

The Effect of Decrease of Copying Cost on Optimal Copyright Duration: The Role of an Intermediary

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Abstract

Technological and demographic changes have been cited to support copyright term extension. Increase in demand for information products has been suggested in the literature to call for longer copyright protection. This paper revisits these suggestions using models of an information market with an intermediary between creators and consumers. The market with an intermediary is more realistic than markets without intermediaries. Similar to earlier study, we found no support for the suggestion that decrease in copying cost and increase in demand for information products require longer copyright protection. Different from earlier study, we found no support for the idea that longer life expectancy and delayed child-bearing call for longer copyright duration.

1. Introduction

Copyright duration has been extended successively over time. It has been extended from "zero year" (no copyright) to 14 years plus a 14 year renewal term in 1709 in England and in 1790 in the U.S., and in the U.S., to 28 years plus a 14 year renewal term in 1831, to 28

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years plus 28 year renewal term in 1909, to life of the author plus 50 years in 1976, and to life of the author plus 70 years in 1998.

The cost of copying has been decreasing consistently over time. The decreases have corresponded to major technological progresses in copying: Gutenberg printing press in 1436, Chester Carlson's Xerography 1937, IBM's personal computer in 1981, and the World Wide Web in 1995.

It has been suggested that the reduction of copying costs support extension of copyright duration. The U.S. Senate Report (1996) introduced the Senate bill S. 483 which became the 1998 Sonny Bono Copyright Term Extension Act. The report argues that new media technologies enhance the marketable life of information products, which in turn requires longer copyright duration. An information product is marketable if the value of a copy of the product is greater than the cost of making and distributing the copy. Therefore, decrease in copying cost enhances the marketable life of information products and supports longer copyright duration.

The effect of decrease in copying cost on copyright duration can be used in debates of changes of copyright duration in other countries and in the future. The effect has been studied in Yuan (2005). Optimal duration of copyright is found to decrease with decrease in copying cost. The result is based on a model of a market where creators sell copies of their products directly to consumers. However, creators mostly sell copies of their products through intermediaries in reality.

This paper studies the effect of decrease in copying cost on copyright duration with models of a market where creators sell copies of their information products to consumers through an intermediary. The intermediary allows creators to specialize in creation, and to outsource other activities such as storage, reproduction (copying), and distribution. The intermediary also requires the regulator to add its welfare in the total social welfare. These changes alter the operation of the market and may affect the relationship between copyright duration and parameters of the market, including copying cost.

This paper also studies the effect on copyright duration of the longer life expectancy and delayed child bearing of creators and consumers. Senate Report (1996) suggests longer life expectancy and delayed child-bearing of authors and their descendents require longer copyright duration to afford adequate protection for the creators and their heirs. However, effect of such demographic changes should also include consumers' longer life expectancy and delayed child-bearing. Models in this paper approximate both.

This paper further simulates the effect of higher demand for information products on copyright duration. As the economy becomes more information-based and society becomes richer, demand for information products is increasing. Based on a unique model, Landes and Posner (1989) suggested that higher demand for information products leads to longer optimal duration of copyright.

Similar to Yuan (2005), this study finds no support for the suggestions that decrease in copying cost and increase in demand for information products require longer copyright protection. Different from Yuan (2005), this study finds no support for the idea that longer life expectancy and delayed child-bearing call for longer copyright protection.

The rest of paper is organized as follows. The next section reviews the literature. The section after develops the models. The results are then represented before the paper concludes.

2. Literature Review

The models in this paper are related to two streams of literature. The first is the optimal copyright and patent literature; the second is the two-sided market literature.

Extant models of optimal copyright and optimal intellectual property can be classified into four categories according to whether they describe competition in creation and competition in production. Models in the first category allow no competition in either creation or production. In these models, a single creator invests in creation and monopolizes production when the creator's products are within the duration of protection. The earliest models in intellectual property, such as Nordhaus (1969, 1972) and Sherer (1972), fall into this category. Landes and Posner (1989), Gilbert and Shapiro (1990), Takalo (2001), Gans & King (2004), and Adilov (2005) are more recent examples of the category. Most models in this category capture the tradeoff between encouraging creation and reducing restrictions on consumption. The model in Landes and Posner (1989) is unique in that it describes the trade-off between the incentive for creation through increasing demand of the copyright owner by reducing copiers' supply and the disincentive of increasing creative cost by limiting the usage of information products in creation. Although the model in Landes and Posner (1989) allows for many creators, however, each creator creates a single work and no competitive interaction exists among creators. Therefore, the model is equivalent to a model with a single creator who creates many

works. Adilov (2005) is unique in that it models quality enhancement investment after products are created.

Models in the second category allow competition in creation but no competition in production. Many of the patent race models, where the winner of the inventing race "takes all" in the production stage, belong to this category. Examples include Denicolo (1996, 1999, and 2000) and Judd and Schmedders (2003).

Models in the third category allow competition in production but not in creation. These models deal with issues like competition from imitators and optimal licensing. Examples are Tandon (1982), Klemperer (1990), Gallini (1992), and Wright (1999).

Models in the fourth category describe competition in both creation and production. Veall (1992), O'donoghue, et al. (1998), Waterson (1990), and Yuan (2005a and 2005b) belong to this category. The models in this paper also fall into this category.

Our models differ from the extant models in the fourth category in the composition of market players and competitive decisions they make in creation and production. In Veall (1992), creators make entry decision with a single product. In O'donoghue et al. (1998), innovators decide whether or not to incur a fixed cost for random quality improvement. Waterson (1990) considers two-firm competition in patenting, entry, and location. Yuan (2005a and 2005b) assumes creators publish and sell their products directly to consumers. In this paper, like in Yuan (2005a and 2005b), creators make decisions on entry, on how many first-copy products to create, and on pricing in selling copies of their products in a monopolistically competitive product market. This paper differs from Yuan (2005a and 2005b) in that creators sell through an independent and active intermediary.

The second stream of literature related to the models in this paper is studies on the two-sided markets and online intermediaries. This literature studies markets where sellers interact with buyers through intermediaries. The intermediaries are active market players that balance their dealings with sellers and buyers and consider the often significant indirect network externality across sellers and buyers and direct network externality within sellers or buyers. Examples include Yuan (1997), Baye and Morgan (2001), Belleflamme and Toulemondey (2004), Caillaud and Jullien (2001), Caillaud and Jullien (2003), Choudhary and Mukhopadhyay (2003), Yoo et al. (2003), Ambrus and Argenziano (2004), Bhargava and Choudhary (2004), Gabzewicz and Wauthy (2004), and Owan and Nickerson (2004).

The two-sided market literature can be classified according to whether and how the competition among intermediaries is considered and what network externality and what decisions of sellers and buyers are modeled. In Baye and Morgan (2001), Yoo et al. (2003), Bhargava and Choudhary (2004), Belleflamme and Toulemondey (2004), Hagiu (2004a), and Hagiu (2004b), pure monopolistic intermediary is modeled.

Caillaud and Jullien (2001), Armstrong (2002), Caillaud and Jullien (2003), Rochet and Tirole (2003), Ambrus and Argenziano (2004), Gabzewicz and Wauthy (2004), Rochet and Tirole (2004) consider indirect network effect across sellers and buyers but no direct network effect within sellers or within buyers.

Caillaud and Jullien (2001), Armstrong (2002), Caillaud and Jullien (2003), Rochet and Tirole (2003), Yoo et al. (2003), Ambrus and Argenziano (2004), Bhargava and Choudhary (2004), Gabzewicz and Wauthy (2004), Owan and Nickerson (2004), Hagiu (2004a),

Reisinger (2004) consider decisions of sellers and buyers to participate in the intermediary but no other decisions of sellers or buyers, such as sale decisions from sellers to buyers.

This study extends the models in Yuan (1997) and applies them to copyright modeling. As in Yuan (1997), this study models the competition of an incumbent digital library with potential entrants and the negative direct network effect within creators as well as positive indirect network effect across creators and consumers. The direct network effect is due to the competition between creators for consumers' demand for information products. A new creator entering the market reduces demand for products of extant creators, which is not considered by the entrant. The indirect network effect is that consumers like intermediaries with more creators and products; and creators prefer intermediaries with more consumers. In addition, this study models the decisions of creators on pricing, number of first-copy products to develop, and whether to stay on the market. The study differs from the models in Yuan (1997) by adding a time variable in the models.

3. The Models

The operation of the information market is first described qualitatively. Players in the market of information markets are creators, consumers, a digital library, and the regulator. Creators develop first-copy information products, place their products in the digital library, and sell copies of their products to consumers. The digital library provides creators with services of storage, advertising, reproduction, distribution, copyright management, and payment collection, etc., and provides consumers with access and search services.

Digital libraries have low barriers to entry. Barriers to entry can be represented by sunk fixed costs. Examples of sunk fixed costs are those of special purpose hardware and

software and costs of labor in setting up the library and cost of advertising. However, the costs of general-purpose hardware and software may not be sunk. Katcovich and Smith (2001) suggest the sunk fixed cost of setting up an online bookstore is low and sunk cost of advertising is significant. We assume the possibility that sunk fixed costs are small, relative to the potential profit of a pure monopolistic digital library. That is, there are low barriers to entry.

Digital libraries display increasing returns to scale. There are two kinds of variable costs for a digital library: costs depending only on the size of the library, such as costs of storage and cataloging, and costs depending only on the usage of the library by information users, such as costs of reproduction, delivery, and payment collection. The variable costs can be assumed to be small relative to fixed costs and to increase sub-linearly with size and usage of the library.

Because of the size-sensitive and usage-sensitive costs, a digital library sets a size-sensitive fee and a usage-sensitive fee for creators to use its services, called “storage fee” and “sales fee”, respectively. By the storage fee, creators are charged per product per period of time they place in the library, independent of sales of the product. Storage fees are fixed cost to creators for given first-copy information products of fixed copyright duration. By the sales charge, creators are charged by the digital library per copy of their products sold to information users. Sales charges are variable cost to creators of given first-copy products.

Creators develop first-copy information products, place them in the digital library, and sell copies of them to consumers. Creators are the sole sellers of their respective products

within copyright duration. However, creators compete with creators of similar products. Because products of different creators cannot be exactly the same by copyright law, the competition between creators is monopolistic. Due to high creative cost, creation is critical to the market of information products. Therefore, competition in creation between creators is critical.

Creation can be for profit or non-profit purposes. We consider commercial creators only. Under monopolistic competition, creators price above marginal cost, which is equal to the sales, in order to maximize profits. Profits above marginal costs allow creators to recover creative cost and produce net profits. However, above-marginal-cost pricing causes loss in consumer surplus. The difference between the loss in consumer surplus and the gain in creators' revenue is the deadweight loss of social welfare.

After copyright expires, anyone is free to reproduce and distribute the products. Assuming the digital library and anyone else incur the same marginal cost of reproduction and distribution, competition will drive prices down to the marginal cost of reproduction and distribution. Digital library can only distribute the product at price equal to marginal cost of reproduction and distribution. At the same time, consumers enjoy maximal surplus from the information products. Deadweight loss is avoided.

Each creator decides how many first-copy products to create. The decision depends on the cost of creation and the profit of the product from the above-marginal-cost pricing within copyright duration. On the margin, the cost of creation equals the profit from above-marginal-cost pricing.

Creators further choose whether to enter the information market. In general if there are economic profits to be made, potential creators will enter the market. Assuming average information products are substitutes, new entrants will reduce demand for products of existing creators and reduce profitability of further entry. Entry stops when economic profit of marginal entrant becomes zero.

Consumers access digital libraries for free and pay to get copies of information products. The prices of the information products are set by creators. The payment and the delivery are handled by the library. Free access to the library by consumers makes sense because both the library and creators want to attract consumers and because the costs of consumers' library use to consumers and to the digital library, other than the variable costs listed above, are negligible.

There is positive indirect network externality across creators and consumers. That is, consumers prefer digital library with more creators and more first-copy information products; and creators prefer digital library with more consumers and higher demand for their products, everything else being equal.

This positive indirect network effect and the increasing returns to scale mentioned above suggest that a digital library is a natural monopolist. However, low barriers to entry imply that the digital library may face competition from potential entrants.

Finally, the regulator chooses the duration of copyright. The goal of the regulator is to maximize social welfare. Social welfare is the sum of surplus of creators, consumers, and the digital library. The regulator must consider the behavior of the creators, consumers, and digital library to making its choice of copyright duration.

Several assumptions are made to simplify the modeling of the information market. Firstly, there is no quality enhancing investment after the products are created and no other dynamic creative decisions by the creators. All creators enter the market and create first-copy information products instantly at the same time; copies of products are made and sold overtime afterwards.

Secondly, products are symmetric and only horizontally differentiated. Although there can be multiple independent categories of information products, there is no interaction among the categories. And within a category, first-copy products are of the same quality, symmetric, and horizontally differentiated. Note the distinction between quality difference and product differentiation and the distinction between the quality of first-copy products and the quality of copying. Quality difference is "vertical"; product differentiation is "horizontal". Symmetry means that there is no horizontal ordering among first-copy information products. We assume copies of information products made by the creators or by others are of the same quality. This assumption may be true for digital information products.

Thirdly, at any given point of time, each creator sets one price for all its information products. A creator does not price-differentiate its first-copy products. If there are no quality difference and ordering among first-copy information products, prices of the products of a creator should be the same. This assumption also means that price discrimination across customers is not considered. This assumption ignores the interaction among the products of the same creator. Note that the price may still change over time.

Fourthly, copyright protection is perfectly enforced within copyright duration. This study is concerned about the design of optimal copyright. Although enforcement is an interesting issue due to the ease of copying of electronic information products, it is different from the design of optimal copyright. In addition, imperfect enforcement of copyright can be partially treated in our models by amending the demand function to reflect the increased demand due to consumers' ability to copy.

Finally, the effect of changes in availability of information due to changes in copyright duration or copyright fee on further creation of information products is not considered. Landes and Posner (1989) uniquely modeled the effect of copyright protection on the cost of creation. We think the feedback of copyright through information availability on creation and back to copyright is of secondary order in nature. And part of that effect is partially included in "consumer surplus".

The difficulty of modeling this market is in the behavior of the library. As mentioned earlier, the digital library is a natural monopolist because of increasing returns to scale and the positive indirect network effect across creators and consumers; at the same time, the digital library may face competition from potential entrants due to low barriers to entry.

The difficulty is how the natural monopolist responds to potential entry. We develop two models based on two theories: contestable market theory and pure monopoly theory. According to contestable theory, the digital library acts to preempt threat of entry. On the other hand, pure monopolist ignores threats of entry. In contestable theory, the effect of threat of entry may be taken as too strongly, because the incumbent monopolist may have other means to combat threat of entry. In the pure monopolistic theory, the effect of threat

of entry may be described too weakly, because it is ignored. Therefore, the two models describe two extremes. They may be thought as providing upper and lower limits for the real behavior of the monopolistic digital library. If the two models point to the same direction about the effect on copyright duration of a change in information product market, then the effect should be in that direction; on the other hand, if the two models disagree on the direction of the effect, then the models gives no evidence suggesting one way or the other.

The following notations are used in models.

i : index over information creators;

n : number of information creators on the market;

s_i : number of first-copy products of creator i ;

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

p_{it} : price (per copy or per use) of each first-copy product of creator i at time t ;

p_{-it} : vector of prices (per copy or per use) of products of creators other than i at time t ;

P : storage fee per product for creators to place in the digital library;

R : sales fee (per copy or per use) for creators to sell through the library;

$d_i(p_i, p_{-i}, s_i, s_{-i})$: rate of demand for creator i 's information products at time t ;

S : size of the digital library; that is the total number of first-copy products of all creators: $S = \sum_{i=1}^n s_i$;

D : rate of usage of the digital library; that is the total rate of demand for information products of all information creators from information users at time t : $D = \sum_{i=1}^n d_i$;

b : reproduction and distribution cost of information products;

$c_i(s_i)$: the total cost of creation of creator i when it creates s_i products, assumed uniform for all creators;

$C_1(S)$: size-sensitive cost of the digital library per unit of time, such as storage cost;

B : library's entry cost;

T : copyright duration

3.1 A Model of Information Market with Contestable Digital Library

The profit of creator i is:

$$\pi_i = \int_0^T [(p_i - R) d_i(p_i, p_{-i}, s_i, s_{-i}) - Ps_i] e^{-\delta t} dt - c_i(s_i) \quad (1)$$

The problem of the creator is:

$$\underset{p_i, s_i}{Max} \pi_i = \int_0^T [(p_i - R) d_i(p_i, p_{-i}, s_i, s_{-i}) - Ps_i] e^{-\delta t} dt - c_i(s_i) \quad (2)$$

The digital library is naturally monopolistic and faces threat of entry from potential entrants. The incumbent digital library and potential entrants compete for the creators who are currently on the market. This may be because it is more difficult to collect information about potential creators than to get information about creators who are currently on the market.

The incumbent digital library acts to maintain its dominant market position. The incumbent cannot make profit more than an entrant's entry cost. If the incumbent makes profit higher than entry cost, an entrant can take over the market by incurring the entry cost and providing the same service to creators and consumers plus spending a small amount as incentive for the creators to switch to it. Moreover, the incumbent provides creators the best services possible under a profit equal to the cost of entry. If the services are not the best possible under the profit equal to the cost of entry, an entrant can enter, providing better services and making a profit covering entry cost. And the better services mean that it can charge slightly higher prices, extracting part of the additional surplus from creators and making a profit above entry cost.

The above description may be considered as an upper boundary for the effect of competition from potential entrants. The behavior of the incumbent described above is highly contestable in the sense of Baumol, Panzar, and Willig (1988), except that there is a positive cost of entry. The contestable market theory has been criticized as ignoring the ability of the incumbent to prevent entry by dynamically adjusting price when actual entry occurs (e.g. Schwarts and Reynolds, 1983). However, such criticism has been countered by citing the ability of potential entrants to sign long term contract with customers, which suggest that adjusting price only when actual entry occurs may be too late (Trains, 1991, p. 305). Recently, Goolsbee, Austan and Syverson, Chad (2004) find that airlines dominant on specific routes respond to mere threats of entry.

A proper measure of quality of services to creators is the total profits of the creators on the market, given that the creators always make the best use of given services of the digital library. We assume that the digital library has the information to calculate the total profit of the creators. In practice, digital library may find the "best services" through testing various offerings.

The decision dynamics on the information product market is as follows: First, for any storage fee and sales fee, each creator on the market chooses prices of their products and number of first-copy products to create to maximize profit. Second, the incumbent digital library identifies the creators on the market and calculates their total profit; it sets the storage fee and sales fee to maximize the total profit, given that the library itself makes a profit equal to the cost of entry. Third, the creators make exit decisions and potential creators make entry decisions based on profitability of creators, given the storage fee and

the sales fee of the digital library. Note that, if a creator decides to exit, it is because there are too many creators on the market and the creator is making negative profit. However, the creator cannot increase its profit by switching to an entrant digital library because no entrant could provide better services to the creators. But its exit makes other creators on the market better off. The exit/entry decisions of creators may change the set of creators on the market. The incumbent goes back to the second step. If the library sees a new set of creators on the market, it resets its fees best for the new set of creators and the process goes on. If the digital library finds the same set of creators, equilibrium has been reached and the process stops.

Assume the incumbent library is required to hold and serve the information products after the products are in public domain. At that time, the library charges users per copy of the information products at its marginal cost b of reproduction and distribution.

The library's profit is:

$$\Pi = \int_0^T [PS + (R - b)D_t - C_1(S)]e^{-\lambda t} dt - \int_T^{\infty} C_1(S)e^{-\lambda t} dt - B$$

The library can only make even:

$$\Pi = \int_0^T [PS + (R - b)D_t - C_1(S)]e^{-\lambda t} dt - \int_T^{\infty} C_1(S)e^{-\lambda t} dt - B = 0 \quad (3)$$

For any given n number of creators on the market, the library calculates the sum of their profits:

$$\sum_{i=1}^n \pi_i = \sum_{i=1}^n \int_0^T [(p_i - R) d_i(p_i, p_{-i}, s_i, s_{-i}) - P s_i] e^{-\lambda t} dt - c_i(s_i)$$

To prevent entry, the library maximizes the sum of profits of the creators on the market:

$$\text{Max}_{P,R} \sum_{i=1}^n \pi_i = \sum_{i=1}^n \int_0^T [(p_i - R) d_i(p_i, p_{-i}, s_i, s_{-i}) - P s_i] e^{-\lambda t} dt - c_i(s_i) \quad (4)$$

S.t. (2) and (3)

The marginal entry condition is:

$$\pi_n = 0 \quad (5)$$

Consumer surplus is:

$$CS = \sum_{i=1}^n \int_0^{\infty} \int_b^{\infty} d_{it} dp e^{-\lambda t} dt - \sum_{i=1}^n \int_0^T \int_b^{p_{it}} d_{it} dp e^{-\lambda t} dt$$

Because both creators and the library make zero profit on equilibrium under symmetry, social welfare is the same as consumer welfare.

The problem of the regulator is:

$$\text{Max}_T W = CS \quad (6)$$

S.t (4) and (5)

3.2 A Model of an Information Market with Pure Monoplist Library

the pure monopolist model provides lower limit of behavior of the digital library. The problem of the creator is:

$$\underset{p_i, s_i}{Max} \pi_i = \int_0^T [(p_i - R) d_i(p_i, p_{-i}, s_i, s_{-i}) - Ps_i] e^{-\gamma} dt - c_i(s_i) \quad (7)$$

The marginal entry condition is:

$$\pi_n = 0 \quad (8)$$

The library's problem is to maximize its profit, i.e.:

$$\underset{P, R}{Max} \Pi = \int_0^T [PS + (R - b)D_t - C_1(S)] e^{-\gamma} dt - \int_T^{\infty} C_1(S) e^{-\gamma} dt - B \quad (9)$$

S.t. (7) and (8)

Consumer surplus is:

$$CS = \sum_{i=1}^n \int_0^{\infty} \int_b^{\infty} [d_{it} dp] e^{-\gamma} dt - \sum_{i=1}^n \int_0^T \int_b^{p_{it}} [d_{it} dp] e^{-\gamma} dt$$

Because creators make zero on equilibrium under symmetry, social welfare is:

$$W = \Pi + CS$$

The problem of the regulator is:

$$\underset{T}{Max} W = \Pi + CS \quad (10)$$

S.t (9)

4. The Results

Specific functions for demand $D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t)$, creative cost $c_i(s_i)$, and library cost $C_1(S)$ are needed to solve the models. Assume:

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

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

$$c_i(s) = c_0 + as^\rho \quad (13)$$

$$C_1(S) = a_1 S^{b_1} \quad (14)$$

where $0 < \alpha < 1$, $\delta > 1$, $\beta > 0$, $0 \leq \theta < 1$, $\rho > 1$, and D_0 , T_0 , c_0 , a , a_1 , and b_1 are positive constants.

These functions represent the basic properties of the consumers, the creators, and the digital library. The demand function (11) is selected to reflect how demand for a creator's products changes with its price, the prices of other creators, and number of its first-copy

products and number of first-copy products of other creators. The factor $\left(\sum_{j=1}^n s_j \right)^\alpha$ in (11)

and $0 < \alpha < 1$ mean that the total demand increases with the total number of first-copy information products. The parameter α is the percent increase in demand from a percent increase in the number of first-copy products. The parameter α reflects the degree of differentiation of first-copy information products and consumers' preference for variety of information products. The bigger the α , the more differentiated the first-copy products or

the stronger the preference of consumers for variety. One can identify four different values and value ranges for the parameter: 1) $0 < \alpha < 1$ means that the demand increases sub-linearly with the number of first-copy products. That is, first-copy products are substitutes. 2) $\alpha = 0$ would indicate that all products are perfect substitutes; 3) $\alpha > 1$ would mean that the demand increases super-linearly with the number of first-copy products. That is, information products are complements; 4) $\alpha = 1$ would mean the total demand for information products increases linearly with the total number of first-copy products. The products are neither substitutes nor complements. Although, individual information products can be complements to each other, average information products are most likely substitutes within a product category.

The factor $\prod_{j \neq i} p_j^{\frac{\beta}{n-1}}$ and positive β mean that demand for a creator's products increases with the prices of products of other creators, further reflecting the assumption that information products are substitutes on average. The parameter β is the cross-price elasticity.

The factor $s_i / \sum_{j=1}^n s_j$ in (11) implies that total demand for information is distributed among creators in proportion to their numbers of first-copy products, other things being equal.

Positive δ means that demand for a creator's products decreases with its price. The parameter δ is the price elasticity of demand for a creator's products. The condition of $\delta > 1$ is necessary for consumer surplus to be finite. Note that demand D_i in (11) depends on p_{it}

only through the factor $p_{it}^{-\delta}$. From (11) and the creator's problem in the models, one can derive that during copyright protection:

$$p_{it} = p \equiv \frac{\delta}{\delta-1} R \quad (15)$$

The factor $g(t)$ represents the change over time in the rate of demand for information products. The specific form (12) assumes that the demand decreases linearly over time to θ at time $T_0^*(1-\theta)$ and then it remains at that level.

In (11), all first-copy products are related to demand in the same way, reflecting the assumption that there is no ordering among first-copy products. In the cost function (13), parameter " c_0 " represents the fixed cost of information creation; the parameter " a " is related to per-product creative cost; and $\rho > 1$ means that there are decreasing returns to scale in creation.

The above specifications assume that creators are symmetric: they have identical costs of creation, reproduction, and distribution; they have symmetric demand functions. Thus, in equilibrium, all creators should have the same size and charge the same price.

That $b_1 < 1$ and a large fixed cost B represent that there is scale of economies in digital library.

With the above specific demand and cost functions, explicit analytical solutions are not found. Numerical methods are used to solve the models for given values of the parameters of D_0 , α , δ , β , b , T_0 , θ , γ , c_0 , a , and ρ , a_1 , b_1 , and B .

The following parameter values are assumed for the baseline simulation:

$$[D_0 \alpha \delta \beta b T_0 \theta \gamma c_0 a \rho a_1 b_1 B]=$$

$$[6 \cdot 10^7 \ 0.2 \ 2 \ 0.2 \ 5 \ 100 \ 0.001 \ 0.05 \ 3 \cdot 10^5 \ 10^4 \ 1.2 \ 10 \ 0.9 \ 10^7]$$

These parameter values are not selected to represent any particular actual information market. Rather, the intention is to change these parameters and see how optimal duration of copyright change with them.

With these parameter values, the results for some variables of the information market from the models are shown in Table 1.

Table 1. Baseline Solution of Two Models

	Contestable Digital Library	Pure Monopolistic Digital library
Copyright Duration	7	12
# of first-copy Products per Creator	63	43
# of Creators	103	34
Storage Fee per Product (\$) per Year	-277	10219
Sales Fee per Copy Sold (\$)	5.7	5.9
Price per Copy during Copyright (\$)	10.5	10.7
Total Copies Sold in 10 Years (m)	82	33
Total Copies Sold in 100 Years (m)	922	638
Library Profit (\$M)	10	142
Social welfare (\$B)	1.6	1.2

In Table 1, relative to contestable digital library, the pure monopolistic digital library charges higher storage fee and higher sales fee; there are fewer creators; each creates fewer

number of first-copy products; information prices to consumers are higher; consumption is lower; social welfare is smaller. The higher storage fee and higher sales fee reduce the incentive for creators to create; in response, the regulator sets longer copyright protection to compensate the reduced incentive due to higher library fees. However, longer copyright duration cannot compensate all of the lost incentive and social welfare.

The optimality of the solutions of the two models is shown in Figure 1 and Figure 2. The figures show that the behavior of each creator, the digital library, and the regulator are optimal relative to their respective goals, given behavior of the others. For example, Figure 1 shows that the copyright duration of 7 years is optimal, given the behavior of the digital library and the behavior of the creators, which respond to the duration; the \$5.7 sales fee is optimal, given the 7 year copyright duration and the behavior of the creators, which react to its fee in maximizing their individual profits; and the 63 first-copy products are optimal to a creator given the -\$277 storage fee and \$5.7 sales fee of the digital library and the copyright duration of 7 years set by the regulator. Note that the negative storage fee is similar to a royalty paid to the creator. The storage fee is omitted from the Figure 1, because it is determined through the sales fee by the profit constraint of the contestable digital library.

More critical is how duration of copyright changes with changes in parameters of the market, including copying cost, discount rate, and demand for information products.

Figure 1. Optimality of Baseline Solution of Contestable Model

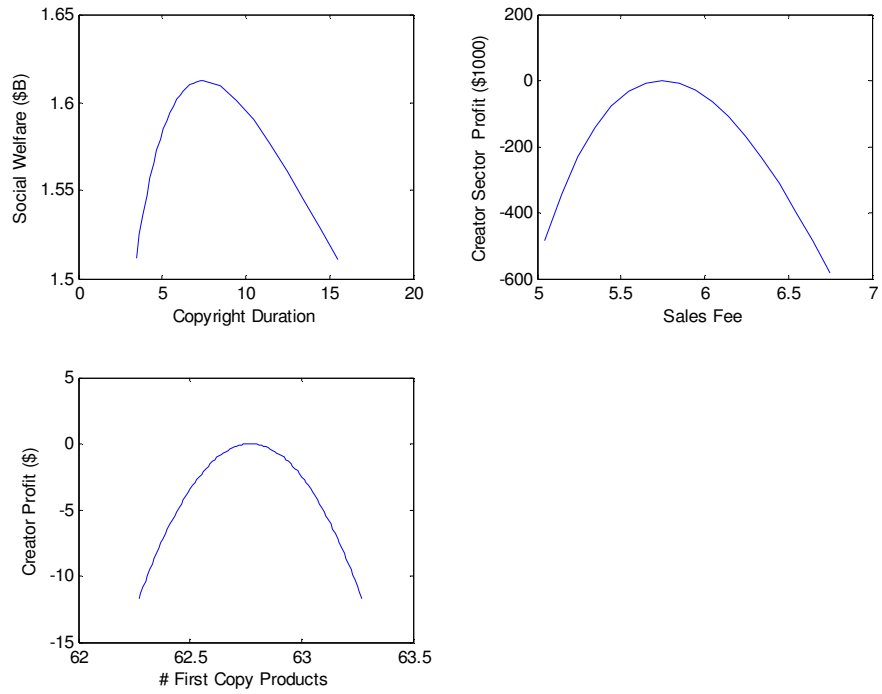
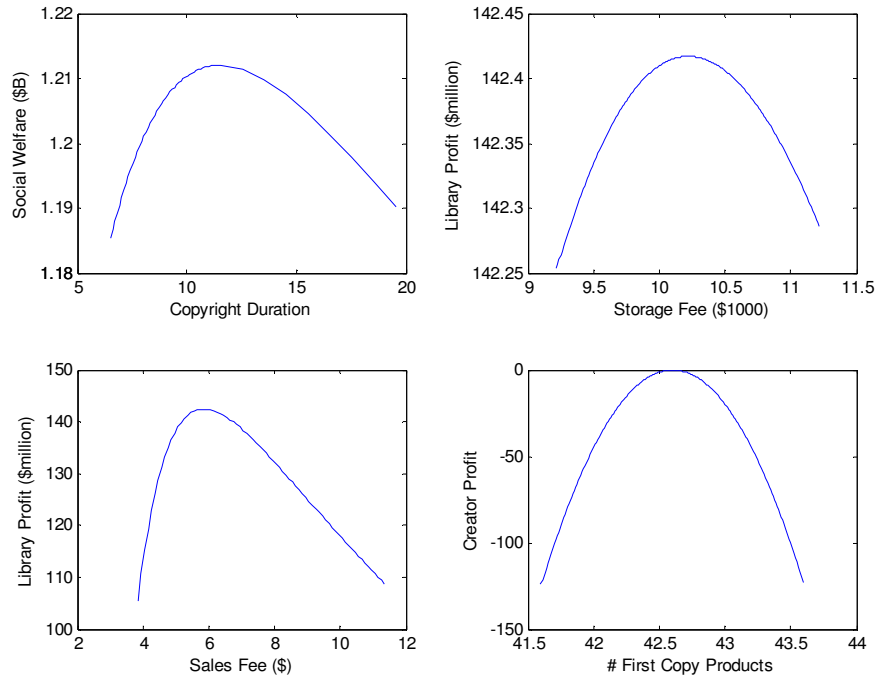


Figure 2. Optimality of Baseline Solution of Pure Monopolist Model



4.1 The Effect of Decrease in Reproduction and Distribution Cost on Optimal Copyright Duration

In the models, the parameter b represents the reproduction and distribution cost. Selecting different values for b and recalculating the models lead to the result shown in Figure 3

Figure 3. Effect of Copying Cost on Optimal Duration of Copyright

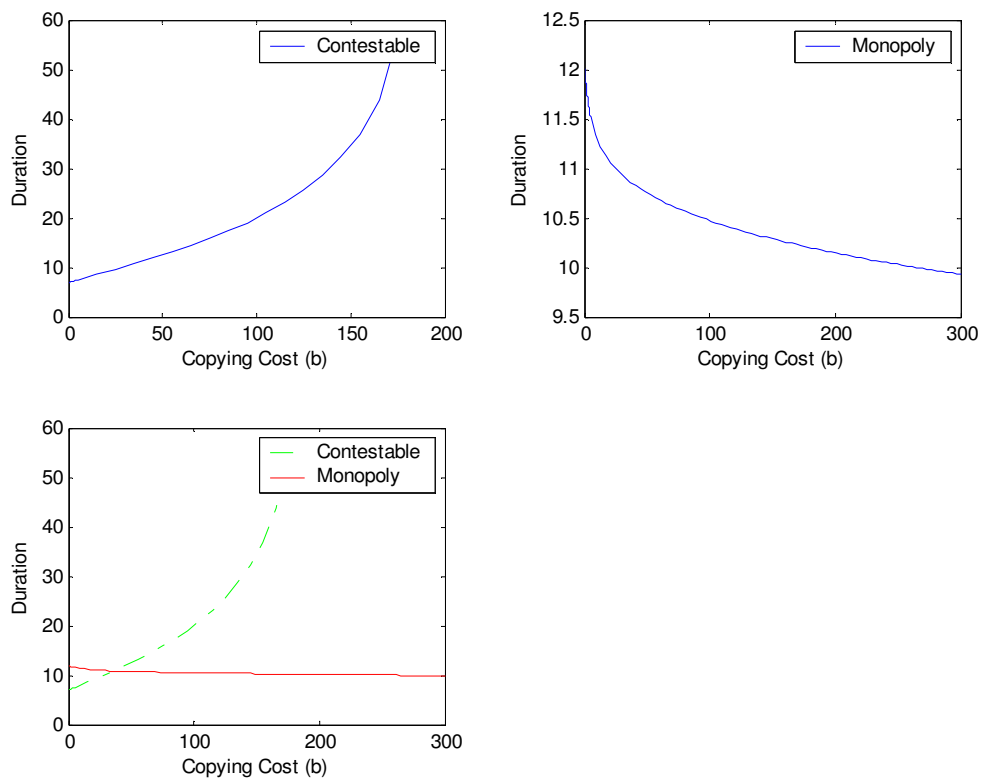


Figure 3 shows, according to the contestable model, decrease in copying cost leads to decrease in optimal duration of copyright. According to the pure monopolistic digital library model, decrease in copying cost leads to increase in optimal copyright duration. In the graphs, the optimal copyright protection in the pure monopolistic model changes much

more slowly than in the contestable model. Therefore, the line representing the monopolistic model appears to be flat when the two are drawn in the same graph.

The two models do not agree on the direction of the effect of decrease in copying cost on copyright duration. Since the two models may best be thought as providing upper and lower limits on the behavior of the real market with a monopolistic digital library, the result does not give definite answer on the direction of the effect in a real market. It cannot provide support for the suggestion that the decrease in copying cost requires longer copyright protection.

Why do the two models differ on the direction of effect? Decrease in copying cost means that information products are more desirable socially; more incentive should be given to the creation of the information products. On the other hand, decrease in copying cost means that deadweight loss during copyright protection is larger; therefore, copyright duration should be shorter. Furthermore, lower copying cost itself can provide higher incentive for creation by increasing the profit opportunity for creators. The difference between the contestable model and the pure monopolistic model is that the contestable digital library may pass more benefit of lower copying cost to the creators in its effort to prevent entry; the pure monopolist digital library does its best to take advantage of the lower copying cost to benefit itself and pass less of the benefit to the creators. Combined with the higher social desirability of information products and effect on deadweight loss, the contestable model means shorter copyright protection is needed when copying cost is lower; and the pure monopolistic digital library means that longer copyright protection is required.

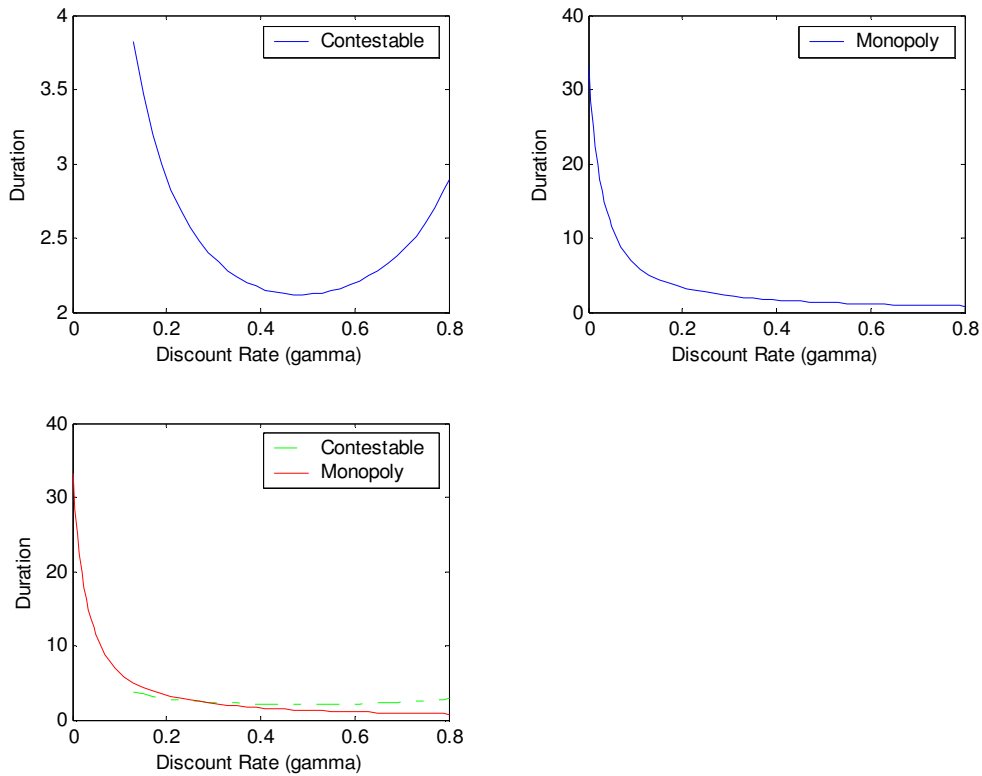
4.2 The Effect of Longer Life Expectancy on Optimal Copyright Duration

Another change in the information market is the longer life expectancy and delayed child-bearing of creators and consumers of information products. Longer life expectancy and delayed child-bearing can be represented as a lower discount rate in calculating present values of future profits and surpluses. Assume that creators care about values delivered to themselves and to a limited number of generations of their immediate descendents more than values delivered to more distant descendents. Longer life expectancy and delayed child-bearing mean that the period within which values are more highly weighted is extended. This can be approximated as creators' having a lower discount rate for future profits. However, not only creators but also consumers live longer and delay child-bearing. Therefore, the lower discount rate applies to creators' future profits, consumer future surplus, and future deadweight loss. Note that longer life expectancy and delayed child-bearing may have some effects on demand for information products, which in turn may affect copyright duration. Because the U.S. senate report for copyright term extension focuses on the need to protect the ability to collect revenue in the extended lifetime of creators and their heirs, the effect of longer life expectancy and delayed child-bearing on copyright duration is estimated through a lowered discount rate. Changing the discount rate γ and recalculating the model lead to the result shown in Figure 4.

Figure 4 shows, according to the pure monopolistic model, a decrease in the social discount rate would mean a longer optimal duration of copyright. However, according to the contestable model, the effect of lower social discount rate is not linear. When social discount rate is low, a decrease in social discount rate calls for increase in optimal duration;

when social discount rate is high, a decrease of the rate would call for a decrease in optimal duration of copyright. There is no agreement between the two models. Therefore, the models cannot offer support to the suggestion that lower social discount, or longer life expectancy and delayed child-bearing, require long protection of copyright.

Figure 4. Effect of Lower Discount Rate on Optimal Duration of Copyright

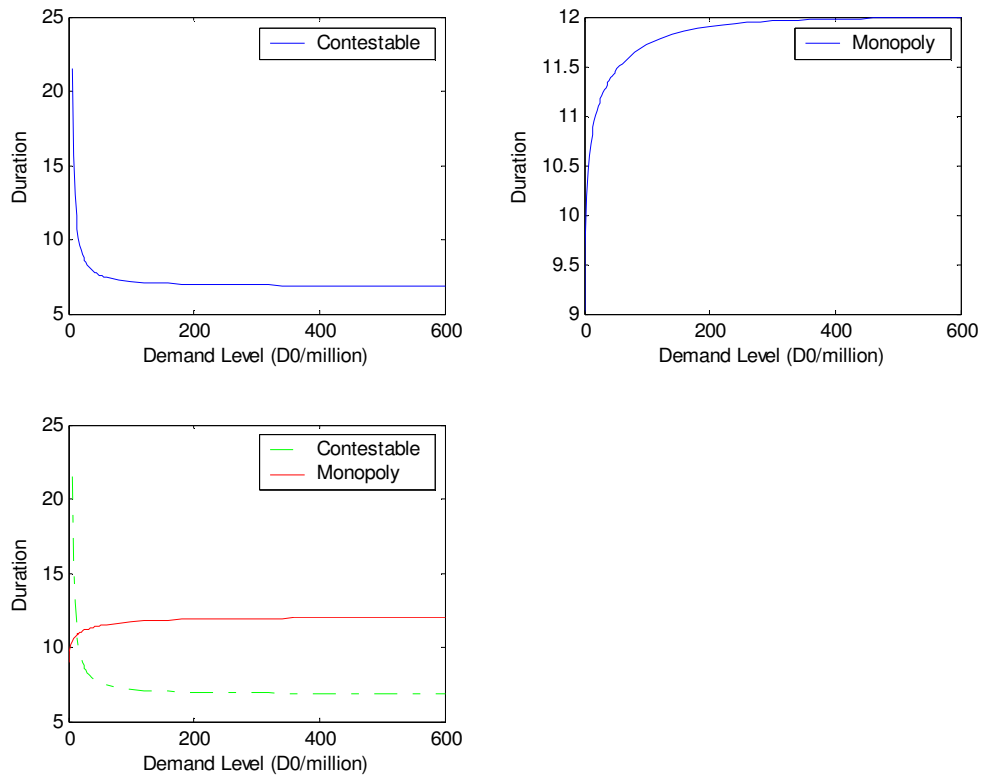


4.3 The Effect of Higher Demand for Information on Optimal Duration

The demand level for information is represented by the parameter D_0 in the models. Changing the parameter D_0 and recalculating the model lead to the results shown in Figure 5.

Figure 5 shows, according to the pure monopolistic digital library model, higher demand for information products leads to increase in optimal copyright duration; according to the contestable model, higher demand for information products leads to decrease in optimal duration of copyright.

Figure 5. Effect of Increase in Demand on Optimal Duration of Copyright



The two models do not agree on the direction of the effect of increase in demand for information products on copyright duration. It cannot provide support for the suggestion that the increase in demand for information products calls for longer copyright protection.

Why do the two models differ on the direction of effect? An increase in demand for information products reflects that information products are more desirable socially; more

incentive should be given to creation of the information products. On the other hand, the increase means that deadweight loss during copyright protection is larger; therefore, copyright duration should be shorter. Furthermore, higher demand for information products itself may provide more incentive for creation by increase the profit opportunity for creators. The difference between the contestable model and the pure monopolistic model is that the contestable digital library may pass all the benefit of increase demand to the creators in its effort to prevent entry; the pure monopolist digital library does its best to take advantage of higher demand to benefit itself and pass less of the benefit to the creators. Combining with the higher social desirability of information products and effect on deadweight loss, the contestable model calls for shorter copyright protection; and the pure monopolistic digital library calls for longer copyright protection.

5. Conclusion

We have developed models to detect the effects on optimal copyright duration of changes in the markets of information products. The models include an intermediary between creators and consumers. The computational approach allows us to use non-trivial demand and cost functions. We use contestable model and pure monopolist model to represent two ends of the spectrum for the behavior of a natural monopolist in a market with low barrier to entry.

Models give no consistent direction on the effects on optimal copyright duration of decrease in copying, increase in demand for information products, and longer life expectancy and delayed child-bearing. Therefore, they do not provide support for the suggestions that decrease in copying cost and longer life expectancy and delayed child-

bearing require longer copyright duration and higher demand for information products may call for longer copyright protection.

The study is only an initial step in the direction of modeling a market of information products with intermediaries for copyright study. The two models represent two ends of a possible spectrum. The area between the ends could be wide. It would be desirable to be able pin-point the behavior of the intermediary or intermediaries in an information market. This is left for future studies.

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