Pricing Strategy of eBooks in a Two-Sided Market under the Threat of Piracy

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

This thesis analyzes the effect of piracy on the price of eBook when the publisher uses the market platform for the sale of eBook. Under the traditional sales mechanism, called "resale model", the market platform or an intermediary purchases eBook from the publisher at a wholesale price and sets the retail price. Under the new sales mechanism, called "agency model", the publisher sets the retail price directly and pays a share of revenue to the platform as a fee for its service. Using a theoretical model, this thesis compares the equilibrium outcomes under both sales mechanisms. It shows that the retail price is always higher in the resale model regardless of the presence of piracy due to the presence of double marginalization associated with the resale model. In the presence of piracy, the size of the price increase is higher under the agency model due to investment in Digital Right Management (DRM) by the publishers. Under the agency model, publisher can recoup DRM cost only by setting higher retail price. However, under the resale model, platform recovers DRM cost in two ways: paying lower wholesale price and charging on retail price. Therefore, the demand for an original eBook reduces more with piracy under the agency model than under the resale model. The equilibrium amount of investment for DRM is the same under the both models, because consumer's piracy behavior does not relate to the pricing model adopted by the industry. The amount of profits for publisher and marketplace vary according to pre-specified share of revenue. This thesis suggests that, in the presence of piracy, the agency model may not be a better strategy for the publisher if the market structure is monopoly; the resale model may be better for the publisher in this situation.

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Dedication

To My Lovely Wife Mst Hasnat Jahan

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Chapter 1: Introduction

This is an age of digitalization. Today 2.7 billion people use the Internet worldwide and more than $2 trillion is spent on information technologies and services annually (The Software Alliance, 2014). Digital products, which can be converted into digital format and transferred through computers and other devices, have gained increasing importance in music, movie and book industries (OECD 2012). The book industry is undergoing a digital transformation enabled by the development of the Internet and information communication technologies; and the industry increasingly sells digital books to consumer as a form of file in online marketplaces instead of selling the traditional form of paper books (Jiang & Katsamakas, 2010). The size of the global book industry ($151bn) is larger than music ($50bn), video games ($63bn), magazines ($107bn) and even the movie and entertainment ($133bn) industries (Global eBook Report, Spring-2014). At present, the U.S. is the market leader of eBooks consumption. The U.S. eBook market has grown rapidly and it now constitutes $3 billion revenue out of the total $15 billion book industry (2012) and its market size is expected to increase to $8.2 billion by 2017 (PwC, 2013). Although the availability of the Internet and digital devices accelerate the demand for eBooks, it also fuels digital piracy. Digital pirates can easily copy digital products such as software, movie, music, and eBook without reducing the product quality. Loss from piracy is huge. For instance, the commercial value of unlicensed PC software installation totaled $62.7 billion globally in 2013 (The Software Alliance, 2014). The U.S. movie industry was argued to have lost $6.1 billion in 2005 due to piracy (McBride & Fowler, 2006). Global piracy of music causes $12.5 billion economic losses in 2009 (Vernik et al. 2011). A recent study shows that nearly 3 million

people daily search for unauthorized downloads of the top 90 books on Amazon, leading to revenue losses from piracy of approximately $3 billion annually (Digimark, 2014).

Traditional sales mechanism of most products can be described as a resale model in which an intermediary (such as Sears and Home Depot) purchases products from suppliers and then sells them to consumers (Hagiu, 2007). Since late 2000s, an alternative mechanism, called an agency model, started to become popular in which an intermediary (such as Amazon, eBay, and Apple's iTune) operates as a marketplace where suppliers directly sell products to consumers. Although it is possible to sell digital product directly from seller to consumer through dedicated website, the demand for platform marketplace as an intermediary of digital products is growing. Gans (2013) noted two possible reasons of this changing behavior of the sellers; first, platform mitigates the transaction cost of consumers by providing security and other benefits, and second, most of the platforms have their own devices (e.g., Amazon has Kindle and Apple has iPad), which help consumers to purchase a product very easily, usually through one touch on related 'apps'. Other reasons may include large fixed cost and diversity of related products that are available on marketplace. If a seller wants to set up his own website instead of platform for selling directly to the consumer, (s)he has to incur large fixed cost. Platform also provides a variety of products that helps consumers compare among various products from different competing sellers. Apple started to use the agency model in 2010 for selling eBook through its iPad. Before the entry of Apple, Amazon was the only significant player in the eBook market as a reseller and it sells eBook through its dedicated eBook reader, Kindle. Publishers claimed that Amazon was setting the retail price below the wholesale price which hampered the sales of printed books.

Publishers supported the agency model adopted by Apple and forced Amazon to apply the agency model because it enables them to set the retail price, and Amazon eventually adopted the agency model. Today, the agency model approach is commonly used by companies that support marketplaces for applications ("apps") used on mobile devices, and the key intermediaries in the e-book market (Gans, 2012; Johnson, 2013a , 2013b; Abhishek et al. 2013; Foros et al., 2013; and Hagui & Wright, 2013). A fundamental difference between the two models is the allocation of control rights (such as prices, advertising, customer service, etc.) between suppliers and intermediaries (Haigu & Wright, 2013). For example, under the agency model the retail prices are set by publishers who directly sell to consumers, whereas in resale model they are set by an intermediary (Abhishek, 2013). Following the adoption of the agency model in 2010 by Apple and Amazon, it was reported that the prices of many e-books have significantly increased, leading to global antitrust scrutiny (Carr, 2012; Global eBook Report, 2013). Several studies (Gans, 2012; Johnson, 2013a , 2013b; Abhishek et al., 2013; Foros et al., 2013; Hagui & Wright, 2013) analyzed the differences in retail prices under both approaches. However, those studies do not consider the effects of piracy that could be one of the biggest challenges in the growth of the e-book industry (The Economist, September 10, 2011).

The objective of this thesis is to analyze the effects of piracy on retail prices under the agency and resale models, respectively. To fulfill our objective, first, we consider a benchmark case and show how price differs under the agency and resale models. Then, we consider piracy case and show how equilibrium price differs under the both models. Finally, we compare benchmark and piracy scenarios of the both models.

We find that in the benchmark case without piracy, the retail price is higher under the resale model. In resale model, platform sets retail price and publisher sets wholesale price. Platform pays wholesale price to the publisher for each eBook. The platform exercises the mark-up of the retail price on the basis of the wholesale price. Therefore, in resale model, price set-up is a two steps process, which leads to higher price than price in agency model, where publisher sets retail price and no additional mark-up on retail price by the platform.

In the presence of piracy, the size of price increase is higher in agency model. If the investment in DRM increases, after a certain level, price will be same under the both models, because under the agency model, only publisher bears the DRM cost. Publisher, then, recovers this cost by charging higher price on consumer. Under the resale model, platform invests in DRM to protect piracy. Platform recovers DRM cost in two ways: (i) Paying lower wholesale price to the publisher; the publisher may set lower wholesale price in the presence of DRM believing that DRM will create more demand, and (ii) incorporating portion of DRM cost in retail price. Therefore, demand for original eBook reduces at a higher rate with the increasing amount of DRM investment under the agency model than that of resale model. We find that cost of DRM is same under the both models, because consumer's piracy behavior does not relate to the pricing model adopted by the industry. We find that wholesale price reduces in the presence of DRM investment, because with higher piracy protection, publisher charges lower wholesale price under the resale model.

The comparison between the benchmark and piracy scenarios illustrates that the price is higher in the presence of piracy due to the investment in DRM. We find that the retail price is higher under the resale model in the both scenarios due to the double marginalization
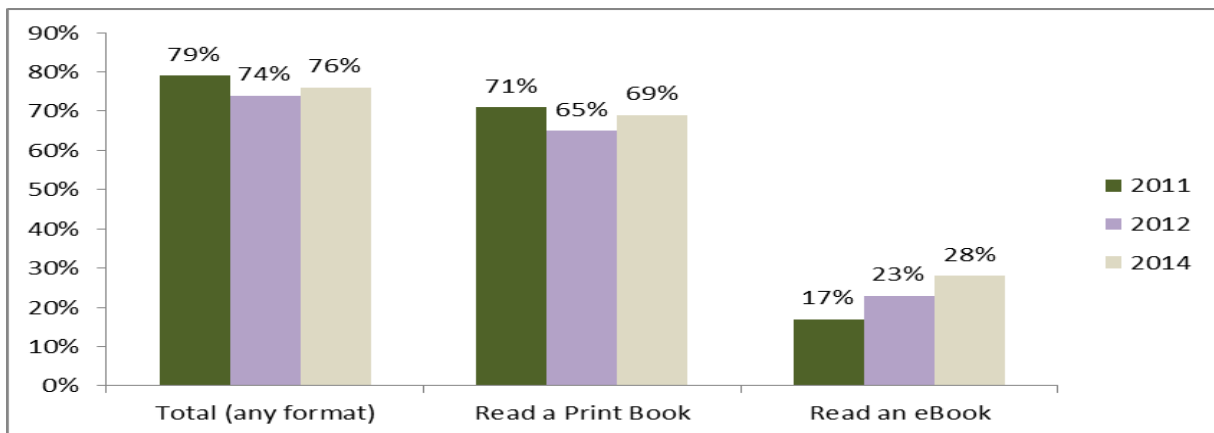
problem (Gans, 2013). However, further investment in piracy protection will increase the retail price under the agency model, because only publisher bears the DRM cost. Publisher, then, recovers this cost by charging higher price on consumer. As we mentioned earlier, under the resale model, platform recovers this cost in two ways: paying lower wholesale price to the publisher and charging more on consumers. In the benchmark scenario, demand for original product is higher under the agency model due to the lower price than that of resale model. However, in the presence of piracy, demand for original product reduces with the higher rate of price increase due to increasing investment on DRM under the agency model than the demand under resale model. Wholesale price is higher in the benchmark case; however, it is lower in the piracy case due to the DRM investment by the platform. To recoup part of the cost, platform pays relatively lower wholesale price to the publisher. We find that investment in DRM is same in both models, because consumer behaves in the same way under whatever model employed by the industry. Finally, we show that piracy affects aversely on the profits of publisher and platform.

The rest of the paper is organized as follows. In the next chapter, we describe market structure of eBook. In chapter three, we incorporate literature review. In chapter four, we specify the model. In chapter five, we discuss the effects of piracy. Finally, in chapter six, we conclude and discuss possible extensions of our model.

Chapter 2: Market Structure of the eBook Industry

An e-book is defined as a book-length publication, consisting of text (and, sometimes, images) in digital form formatted to be read on the electronic screens of user devices such as e-readers, computers and mobile phones (OECD, 2012). Michael Hart, founder of Project Gutenberg, introduced e-books in 1971. Project Gutenberg is a volunteer effort to encourage the creation and distribution of e-books. Although eBook first launch in 1971, its proliferation was spurred by the introduction of Sony's e-reader in 2006, Amazon's Kindle in 2007, and Barnes & Noble's Nook in 2009. Furthermore, Apple's iPad, which was released in 2010, creates wide scale ground for e-book market. To take a position in the tablet market, Amazon introduced Kindle Fire in 2011. The percentage of Americans who read eBook is growing from 17% in 2012 to 28% in 2014 (See Figure 2-1). E-book has the potential to fundamentally change the way that books and other publications are consumed, as well as the business and legal structure that surround them (OECD, 2012).

Figure 2-1Growing Percentages of eReading

Source: PewResaerchCentre, 2014

An eBook offers many distinctive benefits over printed book. One can easily purchase, download, and read eBook without going to traditional bookstore. In an eBook device, one can store thousands of eBooks, easily change font size of text, enjoy related visual image and sound, and use text-to-speech if required. One can use computer or 'cloud' to create back up for an eBook. Production of eBook does not require paper and ink. Marketers can easily distribute eBooks through the web with lowest possible cost. Figure 2-2 shows some areas where eBooks serve well than printed books.

Figure 2-2 Percentages of Consumers' Preferences Based on Purpose: Printed book vs. eBook
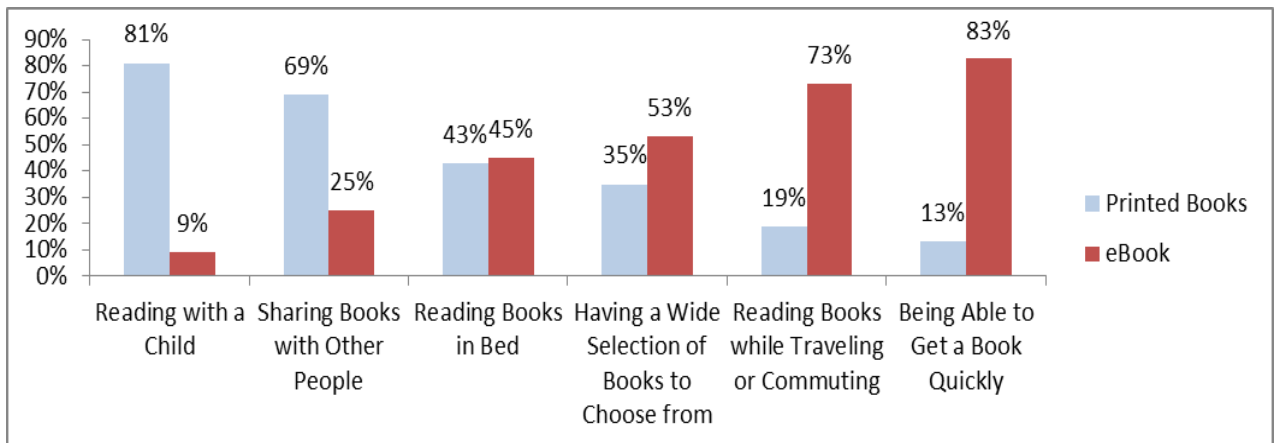
Source: PewResearchCentre, 2012

2.1 eBook Market

The United States is the market leader of eBooks consumption at present. According to AAP BookStats (2013), eBooks has grown 45% since 2011 and now constitute 20% of the 'trade market', trade market is a book industry term, which means market for general readership. PwC (2013) predicts the U.S. eBook market will outstrip the printed book market in 2017. It estimates that trade eBooks, books produced for general readership, will reach $8.28 billion

in sales by 2017 to surpass printed trade book sales, which are expected to fall from $11.84

billion in 2012 to $7.72 billion in 2017 (See Table 2-1).

Table 2-1 The U.S. Trend of eBook Sales and Its Projection (values in billions of USD)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Print & Audio Books	15.96	15	14.12	13.04	11.84	10.86	9.76	8.96	8.32	7.72
eBook	0.2	0.8	1.56	2.32	3.4	4.64	5.72	6.8	7.48	8.28

Source: PwC 2013

The market Share of e-Books is increasing throughout the world. At present, the

United States (21% of all trade books) and the United Kingdom (25% of all trade books)

dominate the e-book market (Global eBook Report, Spring-2014). Within 2-3 years China

and India appear as the significant e-book market in the world, because they have huge

demand for books due to large population, growing economy, and widely available mobile

Internet infrastructure (Global eBook Report, Spring-2014).

Table 2-2 Market Shares of eBooks in Selected Markets

Country	eBooks Titles Available from Publishers	% of eBook in Total market	% of eBook in Trade Market
United States	1,700,000	13%	21%
United Kingdom	1,750,000	11.5%	25%
Germany	91,110	5%	10.6%
France	126,000	1.1%	3%
Spain	30,000-50,000	3 to 5%	8%
Italy	71,243	-	4 to 5%
Sweden	4800	1%	1%
Denmark	13,000	-	1% -2%
Norway	3,500	-	
Netherlands	30,000	4 to 7%	10%
Russia	80,000-100,000	-	> 1%
Brazil	25,000	-	2.5%
China	11,154	-	-
India	-	-	< 1% but, 20-25% within 2-3 yeras

Source: Compiled from Wischenbart's Global eBook- a report on market trends and
developments, Spring- 2014

2.2 Software

There are many e-book formats available in the market. However, PDF, EPUB, AZW, and HTML are widely used by device manufacturers (OECD, 2012). Adobe System introduced PDF in 1993 to allow users to exchange and view electronic documents independent of the environment in which they were created or the environment in which they are viewed. PDF was released as open standard on July, 2008. PDF helps to make and distribute eBooks easily. Open eBook Forum introduced EPUB as open eBook formatting standard on September, 1999. At present, EPUB is the open standard for digital publications set by the International Digital Publishing Forum. Most devices such as Kobo e-reader, various iOS devices, Barnes and Noble's Nook, Sony Reader, various Android based devices use EPUB format. Amazon introduced AZW format for its Kindle eBook reader. AZW is based on Mobipocket standard, with a unique serial number scheme and its own DRM formatting.

To protect e-books from illegal copying, printing, and sharing, most of the publishers and retailers use digital right management (DRM) software. DRM includes provisions such as limit to make personal copies, lend copies to others, service discontinuation, technological upgrading etc. However, DRM is not universally acceptable software. Some e-book providers think DRM helps to fight online copyright infringement. However, others say DRM creates inconvenience for legal consumers and hinders innovation. Details of DRM will be discussed in literature review section.

2.3 Hardware

E-books can be read in e-book readers, computers, tablets, and smartphones. However, e-reader and tablet contribute to the significant development of the e-book market. E-reader is

an electronic device designed to access, store, and read digital publications. The special

feature of e-book is the use of "e-ink" and "e-paper" technology, which replace LED lighting

that causes eye fatigue. "e-ink" and "e-paper" technologies eliminate the problem created by

LED lighting and help to read a book for long time.

Introduction of tablets further stimulate the demand of e-book worldwide. Apple's

iPad, which was released in 2010, creates wide scope for e-book market. EPUB, PDF, and

HTML formats are available in Apple's iPad. It even has an app to access Amazon's Kindle

books. Amazon introduced its first tablet known as Kindle Fire in September, 2011. In 2013,

Book Industry Study Group (BISG) and Bowker Market Research conducted a survey on

'Consumer Attitudes toward E-Book Reading'. The result of this study shows that tablets

have become consumers' preferred e-Reading devices, overtaking dedicated e-Readers (See

Figure 2-3).

Figure 2-3 Percentages of Users Prefer Tablet for eReading
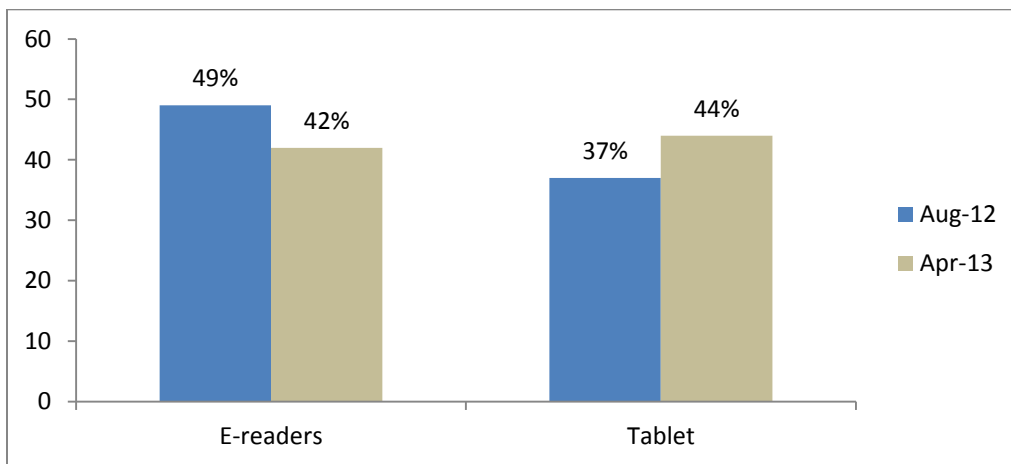
Source: Bowker Market Research, 2013

A survey conducted by Pew Research in January 2014 shows that overall 50% of American adults now have either a tablet or an e-reader for reading e-content. The survey also found that 92% of adults have cellphones and 75% have a desktop computer or laptop. A survey conducted by Book Industry Study Group (BISG) in August 2013 shows that nearly 40% of U.S. adults who have said they read e-books own a Kindle-reader compared with about 27% who own an iPad (See Figure 2-4).

Figure 2-4 Percentages of Current Device Ownership and Purchase Intent, August 2013
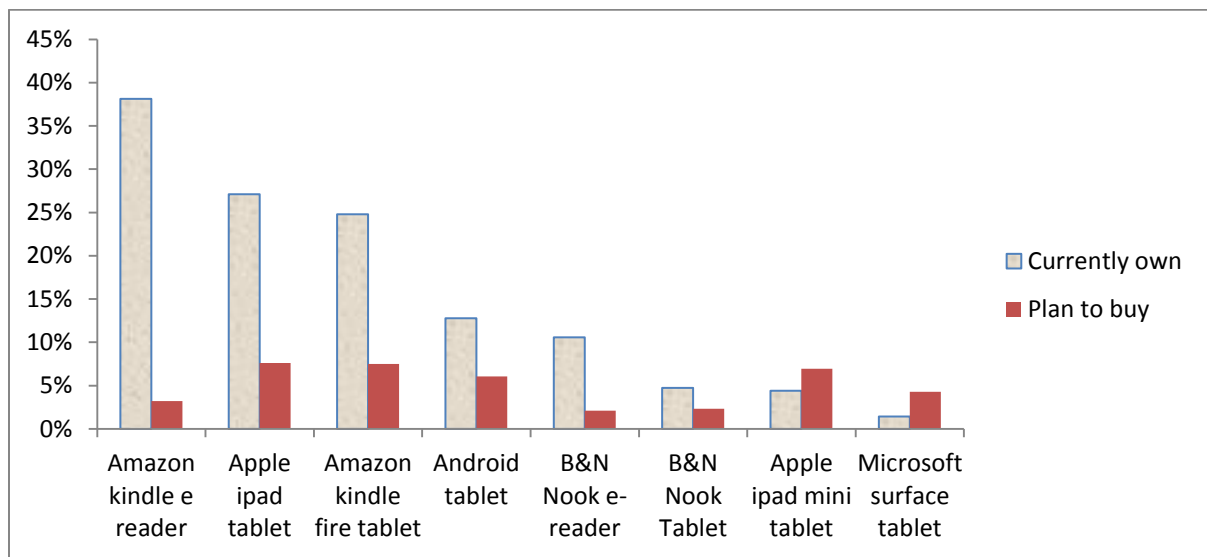
Source: Book Industry Study Group (BISG) in August 2013

The above discussion shows that eBook market is expanding throughout the world. Therefore, researchers and policy makers should work on to deal with various emerging issues related to this market.

Chapter 3 Literature Review

Our work is related to three streams of literature: a two-sided market, agency vs. resale models, and digital piracy & Digital Right Management (DRM). We review each of these streams and show how our research differs from existing literatures.

3.1 Two-Sided Market

In general, a two-sided market can be defined as a market which involves one or more platforms that enables interaction between consumers and sellers by charging both parties (Rochet & Tirole, 2006). The examples of two-sided market include academic journals (Wright, 2004), heterosexual dating agencies (Armstrong, 2006), video game systems (Rochet & Tirole, 2006), newspapers (Eisenmann et al. 2006), credit cards (Rysman, 2009) etc. In two-sided market, the decision of one group depends on the decision of another group usually through a network externality (Armstrong, 2006; Eisenmann et al. 2006; Evans & Schmalensee, 2007; McCabe & Snyder, 2007; Rysman, 2009). The price structure in two-sided markets depends heavily on the size of indirect network externalities between user groups (Caillaud & Julllien, 2003; Evans, 2003; Roson, 2005; Armstrong, 2006; Rochet & Tirole, 2003, 2006; Hagiu, 2006, 2009).

The eBooks are usually sold through a marketplace or a platform such as Amazon or Apple's iBook store. Platform attracts publishers on one side and consumers on other side. The publishers' decision to join a platform usually depends on the number of consumers in the platform and vice versa. Most of the platform- providers have their own devices to sell digital contents. Examples of devices include Amazon's Kindle, Apple's iPad, Sony Reader,

Barnes & Noble's Nook, Kobo eReader etc. Sometime prices of the digital devices depend on the prices of the contents and vice versa. Yu et al. (2011) find that content price plays a significant role in affecting the price of the digital device. However, in this paper we do not consider impact of digital devices on price.

3.2 Agency and Resale Models

There are two alternative pricing models usually adopted by platforms: (i) resale model, sometimes known as wholesale model (Johnson, 2013), resale agreement (Abhishek et al, 2013), reseller mode (Hagiu & Wright, 2013). or merchant mode (Hagiu, 2007) and (ii) agency model. Between these two, the agency model is widely used now-a-days (Jiang et al. 2011; Kwark et al. 2012; Abhishek et al. 2013 and Johnson, 2013a). The main difference between these two models is who sets the retail price (Abhishek et al. 2013). In the agency model, the pricing decision comes from the authors or content providers, whereas in the wholesale model, the retail price is set by the platform marketplace (Gans, 2012; Johnson, 2013a & 2013b; Abhishek et al. (2013); Foros et al., 2013; and Hagui & Wright, 2013).

The comparison between resale model vs. agency model for market intermediation is first introduced by Hagiu (2007). He shows that trade-off between the two models is affected by several economic factors such as degree of complementarity, seller's investment incentive, asymmetric information etc. Only a few papers have been published so far on agency vs. wholesale model of pricing for digital goods in two-sided market condition. The authors of those papers have been motivated by recent debate on Apple's use of agency model (Carr, 2012; Global eBook Report, 2014). The notable papers on agency vs. wholesale

models include Gans (2012), Abhishek et al. (2012), Johnson (2013a, 2013b), Hagiu & Wright (2013), and Foros et al. (2013). All these papers are very close to our work.

Gans (2012) considers pricing under the direct access model, agency model and wholesale model. He shows that under direct access model platform plays no role and, therefore, transaction cost plays important role in retail price. He shows that price is higher under resale model than agency model due to double marginalization problem. Gans also identifies a hold-up problem, which arises when consumers invest in platform before the app providers set prices. He argues that Most Favoured Nation (MFN) clause may solve hold up problem by imposing a price cap on the app. MFN clauses ensure that price of a digital content in a particular platform is not more expensive than equivalent digital offering by publishers elsewhere.

Abhishek et al. (2012) focus on timing decision of using agency model instead of using the more conventional reselling model. They focus on the effect of competition among platform marketplaces and reaction of the sellers due to the impact of platforms on the sales in traditional channels. They show that if the platform has a negative cross-effect on demand in the traditional channel, the platform adopt agency selling model. But, if the channel has positive cross-effect on demand in the traditional channel, the platform prefers to adopt reselling model. They show that platforms prefer agency model when intensity of competition among them increases. They also show that agency model ensures lower price for consumers than reselling model. However, in our model, we do not consider competition, but we consider impact of piracy on platform and publisher.

Johnson (2013a) focuses on how competition among platforms such as Amazon, Apple, and eBay differs when the agency model is used instead of resale model. He shows that agency model lowers retail price if retailers compete for revenue share. His paper also examines the effects of most-favored nation (MFN) clauses on agency model vs. wholesale model. MFN clauses help raise industry profits, because under the contractual provisions of MFN each supplier charges the same retail price. He shows that MFN contracts under the agency model kill retail competition and, therefore, ensure higher price. He also shows that MFNs have no effect under the wholesale model, because suppliers have no incentive to charge different prices to different retailers.

In his another paper, Johnson (2013b) investigates the effect of the agency model on pricing when there is consumer lock-in in a two-period model. He explains why price increases just after adoption of agency model. He shows that agency model eliminates the ability of retailers to act on their strategic decisions to cut price in early periods, and hence, raises early prices. He also shows that the agency model ensures tough competition directly between suppliers in later periods thereby lowering future price, because agency model ensures that retail competition transfers from monopoly retailer to many suppliers. Due to consumer lock-in, retailers become monopolists in the second period and charge higher prices. However, in agency model, retailers have no role on price setting, price competition remains in suppliers and causes lower retail price.

Hagiu & Wright (2013) offer a guide to how intermediaries should optimally position themselves between the agency and resale models. They examine whether control rights over a non-contractible decision variable are better held by agency model or resale model. They

show that the agency model is preferred to the resale model whenever local information held by supplier is more important than the local information held be the reseller.

By comparing agency model and resale model, Foros et al. (2013) find that retail price will be higher in equilibrium under the agency model if competitive pressures are lower upstream. Therefore, when the platform wants to induce higher price, it allows upstream firms to set retail price by adopting agency model. They also show that equilibrium revenue shares depend on competition at both levels, and upstream firms earn positive surplus even when platform providers have all the bargaining power. They also show that under asymmetric adoption of business formats, retail MFN clauses may lead to higher equilibrium retail prices.

However, all the papers discussed above do not consider the effect of piracy in two-sided eBook market. They do not show, in the presence of piracy, which model ensures maximum benefit for publishers, platforms or other parties.

3.3 Digital Piracy & Digital Right Management

An abundance of literature has been published on pricing of information goods. Some of the authors incorporate piracy in their models. These papers mostly deal with impact of piracy on pricing, consumer behavior, how to combat with piracy problem and government policies. In their survey paper, Peitz & Waelbroeck (2006) state that digital products can be copied at most no cost and are subject to non-commercial copying by final consumers. Bae & Choi (2006) analyze the short-run effects of piracy on software usage and the long-run effects on development incentives. They consider reproduction cost and degradation cost of piracy.

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They find that reproduction cost is constant across users, but, degradation cost is proportional to consumers' valuation of the original product. However, in our model, we assume consumers' cost of piracy varies according to the investment in DRM by platform under resale model and publisher under the agency model. Consumers may engage in piracy for many reasons, including economic, legal, ethical, network, and behavioral aspects (Coyle et al. 2009). However, attitudes towards original vs. pirated products vary from consumer to consumer. Khouja & Park (2008) consider a heterogeneous consumer market with different segments and show each segment has a different affinity to piracy. Mussa & Rosen (1978) developed a model of vertical product differentiation to investigate the effects of digital piracy. They stated that consumers have a demand and make the choice between the original and the copy, dependent upon their willingness to pay for the product. Belleflame (2002), Yoon (2002), and Bae and Choi (2006) also utilize this view of consumers, and state that a consumer obtains utility from purchasing an original. In our model, we assume that consumers' preference varies between pirated and original eBooks. We also assume that consumers will pay more for an original eBook, because they get more utility from it.

Some literature argued that piracy is not harmful at all if it provides product information to consumers (Peitz & Waelbroeck, 2003), if it reduces price competition (Gu & Mahajan, 2004) or if it helps to develop an initial user base that can be monopolized later (Prasad & Mahajan, 2003). However, King & Lampe (2003) show that allowing piracy cannot raise profit if the monopoly producers can directly price discriminate between potential pirates and other customers. Piracy always results in opportunity loss, its adverse effect on profits needs to be incorporated in strategic decisions such as pricing (Nascimento

& Vanhonacker, 1988). Varian (2005) and Nascimento & Vanhonacker (1988) consider the presence of coping when they develop pricing strategies for reproducible consumer goods. However, they do not consider two-sided market situation, which is more applicable for today's digital products. Rasch & Wenzel (2013) consider the impact of software piracy in a two-sided market setting and show equilibrium price structure is affected by piracy. They show that in the presence of piracy, incompatible platform provides more software protection by raising license fee for developers. This effect decreases software developer's profit and increases platform's profit. However, they do not consider the agency perspective of pricing. In our model we assume that piracy always creates losses for publisher and marketplace.

Literature shows different ways to combat with piracy. For example, Khouja & Rajagopalan (2009) show how a two-price strategy and dual distribution channels may help in reducing the negative effects of piracy. They conclude that two-price strategy is successful when impending price increase causes consumers to buy a product early ; and dual distribution strategy is successful when market is segmented in two parts and the second channel takes advantage of information technology to enable quick product distribution at low cost. Khouja & Wang (2010) examine the impact of a digital channel for experience goods on piracy and find that consumers' access to the digital channel reduces piracy in both digital and dual-channel distribution. They find that dual channel suffers least from piracy because it allows retail captive consumers to still legally obtain the product. Chellappa & Shivendu (2005) develop a pricing model for digital experience goods in a segmented market and finds the optimality of sampling as a piracy-mitigating strategy. Chen & Png (2003) consider how the government should set the fine for copying, tax on copying medium, and

subsidy on legitimate purchases, whereas a monopoly publisher sets price and spending on detection. They conclude that society prefers the publisher to manage piracy by lower price than increased enforcement of other strategies. However, in this paper we are interested in Digital Right Management (DRM) as a piracy protection mechanism.

According to Ahn & Shin (2010), DRM refers to technologies designed to control how end-users can access, copy, convert, or convert digital products, such as software, music, movies and books. The role of DRM is to protect and manage digital information or intellectual property ownership as contents travels through the value chain from the content creators to consumers and even from consumers to consumers (Fetscherin, 2002). Different authors (Park & Scotchmer, 2005; Li & Lin, 2009; Choi et al, 2010; Ahn & Shin, 2010) consider the impact of DRM with other strategies. Sundararajan (2004) analyze the optimal choice of pricing schedules and technological deterrence levels in a market with digital piracy where sellers can influence the degree of piracy by implementing digital rights management systems. DRM may work as substitute or complement with strong copyright enforcement by government. For example, Choi et al. (2010) show that DRM works better if it complements copy protection by government. Ahn & Shin (2010) presents a framework that helps to find out the optimal level of DRM and price. They show that stronger copyright enforcement reduces the inefficient usage of DRM.

DRM restricts consumers' piracy behavior; however it reduces flexibility of usage of the digital content that adversely impacts on legal users (Li & Lin, 2009; Choi et al, 2010; Sinha et al. 2010; Ahn & Shin, 2010; Vernik et al. 2011; Sudler, 2013). Even DRM may stimulate piracy. Oestreicher-Singer & Sundararajan (2004) show the impact of DRM on

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digital piracy. They find that granting certain rights may increase the availability of pirated substitutes. For example, right to print of eBook may enable the creation of illegal Pdf version of that book. Therefore, they suggest appropriate choice of digital rights, which depends on many technological and business factors. DRM increases cost of management and fails to prevent piracy (Sudler, 2013). Based on empirical studies, Sinha et al. (2010) conclude that DRM free environment enhances both consumer and producer welfare by increasing the demand for legal products and consumers' willingness to pay for that product. Removing DRM helps to convert some pirates to paying consumers. DRM can be assigned by content provider (Li & Lin, 2009; Park & Scotchmer, 2005) or platform (Choi et al, 2010; Ahn & Shin, 2010). Park & Scotchmer (2005) show that effect of DRM on price depends on whether content provider applies DRM independently or shared with platform. In our model, we assume that the party who sets retail price, also responsible for cost of DRM. In the agency model, publisher invests in DRM; whereas, in the resale model, marketplace invests in DRM.

Li and Lin (2009) argue that DRM protection level decreases and pirating activities becomes relatively tolerable as the content provider and platform provider operate collaboratively. Sinha et al. (2010) argue that the music industry can benefit from removing DRM because such a strategy has the potential to convert some pirates into paying consumers. In addition, a DRM-free environment enhances both consumer and producer welfare by increasing the demand for legitimate products as well as consumers' willingness to pay for those products. However, a protection mechanism does not always protect piracy and is not always good for society. Kogan et al. (2013) present a model for a monopolistic

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company offering software which is updated periodically, but, by the end of one period, a pirated version is always available at a transaction cost regardless of how tough the product's protection measures are. Lahiri and Dey (2013) show that in certain situation, monopolist's incentive to invest in quality of information goods in increased by lower piracy protection. They show that increases in detection affect welfare more negatively than price cuts. In our model, we assume that DRM protects piracy behavior of consumers.

Given this theoretical framework, this thesis analyzes the impact of digital piracy on pricing strategy of eBook under the agency and resale models in monopoly market perspective. To serve this objective, first, we develop a benchmark model and show in the absence of piracy, which model, agency or resale, is better for publisher and for marketplace. Then, we will investigate, under the presence of piracy which model best serve the interest of publisher and of marketplace. We, then, show comparison between benchmark model and piracy model. We conclude this paper by discussing about possible extensions of our model.

Chapter 4: Model Specification

In this study, as we mentioned earlier, we compare agency vs. resale models of pricing in two-sided market under the presence of piracy. We assume a monopoly publisher sells eBook to consumers through a monopoly platform. Under the agency model, a publisher makes a pricing decision and pays a share of revenue $\alpha, (0 \leq \alpha \leq 1),$ to the platform as a per unit fee for having access to consumers (Gans, 2012; Johnson, 2013a, 2013b; Abhishek et al. 2013; Foros et al., 2013; and Hagui & Wright, 2013). Under the resale model, platform makes a pricing decision and pays wholesale price, w to the publisher. We denote the agency model as a superscript A and the resale model as a superscript R. Subscripts s indicates publisher and m indicates platform marketplace.

4.1 Consumer Demand

Consumers have three options regarding the purchase decision of an eBook: buy an original eBook, obtain a pirated eBook, or do not buy anything. We assume that consumers already have access to the marketplace through devices such as Kindle, iPad, Kobo etc. The utility from buying an original eBook is $u_b = \theta s_b - p^i$, where s_b is the quality of an original ("best") eBook, $\theta \in [0, 1]$ is consumer's preference or willingness to pay parameter, and p^i is price of an eBook under i $(i = A \ or \ R)$. Consumers are heterogeneous and θ is uniformly distributed over [0, 1]. The utility from a pirated eBook is $u_c = \theta s_c - h(x^i)$, where s_c is the quality of a pirated ("copied") eBook and $h(x^i)$ represents consumer's cost of pirating ebook when a publisher or a platform invests DRM cost x to prevent piracy. We

assume $h'(x) > 0$ and $h''(x) < 0$. A consumer's utility is zero if he does not obtain an eBook.

A marginal consumer is indifferent to purchasing an original eBook (u_b) and a pirated eBooks (u_c). The preference parameter of the marginal consumer θ_1 is defined as

$$\theta s_b - p^i = \theta s_c - h(x^i) \ , \quad \text{which leads to:}$$

$$\theta_1 = \frac{p^i - h(x^i)}{s}$$

where, $s \equiv s_b - s_c$. Similarly, the preference parameter θ_0 of a marginal consumer who is indifferent to a pirated ebook (u_c) and no eBook buying/pirating (u_0) is defined as

$$\theta s_c - h(x^i) = 0$$

$$\theta_0 = \frac{h(x^i)}{s_c}$$

Given a uniformed distributed parameter of θ, the demand for an original eBook is

$$q^i = 1 - \theta_1 \ = \frac{s - p^i + h(x^i)}{s}$$

4.2 Agency model

Under the agency model, the publisher sets the retail price of eBook. To prevent piracy, (s)he also needs to invest x in DRM to protect his product from piracy. A publisher's objective is to maximize his/her profit by determining the optimal level of p^A and x^A.

$$\max_{p^A, x^A} \pi_S^A = (1 - \alpha)(p^A - x^A)q^A$$

The publisher keeps only (1 - α) of the revenue, leaving the rest to a platform. We assume, value of α is exogenously given. The platform is simply a recipient of revenue from the publisher in this model. The profit of a platform marketplace is expressed as

$$\pi_m^A = \alpha p^A q^A$$

4.3 Resale model

Under the resale model, the marketplace, not the publisher, makes a pricing and DRM investment decision. The profit maximizing decision of a marketplace is

$$\max_{p^R, x^R} \pi_m^R = (p^R - w - x^R)q^R$$

where w is the wholesale price of eBook. The publisher sets the wholesale price w of eBook to maximize his profit:

$$\max_w \pi_S^R = wq^R$$

4.4 Benchmark Model with No Piracy

As a benchmark case, we consider a situation without any piracy by consumers. Consumers either purchase an original eBook or do not purchase anything. The preference of a marginal consumer is defined as $\theta = \frac{p^i}{s}$, where s is the quality of an original eBook. The demand for eBook is $q_i = 1 - \theta = \frac{s-p^i}{s}$.

4.4.1 Agency model

The publisher maximizes the profit by deciding the retail price

$$\max_{p^A} \pi_S^A = (1 - \alpha)p^A q^A = (1 - \alpha)p^A \left(\frac{s - p^A}{s}\right)$$

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From the first order condition, we can determine the equilibrium price and quantity of eBook

as
$$p^A = \frac{s}{2} \tag{1}$$

$$q^A = \frac{1}{2} \tag{2}$$

Then, the equilibrium profits of publisher and platform are, respectively,

$$\pi_S^A = \frac{(1-\alpha)s}{4} \tag{3}$$

$$\pi_m^A = \frac{\alpha s}{4} \tag{4}$$

From the above outcomes, we see that how much profit the marketplace will make depends only on the percentage of revenue share (α). However, as publisher is the price maker, his profit varies according to quality of his product and percentage of revenue share.

4.4.2 Resale model

Under the resale model, the marketplace sets the retail price of an eBook.

$$\max_{p^R} \pi_m^R = (p^R - w)q^A = (p^R - w)\left(\frac{s - p^R}{s}\right)$$

From the first order condition, we can derive the price of and quantity of eBook as

$$p^R = \frac{s + w}{2} \quad \text{and} \quad q^R = \frac{s - w}{2s}$$

The publisher sets the wholesale price w to maximize his profit

$$\max_{w} \pi_S^R = w\left(\frac{s - w}{2s}\right)$$

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The equilibrium wholesale price is

$$w = \frac{s}{2}$$

Thus, the price and demand for eBook at the equilibrium price are, respectively

$$p^R = \frac{3s}{4} \qquad (5)$$

$$q^R = \frac{1}{4} \qquad (6)$$

The profits of publisher and platform are, respectively,

$$\pi_s^R = \frac{s}{8} \qquad (7)$$

$$\pi_m^R = \frac{s}{16} \qquad (8)$$

4.4.3 Discussion of the benchmark case

In the benchmark case, price is higher under the resale model than under the agency

model [*See the equations* (1) *and* (5)]. Under the resale model, publisher sets wholesale

price. Platform pays wholesale price to the publisher and sets retail price. Platform mark-ups

the retail price on the basis of the wholesale price. Therefore, in resale model, price set-up is

a two steps process, which leads to higher price than price in agency model. This finding is

consistent with the observation of Gans (2013), who find that double marginalization

problem is the cause of higher wholesale price. Our result also matches with the finding of

Johnson (2013a), who shows that retail prices are higher under the wholesale model due to

the two layers of the supply chain. However, our result is different from the finding of

Johnson (2013b), who conducted two-period analysis in a bilateral oligopoly situation and

shows that price is initially goes up as a result of adoption of agency model, because retailer

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and consumers value consumer lock-in very differently. In the first period supplier has no incentive to reduce price, however, locking-in consumer in the first period is valuable to retailer to monopolize in the second period. Johnson (2013b) also shows that second period prices are lower under the agency model due to competition in the supplier side. However, we do not consider two-period, effect of 'lock-in' and competition in our benchmark model.

Table 4-1 Summary of Benchmark Model

	Agency	*Comparison*	*Resale*
p	$\dfrac{s}{2}$	$<$	$\dfrac{3s}{4}$
q	$\dfrac{1}{2}$	$>$	$\dfrac{1}{4}$
w			$\dfrac{s}{2}$
π_s	$\dfrac{(1-\alpha)s}{4}$	$> \left(if\ \alpha < \dfrac{1}{2}\right)$ $< \left(if\ \alpha > \dfrac{1}{2}\right)$	$\dfrac{s}{8}$
π_m	$\dfrac{\alpha s}{4}$	$> \left(if\ \alpha > \dfrac{1}{4}\right)$ $< \left(if\ \alpha < \dfrac{1}{4}\right)$	$\dfrac{s}{16}$

The percentage of revenue share (α) determines the profit variations between publisher and marketplace under the both models. If the value of α is less than 0.5, agency model is better for the publisher than resale model, because publisher earns more profit under this condition [*See the equations* (3) *and* (7)]. Again, if the α is greater than 0.25, agency model is better than resale model for the marketplace [*See the equations* (4) *and* (8)]. Our intuition is that if the monopoly marketplace tries to raise the value of α to maximize its

revenue from eBook, the publisher will set lower price to maximize its profit and vice versa.

However, our observation might be complicated if publisher and marketplace face

competition.

Chapter 5: Effects of Piracy

5.1 Agency Model

When the agency model is in work, the publisher sets the price of eBook and the amount of DRM to maximize the profit.

$$\underset{p^A, x^A}{max} \pi_S^A = (1-\alpha)(p^A - x^A)q^A = (1-\alpha)(p^A - x^A)\left(\frac{s - p^A + h(x^A)}{s}\right)$$

From the first order conditions, the price of eBook under the agency model is derived as

$$p^A = \frac{s + x^A + h(x^A)}{2} \tag{9}$$

The amount of DRM investment, x, is the solution of the following equation.

$$\left(1 + h'(x^A)\right)p^A = s + h(x^A) + x^A h'(x^A) \tag{10}$$

Without a functional form of $h(x)$, we cannot explicitly solve for x^A. Using equation (9) and (10) in equilibrium, we can derive the following condition.

$$(h'(x^A) - 1)(s - x^A + h(x^A)) = 0 \tag{11}$$

The demand for eBook is expressed as

$$q^A = \frac{s - \dfrac{s + x^A + h(x^A)}{2} + h(x^A)}{s} = \frac{s - x^A + h(x^A)}{2s} > 0$$

In order to have a positive demand for eBook, we should have the following relation from equation (11).

$$h'(x^A) = 1 \tag{12}$$

That is, the slope of the DRM cost function should be one at equilibrium (see Appendix 2 for details).

The profits of publisher and platform are, respectively,

$$\pi_S = (1 - \alpha)\frac{(s - x + h)^2}{4s} \tag{13}$$

$$\pi_m = \alpha\frac{(s - x + h)(s + x + h)}{4s} \tag{14}$$

5.2 Resale Model

When the resale model is in work, the marketplace sets the price of eBook and the amount of

DRM.

$$\max_{p^R, x^R} \pi_m^R = (p^R - w - x^R)q^R = (p^R - w - x^R)\left(\frac{s - p^R + h(x^R)}{s}\right)$$

From the first order condition, the price of eBook under the resale model is derived as

$$p^R = \frac{s + w + x^R + h(x^R)}{2} \tag{15}$$

The amount of DRM investment should satisfy the following equation.

$$(h'(x^R) - 1)(s - w - x^R + h(x^R)) = 0 \tag{16}$$

The demand for the eBook under the resale model should be positive and we have the

following relation from equation (16).

$$h'(x^R) = 1 \tag{17}$$

Based on the equations (12) and (17), the equilibrium investment of DRM is the same under

both models.

The publisher sets the wholesale price of eBook.

$$\max_w \pi_S^R = wq^R = w\left(\frac{s - w - x^R + h(x^R)}{2s}\right)$$

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From the first order condition, we derive the wholesale price

$$w = \frac{s - x^R + h(x^R)}{2} \tag{18}$$

Putting the value of w in equation (15) and in q^R we get price and demand of eBook under the resale model

$$p^R = \frac{3s + x^R + 3h(x^R)}{4} \tag{19}$$

$$q^R = \frac{s - x^R + h(x^R)}{4s} \tag{20}$$

The profits of publisher and platform are, respectively,

$$\pi_s = \frac{(s - x + h)^2}{8s} \tag{21}$$

$$\pi_m = \frac{(s - x + h)^2}{16s} \tag{22}$$

5.3 Discussion on the Effect of Piracy

In the presence of piracy, the retail price is higher under the resale model due to the same reason explained in the benchmark case. However, the size of price increase is higher in the agency model[$see\ equations\ (9)\ and\ (19)$]. If the investment in DRM increases, after a certain level, price will be same under the both models. The intuition behind this phenomenon is straightforward: under the agency model, only publisher bears the DRM cost. Publisher, then, recovers this cost by charging higher price on consumer. Under the resale model, publisher sets the wholesale price and marketplace sets the retail price. Marketplace invests in DRM to protect piracy. Marketplace recovers DRM cost in two ways: (i) Paying lower wholesale price to the publisher; the publisher may set lower wholesale price in the

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presence of DRM believing that DRM will create more demand, and (ii) incorporating

portion of DRM cost in retail price. Therefore, marketplace has two ways to recoup the DRM

cost. However, publisher does not have such option and, as a result, charges relatively more

on the consumer under the resale model in the presence of piracy. Consumer's cost of

pirating eBook varies according to the DRM investment of the price maker. We find that cost

of DRM is same under the both models $[see\ equations\ (12) and\ (17)]$, because

consumer's piracy behavior does not relate to the pricing model adopted by the industry.

Table 5-1 Summary of Piracy Model

	Agency	*Comparison*	*Resale*
p	$\dfrac{s}{2} + \dfrac{x^A + h(x^A)}{2}$	$<$ Agency price increase is higher	$\dfrac{3s}{4} + \dfrac{x^R + 3h(x^R)}{4}$
x	$h'(x^A) = 1$	$=$	$h'(x^R) = 1$
q	$\dfrac{1}{2} + \dfrac{-x^A + h(x^A)}{2s}$	$>$ Reduction is higher under agency	$\dfrac{1}{4} + \dfrac{-x^R + h(x^R)}{4s}$
w			$\dfrac{s}{2} + \dfrac{-x^R + h(x^R)}{2}$
π_s	$(1 - \alpha)\dfrac{(s - x + h)^2}{4s}$	$> (if\ \alpha < 0.5)$ $< (if\ \alpha > 0.5)$	$\dfrac{(s - x + h)^2}{8s}$
π_m	$\alpha \dfrac{(s - x + h)(s + x + h)}{4s}$	$> (if\ \alpha \geq .11)$ $< (if\ < .11)$	$\dfrac{(s - x + h)^2}{16s}$

We find that the wholesale price reduces $[see\ equation\ (18)]$ in the presence of

DRM investment which means that with higher piracy protection, publisher charges lower

wholesale price under the resale model. We can explain this observation in the following

way. Higher piracy protection reduces the consumer's piracy behavior and, eventually, increases the demand of original eBook. Alternatively, we can say that invest in DRM reduces the publisher's opportunity loss due to piracy. Marketplace is aware about this impact of DRM and, then, bargains with the publisher to set relatively lower wholesale price. Publisher, then, observe the market demand, which is higher under resale model, and reduces wholesale price.

Demand for original eBook reduces at a higher rate with the increasing amount of DRM investment under the agency model than that of resale model, because price is increasing at a higher rate in agency model than that of resale model due to the reason explained above. In this case, publisher earns more profit if revenue-share (α) is less than 0.5 [*see equations* $(13) and (21)$]. If $\alpha \geq 0.5$, resale model is beneficial for the publisher. The marketplace earns more profit under the agency model than that of resale model if $\geq .11$ [*see equations* $(14) and (22)$].

5.4 Comparison: Benchmark and Piracy Scenarios

In general price is higher under the both models in the presence of piracy than the price of benchmark scenario, because in the presence of piracy either publisher in the agency model or marketplace in the resale model invests in DRM to protect piracy, which, then, increases the cost that increases retail price.

We find that retail price is higher under the resale model in the both scenarios due to the double marginalization problem. However, further investment in piracy protection will increase the retail price under agency model, because only publisher bears the DRM cost. Publisher, then, recovers this cost by charging higher price on consumer. Under the resale

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model, marketplace invests in DRM. Marketplace recovers this cost in two ways: paying lower wholesale price to the publisher and charging more on consumers.

In the benchmark scenario, demand for original product is higher under the agency model due to the lower price than that of resale model. However, in the presence of piracy, demand for original product reduces with the higher rate of price increase due to increasing investment on DRM under the agency model than the demand under resale model.

Wholesale price is higher in the benchmark case; however, it is lower in the piracy case due to the DRM investment by the marketplace. DRM investment increases cost. To recoup part of the cost, marketplace pays relatively lower wholesale price to the publisher.

Consumer's cost of pirating eBook increases with the increasing investment on DRM by publisher or marketplace to prevent piracy. However, consumer's cost of pirating eBook is same under the both models, because consumer behaves in the same way under whatever model employed by the industry.

Piracy affects aversely on the profits of publisher and marketplace. However, amount of profits vary according to the share of revenue (α). In the presence of piracy, publisher's profit will be higher under the agency model than that of resale model if share of α is less than 0.5. This observation is similar to the finding of benchmark case, where publisher earns more profit under the agency model than that of resale model if the value of α is less than 0.5. Marketplace makes more profit under the agency model than that of resale model in the presence of piracy if the value of α is more than 0.11. However, in the benchmark case, marketplace earns more profit if the value of α is more than 0.25. Therefore, under the

piracy, publisher has less flexibility in price setting than that of marketplace due the less choice on revenue share. Furthermore, as we explain earlier, publisher cannot share his DRM cost with other. However, Marketplace shares part of the DRM with the publisher by paying reactively lower wholesale price.

Chapter 6: Conclusion

In this paper, we analyze the effects of piracy on retail prices of eBooks under the agency and resale models in monopoly market perspective. We setup agency and resale models under benchmark and piracy scenarios and compare them. The comparison between benchmark and piracy scenarios shows that in general price is higher under both models in the presence of piracy than the price of the benchmark scenario. We find that retail price is higher under the resale model in both scenarios due to the double marginalization problem (Gans, 2013). However, further investment in piracy protection will increase the retail price under the agency model, because only the publisher bears the DRM cost. In the benchmark scenario, demand for original product is higher under the agency model due to the lower price than that of resale model. However, in the presence of piracy, demand for original product reduces with the higher rate of price increase due to increasing investment on DRM under the agency model than the demand under resale model. Wholesale price is higher in the benchmark case; however, it is lower in the piracy case due to the DRM investment by the marketplace. We find that investment in DRM is same in both models, because a consumer behaves in the same way under whatever model employed by the industry. Piracy affects aversely on the profits of publisher and marketplace. However, amount of profits for publisher and marketplace vary according to the share of revenue . In the presence of piracy, publisher has less flexibility in price setting than that of marketplace due the less choice on revenue share. This paper suggests that, in the presence of piracy, the agency model may not be a better strategy for the publisher if the market structure is monopoly; resale model may be better for the publisher in this situation.

Our paper fills the gap of existing literature by incorporating piracy in a two-sided market and shows which model, agency vs. resale, is helpful for publishers and the marketplace in the presence of piracy. We hope this paper is a good starting point to think about digital piracy in two-sided market context. In this paper we consider monopoly publisher and monopoly marketplace. However, in real world there exist multiple publishers and multiple platforms. One possible extension of our model is to introduce competition in our piracy model. Another possible extension may be inclusion of device in our model that may be more realistic in today's world. One can further extend the model by changing two important variables in the existing model: wholesale price and cost of DRM. Currently, wholesale price is set by the publisher and DRM cost is set by the party who is responsible for setting retail price. However, if anyone changes the model where wholesale price set by the platform and DRM cost always by the publisher, (s) he will get different result. Finally, one may even remove DRM and include the impact of government's IPR regulations in our model and solve for equilibrium price for publisher and marketplace.

Appendix 1

Notations

Superscript A = Agency model

Superscript R = Resale model

Subscript s = Publisher

Subscript m = Platform marketplace

Subscript b = An original eBook

Subscript c = A pirated eBook

U_b = Utility from buying an original eBook

U_c = Utility from buying a pirated eBook

s_b = Quality of an original eBook

s_c = Quality of a pirated eBook

s = Quality difference between original and pirated eBooks

θ = Consumer's preference or willingness to pay, $\theta \in [0,1]$

α = Revenue share, $\alpha \in [0,1]$

p^i = Price of eBook under i ($i = A \ or \ R$)

q^i = Demand of eBook under i ($i = A \ or \ R$)

w = Wholesale price

x = Cost of DRM

$h(x^i)$ = Consumer's cost of pirating an eBook when publisher or platform invest DRM cost x to

protect piracy

π_s^A = Profit of publisher under agency model

π_m^A = Profit of platform under agency model

π_s^R = Profit of publishers under resale model

π_m^R = Profit of platform under resale model

Appendix 2

The slope of DRM cost function at equilibrium

In the agency model, the publisher's profit function is:

$$\max_{p^A, x^A} \pi_S^A = (1 - \alpha)(p^A - x^A)q^A = (1 - \alpha)(p^A - x^A)\left(\frac{s - p^A + h(x^A)}{s}\right)$$

The first order conditions are, respectively

$$\frac{\partial \pi_S^A}{\partial p^A} = (1 - \alpha)\left(\frac{s - p^A + h(x^A)}{s} - \frac{p^A - x^A}{s}\right) = \frac{(1 - \alpha)}{s}(s + x^A + h(x^A) - 2p^A) = 0$$

$$\frac{\partial \pi_S^A}{\partial p^A} = (1 - \alpha)\left(-\frac{s - p^A + h(x^A)}{s} + \frac{h'(x^A)(p^A - x^A)}{s}\right)$$

$$= \frac{(1 - \alpha)}{s}\left(-s + (1 + h'(x^A))p^A - h(x^A) - x^A h'(x^A)\right) = 0$$

The price of eBook under the agency model is

$$p^A = \frac{s + x^A + h(x^A)}{2} \qquad\qquad (i)$$

The amount of DRM investment , x, is the solution of the following equation.

$$(1 + h'(x^A))p^A = s + h(x^A) + x^A h'(x^A) \qquad\qquad (ii)$$

Without an explicit functional form of $h(x)$, we cannot explicitly solve for x^A. Using equation (i) and (ii) in equilibrium, we can derive the following condition.

$$(1 + h'(x^A))\left(\frac{s + x^A + h(x^A)}{2}\right) = s + h(x^A) + x^A h'(x^A)$$

$$(h'(x^A) - 1)(s - x^A + h(x^A)) = 0 \qquad\qquad (iii)$$

The demand for eBook is expressed as

$$q^A = \frac{s - \frac{s + x^A + h(x^A)}{2} + h(x^A)}{s} = \frac{s - x^A + h(x^A)}{2s} > 0$$

In order to have a positive demand for eBook, we should have the following relation from equation (iii).

$$h'(x^A) = 1 \qquad\qquad (iv)$$

That is, the slope of DRM cost function should be one at equilibrium.

In the resale model is in work, the marketplace sets the price of eBook and the amount of DRM.

$$\max_{p^R,\,x^R} \pi_m^R = (p^R - w - x^R)q^R = (p^R - w - x^R)\left(\frac{s - p^R + h(x^R)}{s}\right)$$

The first order conditions are, respectively

$$\frac{\partial \pi_S^R}{\partial p^R} = \frac{s - p^R + h(x^R)}{s} - \frac{p^R - w - x^R}{s} = \frac{s + w + x^R + h(x^R) - 2p^R}{s} = 0$$

$$\frac{\partial \pi_S^R}{\partial p^R} = -\frac{s - p^R + h(x^R)}{s} + \frac{h'(x^R)(p^R - w - x^R)}{s}$$

$$= \frac{-s\left(1 + h'(x^R)\right)p^R - h(x^R) - wh'(x^R) - x^R h'(x^R)}{s} = 0$$

The price of eBook under the resale model is

$$p^R = \frac{s + w + x^R + h(x^R)}{2} \qquad\qquad (v)$$

The amount of DRM investment is the solution of the following equation.

$$\left(1 + h'(x^R)\right)p^R = s + h(x^R) + wh'(x^R) + x^R h'(x^R) \qquad\qquad (vi)$$

Using equation (v) and (vi) in equilibrium, we can derive the following condition.

$$\left(1 + h'(x^R)\right)\left(\frac{s + w + x^R + h(x^R)}{2}\right) = s + h(x^R) + wh'(x^R) + x^R h'(x^R)$$

$$(h'(x^R) - 1)(s - w - x^R + h(x^R)) = 0 \qquad\qquad (vii)$$

The demand for the eBook under the resale model is expressed as

$$q^R = \frac{s - \dfrac{s + w + x^R + h(x^R)}{2} + h(x^R)}{s} = \frac{s - w - x^R + h(x^R)}{2s} > 0$$

Again, in order to have a positive demand for eBook, we should have the following relation from equation (vii).

$$h'(x^R) = 1 \qquad\qquad (viii)$$

Based on the equations (iv) and (viii), the equilibrium investment of DRM is the same under both models.

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