggregate welfare is the sum of (17) and (20). If condition 4 holds, this is $W \geq \frac{3}{2}t + \frac{(\varepsilon+t)(t-\varepsilon)}{8t} + \frac{(t+3\varepsilon)(t-\varepsilon)}{16t} - F_2$ or:

(22) $W \geq \frac{3}{2}t + \frac{(t-\varepsilon)(5\varepsilon+3t)}{16t} - F_2$.

Independent pricing benefits welfare if:

(23) $\frac{(t-\varepsilon)(5\varepsilon+3t)}{16t} > F_2$

Since firm 2 will not enter if its profits are lower than fixed costs, the highest possible value of these fixed costs if firm 2 enters is:

(24) $F_2 \leq \frac{(t-\varepsilon)^2}{8t}$

Combining (23) and (24) indicates that welfare is higher under independent pricing and entrance of firm 2 compared to tying or independent pricing but firm 2 stays out if: $\frac{(t-\varepsilon)(5\varepsilon+3t)}{16t} > \frac{(t-\varepsilon)(2t-2\varepsilon)}{16t}$

Since $t > \varepsilon > 0$ and $(5\varepsilon + 3t) > (2t - 2\varepsilon)$, this is necessarily true.

Appendix B – The extended model

Independent pricing

System $A1/Bi$ is valued $\gamma - c_A$ higher than system $A2/Bi$. Hence, consumers will choose product $A1$ if $U_{A1/Bi} \geq U_{A2/Bi}$ or:

$v_{A1/Bi} - \hat{p}_{A1} - \hat{p}_{Bi} \geq v_{A1/Bi} - (\gamma - c_A) - \hat{p}_{A2} - \hat{p}_{Bi}$

This gives the maximum price at which all consumers purchase $A1$: $\hat{p}_{A1} \leq (\gamma - c_A) + \hat{p}_{A2}$
If it is assumed that $\hat{p}_{A2} \geq c_A$, firm 1 prices good $A1$ as following and makes all good A sales:
(1) $\hat{p}_{A1} \leq \gamma$

If (1) holds, a consumer will buy product $B1$ if $U_{A1/B1} \geq U_{A1/B2}$ or:

$\theta - tx - \hat{p}_{A1} - \hat{p}_{B1} \geq \theta - t(1-x) - \hat{p}_{A1} - \hat{p}_{B2}$

If the presence of firm 2 is ignored, the condition for full market coverage is derived in a similar way as in the basic model:
(2) $\theta \geq 2t + c_A + c_B$

The consumer indifferent between system $A1/B1$ and $A1/B2$ is defined by:
(3) $x_{12} = \frac{\hat{p}_{B2} - \hat{p}_{B1} + t}{2t}$

If (1) and (2) hold, total demand for system $A1/B1$ is x_{12} and total demand for system $A1/B2$ is $(1 - x_{12})$. If $\hat{p}_{A1} = \gamma$, profits for firm 1 are:
(4) $\hat{\pi}_1 = (\hat{p}_{A1} - c_A) + (\hat{p}_{B1} - c_B)x_{12} = \gamma - c_A + (\hat{p}_{B1} - c_B)\frac{\hat{p}_{B2} - \hat{p}_{B1} + t}{2t}$

The optimal price for good $B1$ is given by the first-order condition of (4) and substitution with (3) gives:
(5) $\hat{p}^*_{B1} = \frac{t + \hat{p}_{B2} + c_B}{2}$

Firm 2 makes profits of:
(6) $\hat{\pi}_2 = (\hat{p}_{B2} - c_B)(1 - x_{12}) = (\hat{p}_{B2} - c_B)\frac{\hat{p}_{B1} - \hat{p}_{B2} + t}{2t}$

Its optimal price is given by the first-order condition of (6) and substitution with (3) gives:
(7) $\hat{p}^*_{B2} = \frac{t + \hat{p}_{B1} + c_B}{2}$

Equations (5) and (7) are respectively firm 1 and firm 2's reaction curves. Their intersection gives the Bertrand equilibrium prices. This is the case for:

$\hat{p}^*_{B1} = \frac{3t + \hat{p}_{B1} + 3c_B}{4}$ and $\hat{p}^*_{B2} = \frac{3t + \hat{p}_{B2} + c_B}{4}$

This can be rewritten as:

(8) $\hat{p}^*_{B1} = \hat{p}^*_{B2} = c_B + t$

The indifferent consumer defined by (3) at this price is:

(9) $x_{12} = \frac{1}{2}$

This consumer only buys if $\theta - tx_{12} - \hat{p}_{A1} - \hat{p}_{B1} \geq 0$; substituting $\hat{p}_{A1} = \gamma$, (8) and (9) in this inequality gives $\theta - \frac{3}{2}t - \gamma - c_B \geq 0$ or the condition for which half of the consumers buy system $A1/B1$ and the other half buy system $A1/B2$:

(10) $\theta \geq \gamma + c_B + \frac{3}{2}t.$

Substitution of (8) into (4) gives optimal profits for firm 1:

(11) $\hat{\pi}^*_1 = \gamma - c_A + \frac{1}{2}t$

Substitution of (8) into (6) gives optimal profits for firm 2:

(12) $\hat{\pi}^*_2 = \frac{1}{2}t - F_2.$

Tying

Consumers have to choose between system $A1/B1$ and $A2/B2$. The indifferent consumer characterized by $U_{A1/B1} = U_{A2/B2}$ or $v_{A1/Bi} - \tilde{p}_1 \geq v_{A1/Bi} - (\gamma - c_A) - \tilde{p}_2$is located at:

(13) $x_{12} = \frac{t+\gamma-\tilde{p}_1+\tilde{p}_2}{2t}.$

If all consumers buy a system, demand for firm 1 equals $\tilde{q}_1 = x_{12}$ and demand for firm 2 is $\tilde{q}_2 = (1 - x_{12})$.

Substituting (13) and demand in firm 1 its profit function gives:

(14) $\tilde{\pi}_1 = (\tilde{p}_1 - c_A - c_B)\frac{t+\gamma-\tilde{p}_1+\tilde{p}_2}{2t}$

The first order condition of (14) gives the optimal price as a reaction to firm 2's tying price:

(15) $\tilde{p}^*_1 = \frac{t+\gamma+\tilde{p}_2+c_A+c_B}{2}$

Substituting (13) and demand in firm 2 its profit function gives:

(16) $\tilde{\pi}_2 = (\tilde{p}_2 - c_A - c_B)\frac{t-\gamma+\tilde{p}_1-\tilde{p}_2}{2t} - F_2$

The first order condition of (16) gives the optimal price as a reaction to firm 1's tying price:

(17) $\tilde{p}^*_2 = \frac{t-\gamma+\tilde{p}_1+c_A+c_B}{2}$

Equilibrium prices are found by substituting (17) in (15):

(18) $\tilde{p}^*_1 = t + c_A + c_B + \frac{1}{3}\gamma$

(19) $\tilde{p}_2^* = t + c_A + c_B - \frac{1}{3}\gamma$

Substituting (18) and (19) in (13) gives the associated indifferent consumer:

(20) $x_{12} = \frac{t+\frac{1}{3}\gamma}{2t}$

Substituting (18) and (19) in (14) gives maximal profits for firm 1:

(21) $\tilde{\pi}_1^* = \frac{\left(t+\frac{1}{3}\gamma\right)^2}{2t} = \frac{1}{2}t + \frac{\gamma}{3} + \frac{\gamma^2}{18t}$

For firm 2, optimised profits are found by substituting (18) and (19) in (16):

(22) $\tilde{\pi}_2^* = \frac{(t-\frac{1}{3}\gamma)^2}{2t} - F_2 = \frac{1}{2}t - \frac{\gamma}{3} + \frac{\gamma^2}{18t} - F_2$

Equilibrium

Firm 2 its profits are assumed to decline if its goods become more inferior; thus, the first derivative of (22) with respect to γ is negative:

$\frac{d}{dz} = \frac{2\left(t-\frac{1}{3}\gamma\right)*-\frac{1}{3}}{2t} = \frac{\frac{1}{3}\gamma - t}{3t} \leq 0$

This gives the maximum mark-up and minimum value for heterogeneity in preferences:

(23) $\gamma \leq 3t$

(24) $t \geq \frac{1}{3}\gamma$

The difference between profits under independent pricing and tying is (12) minus (22):

(25) $\hat{\pi}_2^* - \tilde{\pi}_2^* = \frac{1}{2}t - F_2 - \left(\frac{\left(t-\frac{1}{3}\gamma\right)^2}{2t} - F_2\right) = \frac{\gamma}{3} - \frac{\gamma^2}{18t} = \gamma\left(\frac{1}{3} - \frac{\gamma}{18t}\right)$

Substituting (23) in (25) gives:

$\gamma\left(\frac{1}{3} - \frac{\gamma}{18t}\right) \geq \gamma\left(\frac{1}{3} - \frac{3t}{18t}\right) = \frac{1}{6}\gamma \geq 0$

Because $\gamma \geq 0$, firm 2 always makes higher profits under independent pricing.

The difference between profits firm 1 makes under independent pricing (11) and tying (21) is:

(26) $\hat{\pi}_1^* - \tilde{\pi}_1^* = \frac{2\gamma}{3} - \frac{\gamma^2}{18t} - c_A$

If $t = \infty$, $\frac{\gamma^2}{18t} \approx 0$ and profits are highest under tying if:

$\frac{2\gamma}{3} - c_A \leq 0$ or $\gamma \leq \frac{3}{2}c_A$

For lower degrees of heterogeneity t, profits under tying are highest for even higher mark-ups than $\frac{3}{2}$. This is illustrated graphically in the main text.

Welfare

Producer surplus

Under independent pricing, producer surplus is the sum of (11) and (12):

(27) $\widehat{PS} = \gamma - c_A + t - F_2$

Under tying, producer surplus is the sum of (21) and (22):

(28) $\widetilde{PS} = \frac{\left(t+\frac{1}{3}\gamma\right)^2}{2t} + \frac{\left(t-\frac{1}{3}\gamma\right)^2}{2t} - F_2 = t + \frac{\gamma^2}{9t} - F_2$

The difference between producer surplus under independent pricing and tying is represented by (27) minus (28):

(29) $\widehat{PS} - \widetilde{PS} = \gamma - c_A + t - F_2 - \left(t + \frac{\gamma^2}{9t} - F_2\right) = \gamma - c_A - \frac{\gamma^2}{9t}$

Consumer surplus

As in the basic model, consumer surplus is given by the definite integral of the demand function with respect to quantity for the total amount of consumers purchasing a system. Assume condition (10) holds.

Under independent pricing, consumer surplus is:

(30) $\widehat{CS} = \int_0^{x_{12}} (\theta - tx - \hat{p}_{A1} - \hat{p}_{B1})dx + \int_{x_{12}}^{1} (\theta - t(1-x) - \hat{p}_{A1} - \hat{p}_{B2})dx$

$= x_{12}(t - tx_{12} + \hat{p}_{B2} - \hat{p}_{B1}) + \theta - \hat{p}_{A1} - \hat{p}_{B2} - \frac{t}{2}$

Substituting the indifferent consumer (9), optimal prices $\hat{p}_{A1}^* = \gamma$ and (8) in (30) gives:

(31) $\widehat{CS} = \theta - \gamma - c_B + \frac{3}{4}t$

In the tying game, consumer surplus is defined as:

(32) $\widetilde{CS} = \int_0^{x_{12}} (\theta - tx - \tilde{p}_1^*)dx + \int_{x_{12}}^{1} [\theta - t(1-x) - (\gamma - c_A) - \tilde{p}_2^*]dx$

$= \theta - \frac{t}{2} - (\gamma - c_A) - \tilde{p}_2^* + (t - tx_{12} + \gamma - c_A + \tilde{p}_2^* - \tilde{p}_1^*)x_{12}$

Substituting the indifferent consumer defined in (20) and prices given in (18) and (19) gives:

(33) $\widetilde{CS} = \theta - \frac{3}{2}t - \frac{2}{3}\gamma - c_B + \frac{\left(t+\frac{1}{3}\gamma-2c_A\right)\left(t+\frac{1}{3}\gamma\right)}{4t} = \theta - \frac{5}{4}t - c_B - \frac{1}{2}(c_A + \gamma) + \frac{\gamma(\gamma-6c_A)}{36t}$

The difference in consumer surplus between the independent pricing game and the tying game is (31) minus (35):

(34) $\widehat{CS} - \widetilde{CS} = \theta - \gamma - c_B + \frac{3}{4}t - \left(\theta - \frac{5}{4}t - c_B - \frac{1}{2}(c_A + \gamma) + \frac{\gamma(\gamma-6c_A)}{36t}\right)$

$= 2t + \frac{1}{2}(c_A - \gamma) - \frac{\gamma(\gamma-6c_A)}{36t}$

The fist derivative of (34) with respect to t is:

$\frac{d}{dt} = 2 - \frac{\gamma(\gamma - 6c_A)}{36t^2} \geq 0$ if $\gamma(\gamma - 6c_A) \leq 72t^2$

Moreover, $72t^2 \geq 8\gamma^2$ because (23) holds. For this reason, the derivate above is positive if:

$\gamma(\gamma - 6c_A) \leq 8\gamma^2$ or $\gamma \geq -\frac{6}{7}c_A$

This holds because $\gamma \geq c_A$. An increase in t has a positive effect on $\widehat{CS} - \widetilde{CS}$.

As a consequence, the lowest value for (34) can be found for the minimum value of t as given by (23). For $t = \frac{1}{3}\gamma$ the value for (34) is:

$\frac{2}{3}\gamma + \frac{1}{2}(c_A - \gamma) - \frac{\gamma(\gamma - 6c_A)}{12\gamma} = \frac{1}{12}\gamma + c_A \geq 0$

Even in the situation where (34) is minimal, consumer surplus is higher under independent pricing than under tying. This has been illustrated in the main text.

Aggregate welfare

Total welfare consists of consumer and producer surplus; thus, the difference between welfare under independent pricing and tying is given by the sum of (34) and (41):

(35) $\widehat{W} - \widetilde{W} = \gamma\left(1 - \frac{\gamma}{9t}\right) - c_A + 2t - \frac{1}{2}(\gamma - c_A) - \frac{\gamma(\gamma - 6c_A)}{36t} = 2t + \frac{1}{2}(\gamma - c_A) + \frac{\gamma(6c_A - 5\gamma)}{36t}$

The effect of an increase in the degree of heterogeneity is analysed by differentiating to t:

$\frac{d}{dt} = 2 + \frac{\gamma(6c_A - 5\gamma)}{36t^2} \geq 0$ if $\frac{\gamma(5\gamma - 6c_A)}{36t^2} \leq 2$

Because $t \geq \frac{1}{3}\gamma$, this can be rewritten as:

$\frac{\gamma(5\gamma - 6c_A)}{36t^2} \leq \frac{5\gamma - 6c_A}{4\gamma} \leq 2$ since $5\gamma - 6c_A \leq 8\gamma$ $(\gamma \geq c_A \geq 0)$

Hence, a positive relationship has been found between t and $W_{\hat{E}} - W_{\tilde{E}}$ and the minimum value for (35) can be found by substituting $t = \frac{1}{3}\gamma$:

$\frac{2}{3}\gamma + \frac{1}{2}(\gamma - c_A) + \frac{6c_A - 5\gamma}{12} = \frac{3}{4}\gamma$

Thus, welfare is always highest under independent pricing and tying is detrimental to welfare.