

A Better Copyright System? Comparing Welfare of Indefinitely Renewable Copyright and the Current Copyright System

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Abstract

The current copyright system and a proposed alternative system of indefinitely renewable copyright are modeled, simulated, and compared by social welfare. Evidence is found that the proposed renewable system has lower maximal social welfare than the current system.

1. Introduction

The current copyright system faces tremendous technological and theoretical challenges. In the current copyright system, certain exclusive rights of the information products, such as reproduction, are awarded to copyright owners and protected for certain duration of time. This duration is chosen by the legislature. After duration of copyright expires, information products fall into public domain, unless the duration is extended by the legislature. Landes and Posner (2003) have proposed indefinitely renewable copyright as an alternative to the current system. Contrary to the current system, owners of information products can choose to renew their copyrights for the next period by paying a copyright fee when the current period of copyright expires. If the owner chooses not to renew of the copyright of the product for the next period and not to pay the copyright fee, the product falls into public domain.

An obvious attractive feature of the proposed system is that the copyright system is inherently self-financing, reducing the need for charging administrative fees, which distorts the copyright system from its original rationale or the need for public financing, which causes distortion in other sectors in the economy.

Landes and Posner discussed some other features of the indefinitely renewable system relative to the current system. For example, first, it is suggested that, under the renewable system, actually copyright is likely to be limited for most information products and that the average copyright duration could be actually shorter than that under the current system and that the public domain might be expanded. Second, a copyright registration and renewal system with required notice of information related to copyrights and their owners may reduce the cost of tracing copyright owners by users of information products. Third, aggregate transaction cost could be reduced if the total number of renewals turns out to be small, as suggested above. Fourth, renewable system avoids rent seeking behavior to extend copyright term of the current system by copyright owners.

This paper seeks to compare the essential welfare property of the proposed system and the current copyright system. Social welfare should be the key measure to compare the systems. Unfortunately, it is difficult to measure the overall social welfare of the copyright systems. To enable our the comparison, first, our welfare will only account for consumer surplus and the more essential costs of creating, reproducing, and distributing the information products, but will assume away the tracing cost and transaction cost. Second, the welfare of each system will be measured in its best possible light. That is, the welfare of the current system will be measured at its optimal duration; and the welfare of the proposed system will be measured at its optimal copyright fee. The welfare of an actual copyright system may be different from the optima, because the actual system may be not designed at optima for technical reasons, such as the difficulty of finding the optimal copyright duration or optimal copyright fee, or for political reason, such as unwilling to find the optima, or both. Third, the two systems will be compared based on the same set of functions of creation and reproduction costs and consumer demand for information products. Fourth, only simplified versions of the two systems will be compared. That means, scope of copyright protection, i.e. the boundary of exclusive rights and issues of fair use, will not be considered but assumed to be fixed and the same for the two systems. Especially, the renewable system will have infinitely small renewable terms. As a result, copyright owners can stop renewing copyrights anytime and choose copyright for their products continuously.

This study complements Landes and Posner's discussion of tracing cost and transaction costs, which are needed in an overall comparison of the two systems. It also offers a different perspective on comparing the duration of copyright and size of public domain of the two systems from that of Landes and Posner. Their perspective is empirical and inductive. The perspective here is model-based and deductive.

The paper is organized as follows: section 2 discusses the operations of the industry of information products under the two copyright systems and develops the mathematical models of the two systems; section 3 presents the results of simulation of the two models; section 4 concludes the paper.

2. The Models of the Two Systems

2.1 The operation of the Copyright Markets

This section qualitatively describes how the information market operates under the two copyright systems. The players in the market are creators, consumers, and the legislature. Creators develop first-copy information products and sell copies of them to consumers. During copyright protection, creators are the sole sellers of their respective products. However, the creator of an information product may compete with creators of similar products and a product of a creator may compete with other products of the same creator. Because the products are not identical, each creator enjoys partial monopoly over their products and the competition between creators is monopolistic. Since creation is the most costly activity and the bottleneck of the information industry, allowing and encouraging competition should be desirable in a copyright system.

Creators price above marginal cost of reproduction and distribution during copyright protection in order to maximize profits. Profits above marginal costs are used to cover cost of developing first-copy products and produce net profits. Above-marginal-cost pricing causes loss in consumer surplus. The difference between loss in consumer surplus and gain in creators' profits is the deadweight loss of welfare.

After copyright expires, anyone is free to reproduce and distribute the products. Assuming creators and anyone else incur the same marginal cost of reproduction and distribution,

price will drop to the marginal cost. Creators make the least profit above variable cost of reproduction and distribution. At the same time, consumers enjoy maximum possible surplus from the information products. Deadweight losses are avoided.

Creators also decide 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 or stay the information market. In general if there are profits to be made, potential creators will enter. As information products may be assumed to be, on average, substitutes, a new entrant will reduce demand for products of existing creators and profitability of other entrants. Entry will continue until economic profit of marginal entrant becomes zero.

The above description of the operation of the copyright industry applies to both the current system and the indefinitely renewable system. The two systems differ in the following:

Under the current system, the legislature chooses the duration of copyright to maximize social welfare. Longer copyright duration increases creator's ability to make profits and induces more creators and first-copy products into the market and, therefore, encourages creation. Increase in the number of first-copy products brings higher surplus to consumers. However, additional first-copy products partially substitute existing products and draw profits away from creators of the existing products. Longer copyright protection also means more severe restriction on utilization and increases in deadweight loss for existing products. On the margin, the three effects of changing copyright duration should cancel out.

Under the indefinitely renewable system, creators pay a fee for each period they register or renew the copyright of a product. The creators choose when to stop renewing copyright of their information products. When they choose not to renew copyright of and stop paying the copyright fee for a product, the product falls into the public domain.

The copyright fee is set the by the legislature. An apparent goal for the legislature in setting the copyright fee could be to cover the costs of operating the copyright system. However, the proper goal is for the legislature to maximize social welfare in setting the copyright fee, given the behavior of the creators and consumers of information products as described above.

2.2 Simplifying Assumptions

The above description of the markets is simple because the following simplifying assumptions are implicit. First, the models assume the tracing costs and transaction costs and other costs of operating the copyright systems are zero or the same across the systems. The study includes costs of creating, reproducing, and distributing information products. Tracing cost and transaction cost and other costs of operating the copyright system are considered secondary to the above costs. However, a complete comparison of the two systems needs to consider both sets of costs. Therefore, this study is complementary to discussions of tracing costs and transaction costs.

Second, price discrimination by information creators in selling copies of the products is not considered. Price discrimination can improve welfare. And it affects optimal copyright policy, such as public performance rights, derivative right, importation right (Meurer, 2001; Shapiro and Varian, 1998). It is assumed here that its effects on welfare under the two systems are the same.

Third, creators enter the market and create the first-copy products instantly at beginning of time. They then sell copies of the products afterwards. That is, there is a single generation of information products. Interactions between generations of information products are not considered. In reality, older information products may be used in the creation of newer information; older products may generate demand for newer products or compete with them. However, considering such interactions would much complicate the model.

Fourth, there is a single category of information products. In reality, there are many categories. Information products of different category may differ in cost of creation, reproduction and distribution, differ in demand, and differ in substitutability, etc. However, considering a single category can be representative to the whole information industry. If the

result of the models is applicable to one single category, it can be applicable to each category; then it could be applicable to all categories all together, that is, the information industry, assuming the interaction between the categories does not affect the change the results.

Fifth, all first-copy products are of the same quality. To a degree, quality and quantity of the first-products are interchangeable in the creation of information products. They both require more resources and increase demand. The models combine the two into one single variable. In reality, creators choose both quality and quantity and the two are not perfectly interchangeable. This is a strong assumption of the models. Note also that quality difference is not the same as product differentiation. The quality of the products may be the same. But all first-copy information products can still be different from each other.

Sixth, there is no ordering among first-copy information products. Each first-copy product is different from every other product in the same way. If there is no quality difference between first-copy products, this assumption is natural.

Seventh, all copies made by the creators or others are of the same quality. This assumption is plausible for digital information products. Note that quality of copying is different from the quality of creation.

Eighth, each creator sets one price for all its information products at a given point of time. A creator does not price differentiate its first-copy products, but competes with products of other creators. If there is no quality difference or ordering among first-copy information products, this assumption is reasonable. Note that the price may still change over time.

Ninth, copyright protection is perfectly enforced within copyright duration. In reality, enforcement is imperfect. However, imperfect copyright protection may be treated by amending the demand function of the models to include the increased demand due to users' 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 considered in Landes

Posner (1989) is not considered. Creators are considered as part of the “consumers” when they are users of information. The effect of changes in availability of information on further creation is partially included in "consumer surplus".

2.3 A Model of the Current Copyright System

The model for the current system is the same as that developed in (Yuan, 2004). Use the following notations:

n : number of creators in the market;

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

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

p_{it} : price per copy of each product of creator i at time t ;

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

$D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t)$: the rate of demand for products of creators i at time t ;

$c_i(s_i)$: the cost of first-copy development of s_i ;

b : the cost of reproducing and distributing a copy of information product, uniform over all information products and over all creators and consumers;

γ : the discount rate of consumers and creators;

T : duration of copyright protection.

The problem of optimal duration is to choose copyright duration T to maximize social welfare:

$$\begin{aligned}
 L = & \sum_{i=1}^n \int_0^{\infty} \left(\int_b^{\infty} D_{it}(s_i, p, s_{-i}, p_{-it}, t) dp \right) e^{-\gamma t} dt \\
 & - \sum_{i=1}^n \int_0^T \left(\int_b^{p_{it}^*} D_{it}(s_i, p, s_{-i}, p_{-it}, t) dp \right) e^{-\gamma t} dt \\
 & + \sum_{i=1}^n \int_0^T D_{it}(s_i, p, s_{-i}, p_{-it}, t) (p_{it}^* - b) e^{-\gamma t} dt \\
 & - \sum_{i=0}^n c_i(s_i)
 \end{aligned} \tag{1}$$

subject to behavior of creators:

$$\frac{\partial}{\partial p_{it}} [D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t)(p_{it} - b)] = 0, \quad i=1, 2, \dots, n \quad (2)$$

$$\frac{\partial}{\partial s_i} \left[\int_0^T D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t)(p_{it} - b)e^{-\gamma t} dt - c_i(s_i) \right] = 0, \quad i=1, 2, \dots, n \quad (3)$$

and

$$\int_0^T D_{it}(s_i^*, p_{it}, s_{-i}, p_{-it}, t)(p_{it} - b)e^{-\gamma t} dt - c_i(s_i^*) = 0, \quad i=1, 2, \dots, n \quad (4)$$

where p_{it}^* is the price determined by (2) and s_i^* is the size of creator i determined by (3).

The first term in social welfare function (1) is the maximum possible consumer surplus by developing s_i , $i=1, 2, \dots, n$. The inner term of the integration over p is the rate of consumer surplus from the products of creator i at time t . The outer integration is to sum the consumer surplus from products of creator i over time with a discount rate of γ . Then the consumer surpluses from products of all creators are summed.

The second term is the loss of consumer surplus during copyright protection. There are integrations and summation similar to those in the first term, but different in price and time ranges. The ranges reflect that the loss is within time 0-T of copyright protection and due to the price raised from marginal cost b to p_{it} at time t within 0-T. The third term is the total revenue of all creators above their copying and distribution costs during copyright protection; the difference between the second term and the third term is the deadweight loss; the fourth term is the total cost of developing s_i , $i=1, 2, \dots, n$.

The first set of constraints (2) represents the pricing decision of each creator in selling copies of its products at time t during copyright protection. The price maximizes the firm's profit at each point of time t . The second set of constraints (3) indicates that each creator chooses the number of first-copy products to maximize its total profit during copyright protection, accounting for development cost. The third constraint represents the marginal

creator's entry condition of zero economic profit. If all creators have the same creating technologies, this condition holds for all creators $i=1, 2, \dots, n$.

2.4 A Model of Indefinitely Renewable Copyright System

This section develops the model of the indefinitely renewable system. Two additional notations are used in the model of renewable copyright system:

f : copyright fee per product per unit of time

T_i : copyright duration chosen by creator i .

Note, T_i is used to denote the copyright duration for all products of creator i . In principle, each creator can choose copyright duration for each of its products. However, because there is no quality difference and ordering between these products, copyright duration for all products will be the same. This notation is convenient.

The problem of the indefinitely renewable copyright is to choose the copyright fee, f , to maximize social welfare:

$$\begin{aligned}
 L = & \sum_{i=1}^n \int_0^{\infty} \left(\int_b^{\infty} D_{it}(s_i, p, s_{-i}, p_{-it}, t) dp \right) e^{-\gamma t} dt \\
 & - \sum_{i=1}^n \int_0^{T_i} \left(\int_b^{p_{it}^*} D_{it}(s_i, p, s_{-i}, p_{-it}, t) dp \right) e^{-\gamma t} dt \\
 & + \sum_{i=1}^n \int_0^{T_i} D_{it}(s_i, p, s_{-i}, p_{-it}, t) (p_{it}^* - b) e^{-\gamma t} dt \\
 & - \sum_{i=0}^n c_i(s_i)
 \end{aligned} \tag{5}$$

subject to behavior of the creators under the new system:

$$\frac{\partial}{\partial p_{it}} [D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t) (p_{it} - b) - f \times s_i] = 0, \quad i=1, 2, \dots, n \tag{6}$$

$$\frac{\partial}{\partial s_i} \left[\int_0^{T_i} [D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t) (p_{it}^* - b) - f \times s_i] e^{-\gamma t} dt - c_i(s_i) \right] = 0, \quad i=1, 2, \dots, n \tag{7}$$

$$\frac{\partial}{\partial T_i} \left[\int_0^{T_i} [D_{it}(s_i, p_{it}, s_{-i}, p_{-it}, t)(p_{it}^* - b) - f \times s_i] e^{-\delta t} dt - c_i(s_i) \right] = 0, \quad i=1, 2, \dots, n \quad (8)$$

and

$$\int_0^{T_i^*} [D_{it}(s_i^*, p_{it}, s_{-i}, p_{-it}, t)(p_{it}^* - b) - f \times s_i] e^{-\delta t} dt - c_i(s_i^*) = 0, \quad i=n \quad (9)$$

where p_{it}^* is the price determined by (6); s_i^* is the size of creator i determined by (7); and T_i^* is determined by (8).

Because copyright fee is a transfer from creators to public treasure through the copyright systems, the copyright fee does not appear in the objective function of the social welfare. Therefore, the welfare function is the same as (1) for the current system. Note, although copyright fee, f , does not appear in the object function L , it appears in the constraints (6), (7), (8), and (9) and affects the optima of the model.

Constraints (6) are the pricing decisions of the creators at time t ; (7) represent how the creators decide the number of first copy products to develop; and (9) is the marginal creator's entry condition of zero profit. (6), (7), (9) correspond to the constraints (2), (3), (4) in the model for the current copyright system, respectively. The difference is that the term for profit of creator i in (6), (7), and (9) contains the variable of the copyright fee, f . Constraints (8) are the copyright renewal decisions of the creators.

3 Simulation of the Two Systems

3.1 Specification of Demand and Costs

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

$$D_i(s_i, p_{it}, s_{-i}, p_{-it}, t) = D_0 \left(s_i / \sum_{j=1}^n s_j \right) \left(\sum_{j=1}^n s_j \right)^\alpha p_i^{-\delta} \prod_{j \neq i} p_j^{\frac{\beta}{n-1}} g(t) \quad (10)$$

$$\text{where } g(t) = \begin{cases} 1 - \frac{t}{T_0} & \text{if } t < T_0(1 - \theta) \\ \theta & \text{otherwise} \end{cases} \quad (11)$$

$$c_i(s) = c_0 + as^\rho \quad (12)$$

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

The factor $\left(\sum_{j=1}^n s_j \right)^\alpha$ in demand function (10) means total demand for information increases with the total number of first-copy information products. The parameter $0 \leq \alpha \leq 1$ is the percent increase in demand from a percent increase in the number of first-copy products. It reflects the degree of differentiation of first-copy information products and the consumers' preference for variety of information. $\alpha=0$ means that all products are perfect substitutes; $\alpha=1$ indicates that first-copy products are not substitutes at all. $\alpha > 1$ means products are complements. Individual information products can be complements to each other. However, on average, information products are most likely substitutes within a product category. Thus, the parameter α is assumed to be no bigger than one.

The factor $s_i / \sum_{j=1}^n s_j$ in (10) 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 and β mean that demand for a creator's products decreases with its price but increases with the prices of products of other creators. The parameter δ is the price elasticity of demand for a creator's products; β is the cross-price elasticity. The condition of $\delta > 1$ is necessary for consumer surplus to be finite. With (10), it can be derived that:

$$p = \frac{\delta}{\delta - 1} b \quad (13)$$

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

In (10), all first-copy products are related to demand in the same way, reflecting the assumption that there is no order between first-copy products. In cost function (12), c_0 represents the fixed cost of information creation; $\rho > 1$ means that there are decreasing returns to scale in creation.

The above specifications assume that creators are symmetric: they have identical creation, reproduction, and distribution costs and symmetric demand functions. Thus, in equilibrium, one can expect that all creators have the same size and charge the same price, and in the indefinitely renewable system, choose same duration of copyright for their products.

3.2 The Results

With the above specific demand and cost functions, numerical method is used to compute the values for copyright duration T , number of products per creator s , number of creators on the market n , social welfare L , and copyright fee f (for the indefinitely renewable system) for given values for the market parameters D_0 , α , δ , β , b , T_0 , θ , γ , c_0 , a , and ρ .

Assume the following parameter values:

$$[D_0, \alpha, \delta, \beta, b, T_0, \theta, \gamma, c_0, a, \rho] = [10^7, 0.3, 2, 0.5, 5, 100, 0.001, 0.05, 3 \cdot 10^5, 10^4, 1.2]$$

Note, $b=5$ is the per-copy cost of reproduction and distribution; $\gamma=0.05$ is the discount rate; $D_0=10^7$ reflects the general level of demand; $T_0=100$ and $\theta=0.001$ indicate that demand falls off linearly to one thousandth of the initial demand in 99.9 years and stay at that level afterwards; price elasticity δ is 2 and across-price elasticity β is 0.5. With these parameters values, the results of two models are as shown in Table 1.

Under the current system, optimal copyright duration is 14 years; under 14 years of copyright protection, there are 130 creators on the market; each creates 63 first-copy products and makes zero profit; price of the product is \$10 a copy during copyright protection of the first 14 years and \$5 a copy afterwards; 729 million copies of their products are sold within the first hundred years after the products are developed (1.04 billion copies in the first two hundred years). Note, the numbers include 63 million copies sold during the 14 years under copyright protection and the rest sold when the products are

in public domain. Total social welfare of the industry of information products is \$1.06 billion.

Table 1. Difference of Renewable System from Current System

	Current System	Renewable System	Difference (%)
Copyright duration	14	92	78 (557%)
Creator size	63	64	1 (2%)
Number of creators	130	228	98 (75%)
Total number of first-copy products	8,213	14,596	6383 (78%)
Copyright fee per first-copy product per year (\$)	N/A	159	N/A
Price per copy of copyrighted product (\$)	10	10	0(%)
Total number of copies sold in 100 years (millions)	729	387	-342(-47%)
Social welfare (\$billion)	1.06	0.95	-0.11 (-10%)

Under the indefinitely renewable system, optimal copyright fee is \$159 per product per year. With this fee, creators choose copyright protection of 92 years, 78 years longer than the optimal duration of 14 years under current system; there are 228 creators in the market, 98 more than under the current system; there are 14,596 first-copy products in the market, 6,406 more than under the current system; prices of information products are \$10 per copy during the first 92 years and \$5 a copy afterwards; 387 million copies will be sold in the first 100 years after creation and 757 million in the first 200 years. These include 337 million copies sold during the 92 years under copyright protection and the rest sold when the products are in public domain. Total social welfare of the industry of information products is \$0.95 billion, \$0.11 billion or 10% less than the current system.

Fourteen years is the socially optimal copyright duration under which creators operate optimally to their best individual interests and collectively bring maximal social welfare of \$1.06 billion under the current system, as shown in Figure 1. Figures 2-4 show that number

and size of creators and number of first-copy products increase with copyright protection monotonically. When copyright protection is shorter than 14 years, fewer than optimal numbers of creators and first-copy products are there on the market; when copyright protection is longer-than 14 years, more than optimal numbers of creators and first-copy products are induced into the market; both cause losses in social welfare. Under protection happens when there is not enough time for creators to recover high development cost of the first-copy products before anyone else can come to reproduce and sell the products. Over-protection can happen because it leads to too large deadweight losses and because it induces too many additional products, which reduce demand for other products.

One hundred-fifty-nine dollars per product per year is the socially optimal copyright fee under which creators operate optimally according to their best interests and collectively bring maximal social welfare of \$0.95 billion under the indefinitely renewable system, as shown in Figure 5. Figures 6-10 show that copyright duration and number of first-copy products decrease with copyright fee monotonically. And Figure 10 shows that consumer surplus also decrease with copyright fee monotonically. This may not be too surprising. Creators not only dislike copyright fees but can also pass part of the copyright fee to consumers. Therefore, copyright fee hurts consumer welfare. However, copyright fee brings revenue to the public treasure. Figure 11 shows that that public copyright revenue increases with copyright fee and reaches maximum at a fee of \$2,552 per year and then decreases thereafter. The sum of consumer surplus and public copyright revenue, which is the social welfare under the indefinitely renewable system, reaches maximum at a fee of \$159 per year. When copyright fee is low, it improves social welfare by bringing more revenue to the public treasure than the loss it may cause on consumer welfare. When copyright fee is higher, there are fewer first-copy products on the market. The revenue it can bring to the public treasure by raising copyright fee is diminished. When copyright fee is too high, the revenue it brings to the public treasure is less than the loss it causes on consumer welfare. Social welfare suffers.

Most importantly, the maximal social welfare of the indefinitely renewable system is lower than the maximal social welfare of the current system. Considering consumer welfare may help understand this result. The renewable system makes consumers worse off relative to

the current system. This can be seen from the following three reasons. First, consumers are indifferent toward a renewable system of zero-copyright fee and a current system of an infinite term. This is because a zero-copyright fee under the renewable system is equivalent to an infinite copyright duration under the current system. This is, in turn, because creators will choose infinite copyright duration under zero-copyright fee as long as there is positive demand for their products. Second, consumers are better off under optimal copyright term than under infinite term of the current system, except the special case where infinitely long copyright protection is optimal, which is not the case for the model with parameter values used here. Note that under the current system, creators make zero economic profit in an open competitive information creation industry and there is no public revenue from copyright protection, consumer surplus and social welfare are identical. Third, consumers are worse off under optimal copyright fee than under zero-copyright fee in renewable system, as shown in Figure 10.

Although a proper copyright fee can bring a public revenue bigger than the loss of consumer surplus relative to the consumer surplus when copyright fee is zero and copyright protection is infinitely long, the optimal public copyright revenue it brings under the renewable system does not make up the loss of consumer welfare relative to the consumer surplus at the optimal length of copyright protection under the current system.

Why does it not? The reason may be that copyright fee is a more indirect instrument than the current copyright system to solve the particular problem of the information industry. The problem is the large creation cost and small reproduction cost of information products. Current copyright system can be thought as the second best solution to solve this problem. The First best solution is public financing of information products. However, the first best solution would not only create distortion in other sectors of the economy due to its need for public financing but also discourage competition in the creation of information products. The current copyright system avoids public financing of information creation and allows competition in the creation of information products. The current copyright system maintains a balance between the incentive for creation of information products and the opportunity of utilization of created information products, although it leaves the need for public financing of operating the copyright system itself.

The indefinitely renewable system tries to reach that balance between the incentive for creation and the opportunity of utilization through a copyright fee. It retains the properties of avoiding public financing of and allowing competition in information creation. It further helps finance the copyright system itself. However, it is an indirect way to reach the balance achieved by the second best solution, therefore, an indirect instrument to solve the problem in provision of information products. In this sense, the renewable system can be considered as the third best solution of the copyright problem. Similar to the relation of the second best solution to the first best solution, the third best solution has the desirable property of inherent self-financing but leads to lower social welfare compared to the second best solution.

Can copyright fee be used to induce creators to choose the same balance, i.e., the same copyright duration of the current system? Landes and Posner's conjecture is that one could always do that. However, simulation of the model suggests not always. Copyright duration does become shorter and closer the optimal duration of the current system to as copyright fee increases. However, in some cases, before it reaches the optimal duration of the current system, all creators may exit the market due to the high copyright fee. Therefore, optimal duration of copyright of the current cannot always be induced through copyright fee.

The optimal duration can be reached through a copyright fee in other cases, example of which will be given in the next sub-section. However, in such case, creators will not behave the same as in the case of the current system, because the copyright fee changes the cost structure of the creators.

The results also show that copyright duration chosen by creators under optimal copyright fee is longer than the optimal copyright duration of the current system. This is different but not necessarily contradictory to the point in Landes and Posner (2003) that the average copyright duration under the renewable system could be actually shorter than that under the current system. The duration of the current system in Landes and Posner (2003) refers to the actual duration of the current law, such as 95 years after the death of the author.

The actual duration may not be the same as the optimal duration, which could be much shorter.

In addition, the result of the model may agree that the public domain may be expanded under the renewable system, even though the expanded public domain may be a delayed one due to the longer copyright duration. It may be expanded for the reason that there will be more first-copy products under the renewable system. The reason implied in Landes and Posner (2003) is that products will fall into public domain earlier.

3.3 Sensitivity Analysis

Sensitivity analysis is done by changing the value of each parameter of $[D_0, \alpha, \delta, \beta, b, T_0, \theta, \gamma, c_0, a, \rho]$ and by changing the function form of $g(t)$, which describes how the demand for information products changes over time. The results that maximal welfare of the indefinitely renewable system is lower than that of the current system and that creators choose longer copyright duration under optimal copyright fee in the renewable system than the optimal duration of the current system are found robust.

For example, changing the reproduction cost b from \$3000 per copy to \$0.5 per copy, fixing the values of other parameters, recalculate the models. Figures 12 and 13 show that percentage loss of welfare remains between 9% and 11% and copyright duration under the renewable system exceeds by 76 to 78 years that of the current system.

Changing the demand level parameter D_0 from 400,000 to 20,000,000, fixing values of other parameters, recalculate the model. Figures 14 to 16 show that percentage loss of welfare remains between 9% and 11% and copyright duration exceeds by 77 to 82 years under the renewable system relative to the current system.

Changing the function $g(t)$ from its linear form to an exponential form of $g(t) = e^{\frac{t}{T_0}}$, using same parameter values, recalculate the models. The results remain qualitatively the same as shown in Table 2.

Table 2. Difference of Renewable System from Current System

	Current System	Renewable System	Difference (%)
Copyright duration	15	249	234(1560%)
Creator size	63	64	1 (2%)
Number of creators	137	242	105 (77%)
Total number of first-copy products	8,685	15,499	6814 (78%)
Copyright fee per first-copy product per year (\$)	N/A	154	N/A
Total number of copies sold in 100 years (million)	735	361	-374(-51%)
Social Welfare (\$billion)	1.12	1.00	-0.12 (-11%)

Note that, with the exponential form of $g(t)$, if copyright fee in the renewable system is increased to \$56,805, creators will choose a copyright duration of 15 years of the optimal duration of the current system. However, the social welfare will further drop to \$0.3 billions and there will be only 12 creators in the market, and each creates 7 first copy products.

4. Concluding Remarks

This paper compared the current copyright system and the indefinitely renewable copyright system by their welfare property. It found evidence that the proposed renewable system has lower maximal social welfare than the current system. The study only considers primary costs of creation, reproduction and distribution of information products. It complements studies considering other costs of tracing, transaction, and operation of the copyright system. The rent-seeking behavior has not been discussed, though it is extensive in the form of lobbying to extend copyright term under the current system. We just mention that rent-seeking may not be exclusive of the current system. It is likely to exist in the form of lobbying to reduce the copyright fee under the proposed indefinitely renewable system.

Acknowledgement

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Figure 1. Effect of Copyright Term on Social Welfare under Current System

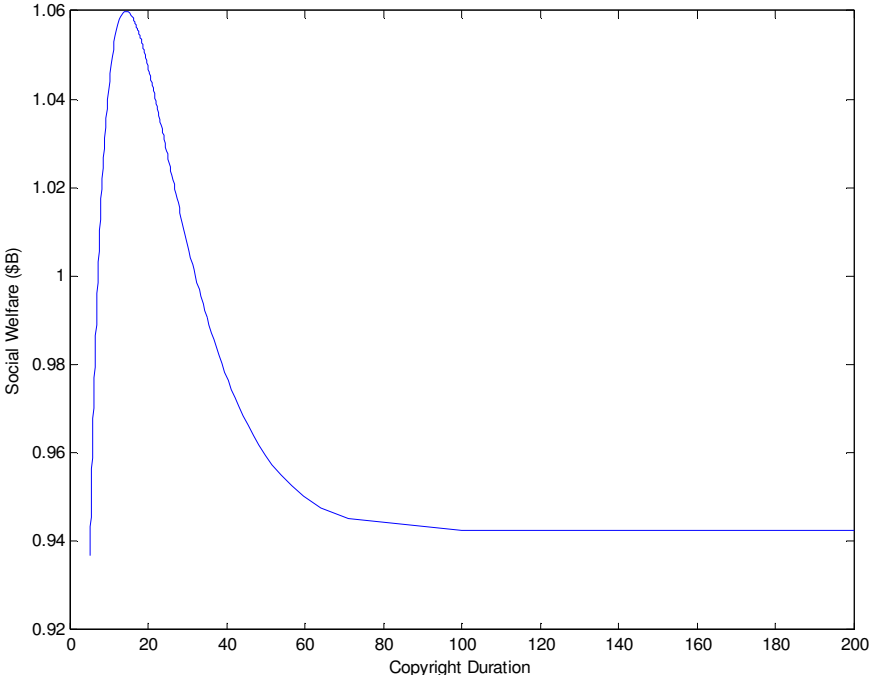


Figure 2. Effect of Copyright Term on Number of Creators under Current System

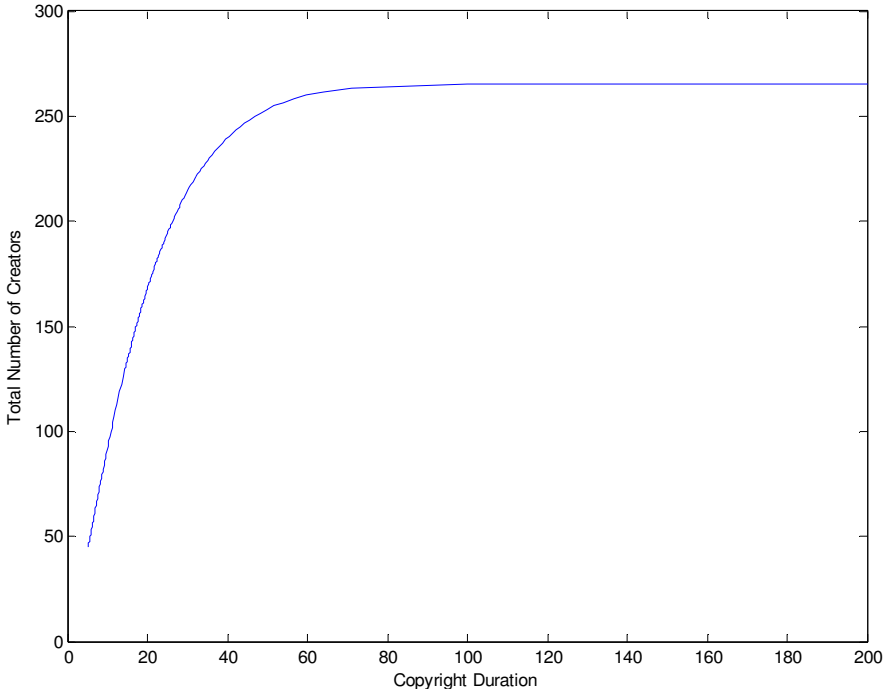


Figure 3. Effect of Copyright Term on Creator Size under Current System

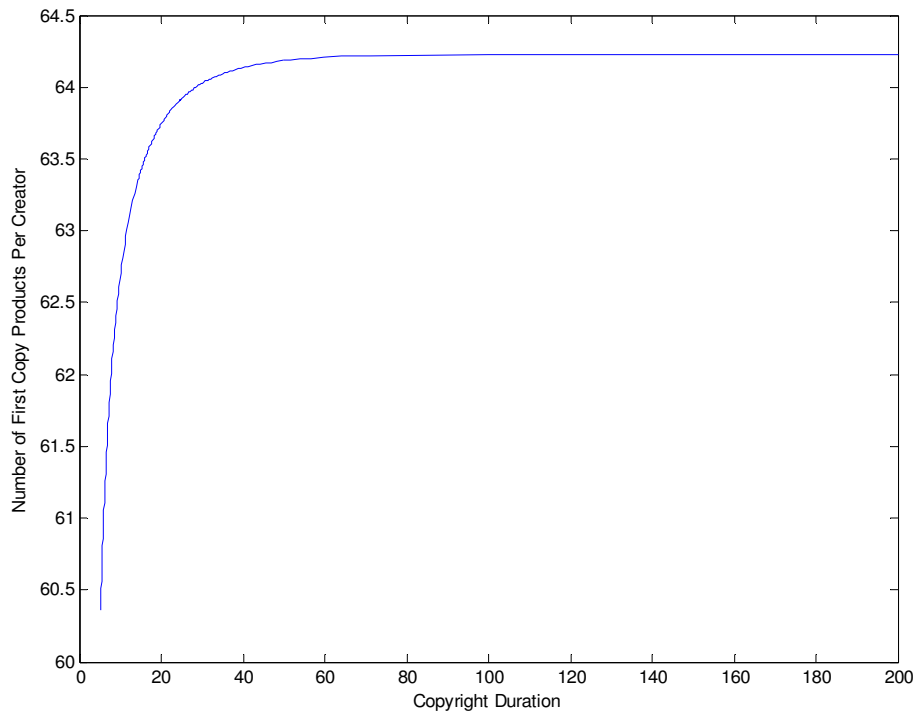


Figure 4. Effect of Copyright Term on Information Availability under Current System

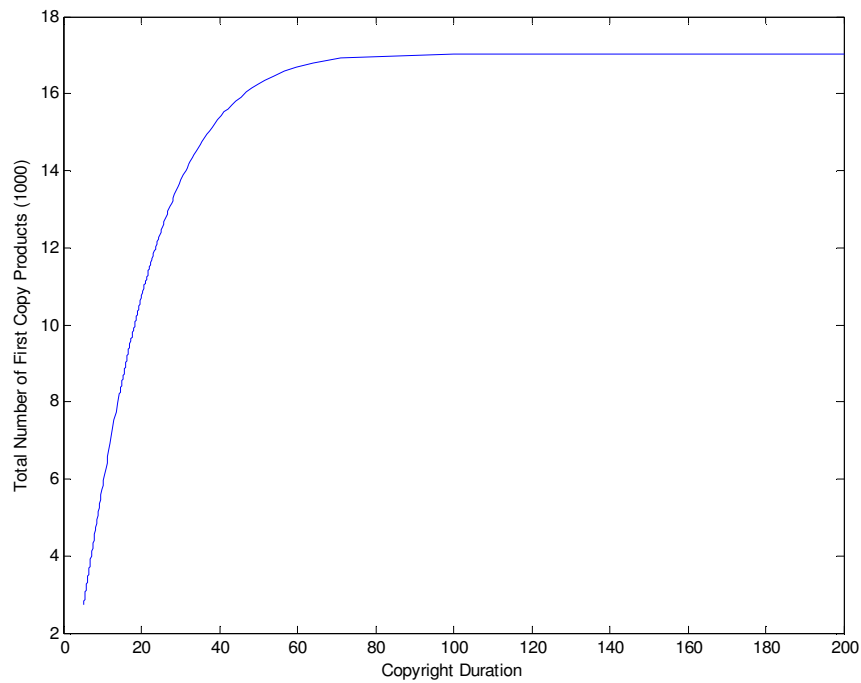


Figure 5. Effect of Copyright Fee on Social Welfare under Renewable System

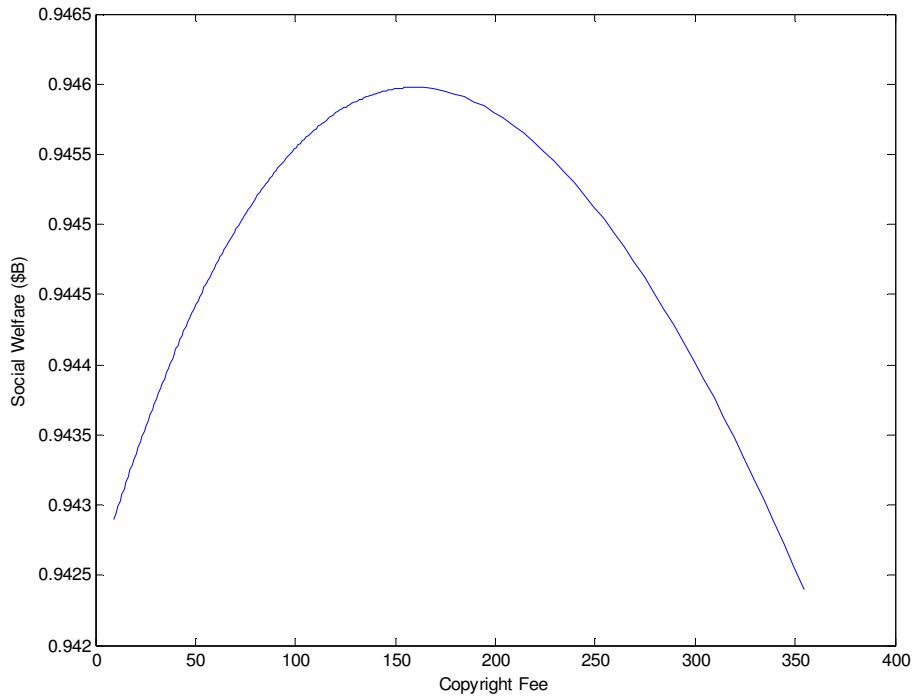


Figure 6. Effect of Copyright Fee on Copyright Duration under Renewable System

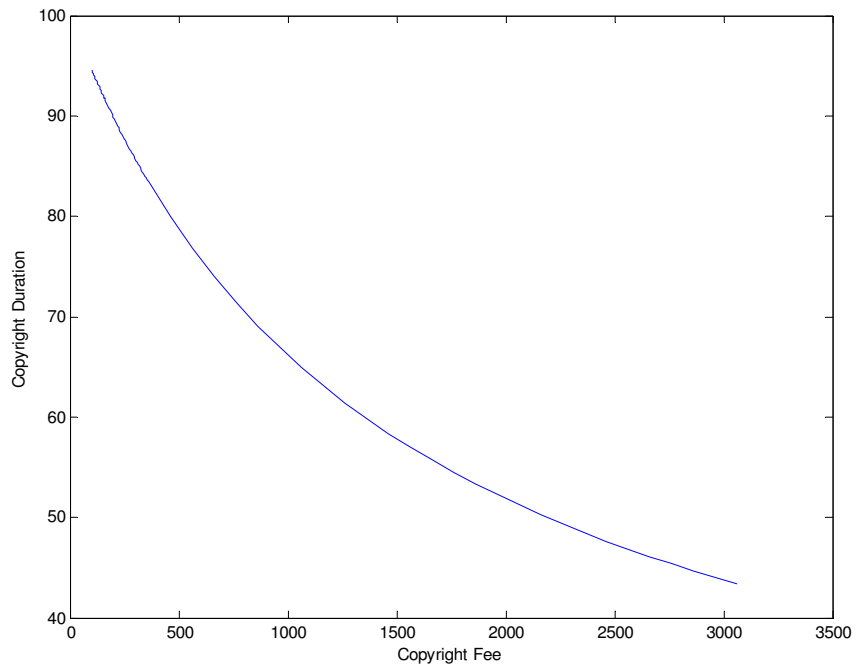


Figure 7. Effect of Copyright Fee on Number of Creators under Renewable System

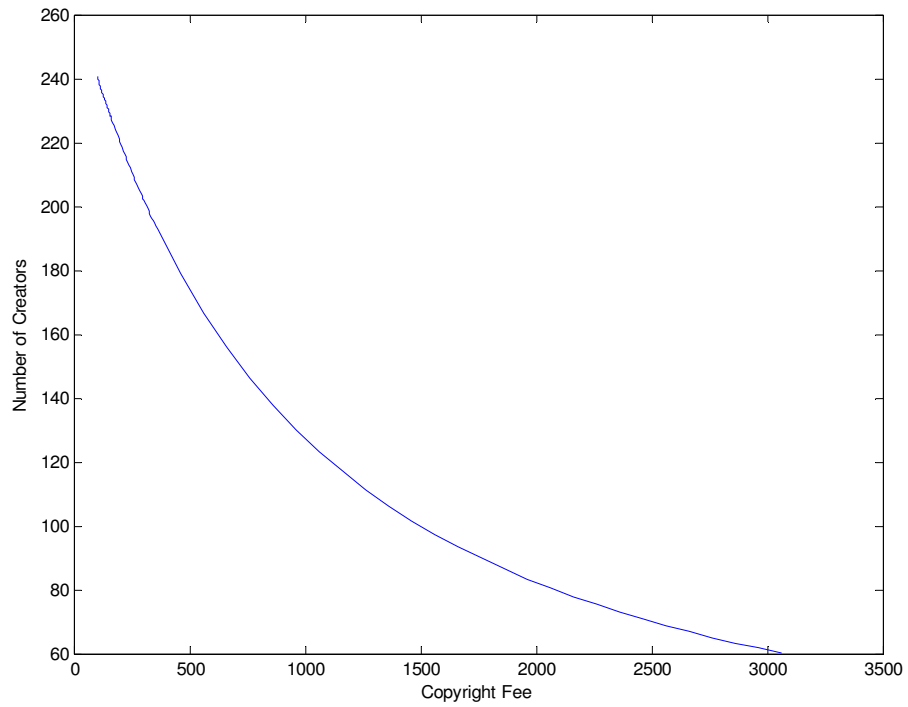


Figure 8. Effect of Copyright Fee on Creator Size under Renewable System

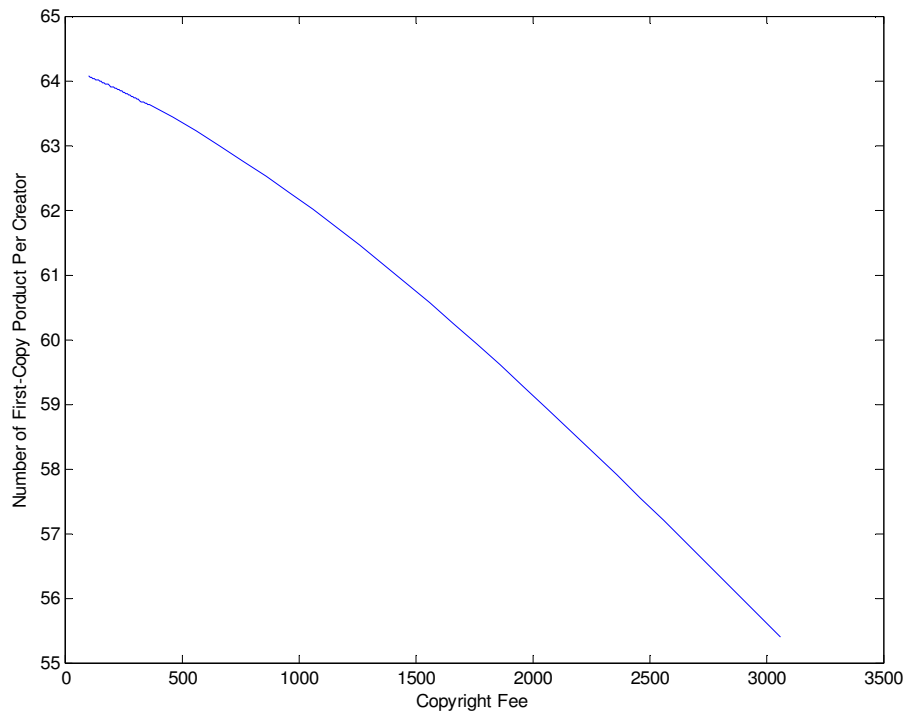


Figure 9. Effect of Copyright Fee on Information Availability under Renewable System

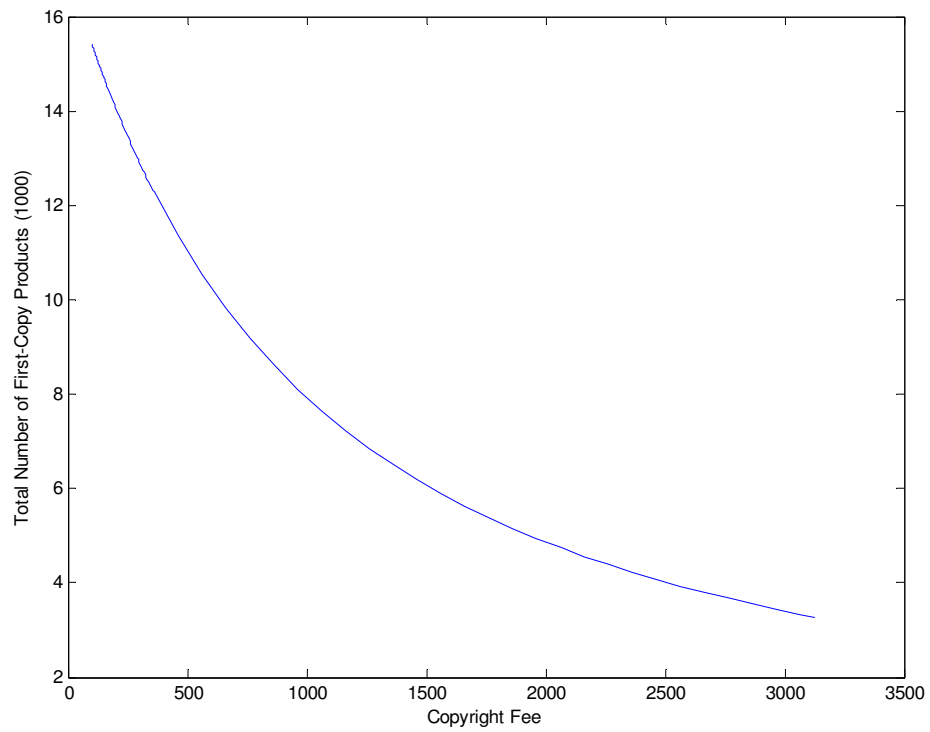


Figure 10. Effect of Copyright Fee on Consumer Welfare under Renewable System

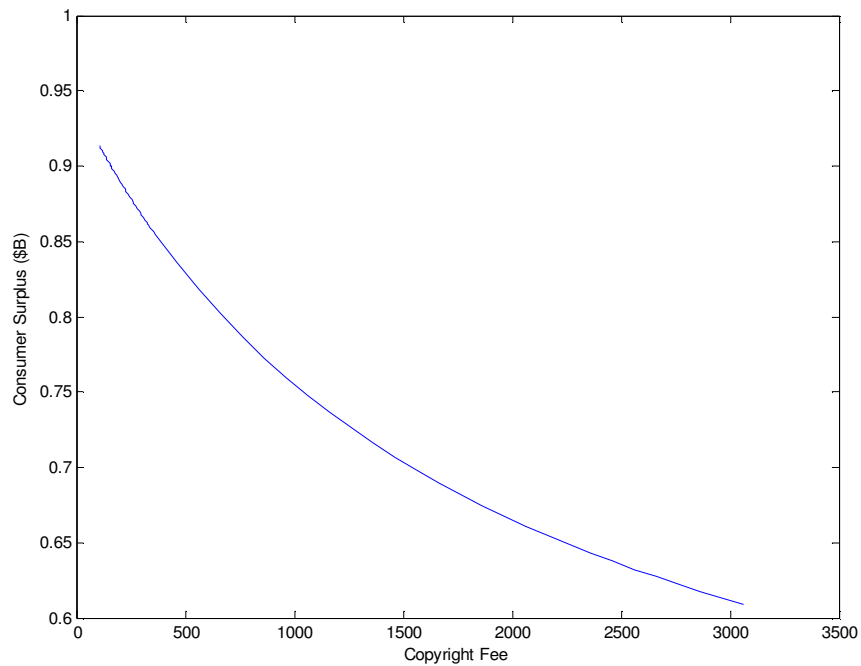


Figure 11. Effect of Copyright Fee on Public Copyright Revenue under Renewable System

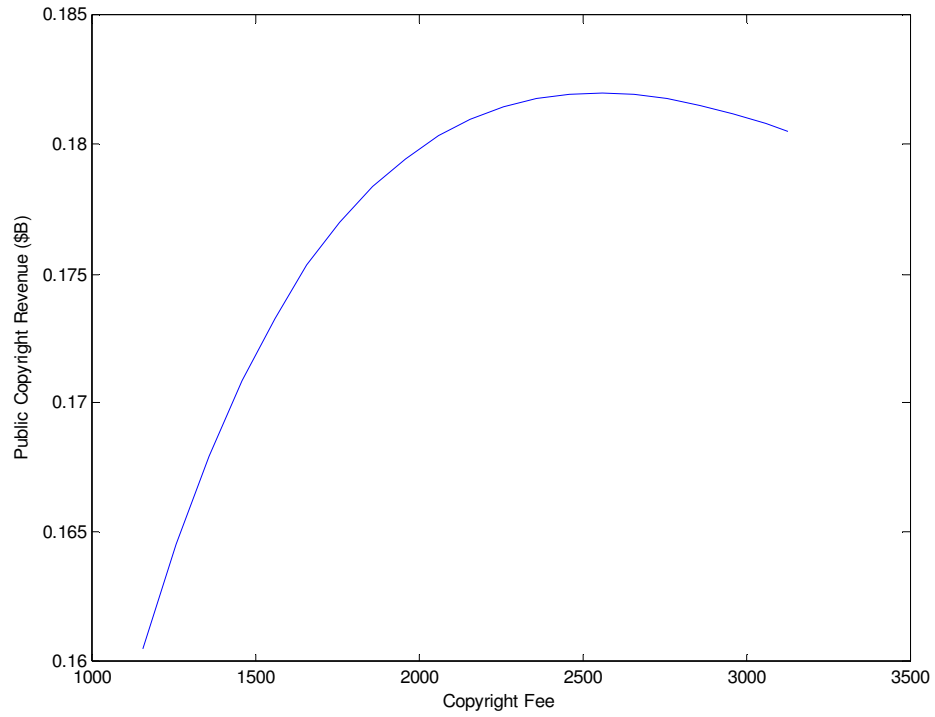


Figure 12. Robustness of Welfare Loss to Reproduction Cost

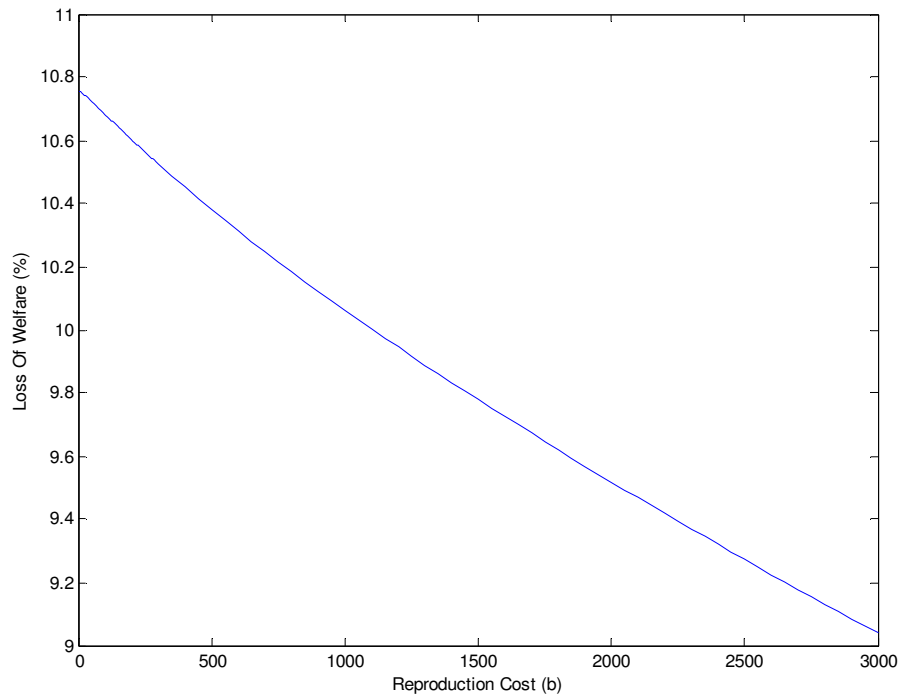


Figure 13. Effect of Reproduction Cost on Difference of Copyright Duration

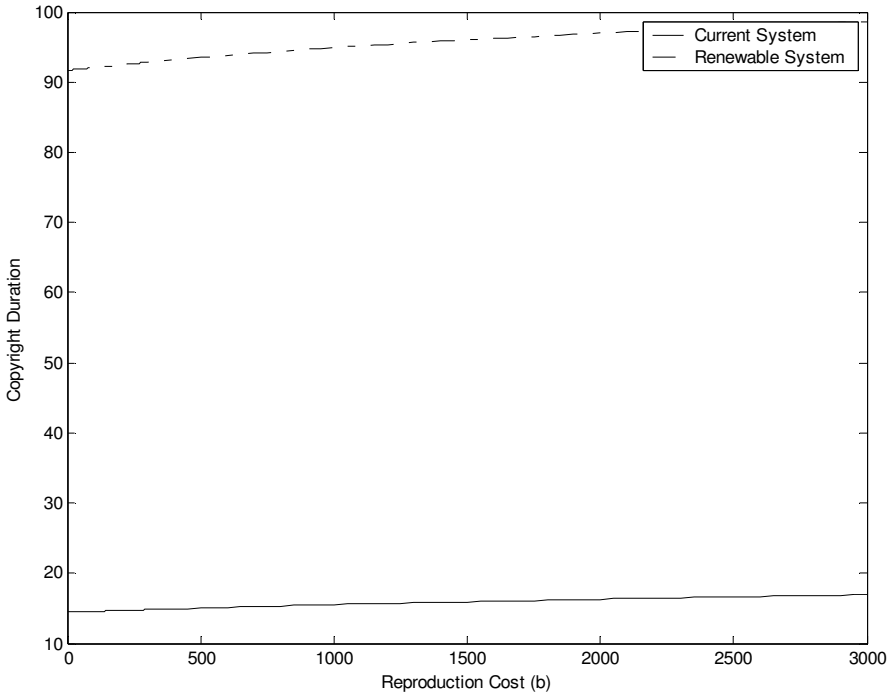


Figure 14. Robustness of Welfare Loss by Renewable System (I)

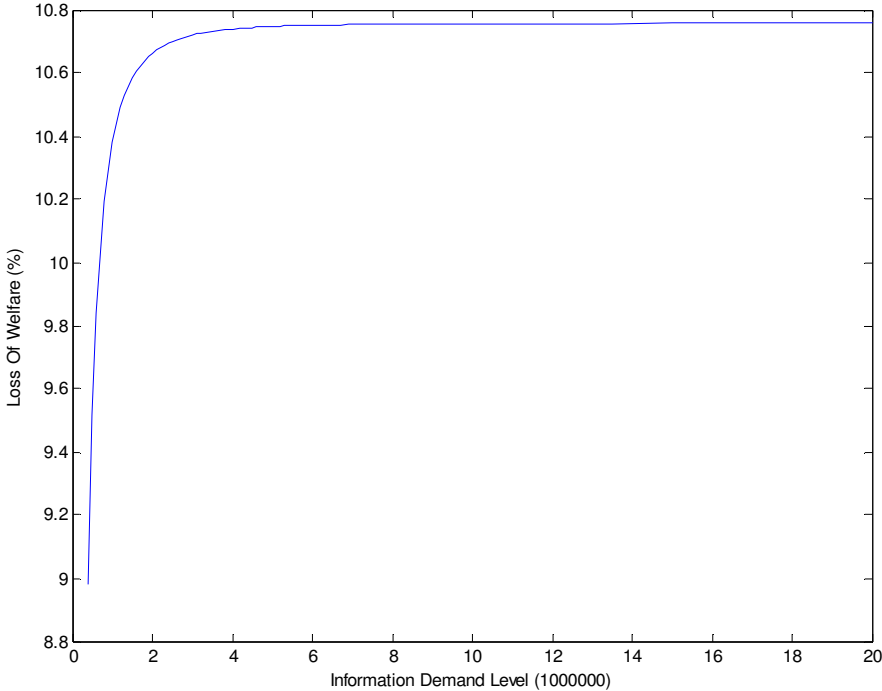


Figure 15. Robustness of Welfare Loss by Renewable System (II)

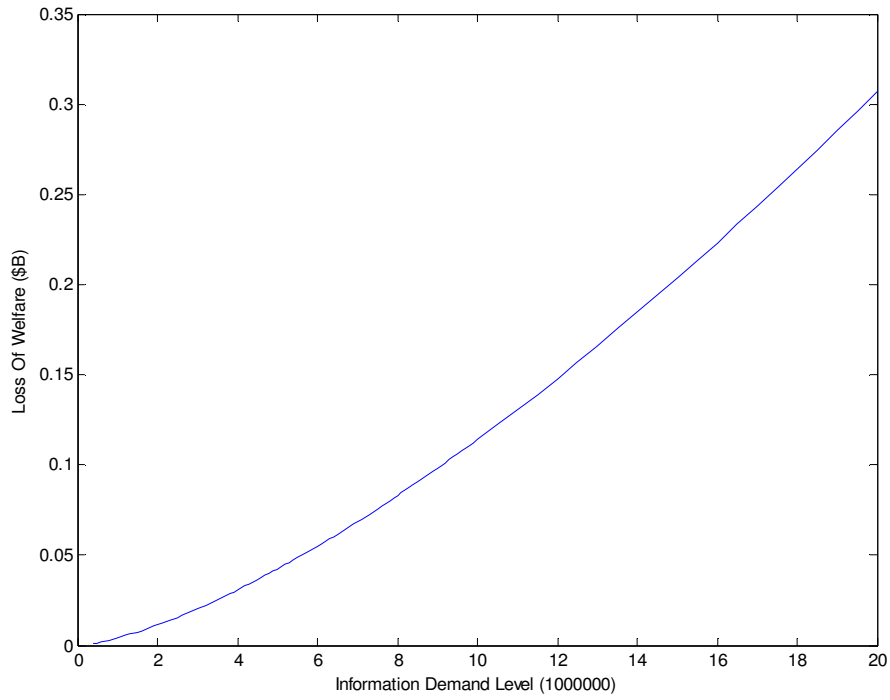


Figure 16. Effect of Information Demand Level on Difference of Copyright Duration

