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EXPLORING A BETTER DESIGN OF COPYRIGHT LAW

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Abstract. This study proposes a simulation model aimed at exploring how copyright law should be designed; that is, a desirable combination of copyright length and breadth. The model incorporates the specific properties of creative industries but is hard to deal with analytically because of its dynamic characteristics. Changes in social welfare under different copyright designs are thus examined by using numerical simulation. The simulation results reveal that a short and narrow copyright is the best, whereas a long and broad copyright is the worst. Moreover, in the long run, a long copyright can reduce social welfare even if the breadth is narrow.

1. Introduction

People are discontented with current copyright law, and disagreement between rights holders and users has been growing. A recent example of such disagreement was seen in the Trans-Pacific Partnership (TPP) negotiations. Influenced by large rights-holding companies, negotiators proposed extending copyright terms by 20 years beyond the minimum 50-year copyright term in the 1994 Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement. Many non-government groups, including Creative Commons, opposed it.[1]

Several economists have attempted to mitigate this situation by analyzing the optimal level of copyright protection, focusing either on its length or its breadth. Length refers to the term of copyright protection, and breadth to the extent of the right to exclude use by non-rights holders. Theoretical studies of optimal copyright length include those by Yuan (2005), Pollock (2009), and Adilov and Waldman (2012). Studies of optimal copyright breadth include those

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[1] Creative Commons Blog News, "An Open Letter to TPP Negotiators: Copyright Term Extension Makes No Sense," Ryan Merkley, July 9, 2014 (http://creativecommons.org/weblog/entry/43256, last accessed on May 30, 2017).

by Novos and Waldman (1984), Landes and Posner (1989), Yoon (2002), and Miceli and Adelstein (2006).[2] Unlike in the patent design literature, the combination of length and breadth has not yet been explored in copyright law design literature.[3]

Furthermore, most studies of optimal copyright protection focus on the effect of a policy change on a creator's revenue from a work, which is the incentive to create a new work. The exception is the model of Landes and Posner (1989), which states that a change in the level of copyright protection affects the cost of creating new works (the "expression cost") as well as the creator's revenue. While strengthening copyright protection increases a creator's monopolistic profit from selling copies of a work, it can also increase the expression cost because past works are important inputs for creating a new work.

This study attempts to integrate these issues and provides a theoretical framework to examine the optimal combination of copyright length and breadth. The model incorporates several characteristics of the model of Landes and Posner (1989), including the idea of the expression cost, and the specific properties of creative industries (e.g., books, records, and films), including the *infinite variety* and *nobody knows* properties (Caves, 2000). The *infinite variety* property implies that old creative works are not necessarily replaced by new ones, and thus the model assumes that the markets for old and new works coexist. The *nobody knows* property indicates that there is great uncertainty about how consumers will value a new creative work. Based on this property, the model is constructed as a series of static problems where a creator maximizes short-run profit in each period. This feature of the model differs from that in previous studies of the optimal design of intellectual property rights, where the monopolist maximizes the discounted sum of all future profits. Other important features of the theoretical models in previous studies of optimal copyright law design, such as investment

[2]Landes and Posner (1989) explain that the level of copyright protection in their model can include the length of the copyright term. Their model, however, is static, and thus ignores the dynamic process of creators' behavior.
[3]For literature on optimal patent design, see the survey by Rockett (2010).

in the quality of a work (Novos and Waldman, 1984; Adilov and Waldman, 2012), are omitted for simplicity.

The model, in spite of its simplicity, is hard to deal with analytically because it specifies that the expression cost varies stochastically and dynamically depending on the number of successful works and their protection status. Therefore, changes in social welfare under different copyright designs are examined by using numerical simulation.[4] The simulation results reveal that a short and narrow copyright is the best, whereas a long and broad copyright is the worst. The desirability of a short and narrow copyright is robust to different levels of expression costs and works' depreciation rates, which determine the effects of different copyright designs on social welfare. Moreover, in the long run, a short copyright is more important than a narrow copyright for social welfare because the growth of social welfare is significantly limited under a long copyright even if the breadth is narrow.

The rest of the paper proceeds as follows. Section 2 explains the model. Section 3 presents the results of the numerical analysis. Section 4 concludes by discussing the implications of the results.

2. Model

2.1. **Basic assumptions.** In each period t, there are N_t creators of works such as books, music, and films. As in the model of Landes and Posner (1989), a creator is not distinguished from a publisher, recording company, or film company. Both the marginal and fixed costs of making and distributing copies (or reproductions) are set to zero, and creators incur only the cost of creating new works, herein termed the expression cost.

Each creator i decides the number of new works produced at the beginning of each period t, which is denoted as K_{it}. The time period when a new work is published is denoted by p, and the term of copyright protection (copyright length) is denoted by T: a copyrighted

[4]A similar approach is taken by Muller and Pénin (2006), who use a simulation model to describe the dynamics of innovation networks and the role of open knowledge disclosure.

work is protected for T periods from its publication period, p. During the copyright term ($t - p < T$), a work's creator is the only provider of copies of the work. As in the model of Landes and Posner (1989), all the different ways to exploit a work are treated identically and are called "providing copies," which include different media (e.g., CD, MP3, and music streaming), licensing, and derivative works. Moreover, each work is sufficiently differentiated, and the market for copies of a work is independent. This feature of creative products is called the *infinite variety* property by Caves (2000), who explains that two songs, two paintings, or two movies may be quite similar but are not identical.[5]

Let v_{ikpt} be period t's market value of creator i's k-th work published in period p ($\leq t$), defined as the sum of all consumers' willingness to pay for copies of that work during period t. Since the marginal cost of providing copies is zero, v_{ikpt} equals consumer surplus at the competitive price. Before a work is published, its market value v_{ikpt} is unknown and is defined as the following stochastic variable:

$$v_{ikpt} = \begin{cases} v(1-\delta)^{t-p} & \text{with probability} \quad \rho \\ 0 & \text{with probability} \quad 1-\rho, \end{cases}$$

where $0 < \delta < 1$, $0 < \rho < 1$ and $v > 0$.

The value of a work in the publication period ($t = p$) is v or 0 for any work. If a work's initial value is v, it depreciates at the rate of δ in every period. A work with a non-zero value is called a "longtime seller." Such a simplification of a work's value is based on the well-known fact that a great majority of copyrighted works never have much market value and that a small percentage of titles constitutes a large share of the sales of copyrighted materials (Liebowitz and Margolis, 2005).[6] For example, in the music record industry, approximately 80 percent of albums and 85 percent of single records released fail to cover their costs (Caves, 2000). Moreover, the probability of success ρ, which would be very low because of the above fact, is

[5] The model in Landes and Posner (1989) also uses this assumption, although consumers' marginal utility from an additional new work is assumed to be diminishing.

[6] Liebowitz and Margolis (2005) also demonstrate that the longevity of best-selling books is quite long (more than 85 years) based on sample titles reviewed in the *Book Review Digest* in the 1920s.

exogenously given based on the *nobody knows* property: the risk associated with any given creative product is high, and no signal has any statistical ability to predict which product will succeed (Caves, 2000). [7]

In addition to copyright length T, copyright breadth z is another parameter that controls copyright protection. The breadth parameter $0 < z \leq 1$ determines how much a creator can earn from her/his work. For a copyright-protected work with value $v_{ikpt} > 0$, consumers pay only for zv_{ikpt} of the copies because $(1-z)v_{ikpt}$ of the copies are freely available to them. Limitations on copyright, such as the fair use doctrine, make z less than 1, and z decreases as the copyright limitation is extended. Thus, during the copyright term, a creator's gross monopolistic profit from a work in a period is $\alpha z v_{ikpt}$ and the consumer surplus is $\beta z v_{ikpt} + (1-z)v_{ikpt}$, where $\alpha, \beta > 0$ and $\alpha + \beta < 1$. $(1-\alpha-\beta)zv_{ikpt}$ equals the deadweight loss during the copyright term. Once the copyright expires, all the value of v_{ikpt} goes to the consumers.

2.2. **Dynamics of the model.**

Creators start publishing new works from $t = 1$, possessing no proprietary works at the beginning of the initial period. Creator i's total profit during a period after publishing new works is given as follows: for $t = 1$,

$$\pi_{i1} = \alpha z \sum_{k=1}^{K_{i1}} v_{ik11} - e(K_{i1}),$$

and for $t \geq 2$,

$$\pi_{it} = \alpha z \left(\sum_{k=1}^{K_{it}} v_{iktt} + \sum_{p=1}^{t-1} \sum_{k=1}^{K_{ip}} 1[t-p<T] v_{ikpt} \right) - e(K_{it}),$$

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[7] This assumption largely simplifies the dynamic process but can be very strong because popular creators' probability of success in creating new works will be affected by their previous hits. However, the assumption based on the *nobody knows* would not be decisive in the simulation results by the specification of expression cost explained in the next subsection, where a creator having more longtime sellers has lower expression cost and can create more new works than others. Thus, if a creator succeeds in having a longtime seller in a period, her/his likelihood of having another longtime seller in the next period increases compared to creators without a longtime seller.

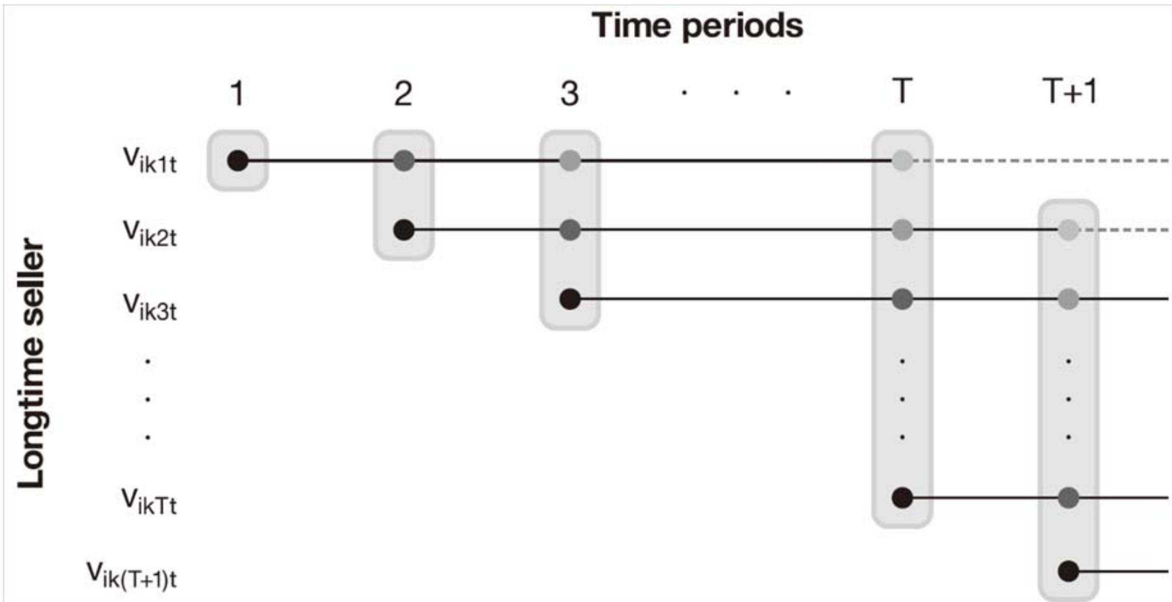

FIGURE 1. Revenue dynamics

where $1[t-p<T]$ is the indicator function taking 1 if $t-p<T$ and 0 otherwise, and $e(K_{it})$ is creator i's cost of creating K_{it} new works in period t (the expression cost), with $e'(K_{it})>0$ and $e''(K_{it})>0$.

Figure 1 depicts the dynamics of creator i's revenue. For explanatory purposes, it is assumed that creator i succeeds in creating just one longtime seller (k-th work) every period, which is depicted on the vertical axis. The dots in the figure depict a work's revenue in each period, and the color fading over different periods depicts decreases in revenue due to the depreciation of the work's value. From $t=1$ to T, each period's total revenue, which is shown by the gray square, keeps accumulating. After the copyright expires, a work does not earn its creator revenue. For example, the longtime seller published in $t=1$ (v_{ik1t}) stops making revenue for its creator after $t=T$. However, it produces consumer surplus as a public domain work from $t=T+1$.

The expression cost $e(K_{it})$, which creator i has to incur before publication, is affected by the stock of past works, the inputs for the creation of new works. The expression cost decreases when a larger part of the stock is freely available and increases otherwise. The reason is that when other creators' proprietary works are not freely available, a creator has to pay licensing fees to use those works or must invent a new expression if she/he does not use those works.

The value of past works used as inputs in new works at the beginning of period $t \geq 2$ are categorized into the following three types:

(1) Creator i's own proprietary works

$$C_{it}^{OP} \equiv \sum_{p=1}^{t-1} \sum_{k=1}^{K_{ip}} 1[t-p<T] v_{ikpt},$$

(2) All creators' proprietary works

$$C_{t}^{AP} \equiv \sum_{p=1}^{t-1} \sum_{i=1}^{N_p} \sum_{k=1}^{K_{ip}} 1[t-p<T] v_{ikpt},$$

and (3) Public domain works

$$C_{t}^{PD} \equiv \sum_{p=1}^{t-1} \sum_{i=1}^{N_p} \sum_{k=1}^{K_{ip}} 1[t-p \geq T] v_{ikpt} + (1-\delta)^t C_0^{PD},$$

where $C_0^{PD} > 0$ is the value of public domain works that exist before the initial period, which is given exogenously. Then, the expression cost is specified as the following: for $t = 1$,

$$e(K_{i1}) = \theta \left\{ \frac{1}{(1-\delta) C_0^{PD}} \right\} K_{i1}^2,$$

and for $t \geq 2$,

$$e(K_{it}) = \theta \left\{ \frac{1 + z\left(C_t^{AP} - C_{it}^{OP}\right)}{C_t^{PD} + z C_{it}^{OP} + (1-z)\left(C_t^{AP} - C_{it}^{OP}\right)} \right\} K_{it}^2,$$

where $\theta > 0$. For some types of works such as movies, copyright clearances are important costs, but for other types of works, ideas or styles of other works, which are not protected by copyright, may be sufficient as inputs. The parameter θ represents such differences in dependencies on other copyrighted works.

Creator i's expression cost decreases as the extent of freely available past works (C_t^{PD} and $(1-z)\left(C_t^{AP} - C_{it}^{OP}\right)$) increases. Moreover, the expression cost varies by creators. Creators possessing a large number of longtime sellers (C_{it}^{OP}) have cost advantages over others.

The effects of changes in copyright length and breadth on the expression cost also vary by creator. For example, the effect of a change in breadth z on creator i's expression cost ($t \geq 2$),

$$\frac{\partial e(K_{it})}{\partial z} = \theta \left[\frac{C_t^{PD}\left(C_t^{AP} - C_{it}^{OP}\right) + \left(C_t^{AP} - C_{it}^{OP}\right)^2 + C_t^{AP} - 2C_{it}^{OP}}{\left\{C_t^{PD} + zC_{it}^{OP} + (1-z)\left(C_t^{AP} - C_{it}^{OP}\right)\right\}^2} \right] K_{it}^2,$$

is positive when, for example, $C_t^{AP} > 2C_{it}^{OP}$ and negative when, for example, $C_t^{AP} = C_{it}^{OP}$. The parameter θ plays an important role in determining the extent of the effects of changes in copyright length and breadth. Landes and Posner (1989) predict that if the derivative of the expression cost with respect to copyright breadth is larger, which is assumed to be positive, the optimal level of protection will be lower. Thus, a narrower copyright can be more desirable for works such as documentary films and derivative works, which use other creators' works extensively, than for works that depend less on others' creations. In the following analysis, the effects of changes in protection levels are examined under different levels of θ.

In each period t, after the values of new works and creators' profits are determined, a (real-world) constraint is placed on creators: each creator's total profit accumulated from the initial period $\sum_{s=1}^{t} \pi_{is}$, where the interest rate is set to zero for simplicity, must remain non-negative. Otherwise, a creator is considered to be bankrupt. Such a creator, whose accumulated profit becomes negative in period t, exits the market, stops publishing new works, and no longer provides copies of all past proprietary works after t. Furthermore, it is assumed that an exiting creator neither transfers the copyrights of all proprietary works to other creators nor donates the copyrighted works to the public domain. Although copies of bankrupt creators' works are not provided to consumers during their copyright terms, those works affect the expression cost until their copyrights expire. Thus, in calculating the expression cost $e(K_{it})$ in period t, the number of past works' creators N_p ($p \leq t-1$) includes all creators who exited by the end of period p. Although this assumption is for simplicity, it imitates the real world "orphan works" problem.[8] Even during the copyright term, $(1-z)$ of those orphan works' values are available to creators and consumers, and they become fully available after their copyrights expire.

In addition to the exit of creators, the model also incorporates new entries. The number of new creators who enter in period $t+1$ is assumed to be a stochastic variable whose mean depends on the value of the stock of freely available past works so that new entrants are likely to increase if the value of public domain works increases and a freely available part of proprietary works expands. The distribution of new entries in $t+1$ is specified as a Poisson distribution whose mean is given as $\lambda \ln \left\{\mu + (1-z)C_t^{AP} + C_t^{PD}\right\}$, where $\lambda, \mu > 0$. [9]

Finally, the desirability of different copyright designs is compared on the basis of social welfare in period t, w_t. This is defined as the sum of creators' total profits from all protected works and consumers' surpluses from all available works minus the costs of creating new works in that period. Let $j = 1, ..., \tilde{N}_t$ denote the creators who survived in period $t-1$ plus new entries in period t, and $i = 1, ..., N_t$ denote all creators including those gone bankrupt by period t. Then, w_t is defined as

$$w_t = \sum_{p=1}^{t} \sum_{j=1}^{\tilde{N}_t} \sum_{k=1}^{K_{jp}} 1[t-p<T](\alpha+\beta)zv_{jkpt}$$

[8]For the orphan works problem, see, for example, the report by the US Copyright Office "Orphan Works and Mass Digitization: A Report of the Register of Copyrights in June 2015" (available at http://www.copyright.gov/orphan/, last accessed on May 30, 2017). In this report, an orphan work is defined as any original work of authorship for which a good faith prospective user cannot readily identify and/or locate the copyright owner(s) in a situation where permission from the copyright owner(s) is necessary as a matter of law.

[9]Under the assumptions on bankruptcy and exit explained above, which are for simplifying a creator's decision problem as explained in the next subsection, an entrant who fails to create a longtime seller in her/his first period exits immediately. This assumption can be too strong because in reality, many new creators persist in establishing themselves as professionals even if they commercially fail. According to Caves (2000), "although starving artists are numerous, starved artists are not." However, the assumption would not be decisive in the simulation results. If creators with negative profits stay in the model, their impacts on social welfare will be limited because they are less likely to succeed in creating longtime sellers due to the relatively high expression costs.

$$+\sum_{p=1}^{t}\sum_{i=1}^{N_p}\sum_{k=1}^{K_{ip}}\{1[t-p<T](1-z)v_{ikpt}+1[t-p\geq T]v_{ikpt}\}-\sum_{j=1}^{\tilde{N}_t}e(K_{jt}),$$

where the first, second, and third lines correspond to the total surplus of all commercially available proprietary works, consumers' surpluses of the freely available part of all protected works and public domain works, and the cost of creating new works in period t, respectively.

2.3. **Decision-making on the number of publications.** The last remaining part of the model is a creator's decision-making regarding the number of publications in each period. In the literature on the optimal duration of intellectual property law, the conventional assumption about the right holder's decision is that she/he maximizes the discounted sum of future expected profits during the term. Following this conventional assumption, a creator's objective function in period $t = p$ is

$$\alpha z E\left[\sum_{t=p}^{p-1+T}\sum_{k=1}^{K_{it}}(1-\epsilon)^{t-p}v_{ikpt}\right]-e(K_{ip}),$$

where ϵ is the discount rate.

In this study, it is assumed that a creator places an extremely high value on the current profit setting discount rate $\epsilon = 1$, where $0^0 \equiv 1$. Therefore, a creator's decision problem is formulated as a series of the following static optimizations: creator i determines the number of new works to be produced at the beginning of period t to maximize the expected profit from new works during *that* period,

$$\alpha z E\left[\sum_{k=1}^{K_{it}}v_{iktt}\right]-e(K_{it}).$$

This assumption, which seems to be an excessively simplifying one, would be harmless for examining the effects of different copyright designs on social welfare for the following reasons. First, the assumption that a creator highly values the current period's profit is realistic to some extent for creative industries. Individual writers or artists may want to increase their works if the copyright term is extended and their expected future profits increase slightly, as pointed out by Liebowitz and Margolis (2005). However, "gatekeepers," intermediaries such as publishers or record labels, who have to incur high fixed costs to publish new works regardless of their success or failure, may not. For example, Caves (2000) states that the chances of creators being accepted by gatekeepers are small, by referring to the statement of the president of the publisher Doubleday that three or four of the 10,000 submissions received "over the transom" each year were accepted. Moreover, although gatekeepers usually formulate business plans based on multi-year cash-flow projections, the duration is much shorter than the copyright term, and thus the above single-period projection assumption does not affect the analysis of copyright length.

Second, the above assumption would be necessary for creators to survive in this model because of the *nobody knows* property and exit condition. Since many new works can have zero value and the expression cost is determined by the number of works, regardless of their success or failure, producing a large number of new works in anticipation of future revenues raises the risk of negative profit and exit from the market. For example, at $\rho = 0.2$, the probability that the number of successes is less than the mean is 0.38 for $K_{it} = 10$ and 0.46 for $K_{it} = 100$. Evaluating the investment return by using only single-period revenue and producing a relatively small number of new works thus mitigates the risk of going bankrupt.[10]

Finally, the copyright term extension can have a positive effect on new works' creation through a decrease in expression cost even without an increase in the sum of discounted future profits. If a creator possesses a large number of longtime sellers compared with other creators, a longer copyright term increases the duration of the creator's cost advantage. Moreover, even if such a creator's profit becomes negative, she/he can survive longer and create more new works under a longer copyright term.

[10] In the numerical simulation below, when the discounted sum of future expected revenues during the copyright term was used for creators' maximization problems, no creator survived the first period under the discount rate, for example, 30 percent, which is much higher than normal.

Creator i's total profit from K_{it} new works during period t expected at the beginning of the period (before publication) is

$$E[\pi_{it}^{new}(K_{it})] = \alpha z E\left[\sum_{k=1}^{K_{it}} v_{iktt}\right] - e(K_{it})$$
$$= \alpha z \rho K_{it} v - e(K_{it}).$$

Let $\tilde{K}_{it}$ be the number of creator i's new works in period t defined as a real number. By the above argument, in each period t, creator i solves

$$\max_{\tilde{K}_{it}} E[\pi_{it}^{new}(\tilde{K}_{it})].$$

The solution $\tilde{K}_{it}^*$ is given for $t = 1$,

$$\tilde{K}_{i1}^* = \frac{\alpha z \rho v}{2\theta} \left\{ \frac{1}{(1-\delta)C_0^{PD}} \right\}^{-1},$$

and for $t \geq 2$,

$$\tilde{K}_{it}^* = \frac{\alpha z \rho v}{2\theta} \left\{ \frac{1 + z\left(C_t^{AP} - C_t^{OP}\right)}{C_t^{PD} + zC_{it}^{OP} + (1-z)\left(C_t^{AP} - C_{it}^{OP}\right)} \right\}^{-1}.$$

Then, the optimal number of creator i's new works in period t, K_{it}^*, is defined as the smallest integer larger than or equal to $\tilde{K}_{it}^*$, i.e., $K_{it}^* \equiv \lceil \tilde{K}_{it}^* \rceil$. After publishing K_{it}^* new works, profit π_{it} is determined. As noted above, if $\sum_{s=1}^{t} \pi_{is} < 0$, creator i stops creating new works and also stops providing copies of all proprietary works from period $t + 1$.

2.4. **Setting for the numerical analysis.** Although creators solve static problems in every period, their expression costs vary stochastically over time depending on the number of long-time sellers successfully produced by each creator and whether these works are protected, which is determined by their publication periods and the length of the copyright term. The model is hard to deal with analytically because the time, or "when" creators optimize, affects their decision-making.[11] Therefore, the effects of changes in the two copyright design

[11]Therefore, the model does not satisfy stationarity, which is vital to the dynamic programming approach.

parameters T and z on the sequence of social welfare w_t are examined by using numerical simulation.

Each simulation runs for 200 periods ($t = 1$ to 200) and is repeated 100 times. For each of the two copyright policy parameters, T and z, four values are given. The benchmark is perfect protection: $T = 200$ and $z = 1$. Then, each parameter is reduced by half: $T = 100, 50, 25$ and $z = 0.5, 0.25, 0.125$. Thus, there are 16 different designs of (T, z) combinations. Although changes in the parameter values are coarse, the parameter set includes a broad range of copyright designs, from perfect protection ($T = 200, z = 1$) to highly limited protection ($T = 25, z = 0.125$).

Moreover, these 16 designs of copyright law are examined under different values of θ, the expression cost parameter that determines sensitivity to policy changes, and δ, the depreciation rate of a longtime seller. These parameters can have determining effects on the simulation results. The expression cost parameter θ is determinative of the effects of changes in both copyright length and breadth, as explained earlier. The depreciation rate of a work's value can also determine the effects of changes in copyright length and breadth because it affects the value of longtime sellers after their publications and thus the expression cost. For example, if the depreciation rate is high, extending or shortening the length when it is already very long would have little effect on the expression cost because longtime sellers would have little value when they enter the public domain. With a high depreciation rate, changes in copyright breadth would also have limited impact on the expression cost because the value of proprietary works quickly approaches zero. Each of θ and δ is given two values, and thus, the 16 different copyright designs are examined under four combinations of expression costs and depreciation rates.

The values of these parameters are shown in Table 1. The values of δ are chosen to be close to the estimated annual depreciation rate of copyright materials by Landes and Posner (2003). Based on the data on renewals and registrations of the US Copyright Office, they found the

TABLE 1. Copyright design, expression cost, and depreciation rate parameters

Parameter	Values
T (length)	200, 100, 50, 25
z (breadth)	1, 0.5, 0.25, 0.125
θ (expression cost parameter)	0.5, 0.1
δ (depreciation rate)	0.08, 0.04

TABLE 2. Other simulation parameters

Parameter	Definition	Value
ρ	Probability of success that a work is a longtime seller	0.2
α	Ratio of a creator's profit to a work's value	0.5
β	Ratio of consumer surplus to a work's value	0.25
μ	A parameter for new entries	1.5
λ	A parameter for new entries	0.005
N_1	Number of creators in the initial period	5
v	The initial value of a longtime seller	20
C_0^{PD}	Value of public domain works before the initial period	20

overall average to be 8.3 percent. They also estimated category-specific depreciation rates for books (9 percent), music (4 percent), and graphic arts (14 percent). For another value of the depreciation rate, the lowest among these three, which is about half of the overall average, is chosen.

The values of all other simulation parameters are shown in Table 2. The probability of success that a work is a longtime seller is set very low based on the specific property of creative industries explained in Section 2.1. The parameters for creators' and consumers' surpluses, α and β, are determined by the assumption that the demand curve is linear.[12] Other parameters are arbitrary and set at the same values for all the simulations, conjecturing that they are determinative of the level of social welfare but may not be so determinative of the effects of different copyright designs on social welfare compared to the expression cost and depreciation rate parameters.

[12]Let the (inverse) demand function of a work's copies be $q = a - bx$, where q is the price and x is the quantity. With zero marginal cost, the total surplus under the competitive price is $\frac{a^2}{2b}$. During a copyright term, a creator's monopolistic profit is $\frac{a^2}{4b}$, consumer surplus is $\frac{a^2}{8b}$, and the dead weight loss is $\frac{a^2}{8b}$.

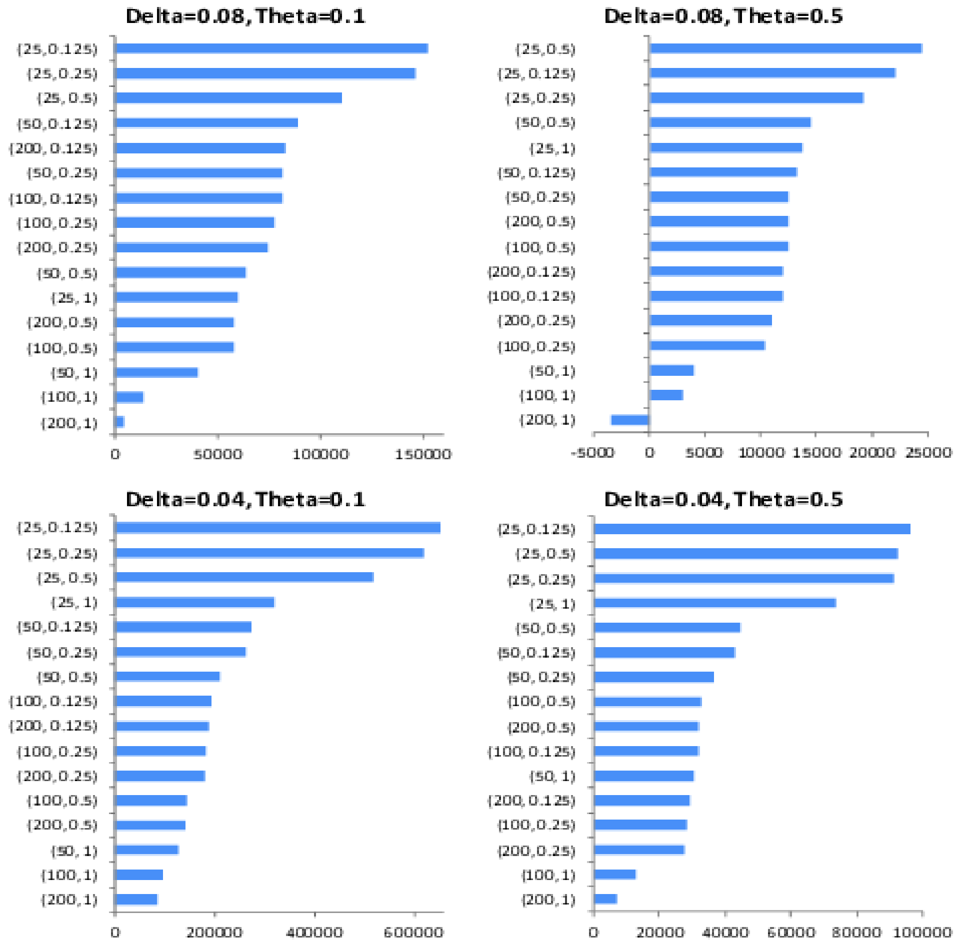

Figure 2. Average total social welfare

3. Simulation results

First, to briefly compare the performance of each copyright design, the values of social welfare w_t over 200 periods are simply added for each simulation run (termed "total social welfare" in the following), and the average of 100 simulation runs is taken for each copyright design, which is denoted by the vector (T, z). Figure 2 depicts the results under the four settings of δ (depreciation rate) and θ (expression cost) in descending order from the top.

The results indicate that long and broad copyright designs tend to produce low social welfare whereas short and narrow copyright designs produce high social welfare. Under all the four settings, the design $(200, 1)$, perfect protection, is the lowest, and $(100, 1)$ is the second-lowest. On the other hand, the design $(25, 0.125)$, the most limited protection, is the highest, and $(25, 0.25)$ is the second-highest except for the setting $\delta = 0.08$ and $\theta = 0.5$, which is a little puzzling because the design $(25, 0.5)$ is the highest, followed by $(25, 0.125)$ and $(25, 0.25)$.

In the middle range, the pattern is less clear, and a substitutional relationship between length and breadth is observed among some designs. For example, under the setting $\delta = 0.08$ and $\theta = 0.1$, the designs $(50, 0.25)$ and $(100, 0.125)$ have a very close level of total social welfare, and under the setting $\delta = 0.04$ and $\theta = 0.1$, the designs $(200, 0.125)$ and $(100, 0.25)$ have a very close level of total social welfare. Overall, social welfare appears to be higher the shorter the copyright term is. Even if the value of breadth is the maximum ($z = 1$), the level of total social welfare is relatively high when the copyright term is the shortest ($T = 25$), especially for a low depreciation rate ($\delta = 0.04$).

The differences among the 16 copyright designs can be more clearly observed with changes in w_t over 200 periods. Figures 3 to 6 depict the average w_t of the 100 simulation runs in each period under the four settings of δ and θ, with the graphs separated by the four values of copyright length T.

Figure 3 shows the results for the setting $\delta = 0.08$, $\theta = 0.1$. For all the four values of length, breadth seems to determine the pattern of the time series. With more breadth, a higher level of social welfare in the earlier periods declines rapidly and stays at a lower level. For designs $(100, 1)$ and $(200, 1)$, social welfare declines to become negative in the latter periods.[13] On the other hand, with less breadth, an increase and decrease in social welfare in the early periods

[13] After becoming negative, social welfare goes back to zero for both designs, which means that the number of creators decreases to zero. The difference between $T = 100$ and 200 is that negative social welfare continues in the latter periods for $T = 200$. The reason is that creators are more likely to survive even when their profits in a period are negative for $T = 200$ because longtime sellers never enter the public domain and keep generating revenues.

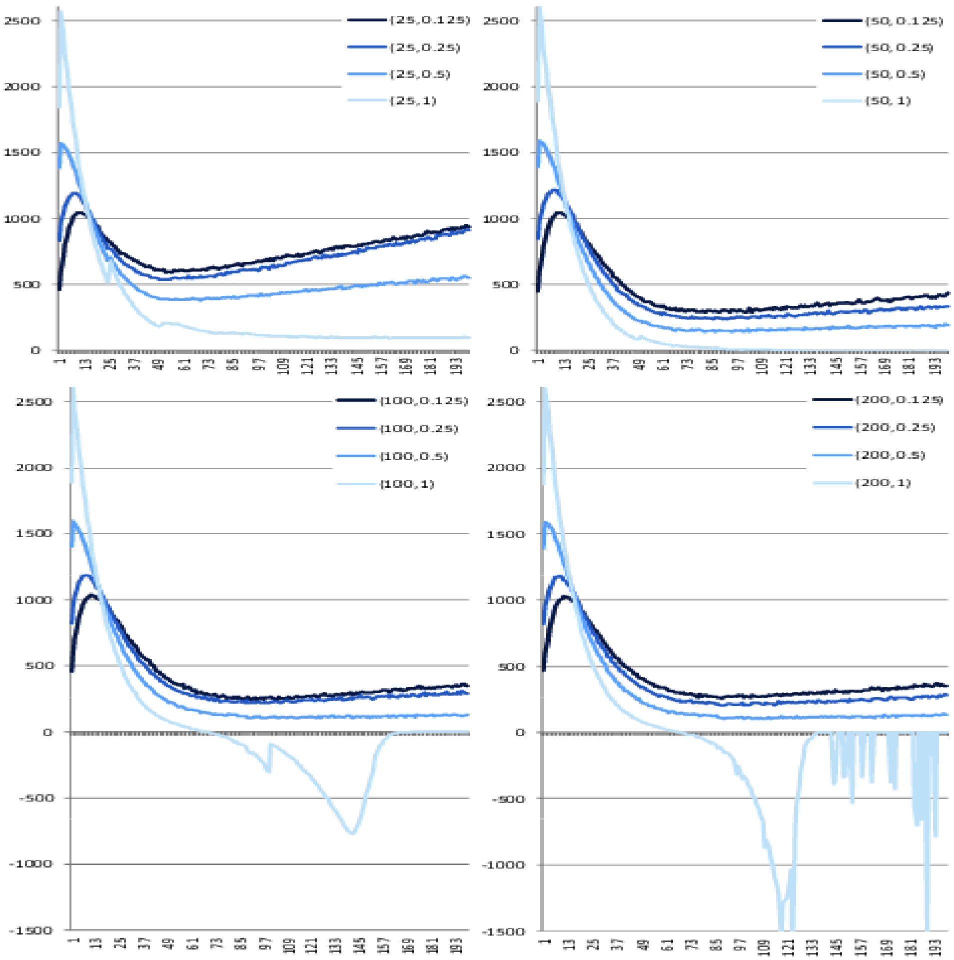

FIGURE 3. Average social welfare in each period: $\delta = 0.08, \theta = 0.1$

is relatively moderate, and social welfare stays at higher level in the latter periods. Moreover, as the length shortens, social welfare in the latter periods grows more rapidly, although the difference in social welfare growth is not obvious between $T = 200$ and 100.

Similar patterns are observed for the setting $\delta = 0.08$, $\theta = 0.5$ (Figure 4), although the differences in social welfare growth in the latter periods are much smaller than in the setting with $\theta = 0.1$, the low expression cost case. A puzzling aspect of Figure 2, which is that total social welfare for the design $(25, 0.5)$ is the highest, can be explained by these patterns. The

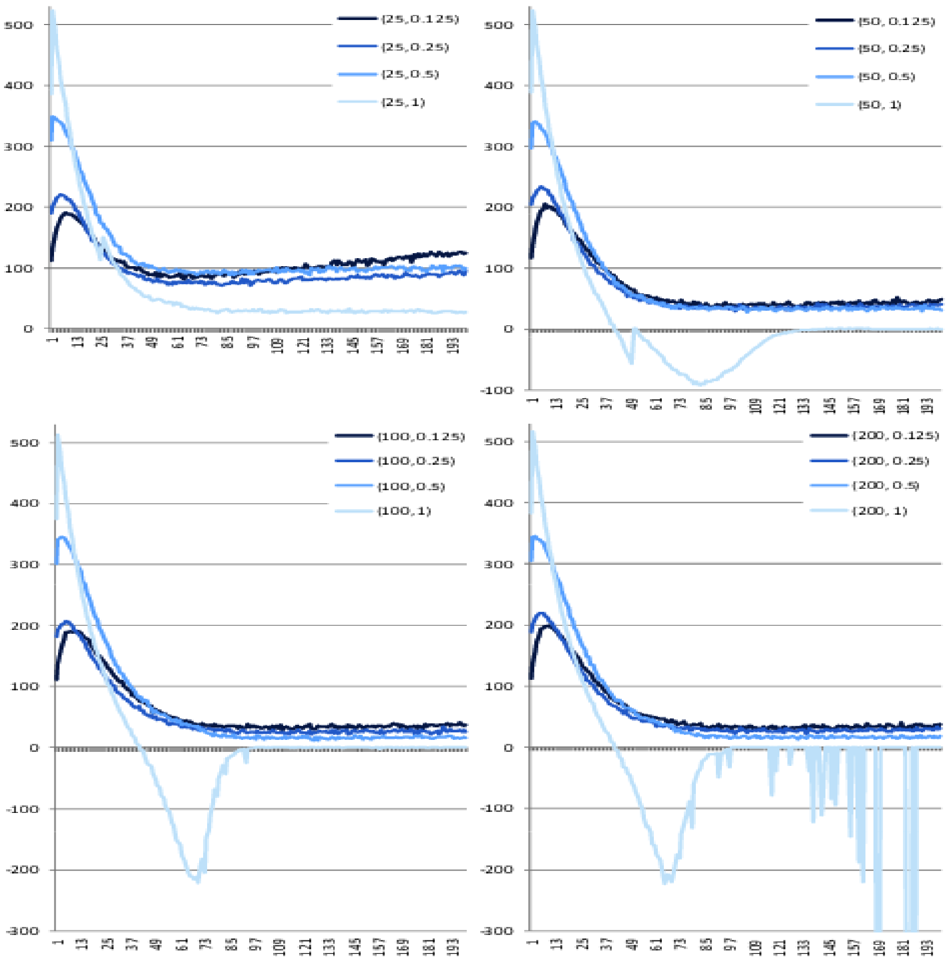

FIGURE 4. Average social welfare in each period: $\delta = 0.08, \theta = 0.5$

social welfare in the earlier periods is higher when the breadth is greater, but the growth of social welfare in the latter periods is small even for the least breadth $z = 0.125$. Therefore, total social welfare is lower for $z = 0.125$ than for $z = 0.5$.

A noteworthy difference is observed between the low and high expression cost cases when the length $T = 25$. For the low expression case ($\theta = 0.1$), the upward shift of social welfare in the latter periods appears to be large when the breadth z decreases from 0.5 to 0.25, while the shift when z decreases from 0.25 to 0.125 is only marginal (the upper left graph in Figure

3). From the results, it can be conjectured that when the expression cost is low, decreasing the breadth z to less than 0.125 may not further improve social welfare and thus the optimal breadth can be very close to 0.125. On the other hand, for the high expression cost case ($\theta = 0.5$), no upward shift in the latter periods is observed when the breadth z decreases from 0.5 to 0.25, but when z decreases from 0.25 to 0.125, there is a relatively large upward shift in the latter periods (the upper left graph in Figure 4). Thus, it can be conjectured that when the expression cost is high, decreasing the breadth z to less than 0.125 might further increase social welfare and thus the optimal breadth could be less than 0.125. The difference in the optimal breadth between the low and high expression cost cases may be small, but the above conjectures accord with the result of Landes and Posner (1989) that as the derivative of the expression cost with respect to copyright breadth increases, the optimal level of protection will fall.

This conjecture can be supported by the following additional simulation runs with the breadth parameter z set to be less than 0.125 with $T = 25$, whose results are depicted in Figure 5. For $\theta = 0.1$, the narrower breadth ($z = 0.105, 0.085$) does not seem to improve social welfare, and thus, $z = 0.125$ would (at least locally) maximize social welfare. On the other hand, for $\theta = 0.5$, social welfare improves under $z = 0.085$. Although the difference is marginal, the optimal breadth is narrower when the expression cost is more responsive to a change in copyright breadth.

When the depreciation rate of works is low ($\delta = 0.04$), the differences in social welfare's growth patterns among the four length parameters are more obvious: social welfare grows more when the length is shorter (Figure 6 for $\theta = 0.1$ and Figure 7 for $\theta = 0.5$). When the depreciation rate is lower, the effects of shorter copyright length on social welfare are more significant because the values of longtime sellers remain relatively high when they enter the public domain. Thus, increases in the level of social welfare when the length decreases are much larger than in the high depreciation case.

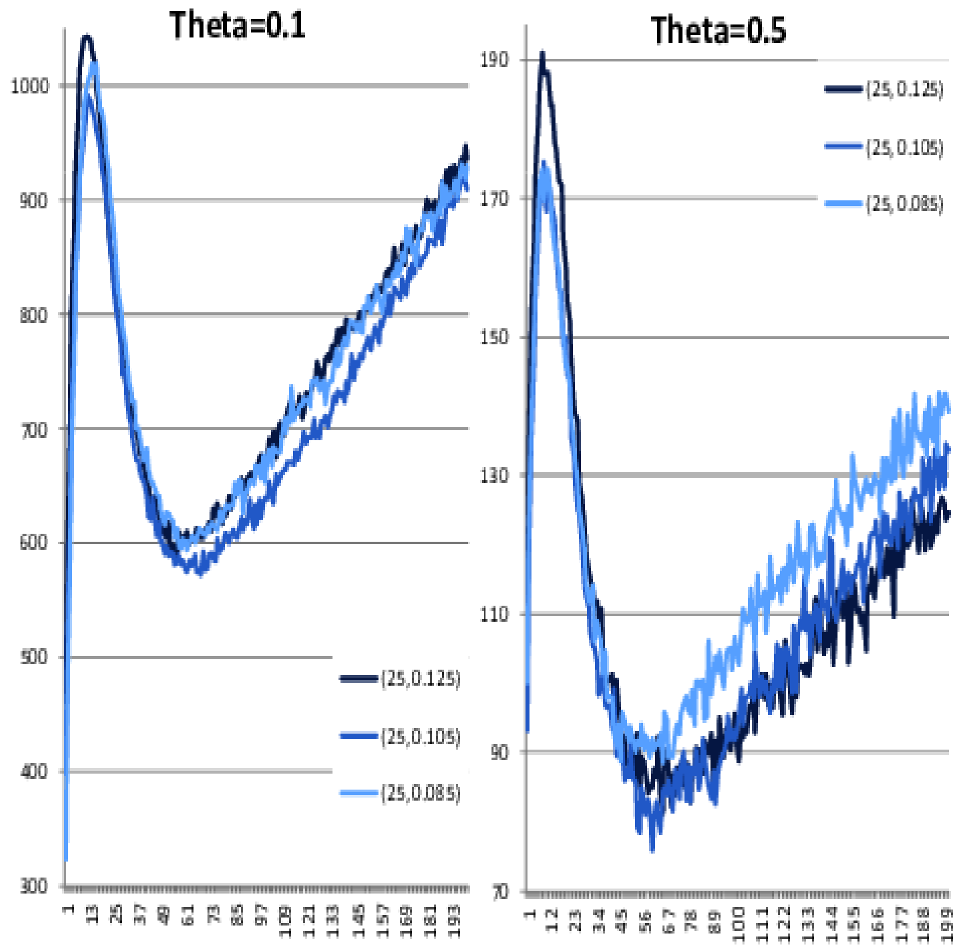

FIGURE 5. Additional simulation runs: $\delta = 0.08$

Finally, differences in the upward shift of social welfare between from $z = 0.5$ and from $z = 0.25$ are also similar to those of the high depreciation rate case. Large shifts from $z = 0.5$ to 0.25 and small shifts from $z = 0.25$ to 0.125 are clearly observed for all the four lengths in the low expression cost case (Figure 6), with the opposite pattern appearing for the length $T = 25, 50$, and 100 in the high expression cost case (Figure 7). Thus, the same conjecture as in the high depreciation case ($\delta = 0.08$), which accords with the result of Landes and Posner (1989), could be made. However, contrary to the high depreciation case, the low

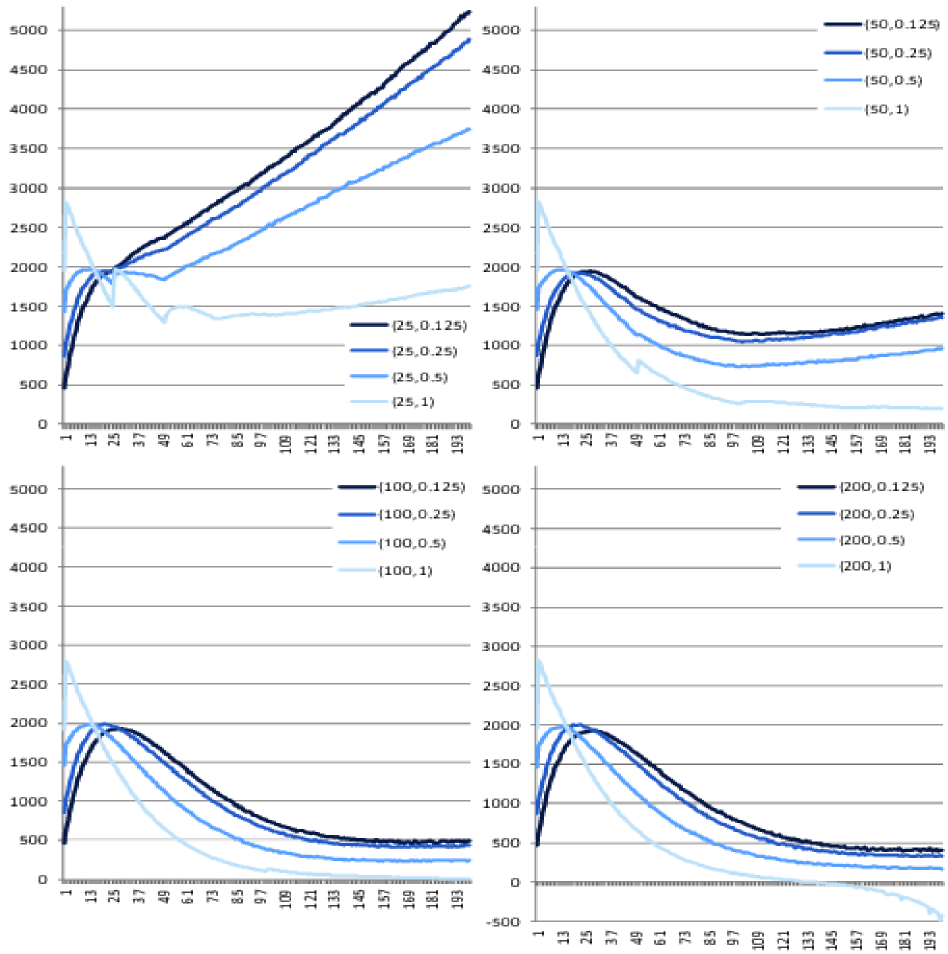

FIGURE 6. Average social welfare in each period: $\delta = 0.04, \theta = 0.1$

depreciation case's additional simulation runs using the same breadth parameters as in Figure 5 ($z = 0.105, 0.085$) show that narrowing breadth to less than $z = 0.125$ may not improve social welfare for both $\theta = 0.1$ and 0.5 (Figure 8).

A possible reason for the different results between the two depreciation parameters is the contribution of freely available works to the expression cost. With the low depreciation rate, a longtime seller stays valuable longer and thus can have larger effects on the expression cost for longer periods. Thus, when the depreciation rate is low, the difference in the two expression

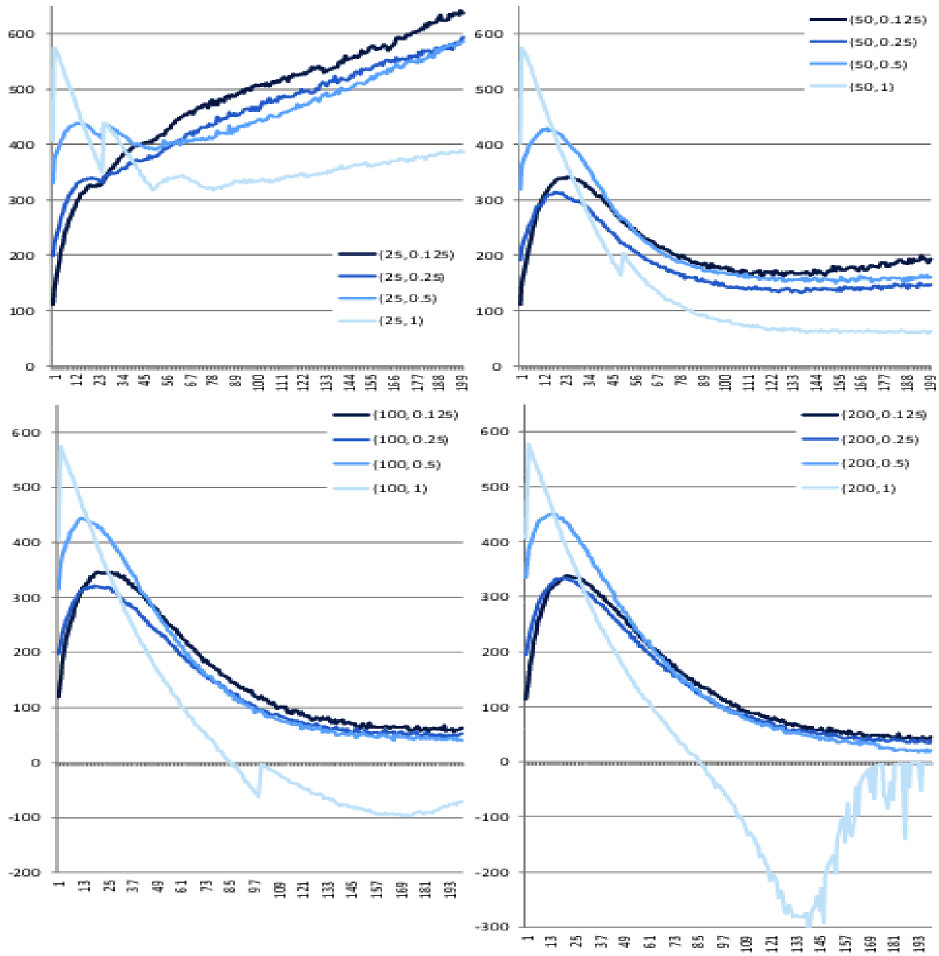

FIGURE 7. Average social welfare in each period: $\delta = 0.04, \theta = 0.5$

cost parameters (θ) have relatively little effect on changes in the level of expression cost caused by an increase in the freely available part of proprietary works under narrower breadth. When the depreciation rate is high, on the other hand, the values of longtime sellers more quickly approach zero, and thus the effects of narrowing the breadth would be more responsive to the expression cost parameter.

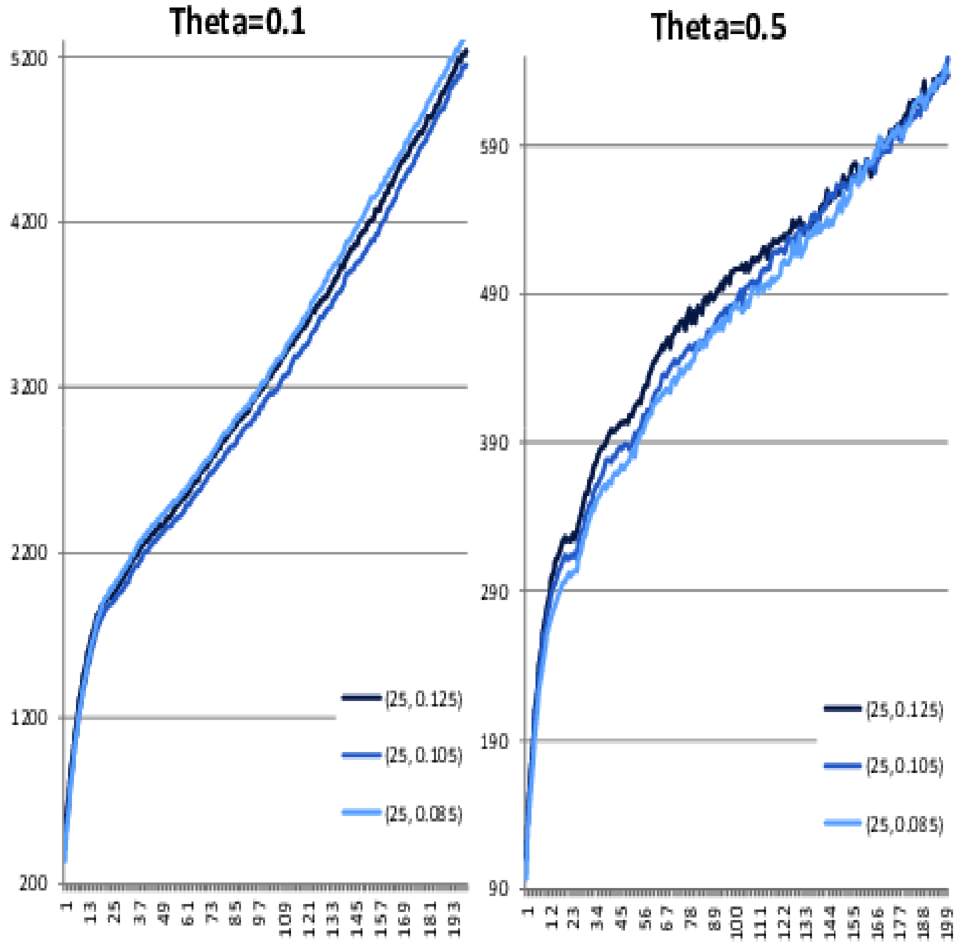

FIGURE 8. Additional simulation runs: $\delta = 0.04$

4. Discussion

Copyright protection is important for the provision of many commercial works, and few people would argue against it. However, there has been disagreement on how copyright law should be designed. Previous studies have focused either on the length or on the breadth of protection. This study integrates them into a theoretical framework, incorporating the specific properties of creative industries. Another feature of the model is the cumulative process of content creation: past works are inputs of new works, and the cost of creating new works decreases as past works become more freely available, which resembles the cumulative innovation models of optimal patent design literature. The cost of this modeling approach is that the analytical solution for the optimal design is hard to obtain.

The simulation results imply that social welfare can be maximized by a short and narrow copyright, regardless of the level of expression cost and the depreciation rate of a work's value. Furthermore, in the long run, a short copyright can have more significant effects on social welfare than a narrow copyright because social welfare grows faster if the copyright term is shorter. Under a long copyright, on the other hand, the growth of social welfare would be suppressed even if the breadth is narrow and could even become negative if the breadth is broad.

The reason for the importance of a short length would be that a shorter copyright moves valuable works into the public domain faster, as Lessig (2004) argues. An increase in the number of public domain works decreases the expression costs of all creators and can boost the publication of new works. Such effects of public domain works are larger if the copyright term is shorter because proprietary works enter the public domain when their values are higher. In contrast, when the length is greater and the values of public domain works continue to decrease, the social welfare growth can be suppressed. Therefore, a long copyright, which is favorable only to particular creators possessing a large number of valuable proprietary works, is surpassed by a short copyright, which is favorable to all creators, including potential new entrants.

The results differ from those of the optimal patent design literature for cumulative innovation, which states that the same initial investment incentive can be achieved under a short broad patent or a long narrow patent (Rockett, 2010). Unlike technological innovation, past and future creative works do not necessarily compete with each other, even when the latter borrows both the idea and expression of the former (the *infinite variety* property). This makes imitation socially desirable because it efficiently boosts the variety of titles available to consumers. A real-world example of such an argument is Walt Disney's 1928 cartoon *Steamboat Willie*, which was created as a direct parody of the silent film *Steamboat Bill, Jr.* and which also brought Mickey Mouse to life (Lessig, 2004). A short and narrow copyright can be better than a long and broad copyright because the cost of creation more significantly influences publication activities than the expected revenue does when the latter is highly uncertain (the *nobody knows* property).

In reality, however, drastically shortening the current copyright terms would be almost impossible for countries ratifying the Berne Convention, an international agreement governing copyright ruling that the protection must last for at least the life of the author plus 50 years. Changing copyright length slightly from the current one, whether increasing or decreasing it, might have only limited effects on social welfare: since the length is already substantial, most works with an average depreciation rate, which is estimated at about 8 percent by Landes and Posner (2003), would enter the public domain when their values are close to zero. If so, breadth is the only tool available to improve social welfare. Some copyright law scholars argue that the digital age requires new user privileges that grant users dramatically increased access to protected works compared with the fair use doctrine (Parchomovsky and Weiser, 2010). Although such a policy change might have limited effects on improving social welfare under a very long copyright term, it might be necessary to avoid a decrease in social welfare.

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