Review of Economic Research on Copyright Issues, 2010, vol. 7(1), pp. 39-55

DIGITAL TECHNOLOGY, PRICE DISCRIMINATION, AND COPYRIGHT DURATION EXTENSION

MICHAEL YUAN

Abstract. Many countries have yet to decide whether extend copyright duration. Technological changes were cited by a U.S. Senate report to support duration extension. This study adds to the assessment of the validity of the technological argument by simulating the effect on optimal copyright duration of increased price discrimination caused by digital technology. Simulation of a model of information product market indicates that increase of price discrimination on high-end market calls for shorter copyright duration; that on low-end market may support extension, if the discrimination benefits consumers, and otherwise work against it. It further suggests price discrimination on low-end market increases welfare and supply of original information products but that on the high-end market may either increase or decrease them.

1. Introduction

This paper simulates the effects of increased price discrimination on the optimal duration of copyright. Copyright duration is a key parameter of the copyright system. According to U.S. copyright law, for a limited period of time, creators of original works of authorship have exclusive rights of reproduction, distribution, public performance, public display, and derivative preparation over their works, once the works are fixed in any tangible medium of expression.

The 1998 Sonny Bono Copyright Term Extension Act extended U.S. copyright duration for 20 years, from life of the last surviving author plus 50 years to life of the last surviving author plus 70 years. The U.S. Senate Report accompanying the U.S. Senate bill S. 483 of copyright term extension cited technological changes in supporting the extension (Senate Report, 1996).

There has been heated debate on the wisdom of copyright term extension – see for example Akerlof et al. (2002), Bard and Kurlantzick (1999), Hamilton (1996), Karjala (1997), Lavigne (1996), Ochoa (2002), Rappaport (1998), Reichman (1996), Walterscheid (2000), and Yuan (2005). In particular, Yuan (2005) analyzed the validity of the technological argument using the effect of decreased copying cost.

The author is grateful to the Editor, Prof. Richard Watt, for help on improving the exposition of the paper, and an anonymous referee for suggestions on revising the paper. All errors remain the responsibility of the author.

The same debate is still relevant today. Apparently, the U.S. seeks to have copyright duration extended to life plus 70 years in other countries. This has been demonstrated by the inclusion of terms of copyright duration extension in virtually all free trade agreements between U.S. and other countries signed since 1998 (see for example Boymal and Davidson, 2004, and Nam, 2006). However, the majority of countries in the world have yet to make similar extensions. These include countries like Canada, Japan, China, and Indonesia.

This paper adds to the analysis of the technological argument by simulating the effect of increased price discrimination caused by digital technology on optimal copyright duration. It is widely believed that digital technologies increase the practice of price discrimination in markets of information products (Lunney, 2008). First, digital technologies increase the ability of copyright owners to price-discriminate. Digital technologies make it easier to collect customer information (Ulph and Vulkan, 2000) and they reduce the costs of customization, versioning, and bundling of information products (Shapiro and Varian, 1998, Bakos and Brynjolfsson, 1999 and 2000, Viswanathan and Anandalingam, 2005).

Second, digital technologies make price discrimination more important to the bottom line of copyright owners. When the marginal cost of digital information products is reduced to near zero, value-based pricing, which varies or discriminates across customers, becomes more important, as it is more difficult for cost-based pricing to recover the creative cost of original works (Shapiro and Varian, 1998).

Third, digital technologies may reduce the ability of consumers to engage in arbitrage. Software and databases with information content are increasingly provided through licenses and contracts and under DRM protection and/or as services. The licenses and contracts may include terms prohibiting resale and arbitrage. Unlike products, services are produced and consumed at the same time, therefore, they are inherently difficult to resell. DRM, especially those based on Trusted Computing (TC) technology, gives copyright owners greater control over their works (Anderson, 2003), reducing the possibility of arbitrage by consumers. In addition, the first-sale doctrine may be weakened in the digital environment (Hyde, 2001). Under U.S. copyright law, the first-sale doctrine allows buyers of information products to resell their purchased copies. However, re-selling digital information products no longer means that consumers have to give up their copies of the digital goods but instead requires making additional copies, which runs against copyright law. Empirical evidence of the increase of the use of price discrimination for information products exists in different versions of software programs such as Windows, various plans of cable television, phone, and Internet services, paperback, hardcover, and digital versions of books, etc. A quantitative piece of evidence may be the large

price dispersions found for books and other products sold over the Internet (Clay et al., 2001; and Clemons et al. 2002).

There have been few studies on how price discrimination might affect optimal copyright law. Extant studies focus on how copyright law affects price discrimination. For example, Gordon (1998) and Meurer (2001) discussed how copyright law facilitates price discrimination; Boyle (2000) analyzed the content industry's arguments for expanding intellectual property rights in order to facilitate price discrimination; Mortimer (2007) studied how differences between U.S. and E.U. copyright laws affect the choice of pricing strategy of movie studios and the resultant welfare effect. Extant models of optimal copyright law do not incorporate price discrimination, and so they do not analyze how price discrimination affects optimal copyright. Such models include Landes and Posner (1989), Yoon (2002) and Yuan (2005). Liebowitz (1986, 1985) may be the single exception, who analyzes how price discrimination weakens the justifications for enhancing copyright protection in the context of photocopying through indirect appropriation.

This paper adds price discrimination to the model of optimal copyright of Yuan (2005). Yuan (2005) is a model of optimal copyright duration, considering the trade-off between incentivizing creation and promoting utilization, taking into account competition among creators and information products, as well as the decisions of entry, creation, and pricing of creators.

Price discrimination increases the profits of creators. It transfers surplus from consumers to creators on the high-end market and expands served demand on the low-end market. The low-end market (or low-valuation demand) refers here to the market which would not be served without price discrimination; the high-end market (or high-valuation demand) is the market which is served regardless.

Price discrimination, therefore, may be expected to weaken optimal copyright protection, e.g. shorten its optimal duration, as implied by Liebowitz (1986). Increased profits from price discrimination may substitute some of the incentive provided by copyright protection.

The main result of the study is that price discrimination on the high-end market calls for shorter copyright duration; and that on low-end market it also calls for shorter duration if the customers do not share in the deadweight loss that is recovered by price discrimination. However, discrimination on the low-end market calls for longer copyright duration when consumers do retain a share of the recovered deadweight loss by the discrimination.

This result generally does not support the technological argument for copyright term extension from the increased use of price discrimination. It also contradicts the notion that price discrimination calls for weaker copyright protection.

The rest of paper proceeds as follows: The next section describes the model of copyright with price discrimination; the section after that presents the results; the paper then concludes.

2. The Model

Assume a market for information products where a copyright authority sets the duration of copyright and creators compete monopolistically with each other and price discriminate against consumers. Given the copyright duration set by the copyright authority, a creator decides whether to enter the market, how many original information products to create, and the prices of the copies of their products. According to copyright law, the products of different creators cannot be completely the same. On average, information products of different creators can be assumed to be substitutes for each other. During the term of copyright protection, each creator is the sole seller of its products and competes monopolistically with other creators. Due to imperfect competition, creators are able to price-discriminate. After copyright expires, anyone is free to copy the information products. Creators lose their ability to price discriminate and they must price their products at marginal costs. Therefore, creators' decisions are affected the copyright duration set by the copyright authority. Given the above behavior of the creators in response to copyright duration, the copyright authority chooses the optimal length of copyright to maximize social welfare.

Extending Yuan (2005), we use the following notations:

n: number of creators on the market;

s_i: number of first-copy products of creator i, $i = 1, 2, \ldots, n$;

s_{-i}: vector of numbers of first-copy products of creators other than i;

p_{it}: price of products of creator i at time t;

p_{-it}: vector of prices of products of creators other than i at time t;

$D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t)$: demand per unit of time for products of creator i at time t;

$c_i(s_i)$: cost of creating s_i units of first-copy products of creator i;

b: cost of reproducing and distributing a copy of a product of a creator;

γ: discount rate of consumer surplus and creator profit;

T: copyright duration;

λ: percent of deadweight loss recovered through price discrimination;

λ_1: percent of recovered deadweight loss shared by creators as profit. $(1 - \lambda_1)$ is the percent shared by consumers as surplus;

λ_2: percent of surplus of high-valuation customers extracted by creators through price discrimination.

The demand $D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t)$ will be assumed to well behaved: the first derivative of D_{it} with respect to its own price is negative; the second derivative is positive; the first derivative with respect to each other price is positive; the second derivative is negative.

The parameter $0 \leq \lambda \leq 1$ is the percent of dead-weight loss recovered on low-valuation demand; $0 \leq \lambda_2 \leq 1$ is the percent of consumer surplus extracted from high-valuation customers through price discrimination. These variables can be considered as the strength of price discrimination on the low and high-end markets respectively. When $\lambda = 0$ and $\lambda_2 = 0$, there is no price discrimination; when $\lambda = 1$ and $\lambda_2 = 1$, there is perfect price discrimination on both high and low-end markets. Furthermore, when $\lambda_1 = 1$, creators take all recovered deadweight loss as profits; When $\lambda_1 = 0$, consumers take all recovered deadweight loss as surplus.

The parameters λ, λ_1, λ_2 are exogenous in the model. The effect of different values of λ, λ_1, λ_2 on optimal copyright is to be investigated.

The timing of decisions in the market is as follows: First, the copyright authority sets copyright duration; second, creators compete by choosing the prices of their products, the numbers of original works to create, and whether to stay on the market.

We describe the decisions of creators first. Without price discrimination, the rate of quasi-rent of creator i at time t is:

$$\pi_{it}^0 = D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t)(p_{it} - b) \tag{1}$$

The rate of deadweight loss is:

$$\int_b^{p_{it}} D_{it}(s_i, p, s_{-i}, p_{-it}, t)dp - D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t)(p_{it} - b) \tag{2}$$

We assume creators have the ability to identify high-evaluation customers from low-evaluation customers and engage in third degree price discrimination. With price discrimination, a creator charges lower prices to serve low-valuation demand, recovering the deadweight loss, and charges higher prices on high-valuation demand, extracting surplus from high-valuation customers. The rate of quasi-rent above reproduction cost of creator i at time t becomes:

$$\begin{aligned} \pi_{it} \quad = \quad & D_{it}(p_{it}, t)(p_{it} - b) \\ & + \lambda\lambda_1 \left[\int_0^{p_{it}} D_{it}(p, t)dp - D_{it}(p_{it}, t)(p_{it} - b) \right] \\ & + \lambda_2 \int_{p_{it}}^{\infty} D_{it}(p, t)dp \end{aligned} \tag{3}$$

where $D_{it}(p,t) = D_{it}(s_i, p, s_{-i}, p_{-it}, t)$. The first term is the quasi-rent without price discrimination; the second is the creator's share of recovered deadweight loss; and the third is the surplus extracted from high-valuation customers.

The total quasi-rent of creator i is the present value of quasi-rent of the creator within the copyright duration $0 - T$, that is $\int_0^T \pi_{it} e^{-\gamma t} dt$. Using (3), this is equal to

$$\begin{aligned}
&\int_0^T D_{it}(p_{it}, t)(p_{it} - b) e^{-\gamma t} dt \\
&+\lambda\lambda_1 \int_0^T \left[\int_0^{p_{it}} D_{it}(p,t) dp - D_{it}(p_{it}, t)(p_{it} - b) \right] e^{-\gamma t} dt \\
&+\lambda_2 \int_0^T \int_{p_{it}}^{\infty} D_{it}(p,t) dp e^{-\gamma t} dt
\end{aligned} \tag{4}$$

The profit is the quasi-rent minus creative cost $c_i(s_i)$:

$$\Pi_i = \int_0^T \pi_{it} e^{-\gamma t} dt - c_i(s_i) \tag{5}$$

Without price discrimination, each creator is assumed to choose a single price for all its products at a given time. This assumption is partially based on the symmetry among products which is discussed later. So, without price discrimination a creator sets price to maximize the rate of quasi-rent at each point of time. The first-order condition is:

$$\frac{\partial \pi_{it}^0}{\partial p_{it}} = 0 \tag{6}$$

Each creator further chooses the number of its first-copy products to maximize profit. The first-order condition is:

$$\frac{\partial \Pi_i}{\partial s_i} = 0 \tag{7}$$

Finally, creators make an entry decision. In general, if there are profits to be made, new creators will enter. Assuming that information products are substitutes on average, new entrants reduce the demand for the products of current creators and the profitability of further entry. Entry continues until economic profit of marginal entrant becomes zero. Thus, in equilibrium, the marginal creator makes zero profit:

$$\Pi_n = 0 \tag{8}$$

When all creators have an identical technology, they all make zero profit.

Next, we describe the behavior of the copyright authority. The copyright authority chooses copyright duration. It sets the duration so as to maximize social welfare, considering the response of creators to its decision. Social welfare is sum of profits of creators and consumer surplus. Assuming creators have an identical technology, the profits of all creators are zero. In this case social welfare, L, equals

consumer surplus:

$$\begin{aligned} L(T) &= \sum_{i=1}^{n} \int_{T}^{\infty} \left(\int_{b}^{\infty} D_{it}(p,t)dp \right) e^{-\gamma t} dt \\ &\quad +(1-\lambda_2) \sum_{i=1}^{n} \int_{0}^{T} \left(\int_{p_{it}^*}^{\infty} D_{it}(p,t)dp \right) e^{-\gamma t} dt \\ &\quad +(1-\lambda_1)\lambda \sum_{i=1}^{n} \int_{0}^{T} \left(\int_{b}^{p_{it}^*} D_{it}(p,t)dp - D_{it}(p_{it}^*,t)(p_{it}^*-b) \right) e^{-\gamma t} dt \end{aligned} \tag{9}$$

The first term is consumer surplus after copyright duration; the second term is residual consumer surplus from high-valuation demand during copyright protection after the extraction of surplus through price discrimination by creators; the third term is the consumers' share of recovered deadweight loss.

The copyright duration is chosen to maximize social welfare:

$$\max_{T} \; L(T) \quad \text{subject to (6), (7) and (8)} \tag{10}$$

Given λ, λ_1, λ_2 and the demand function of consumers and cost functions of creators, (6) – (9) can, in principle, be solved for the price of information products without price discrimination, p_{it}; and the number of creators, n, the number of first-copy products of each creator, s_i, and the optimal copyright duration, T, under price discrimination.

3. Simulation Results

3.1. **Specifications of Demand and Cost.** The demand for information products differs from the normal demand functions for other products. The demand for the information products of a creator in a market depends on i) the price of the creator's products in that market, ii) the prices of other creators' products in the market, iii) the number of original products of this creator, iv) the number of original products of other creators, and v) time. The creative cost of a creator may include a fixed cost incurred when becoming a creator in the first place and a variable cost that depends on the number of original products created. Following (Yuan, 1997), here we assume specific functions for demand and cost $c_i(s_i)$:

$$D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t) = D_0 \left(\frac{s_i}{\sum_{j=1}^{n} s_j} \right) \left(\sum_{j=1}^{n} s_j \right)^{\alpha} p_i^{-\delta} \prod_{j \neq i} p_j^{\frac{\beta}{n-1}} g(t) \tag{11}$$

where

$$g(t) = \begin{cases} 1 - \frac{t}{T_0} & \text{if } \; t < T_0(1-\theta) \\ \theta & \text{otherwise} \end{cases} \tag{12}$$

$$c_i(s) = c_0 + a s^{\rho} \quad \text{for all } i \tag{13}$$

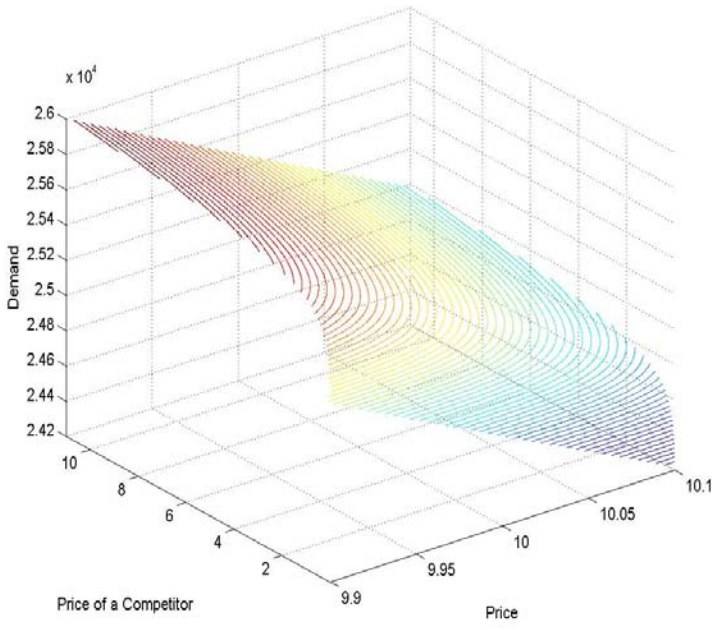

FIGURE 1. The demand function in terms of own price and the price of a competitor

$0 < \alpha < 1$, $\delta > 1$, $\beta > 0$, $0 \leq \theta < 1$, $\rho > 1$, and D_0, T_0, c_0, and a are all assumed to be positive constants.

Figures 1 and 2 provide a visualization of the demand function (11) at time zero based on the baseline parameters discussed below and assuming that other creators take the equilibrium size and prices without price discrimination obtained below. The figures show that the demand for the products of a creator decreases with the price of the products of the creator, increases with the prices of its competitor, increases with the number of original products (the size) of the creator, and decreases with the number of original products of the competitor.

Note that, in (11), all first-copy products are related to demand in the same way. They are symmetric to each other. A creator can be expected to set the same price for all its products and concentrate on competing with other creators. Furthermore, α is the percent increase in total demand from a percent increase in the total number of first-copy products. $\alpha < 1$ will be assumed; and β will be positive. This represents first-copy products being substitutes for each other. The factor $s_i / \sum_{j=1}^{n} s_j$ implies that the total demand is distributed among creators in proportion to their numbers of first-copy products, other things being equal. δ is the price elasticity of demand for a creator's products. $\delta > 1$ is necessary for

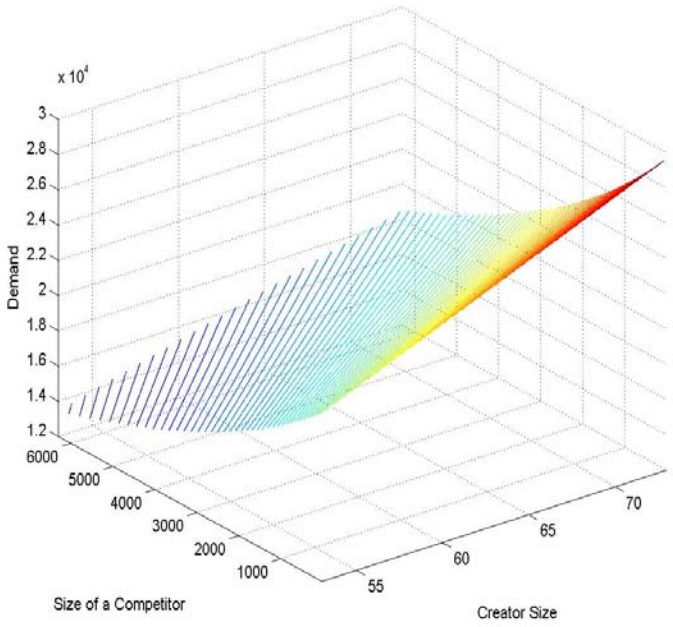

FIGURE 2. The demand function in terms of own size and the size of a competitor

consumer surplus to be finite. Note that D_i depends on p_{it} only through the factor $p_{it}^{-\delta}$ in (11). From (11) and the constraints (6), one can derive:

$$p_{it} = \frac{\delta}{\delta - 1} b \equiv p \tag{14}$$

The factor $g(t)$ represents the change in demand for over time. (6) implies that demand decreases linearly over time to the initial level θ, and stays constant after time $T_0^*(1-\theta)$.

In the cost function (13), the parameter c_0 represents the fixed cost of creation; the parameter a is related to per-product creative cost; and $\rho > 1$ means that there are decreasing returns to scale in creation.

3.2. **Results.** Based on the above demand and cost functions, an analytical solution cannot be found. Computational methods are therefore used to obtain solutions of optimal duration T, the number of first-copy products per creator s, the number of creators n, and social welfare L, for given values of the market parameters D_0, α, δ, β, b, T_0, θ, γ, c_0, a, ρ, λ, λ_1 and λ_2.

First, consider the baseline situation of no price discrimination with $\lambda = 0$ and $\lambda_2 = 0$, and $D_0 = 10^7$, $\alpha = 0.25$, $\delta = 2$, $\beta = 0.5$, $b = 5$, $T_0 = 100$, $\theta = 0.001$, $\gamma =$

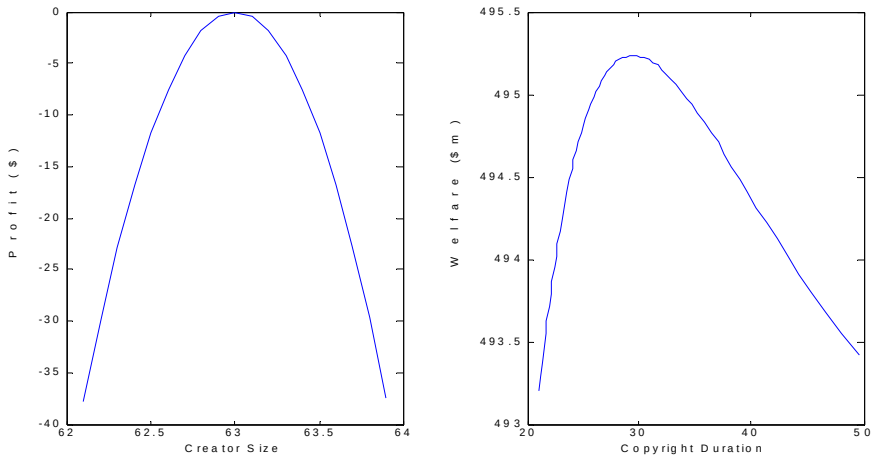

FIGURE 3. Optimal Creator Size and Optimal Copyright Duration

0.05, $c_0 = 3 \times 10^5$, $a = 10^4$, and $\rho = 1.2$. When $\lambda = 0$, λ_1 is inconsequential. These parameter values are not intended to represent an actual market of information products but to be within economically valid ranges and will be changed later.

With these parameter values, the solution is $T^* = 29$, $n = 114$, $s = 63$, $p = 10$, and $L = 0.50 \times 10^9$. The optimality of the solution can be seen in the left-hand panel of Figure 3. In Figure 3, each creator breaks even at optimal size of 63 first-copy products, given copyright duration of 29 years and 63 first-copy products per other creators. In the right-hand panel of Figure 3, we can see that social welfare is maximal when copyright duration is 29 years.

3.2.1. *The Effect of Increasing Price Discrimination against High-Valuation Demand.* The parameter λ_2 represents the strength of price discrimination on high-valuation demand. As an example of looking at its effect, we use the baseline values for D_0, α, δ, β, b, T_0, θ, γ, c_0, a, and ρ, and let $\lambda = 0$, i.e., there is no price discrimination on low-valuation demand. We then let the value of λ_2 vary from 0 to 1, and we repeatedly solve the model. The effects of changing λ_2 are shown in Figure 4. In the figure, the optimal copyright duration, social welfare, and the availability of first-copy information products all decrease with discrimination on the high-end market.

A critical question is whether the above effects always hold for all market conditions, which are represented by different values of the parameters of D_0, α, δ, β, b, T_0, θ, γ, c_0, a, and ρ. To answer this question, I randomly draw values for D_0, α, δ, β, b, T_0, θ, γ, c_0, a, and ρ, and for each set of random values of these parameters,

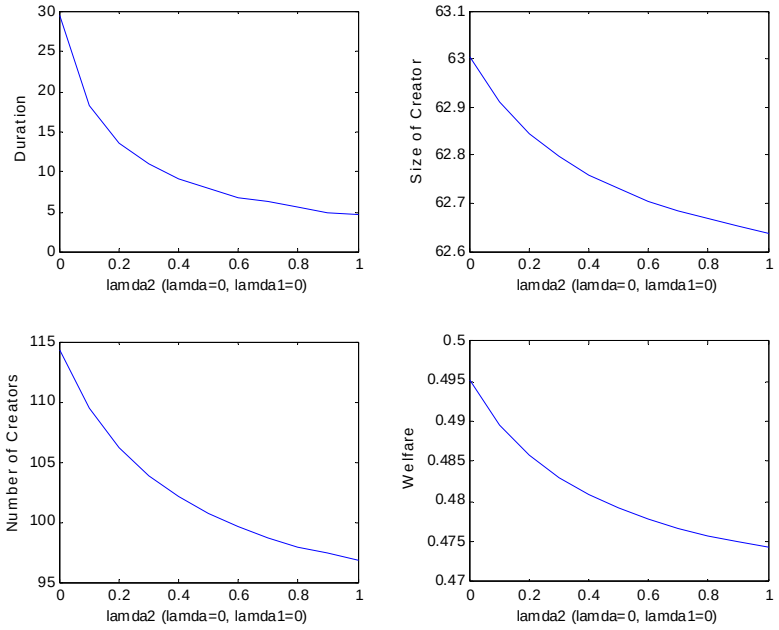

FIGURE 4. Example of the Effect of Discrimination on the High-end Market

I let the value of λ_2 vary from 0 to 1. For each λ_2 the model is solved with $\lambda = 0$. The process is repeated for $\lambda = 1$ and $\lambda_1 = 1$, and again for $\lambda = 1$ and $\lambda_1 = 0$.

D_0, α, δ, β, b, T_0, θ, γ, c_0, a, and ρ are randomly drawn from the respective intervals of $0-10^9$; $0-1$; $1-100$; $0-10$; $0.1-3000$; $1-1000$; $0-1$; $0-0.2$; $1000-3\times10^7$; $10-10^6$; and $1-10$ according to uniform distributions. The intervals cover all possible values for α and θ and wide ranges for the other parameters. Parameter values which do not lead to numerical solutions for the model for different values of λ_2 are disregarded.

The process is repeated for 397 solvable sets of randomly drawn values for D_0, α, δ, β, b, T_0, θ, γ, c_0, a, and ρ from the above mentioned intervals.

The results are the following. First, optimal copyright duration always decreases with λ_2. This means that stronger price discrimination on the high-end market calls for shorter copyright duration. This result may be understood as follows. Price discrimination on high-evaluation demand transfers surplus from consumers to creators. It therefore increases the incentive for creation, reducing the need for lengthy copyright protection; and it decreases the value of information products to consumers, reducing the desirability of information products and the need for long copyright protection.

Second, social welfare and the number of first-copy products may increase or decrease with λ_2. Specifically, when $\lambda = 0$, in 285 of the 397 cases, social welfare and the number of first-copy products decrease with λ_2, and in the other cases, they increase with λ_2. When $\lambda = 1$, social welfare and the number of first-copy products always decrease with λ_2 regardless the value of λ_1.

When creators extract greater surplus from high-evaluation demand through price discrimination, consumer surplus during copyright protection is reduced directly but increased indirectly due to the resultant shorter copyright duration; the incentive for creation is increased directly by the extracted profit and decreased indirectly through the resultant shorter copyright duration. This all means that the net change in consumer surplus and in the number of first-copy products can be positive or negative. In the special case of $\lambda = 1$, there is no deadweight loss in the low-end market, so a shorter copyright duration does not reduce deadweight loss. In this case the simulation shows that discrimination in high-end market only reduces consumer welfare and the availability of the first-copy products.

The welfare effect of price discrimination at the high-end market can further be understood from the nature of open monopolistic competition in the creative sector. In such a sector, creators make zero economic profit in equilibrium. The social welfare of information products comprises only the consumer surplus they bring to consumers. Price discrimination on high-end market reduces consumer surplus, therefore, it reduces the desirability of information products to the society. As a result, social welfare and number of first-copy products may decrease. This reason is different from the one discussed in Lunney (2008), which requires an imperfectly competitive sector external to the copyright sector. In addition, social welfare and number of first-copy products may increase if the resultant shorter copyright duration reduces enough deadweight to compensate for the extracted consumer surplus on the high-end market. This may happen if there is no price discrimination on the low-end market.

3.2.2. *The Effect of Increasing Price Discrimination against Low-Valuation Demand.* The parameter λ represents the strength of price discrimination on low-valuation demand. As an example of looking at the effect of λ, we use the baseline values for D_0, α, δ, β, b, T_0, θ, γ, c_0, a, and ρ and let $\lambda_1 = 0.5$ and $\lambda_2 = 0$, i.e., creators and consumers each take half of the recovered deadweight loss and there is no price discrimination in the high-end market. We then let λ vary from 0 to 1, and repeatedly solve the model. The effects of λ are shown in Figure 5.

In the figure, optimal duration decreases, allbeit marginally, with λ; and welfare and the availability of first-copy information products both increase with λ.

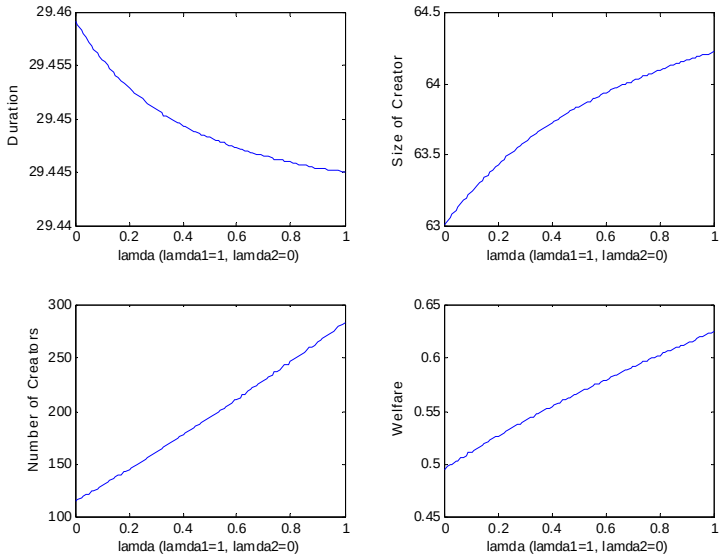

FIGURE 5. Example of the Effect of Price Discrimination on the Low-End Market

A critical question is whether the effects of λ always hold for all market conditions, represented by different values of D_0, α, δ, β, b, T_0, θ, γ, c_0, a, and ρ. To answer this question, I randomly draw values simultaneously for D_0, α, δ, β, b, T_0, θ, γ, c_0, a, and ρ from the same intervals described above, and I set $\lambda_1 = 1$ and $\lambda_2 = 0$. For each set of values of these parameters, λ is varied from 0 to 1, and the model is solved repeatedly. Then, the entire process is repeated for values of $\lambda_1 < 1$, keeping $\lambda_2 = 0$.

The results are the following. First, optimal copyright duration may increase or decrease with λ, depending on the value of λ_1, the division of recovered deadweight loss between creators and consumers. When $\lambda_1 = 1$, i.e., creators take all recovered deadweight loss as profit, optimal copyright duration decreases with λ in all of the 129 cases that were soved. As λ_1 decreases toward zero, i.e., consumers take more and more of recovered deadweight loss as surplus, the optimal copyright duration switches from decreasing with λ to increasing with λ.

The dependence of the result on the distribution of recovered deadweight loss between creators and consumers may be understood as follows. When creators take recovered deadweight loss as profit, it increases the incentive for creation and, therefore, reduces the need for lengthy copyright protection. When consumers share the recovered deadweight loss, it increases the net value of information products to society and, therefore, calls for more information products to be created and more

incentive for creation to be given through longer copyright duration. Therefore, the net effect depends on the share of recovered deadweight loss between creators and consumers. When creators take all of the recovered deadweight loss as profits, the net effect calls for shorter optimal copyright duration; when consumers get a larger share of the recovered deadweight loss as surplus, the net effect calls for longer copyright.

Second, social welfare and the number of first-copy products always increase with λ. This is reasonable as price discrimination on low-evaluation demand reduces deadweight loss and increases either the incentive for creation or the desirability of information products to consumers or both.

Note the difference of the effect of discrimination on the high-end market from that on the low-end market. Discrimination on the high-end market always reduces optimal duration and may increase or decrease welfare and the availability of original information products; discrimination on the low-end market always improves welfare and the availability of original information products but may increase or decrease the optimal copyright duration.

It may be interesting to look at the combined effect of simultaneous price discrimination on both the high-end and the low-end markets, as this may be more realistic. In order to do this, we vary the values of λ, λ_1 and λ_2 within the three dimensional space from 0 to 1, and solve the model using the baseline values for other parameters of D_0, α, δ, β, b, T_0, θ, γ, c_0, a, and ρ. Three sets of solutions indicate that the results essentially remain the same.

First, Figure 6 shows an example of the combined effect of λ and λ_2 for a given value of λ_1. In Figure 6, the optimal copyright duration decreases with λ_2, the discrimination on high-end market, and increases with λ, the discrimination on the low-end market. The figure assumes $\lambda_1 = 0.88$.

Second, solutions are found for 1328 sets of values of λ, λ_1 and λ_2 taken from the grid between 0 and 1, with step size equal to 0.1. Compared to the baseline solution of no price discrimination, in 196 cases of these 1328 cases, the optimal copyright duration increases; in 1121 cases, it decreases; in 1032 cases, welfare and availability of original information products are increased; and in 285 cases, they are decreased.

Third, solutions are found for values for λ, λ_1 and λ_2 randomly drawn from the uniform cube on 0-1. Compared to the baseline solution of no price discrimination, in 152 out of 1331 cases, the optimal copyright duration increases; and in the other cases, it decreases; in 1053 cases, social welfare and the availability of original information products increase; and in 278 cases, they decrease.

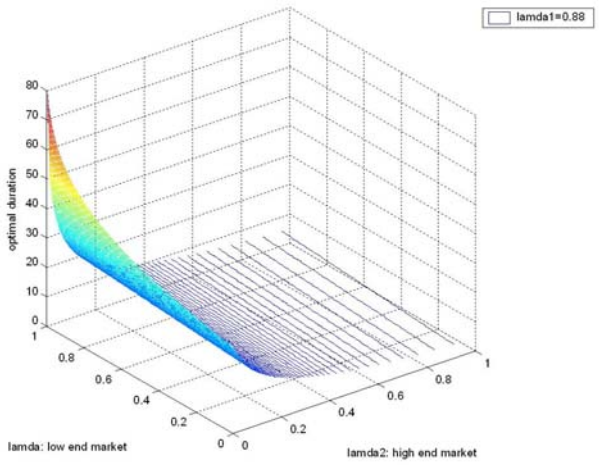

FIGURE 6. The Combined Effect of Discrimination on the Low and the High-end Markets

4. CONCLUSION

This study added price discrimination to a model of optimal copyright and simulated the effects on optimal copyright duration of price discrimination on the market for information products. The simulation suggests that i) price discrimination on the high-end market reduces optimal copyright duration; ii) discrimination on the low-end market reduces the duration if the consumers' share of the recovered deadweight loss is small enough; and iii) it increases the duration if the consumers' share of recovered deadweight loss is great enough.

Results i) and ii) run against the legislative argument that technology calls for an extension of copyright duration. Result iii) contradicts the notion that price discrimination may call for weaker copyright protection, as suggested in Liebowitz (1986).

The simulation further suggests that price discrimination on the low-end market increases welfare and the availability of original information products; while price discrimination on the high-end market increases welfare and availability when there is little price discrimination on low-valuation market, otherwise, it may decrease them. This suggests that price discrimination on the low-end market of information products should be encouraged, and given that, discrimination on the high-end market should be discouraged.

Finally, note there are two limitations with the simulation. First, the simulation uses specific demand and cost functions; second, the random experiments depend on values drawn from bounded intervals for certain unbounded parameters. As

counter examples against an argument for copyright term extension or a notion about the effect of price discrimination, the results are not affected by the limitations. As general statements themselves, the results are not conclusive but subject to verification by future studies.

References

Akerlof, G. A., et. al. (2002), "The Copyright Term Extension Act of 1998: An Economic Analysis", U.S. Supreme Court Brief 02-1.

Anderson, R. (2003), "Trusted Computing Frequently Asked Questions", Version 1.1. Available from: http://www.cl.cam.ac.uk/~rja14/tcpa-faq.html.

Bakos, Y. and E. Brynjolfsson (1999), "Bundling Information Goods: Pricing, Profits and Efficiency", *Management Science*, 45(12); 1613-30.

Bakos, Y. and E. Brynjolfsson (2000), "Bundling and Competition on the Internet", *Marketing Science*, 19(1); 63-82.

Bard, R.L. and L.S. Kurlantzick (1999), *Copyright Duration: Duration, Term Extension, the European Union and the Making of Copyright Policy*, San Francisco: Austin & Winfield Publishers.

Boyle, J. (2000), "Cruel, Mean, or Lavish? Economic Analysis, Price Discrimination and Digital Intellectual Property", *Vanderbilt Law Review*, 53(6); 2007-39.

Boymal, J. and S. Davidson (2004), "Extending Copyright Duration in Australia", *Agenda 11*, 3; 235-46.

Clay, K., R. Krishnan and E. Wolff (2001), "Prices and Price Dispersion on the Web: Evidence From the Online Book Industry", *Journal of Industrial Economics*, 49(4); 521-39.

Clemons , E.K., I. Hann and L.M. Hitt (2002), "Price Dispersion and Differentiation in Online Travel: An Empirical Investigation", *Management Science*, 48(4); 543-9.

Gordon, W.J. (1998), "Intellectual Property as Price Discrimination: Implications for Contract", *Chicago-Kent Law Review*, 73; 1367.

Hamilton, M.A. (1996), "Copyright Duration and the Dark Heart of Copyright", *Cardozo Arts & Entertainment Law Journal*, 14(3); 655-60.

Hyde, B. (2001), "The First Sale Doctrine and Digital Phonorecords", *Duke Law & Technology Review*, 0018. Available at http://www.law.duke.edu/journals/dltr/articles/2001dltr0018.html

Karjala, D.S. (1997), "The Term of Copyright", in Laura Gasaway, N. (Ed.), *Growing Pains: Adapting Copyright for Education and Society*, Littleton, Colorado: Fred B. Rothman & Co.

Landes, W.M. and R.A. Posner (1989), "An Economic Analysis of Copyright Law", *Journal of Legal Studies*, 18(2); 325-63.

Lavigne, J.A. (1996), "For Limited Times. Making Rich Kids Richer Via the Copyright Term Extension Act of 1996", *University of Detroit Mercy Law Review*, 73(2); 311-60.

Liebowitz, S.J. (1985), "Copying and Indirect Appropriability: Photocopying of Journals", *Journal of Political Economy*, 93(5); 945-57.

Liebowitz, S.J. (1986), "Copyright Law, Photocopying, and Price Discrimination", *Research in Law and Economics*, 8; 181-200.

Lunney, G.S. (2008), "Copyright's Price Discrimination Panacea", *Harvard Journal of Law & Technology*, 21(2); 387-456.

Meurer, M.J. (2001), "Copyright Law and Price Discrimination", *Cardozo Law Review*, 23; 55-148.

Mortimer, J.H. (2007), "Price Discrimination, Copyright Law, and Technological Innovation: Evidence From the Introduction of DVDs", *The Quarterly Journal of Economics*, 122(3); 1307-50.

Nam, H. (2006), "Copyright Issues in Proposed FTA between Korea and US, World Library And Information Congress", 72nd Ifla General Conference and Council, 20-24 August, Seoul, Korea.

Ochoa, T.T. (2002), "Patent and Copyright Term Extension and the Constitution: A Historical Perspective", *Journal of Copyright Society*, 49; 19-125.

Rappaport, E. (1998), "Copyright Term Extension: Estimating the Economic Values", Congressional Research Service, Washington, D.C.: Library of Congress.

Reichman, J.H. (1996), "The Duration of Copyright and the Limits of Cultural Policy", *Cardozo Arts & Entertainment Law Journal*, 14(3); 625-54.

Senate Report (1996), "Copyright Term Extension Act of 1996", 104th Congress, 2nd Session, Calendar No.491, July 10. http://www.copyright.gov/legislation/s-rep104-315.html.

Shapiro, C. and H.R. Varian (1998), "Versioning: The Smart Way to Sell Information", *Harvard Business Review*, 76(6); 106-14.

Ulph, D. and N. Vulkan (2000), "Electronic Commerce and Competitive First-Degree Price Discrimination", mimeo, University College London.

Viswanathan, S. and G. Anandalingam (2005), "Pricing Strategies for Information Goods", *Sadhana, Journal of the Indian Academy of Sciences*, 30; 257-74.

Walterscheid, E.C. (2000), "Defining the Patent and Copyright Term: Term Limits and the Intellectual Property Clause", *Journal of Intellectual Property Law*, 7; 316-56.

Yuan, M.Y. (1997), *Essays on Internet Business and Markets for Digital Information*, Doctoral Dissertation, Carnegie Mellon University.

Yuan, M.Y. (2005), "Does Decrease in Copying Cost Support Copyright Term Extension?", *Information Economics and Policy*, 17(4); 471-94.

Yoon, K. (2002), "The Optimal Level of Copyright Protection", *Information Economics and Policy*, 14(3); 327-48.

Roger Williams University