Privacy or piracy, why choose? Two solutions to the issues of digital rights management and the protection of personal information

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Abstract: The decrease of privacy caused by Digital Rights Management (DRM) is a serious issue, since it slows down the adoption by the consumers of DRM technologies at a time when a very large adoption is needed to win the fight against piracy. This article presents two outlines of solutions that are expected to allow the fight against piracy and the respect of privacy to coexist. The first solution consists of combining first-degree price discrimination and rewarded disclosure in a mutually advantageous trade. The second solution introduces a different type of DRM system that aims to make digital goods rival, thereby leading to anonymous DRM.

Keywords: privacy; Digital Rights Management; DRM; digital goods; price-discrimination; public goods; piracy.

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1 Introduction

There have been growing concerns about collection of personal information since the development of the internet and these concerns have been intensified with the increasing usage of e-commerce. When browsing the internet, people leave traces of their internet activities, cookies and other technologies are used by firms to collect the information about consumers. One of the technologies that creates privacy concerns is Digital Rights Management (DRM).

The purpose of Digital Rights Management is to help content creators protect the content from uncontrolled use and distribution, *i.e.*, piracy. DRM systems work in such a way that any action of the consumer who is not explicitly authorised by the producer is, by default, prevented. As such, these systems allow to prevent the copying, sharing, as well as the simultaneous use of digital goods. As a consequence, DRM systems make the anonymity of consumption impossible since they require a formal identification before protected digital goods can be consumed.

The stakes are high for producers of digital goods since the success of their crusade against piracy strongly depends on a wide adoption of the DRM technologies by consumers. Consumers have, however, been increasingly reluctant to follow this trend and to purchase digital goods protected by DRM systems. Although other factors can be named, the decrease of privacy caused by DRM technologies is certainly one of the main reasons behind the wariness of consumers towards DRM.

The privacy issues associated with DRM have been highlighted by scholars from engineering (Feigenbaum *et al.*, 2001) and law (Burk and Cohen, 2001; Cohen, 2003). Nonetheless, the economic and managerial aspects of this issue have, so far, been left aside. Furthermore, apart from the analysis of a, somewhat expected, tension between consumers and producers in regard to the right trade-off between piracy and privacy, few attempts have been made to resolve the problem at hand.

The aim of this article is to discuss and analyse the issue of DRM and privacy from an economic and managerial perspective. A second important objective is to supply an outline of solutions that would permit to reconcile control of piracy with respect of privacy.

The first part of this article briefly outlines the rationales behind DRM. In the second section, the issue of privacy and DRM is discussed. The third section presents a first solution to the problem of DRM and privacy, consisting of combining first-degree price discrimination and rewarded disclosure in a mutually advantageous trade. The fourth section introduces a second solution based on a different type of DRM systems that aims at making the digital goods rival in consumption, thereby leading to anonymous DRM systems.

2 Digital rights management and its rationales

Nowadays, most entertainment goods (such as music, movies, computer games and books) and also many professional tools (such as software, documentation, stock pictures) are distributed in digital format. These digital goods share, because of this digital nature, a common characteristic: they are replicable and can be infinitely copied without any loss of quality or information.

The digital nature of these goods has important consequences in regard to the economic characteristics of these goods. The most remarkable of these characteristics certainly is their tendency to behave as public goods. Indeed, since digital goods are replicable they are non-rival (consumers can make copies of digital goods and thus many consumers can enjoy the same unit of digital goods at the same time) and since they are non-rival, they are indirectly non-excludable (producers are able to exclude consumers directly but cannot prevent consumers from copying the good from other consumers). As a consequence, as digital goods spread among the population of consumers they virtually become fully non-excludable, thereby giving them the same economic characteristics as public goods (Rayna, 2006).

The public nature of digital goods has dreadful consequences for the firms producing these goods. First of all, the public nature of digital goods is likely to lead to a free-riding behaviour of consumers (Ramello, 2005). The inability of firms to exclude consumers leads to a wide piracy phenomenon and, thus, undermines their ability to make profits and recover the initial fixed cost of production. Moreover, digital goods have common characteristics with ideas, information and innovation. All these types of good are also known in the literature as leading to market failure because of their nature. The usual argument (Arrow, 1962; Nordhaus, 1969; Aghion and Howitt, 1992) is that, in the absence of a proper protection system, the market fails to produce a sufficient quantity of these goods. This is due to the fact that, since the replication cost for these goods is negligible, the marginal cost of such goods is equal to zero. Therefore, in a competitive environment, the price of these goods is expected to equal zero.

Firms have long tried to impede consumer piracy. All the strategies used to fight piracy implicitly aim to decrease the public characteristic of digital goods by either increasing the degree of excludability (serial numbers, Windows Product Activation, *etc*.) or the degree of publicness (dongles, network scans, use of central server, *etc*.) of the goods (Rayna, 2006). DRM systems belong to the former category and aim to prevent piracy by enabling a total excludability of the digital goods.

The purpose of DRM is to help content creators protect their products from uncontrolled use and distribution. As opposed to enforcement of Intellectual Property Rights, which occurs after the infringement (and is thus punitive) has occurred, DRM aims at preventing the infringement from initially taking place (and is thus preventive). The DRM protection is embedded into the digital good itself and consists of encrypting the digital good, which can therefore not be consumed without being decoded first. The DRM tags embedded in the file contain precise information about the owner of the file and the rights of usage this owner has. For example, in order to be played on a computer or on a media player, a music file protected by DRM has to be activated. The activation is made by contacting a central server on the internet. The consumer is then asked to identify herself, and this information is compared with the owner's information included in the file. If the authentication is confirmed, the computer receives a key allowing to decode, and play, the music file. In addition to the decoding key, data containing instructions about potential restrictions may be transmitted to the computer. Indeed, DRM systems allow to restrict the number of times the music file is activated, so that consumers cannot consume the same music file on more than one computer at the same time, it can also prevent the file from being copied/transferred, or exported, more than a certain number of times.

The most popular (in terms of usage) DRM technology, at the time of this writing, is FairPlay which was created by Apple and is used by its products and services, such as iPod, iTunes and iTunes Store. The files protected by FairPlay can only be played on authorised computers and at most five computers may be authorised at the same time. Consumers can, however, burn their music files on CDs which will have legal, but not physical restrictions. Yet, a particular playlist can only be burnt up to seven times, though the overall number of burns is not limited. The main issue related to FairPlay is that, because of Apple's refusal to licence its technology, songs purchased from iTunes Store can only be played on Apple's iPod media player (although they play on any Windows or Mac computer) and the only DRM protected songs compatible with iPod are the ones purchased from the iTunes Store. Despite these limitations, this technology is the most used one, certainly owing to iPod's 80% market share in the market for portable media players. Since the introductions of films, video clips and TV programmes on the iTunes Store, FairPlay technology is also available to protect video content.

Other DRM technologies are much less popular and are (by order of popularity): Microsoft's PlayForSure, RealNetworks' Helix, Sony's ATRAC. These three DRM systems are able to protect both audio and video files. These technologies allow to establish similar restriction as Apples FairPlay. For example, both Helix DNA, used by RealNetworks, and Windows PlayForSure, used by Napster, allow the file to be played simultaneously on at most three computers and unlimited number of burns, provided that a particular playlist is not burnt more than five times. Sony's ATRAC DRM technology also allows three simultaneous computers to be authorised, but only five burns per file.

Both Microsoft and RealNetworks licence out their technologies. There are still, however, some restrictions. Microsoft PlayForSure only functions on Windows (which leaves aside computers running other operating systems, such as Mac OS or Linux/Unix) and RealNetworks Helix has to be used in conjunction with their Real's content distribution server. Like Apple, Sony has refused to licence out its ATTRAC technology and is, to this day, the sole user of this system. Microsoft recently adopted a similar approach, since they developed a new DRM technology (used by the new portable media player Microsoft Zune) that they have decided not to licence out.

Thus, with regard to the publicness of digital goods, DRM enables to increase the excludability of digital goods, and thus to reduce (or eliminate) piracy. Since DRM protection requires an authentication for the digital good to be consumed, a consumer able to obtain a pirated copy of the good is unable to consume this digital good unless it is activated. Since the activation is granted by firms only, this means that DRM restores the excluding capability of firms.

3 Privacy and digital rights management

One of the controversial issues associated with DRM is the question of privacy. Indeed, nowadays, all the DRM systems collect information about consumers and their consumption activities.

Privacy can be defined in several ways. Westin (1967) states that "privacy is the claim of individuals, groups, or institutions to determine for themselves when, how, and to what extent information about them is communicated to others". Similarly, Stigler (1980) defines privacy as the individuals ability to control the collection and usage of

personal information. According to Rowlingson (2006) privacy is lost when individuals lose control of their personal information. Solove (2005), however, points out that privacy means so many different things to so many different people that it has lost any precise legal connotation. Privacy generally guarantees that personal information, which is not in the public domain, is not released without authorisation.

The increasing importance of privacy issues called for change in regulations. Posner (1978) and Stigler (1980) believed that there was no need to regulate market for personal regulation, as it would be a subject of self-regulation. The main idea behind this argument is that the transaction costs created by the privacy make it economically inefficient and therefore both individuals and customers will choose to disclose their personal information.

Despite this view, a number of new laws have been introduced to solve this issue. In the USA, privacy was addressed by the Privacy Act passed in 1974. In Europe, privacy was treated under Article 8 of the 1950 European Convention of Human Rights and Fundamental Freedoms, and later addressed by Directive 2002/58/EC of the European Parliament. Privacy principles outlined by the European Parliament cover data collection and processing, data retention and data protection.

It is argued that personal information is collected for two main purposes: to produce customised goods and services, and to enable the use of price discrimination strategies (Varian, 1985; Tirole, 1988). In other words, companies claim to use personal information to identify customers' needs and to improve customer service (Moe and Fader, 2004; Sismeiro and Bucklin, 2004). In this case, customers benefit from providing companies with their personal information. On the other hand, personal information can be also used for the purposes of price discrimination, which is regarded by the majority of customers as unfair. Basically, consumers are eager to tell what they like but not how much are prepared to pay for the goods they like.

Overall, data, collected by companies, can be useful both for them and for the consumers; however, it can also be harmful (Feigenbaum *et al*., 2001). Consumers can be affected by unsolicited marketing, especially spam. Furthermore, in cases when personal data are not sufficiently protected, they can be used for illegal activities.

In addition to the issue of how the information collected is used by the company that collected it, other problems arise from the diffusion of the information to third parties. For instance, some organisations (*e.g.*, Amazon.com) state in their policy that the collected personal data may be transferred to third parties in case the company acquires new business units or in case if it is acquired by another company. There are also a number of companies who do not even state that the personal information may be disclosed to the third parties and therefore violate consumer rights when they do so.

It is true that some of the privacy threats discussed above arise because digital material is distributed through the web and not solely because of the use of DRM. For example, most of the security threats are relevant to any e-business or digital distribution. Similarly to e-business technologies, such as cookies, DRM technology is an easy way to conduct marketing research and collect data which can be used by companies for purposes such as market segmentation, price discrimination and dynamic pricing. Indeed, DRM systems remove the anonymity of consumption (since authentication is required for consumption to take place), and allow firms to know which digital good was consumed, when and how often and by whom. Consequently, very elaborated pricing strategies can

be devised. For example, consumers who listen to a certain group/artist on a regular basis could be charged a standard price when a new album is released, whereas those who are not familiar with this group/artist could be offered a discount to encourage the purchase.

There is however a major difference between cookies and DRM technology as the former can be easily disabled (in addition, cookies only collect data on browsing and purchasing, not on consuming), whereas as long as the DRM protection is in used, it is not possible for consumers to prevent firms from collecting information. Moreover, even when signing an agreement in order to purchase a digital file, consumers often do not have sufficient information regarding what type of information is collected, when this information is collected, how it is going to be used, for how long and where this information is going to be stored. The main concern is that information may be collected by unauthorised parties and/or used for unauthorised purposes.

4 Rewarded (and mutually advantageous) disclosure

Although the main advantage of DRM is to prevent piracy, thereby maintaining a high demand for legitimate products and enabling firms to recover initial sunk costs, it also has some crucial additional benefits. One of these additional benefits lies in the information that is revealed by the consumers due to the need to activate any digital products protected by DRM systems. This revealed information can indeed be very valuable for firms, since it enables them to use price discrimination and increase their profits. This is precisely this collection of information that is criticised by the proponents of piracy.

Theoretically, DRM systems could be designed in such a way that the quantity and scope of information collected would enable firms to use first-degree price discrimination. For example, the system could require that a new authorisation has to be requested each time a particular digital good is consumed. In this case, firms would be aware of the exact consumption pattern of digital goods of each consumer.[1] With such information, it would not be difficult to determine the value of each digital good (or type of digital good) and subsequently charge, for each good, a price equal to the reservation price/marginal value of the consumer.

In practice, however, first-degree is unlikely to happen. The first reason for that is that consumers have access to multiple sources of digital goods, most of which do not use first-degree price discrimination. If a firm were to use first-degree price discrimination and attempt to charge a consumer, who values one particular digital goods a lot, a high price, it is quite likely that this consumer would be able to obtain (legally or not) the same digital good at a lower price (the consumer could buy the CD of an album instead of downloading it or could download it from a pirate source). Since consumers may, in contrast, be willing to buy from the discriminating producer all the digital goods they value less (*i.e.*, the digital goods for which their reservation price is below the market price), the profits of the price discriminating firm are expected to fall dramatically (consumers buy the highly valued digital goods from other sources and only buy less valued digital goods from the discriminating firm), thereby making first-degree price discrimination unprofitable for firms to use.

The second reason is that consumers are unlikely to be willing to reveal enough information for companies to be able to apply first-degree discrimination. First-degree price discrimination leads to a full capture of the consumer surplus by firms. Since it

leaves consumers with no surplus, we can reasonably expect that consumers would protest against such a breach of privacy and would refuse to use DRM systems that collect personal information.

Therefore, as long as alternative sources of digital goods exist, it is improbable that firms will be able to profitably use first-degree price discrimination. Furthermore, the fact that DRM systems force consumers to reveal information about their consumption habits is likely to decrease the demand for DRM protected digital goods and to increase the demand for unprotected digital goods. As a consequence, nowadays, DRM systems are designed to collect very little information,[2] which prevents firms from using first-degree price discrimination.

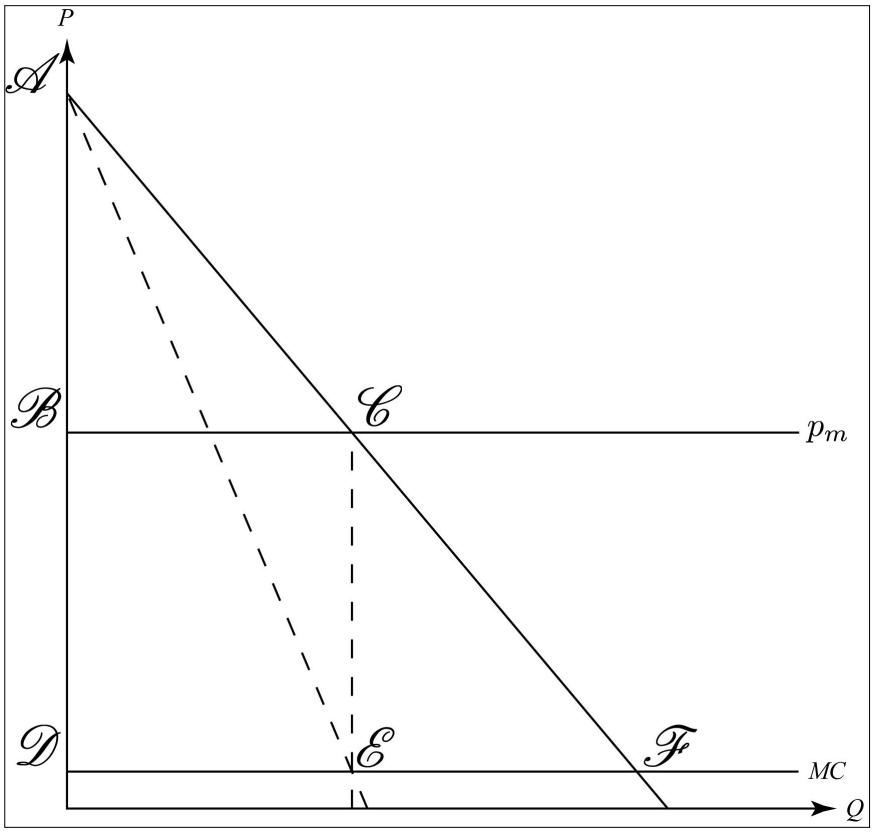
However, this problem is not inevitable. Recent history shows that consumers are not opposed to reveal information and to give up some privacy, as long as they are rewarded for that. The business model of Google is based precisely on trade of personal information for services (users of Google GMail, for instance, get 2 GB of storage space for their e-mail in exchange to allowing Google to index the content of their e-mails). In addition, theory shows that, although consumer surplus is equal to zero, first-degree price discrimination is as desirable, from society's point of view, as perfect competition, since the quantity produced is the same as in perfect competition. It is thus expected that, if properly rewarded, consumers would be willing to give up enough privacy to enable firms to use first-degree price discrimination. The question is, however, whether mutually advantageous disclosure is feasible, *i.e.*, whether consumers can be sufficiently rewarded to disclose enough information to guarantee higher profits for firms.

Considering the following model, we think that it is indeed possible. Figure 1 represents the demand function of a consumer for undifferentiated digital products.[3] We assume that, as it is the case with most digital product, the marginal cost is constant and is fairly low. In fact, the marginal cost is so low that it would not allow to cover the initial investment, we therefore assume that firms have some degree of monopoly power. In a perfectly competitive environment, market price would be equal to marginal cost. The consumer surplus would be the area ADF and the producer surplus would be equal to zero. Since we assume that firms have some degree of monopoly power, the market price p_m is higher than the marginal cost and the consumer surplus is the area ABC and the producer surplus is the area BCED.

If firms were able, through the usage of DRM, to collect enough information to create first-degree price discrimination, they would capture the whole surplus and the producer surplus would be ADF while the consumer surplus would be equal to zero. However, as exposed above, consumers are unlikely to accept such a change. Nevertheless, first-degree price discrimination would be possible if consumers were fairly rewarded for revealing personal information.

It can be assumed that consumers would be willing to reveal information as long as they obtain the same surplus as in the initial situation. Thus, provided that firms pay off an amount ABC to the consumers, the latter would be willing to use DRM systems that collect a large amount of information. In exchange for this payment, firms would be able to use first-degree price discrimination and would thus have a surplus equal to ADF. It is clear that firms would be better off, even though they paid off the consumers. After paying ABC, their remaining surplus would be equal to BCFD. In comparison to the initial situation, firms gain CFE. Therefore, it is possible to find a mutually advantageous trade between consumers and firms.

Figure 1 Demand and surpluses



It is possible to solve the problem caused by DRM in regard to privacy by establishing an incentive scheme that would lead to a mutually advantageous disclosure of information. In contrast to what happens nowadays, the information collected by the firms could lead to an actual first-degree price discrimination and this would occur with the consent of consumers. Since consumers would be compensated for the decrease in privacy, they would not have any reason to fight against DRM protected digital goods.

From a social point of view, rewarded disclosure of information would lead to a Pareto improvement over the monopolistic situation. Actually, the potential gain of firms is precisely equal to the deadweight loss caused by the imperfectly competitive environment. Furthermore, in comparison to perfect competition (for which there is no deadweight loss either), mutually advantageous disclosure allows firms to obtain a positive profit, thereby permitting initial investment sunk costs to be covered. Consequently, first-degree price discrimination with mutually advantageous disclosure is dynamically superior to perfect competition.

The problem of DRM and privacy can thus be solved by using first-degree price discrimination based on mutually advantageous disclosure. This solution, in addition to improving the welfare of both consumers and firms, also leads to a social improvement, in comparison to the oligopolistic environment, and outperforms perfectly competitive environment, since it allows initial sunk costs of the firms to be covered. The usage

of first-degree price discrimination matches well with the public nature of digital goods. Indeed, an efficient market for public goods requires each consumer to pay an amount equal to their marginal valuation for the digital good (Samuelson, 1954; Buchanan, 1965).

It is important to note that first-degree price discrimination is expected to be easier to set-up for digital products that are repeatedly consumed (such as music, software, video games) or are supplied by parts (TV shows). Thus this method may not be easy to use for products such as films or books. Also, consumers may value privacy intrinsically (and not just because of the increased market power gained as a result of the revealed information). In this case, the reward offered to the consumers might have to be higher than the (oligopolistic) consumer surplus. However, even in this case, the gains on the supplier side are likely to be sufficient for a mutually advantageous disclosure to happen.

5 Rivalness-based anonymous digital right management

As discussed in Section 2, two paths can be followed in order to address the piracy issue. DRM systems have, so far, followed the path of excludability. Since the *sine qua non* condition of excludability is to be able to exactly identify the users of digital goods, this raises privacy concerns. The second path, which is increasing the level of rivalness of digital goods, has been left aside.

DRM systems based on rivalness would have to ensure that one particular unit of digital good is consumed by at most one consumer at the same time. This would require the DRM system to be able to precisely identify each unit of digital good sold (each digital good could be encrypted and tagged with a unique identification code) and to centralise the usage of digital goods so that only one copy of a particular digital good would be used at a time. The software would contact the central server, before each consumption, to ensure that the digital good is not already being used. Since such a type of DRM would only require the digital good to be identified, and not the users, this would eliminate the privacy concerns since these DRM systems would be totally anonymous. Also, rivalness-based DRM systems would not at all prevent the copy of digital goods. On the contrary, consumers would be able to copy the original digital good as many times as needed (for backup purposes, but also onto the different device they own and use). However, since the ID-Tag would be embedded in each copy, the rival DRM system would ensure that only one copy of the digital good is used at the same time. In regard to privacy, rival DRM systems would be an adequate solution, since these systems would be designed to track the usage of a particular file and not the usage of a particular user.

Rivalness-based DRM would also have additional advantages. In fact digital goods are very peculiar public goods in the sense that, as opposed to the other public goods, they are non-excludable only because they are non-rival (Rayna, 2006). Indeed, digital goods always remain directly excludable (as opposed to a lighthouse that is both directly and indirectly non excludable) and become *de facto* non-excludable only because there are a significant number of consumers that are willing to share their digital goods with other consumers. When many consumers are willing to share, although digital goods always are directly excludable, the fact that they are indirectly non-excludable (firms cannot prevent consumers from copying digital goods from other consumers) makes them actually non-excludable.

Consumers are willing to share digital goods only because sharing does not deprive them at all from the potential consumption of these goods. If digital goods were made rival, it is certain that the consumers would not be willing to share them (besides the usual sharing that takes place among relatives, friends, *etc*., with any other durable private good) more than they are willing to leave their car out in the street with the door open and the keys in the ignition. Without consumers sharing, digital goods are fully excludable. Thus by adopting DRM that makes digital goods non-rival, firms are able to solve, at once, the problem of piracy and the problem of privacy. As a bonus, they alter the economic nature of digital goods and turn them into fully private goods (both rival and excludable).

Rival-DRM systems have another advantage over the traditional excludable-DRM systems, since they intrinsically impede the diffusion of illegitimate copies. Indeed, excludable DRM systems do not at all prevent consumers from sharing. In fact, since consumers who legitimately own the good are sure that, since their identity can be established, they will always be able to consume the good regardless of how many copies were made of this good. Higher excludability can even increase the propensity to share since consumers are more certain not to suffer from rivalness effects (Rayna, 2006). Of course copying a digital good protected by excludable DRM may seem useless since it cannot be consumed without a proper identification. Nonetheless, DRM systems are often hacked and ways to bypass these systems become known to the public on a regular basis. Due to excludability, legitimate consumers are willing to share digital goods, so their copies are widely available among consumers and, as soon as a hack is released, millions of non-legitimate users are able to consume these digital goods.

Contrariwise, DRM systems based on rivalness tend to limit the diffusion of illegitimate copies among consumers. Indeed, the more copies of a particular digital good are available on the internet, the less it is likely that the legitimate owner of this digital good will be able to consume it due to other consumers using copies of this good. It is thus expected that owners of digital goods protected by rivalness-based DRM will not share these goods with other consumers in the same way they usually do not share any other private good they own. Consequently, if a hack allowing to circumvent the DRM system is discovered, it is quite likely that this would only have a limited effect, since only legitimate users will be in possession of the digital goods. By the time the digital goods start to be spread among consumers, it is most likely that the designer of the DRM systems will have had enough time to update their software and invalidate the hack.

DRM systems based on rivalness also re-align the incentives of producers and consumers by transferring the burden of piracy to consumers. With the current DRM systems, based on excludability, consumers do not suffer from piracy (they may suffer indirectly, due to the insufficient production of digital goods that piracy might lead to, but this effect is so weakly correlated to their individual actions that it can be seen as an externality). Quite on the contrary, they benefit from piracy if more pirated digital goods are available, since they do not have to pay for these digital goods. The interests of the consumers are therefore aligned with the interests of the pirates and they do not have any incentive to act against piracy (and they have many incentives to help piracy, by diffusing digital goods and hacks); their interests are completely opposite to those of the firms). With rivalness-based DRM, the interests of consumers and producers are re-aligned, since, in this case, they both suffer from piracy (firms because of the decreased sales and consumers because of the inability to consume a good they own). If the digital good owned by a consumer were (accidentally or because it is stolen) made available on the

internet, this consumer would be eventually unable to consume this good, because of all the other consumers using a pirated copy. The fact that this consumer is the legitimate owner would not change anything, since rivalness-based DRM systems are fully anonymous.[4] It is thus expected that the general opinion of consumers in regards to piracy, which is at the moment rather lenient, would shift towards a much more repressive stance, since pirated digital goods would be as prejudicial for consumers as stolen cars or burglaries.

In addition, rivalness-based DRM systems are also expected to have an effect on pirating consumers. With the current DRM systems, a pirating consumer is either able to consume a downloaded pirated copy of a digital good (if the DRM systems can be bypassed) or not (if the DRM systems are fail-proof). Once the DRM system is bypassed, a pirating consumer can use the pirated good without restriction. In contrast, a consumer downloading a pirated copy of a digital good protected by rivalness-based DRM would be able to use this product without bypassing the DRM system. However, she would only be able to do so if nobody else were using the digital good or one of the copies of this good. As the number of consumers owning a pirated copy of the good grows, the consumer would not be, eventually, able to use the good at all, since there would always be someone else using it. If the consumer is willing to continue using the digital good, the only possible option (apart from downloading another pirated copy that would become, inevitably, as much used as the previous one) would to purchase a legitimate copy. The risk borne by consumers who pirate digital goods protected by excludability-based DRM is quite remote (since it is only related to a very hypothetical court appearance for copyright infringement). In contrast, the risk borne by consumers who pirate digital goods protected by rivalness-based DRM is large (it is quite likely that they will not be able to consume pirated digital goods when they want to, which is equivalent to not having these goods at all) and increases with the number of pirating consumers. Rivalness-based DRM are thus expected to strongly decrease the value of pirated digital goods and the value of piracy, in general.

From a social point of view, rivalness-based DRM would turn digital goods into fully private goods. Although this would certainly improve the situation on the market of digital goods, this would not allow for an efficient market allocation to take place, due to the necessity to introduce some degree of market power for the producers, so they can recover their initial investment.[5]

In practice, rivalness-based DRM might be more difficult to design than the current DRM systems. Ideally, rivalness-based DRM systems would require collecting information in real time about the usage of all copies of protected digital goods. Although this is achievable for digital goods that are consumed using a personal computer or a mobile phone, since they are connected to internet or a network, this is more difficult to accomplish for the non-connected devices, such as portable digital media players (iPod, Playstation, *etc*.). Nonetheless, almost all digital electronic devices are connected (for update, maintenance purposes or to add content) on a regular basis to the internet. While this would not permit to prevent multiple simultaneous uses of the same digital good, the consumption of digital goods on these devices could be recorded and uploaded to the central server each time the device is connected to the internet. A punishment mechanism could be then set-up: when the information compiled shows that a particular digital good has been consumed on more than one device at the same time, the consumers could then be prevented from using this digital good (or other digital goods, in the case of goods that are consumed only once) for a certain period of time.

6 Conclusion

The decrease of privacy caused by DRM is a serious issue, since it slows down the adoption by the consumers of the DRM technologies, even though a very large adoption is required to win the fight against piracy. This article presented two outlines of solutions that permit a coexistence of fight against piracy and respect of privacy.

Two possible answers to this problem are either to keep the current DRM technology, but to reward customers for disclosing their personal information, or, alternatively, to establish anonymous DRM, by making digital goods rival in consumption. The suggested solutions can be then individually tailored depending on the nature of digital goods (*e.g.*, films, music, books, *etc*.) and the strategies used by firms. Whichever solution will be adopted by the companies, a serious change of strategies is needed for DRM to be used to its fullest potential.

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Notes

1 One could also argue that the DRM systems could be designed to collect information beyond the consumption of protected digital goods. In the same way as internet cookies are often used to collect (and store) information additional to the information related to the usage of a particular website, DRM systems could also collect information about unprotected digital goods, digital goods protected by other DRM systems, *etc*.

2 The most used DRM system nowadays, Apple's FairPlay, requires digital goods to be activated only once per device. If the consumer uses just one device, the only information revealed is that this particular consumer has indeed purchased this particular digital good. This is nothing more than what is revealed when purchasing a CD with a credit card.

3 Without changing the results of the model, it can also be seen as the demand functions of all consumers for a particular digital product.

4 It can still be expected that the designers of the DRM system could, at the request of the legitimate owner, invalidate all the copies made of a particular digital good and provide the legitimate owner with a new digital good with a different ID-Tag. Designer of DRM systems could even charge for that.

5 This is the usual trade-off between static efficiency and dynamic efficiency (Arrow, 1962).

White Knight or Trojan Horse? The consequences of Digital Rights Management for consumers, firms and society (*)

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Abstract: Due to its ability to solve all main problems associated with digital goods, Digital Rights Management is the favourite option used by companies to tackle piracy. The aim of this article is to discuss the consequences of DRM for consumers, firms and society. The rationales of DRM are discussed and the expected benefits for firms are presented.. In contrast, consumers are shown to be likely to see few benefits in DRM. This article demonstrates that even a standard DRM system is unlikely to improve social welfare. The article concludes with some public policy recommendations.
Key words: Digital Rights Management; Digital Goods; Piracy; Excludability; Durability; Sampling

The content industry is, especially since the appearance of the digital goods, one of the fast growing and innovative industries. However, the growth and viability of the companies in this industry are seriously undermined by the extent of consumer piracy, which seems to be, in addition to innovation, the main characteristic of this sector. One of the most common solutions to fight against piracy and enforce intellectual property rights is the introduction of Digital Rights Management (DRM) technologies.

The purpose of Digital Rights Management is to help content creators protect the content from uncontrolled use and distribution. DRM systems work in such a way that any action of the consumer that is not explicitly authorised by the producer is, by default, prevented. As such, these systems

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allow to prevent the copying, sharing, as well as the simultaneous use of digital goods. Furthermore, DRM systems make the anonymity of consumption impossible since they require a formal identification before protected digital goods can be consumed. Supporters of DRM believe that DRM can provide a secure distribution of digital content. As a side effect, DRM can allow the firms to gain some additional strategic advantages (switching costs, consumers lock-in, barriers to entry, absence of second-hand market, collection of information on the consumers' behaviour) and can also help the firms appropriate extra revenues (DRM allows the firms to charge the consumers several times for the usage of the same digital goods at different locations e.g. home, work, car).

The opponents argue that DRM is not very effective in preventing piracy, but can prevent the legitimate users to take the full advantage of the digital media. The Foundation for a Free Information Infrastructure notes that DRM can act as a trade barrier. There is also a view that DRM can prevent future historians from recovering the necessary data due to the variety of technology required to read the data. Finally, the DRM opponents state that DRM infringes private property rights and very often restricts user's activities. The other problem associated with the DRM is that, since there is no standard for DRM and no compatibility between the existing systems, it causes additional problems for the consumers, the firms and eventually for the society.

The aim of this article is to discuss the consequences of DRM for consumers, firms and society. First, the rationales of DRM are detailed. This is followed by an analysis of the strategic advantages created by DRM and the possible limitations. The issue of the impact of DRM on consumers is then assessed. Finally, this article conducts an in-depth study of the consequences of DRM on social welfare and recommends some policy changes as well as some improvements of the DRM strategies of firms.

The rationales of Digital Right Management

Digital goods are goods that are distributed in digital format (i.e. encoded in binary form, as a succession of 0s and 1s). Nowadays, most entertainment goods (such as music, movies, computer games and books) and also a large number of professional tools (software, documentation, stock pictures) are digital goods.

Due to their digital nature, all these goods have a common characteristic: they are replicable. Indeed, digital goods can be copied without loss of quality or information. Therefore, a copy of a digital good is a perfect replica (a clone) of the original. As a consequence, digital goods are independent from the medium used to distribute and store them. More precisely, the binary form used for encoding them ensures that these goods can be transferred from one medium to another without loss of quality or information.

The digital nature of digital goods has important consequences in regard to the economic characteristics of these goods. First of all, their replicability makes digital goods both public and durable. Secondly, the economic value of digital goods lies in the content embedded in these goods. As this content is either information, culture or entertainment, digital goods are experience goods.

These three economic characteristics are expected to lead to important challenges for the firms that produce digital goods. First of all, the public nature of digital goods is likely to lead to a free-riding behaviour of consumers (Ramello, 2005). The inability of firms to exclude consumers leads to a wide piracy phenomenon and, thus, undermines their ability to make profits and recover the initial fixed cost of production. Moreover, digital goods have common characteristics with ideas, information and innovation. All these types of good are also known in the literature as leading to market failure because of their nature. The usual argument (Arrow, 1962; Nordhaus, 1969; Aghion and Howitt, 1992) is that, in the absence of a proper protection system, the market fails to produce a sufficient quantity of these goods. This is due to the fact that, since the replication cost for these goods is negligible, the marginal cost of such goods is equal to zero. Therefore, in a competitive environment, the price of these goods is expected to equal zero.

Secondly, the potentially infinite durability of digital goods deprives firms from the large amount of revenues they used to enjoy because of the renewed purchase of consumers. Its important to note that sales are further decreased by the universality of digital technology and the perfect replicability: consumers are now able to use the same unit of digital good with various devices: Hi-Fi, computers, MP3 players, etc., whereas before the advent of digital technology, several purchase could be required in order to obtain an optimal quality (e.g. consumers could have to purchase both a vinyl and an audio tape of the same album).

Finally, the fact that digital goods are experience goods makes consumers reluctant to purchase these goods before they are able to experience them and determine their value. As a consequence, firms have to supply consumers with samples of the digital goods. If they do not do so, consumers may be encouraged to conduct their own sampling activity by pirating. In this case, they are very unlikely to be willing to pay for a legitimate version of the digital goods once the good has been experienced. However, providing consumers with samples is not always an easy option. Indeed, firms need to ensure that the consumers are only able to consume the sample a small number of times, as otherwise consumers will probably decide to not purchase the product. For some digital goods, it may be possible to offer, as a sample, a truncated/stripped down version of the digital good (as it is often the case with electronic books, films and software). Nevertheless, such a strategy may cause consumers to underestimate the value of the digital good, thereby reducing their willingness to pay. In addition, the value of some digital goods, such as music, is unlikely to be revealed by partial sampling, and may even require repeated experience.

These three economic characteristics of digital goods raise a serious challenge for government and policy makers: without public intervention, the number of market failures and the resulting loss of social welfare are likely to be very high. The usual solution to this type of problems is the use of intellectual property rights, which can help to safeguard creator's award (Mergers and Nelson, 1990). However, although IPRs may act as an efficient deterrent in the case of inventions, they do not have much effect in the case of digital goods, because of the massive scale of piracy phenomenon (Rayna, 2006a).

Digital Right Management systems

The purpose of Digital Rights Management is to help content creators protect their products from uncontrolled use and distribution. As opposed to enforcement of IPR, which occurs after the infringement (and is thus punitive) has occurred, DRM aims at preventing the infringement from initially taking place (and is thus preventive). The DRM protection is embedded into the digital good itself and consists of encrypting the digital good, which can therefore not be consumed without being decoded first. The DRM tags embedded in the file contain precise information about the owner of the file and the rights of usage this owner has. For example, in order to be played on a computer or on a media player, a music file protected by DRM

has to be activated. The activation is made by contacting a central server on the internet. The consumer is then asked to identify herself, and this information is compared with the owner's information included in the file. If the authentication is confirmed, the computer receives a key allowing to decode, and play, the music file. In addition to the decoding key, data containing instructions about potential restrictions may be transmitted to the computer. Indeed, DRM systems allow to restrict the number of times the music file is activated, so that consumers cannot consume the same music file on more than one computer at the same time, it can also prevent the file from being copied/transferred, or exported, more than a certain number of times.

The most popular (in terms of usage) DRM technology, at the time of this writing, is FairPlay which was created by Apple and is used by its products and services, such as iPod, iTunes and iTunes Store. The files protected by FairPlay can only be played on authorised computers and at most five computers may be authorised at the same time. Consumers can, however, burn their music files on CDs which will have legal, but not physical restrictions. Yet, a particular playlist can only be burnt up to seven times, though the overall number of burns is not limited. The main issue related to FairPlay is that, because of Apple's refusal to licence its technology, songs purchased from iTunes Store can only be played on Apple's iPod media player (although they play on any Windows or Mac computer) and the only DRM protected songs compatible with iPod are the ones purchased from the iTunes Store. Despite these limitations, this technology is the most used one, certainly owing to iPod's 80% market share in the market for portable media players. Since the introductions of films, video clips and TV programmes on the iTunes Store, FairPlay technology is also available to protect video content.

Other DRM technologies are much less popular and are (by order of popularity): Microsoft's PlayForSure, RealNetworks' Helix, Sony's ATRAC. These three DRM systems are able to protect both audio and video files. These technologies allow to establish similar restriction as Apple's FairPlay.

Both Microsoft and RealNetworks licence out their technologies. There are still, however, some restrictions. Microsoft PlayForSure only functions on Windows and RealNetworks Helix has to be used in conjunction with their Real's content distribution server. Like Apple, Sony has refused to licence out its ATTRAC technology and is, to this day, the sole user of this system. Microsoft recently adopted a similar approach, since they developed a new

DRM technology (used by the new portable media player Microsoft Zune) that they have decided not to licence out.

Digital Right Management as universal solution?

Although Digital Rights Management systems were primarily developed as a solution to piracy (and thus addressed the problem caused by the publicness of digital goods), these systems also provide a solution to the problems caused by durability and uncertain *ex-ante* value of digital goods.

With regard to the publicness of digital goods, DRM enables to increase the excludability of digital goods, and thus to reduce (or eliminate) piracy. Since DRM protection requires an authentication for the digital good to be consumed, a consumer able to obtain a pirated copy of the good is unable to consume this digital good unless it is activated. Since the activation is granted by firms only, this means that DRM restores the excluding capability of firms. To this respect, Bomsel and Geffroy (2006) note that "[...] DRMs are intellectual property institutions [and] transpose the empirical principle of copyrights [...] into the digital era". In fact, although DRM and IPR defend the same rights, DRM is superior to IPR laws, since it prevents copyright infringement and does not bear additional costs (such as litigation costs)(Rayna, 2006a). IPR laws, on the contrary, can only be used after the infringement has occurred.

In terms of durability, DRM allows the firms to control the life span of digital files. It is indeed possible to restrict the consumption to a fixed amount of time. Although firms do not usually sell "short-lived" digital goods, DRM also created the possibility to rent digital goods instead of selling them. Without DRM, renting digital goods online is obviously not a feasible option, since the consumer would still be able to enjoy the digital good (or a copy of this good) even without paying the rent. DRM enables firms to set up a time period after which the good will not be playable anymore unless the authorisation is, once again, granted. This ability to rent is extremely important for firms. Indeed, the main consequence of durability is that it reduces the market power of the firms and leads them eventually to sell at the price equal to marginal cost (Coase, 1972; Stokey, 1981; Bulow, 1982, 1986).

In regard to durability, DRM also allows to make digital goods, which are potentially infinitely durable, as obsolete as the hardware which is used to

play/execute them. Indeed, DRM systems are such that the consumption of a protected digital good is authorised on a particular piece of hardware (a computer, a portable media player, etc.) that is identified by a unique number. If this hardware is replaced by a new one and the digital goods stored on the old hardware are transferred by consumers onto the new hardware, these a new authorisation will be required in order for the goods to be played. Firms are thus able to charge consumers each time they change their hardware. As such, DRM prevents digital good from having a higher durability than hardware. Since most electronic devices have a life expectancy of, at most, three years, DRM systems ensure a constant and sustained demand for digital goods instead of a constantly decreasing one, as it is the case with durable goods.

Finally, DRM makes it possible for the firm to use sampling for digital goods. First of all, sampling is made possible since firms can set-up a free trial period of the digital goods, enough for the consumers to assess the value of the goods, after which the consumption is made impossible without authorisation (and payment). In addition, DRM enables firms to design fine-tuned sampling: since DRM requires a formal identification of consumers, a per-user sampling system can be designed. This ensures that the trial period, the length of which is based on the tastes of each consumer, is long enough for the consumer to fully assess the value of the product, but short enough to keep the incentive to purchase the product.

All economic characteristics of digital goods tend to lead to a decrease in the demand for legitimate digital goods. Because of its ability to enforce excludability and to make renting and sampling practical, DRM allows to restore the demand for legitimate digital goods. In addition, since DRM enables fine-tuned sampling and expands the marketing options; it is even likely that it will *in fine* lead to an increase of the demand for legitimate digital products.

It is important to note that, although DRM provides firms with important advantages, it also has some important limitations. First of all, only a minority of digital goods is nowadays protected by DRM, and for any digital good protected by DRM, it is still possible to purchase the same digital good in an unprotected format.

The second important limitation, which is linked to the previous one, is that all existing DRM systems have been cracked, and patches allowing to remove the protection can be downloaded on the internet. Even if that were not the case, as long as protected digital goods can be transformed in an

unprotected format (it is the case with most DRM systems since they allow to burn the downloaded protected digital goods on CDs or DVDs) piracy is made possible. Ultimately, the rule of thumb is that as long as it is possible to see or to hear a digital good, it is possible to copy it (for example, many computer programmes are nowadays able to intercept the video and/or audio signal sent by the computer to the monitor and/or to the speakers when a protected digital good is played, and to create an unprotected file from this signal).

A third shortcoming of DRM is the absence of standard and the incompatibilities between DRM systems. This is indeed likely to slow the adoption of DRM protected digital goods by consumers, since they are aware of the switching costs created by DRM.

Digital Right Management and consumers

From the consumers' point of view, DRM decreases consumer welfare, because it enables firms to charge a price above marginal cost. Although consumers may anticipate that this short-run loss of welfare may be later compensated by an increase of welfare caused by an increase in the quality and variety of the goods supplied, the restrictions usually imposed on the consumers by the DRM systems make it likely that consumers will avoid, as much as possible, consuming protected digital goods.

First of all, DRM can remove some of the characteristics that are normally associated with digital goods. DRM makes protected digital products inferior to the non-protected ones, for instance e-books or protected audio files cannot be lent and it might be not possible to make a backup copy. In addition, as discussed above, DRM systems remove the ability to resell digital goods and reduce their universality and durability.

This is likely to have important consequences, since consumers still have a possibility to access digital goods, legally or illegally, that are not protected by DRM. For example, Audio-CDs are not protected by DRM. In contrast to a protected audio file, the content of a CD can freely be transferred to many devices (computers, portable media players, etc.). The consumer is able to lend the CD, to make backup copies of the CD. The good is thus infinitely durable and fully universal. Regardless of the new standards and new devices being created in the future, the owner of a CD is certain to be always able to consume the music recorded on this CD. When the consumer

is not willing anymore to consume this particular CD, it can be sold on the second hand market.

Likewise, there are important differences between the films protected by DRM and the films distributed on DVD-Video. Although DVD-Video cannot, theoretically, be copied (widely available software still allows to easily bypass the copy protection), they can be lent and resold. Their durability is also high, and they can be used on any compatible device. Similar examples can be found for most digital goods.

This lack of features, in comparison to unprotected digital goods, means that consumers are unlikely to be willing to pay as much for protected digital goods as for unprotected ones. As a matter of fact, protected digital goods are often sold at a cheaper price than unprotected ones or than their physical equivalents. Nevertheless, in addition to the loss of value created by the presence of DRM, digital goods sold online often have additional differences with the other digital goods. For example, music and movies sold online are heavily compressed, which causes a sharp decrease in quality, as opposed to the same good being distributed on a CD of DVD. This means that, for consumers, digital goods protected by DRM may have much lower value (since they have fewer features and a lower quality) than the equivalent unprotected ones. Yet, the difference in price between these two types of digital goods is often rather small.

It could still be argued that protected digital goods bring extra value to the consumers because of their fast online access and their low transaction cost. Although this is undeniable, consumers also have access to unprotected digital goods that have similar features: pirated digital goods. These digital goods also are available online for a low transaction cost. In addition, they are available for free. Moreover, their determinant feature from the consumers' point of view is that they do not have any of the restrictions created by DRM.

Thus, consumers are facing a dilemma. If they want to access digital goods online, they can either choose DRM protected files, which are legal, but have a low value due to the restrictions of DRM, and a comparatively high price or they can download pirated digital goods, which are illegal, but have no restrictions, and are available at no cost. It can even be argued that law-abiding consumers are, in a way, "punished": although they do pay for their digital goods, the digital goods they obtain have fewer features and involve tedious authorisation process. In contrast, consumers who decide to pirate obtain full-featured digital goods, for free.

Another important consequence of the presence of DRM for consumers is the absence of secondary market. Indeed, digital goods are, for most of them, experience goods: their value is, for consumers, uncertain and only becomes known after at least one episode of consumption and, sometimes, only after many episodes. The durability of digital goods usually makes up for this uncertainty. Since the digital good is durable and can be sold on the second-hand market, the consumer is able to recover at least part of her initial spending if the good is revealed to be unsatisfactory or not to her taste. However, the absence of second hand market removes this possibility and increases the potential loss of consumers who are thus expected to be even more reluctant to spend money on digital goods that they did not experience. Thus, by preventing the existence of secondary market, DRM makes the existence of sampling even more critical.

Unfortunately, in spite of the great potential improvements brought by DRM in regard to sampling, little has been done, so far, by firms to take advantage of this feature. Regardless of the type of digital good, the samples offered by the firms are very much alike what existed before the introduction of DRM. For example, the iTunes Store offers 30 seconds sample for music; films samples still rely on trailers/teasers of 30 seconds to one minute; software samples are still either limited in time or in terms of features. Despite of the fact that DRM makes it possible to personalise and tailor sampling for each consumer and each type of digital good, the same sampling strategy is used for all consumers and all digital goods.

Since one of the main motivations of consumers for downloading pirated digital goods is sampling, chances are that, unless a proper sampling strategy is used, consumers will be even more incited to pirate.

Overall, it is important to note that DRM is expected to increase consumer piracy, because of the lack of features of protected files, the increased risk brought by the absence of second hand market and the insufficient sampling. This is indeed a paradox, since the very goal of DRM is to reduce piracy.

Digital Right Management and society

In regard to social welfare, although DRM may lead to an improvement, it does not completely solve the economic problems caused by the nature of digital goods. Indeed, because the marginal cost of digital goods is close to

zero, so should be their market price in order to achieve static efficiency. However, dynamic efficiency requires the price to be above marginal cost, as otherwise the initial fixed/sunk costs could not be recovered and few, if any, digital goods would be produced. Thus, due to the nature of digital goods, it is not possible to actually achieve a total efficiency. There is always a trade-off between static and dynamic efficiency.

From society's point of view, the challenge raised by DRM is thus quite similar to the usual trade-off between static cost and dynamic efficiency that applies to any good protected by intellectual property rights. The three particular characteristics of digital goods (they are public, durable and experience goods) cause the competitive market price for digital goods to be extremely low, thereby leading to underprovision of digital goods. By allowing firms to fully exclude consumers, reduce the durability of digital goods, and enable adequate sampling, DRM permits firms to charge a price significantly higher than the marginal cost of producing digital goods. Although the positive economic profits are expected to provide firms with sufficient incentives to produce digital goods, hence solving the underprovision problem, the high price tag of digital goods excludes consumers, who would have otherwise found worthwhile purchasing the goods, from the consumption of digital goods. Thus DRM may solve the problem of underprovision of digital goods, but this comes at a cost: underutilisation will appear, and the role of governments is to ensure that the level of protection of digital goods is such that the right trade-off between these two issues takes place.

An important problem for governments is the multiplicity and incompatibility of DRM systems. DRM has a very low (or non-existent) level of interoperability as digital good protected by a particular DRM system can only be decrypted by hardware or software compatible with this DRM system. As DRM only allows compatible files to be played by a certain technology, it might lead to anti-competitive and even monopolistic behaviour. Furthermore, as there is no interoperability between DRM technologies, the switching costs are high and consumers are often locked in one particular DRM technology. The current situation is quite different from other industries, where special bodies ensure that established standards are not only based on self-interest.

The issues associated with interoperability, in general, have been of vital importance over decades now. Companies constantly release new technologies and thus create a need for standards; if not for the common protocols and data, it would have been impossible to exchange data, and

therefore information, using new technologies. One way to achieve interoperability is through standards. Standards make coordination and cooperation easier as they create similarities between otherwise different organisations (Brunsson and Jacobsson, 2002). They can be used as "external points of reference" when there is a need to assess the performance or quality of a product or a service (Leiss, 1995). Moreover, Zhu et al. (2006) discuss the "excess inertia" phenomenon when older standards prevent the shift to new standards through creating switching costs. The issue of the switching costs introduced by incompatible DRM technologies is even more crucial, since switching costs are considered to be even more important in networked environment (Arthur, 1996; Shapiro and Varian, 1999; Hax and Wilde II, 1999). Moreover, switching costs are higher when there is no interoperability and consumers need to switch between different standards and lower when consumers switch within one standard, therefore consumers are more locked in the same product or service when there are several competing standards.

Interoperability can be increased, and switching costs decreased, if the same DRM technology is adopted by several market players. Unfortunately, none of the major DRM systems is universal enough to lead to a large adoption. There is thus a strong need for an universal DRM technology.

Several attemps have been made to develop universal DRM systems that would make the exchange of content between different DRM platforms possible. However, none of these universal systems managed to reach a significant market share.

Thus, besides the question of whether the concept of DRM can improve social welfare, it is clear that a minimum requirement for DRM to be socially desirable is the existence of a standard and open DRM system. Open and universal standards such as the ones developed by the W3C (World Wide Web Consortium, organisation in charge of the standardisation of the technologies used on the Web), played a determinant role in the development, growth, and adoption of the internet. The absence of standards makes the market environment less competitive and therefore customers are offered fewer choices in terms of products compatible with a certain standard and in terms of payment packages.

However, even assuming that a universal DRM system existed, the positive effects of DRM on society are quite arguable. Indeed, the assumed positive effect of DRM lies in its ability to prevent piracy. Nevertheless, piracy is always possible as long as non-protected digital goods are

available. Not only is it still the case nowadays, but it is even likely that it always will be. So far, all DRM and anti-copy systems have been cracked and consumers have been able to remove the protection from protected digital goods. In addition, it takes only one leaked unprotected copy of digital good to start a whole stream of piracy. DRM is expected to hinder piracy by preventing consumers who purchased digital goods from sharing these goods with other consumers. However, as long as other unprotected sources are available, it is quite arguable that DRM has any effects on piracy at all. In fact, there is currently no empirical proof that the introduction of DRM, a few years ago, had any effect on consumer piracy. Quite on the contrary, piracy rate has kept increasing.

The fact that DRM has not made the access to pirated digital goods more difficult, means that the pirated digital goods still have, from the consumers' point of view, the same value as before the introduction of DRM. In contrast, as discussed in the previous section, the restrictions introduced by DRM are likely to have reduced the value of legal digital goods. If only these two types of digital goods (unprotected/pirated and protected/legal) were available, the introduction of DRM would undeniably have decreased social welfare, since the situation of pirating consumers would be unchanged, while that of law-abiding consumers would worsen due to the lower value of digital goods. In addition, resources would be used to develop and maintain the DRM system.

However, at the moment, non-DRM-protected digital goods, such as Audio-CDs, are still available to consumers. As mentioned above, these goods have a greater value than protected digital goods, since they are full-featured, but are also expected to be sold at a higher price. In this case the introduction of DRM is nothing more than a hidden form of versioning. By offering DRM-protected digital goods at a lower price than unprotected digital goods, firms attempt to capture additional consumer surplus through second-degree price discrimination. The goal is to lure the consumers with a medium reservation price for digital goods (e.g. consumers who were either pirating or not consuming, but, in any case, were not buying legal unprotected digital goods), into purchasing digital goods. However, such a strategy is successful in increasing the demand for digital product only if consumers with high reservation price (e.g. consumers that were beforehand paying for legal unprotected digital goods) are put-off from consuming DRM-protected digital goods. Hence the restrictions and lower quality introduced. DRM protected digital goods are, in fact, "value-substracted versions" (Shapiro and Varian, 1999).

Although second-degree price discrimination is not, *per se*, expected to decrease social welfare, the small number of version offered (three) makes it unlikely to allow for a social welfare improvement. Furthermore, the introduction of lower quality digital goods is, in the case of DRM, not neutral, since (as it is often the case with information technologies) introducing value-substracted versions is actually costly. Indeed, the cheaper option for firms would be to distribute full-featured legal digital goods. DRM systems are costly to develop and to maintain, especially once taken into account the actions of hackers that force DRM systems developers to upgrade their systems on a continuous basis. Although value-subtracted versions may allow firm to obtain higher profits, the cost of development and maintenance of DRM systems and the fact that DRM leads, at best, to a gross second-degree price discrimination, makes DRM systems (at least in the way they are developed and used nowadays) wasteful and socially undesirable.

A final source of concern is that DRM creates privacy issues that have to be dealt with. Not only DRM technology is used to collect personal information, but also, very often, does it without the knowledge of the parties concerned. This characteristic of DRM undermines ethical values and expectations of the public.

Conclusion

This article showed that Digital Rights Management is, *a priori* a very interesting concept, since it is supposed to solve at once the three main problems associated with digital goods. Indeed, DRM enables firms to fully recover their excluding power (thereby making digital goods private), to reduce the durability of digital goods and to use sampling (thereby making the true value of the good known to consumers).

Although DRM theoretically provides firm with important advantages, it has, in practice, serious limitations. Among them, the fact that many non-protected digital goods are available to consumers is certainly a crucial one. This article also emphasises that all DRM systems have so far been eventually “cracked” and that consumers are able to remove the DRM protection. To this respect, consumers are shown to have very little incentives to favour DRM protected digital goods over non-protected ones. In fact, the restrictions introduced by DRM strongly decrease the value of digital goods, making protected digital goods very poor competitors in comparison to unprotected digital goods (both legal and illegal).

From a social point of view, it is shown that, although DRM may, in theory, permit an efficient provision of digital goods, the absence of standard among DRM systems and their incompatibilities are likely to decrease social welfare even further. In addition, as long as unprotected digital goods are still available, DRM is unlikely to prevent, or even diminish piracy. In fact, it is demonstrated that the introduction of DRM is not expected to increase social welfare, even in the case when one standard system exists. The main effect of the advent of DRM is that it provides firms with the ability to price discriminate consumers. However, since this price discrimination requires a costly reduction of the quality of digital goods, it is obvious that it is expected that DRM systems are wasteful and socially undesirable.

Overall DRM helps companies to strengthen their market position. DRM can be a useful tool to create corporate value, however, as any tool it may have a destructive power as well. The problematic issues associated with DRM, such as anti-competitiveness, privacy, etc. make it very challenging for companies and governments to balance corporate and public interests.

In terms of public policy, it is clear that the establishment of a standard and universal DRM system is a minimal requirement. Other social (and corporate) improvements could be brought by rethinking Digital Rights Management. It is thought that DRM more often stands for Digital Restrictions rather than for Digital Rights Management. “R” should stand for rights, not for restrictions. Instead of stripping digital goods of their distinctive positive features, firms using DRM should instead increase the value of protected digital goods. So far, law-abiding consumers are punished for their honesty: the digital goods they pay for have fewer features than pirated digital goods. Such consumers should, on the contrary be rewarded. It is clear when examining the current DRM policies used by the firms that they do not use DRM to its full potential, but merely as a way to capture additional surplus from honest consumers, who end up paying for pirating consumers. DRM is a very powerful tool, and it could enable firms to achieve near-first degree price discrimination. But this would certainly require a complete rethinking of firms marketing and pricing strategies.

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Understanding the Challenges of the Digital Economy: The Nature of Digital Goods

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Abstract: This article investigates the economic nature and characteristics of digital goods. Such goods are, due to their replicability, shown to be public goods (albeit in an evolutionary way) and durable goods. Furthermore, the content of such goods, combined with their durability, makes them experience goods. While only one of these characteristics would be sufficient to create difficulties for producers and lead to market failure, this article demonstrates that each of the characteristics reinforces the other. The framework presented in the article is then applied to two important issues: the new trend of massive consumer piracy and the overall problem of value of digital goods.

Key words: digital goods, public goods, durable goods, experience goods, piracy.

The last decade has seen the advent and growth of two strongly linked phenomena which have led to important changes in the worldwide economy. The first is the development of the digital economy, based on the digitalisation of previously existing goods and on the development of new purely digital goods. This technology has not only permitted the creation of many new goods or services, but has also dramatically changed the way an entire category of goods in the economy are created, produced, distributed, exchanged and consumed. Digital technology has caused a drastic decrease in reproduction costs and distribution costs (and even, sometimes, in initial production costs), thereby leading to important structural changes in the economy and potentially a global rise of social welfare, due to the increase in quantity, quality and variety of goods and services available in the economy. While originally restricted to a few types of good (software, mostly), the scope of use of digital technology has progressively increased to encompass many kinds of goods: music, films, photos, books, etc.

The second phenomenon, which has followed the same increasing trend as the first, is the development and generalisation of consumer piracy. Although consumer piracy has always existed and had already become an important issue since the release of early consumer-oriented duplicating technologies, the piracy phenomenon has never been as strong as it is

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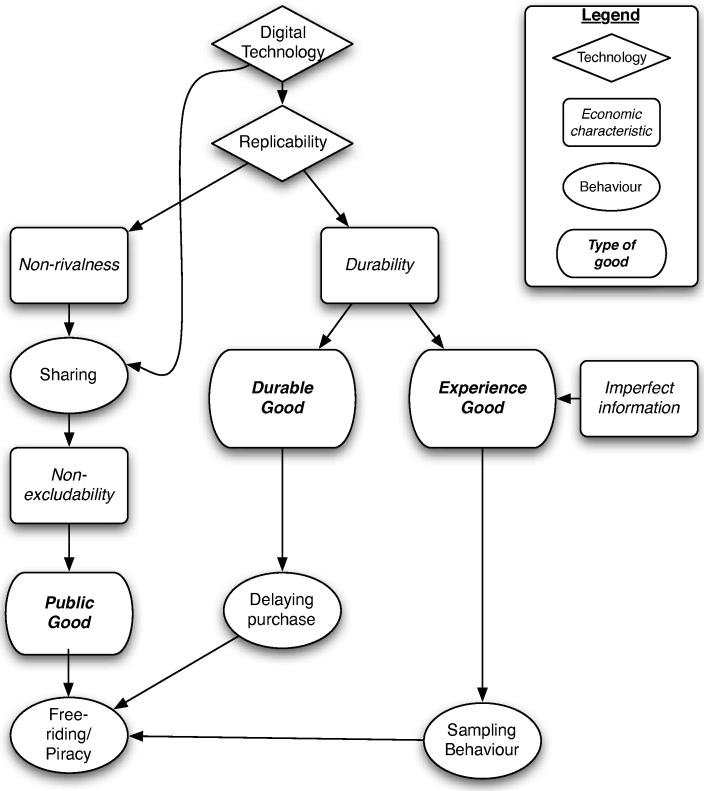
nowadays. Furthermore, none of the many attempts (legal and/or technological) of firms and governments has been able to curb piracy. The link between these two phenomena is clear, since, nowadays, consumer piracy is almost entirely related to digital goods. In fact, the benefits created by digital technology, in terms of distribution and reproduction costs, have been brought to the economy as a whole, thereby allowing the consumers to reproduce, distribute and exchange digital goods (virtually) without incurring any cost. The overall effect on the economy of digital technology is, thus, ambiguous. On the one hand, it has enabled a strong potential growth. On the other hand, consumer piracy endangers firms, since it undermines their ability to recover initial investment. In fact, beyond the sole problem of consumer piracy, digital technology has greatly affected the way companies do business. While some traditional business models have revealed themselves as unsuitable (e.g. paid directory services), firms have had to find new ways to appropriate returns on investment and have increasingly relied on personalisation and indirect funding (e.g. advertisement) (SHAPIRO & VARIAN, 1999).

The thesis developed in this article is that the challenges brought by the advent of the digital economy can be more easily apprehended once the economic nature of digital products has been examined. While it has often (wrongly) been said that traditional economics do not work within the context of the digital economy and that 'new economics' are needed, this article aims to demonstrate, that, on the contrary, sound economic concepts can be used to explain and comprehend the challenges brought about by digital technology. The arguments developed in the article aim to demonstrate that, because of their digital nature, digital goods are fully replicable (can be copied without loss of quality or information). This results in the following fundamental economic characteristics: digital goods are public (1st Section) and durable (2nd Section). These two characteristics are important, since they are known, in the literature, for the loss of market power they induce for the firms that produce such goods and for the market failure they may entail.

In addition to these two fundamental characteristics of digital goods, which exist regardless of the content of the goods, this article considers a third feature. The content of a digital good may be such that its actual value can only be fully realised once the good has been consumed. Thus, in addition to being public and durable, some digital goods are also experience goods (3rd Section). In this respect, it is important to note that, while not a defining characteristic feature of digital goods, many digital goods are, due to the nature of their content (music, films, books, etc.), experience goods.

Figure 1 - The economic nature of digital goods: how technology, characteristics and behaviour interact



Some of these characteristics have been recently discussed in the literature. VARIAN (1998) and SHAPIRO & VARIAN (1999) discuss the consequences of information goods being experience goods. Furthermore, VARIAN (1998) discusses the public aspect of information goods. SHAPIRO & VARIAN (1999) also, briefly, mention the durability of information goods. However, these works are devoted to the study of information goods and, while digital goods *are* information goods (since they are composed of a stream of 0s and 1s) not all information goods are digital goods. The scope of these works is, thus, broader and less specific than the one of this article. Furthermore, a large emphasis in SHAPIRO & VARIAN (1999) is put on the strategies firms can develop to remain successful in the information economy and the economic nature and characteristics are mentioned solely as a support of these arguments. QUAH (2003) analyses in detail the public nature of digital goods and investigates the issue of efficient private

provision of such goods. The novelty of the analysis presented in this article lies in its acknowledgement that the three important economic characteristics of digital goods have, not only similar roots, but also interact with each other (Fig. **Error! Reference source not found.**). Instead of studying each element separately, a combined analysis of these three main features of digital goods is conducted in order to fully comprehend the challenges raised by digital goods for both firms and policy makers.

After introducing each of the characteristics (1st to 3rd Sections), the 4th one revisits the issue of consumer piracy in the light of the analysis conducted in the previous sections. Finally, we investigate how the three characteristics interact and how this interaction affects the value of digital goods.

Digital goods are public goods

Public goods [1] are defined as goods that are both non-rival in consumption and non-excludable (SAMUELSON, 1954; BUCHANAN, 1965) [2]. A good is non-rival in consumption if the consumption activity of each consumer does not decrease the quantity of good available in the economy. A good is non-excludable if no one can be prevented from consuming it. Public goods hold a particular place in the economic literature. The first reason for that is that, until recently, such goods were considered as extremely rare, so rare, in fact, that they were little more than a curiosity. Besides goods such as street lighting, lighthouse and nuclear deterrence, all goods in the economy display at least some degree of rivalness and/or excludability. The second reason is that public goods are the only cause of market failure that cannot be corrected by appropriate market mechanisms and, therefore, require public intervention to be produced at a socially satisfactory level.

Indeed, the non-excludability property of public goods leads consumers to adopt a free-riding behaviour (SAMUELSON, 1954; BUCHANAN, 1965),

1 The economic literature distinguishes between the nature (private/public) of a good and the way (privately/publicly) it is provided. The fact that a good is provided privately does not mean that it is not, by nature, public. Likewise, most goods provided publicly (education, health) are, by nature, private.

2 Public goods are, thus, the exact opposite to private goods, which are both rival in consumption and excludable.

as they are able to enjoy the good even if they do not contribute to its provision. Thus, they do not have any reason to pay for the good or, when the provision is organised through a governmental action, to reveal their actual valuation of the good. Moreover, this free-riding behaviour is rational, as it maximises the individual utility and economic agents are expected to be guided solely by their private interest (BUCHANAN, 1965).

If everybody adopts such (rational) behaviour, the public good cannot be produced because nobody contributes to its provision. However, since individuals actually do value the public good, and everybody would be better off if the public good were, in fact, produced, the private provision of a public good is sub-optimal and leads to market failure. Governments have, thus, to intervene so that the public good can be produced. However, in addition to the potential bias introduced by public intervention, the quantity of public good produced is arbitrary and has no reason to be efficient, as governments do not have the power to make consumers reveal their valuation (because it would translate into an equivalent amount of tax being paid). The fact that digital goods are public goods bears important consequences. The considerably large number of these goods in the economy, as well as their ever growing importance, greatly affects the traditional balance between public goods and private goods in the economy. It also makes market failure more likely to arise and, thereby, leads to an increased public intervention. However, understanding the public nature of digital goods is essential to comprehend one of the biggest challenges of the digital economy: consumer piracy.

The rivalness of digital goods

It is important to note that digital goods may seem, at first, rival in consumption: if a CD is used by a consumer, this particular CD is no longer available for the consumption of other consumers and the consumption activity of one consumer, indeed, reduces the number of units available for other consumers. However, there is rivalness only as far as the medium used to distribute the digital good (floppy disc, CD, DVD, etc.) is concerned, and not the digital good itself. The medium is indeed unique: if a consumer is using it, then the plastic component referred to as "CD" cannot be used at the same time by another consumer. The digital good itself (i.e. the binary code of the software, music file, etc.) can be replicated on another medium for a small (often negligible, cost). While rivalness exists if a consumer borrows a CD from another consumer, it is not present if the digital good is

copied instead, as both consumers can enjoy the same unit of good at the same time. Since digital goods can be copied without any loss of quality or information and are, in general, independent from the medium used to distribute them (the good matters, not the medium), they can be considered as non-rival. In fact, creating a copy can be seen as part of the consumption process (this is definitely the case with digital goods distributed online, legally or not, when they are downloaded), thus the consumption activity of one consumer does not decrease the potential consumption of other consumers. This is, by definition, the case when goods are non-rival.

The excludability of digital goods

The main difference between digital goods and the other traditional public goods is that the producers of digital goods always retain the ability to directly exclude consumers. While nobody can be prevented from consuming a lighthouse once it has been produced, a producer of a digital good is still able to prevent its direct customers from consuming the good (regardless of the number of pirated copies available, an online merchant is always able to prevent people from downloading digital goods from his website if they did not pay). However, since digital goods can be replicated, anybody owning a digital good is a potential supplier of this good. Thus, once the first unit of the good has been sold, the producer starts losing control over the production of the good and part of its power to exclude consumers. As the producer does not have the ability to exclude consumers indirectly, the more the good spreads among consumers, the less it is possible for the producer to actually exclude anybody from the consumption of the good.

Thus, as for any public good, only the first unit of a digital good produced is actually excludable, since as long as nobody else owns the digital good, the producer remains the sole supplier of that good. In contrast to other public goods, though, the next units sold remain partially excludable. This is due to the fact that digital goods are not infinitely expansible: in order to avoid getting the good through the producer, the consumer needs to know another consumer who owns a copy of the digital good. Because of technological limitations, the diffusion of the digital good into the population does not occur instantly. However, as the number of consumers owning the good grows, the number of potential suppliers increases and the number of consumers able to obtain the good from other consumers instead of the producer rises. The rate of consumers in a position to supply the good is

likely to grow exponentially with time, up to the point where every consumer can potentially obtain the good without having to purchase it from the producer. Therefore, the excludability of the digital good, which remains actual for the first units produced, decreases rapidly until the good becomes (virtually) non-excludable. Although the producer always remains able to directly exclude consumers from the consumption of the good, his inability to exclude consumers indirectly is such that the digital goods become *de facto* non-excludable when the number of consumers owning the good becomes large.

Another difference between digital goods and other public goods comes from the fact that non-excludability, which is intrinsic for other public goods, directly results from the non-rivalness of digital goods. Indeed, for a digital good to be non-excludable, consumers should be able to obtain the good from other consumers. For this to happen, digital goods have to be non-rival: no consumer would let other consumers copy from him if this action would deprive him from the usage of the good. Thus, if digital goods were rival, they would also be excludable. This is a particular feature of digital goods, since other goods, such as common pool resources (e.g. pasture, clean water), are, at the same time, rival and non-excludable.

Private provision of digital goods

Understanding the public nature of digital goods enables to make sense of the massive scale of consumer piracy associated with these goods. Since digital goods are public goods, piracy can be considered as a rational behaviour: pirating digital goods is, in fact, free-riding. Leaving aside questions of ethics and morals, this fact is important because it means that consumers cannot be blamed for adopting such behaviour, since it is the individual rational behaviour in presence of a public good. Therefore, the problem of piracy is not caused by consumers, but is instead due to the nature of digital goods itself: if these goods were private, the piracy phenomenon would not exist. This certainly helps to explain the extent of "stolen" digital goods in comparison to the small number of other goods that are stolen: digital goods are subject, due to their publicness, to free-riding, whereas private goods are not.

However, despite the high level of piracy, many digital goods are produced and a large number of companies producing these goods are still able to obtain some profits. In the light of the theoretical prediction that

public goods cannot be provided privately, this could be, somewhat, puzzling. Several reasons can be given to explain this difference between theory and practice.

The first reason is that, even for a traditional public good, consumers are more likely to weakly free-ride (i.e. they contribute to the provision of the public good, albeit insufficiently for an efficient provision) than totally free ride (BRUBAKER, 1975). This phenomenon has been confirmed experimentally (ISAAC *et al*., 1985; ANDREONI, 1988; WEIMANN, 1994) and empirically (HAAN & KOOREMAN, 2002). Consequently, although consumers do not pay for all the digital goods they consume, they might still be inclined to pay for some of them.

A second reason was already discussed above. Since digital goods are not infinitely expansible, they remain excludable for a short period of time. Consumers who are not willing to wait have, thus, no choice but to pay. Furthermore, even when the publicness of a digital good is total, pirating a digital good usually involves costs (reproduction cost, learning and search costs). Since these costs are likely to vary greatly from one consumer to another, it is not always, and for everybody, worthwhile to pirate, as opposed to purchasing digital goods (RAYNA, 2006b).

Furthermore, the actions of the producers of digital goods are also likely to induce additional costs for pirates. Technologies, such as Digital Right Management Systems, may have an adverse effect on consumers willing to pirate (RAYNA, 2006b).

Once all these reasons have been accounted for, it is then possible to envisage another defining feature of digital goods. While other goods are either private or public (or have a mixed, but fixed, status, such as club goods or common pool resources), the publicness of digital goods is not constant and evolves according to factors such as technology, consumer behaviour, firm strategies, government policies. However, regardless of the obstacles, digital goods all become, eventually, public. Digital goods are, thus, *evolutionary public*. Government interventions, through laws and law enforcement, also play an important role in the degree of publicness of digital goods. In countries that either do not have intellectual property rights, or have such property rights but do not enforce them, digital goods are (virtually) fully public. In contrast, strong IPR laws that are strictly enforced tend to decrease the publicness of digital goods.

However, while the effectiveness of IPRs to deter counterfeiting goods is commonly admitted, their ability to impede consumer piracy is more than questionable. Due to the inability to monitor all consumer activities, IPRs can, at best, target public exchange of digital goods (e.g. exchanges taking place on the internet via public servers), which is only the tip of the piracy iceberg. Furthermore, it is important to note that such laws only temporarily alter the level of publicness of digital goods and do not affect their intrinsic public nature. In this respect, QUAH (2003) points out that:

> "Excludability [...] can arise from the law or from technology or from both, but it is not itself intrinsic to digital goods." (p. 13).

To this date, none of the technologies or laws developed to prevent piracy has been anything but marginally effective, and it is quite likely that it will remain so (RAYNA & STRIUKOVA, 2008). Moreover, recent technological progress has always resulted in lowering the costs of piracy, while, at the same time, many consumers have become used to operating pirate software and networks. Consequently, it is quite unlikely that the piracy phenomenon will scale down in the future. The increasing supply of digital goods in the economy, over the past few years, has certainly been the fact that has hidden one of the most important aspects of the economic nature of digital goods: their publicness. Although the evolutionary aspect of this publicness has left enough room for goods to be produced (and profit to be made), it is likely that the quantity and variety of goods produced is sub-optimal and, thus, leads to a lower social welfare. For this reason and, because of the constantly broadening consumer piracy, there have been increasingly frequent public interventions with regard to public goods. In this respect, understanding the public nature of digital goods is a key element in designing efficient public policies.

Digital goods are durable goods

From durable to infinitely durable

The media used to store digital goods are durable but not *infinitely* durable. While the life expectancy of optical media (such as CDs and DVDs) ranges from a few years up to several decades, the durability of magnetic equipment (such as floppy discs, hard-drive and tapes) does not exceed a few years. Moreover, these media are prone to early failure, because of

manufacturing defaults, and can be damaged during usage. In this respect, the media used to store digital goods are thus not significantly more durable that the material out of which non-digital cultural and information goods (vinyl disks, audio tapes, books, etc.) are made. Yet, in contrast to other information goods, digital goods can be replicated, and the available technology is such that the cost of replicating is nearly null. Therefore, although the medium used to store and distribute a digital good is finitely durable, the digital good itself is potentially infinitely durable, provided that it is transferred onto a new medium before the current one fails. Although most non-digital information goods rarely last for more than one or two generations, digital goods can potentially last forever and each digital good purchased is likely to suppress the need for the descendants of the original consumer to purchase this good ever again.

This potential infinite durability is a particular characteristic of digital goods and no other good in the economy, apart from information and land, is thought to have such a property. The advent of digital technology is therefore expected to have important consequences on the economy.

The immediate expected effect of such durability is a progressive decrease of the demand. Indeed, the two main reasons that can cause consumers to purchase a particular cultural or information good more than once are:

- deterioration of the medium (due to usage),
- change of technology.

A damaged medium is, of course, the first reason that could lead to several purchases of the same recording. Vinyl discs and magnetic tape were known to be particularly fragile, and before the advent of digital era, this limitation would insure regular sales, since the copy of the recording to another medium (from a vinyl disc to an audio-tape for example) would result in a loss of quality. Beyond that, the medium technology is short-lived. When a new technology appears, consumers may have to buy the same good once again as no players compatible with the old technology are available anymore. For non-digital cultural and information goods such an issue cannot be resolved by transferring the good from the old medium to the new one, since it would result in a loss of quality. As the digital technology enables to create perfect copies of digital recordings, these two limitations of the durability do not exist anymore because it is always possible to make a backup copy of a recording before the medium gets damaged and because it is possible to transfer a recording on the next generation medium without loss of quality (music from a CD can be transferred onto a DVD).

Durability and loss of market power

However, the consequences of durability of digital goods go far beyond a progressive decrease in demand. Indeed, as stated by Coase (1972), the sole fact that a good is durable may lead to a total loss of market power for the firms producing it. More precisely, COASE (1972) shows that even a monopolist producing a durable good will end up loosing all its market power due to the fact that consumers expect the monopolist to lower its price over time.

The reason for that is that the monopolist always has interest to gradually decrease the price in order to sell more [3] (as long as the price is above marginal cost, there is a residual demand that is a potential source of profit). Since the consumers are rational, they expect this decrease in price and delay their purchase until the price has fallen to the marginal cost. The only price at which the good can be sold is, thus, the competitive price, equal to the marginal cost (which corresponds to a total loss of market power), even when there is only a single firm supplying the good.

Furthermore, the extent of the loss of market power depends negatively on the time lag between the periods of sales (COASE, 1972; STOKEY, 1981; BULOW, 1982; THÉPOT, 1998): it is large if sales take place continuously and low if a large amount of time takes place between the periods of sales. One could add that if the good is really and urgently needed, it is unlikely that the loss of market power will arise. However, in the case of digital goods, it is quite likely it will, since none of these goods is usually a first necessity good nor have they many substitutes. Consumers can wait.

The best known strategy to recover market power is to rent the good instead of selling it (COASE, 1972). A monopolist renting a durable good will see no interest in decreasing its price over time, since a decrease in price for new consumers necessarily means a decrease in price for all consumers (everybody pays the same rent [4]). Consumers have, thus, no incentive to delay their purchase of the good and therefore accept to pay the monopoly

[3] This would not be the case for a non-durable goods as consumers renewing their purchase would then also expect a lower price. With a durable good, consumers never renew their purchase.

[4] When the good is sold, a decrease in price for new consumers leaves unchanged the higher price that was paid before by the other consumers.

rental price. Renting a durable good makes it equivalent to a non durable good that would last only the duration of a rental period.

Unfortunately, such a strategy cannot be efficiently used as long as competition exists [5], which is particularly problematic, since the existence of (even potential) competitors also prevents reducing the negative effects of durability by spreading periods of sales (since competitors would find an advantage in staying continuously open).

Another traditional solution is to make the durable good non-durable (BULOW, 1986; KARP, 1996). This type of strategy is usually referred to as *planned obsolescence* (BULOW, 1986) and can take two forms. Either the intrinsic durability of the good (its quality) is reduced (e.g. components of a TV set which are designed to fail a few days after the guarantee period expires), or a new substitute good with better features is produced and makes the previous durable good obsolete (e.g. Pentium processors made 486 processors obsolete and was itself made obsolete by Core Duo processors).

The economic impact of the durability of digital goods

While far from being fully competitive, there is still a significant amount of competition in most sectors of the digital goods industry. This makes the fight against the negative effects of durability particularly difficult for firms.

In spite of the theoretical inadequacy of renting strategies in such an environment, firms have nonetheless attempted to use renting strategies. While such strategies have encountered a relative success in the context of offline renting of some particular digital goods (Blockbuster has been, until recently, able to establish a quite profitable renting service of Video-DVDs), the advent of online trade of digital goods has considerably undermined the ability to rent digital goods.

The reason for that is essentially technological. Renting out a digital good through the internet necessarily requires a copy of the digital good to be created on the computer (or similar device) of the consumer. Once the lease period is over, not only this copy, but also all the other copies the consumer

[5] BULOW (1986) and BUCOVETSKY & CHILTON (1986) show that a monopoly operating in a contestable market will better deter entry of competitors if it is selling. Likewise, PODDAR (2004) demonstrates that, within an oligopoly, selling is a dominant strategy.

might have made in the meantime have to be destroyed. The problem is that the digital technology itself does not permit that. This is the reason why Digital Rights Management Systems have been designed. Such systems encrypt digital goods in such a way that they cannot be consumed without authorisation. Hence, the problem of renting digital goods was expected to be solved, since after the lease expired, consumers would not be able to consume the (encrypted) copies made on their devices without obtaining the authorisation to do so and would have to pay to renew the lease in order to gain such authorisation.

However, besides the issue that ways were found by consumers to circumvent all existing DRM systems (RAYNA & STRIUKOVA, 2008), such systems require a permanent connection between the devices used to consume the protected digital goods and the authorisation server. This makes DRM fit only for some digital goods (those consumed once and over a short period of time, such as films) and some devices (those permanently connected to the internet, such as computers, but not Digital Audio Players). While the rental of videos online is still at an early stage, online renting of music was introduced to the market some years ago. The companies that used such a strategies (Napster, Rhapsody, Yahoo) have been relatively unsuccessful. While this may be because of the renting strategies being inadequate when there is competition, the technological issues related to DRMs have also played an important role (RAYNA, 2006a).

When renting cannot be used to reduce the negative effect of durability, planned obsolescence (either intrinsic or through substitutes) is often considered. However, in the case of digital goods, the intrinsic durability cannot be reduced (they are intangible) and reducing the durability of the medium or the technology is not effective, because of replicability.

Nonetheless, new substitute goods, making the old ones obsolete, can still be produced. Such a strategy is often used for software. New versions of software and operating systems are released, making the previous version obsolete and pushing consumers to renew their purchase. In this respect, as long as firms release new versions of software, the problems caused by durability do not arise. However, other digital goods, such as music, films or books cannot, as easily, be made obsolete.

Although examples can be found of successful planned obsolescence used for such goods (for example, when CD versions of records previously available on vinyl discs were released) it is usually difficult to produce new versions of the same digital goods that would be improved enough for

consumers to renew their purchase (for example, Audio-DVDs were a commercial failure). The reason for that technological progress has made the quality of digital goods very close to the limit of perception of humans, making any improvement marginal. Only the film industry has been able to release significantly improved versions of their products twice (from VHS to DVD and, more recently, from DVD to Blu-Ray). Nonetheless, although the difference of quality between a film in DVD format and the same film in Blu-Ray format is significant, it is still quite arguable that more than a small proportion of consumers will repurchase films they already own. Besides, there will eventually be a point, as it is the case for other digital goods, when the existing quality of films will be such that any improvement will be imperceptible for most consumers.

However, obsolescence is not necessarily solely due to the production of a new version of the same good, but can be caused by the production of a close enough substitute. In this respect, the impact of the production of a substitute essentially depends on the behaviour of the consumers, in other words on the degree of substitutability between goods. Digital films or books, for example, are seldom consumed repeatedly, despite their durability. In such a case, releasing new products might be enough to overcome the problems caused by durability and any new product may be considered as a close enough substitute.

In contrast, other digital goods, such as music, are consumed repeatedly. In such a case, the definition of a close enough substitute depends strongly on the tastes of the consumers and, as such, is heterogeneous. For example, a die-hard devoted fan of Elvis Presley is only interested in recordings of Elvis, and the degree of substitution with recordings of another singer is likely to be low. As the number of records of Elvis, although large, is fixed, and, as there are no close substitutes, Elvis records are durable, since the demand for records of this consumer will decrease to zero after the consumer has achieved to purchase all the existing Elvis records. In contrast, a consumer who is a dedicated follower of fashion is likely to consider any new record as a substitute close enough to make the previous ones obsolete, since such consumer only consumes the latest hits. In this situation, the durability of a music recording is reduced, since it is not likely that this type of consumer will listen to a record older than a few months.

Between these two extremes, given that the time consumers can devote to the listening of music is fixed, the impact of a new release will depend mostly on the "satiation factor", e.g. the time the consumers devote to old

and newly acquired records and on the difference of quality (or utility) between the newly released record and the previous ones.

It is worthwhile noting that, in contrast to most other digital goods, such as movies and e-books, it is difficult to reduce the durability of music, since music records usually have a high satiation point and can be consumed over and over during years [6]. Only consumers particularly fond of novelties may see music as a non-durable good. Thus, the common strategy consisting of introducing planned obsolescence in order to avoid the loss of market power associated with the selling of a durable good is not likely to be efficient in the case of music.

If the durability of digital goods cannot be reduced, consumers are likely to expect a decrease in price and to defer their purchase. The public nature of digital goods tends to aggravate the problem, since consumers, while they wait for prices to drop are, nonetheless, able to consume illegal versions of the goods. Of course, this means that even if prices eventually decrease to a level they deem acceptable, they have little incentive to purchase something that they own (albeit illegally) already.

Furthermore, even though firms selling digital goods have to progressively decrease their prices, they are usually able to obtain a high profit margin on the units of goods sold to impatient consumers who cannot wait for the prices to drop to the marginal cost. Because of the publicness of digital goods, even impatient consumers have few reasons to buy legally at a high price what they can obtain illegally at a low cost. Consequently, the remaining market power that firms retained on impatient consumers is likely to be completely absorbed by the publicness of digital goods, leaving firms no choice but to sell at marginal cost.

Digital goods are experience goods

NELSON (1970, 1974) defines experience goods as goods whose qualities cannot be determined prior to purchase. KLEIN (1998) builds on this definition and states that there are two circumstances in which a good is considered an experience good: either when full information on the main

6 Software also has a high satiation point and can be consumed over and over during years, but, as mentioned above, can be easily made obsolete.

attributes of the good cannot be known without direct experience, or when the search for information about the main attributes is more costly or difficult than experiencing the product directly. WRIGHT & LYNCH (1995) add to the literature by taking into consideration the fact that consumers are sometimes allowed to experience the product through free samples and, thus, define experience goods as goods whose qualities cannot be determined prior to consumption.

Of course, it could be argued that most goods in the economy correspond to the above definition and are, thus, experience goods. However, the problems brought about by experience goods are most likely to arise when the good is durable (NELSON, 1970). For a non-durable good, over-estimating the value of the good is not an important issue, since it is only related to one or a few episodes of consumption (for this reason, a fruit is, usually, not considered as an experience good). However, this becomes critical when the good is durable, since over-estimating the value of the good is, then, related to a, potentially large, number of episodes of consumption.

When one considers the goods that are supplied digitally, such as music, movies, software or books, it becomes obvious that most of them do indeed correspond to the above definition of experience goods. It is important, here, to differentiate the digital good from its content. While full information about the digital good, as a vector, is always available and unambiguous (e.g. the format used and its quality, such as MP3 128 kb/s), the information about the value of the content (e.g. how valuable the song embedded in the digital good is to the consumer) is often either unavailable or costly to retrieve. Regardless of the information the consumer may be able to obtain *ex-ante* on the attributes of the content, the "true" value of a digital good, which mostly relies on the value of the content, is often realised *ex-post*. Furthermore, the value of the content of some digital goods is so subjective that it is impossible for consumers to obtain full information on the attributes of the goods without experiencing them. This is typically the case of cultural goods such as music, movies, books, pictures, etc. In contrast, it may be possible for the consumers to obtain a sufficient amount of information on the main attributes of goods such as software, news, or technical reports, without experiencing them first. However, obtaining such information is likely to be much more costly than directly experiencing the product. Software suppliers often release demonstration versions of their products for this reason.

In addition, the value of digital goods in not necessarily fully revealed after the initial episode of consumption, and some digital goods, such as

music, software or video games, generally need to be experienced several times before their true value becomes known to the consumer.

However, in contrast to the two other properties of digital goods presented in the previous sections, it is important to note that the fact that digital goods are experience goods is not an intrinsic property of these goods, but is, instead related to their content. While all digital goods are, regardless of the content, public and durable, only a subset of these goods are experience goods. Yet, the content of digital goods, in general, is such that many of these goods are experience goods.

Furthermore, since the main characteristic of an experience good is that its value cannot be determined prior to consumption, this definition can be extended to the goods for which it is possible to obtain full information about their attributes but the value obtained from these attribute remains unknown or uncertain. In such a case, durability plays a crucial role. While all the information about a particular product may be available, the fact that its product is durable makes it uneasy (or even impossible) to accurately determine its present value, since it corresponds to the discounted sum of the value obtained during each future episode of consumption.

Therefore, all durable goods can be considered as experience goods, since the more a good is durable, the more it is likely to be regarded as an experience good by consumers. Since digital goods are infinitely durable, they can all be considered as experience goods, regardless of the nature of the content of the good itself.

Understanding this characteristic of (most) digital goods is essential because experience goods have important effects on the economy. First of all, these goods create difficulties for consumers when making consumption choices and, as such, they tend to reward reputation and create inertia. Another consequence is that experience goods typically have lower price elasticity. In regard to the market structure, the presence of experience goods is likely to lead to a strong market concentration (NELSON, 1970).

For firms, this characteristic of digital goods means that, depending on their ability to make consumers experience their products, they can either benefit from high switching costs or suffer from the switching costs of a more established competitor. For policy makers, the market concentration may lead to important market distortions and require public intervention (Microsoft Windows provides a good example of how an experience digital good can lead to market dominance).

However, even for firms that are talented (and/or lucky) enough to fall on the right side of the fence, the fact that digital goods are experience goods causes additional difficulties. As consumers are reluctant to purchase these goods before they are able to experience them and determine their value, firms have to supply consumers with samples of digital goods. If they do not do so, consumers may be encouraged to conduct their own sampling activity by pirating. This 'illegal sampling' is made possible by another characteristic of digital goods: their publicness. Once this has happened, consumers are unlikely to pay for a legitimate version, even after the good has been fully experienced, since original and pirated copies are identical.

Nonetheless, providing consumers with samples is not always an easy option. Indeed, firms need to ensure that consumers are only able to consume the sample a small number of times, as otherwise consumers' needs might be fulfilled by the sample, in which case they do not purchase the product. For some digital goods, it may be possible to offer, as a sample, a truncated/stripped down version of the digital good (as it is often the case with electronic books, films and software). Nevertheless, such a strategy may cause consumers to underestimate the value of the digital good, thereby reducing their willingness to pay. In addition, the value of some digital goods, such as music, is unlikely to be revealed by partial sampling, and may even require repeated experience.

Durability, plays, here as well, an important role. Indeed, if pirated digital goods were not durable, pirating for sampling motives could have a positive effect on demand. In such a case, consumers would pirate a digital good in order to experience it and when the pirated good would wear down, they probably would be inclined to purchase the original, since they would have discovered its true value. Interestingly enough, in such a case, the equal quality between the original and the copy of the digital goods would, most likely, not be an issue for producers.

The new age of piracy

Although it is true that piracy, in the form of copies of vinyl discs, audio and video tapes, photocopies of books, etc. has existed long before the advent of digital goods, the piracy of the pre-digital era was different and never reached the extent of digital piracy. The reason for this lies in the replicable nature of digital goods.

Indeed, pirating a non-digital information good necessarily leads to the creation of a substitute good of lower quality. Therefore, during the analogue era, a pirated version of an information good was, at best, a good substitute of the original. Furthermore, as copies of copies were made, additional loss of quality or information occurred and after a few rounds of copying, the resulting pirated good would be a very poor substitute to the original. Thus, piracy could not spread infinitely, since each additional copy further decreased the quality.

Successful piracy of an analogue good requires:
- an original or near original copy of the information good, otherwise the quality of the copy is too low;
- a direct copy between the original and the source: as each additional transfer to an alternate medium leads to a decrease in quality, it is not desirable to use any intermediate medium.

This explains why the analogue era piracy was intrinsically restricted, while digital piracy is not. Non-digital piracy requires a large number of originals spread in the population, while digital piracy only requires one original. Furthermore, since any transfer of an analogue good leads to an additional loss of quality, direct contact is required in order for the piracy to take place. Finally, even in the best conditions, analogue piracy only leads to the creation of a substitute of the original, thereby restricting the extent of piracy, since the demand for substitute is likely to be lower than the demand for originals.

The advent of digital technology has allowed piracy to develop to its full potential. First of all, any copy of a digital good is indistinguishable from the original. As a consequence, only one original needs to be sold for all consumers to be able to pirate: one original unit is sufficient to start a virtually infinite stream of absolutely identical copies. Secondly, since additional transfers of a digital good do not lead to any loss of quality, no direct contact between consumers is required for digital piracy to take place. As a result, even a rather isolated consumer is able to pirate the digital good through various intermediaries – such as phone lines (with modems), optical signals, wireless signals, etc. Finally, consumers are expected to be completely indifferent between the original and the copy as these are, due to the digital technology, perfect clones.

To this respect, GANTZ & ROCHESTER (2005) relate that, when asked the difference between taping a song from the radio and copying it onto a computer, EMI vice president Ted Cohen stated that the former intended to

create more demand "since the quality [obtained] was not of the level of something [the consumer] would want to keep", while downloading music from the internet is not serving the music industry as a marketing vehicle. Quite on the contrary, the identical quality between the original digital good and its copy is often seen as the principal cause of the recent decline in records sales.

Thus, what is new in the piracy of digital goods is not piracy itself, since this phenomenon is not new, but, rather, the fact that the technological constraints that had previously endogenously limited the extent of piracy, have disappeared with the advent of digital technology. Therefore, levels of digital piracy are expected to be extremely high, and this is indeed what recent figures show.

The value problem of digital goods

The characteristics of digital goods exposed in the previous sections have a common effect: they all tend to decrease the price consumers are willing to pay for digital goods. The publicness and durability of these goods are both expected to lead to a price equal to marginal cost (i.e. the replicating cost), while the fact that digital goods are experience goods makes (usually risk adverse) consumers reluctant to pay the actual value of the good.

In the case of digital goods, this pressure towards competitive price is an important issue for most of these goods are characterised by high (sunk) initial production costs that would not be recovered within a competitive environment. Thus, unless firms have a sufficient market power, they might not have enough incentives to produce new digital goods. From a social point of view, the issue of the production of digital goods is the traditional dilemma between underprovision and underutilisation (ARROW, 1962).

For firms producing digital goods, though, the previous sections have demonstrated that the nature of digital goods makes it difficult to recover initial investment. It is not one, but three important characteristics of digital goods that threaten their profits. In this respect, piracy might well be the "tree that hides the forest" of multiple issues related to the production of digital goods. Indeed, even assuming that it were possible to totally prevent piracy, the infinite durability of digital goods would still undermine the profits of the digital goods industry. Furthermore, since sampling is one of the important

motives of piracy, it could be expected that without piracy, consumers would be even more reluctant to pay for digital goods they have not experienced.

Furthermore, it is crucial for producers to understand how the different aspects of digital goods interact with each other. With regard to the public nature of a digital good, it is clear that it becomes stronger as time passes (more consumers owning an original or a copy means more potential sources). Producers would, thus, certainly want to concentrate most of their sales near the release date of the digital good. However, durability and the fact that digital goods are experience goods both lead, on the contrary, to consumers delaying their purchase.

Similarly, although renting is a good way of addressing the issues caused by both durability and (lack of) experience, the success of such a strategy can be undermined by the public aspect of digital goods. Indeed, consumers might subscribe to an online music service, download all the songs they need, remove the anti-copy protection and cancel their subscription, thereby leaving the provider with an immense amount of royalties to pay and no income (RAYNA, 2006a). How can renting be successful if consumers are able to retain the good without paying the rent?

In fact, it seems that the sharp decrease in reproduction and distribution costs producers have benefited from, because of digital technology, has been fully integrated by consumers, who are, thus, less inclined to pay a high price for digital goods. This phenomenon has certainly be exacerbated by the fact that consumers have taken an increasing part in the reproduction and diffusion of digital goods and are, now, an integral part of the production process (when a digital good is purchased online, the consumer bandwidth is used to distribute the good, the consumer processor is used to create the copy and the consumer hard drive to store the digital good). Regardless of the value perceived by consumers, how much is their willingness to pay for something that they may consider as having been essentially produced by them?

Although attempts have been made, with Digital Rights Management, to address all the issues caused by the nature of digital goods at once, these have been, so far unsuccessful (RAYNA & STRIUKOVA, 2008). In contrast, there are more and more examples of artists successfully using the nature of digital products to their advantage. Records are freely distributed and used to promote the purchase of tangible goods, such as concert tickets or

merchandising, which are not subject to the same issues [7]. Although such strategy cannot be universally applied to all digital goods, it shows that by understanding the nature of these goods and using it as a strength, instead of fighting against it, there may be some new and profitable ways to do business.

Conclusion

Digital economy is at the same time promising (for companies, but also, in terms of growth, for governments and policy markers) and extremely challenging, since it forces to rethink the way goods are produced, distributed and sold. To fully apprehend the potential of digital economy and anticipate the coming challenges, it is of the utmost importance to consider, and understand, the particular economic nature of digital goods.

As a matter of fact, digital goods are unlike any other good in the economy, in the sense that not only do they combine several particular characteristics, but also that these characteristics are, in their own way, extreme. Digital goods, like non-digital information goods, contain information, but also are themselves information. At the same time, digital goods are public, but unlike other public goods, their publicness varies and is a direct consequence of their non-rivalness. Furthermore, digital goods are infinitely durable, which is, in itself, rare, and are, due to this durability, experience goods.

For both entrepreneurs and policy makers, the challenge is that only one of these characteristics would be sufficient to drive the price of digital goods to an unsustainable level and create a market failure. Yet, with digital goods, three sources of market failure are combined. Although it is true that some firms are able to gain large amounts of profit within the digital economy, it is crucial to understand that the characteristics of digital goods presented in this article are only likely to become even stronger due to technological progress. Thus, the challenges created by digital goods will only become greater.

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[7] Income can also be derived from free downloads. When Radiohead offered their latest album online, letting downloaders free to choose how much to pay, the average price paid was $6, much more than the typical amount of royalties gained per album sale.

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