

# **Comparing Indefinitely Renewable Copyright with Fixed Length Copyright: The Case of Information Market with an Intermediary Publisher**

Michael Y. Yuan  
Roger Williams University, Bristol, RI 02809, USA  
[myuan@rwu.edu](mailto:myuan@rwu.edu)

Zhixiong Chen  
Mercy College, Dobbs Ferry, NY 10522, USA  
[zchen@mercy.edu](mailto:zchen@mercy.edu)

## Abstract

Extant comparisons of indefinitely renewable copyright (IRC) and fixed length copyright (FLC) assume creators of information products publish their products by themselves. More realistic markets are those where creators sell their products through independent publishers. We compare the two copyright systems under this more realistic market condition. Models are developed and simulated for a market of information products where creators compete with each other and sell substitutive products through a digital library under the two copyright systems. Preliminary results indicate that the FLC leads to higher optimal social welfare than that of IRC.

## **1. Introduction**

This study compares the welfare property of the indefinitely renewable copyright (IRC) with that of the fixed length copyright (FLC). IRC was proposed by Landes and Posner (2003) as an alternative to FLC. Under IRC, copyright owners can always choose to renew the copyright of their information products by paying a copyright fee. When an owner chooses not to renew the copyright and avoid paying the copyright fee of a product, the products falls into public domain. The fee is set the regulator.

Under the FLC, a fixed length of copyright is chosen for information products of all creators by the regulator. This length may be accounted differently, e.g. from creation,

publication, or from death of last author and may vary for different categories of information products, e.g. works made for hire and other works.

The IRC has some nice properties. It gives more choices to creators and brings revenue through the copyright fee to the copyright authority. Moreover, The IRC would turn the cost of lobbying on behalf of the copyright owners into an explicit copyright fee. Under FLC, copyright owners and consumers would spend time and money to lobby the regulator to set the duration in their favor. This rent seeking is evident in the process of both leading and following the pass of the 1998 Copyright Term Extension Act in the U.S.

Because of these nice properties of IRC and the importance of the copyright law as a legal underpinning of the growing information economy, the proposed IRC deserves careful study and comprehensive comparison with the FLC.

This study is one effort in that direction. It models the behavior of an information intermediary as well as the creators and consumers and captures the classic high creative cost and low reproduction cost of information products and, therefore, the trade-off between encouraging creation and avoiding under-utilization. It also models the competition among creators and the substitutive effects among their products.

This study differs from the two extant studies. Yuan (2004) and Adilov (2005) have compared welfare of IRC and FLC. Yuan (2004) assumes an information product market where creators sell their information products directly to consumers. This study assumes that there is an intermediary between creators and consumers. The intermediary is an independent player on the market. It helps the market to achieve economies of scale by aggregating sales activities. It reduces buy-seller relationships from the order of  $m$  by  $n$  to the order of  $m$  plus  $n$  in a market of  $m$  creators and  $n$  consumers. A market with an intermediary is more realistic than a direct, self-publishing market.

Adilov (2005) assumes a monopolistic creator who does not make quantity (number of first-copy products) decision. Thus, creative (initial quality and quality enhancement) decisions are affected by the copyright fee only indirectly through its effect on copyright

length chosen by creators. Therefore, any copyright length chosen by creators can be mimicked by a fixed length copyright set by the regulator without affecting creative investment decisions and welfare. Therefore, it concludes that welfare of [the](#) IRC is no higher than that of FLC, assuming homogeneity of information products.

However, if creators make decisions in the numbers of first-copy products to create, as they do in reality, the reasoning behind the above conclusion in Adilov (2005) does not hold anymore. Copyright fee is charged on a per first-copy product basis. The copyright fee affects the creative decision of number of first-copy products directly, as well as indirectly through copyright duration. Therefore, a copyright length chosen by a creator and the same length of copyright set by the legislator does not lead to the same market outcome.

Another difference of this study is that Adilov (2005) models a single monopolistic creator who sells directly to consumers; we model monopolistically competitive creators who sell through an active intermediary.

The single most significant result of the study may be the evidence it found suggesting that the IRC may have strictly lower optimal social welfare than current fixed copyright system, assuming horizontally differentiated and symmetric information products. And the optimal length of fixed length copyright may not be induced through a copyright fee in the IRC without adversely affecting the information product market in a way detrimental to social welfare.

The study is a partial comparison between the copyright systems. It is limited by the absence in the model of factors, such as rent seeking, quality enhancing investment after creation, and interaction among different categories of information products.

The paper is organized as follows. Section 2 reviews the literature and section 3 develops the models. Section 4 presents the results. We conclude the paper in section 5

## 2. Literature Review

This paper is related to two streams of literature. The first is the copyright and patent literature; the second is the two-sided market literature.

The copyright and patent literature deals with three basic questions about copyright and intellectual property. The first is whether copyright is necessary. Studies dealing with this question compare copyright with systems without copyright. Examples include Boldrin & David (2002), Breyer (1972), Hurt & Schuchman (1966), and Plant (1934). The second question is about the effect of private copying, and copyright violation in general, on creator's behavior and social welfare and the optimal enforcement of copyright. Studies dealing with this question include Besen and Kirby (1989), Johnson (1985), Liebowitz (1985), Novos and Waldman (1984), and Yoon (2002). The third question is the design of optimal copyright. This paper is related to the third question.

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, belongs to this category. Examples include Denicolo (1996, 1999, and 2000) and Judd et al. (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), Yuan & Roehig (1997), O'donoghue, et al. (1998), Waterson (2001), and Yuan (2004 and 2005) belong to this category. Our models in this study also fall into this category.

Our models differ from the extant models in the fourth category in the competitive decisions of creation and production and market players. In Veall (1992), creators make entry decision with a single product. In Yuan & Roehrig (1996), entry decision is not endogenous. In O'donoghue et al. (1998), innovators decide whether or not to incur a fixed cost for random quality improvement. Waterson (2001) considers two-firm competition in patenting, entry, and location. Yuan (2004 and 2005) assumes creators publish and sell their products directly to consumers. In this paper, like in Yuan (2004 and 2005), 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 (2004 and 2005) in that creators sell through an independent and active intermediary.

The second stream of literature related to the paper is about 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, considering the often significant indirect network externality across sellers and buyers and direct network externality within sellers or buyers. Example include Yuan (1997), Baye and Morgan (2001), Belleflamme and Toulemondey (2004), Caillaud and Jullien (2001), Caillaud and Jullien (2003), Choudhary and

Mukhopadhyay (2003), Yoo, Choudhary, and Mukhopadhyay (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. Baye and Morgan (2001), Yoo et al. (2003), Bhargava and Choudhary (2004), Belleflamme and Toulemondey (2004), Hagiu (2004a), and Hagiu (2004b) model pure monopolistic intermediary.

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 intermediary 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) in that our models are not static. We introduce time into the models and apply them to copyright.

### **3. The models**

We first describe qualitatively how an information market operates under IRC and FLC. 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 services of storage, advertising, reproduction, distribution, copyright management, and payment collection, etc., and provides consumers access and search services.

Digital libraries have low barriers to entry. Barriers to entry can be represented by sunk fixed costs. A digital library has sunk fixed cost and non-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 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 the fixed costs and 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 charge and a usage-sensitive charge for creators to use its services, called “storage charge” and “sales charge”, respectively. By the storage charge, creators are charged per product they place in the library, independent of sales of the product. Storage charges are fixed cost to creators for given first-copy information products. 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 the sales charge from the digital library, 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 losses are 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 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 faces competition from potential entrants.

The above description of the market of information products applies to both FLC and IRC. The two systems differ in the decision of the regulator: Under FLC, the regulator chooses the duration of copyright; under IRC, the regulator chooses the copyright fee and creators choose duration of copyright for their respective products. Since proponents of each system would present their respective system in its best light, one way to compare the two systems is to assume that the regulator choose copyright duration and copyright fee to maximize social welfare in the respective systems.

Several assumptions are worth mentioning. These assumptions simplify the modeling of the information market. Firstly, our models only include costs of creating, reproducing, and distributing information products. Other costs of tracing copyright owners, operating the copyright systems, and cost of rent-seeking are not included. The costs of operating the copyright system are secondary in nature to the included costs and may be assumed to be the same across LFC and IRC. Rent-seeking may exist in both FLC and IRC in affecting

the determination of copyright length and copyright fee, respectively. Since a complete comparison of the two systems requires considering all costs, this study is complementary to discussions of other costs.

Secondly, there is no quality enhancement 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.

Thirdly, products are symmetric and only horizontally differentiated. Although there can be multiple independent categories of horizontally differentiated and symmetric information products and different categories have different functions of costs of creation, reproduction and distribution and different functions of demands, there is no interaction among the categories. And within a category, first-copy products are of the same quality. Note that quality difference of first-copy products is not the same as product differentiation. Quality difference is "vertical"; product differentiation is "horizontal". First-copy products may be the same vertically, but can differ with each other horizontally. Symmetry means that there is no ordering among first-copy information products. Each first-copy product is different from all other first-copy products in the same manner. Furthermore, 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. Note that quality of copying is not the same as quality of first-copy products.

Fourthly, 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 ignores the interaction among the products of the same creator. Note that the price may still change over time. This assumption also means that price discrimination across customers is not considered.

Fifthly, each creator chooses the same length of copyright for all its products under IRC. If there are no quality difference and ordering among first-copy information products, copyright duration of the products of a creator should be the same.

Sixthly, copyright protection is perfectly enforced within copyright duration. This paper 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 change in availability of information due to change in copyright duration or copyright fee on further creation of information products is not considered. Landes and Posner (1989) uniquely model 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".

In order to setup our models, we need the following notations.

$i$ : 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 charge to creators per product placed in the digital library;

$R$ : sales charge to creators (per copy or per use) of an information product sold 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: fixed cost the library;

f: copyright fee per product per year under IRC;

$T_i$ : copyright duration chosen by creator i for its products under IRC;

T: copyright duration in FLC

### **3.1 A Model of the Fixed Length Copyright with Contestable Digital Library**

The profit of creator i is:

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

The problem of the creator is:

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

Because of the higher fixed cost, low variable cost, consumers' preference for larger digital library, and low barriers to entry, a 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 creators to switch to it. Moreover, the incumbent must provide 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 is controversial. For example, it 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 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 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 placement charge and sales charge, 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 placement charge and sales charge 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 placement charge and the sales charge 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 prices best for the current 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 charge users per copy of the information products at its marginal cost of reproduction  $b$ .

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:

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

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

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

S.t. (2) and (3)

The marginal entry condition is:

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

Consumer surplus is:

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

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 Indefinitely Renewable Copyright with Contestable Digital Library**

The problem of the creator i is:

$$\text{Max}_{p_i, s_i, T_i} \pi_i = \int_0^{T_i} [(p_i - R) d_i(p_i, p_{-i}, s_i, s_{-i}) - (P + f) s_i] e^{-\rho t} dt - c_i(s_i) \quad (7)$$

The library can only make even:

$$\Pi = \sum_{i=1}^n \int_0^{T_i} [Ps_i + (R - b) d_{it}] e^{-\rho t} dt - \int_0^{\infty} C_1(S) e^{-\rho t} dt - B = 0 \quad (8)$$

The library calculates the sum of profits of n creators on the market:

$$\sum_{i=1}^n \pi_i = \sum_{i=1}^n \left\{ \int_0^{T_i} [(p_i - R) d_i(p_i, p_{-i}, s_i, s_{-i}) - (P + f)s_i] e^{-\gamma} dt - c_i(s_i) \right\}$$

The library's problem is:

$$\underset{P, R}{Max} \sum_{i=1}^n \pi_i = \sum_{i=1}^n \left\{ \int_0^{T_i} [(p_i - R) d_i(p_i, p_{-i}, s_i, s_{-i}) - (P + f)s_i] e^{-\gamma} dt - c_i(s_i) \right\} \quad (9)$$

S.t. (7) and (8)

The marginal entry condition is:

$$\pi_n = 0 \quad (10)$$

Consumer surplus is:

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

Public revenue from copyright fee is:

$$F = \sum_{i=1}^n \int_0^{T_i} s_i f e^{-\gamma} dt$$

Because creators make zero profit on equilibrium under symmetry and library makes zero profit, social welfare is the sum of consumer surplus and public revenue from copyright fee. The problem of the regulator is:

$$\underset{f}{Max} W = \sum_{i=1}^n \int_0^{\infty} \int_b^{\infty} d_{it} dp e^{-\gamma} dt - \sum_{i=1}^n \int_0^{T_i} \int_b^{p_{it}^*} d_{it} dp e^{-\gamma} dt + \sum_{i=1}^n \int_0^{T_i} s_i f e^{-\gamma} dt \quad (11)$$

S.t (9) and (10)

### 3.3 A Model of Fixed Length Copyright with Pure Monopolist Library

Pure monopolist models are also developed as lower boundary of behavior of the digital library. Pure monopolist models ignore any threat from potential entrants.

The problem of the creator is:

$$\underset{p_i, s_i}{Max} \pi_i = \int_0^T [(p_i - R) d_i(p_i, p_{-i}, s_i, s_{-i}) - Ps_i] e^{-\delta t} dt - c_i(s_i) \quad (12)$$

The marginal entry condition is:

$$\pi_n = 0 \quad (13)$$

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

$$\underset{P, R}{Max} \Pi = \int_0^T [PS + (R - b)D_t - C_1(S)] e^{-\delta t} dt - \int_T^{\infty} C_1(S) e^{-\delta t} dt - B \quad (14)$$

S.t. (12) and (13)

Consumer surplus is:

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

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

$$W = \Pi + CS$$

The problem of the regulator is:

$$\underset{T}{Max} W = \Pi + CS \quad (15)$$

S.t (14)

### 3.4 A Model of Indefinitely Renewable Copyright with Pure Monopolistic Library

The problem of the creator is:

$$\underset{p_i, s_i, T_i}{Max} \quad \pi_i = \int_0^{T_i} [(p_i - R)d_i(p_i, p_{-i}, s_i, s_{-i}) - (P + f)s_i]e^{-\gamma t} dt - c_i(s_i) \quad (16)$$

The marginal entry condition is:

$$\pi_n = 0 \quad (17)$$

The library's problem is:

$$\underset{P, R}{Max} \quad \Pi = \sum_{i=1}^n \int_0^{T_i} [Ps_i + (R - b)d_{it}]e^{-\gamma t} dt - \int_0^{\infty} C_1(S)e^{-\gamma t} dt - B \quad (18)$$

S.t. (16) and (17)

Consumer surplus is:

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

Public revenue from copyright fee is:

$$F = \sum_{i=1}^n \int_0^{T_i} s_i f e^{-\gamma t} dt$$

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

$$W = \Pi + CS + F$$

The problem of the regulator is:

$$\underset{f}{Max} \quad W = \Pi + CS + F \quad (19)$$

S.t (18)

## 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:

$$D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t) = D_0 \left( s_i / \sum_{j=1}^n s_j \right) \left( \sum_{j=1}^n s_j \right)^\alpha p_{it}^{-\delta} \prod_{j \neq i} p_{jt}^{\frac{\beta}{n-1}} g(t) \quad (20)$$

$$\text{where } g(t) = \begin{cases} 1 - \frac{t}{T_0} & \text{if } t < T_0(1 - \theta) \\ \theta & \text{otherwise} \end{cases} \quad (21)$$

$$c_i(s) = c_0 + as^\rho \quad (22)$$

$$C_1(S) = a_1 S^{b_1} \quad (23)$$

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 (20) 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 (10) and  $0 < \alpha < 1$

mean that the total demand increases with the total number of first-copy information products. The parameter  $\alpha$  is the percent increase in demand from a percent increase in the number of first-copy products. The parameter  $\alpha$  reflects the degree of differentiation of first-copy information products and consumers' preference for variety of information products. The bigger the  $\alpha$ , 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. Since the average case is the most reasonable case to compare two copyright systems,  $0 < \alpha < 1$  can be assumed.

The factor  $\prod_{j \neq i} p_{jt}^{\frac{\beta}{n-1}}$  and positive  $\beta$  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  $\beta$  is the cross-price elasticity.

The factor  $s_i / \sum_{j=1}^n s_j$  in (20) implies that total demand for information is distributed among creators in proportion to their numbers of first-copy products, other things being equal.

Positive  $\delta$  means that demand for a creator's products decreases with its price. The parameter  $\delta$  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 (10) depends on  $p_{it}$  only through the factor  $p_{it}^{-\delta}$ . From (20) and the creator's problem in the models, one can derive during copyright protection:

$$p_{it} = p \equiv \frac{\delta}{\delta - 1} R \quad (25)$$

The factor  $g(t)$  represents the change over time in the rate of demand for information products. The specific form (11) assumes that the demand decreases linearly over time to  $\theta$  at time  $T_0^*(1 - \theta)$  and then it remains at that level.

In (20), 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 (23), parameter "c<sub>0</sub>" 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, and under IRC, choose the same copyright duration.

That  $b_1 < 1$  and a large fixed cost B represent that there is scale if 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  $D_0, \alpha, \delta, \beta, b, T_0, \theta, \gamma, c_0, a,$  and  $\rho, a_1, b_1,$  and B.

The following parameter values are assumed for the baseline simulation:

$$[D_0 \ \alpha \ \delta \ \beta \ b \ T_0 \ \theta \ r \ c_0 \ a \ \rho \ a_1 \ b_1 \ B] = [6 \cdot 10^7 \ 0.2 \ 2 \ 0.7 \ 5 \ 100 \ 0.001 \ 0.05 \ 3 \cdot 10^5 \ 10^4 \ 1.2 \ 10 \ 0.9 \ 10^7]$$

These parameter values are not selected to represent any particular actual information market. Rather, the intention is to get an example within some economically valid range of the parameters and to see whether the same results can be obtained at any valid parameter values, which can be done in sensitive analysis.

With these parameters values, the results for some variables of the information market from the models are shown in Figure 1-6 and Table 1.

Figure 1 shows that, assuming a contestable digital library and given the parameter values, the number of first-copy information products increases monotonically with copyright

duration. Social welfare first increases and then decreases with copyright duration. There is an optimal duration of copyright where social welfare is maximized.

Figure 2 shows that, assuming a contestable digital library and given the parameter values, copyright duration, chosen by creators, and number of first-copyright products decreases monotonically with copyright fee. Social welfare increases and then decreases with copyright renewal fee. There is an optimal copyright fee where social welfare is maximal. In Figure 2a, number of first-copy products and copyright duration is more sensitive than social welfare information. Figure 2b is drawn to show the change of social welfare with copyright fee more clearly.

Figure 3 compares the social welfare of FLC at different copyright duration with the social welfare of the IRC at different copyright fee which lead to the creators to choose the same copyright duration as FLC. Several observations can be made from this figure. First, when copyright duration in FLC is excessively long and copyright fee in IRC is excessively low, which lead to copyright owners choose similarly long copyright, social welfare of FLC is lower than that of IRC. So if, for reasons such as the focused lobbying power of copyright owners, FLC is set excessively long, the society can be better off by switching to IRC with a copyright fee which induces creators to the similarly long duration. This is consistent with similar notion in Landes and Posner (2003).

Second, when copyright duration of fixed copyright is not too long, or copyright fee in IRC is not too low and does not induce too long copyright duration, social welfare of the FLC is higher than IRC.

Third, the maximal social welfare at optimal copyright fee under IRC is lower than the social welfare under the FLC at the same copyright duration. It seems that the copyright fee has distorted the market and lowered social welfare, when it induces the same copyright duration as under FLC.

Fourth, the maximal social welfare under FLC is higher than the maximal social welfare under IRC.

Fifth, copyright duration is very sensitive to copyright fee under IRC when copyright fee is very low and very insensitive when copyright fee is very high.

Sixth, the optimal copyright duration of fixed copyright duration is lower than the copyright duration at the optimal copyright fee under IRC. Furthermore, the optimal copyright duration of FLC is so short that it cannot be induced by a high copyright fee before the market is totally taxed out by the copyright fee. This is inconsistent with the notion suggested in Landes and Posner (2003) mentioned above.

Figure 4-6 are parallel to figures 1-3 for pure monopolistic library. Figure 4 shows that there is an optimal copyright duration for FLC. Figure 5 shows there is an optimal copyright fee for the IRC. Figure 6 shows that FLC lead to higher social welfare than when copyright duration is short and IRC achieves higher social welfare if copyright duration is excessively long. And maximal social welfare of FLC is higher than that of IRC.

Table 1 show that with contestable digital library, the optimal copyright duration of FLC is 5 years; and optimal copyright fee of IRC is \$10,894, which leads to \$1.3 billion total copyright fee. Under the optimal copyright fee of IRC, creators choose a copyright of 30 years, 25 years longer than the optimal duration under FLC; there will be 134 creators, 181 fewer than the 315 creators under optimal FLC; each creator creates 57 first-copy products, 8 fewer than the 65 first-copy products per creators under optimal FLC. The storage charges for both FLC and IRC are negative, which mount to royalty for creators. The royalty per product per year under optimal IRC is \$4,177, which is 98% higher than the \$2,108 royalty under the optimal FLC. The sales charge under optimal IRC is \$10.04 per sale, which is 7% lower than the \$10.79 sales charge under optimal FLC. Lower sales charge and higher royalty under optimal IRC compensate the copyright fee; consumption under optimal IRC in 10 years is about 69 million copies, 76% less than 10 year consumption of 289 millions copies under optimal FLC; corresponding 100 year consumption is 1.3 billion copies, 13% less than the 1.5 billion copies under optimal FLC; and social welfare under optimal IRC is \$4.6 billion, 52% lower than the social welfare of \$9.5 billion under optimal FLC.

Table 1. Comparison of Fixed Length Copyright and Indefinitely Renewable Copyright

	Constestable Library		Monopolistic Library	
	Fixed Length Copyright	Renewable Copyright	Fixed Length Copyright	Renewable Copyright
Copyright fee	NA	10,894	N/A	11,471
Copyright duration	5	30	6	17
Size of creator	65	57	54	37
Number of creators	315	134	64	54
Storage fee per product	- 2108	-4,177	11,873	9,875
Sales Fee per Product	10.79	10.04	10.84	13.07
Price per copy during copyright	21.56	20.08	21.69	26.13
Total copy sales in 10 years	289,277,389	68,917,386	170,740,404	37,484,929
Total copy sales in 100 years (B)	2.5	1.3	1.7	1.2
Library profit (\$B)	0	0	0.4	0.6
Total copyright revenue (\$B)	N/A	1.3	N/A	0.3
Social welfare (\$B)	9.5	4.6	6.8	4.8

Comparison of the two systems based on a monopolistic library is similar. Under IRC, Copyright duration is longer than under FLC; and information availability and information consumption, and social welfare are lower under IRC. The difference from constestable library is that the storage charges are positive and sales charge under IRC is higher than under FLC.

The most important of the above results may be that we have find a market condition, as represented the parameter values, under which IRC has higher social welfare than FLC if copyright duration is excessively long; however, if IRC and FLC are both optimally configured, FLC leads to higher social welfare than IRC.

Does this result hold for other market conditions? We have only finished some initial sensitivity analysis yet by changing individual parameter values. The result is shown in Figures 7-19. The figures shows the changes of maximal welfare of IRC and FLC when individual parameter changes in the case of contestable digital library. In the case of monopolistic digital library, similar figures can be drawn. The result is found robust for change of individual parameter value in economic valid ranges.

Why might IRC lead to lower maximal social welfare than FLC? One reason might be the following: Copyright is to balance the two conflicting goals of encouraging creation of first-copy products and reducing under-utilization of existing products. A proper duration of copyright is the proper balance of the two goals. Under FLC, the length is directly selected by regulator. Under IRC, the duration is induced through a fee. While the fee is used to induce a proper copyright duration, it may also distort the behavior of creators. Therefore, optimal welfare under IRC is lower than the welfare when the duration is directly selected without introducing distortion in the market.

## **Concluding Remarks**

The comparison of IRC and FLC depends on the underlying market of information products. We have developed models of the market which captures the unique cost structure of high first-copy cost and low reproductive cost, competition among creators, and an intermediary of digital library. We found cases where if copyright systems are not optimally configured and copyright duration is excessively long, switching to IRC can improve social welfare. This is relevant if current fixed length copyright duration is not set optimally but too long due to focused lobbying power of copyright owners.

We also found cases where if IRC and FLC can be optimally configured, FLC leads to higher optimal social welfare than IRC. The intuition may that that copyright fee of IRC distorts the behavior of creators.

More sensitive analyses of the initial results are necessary. Our models have also assumed away several factors, such as heterogeneity of creators and information products, generations of information products, non-quality enhancement investment, rent-seeking,

and cost of operating the copyright systems. Future modeling of copyright may include some of these factors.

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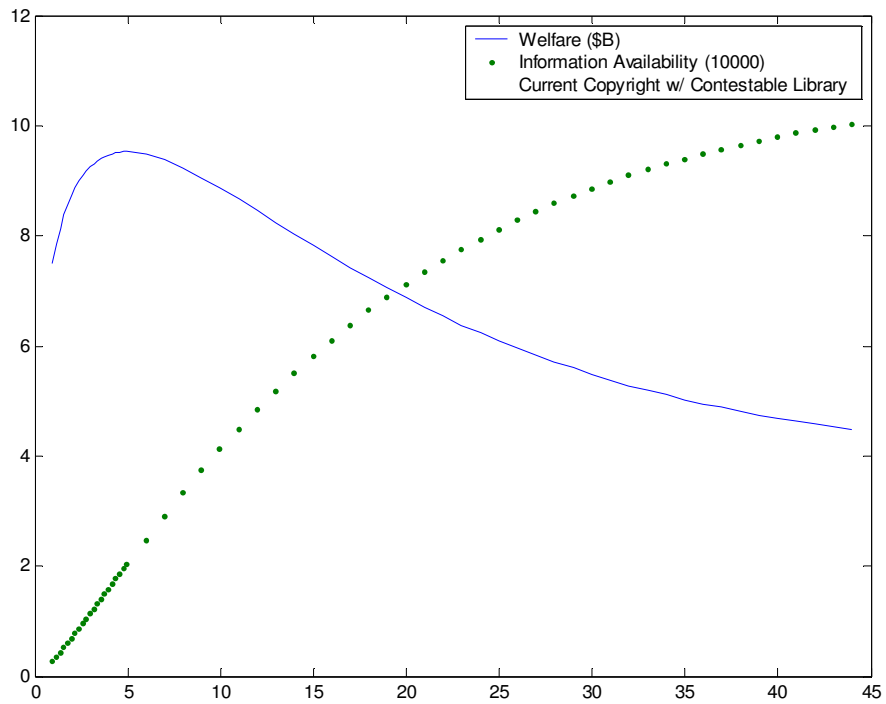


Fig 1: Copyright Duration

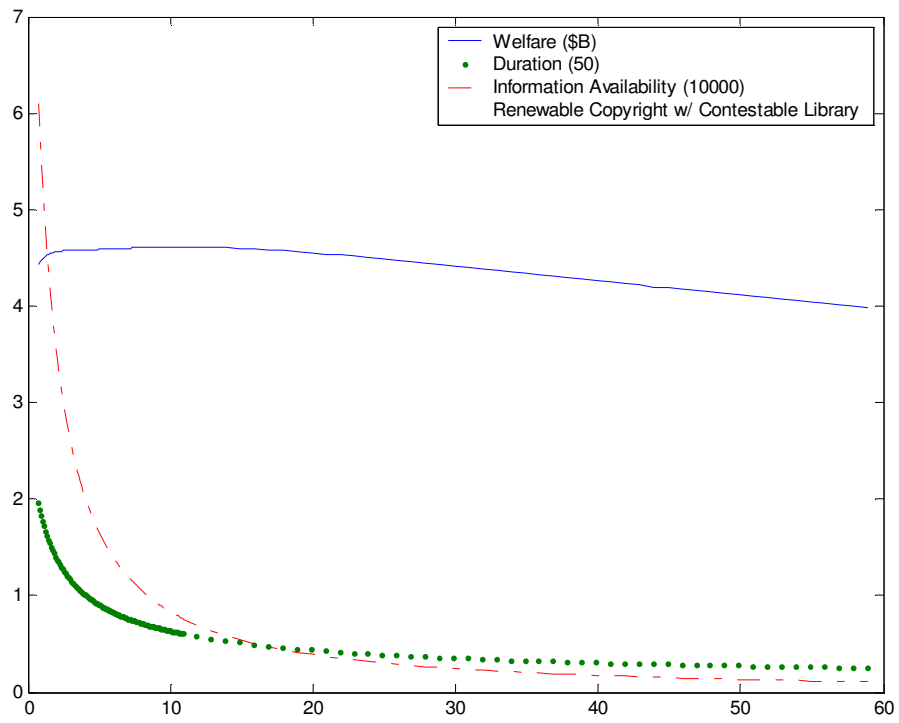
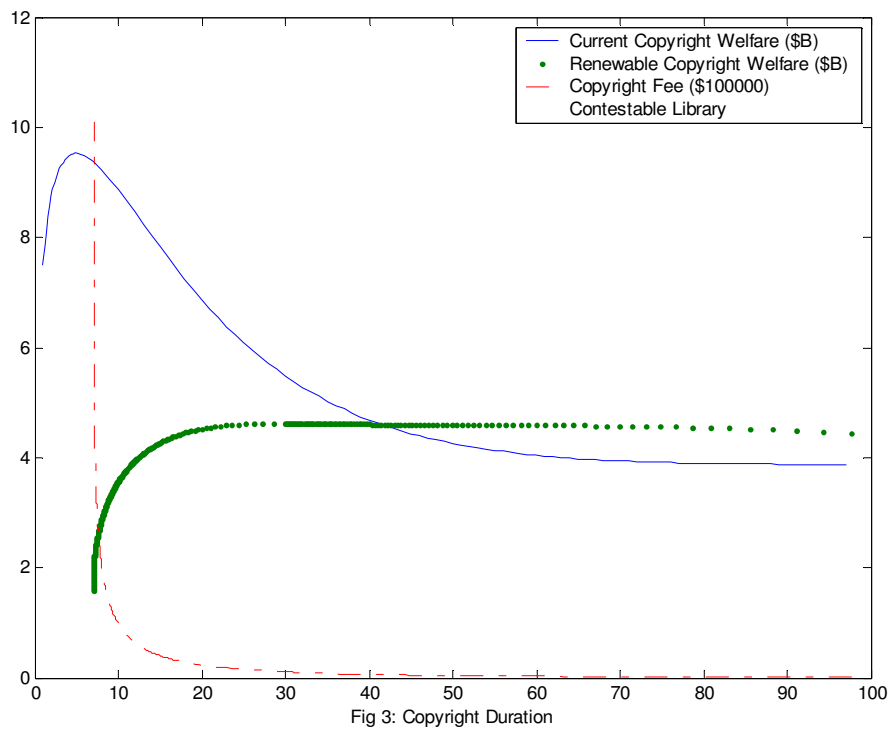
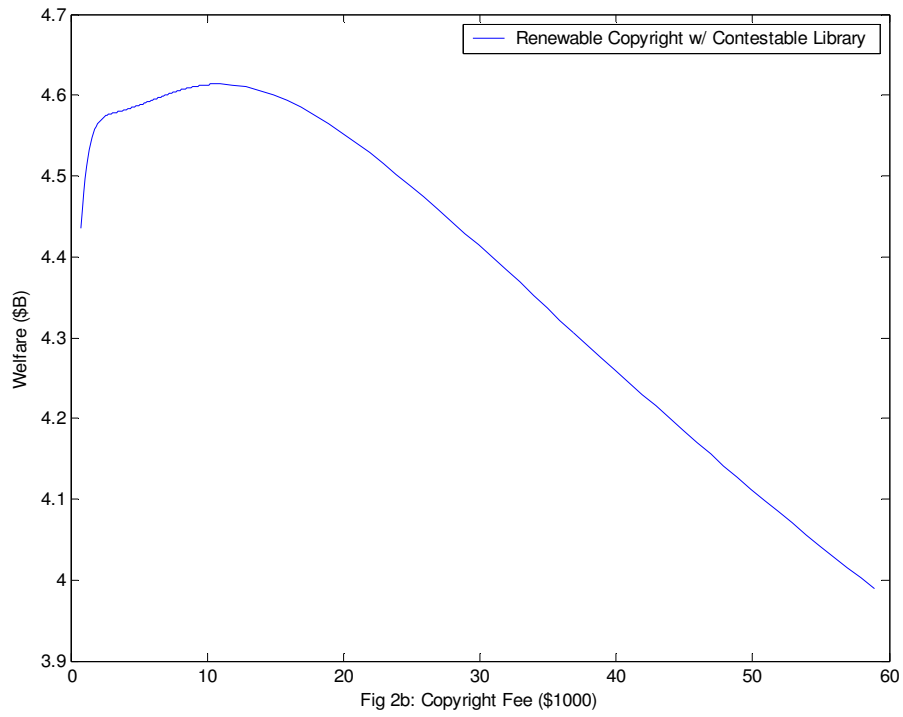


Fig 2a: Copyright Fee (\$1000)



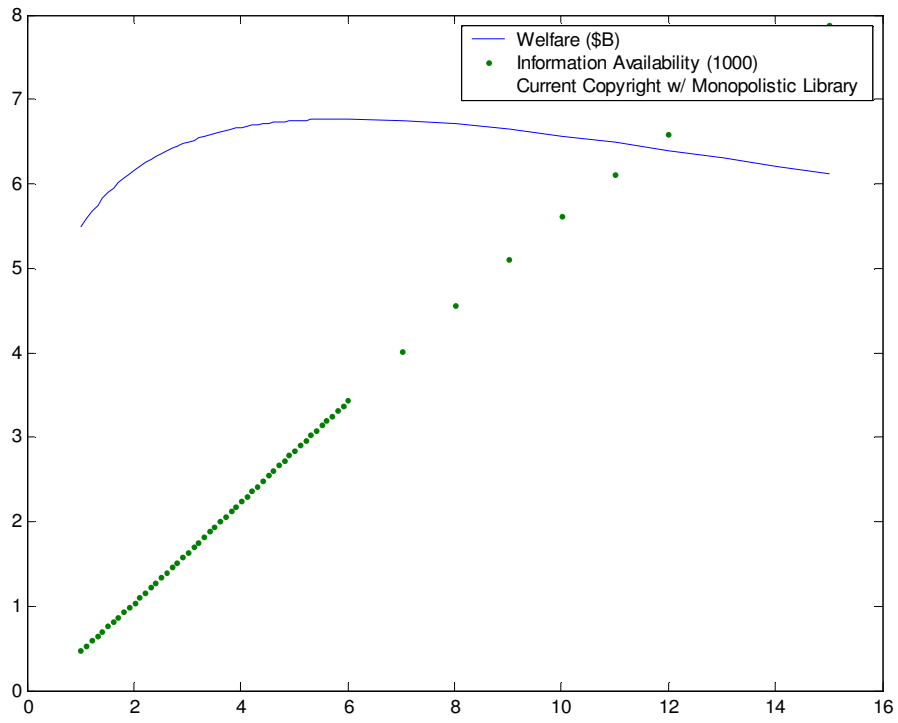


Fig 4: Copyright Duration

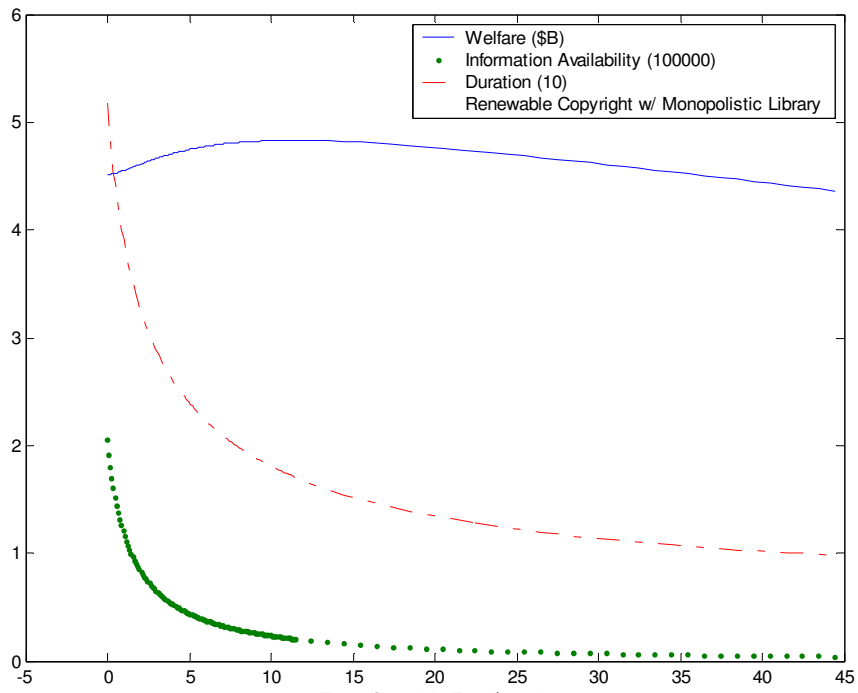


Fig 5: Copyright Fee (\$1000)

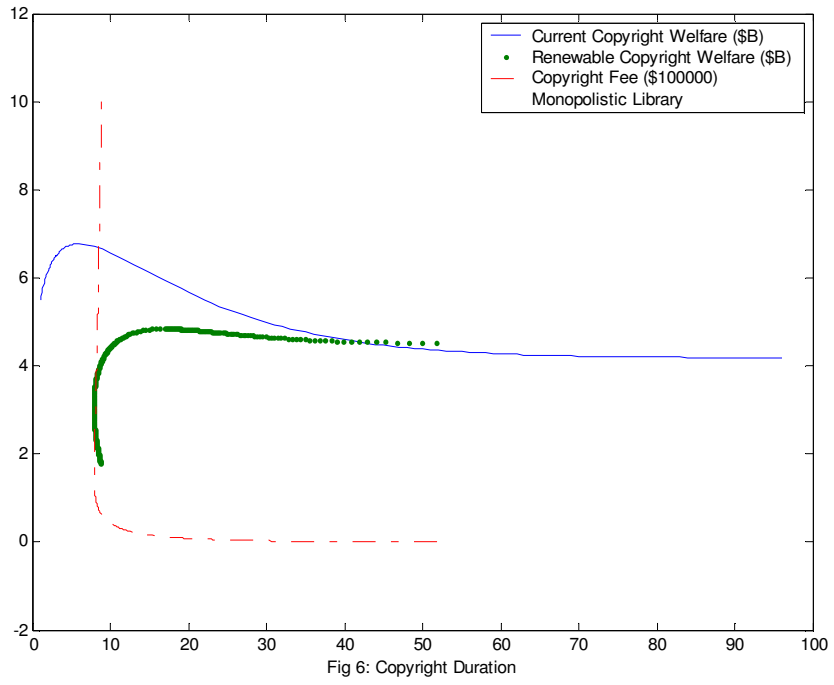
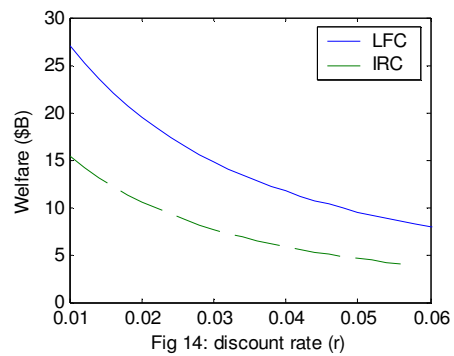
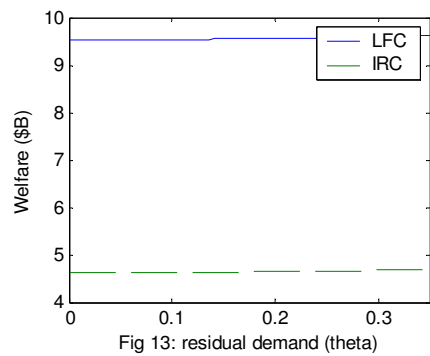
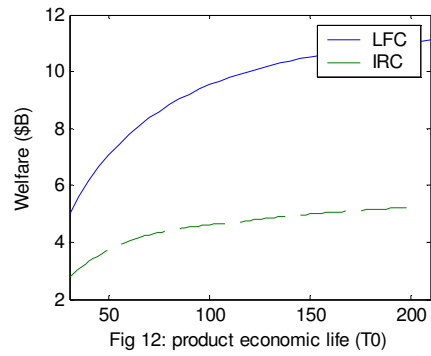
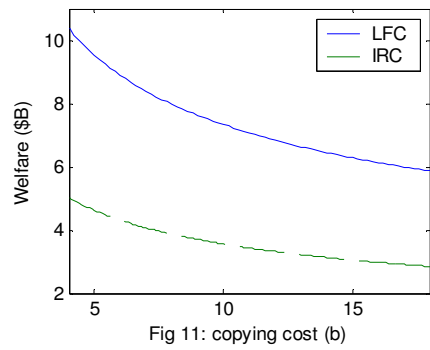
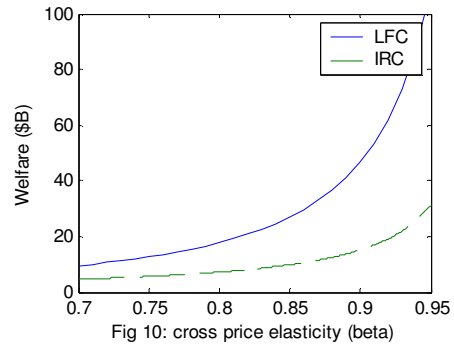
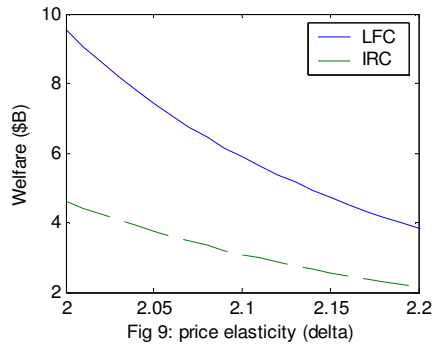
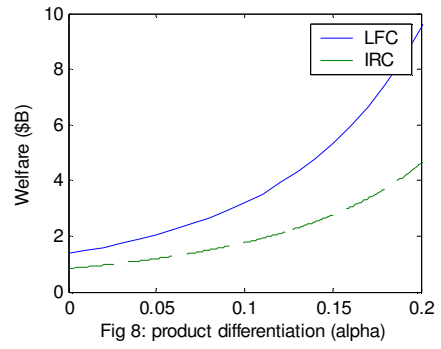
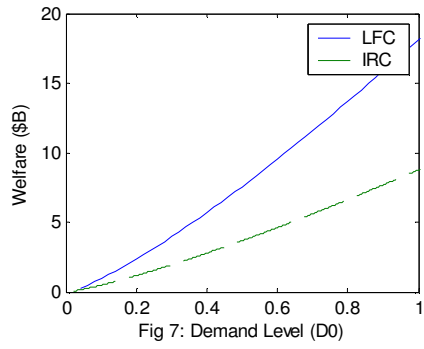


Fig 6: Copyright Duration



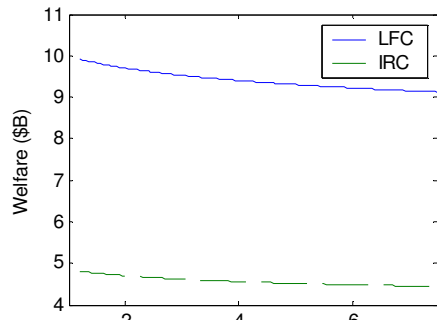


Fig 15: fixed creative cost ( $c_0$ )

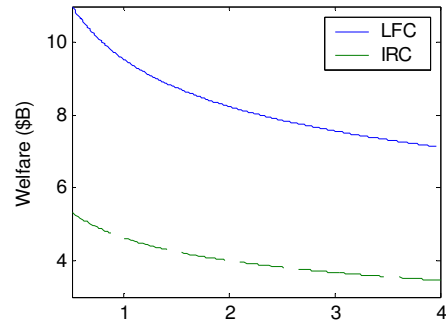


Fig 16: per-product creative cost ( $a$ )

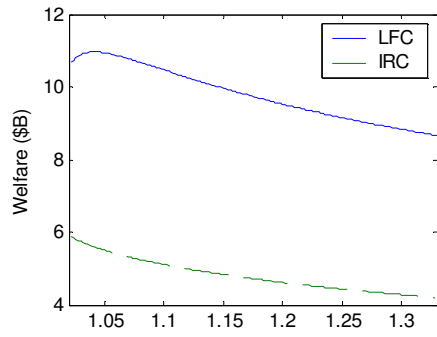


Fig 17: diseconomy of creation ( $\rho$ )

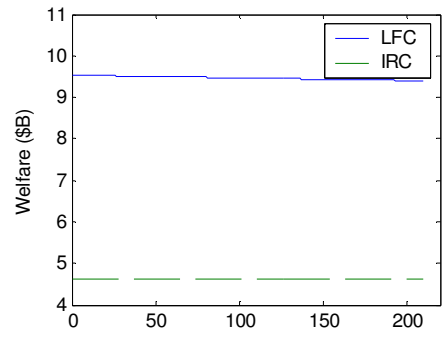


Fig 18: per-product storage cost ( $a_1$ )

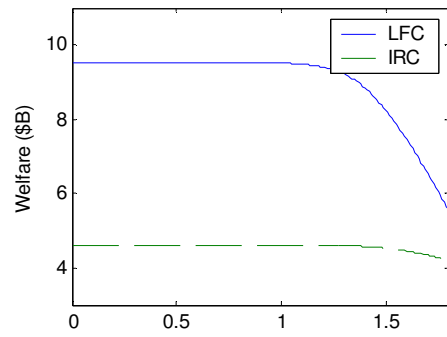


Fig 19: economy of scale in storage ( $b_1$ )