FOREVER MINUS A DAY? SOME THEORY AND EMPIRICS OF OPTIMAL COPYRIGHT

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Abstract. The optimal level for copyright has been a matter for extensive debate over the last decade. This paper contributes several new results on this issue divided into two parts. In the first, a parsimonious theoretical model is used to prove several novel propositions about the optimal level of protection. Specifically, we demonstrate that (a) optimal copyright falls as the costs of production go down (for example as a result of digitization) and that (b) the optimal level of copyright will, in general, fall over time. The second part of the paper focuses on the specific case of copyright term. Using a simple model we characterise optimal term as a function of a few key parameters. We estimate this function using a combination of new and existing data on recordings and books and find an optimal term of around fourteen years. This is substantially shorter than any current copyright term and implies that existing copyright terms are non-optimal.

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1. Introduction

The optimal level of copyright, and in particular, copyright term have been matters of some importance to policymakers over the last decade. For example, in 1998 the United States extended the length of copyright from life plus 50 to life plus 70 years, applying this extension equally to existing and future work.[1] More recently in the EU generally, and particularly in the UK, there has been an extensive debate over whether to extend the term of copyright in sound recordings.

Using a parsimonious framework based on those already in the existing literature (see e.g. Landes and Posner (1989); Watt (2000)) we analyze various questions related to the optimal level of copyright protection, deriving, under a simple set of assumptions, several novel results. In particular, we show that (a) optimal protection decreases as the cost of production falls (and vice-versa); and (b) the level optimal protection, in general, declines over time.

Note that we divide costs into those related to 'production', 'reproduction' and 'distribution' with the distinction between the first two being that production costs are those relating to the creation of the first instance of a work while reproduction relates to the costs of producing subsequent copies. However in this particular case we take 'production' costs to include all expenditures, fixed as well as variable, related to the creation *and* distribution of the first version of the work and all authorised reproductions thereof (these are often termed 'originals' in the literature in opposition to 'copies': unauthorised – though not necessarily illegal – reproductions of the work in question).

This first result is of particular interest because recent years have witnessed a dramatic, and permanent fall, in the costs of production of almost all types of copyrightable subject matter as a result of rapid technological advance in ICT and related fields. With the growth of the Internet costs of distribution have plummeted and will continue to do so as both the capacity and the level of uptake continue to increase. Similarly, cheaper computers, cameras, and software have had a significant impact on basic production costs

[1]It was in hearings prior to the enactment of the Copyright Term Extension Act (CTEA) that Mary Bono, widow of the musician Sonny Bono, famously referred to the proposal of Jack Valenti, president of the Motion Picture Association of America, to have copyright last for 'Forever minus a day': "Actually, Sonny wanted the term of copyright protection to last forever. I am informed by staff that such a change would violate the Constitution. . . . As you know, there is also Jack Valenti's proposal for the term to last forever less one day. Perhaps the Committee may look at that next Congress." (CR.144.H9952)

in both the low and high end market. Consequently, our result implies a reduction in the level of protection currently afforded to copyrighted works.

One caveat needs to be mentioned here. As discussed, there is a distinction to be drawn both between production and reproduction costs and between authorised and unauthorised reproduction. The move to digital reduces the both of *all* of these costs – formally, in a digital environment, there is a high degree of correlation between the reproduction costs of 'originals' and 'copies'. As a variety of authors have pointed out, a reduction in the cost of making 'copies', that is in the cost of unauthorised reproduction, may or may not necessitate an increase in the optimal level of protection – see e.g. (Johnson, 1985), (Novos and Waldman, 1984), Liebowitz (1985) and Peitz and Waelbroeck (2006). Our result, by contrast, deals with the case of a reduction in costs related to 'originals' as well as a technological change that reduces the costs of both 'originals' and 'copies'.

The second result, that optimal protection falls over time, has profound implications for policy. In most systems of law, it is extremely difficult to remove or diminish rights once they have been granted. Thus, once a given level of protection has been awarded it will be all but impossible to reduce it. However, according to our result, the optimal level of protection will decline over time. This being the case, a prudent policy-maker will need to set initial level of protection not at its optimum level but below it – perhaps well below it.

Finally, in the last section of the paper we turn to the specific case of copyright 'term' – that is, the length or duration of the copyright. Building on the framework already developed we derive a single simple equation which defines optimal copyright term as a function of the key exogenous variables: the discount rate, the rate of 'cultural decay', the supply function for creative work and the associated welfare (and deadweight-loss) associated with new works. Combining this with empirical data we are able to provide one of the first properly theoretically *and* empirically grounded estimates of optimal copyright term.[2]

[2]As Png (2006) notes, there is a lack of empirical work on copyright generally. Existing estimates of optimal term are very sparse. Boldrin and Levine (2005) calibrate a macro-oriented model and derive a figure of 7 years for optimal term in the United States. (Akerlof et al., 2002) in an examination of the US Copyright Term Extension Act argue, simply on the basis of the discount rate, that a term of life plus seventy years must be too long. By constrast, Liebowitz and Margolis (2005), argue that the current US term of life plus 70 years might not be too long – though they too do not provide an explicit model.

2. A Brief Note on Copyright Law

The reader should be aware that the term of copyright varies both across jurisdictions and across types of protected subject matter. The right in a recording – as opposed to the underlying composition – is considered a 'neighbouring right' and is treated differently from a normal 'copyright'. In particular, signatories to the Berne convention (and its revisions) must provide for an 'authorial' copyright with a minimal term of life plus 50 years, recordings need only be protected for 50 years from the date of publication.

Furthermore, and rather confusingly, works can sometimes be moved from one category to the other as was the case with film in the UK following the implementation of the 1995 EU Directive on 'Harmonizing the Term of Copyright Protection' (which 'harmonised' copyright term up to life plus 70 years). Prior to this UK law had treated the copyright in the film itself as a neighbouring right and therefore accorded it a 50 year term of protection. Following the implementation of the Directive, the copyright in a film became an 'authorial' copyright and subject to a term of protection of life plus 70 years.[3]

3. Framework

In this section we introduce a minimal framework but one which is still rich enough to allow the derivation of our results.

The strength of copyright (also termed the level of protection) is represented by the continuous variable S with higher values implying stronger copyright. For our purposes here it will not matter exactly what S denotes but the reader might keep in mind, as examples, the length of copyright term and the breadth of the exclusions (conversely the narrowness of the exceptions from the monopoly right that copyright affords its owner).

Many possible possible works can be produced which may be labelled by 1,2,3, ... Let $N = N(S)$ denote the total number of works produced when the strength is S.[4] Note that N may also depend on other variables such as the cost of production, the level of demand etc. however we have omitted these variable from the functional form for the time being

[3]That was not all, as Cornish and Llewelyn (2003, 10-45) note, 'the very considerable investment which goes into major film productions was held to justify a special way of measuring lives. To guard against the consequences of the director's early death, the longest life among "persons connected with the film" is taken; and these include not only the principal director but the author of the screenplay, the author of the dialogue and the composer of any specifically created film score.'

[4]Throughout we shall gloss over the fact that N is discrete and allow the differential both of N and with respect to N to exist.

for the sake of simplicity. Works are orderable: when N works are produced it is those works labelled $1, 2, 3..., N$ (i.e. we can order works by their potential net profitability).

Assumption 1. (The form of the production function for copyrightable work)

(1) At low levels of protection, increasing protection increases the production of works: $\lim_{S\to 0} N'(S) > 0$.
(2) Diminishing returns to protection: $N''(S) < 0$.
(3) (optional) Beyond some level increasing protection further reduces production: $\lim_{S\to\infty} N'(S) < 0$.[5]

Each work created generates welfare for society, and we denote by w_i the welfare generated by the i'th work. The welfare deriving from a given work (once produced) depends on the strength of copyright, so $w_i = w_i(S)$ and it is assumed that increasing copyright reduces the welfare generated from a work so $w_i'(S) < 0$.

Total welfare, denoted by $W = W(N, S)$, is then the aggregation of the welfare from each individual work. This need not be a simple sum as we wish to allow for interactions between works – for example we would expect that as there are more and more works the value of new work declines. We shall discuss this further below, but for the time being we may leave the exact form of aggregation opaque.

Assumption 2. Using subscripts to indicate partial differentials:

(1) Welfare is increasing in the number of works produced: $W_N > 0$.
(2) Keeping the number of works produced fixed, welfare is decreasing in the strength of copyright: $W_S < 0$ (this follows immediately from the assumption of diminishing welfare at the level of individual works).
(3) Diminishing marginal welfare from new works: $W_{NN} < 0$.

Since the number of works produced is itself a function of the level of copyright we may eliminate N as an argument in W and write:

$$W = W(S) = W(N(S), S)$$

[5]This assumption is based on a very similar one in Landes and Posner (1989). Unless otherwise stated this assumption will *not* be used when deriving any of the results below.

Where it is necessary to distinguish the different forms of the welfare function we shall denote this version as the 'reduced form'.

Finally before commencing on the derivation of results we require the technical assumption that all functions are continuous and at least twice continuously differentiable.

4. Results

4.1. **The Relation of the Production and Welfare Maximising Levels of Protection.**

Lemma 3. *Under assumptions 1.1 and 1.2 there exists a unique level of protection which maximizes the production of creative work. We denote this by S^p. Furthermore, EITHER there exists a finite solution to $N'(S) = 0$ and this is S^p OR no such solution exists and $S^p = \infty$. With assumption 1.3 only the first option is possible.*

Proof. By assumption 1.1 N is increasing when the level of protection is 0 (the lowest possible) thus 0 cannot be a maximum. By 1.2 if a finite maximum exists it must be unique and this maximum must be a solution of $N'(S) = 0$ (if there is such a solution then N' is negative from that solution onwards so infinity is not a solution). If no such solution exists then for all $S > 0$ we have $N'(S) > 0$ and the maximizing level of protection is infinite. □

Theorem 4. *If the level of protection which maximizes the production of copyrightable work, S^p, is finite then the optimal level of protection, S^o, is strictly less than S^p.*

Proof. If S^p is finite then $N'(S^p) = 0$ and since $N''(S) < 0$ we have $N(S) \leq 0, \forall S \geq S^p$. Marginal welfare is:

$$W'(S) = \frac{dW(S)}{dS} = \frac{dW(N(S), S)}{dS} = N_S W_N + W_S$$

Now $W_S < 0, \forall S$, so combining this with the properties of the work production function, $N(S)$, we have that:

$$\forall S \geq S^p, W'(S) < 0$$

Hence, welfare is already declining at S^p and continues to decline thereafter. Thus, the optimal, that is welfare maximizing, level of protection, S^o, must lie in the range $[0, S^p)$.

□

Remark 5. If the level of protection which maximizes the production of copyrightable work, S^p, is infinite then no immediate statement can be made as to whether the optimal level of protection, S^o, will be finite (and hence less than S^p) or infinite.[6]

From this point on we make the following assumption:

Assumption 6. The optimal level of protection is finite, and is the unique level of protection, S^o, satisfying $W'(S^o) = 0, W''(S^o) < 0$.

4.2. **Production Costs and the Optimal Level of Protection.** Let us now introduce production costs by writing write $N = (C, U, S)$ where C is a variable denoting production costs of 'originals' (authorised reproductions) and U a variable denoting the production cost of 'copies' (unauthorised reproductions) (we do not need to be specific here as to their form so these may be marginal costs or fixed costs or both).[7] We assume that:

(1) For any given level of protection as the costs of 'originals' increase (decrease) production decreases (increases): $N_C < 0$
(2) For any given level of protection as the costs of 'copies' (unauthorised reproductions) increase (decrease) production increases (decreases): $N_U > 0$
(3) The marginal impact of protection declines with lower costs: $N_{CS} > 0$

Remark 7. While the first assumption is self-evident the second is less so. One justification for it is as follows: the level of production is a function of the level of (average) profit, π, per work: $N = g(\pi)$. With diminishing returns we would expect $g'' < 0$. Profits can be broken up into income and costs, $\pi = I - C$, with the level of protection *only* affecting income and not costs. In that case we have $N_{CS} = g''\pi_S\pi_C$

[6]For example, consider a very simple multiplicative structure for total welfare of the form: $W(S) = f(N(S))w(S)$ with $f(N)$ any functional form with $f' > 0, f'' < 0$ (e.g. $N^a, a \in (0,1)$). Then taking any function $g(S)$ with $g' > 0, g'' < 0$ and defining $N(S) = g(S), w(S) = g(S)^{1-a+\epsilon}, \epsilon \in (0,a)$ we have a setup satisfying Assumptions 1 (excluding 1.3) and 2 and with $W(S) = g(S)^\epsilon$ – a welfare function whose maximising level of protection is clearly infinite.
Finally note that this does *not* require that the number of works produced be infinite, for example we could have $g(S) = 1 + K - K/(1+S)$ in which case there is a finite upper bound on the number of works produced.

[7]Note that we would usually assume that the cost of making 'copies' is itself, at least partially, a function of the level of protection. However here we prefer to keep the effect of the level of protection and of the cost of making 'copies' distinct. Thus, it is perhaps better to think of U as encapsulating copying costs as determined purely by exogenous factors such as technology.

We also need to take account of the impact of costs on welfare. To reflect this we rewrite welfare as a function of both the level of protection *and* the level of costs: $W = W(S, C, U)$. Since an increase in the costs of 'originals' reduce the producer surplus from a work, while an increase in the cost of 'copies' (keeping the number of works produced constant) reduces the deadweight loss, we have:

(1) $W_C < 0$ – welfare declines as costs rise
(2) $W_{NS} < 0$ – increasing S for a given work reduces welfare (which is why $W_S < 0$) and thus increasing the number of works increases the effect on total welfare.
(3) $W_{CS} \geq 0$ – the marginal effect of increasing protection declines as costs rise (remember W_S is negative).
(4) $W_{CN} \leq 0$ – increasing production costs reduces the marginal benefit of new work (as each new work provides less welfare).
(5) $W_U \leq 0$ – the (partial) effect on welfare of an increase in the costs of 'copies' is negative.

Lemma 8. *Take any exogenous variable X which affects the welfare function (whether directly and/or via its effect on production N). Assuming that the initial optimal level of protection is finite, if $d^2W/dXdS$ is positive then an increase (decrease) in the variable X implies an increase (decrease) in the optimal level of protection.*

Proof. Denote the initial optimum level of protection, where X is at its initial value, by S^o. Since we are a finite optimum we have that at S^o:

$$W'(S^o) = N_S W_N + W_S = 0 \tag{4.1}$$

$$W''(S^o) < 0 \tag{4.2}$$

Suppose, X now increases. Since $d^2W/dXdS$ is positive we must now have: $W'(S^o) > 0$. For small changes in X, $W''(S^o)$ is still negative and thus protection must increase to some $S^{o2} > S^o$ in order to have $W'(S^{2o}) = 0$; and S^{2o} is the new optimum level of protection. □

Let us consider first, what occurs is there is an increase (or conversely a decrease) in the costs of producing 'originals' with all other exogenous variables, including the cost of producing 'copies', unchanged. In light of the previous result we focus on $dW^2/dCdS$, we have:

$$\frac{dW}{dCdS} = \frac{d}{dC}(N_S W_N + W_S) = N_{CS} W_N + N_S W_{NN} N_C + N_S W_{NC} + W_{SN} N_C + W_{CS}$$

Now, either by prior assumption or analysis we have: $N_{CS} > 0, W_N > 0, N_S > 0, W_{NN} < 0, N_C < 0, W_S < 0, W_{CN} \leq 0, W_{NS} < 0, W_{CS} \geq 0$. Thus, four of the five terms in the equation are positive while one, $N_S W_{CN}$ is not.

This means, that we cannot unambiguously say whether an increase or decrease in the costs of 'originals' implies an increase or decrease in the level of protection. In some ways this is somewhat surprising. Increased costs reduces the number of works and reduces the deadweight loss per work from protection so we might expect that increasing protection would unambiguously improve welfare. The reason this is not necessarily so is that increased costs also reduce the welfare per work and hence while the number of works falls, which increases the marginal value of a new work, the increase in costs provides a countervailing effect (W_{CN}). As a result it is possible (though perhaps unlikely) that the reduction in welfare per work due to higher costs is so dramatic as to outweigh all the other effects which favour an increase in term. Thus, a general statement is not possible. However, we note that the following are conditions would ensure an that an unambiguously positive effect:

(1) An increase in costs C, results in an increase in the marginal value of new work: $\frac{d}{dC} W_N > 0$
(2) (Weaker) An increase in costs increases marginal benefit of protection: $\frac{d}{dC} N_S W_N > 0$

We thus have the following:

Proposition 9. *Assuming an initial finite optimal level of copyright, a reduction in the cost of 'originals' (leaving other variables unchanged) implies a reduction in the strength* *of copyright if any of the following hold (in order of weakness):*

$$\begin{aligned} \frac{d}{dC} W_N &> 0 \\ \frac{d}{dC} N_S W_N &> 0 \\ \frac{dW^2}{dCdS} &> 0 \end{aligned}$$

Let us now introduce 'technological' change explicitly as a variable T. We shall assume that T has no direct effect on welfare but only operates through its impact on the costs of 'originals' and 'copies': C and U. Then we have:

$$\frac{dW^2}{dTdS} = \frac{d}{dT}(N_S W_N + W_S) = N_{TS} W_N + N_S W_{NN} N_T + N_S W_{TN} + W_{NS} N_T + W_{TS}$$

Focusing on the effect on the output of works: $N_T = N_C C_T + N_U U_T$, the effect of technological change will be ambiguous: the first term is positive since improvements in technology reduce the costs of originals ($C_T < 0$), while the second is negative since production goes up (down) as the cost of unauthorised copying decreases (increases): $N_U > 0$. However unlike welfare, N is (easily) observable, and it seems clear that recent years has seen a substantial increase in the amount of work available. Thus, we may assume $N_T > 0$. Given this we should also have $N_{TS} < 0$ (as costs drop value of increasing protection diminishes), $W_{TS} < 0$ (welfare per work is increasing as T increases and thus negative effect of protection – deadweight losses – increases), $W_{TN} > 0$ (marginal value of new work increases as T increases). Thus, we have:

$$\frac{dW^2}{dTdS} = \text{-ve} + \text{-ve} + \text{+ve} + \text{-ve} + \text{-ve}$$

This is very similar to the situation we encountered above when looking at the costs of 'originals', C (though with signs reversed) and we have the analogous proposition:

Proposition 10. *Assuming that the optimal level of copyright is finite, technological change which reduces the cost of both 'originals' and 'copies' implies a reduction in the strength of copyright if: (a) output of work increases ($N_T > 0$) and (b) any of the following* *hold (in order of weakness):*

$$\begin{aligned} \frac{d}{dT} W_N &> 0 \\ \frac{d}{dT} N_S W_N &> 0 \\ \frac{dW^2}{dTdS} &> 0 \end{aligned}$$

Examples of such technological change are ubiquitous in recent years arising, in the main, from the move to a digital environment. While it is unclear whether these changes have reduced the distribution and production costs of 'originals' more than 'copies' – the reductions in both cases seem dramatic – it nevertheless appears that the overall level of output has risen. In this case (and assuming the second, weaker condition) the result stated in the proposition holds and we should be looking to reduce the strength of copyright.[8]

We should also note that it was assumed that decreases in the cost of unauthorised copying were unambiguously bad for the producers of copyrightable works ($N_U > 0$). However, there are at least two factors which operate in the opposite direction: first, 'copiers' still need to purchase 'originals' and thus producers of 'originals' may still be able to extract rents from 'copiers' by raising the price of originals (much in the way that the price of a first-hand car takes account of its resale value on the second-hand market);[9] second, greater dissemination of a work due to unauthorized copying may lead to increase in demand for 'originals' or for complementary goods, particularly if 'copies' and 'originals' are not perfect substitutes.[10] Clearly, consideration of these factors would only strengthen the results obtained in Proposition 10 (consider what would occur if $N_U \geq 0$). Nevertheless, given the profound uncertainty that still exists it seems prudent to stick with the straightforward, and conservative, assumption that decreases in the cost of unauthorised copying decreases the production of creative work ($N_U > 0$).

[8]One response to this might be to say that the strength of copyright has already been reduced because unauthorised copying has become easier – which acts much like a reduction in copyright itself in that the income to copyright owners goes down (and production falls) while deadweight loss are reduced. However the result above implies that, *even taking account of the reduction in the costs of unauthorised copying*, the strength of copyright should be reduced.

[9]This point was first made in relation to copyright by Liebowitz (1985).

[10]For a recent theoretical model see Peitz and Waelbroeck (2006). Empirical work, mainly centred on the impact of unauthorised file-sharing on music sales has, as yet, provided no decisive answer as to whether 'sampling' may outweigh 'substitution'. For example, Oberholzer and Strumpf (2007), find no impact of file-sharing on sales, while other work such as Blackburn (2004) finds a substantial negative one.

The conclusion of Proposition 10 is particularly interesting since, by contrast, much of the motivation for strengthening copyright in recent years, whether by extending term or by the addition of legal support for technological protection measures (TPMs) – as in the WIPO Copyright Treaty of 1996 and its subsequent translation into national laws such as the DMCA (1998) and the EUCD (2001) – has been based on the implicit assumption of the opposite result: that the move to a digital environment necessitated an increase in the strength of copyright. The main reason for this difference is that many of those advocating the strengthening of copyright have focused only on the reduction in the costs of unauthorised copies and have ignored the impact of technology on authorised production and distribution. As we have shown, such an approach omits a major part of the overall picture and may lead to entirely erroneous policy implications.

4.3. **Optimal Copyright in a Dynamic Setting.** Our previous analysis has dealt only with a static setting in which all production could be aggregated into a single figure, N. In this section we will need to enrich this basic approach by introducing 'time'. To do this let us define n_t as the number of works produced in time period t and N_t as the number of works available to society in period t.[11] N_t will be the 'real' or 'effective' amount of work available, that is it takes account of cultural depreciation and obsolescence – which represent the fact that many works are 'of their time' and are, or at least appear to be, of little value to future generations. Specifically we expect N_t not to be the absolute amount of past and present work available but rather an 'equivalent' amount denominated in the same terms as n_t. Formally, if we let $b(i)$ be the 'rate of cultural decay' after i time periods ($b(0) = 1$), then the 'effective' amount of work in period T is the sum of the production of all previous periods appropriately weighted by the level of cultural decay:

$$N_t = \sum_{i=0}^{\infty} b(i) n_{t-i}$$

Then total welfare calculated at time t is:

$$W_t^{Tot}(S) = \sum_{i=0}^{\infty} d(i) W(N_{t+i}(S), S)$$

[11] Both numbers will have the same set of arguments as the static N we had before so we will have $n_t = n_t(S, C)$, $N_t = N_t(S, C)$ though note that if the arguments can vary over time then the arguments would have be modified appropriately (those to n would need to include future values and those for N both past and future values).

We shall assume this is single-peaked and differentiable (so the first-order condition is necessary and sufficient).

Remark 11. Consider the following formal formulation of this dynamic problem. First assume that $b(i)$ takes a standard exponential form $b(i) = \beta^i$ and also allow S to be set anew each time period (it can then take the role of a standard control variable). Then:

$$\begin{aligned} N_t &= \beta N_{t-1} + n_t \\ n_t &= f(S_t, S_{t+1}, ..., N_t, N_{t+1}, ...) \\ W_t &= W(N_t, S_t) \\ W_t^{Tot} &= W_t + \beta \sum_{i=0}^{\infty} \beta^i W_{t+1+i} = W_t + \beta W_{t+1}^{Tot} \end{aligned}$$

In this formulation the problem has close analogies with the optimal control problems of dynamic growth models: N_t is K_t (capital), n_t is Y_t (production), S_t is c_t (the control variable – usually consumption), W_t is $U(c_t)$ (utility from consumption) and W_t^{Tot} is the value function (overall welfare).[12] These sorts of problems have been extensively analyzed – see Stokey, Robert E., and Prescott (1989) for a mathematical survey – and while it is relatively straightforward to ensure the existence of an equilibrium it is hard to state any general results about the time paths of the state and control variables (see e.g. the 'anything goes' result of Boldrin and Montrucchio (Stokey, Robert E., and Prescott, 1989, Thm 6.1) which demonstrates that any twice-differentiable function g can be obtained as the policy function of a particular optimal dynamic growth problem).

Here we restrict to the case where the control variable may only be set once (S is given forever) and we also assume, when stating our result, that the time path of the number of works ('capital') is non-decreasing – a result obtained in many, though not all, growth models and which appears to fit well with the available data.

Theorem 12. *Assume that at time $t = 0$ production is approximately zero (this could be for several reasons the most obvious being that this type of work only comes into existence at this point, e.g. film around 1900, sound recordings in late 19th century). Then, assuming*

[12]Of course our setup is more complex than the standard growth framework since output (the number for works produced) depends not just on current values for the control variable but on future values of the control variable and future levels of output (this is because creative works are durable).

that sequence of works produced per year, n_i *is such that* $N(t) = \sum_{i=0}^{t} b(t-i)n_i$ *is non-decreasing, optimal protection declines over time asymtoting towards what we term the 'steady-state' level.*

Proof. We first provide an informal justification for this result before turning to a formal, mathematical, 'proof'.

No works are produced before time zero so, as time increases, the backlog of work will grow. As the backlog grows a) the value of producing new work falls and b) the welfare losses from increased protection are levied not just on new works but on the backlog as well.

To illustrate consider the situation with respect to books, music, or film. Today, a man could spend a lifetime simply reading the greats of the nineteenth century, watching the classic movies of Hollywood's (and Europe's) golden age or listening to music recorded before 1965. This does not mean new work isn't valuable but it surely means it is less valuable from a welfare point of view than it was when these media had first sprung into existence. Furthermore, if we increase protection we not only restrict access to works of the future but also to those of the past.

As a result the optimal level of protection must be lower than it was initially in fact it must fall gradually over time as our store of the creative work of past generations gradually accumulates to its long-term level. We now turn to the formal argument.

Optimal protection, S^t, at time t solves:

$$max_S W_t^{Tot}(S)$$

The first-order condition is:

$$\frac{dW_t^{Tot}(S^t)}{dS} = 0$$

Consider this at time t then:

$$\sum_{i=0}^{\infty} d(i) \frac{dW(N_{i+t}(S^t), S^t)}{dS} = 0$$

Recall that $W_{NS} < 0$ (the marginal value of protection goes down as the number of works increases) so that, if $N^1 > N^2$:

$$\frac{dW(N^1,S)}{dS} < \frac{dW(N^2,S)}{dS}$$

Now, by assumption on the structure of n_i, $\forall i, N_{i+t+1} > N_{i+t}$. Thus, we must have:

$$\frac{dW^{Tot}_{t+1}(S^t)}{dS} = \sum_{i=0}^{\infty} d(i)\frac{dW(N_{i+t+1}(S^t),S^t)}{dS} < \sum_{i=0}^{\infty} d(i)\frac{dW(N_{i+t}(S^t),S^t)}{dS} = \frac{dW^{Tot}_{t}(S^t)}{dS} = 0$$

So we have that:

$$\frac{dW^{Tot}_{t+1}(S^t)}{dS} < 0$$

Since W^{Tot} is single-peaked this implies that the level of protection which maximizes W^{Tot}_{t+1} must be smaller than S^t. That is the optimal level of protection at $t+1, S^{t+1}$, is lower than the optimal level of protection at t, S^t.

Finally, we show that the optimal level of protection will tend to what we term the steady-state level. We have just proved that S^t is a declining sequence. Since values for S are bounded below by 0 by Bolzano-Weierstrass we immediately have that the sequence must converge to a unique $S = S^{\infty}$. By analogous arguments associated with this 'steady-state' level of protection will be a steady-state level of output per period n^{∞} and effective number of works N^{∞}.

□

4.3.1. *Remarks.* The preceding result has important implications for policy. In most systems of law, it is extremely difficult to remove or diminish rights once they have been granted. Thus, in most circumstances, once a given level of protection has been granted it will be all but impossible to reduce it. However, according to the preceding result, in general the optimal level of protection will decline over time.

In many ways this is a classic 'dynamic inconsistency' result: the preferences of a welfare-maximizing policy-maker at time zero are different from those at some future point T. Furthermore, it is clear that no particular point in time has any more validity over any other point as regards being chosen as a reference point. Furthermore, from the perspective of any given point in time the ability to 'commit' to a given level of protection is extremely valuable.[13] That said there we still think this result is important for two reasons.

First, whether because of a paucity of data or disagreement about the form of the model, there is frequently significant uncertainty about the optimal level of protection. But one thing we do know from the preceding result is that, whatever optimal level of protection currently, it will be lower in the future. Combined with the asymmetry in decision-making already mentioned – namely, that it is much harder to reduce protection than to extend it – this implies it is prudent for policy-makers to err on the low side rather than the high side when setting the strength of copyright.

Second, and more significantly this result provokes the question: if optimal protection should decline over time why does the history of copyright consists almost entirely of the opposite, that is to say, repeated increases in the level of protection over time (duration, for example, has been increased substantially in most jurisdictions since copyright was first introduced[14]). After all, while one can argue that for 'commitment' reasons a policy-maker would not reduce the level of protection over time, our result certainly runs counter to the repeated increases in protection, many of which have taken place in recent years (when the stock of copyrightable works was already large).

The obvious answer to this conundrum is that the level of protection is not usually determined by a benevolent and rational policy-maker but rather by lobbying. This results in policy being set to favour those able to lobby effectively – usually groups who are actual, or prospective, owners of a substantial set of valuable copyrights – rather than to produce any level of protection that would be optimal for society as a whole. Furthermore, on this logic, extensions will be obtained precisely when copyright in existing, and valuable, material is about to expire. In this regard it is interesting to recall that many forms of copyrightable subject matter are of relatively recent origin. For example, the film and recording industry are only just over a hundred years old with the majority of material, in both cases, produced within the last fifty years. In such circumstances, and with copyright terms around 50 years, it perhaps not surprising that the last decade has seen such a flurry of extensions and associated rent-seeking activities.

[13]It is precisely concerns over the ability of a policy-maker to credibly commit to a particular macroeconomic target that animates many of the traditional models of dynamic inconsistency.

[14]Most prominently in recent times in the United States in 1998 and in the EU in 1995.

5. Optimal Copyright Term

We now turn to the case of optimal copyright term. By interpreting the level of protection, S, as the length of copyright the results above can be re-applied directly. At the same time, because we are now dealing with a more specific case we can add greater structure to the model and, by so doing, to obtain some sharper predictions.

First, let us consider the question of revenue from a work. Let revenue in the ith period after a work's creation be given by $r(i)$ and present value of total revenue to period T be $R(T)$. Let $d(i)$ be, as above, the discount factor for i periods, then:

$$R(T) = \sum_{t=0}^{t=T} d(t)r(t)$$

Revenue decays over time due to 'cultural decay'. We specify cultural decay by $b(t)$, with $r(t) = b(t)r(0)$ so that we have:

$$R(T) = \sum_{t=0}^{t=T} d(t)b(t)r(0)$$

As was shown above, the level of optimal copyright will not be constant over time even if all underlying parameters stay constant. This variation is not our focus here. Instead we are interested in how the basic parameters – the discount rate, the level of cultural decay etc – affect the optimal level of copyright. Thus, when comparing two terms here we shall compare them at their long-run, steady-state, level.[15] Formally, the following assumptions will be made in what follows:

(1) All calculations will be of a comparative static nature with the level of production taken at its long run equilibrium value. Thus we make take the amount of work produced per period n_t to be the constant and equal to the steady-state level which we will denote by n. Similarly the 'effective' amount of work available per period will be constant and will denote it by N.

[15] It it is in this assumption that we differ most significantly from previous analyses such as that of Landes and Posner (1989). Their model implicitly assumes no work already exists and therefore, in the formulation of the previous section, maximizes welfare from the perspective of a social planner at time $t = 0$ rather than at the steady-state. We believe that the steady-state analysis presented here, which includes the prospective and retrospective effects of changes in copyright term, is the more appropriate – particularly since today most forms of copyrightable work have been produced for decades if not centuries.

(2) Discount factors are the same for producers and for society (i.e. we discount welfare at the same rate we discount income for producers).

(3) Revenue and welfare (and dead-weight loss) per work experience the same rate of cultural decay. Thus total welfare per period may be obtained by summing over all vintages of works weighted by the relevant cultural decay.

Since we evaluate welfare at the long run equilibrium, production per period and welfare per period may be taken to be constant and equal to their long run equilibrium values. Therefore in what follows we focus on welfare per period (converting to total welfare is a trivial matter). We have the following result:

Theorem 13. *The marginal change in (per period) welfare with respect to an increase in the term of protection, S, when the current term is S^1, is as follows:*

$$\frac{dW(S^1)}{dS} = ns(n)y(n)b(S^1)\left(d(S^1)\frac{\sum_{i=0}^{\infty} b(i)}{\sum_{i=0}^{\infty} d(i)b(i)} - \theta(n)\right)$$

Where:

$$\begin{aligned}
d(t) &= \textit{Discount factor to time } t \\
b(t) &= \textit{Cultural decay to period } t \\
y(j) &= \textit{Welfare from an extra jth } \text{new } \textit{work} \\
z(j) &= \textit{Deadweight-loss under copyright on the jth } \text{new } \textit{work} \\
\overline{z}(n) &= \textit{Average deadweight-loss under copyright on works } 1\cdots n \\
s(n) &= \textit{Elasticity of supply of works with respect to revenue when there are } n \textit{ works} \\
\theta(n) &= \textit{Ratio of avg. d/w loss to marginal welfare} = \frac{\overline{z}(n)}{s(n)y(n)}
\end{aligned}$$

In particular define the 'determinant', Δ as the bracketed term above, i.e.

$$\Delta = d(S^1)\frac{\sum_{i=0}^{\infty} b(i)}{\sum_{i=0}^{\infty} d(i)b(i)} - \theta(n)$$

Then the optimal copyright term is determined by reference to the 'determinant' alone.

Proof. We can express welfare per period as:

$$\begin{aligned} W &= \text{Welfare under infinite copyright} + \text{Extra welfare on works out of copyright} \\ &= \sum_{j=1}^{n}\sum_{i=0}^{\infty} y(j)b(i) + \sum_{j=1}^{n}\sum_{i=S}^{\infty} z(j)b(i) \qquad (5.1) \end{aligned}$$

With the first sum being over the n works produced each period and the second being over past periods ($i = 1$ corresponding to the period previous to this one, $i = 2$ to two periods ago etc). With the double sum we cover all works ever produced, bringing them up to the present in welfare terms by multiplying by a suitable amount of 'cultural decay'.

Differentiating we have:

$$\begin{aligned} \frac{dW}{dS} &= n'y(n)\textstyle\sum_{i=0}^{\infty} b(i) + n'z(n)\sum_{i=S}^{\infty} b(i) \quad -b(S)\displaystyle\sum_{j=1}^{n} z(j) \qquad (5.2) \\ &= \text{Gain in welfare from new works} \quad -\text{Extra deadweight loss on existing works} \end{aligned}$$

First, note that the middle term in the first line will be small, at least relative to the first one, so we can ignore it in what follows.[16] Second, let us re-express the increase in the number of works, $n'(S^1)$, in terms of the change in revenue:

$$n' = \frac{dn}{dS} = n\frac{n'(R(S))}{n} = n\frac{dn}{dR}\frac{R}{n}\frac{R'}{R}$$

The middle term of the final expression is the elasticity of supply with respect to revenue, $s(n)$, while the last is the percentage increase in revenue. Revenue itself equals:

$$R(S) = \sum_{i=0}^{\infty} d(i)b(i)r(0) \implies R'(S) = d(S)b(S)r(0)$$

Thus, substituting and using $\overline{z}$, for average z we have:

$$\begin{aligned} \frac{dW(S^1)}{dS} &= ny(n)d(S^1)b(S^1)r(0)\frac{\sum_{i=0}^{\infty} b(i)}{\sum_{i=0}^{\infty} d(i)b(i)r(0)} - b(S^1)n\overline{z}(n) \qquad (5.3) \\ &= ns(n)y(n)b(S^1)\left(d(S^1)\frac{\sum_{i=0}^{\infty} b(i)}{\sum_{i=0}^{\infty} d(i)b(i)} - \frac{\overline{z}(n)}{s(n)y(n)}\right) \qquad (5.4) \end{aligned}$$

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[16] Keeping this term would add to the 'determinant': $d(S^1)\frac{z(n)}{y(n)}\frac{\sum_{i=S^1}^{\infty} b(i)}{\sum_{i=0}^{\infty} b(i)d(i)}$. Since deadweight loss per work, $z(n)$ is lower than welfare $y(n)$, and since the sum over $b(i)$ begins at S^1 this term will be small relatively. For example with exponential cultural decay of 4% and a ratio of deadweight loss to welfare of 0.15 and a term of 20 years this term is only around 1/20th of the size of the first.

□

5.1. **The Discount Rate.** We assume a standard geometric/exponential form for the discount function. The relevant discount factor to use here is that related to those producing works so a plausible range is a discount rate in the range 4-9%. Where we need to use a single value we will by default use a rate or 6% (corresponding to a discount factor of 0.943).[17]

5.2. **The Rate of Cultural Decay.** We assume an exponential form for the cultural decay so that $b(i) = b(0)^i$ with $b(0)$ the cultural decay factor. A plausible range for this cultural decay rate is 2-9% and by default we will use 5% (corresponding to a factor of 0.952). Since values for these variables are less well-established than those for the discount rate the evidence on which they are based merits discussion.

The prime source is CIPIL (2006), which reports estimates made by PwC based on data provided by the British music industry which indicate decay rates in the region of 3-10%. As these come from the music industry itself, albeit indirectly, these have substantial authority. To check these we have performed our own calculations using data on the UK music and book industry and obtain estimates for the rate of decay that are similar (in the case of music) or even higher (in the case of books).

Evidence from elsewhere includes the Congressional Research Service report prepared in relation to the CTEA (Rappaport, 1998). This estimates projected revenue from works whose copyright was soon to expire (so works from the 1920s to the 1940s). Rappaport estimates (p.6) that only 1% of books ever had their copyright renewed and of those that had their copyright renewed during 1951 to 1970 around 11.9% were still in print in the late 1990s. The annual royalty value of books go from \$46 million (books from 1922-1926) to \$74 million (books from 1937-1941). Turning to music, Rappaport focuses on songs (early recordings themselves have little value because of improvements in technology) and finds that 11.3% of the sample is still available in 1995. Annual royalty income rises from \$3.4 million for works from 1922-1926 to \$15.2 million for works from 1938-1941. Unfortunately, while such figures are useful, and certainly indicate that a substantial portion of works are

[17]As reported by CIPIL (2006), Akerlof et al. (2002) use a real discount rate of 7%, Liebowitz in his submission to the Gowers review on behalf of the IFPI (International Federation of the Phonographic Industry) used a figure of 5%, while PwC's report to the same review on behalf of the BPI (British Phonographic Industry) used the figure of 9%.

fairly ephemeral they do not provide sufficient information to provide concrete estimates for the decay rates. Furthermore, given the age of the works considered, it is difficult to know whether this data provides accurate guidance for the future.[18]

Liebowitz and Margolis (2005) argues that overall decay rates may be misleading and presents evidence that books that are popular upon release as measured by being bestsellers survive well (for example the table on p. 455 indicates that of the 91 bestsellers in their sample from the 1920s 54% are still in print 58 years later compared to only 33% of non-bestsellers. However it is not clear how one should interpret this sort of evidence.

Simple 'in-print' status of a book only places a lower-bound on sales (furthermore a lower bound that is dropping with advances in technology) and does not allow us to compare the sales of a book today compared to when it was first released. More fundamentally, much heterogeneity is eliminated by the aggregation of copyrights into portfolios by the investors in creative work such as publishers, music labels and movie studios. In this case returns will tend to the average. Furthermore, were such aggregation not to occur it would require a substantial increase in the discount rate to take account of the increased uncertainty due to the reduction in diversification of the portfolio.[19]

5.3. **The Ratio of Average Deadweight-Loss to Welfare Under Copyright from New Works: $\theta(n)$.** Our preference would be to estimate $\theta(n)$ from empirical data. However, this is daunting task given currently available datasets as it requires us to determine: the full demand system for copyright goods *and* the supply function for creative work. Because this task presents such insurmountable difficulties given present data availability we instead take a 'reduced-form' approach where we supply particular functional forms

[18]The issue of technological change is clearly an important one here: one might argue that with improvements in technology, both in production but also in distribution and discovery, the decay rate will fall in future. For example, it has been argued recently that technologies such as the Internet have made it easier to discover and access more obscure works leading to the growing importance of the 'long-tail' and a flattening of the distribution of sales (traditionally sales for most types of copyrightable goods have been dominated by a top 10-20% of works. The 'long-tail' then refers to the tail of this sales distribution). Here we do not explicitly consider the impact of technological change but we note that an earlier section dealt specifically with this question. It was shown there that, in general, technological change that reduced production and distribution costs implied a reduction in the optimal level of copyright.

[19]In these circumstances the issue of serial correlation would also become important. With high serial correlation, that is older successful works are those that were successful when young (and vice versa), the revenue when one extends term goes primarily to the owners works which have already generated substantial revenue (think here of a group like The Beatles). If one makes the standard assumption of diminishing marginal returns to creative output with respect to revenue, then serial correlation implies a very low elasticity of supply with respect to revenue – the revenue from extending term goes to those whose incomes are already high and therefore from whom little extra 'creation' can be expected when their incomes increase.

for the various quantities of interest (the average deadweight loss, marginal welfare etc). Where possible we calibrate these using existing data and we also perform robustness checks to ensure these results are reasonably robust. We begin by making the following assumptions:

(1) The elasticity of production with respect to revenue, $s(n)$, is constant and equal to 1.
(2) The ratio of deadweight-loss to welfare under copyright on any given work is constant. This constant will be termed α.
(3) The ratio of marginal welfare, $y(j)$, to marginal sales is constant. That is welfare follows the same trend as sales. This constant will be termed β.

Assumption 1: nothing is known about the degree to which the elasticity of supply with respect to revenue varies with the number of works produced thus we simply assume it to be constant and equal to 1.

Assumption 2: this assumption is questionable as one might expect that deadweight losses relative to welfare (under copyright) increase as the welfare (and revenue) from a work decline.[20] If this were so then this assumption would be incorrect and would result in an underestimate of the costs of copyright – and hence an overestimate of optimal copyright term. Nevertheless, we shall make this assumption for two reasons. First, it is difficult to derive estimates of this ratio from existing data. Second, as we shall see below, even with it (and the associated upward bias) we find that optimal term is well below the copyright terms found in the real world.

Assumption 3: this requires that the ratio welfare (under copyright) arising from a new work to the sales of that work does not vary over works. Again this is almost certainly not an accurate description of reality but as a first order approximation we believe it is not that bad. Furthermore, this assumption is crucial for our empirical strategy since it is relatively easy to obtain sales data compared to welfare data (which requires information on large segments of the demand curve).

Now, to proceed with the empirics, first let us switch to total welfare for notational convenience and define Y(j) to be total welfare under copyright from j new works so that

[20] For example, this would be the case if there was some fixed lower bound to transaction costs.

$y(j) = Y'(j)$. Also define $Q(j)$ as total sales and $q(j)$ as marginal sales (i.e. sales from the nth work).

What form does $Q(j)$ take? We shall assume it takes a 'power-law' form:

$$Q(j) = Aj^{\gamma}$$

This functional form appears to represent a reasonably good fit for sales of cultural goods and is frequently used in the literature[21]. That said some data (including some of our own) suggests that the decline is even sharper than would be found via this power law. If this were the case using the power law will lead to an under-estimate of θ and thus an over-estimate of optimal term. We will err on the conservative side and proceed using the power-law form.

Working through the algebra we obtain the following expression for θ:

$$\theta(n) \approx \frac{\alpha}{\gamma}$$

Thus, one very convenient aspect of using a 'power-law' form is that $\theta(n)$ is not a function of n – it is 'scale-free'. In this case calculations of optimal copyright term do not depend on, n, the production function for works but only on α and γ.

5.4. **Optimal Copyright Term: Point Estimates.** Combining estimates of the ratio of deadweight losses to welfare under copyright (α) and the rate of diminishing returns (γ) with those provided above for cultural decay (b) and the discount factor (d) we will obtain point estimates for optimal copyright term.

5.4.1. *γ.* Ghose, Smith, and Telang (2004) list a whole range of estimates for $\gamma - 1$ (all derived from Amazon) ranging from -0.834 to -0.952 with the best estimate being -0.871. These imply γ in the range 0.048 to 0.166 with best estimate at 0.129. We shall proceed using this estimate of 0.129.

5.4.2. *α.* Estimating α is harder because of the paucity of data which would permit estimation of off-equilibrium points on the demand curve. However the available evidence

[21]See e.g. Goolsbee and Chevalier (2002); Ghose, Smith, and Telang (2004); Deschatres and Sornette (2004)

though scanty suggests that the ratio could be quite large. For example, Rob and Waldfogel (2004) investigate file-sharing among college students and estimate an implicit value for deadweight-loss of around 36% of total sales. Allowing a producer surplus to be around 50% of sales and consumer surplus to be two to five times that suggests a value for α of between 0.24 and 0.12. Other papers, such as Le Guel and Rochelandet (2005); Ghose, Smith, and Telang (2004), while not providing sufficient data to estimate deadweight loss, do suggest it is reasonably substantial. Thus, we feel a plausible, and reasonably conservative, range for α would be from $[0.05, 0.2]$, that is deadweight loss per work is, on average, from a twentieth to a fifth of welfare derived from a work under copyright. When required to use a single value we will use 0.12 – the lower value implied by Rob and Waldfogel (2004).

5.5. **A Point Estimate for Optimal Copyright Term.** With $\alpha = 0.12, \gamma = 0.129$ then $\theta \approx 0.93$. With our defaults of a discount rate of 6% and cultural decay of 5% this implies an **optimal copyright term of just over 14 years**.

5.6. **Robustness Checks.** Given the uncertainty over the values of some of the variables it is important to derive optimal copyright term under a variety of scenarios to check the robustness of these results. Table 1 presents optimal term under a range of possible parameter values including those at the extreme of the ranges suggested above.

With variables at the very lower end of the spectrum (the first row) optimal term comes out at 51 years which is substantially shorter than authorial copyright term in almost all jurisdictions and roughly equal to the 50 years frequently afforded to neighbouring rights (such as those in recordings). However as we move to scenarios with higher levels for the exogenous variables optimal term drops sharply. For example, with cultural decay at 3%, the discount rate at 5% and the ratio of deadweight loss to welfare under copyright at 7% we already have an optimum term of just over 30 years.

5.6.1. *An Inverse Approach.* An alternative approach to estimating $\theta(n)$ and using that to find the optimal term is to look at the inverse problem of calculating the 'break-even' θ for any given copyright term. The 'break-even' θ is the level of θ for which that term is optimal – if actual θ is higher than this break-even level then term too long and if actual θ is below which it then term is too short. This provides a useful robustness: derive the

Cultural Decay Rate (%)	**Discount Rate (%)**	α	**Optimal Term**
2	4	0.05	51.51
3.5	5	0.07	30.13
5	6	0.1	17.36
6.5	7	0.15	8.06
8	8	0.2	2.82

TABLE 1. Optimal Term Under Various Scenarios. α is the ratio of deadweight loss to welfare under copyright.

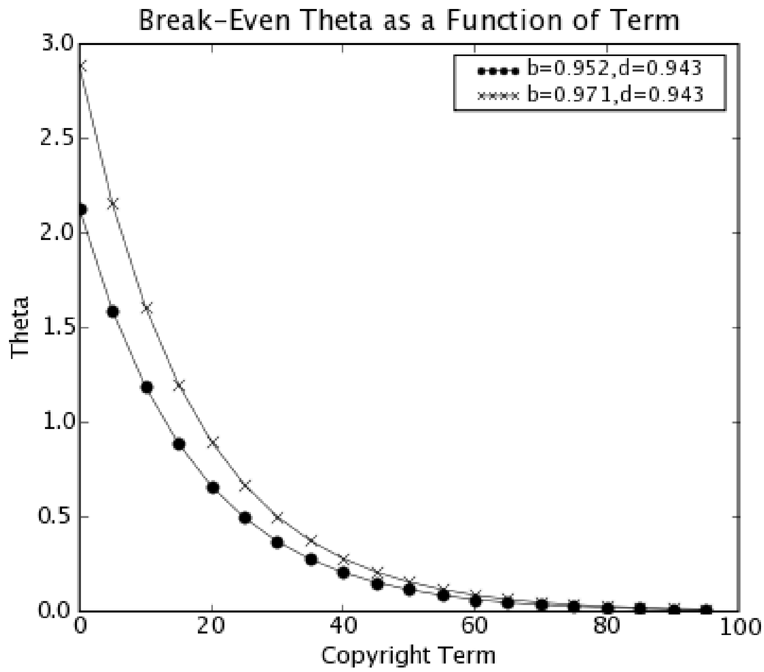

FIGURE 1. Break-even theta as a function of copyright term. b is the cultural decay factor and d the discount factor.

break-even θ corresponding to the copyright term currently in existence and then compare this value to whatever is a plausible range for θ. If the value is outside this range one can be fairly certain that current copyright term is too long.

Given our assumption on the form of the discount factor and the rate of cultural decay theta takes a very simple form:

$$\theta^{-1}(S) = \frac{d(S)(1-b)}{1-db}$$

Figure 1 provides a plot of this inverse, 'break-even', function. Under the Berne convention minimal terms of protection for most types of work is life plus 50 years (and many countries including the US and all of those in the EU now provide for life plus 70). This

Cultural Decay Rate (%)	**Discount Rate (%)**	**Break-even θ**
1	2	0.34
1	4	0.099
3	2	0.29
3	4	0.076

TABLE 2. Break-even θ

in turn will correspond to a copyright length of somewhere between 70 and 120 years (assuming the work is created between the ages of 20 and 70). Let us take a low value in this range, say 80 years. We summarize the 'break-even' θ corresponding to term of this length in Table 2 focusing on a set of very conservative parameter values. As can be seen there, even with a cultural decay rate of 1% and a discount rate of 2% the break-even θ is 0.34 – so for any θ above that value term is too long. This corresponds to a ratio of deadweight-loss to welfare under copyright of around 4% (using our figure of 0.129 for γ). With a slightly higher discount rate of 4% break-even θ falls to 0.099 which corresponds to a deadweight-loss to welfare ratio of around 1.3%. Thus, even even with very low values for the discount and cultural decay rate the level of θ required for current copyright terms to be optimal seem too low to be plausible.

6. Conclusion

In this paper we have developed a simple framework for analysing copyright based on the existing literature. Using it, we obtained two sets of separate, but complementary, results. In the first section, which was entirely theoretical, we demonstrated in substantial generality that (a) optimal protection falls with a decline in the costs of production and distribution (b) optimal protection falls over time.

In the second section we turned our attention to one specific aspect of optimal copyright, namely the term of protection. In Theorem 13 we used our model to derive a single equation that defined optimal term as a function of key exogenous variables. Using the estimates for these variables derived from the available empirical data we obtained an estimate for optimal copyright term of approximately 14 years. To our knowledge this is one of the first estimates of optimal copyright term which is properly grounded, both theoretically and empirically, to appear in the literature.

All our results have significant implications for policy. In recent times technological change has substantially reduced the costs of production and distribution of most copyrightable goods. On this basis our first theoretical result would imply that the level of optimal copyright is dropping. Similarly, given that several types of copyrightable work, for example films and recordings, are now well over fifty years old, the second theoretical result similarly implies that optimal term is falling.

Of course, being theoretical results these can only indicate 'signs' of a change and not its magnitude. As such they provide no guidance on what an optimal level of copyright would actually be. Thus, in the final section we provide an estimate of optimal term – probably the most important aspect of the level of copyright. Our estimate of optimal term (14 years) is far below the length copyright in almost all jurisdictions. This implies that there is a significant role for policymakers to improve social welfare by reducing copyright term as well as implying that existing terms should not be extended. Such a result is particularly importance given the degree of recent debate on this precise topic.

Finally, there remains plentiful scope to extend and build upon the work here. In particular, there is room for further empirical work on all aspects of these results. For example, it would be valuable to calibrate the production costs model to investigate what changes in the level of copyright would be implied by the recent reductions in the cost of production and distribution. Similar work could be done in relation to changes of copyright over time where one would need to collect data on the level of production and the form of the welfare function.

Regarding the derivation of optimal term, the main challenge would be to improve the estimates for the key parameters, especially that of the ratio of deadweight loss to welfare under copyright. As discussed above, the perfect approach would involve estimating the demand-system for the copyrightable goods under consideration. This is a non-trivial task but one of great value – not just in relation to this problem but more generally.

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