The blurred lines of copyright infringement

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Abstract

This paper studies the creative process in a model where the level and direction of artistic effort are affected by judicial copyright enforcement. The analysis compares the performance of common sanctioning rules employed by U.S. courts in infringement cases and provides an economic micro-foundation for the independent creation defense in copyright law. Using a mechanism design approach, the paper highlights the benefits of complementing copyright litigation with a system of compulsory licensing. A calibration of the model to fit a leading music infringement case suggests that the damages awarded by courts may stifle creativity, as they substantially exceed those required to deter excessive entry and copying.

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1 Introduction

Copyrighted work includes musical compositions, software, books and movies. In the U.S., copyright intensive industries accounted for about 7 percent of the GDP in 2019 and experienced an increase in employment of roughly 30 percent between 2010 and 2019 (Toole et al., 2020). Despite their importance, most of the theoretical and empirical work in the economics of intellectual property has neglected copyrights and focused on patents.

A key difference between copyrights and patents is that patent law requires applicants to undergo stringent examination before the Patent Office. Patent applications are screened for novelty, utility and non-obviousness and are published in publicly available databases. Conversely, copyright protection

arises automatically once a work of authorship is fixed in a tangible medium of expression. Registration to the Copyright Office, which is needed to commence a lawsuit, is a pro-forma administrative act which does not involve substantial screening by the agency (Buccafusco and Lemley, 2017). Registration can be made at any time within the life of the copyright and most copyrights are not registered (Lo Pucki et al, 2019). This limited screening before copyrights come to existence implies that ex-post litigation is the key policy instrument through which the strength and the boundary of the property right are assessed. Moreover, the voluntary nature of copyright registration implies that creators operate under substantial uncertainty about the body of existing protected work.

A second important feature of copyright is that, differently from patents, it does not protect against independent invention (Maurer and Scotchmer, 2003). Specifically, copyright does not protect against fortuitous similarity arising from independent creation. Copyright infringement action requires proof of copying, which is generally not witnessed or admitted by defendants. Copying has to be inferred using evidence of 'similarity' between the two creations and of 'access' which is defined as the opportunity by the defendant to view, inspect and potentially copy the plaintiff's work before creating an allegedly infringing work (Three Boys Music Corp. v. Bolton, 212 F.3d 477, 482, 9th Cir. 2000).

The above discussion indicates that a key policy feature shaping the effects of copyrights is the burden of proof: the strength and type of evidence required for the imposition of sanctions. The way evidence of access and similarity is used in copyright infringement cases affects the likelihood of appropriately punishing guilty and innocent infringers. More importantly, the behavior of courts may also have ex-ante effects on the creation of new content, by affecting both the level and the direction of creative efforts.

The need for research on this issue is highlighted by the disagreement across courts on the way evidence of access and similarity should be used in copyright infringement cases. One of the key issues under discussion involves the use of the 'inverse ratio rule' according to which "*the stronger the evidence of access, the less compelling the similarities between the two works need be in order to give rise to an inference of copying*" (Rentmeester, 883 F.3d at 1124). Until recently U.S. circuits were split over the use of this rule, and views in the literature range from describing it as "*a pragmatic and logical tool*" (Menell, 2022) to considering it a "*pseudoscientific principle*" and "*a deleterious doctrine that should be abandoned*" (Aronoff, 2007). The debate has been central in several leading copyright cases

involving multiple types of creative work such as stage plays, motion pictures, TV commercials, and music compositions (Aronoff, 2007).

This paper develops a model of copyright infringement, in which the burden of proof is a key policy tool set by the government. For expositional simplicity and easier mapping to the quantitative analysis, which involves music compositions, I refer to the two works as the original (or pre-existing) song and the new song. The court can perfectly observe the level of similarity between the original and the new song. On the other hand, whether the defendant had the opportunity to copy the original song or not is her private information, and the court only receives a signal with higher distribution for composers with access. Building on Kaplow (2011), I model the burden of proof as a sanctioning rule which determines whether damages will be awarded given the evidence presented. Composing a new song which overlaps with the original song generates a negative externality on the original composer, which increases with the level of overlap. For composers without access, overlap with the original song may arise fortuitously. For composers with access to the original composition, the level of overlap is chosen endogenously through copying. Composing a new song is costly, and overlap decreases the composition cost. In line with the economics of innovation literature, in my model the sanctions and the burden of proof affect the incentive to compose and, for composers with access, also the direction of creative effort as it affects the level of copying.

My first main result provides an economic micro-foundation for the independent creation defense in copyright law. I show that, even if the overlap between two compositions imposes the very same externality independently of whether the overlap is fortuitous or due to copying, welfare can increase when the burden of proof relies on access signals and courts treat more leniently composers that are unlikely to have copied. The intuition for this result is that externalities generated by the independent composer and the composer with access are identical ex-post (after the composition) but differ substantially ex-ante, at the time of composition. Because independent creators generate externalities stochastically, higher expected sanctions only have the negative effect of reducing their composition incentives. On the other hand, composers with access choose their level of copying endogenously. Higher sanctions affect the type of songs they compose (how similar to the original song), without necessarily reducing their incentives to compose. This implies that sanctioning rules that only depend on the level of overlap

may punish excessively independent creators relative to composers with access. Sanctioning rules that depend both on evidence of access and overlap may reduce this distortion. Building on this result, I then compare simple sanctioning rules which use independent thresholds for access and overlap with inverse ratio sanctioning rules. I show that, in several environments, inverse ratio rules are superior. Intuitively, inverse ratio rules provide more policy flexibility than simpler rules, which is useful to discipline more effectively composers with access. The key insights from the baseline model are robust to extensions of the model that include the incentives by first-generation creators and to the use of non-statutory damages.

In the second part of the paper, I use a mechanism design approach to derive the optimal sanctioning scheme. Specifically, I model copyright litigation as a direct-revelation mechanism in which the defendant reports whether she had access or not to the original song. As in Siegel and Strulovici (2022), the mechanism maps the signals regarding access and overlap and the defendant report to a damage award. The key finding is that the welfare maximizing mechanism can be implemented by allowing defendants which only copied a limited amount of the original song to obtain a compulsory license. Defendants claiming independent creation face a trial which ends either with an acquittal or with a conviction and damages lager than the licensing fee. In the law literature, the use of compulsory licenses to address music copyright infringement related to remixes, mash-ups and digital sampling has been strongly advocated by Menell (2022). My result provides support to Menell's proposal, as compulsory licensing emerges as a feature the optimal mechanism and is not an assumed element of the judicial policy.

In the third part of the paper, I exploit a calibration of the model to evaluate the size of the damages awarded in the leading music infringement litigation case *Pharrell Williams, et al. v. Bridgeport Music, et al.* (C.D. Cal. Dec. 2, 2015). I use data from manually coded court decisions to calibrate the frequencies of access and similarity signals in a simplified version of the model. I then use data on music streaming from YouTube to estimate the harm generated by copyright infringement in terms of lost demand. Strikingly, using the the synthetic control method by Abadie et al. (2010) I find no support to the idea that infringement generated a drop in demand for the original composition. I combine this finding with estimates of lost royalties computed using statutory terms for mechanical licensing. Back of the envelope calculations which contrast the damages awarded by the court with those implied by

the model suggest that the damages in *Pharrell v. Bridgeport* exceed those required to deter excessive copying and entry by inefficient creators by a factor of about 1.5.

The paper is organized as follows. Section 2 surveys the related literature. Section 3 presents the model. Section 4 examines the independent creation defense, discusses inverse ratio sanctioning rules and extends the model to consider first generation composers and non-statutory damages. Section 5 derives the optimal judicial mechanism. Section 6 presents the quantitative analysis. Brief concluding remarks close the paper.

2   Related literature

My paper builds on the law-and-economics literature on the optimal burden of proof. Kaplow (2011) develops a model of law enforcement where the burden of proof is a policy instrument which affects ex-ante incentives. The paper shows that burden of proof interacts with enforcement effort and the level of sanctions in ways that depend on the enforcement technology. Siegel and Strulovici (2022) use a mechanism design approach and show that the optimal sentencing scheme includes a plea bargaining and a trial. Siegel and Strulovici (2019) examine the optimality of probabilistic sentencing in a model without plea bargaining. Silva (2019) provides a more general treatment of mechanism design with imperfect type verification. My paper contributes to this literature focusing on the intellectual property application. I depart from previous work by considering the case in which the externality generated by different types of defendants is identical ex-post but differs ex-ante. Moreover, in my model, one type of defendant can choose not only whether to commit a harmful act but also the intensity of the harm.

The paper is also related to the broad literature on innovation policy and the impact of intellectual property on innovation and creativity. The majority of these studies are empirical and focus on patents rather than copyrights. Bryan and Williams (2021) provide a comprehensive review of the literature. My analysis builds on mechanism design studies on the optimal design of patent rights (inter alia see Cornelli and Schankerman, 1999, Scotchmer, 1999, Hopenhayn and Mitchell, 2001 and Galasso et al., 2016). Maurer and Scotchmer (2002) develop a model in which patents do not protect against independent invention and show that in several circumstances this can induce greater licensing and reduce R&D

duplication. Choi (1998) and Bessen and Meurer (2006) analyze models in which patent litigation affects R&D investment. Meurer (1989) develops a model to analyze patent licensing that is induced as part of a settlement agreement to avoid litigation of the issue of patent validity. Schankerman and Schuett (2021) develop an integrated framework which shows that patent office examination interacts with patent litigation in shaping R&D incentive and welfare. This paper contributes to this line of studies by providing a theoretical model of copyright litigation and examining how alternative rules used by courts may affect the level and direction of creative effort.

The paper is also related to the literature examining the effects of copyright protection on market outcomes and welfare. Luo and Mortimer (2017, 2018) provide evidence from randomized experiments showing that settlement rates in copyright infringement disputes are shaped by the monetary offer made by the copyright holder, as well as by the message used to request a settlement. Nagaraj (2018) shows that removal of copyright protection increases re-use of digital images. Reimers (2019) estimates the impact of book copyright protection on consumer welfare through availability and prices. Li, MacGarvie, and Moser (2015) finds the extensions in copyright length generated by the UK Copyright Act of 1814 led to a substantial increase in book market prices. Biasi and Moser (2021) show that the reduction in copyright protection for enemy-owned science books implemented during WWII encouraged the creation of follow-on science. Giorcelli and Moser (2020) find that adoption of copyrights led to an increase in the quantity and quality of operas in Napoleonic era Italy. Waldfogel (2012) shows that the reduction in effective copyright protection due to the emergence of file sharing has not reduced the quality of music composition. Other studies relying on quasi-experimental variation in copyright piracy, found contrasting effects on sales (Oberholzer-Gee and Strumpf 2007, Rob and Waldfogel, 2006).

Gans (2015) examines a setting where original content can be remixed by follow-on creators. The paper compares several IP regimes including traditional copyright protection, no copyright, fair-use exemptions and remix rights. My analysis differs from Gans (2015) as I focus on the copyright litigation process rather than the bargaining frictions associated with copyright licensing negotiations.

3   The model

The central player in the model is an author in the process of creating new artistic work. I use the pronouns 'she/her' for the author. To strengthen the mapping with my quantitative analysis, I will refer to the author as the music composer, and to the artistic work as the song. I assume that, through some random process, the composer may or may not be exposed to another song before composing her own. I call this pre-existing song the original composition. Specifically, I assume that with probability γ the composer will not have access to the original song and ignore its existence. Conversely, with probability $1 - \gamma$ the composer will have access of the original song, and potentially be able to copy it. Composers are assumed to be risk neutral and obtain an utility equal to zero if they do not compose.[1]

Composing a new song costs c. A new song can be more or less similar to the original one. In practice, similarity is assessed making use of experts in a given area of creativity to detect patterns of overlap and differences between creative works (Balganesh, 2012). I capture the degree of overlap between songs with the parameter $\theta \in [0, 1]$. In the absence of access, independent creation can lead to some overlap, which is stochastically distributed according to the density and cumulative distribution functions $f(\theta)$ and $F(\theta)$. In other words, a musician unaware of the original composition (with no access) may still independently compose a song similar to the original, with random overlap. In the case of access, the degree of similarity (overlap) is chosen by the composer. By copying (creating a song which overlaps with the original one) the composer faces lower composition costs. Specifically, I assume that in the case of access to the old song the cost of the new composition is $c(1 - \theta)$ where θ is chosen endogenously by the composer. In the following, I will sometime refer to composers with access as 'type A' and to unaware independent composers as 'type I'.

I assume that the new composition leads to a copyright dispute litigated in court. For simplicity, the model does not consider selection into litigation. I discuss the implications of this assumption in Section 6.5, when I present the calibration exercise. I assume that the court perfectly observes θ, but

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[1]The assumption that access is exogenous is natural in the context of copyright infringement as, differently from the case of patents, registration with national offices is not required and can be made at any time. Indeed, the data we will describe in Section 6 show that music copyright cases litigated in the past two decades often involve alleged infringement of songs that are only locally known and not broadly commercialized, supporting the idea that access to the composition is subject to randomness.

only receives a signal about access. Following Kaplow (2011) I model the signal as the outcome of a random variable, a, with density $g^i(a)$ for $i = \{I, A\}$ assumed to be positive and differentiable. The cumulative distributions are such that $G^I(a) \geq G^A(a)$ with strict inequality except when G^i equals zero or one. The idea is that the probability that a signal about access is below a specific threshold is greater for independent creators than for creators with access. In practice, the strength of the evidence used in court to prove access varies considerably across cases. Sometimes it is possible to show that the alleged infringer owns a copy of the album containing the song, or that she released interviews referring to the original song as source of inspiration. In other cases, it is only possible to prove that the song was shared with a mutual connection or performed in a venue frequently attended by the alleged infringer.

The benefits obtained by the composer when composing a song are indicated with b, which is distributed according to the density $\phi(b)$ and cumulative distribution $\Phi(b)$. The composer knows b before composing the song. Private information about b is the typical assumption in the innovation literature, as the parameter can be interpreted as expected value if there is uncertainty on the costs or the outcome of an investment (Scotchmer, 1999).[2]

A composition with overlap θ generates a harm to the composer of the original song equal to $h(\theta)$. To obtain an interior solution, I assume that h is continuous, increasing and convex. Section 3.1 below discusses a possible interpretation of this function consistent with the cumulative innovation literature (Green and Scotchmer, 1995).

The court awards damages s if the evidence presented (θ, a) exceeds particular thresholds. Specifically, I indicate with $\Pi(a, \theta)$ the rule used by the court with $\Pi(a, \theta) = 1$ if damages are awarded when the evidence is (a, θ), and $\Pi(a, \theta) = 0$ if damages are not awarded when the evidence is equal to (a, θ). The use of thresholds implies that if $\Pi(a', \theta') = 1$ then it is also equal to one for each (a'', θ'') with $a'' \geq a'$ and $\theta'' \geq \theta'$. Similarly, if $\Pi(a', \theta') = 0$ then it is also equal to zero for each for each (a'', θ'') with $a'' \leq a'$ and $\theta'' \leq \theta'$.

The assumption that the level of s does not depend on the evidence follows Kaplow (2011) and

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[2]The assumption that the cost of composition is independent of the privately known benefit is common in the innovation literature (see, for example, Scotchmer, 1999). This fits well the case of pop music compositions as the commercial success of a song is largely driven by marketing investments and touring, rather than the score or the lyrics of the composition (Kruger, 2019).

allows me to isolate the implications of the burden of proof. Indeed, implementing optimal behavior would be trivial if this assumption is relaxed, as the court can make the composer internalize the harm generated by the overlap by awarding $s(\theta) = h(\theta)$ to all (θ, a), but modeling s as a continuous function of the evidence departs from conventional burden of proof notions, which are more consistent with the use of thresholds and Bayesian posterior probabilities (Kaplow, 2011).[3] In some of the theoretical and quantitative results presented below, I characterize the optimal damage level. Also in these cases, to maintain consistency with this assumption, I only consider damages that do not rely on the realization of a and θ.

A natural interpretation of s is that it captures statutory damages, which are damages set by law and independent of the value at stake. Statutory damages are the norm in copyright litigation cases. Data from the legal analytics portal LexMachina on copyright litigation cases pending in US federal courts between 2009 and 2022 show that statutory damages account for more than 90 percent of the 3,552 instances in which infringement damages were awarded. Section 4.5 relaxes the assumption that s is independent of b and discusses the case in which non-statutory 'actual' damages are a specified as a fraction of b.

3.1 Incentives to compose

I begin with the case of an independent music creation. Independent creators may be sanctioned if they fortuitously compose a song with high overlap and cannot make the case that they did not have access to the original composition. More formally, a composer without access to the original song will compose a new song if $b - E(s\Pi(a, \theta)|I) - c \geq 0$ where the expected damages are equal to

$$E(s\Pi(a, \theta)|I) = \int_a \int_\theta s\Pi(a, \theta) g^I(a) f(\theta) da d\theta.$$

In other words, the composer will compose if the benefit exceeds the cost of creation and the expected sanction that may be awarded to her. The key thing to notice is that even if the benefit b exceeds the cost of creation c, some songs are not composed because of the expected sanction faced by independent

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[3]This can also be implemented with stochastic damages $s(\theta) = q(\theta)s$ where $q(\theta) = h(\theta)/s$ is the probability of being required to pay damages s. In principle, the randomization may also be generated by the court using other signals received that are not dependent on the creator's type. These damage schemes are not considered in the analysis.

creators.

A composer with access to the original song that decides to copy $\widehat{\theta}_A$ will compose a new song if $b - E(s\Pi(a, \widehat{\theta}_A)|A) - c(1 - \widehat{\theta}_A) \geq 0$ where the expected sanction is equal to

$$E(s\Pi(a, \widehat{\theta}_A)|A) = \int_a s\Pi(a, \widehat{\theta}_A)g^A(a)da.$$

Notice that in this case the only uncertainty is about the ability to show in court that there was no access. The degree of overlap, $\widehat{\theta}_A$, will be set by the composer optimally solving

$$\widehat{\theta}_A = \arg\min_\theta \int_a s\Pi(a, \theta)g^A(a)da + c(1 - \theta). \tag{1}$$

By increasing the overlap between the original song and the new composition, the composer reduces her composition costs. At the same time, this affects the likelihood that sanctions will be imposed. The optimal level of copying trades-off these two effects.

3.2   Joint surplus and efficient outcomes

The ex-post (after composition) joint surplus added by an independent composition with overlap θ_I is equal to $b - h(\theta_I) - c$ whereas the ex-post surplus generated by a composer with access that copies $\widehat{\theta}_A$ is $b - h(\widehat{\theta}_A) - c(1 - \widehat{\theta}_A)$.

The ex-ante surplus considers the expected value derived from the two types of composers, as well as the effect of the sanctions on entry:

$$W = \gamma \int_{E(s\Pi(a,\theta)|I)+c}^{\infty} \int_0^1 (b - h(\theta) - c) \, f(\theta)\phi(b)d\theta db$$
$$+ (1 - \gamma) \int_{E(s\Pi(a,\widehat{\theta}_A)|A)+c(1-\widehat{\theta}_A)}^{\infty} \left(b - h(\widehat{\theta}_A) - c(1 - \widehat{\theta}_A) \right) \phi(b)db$$

where $\widehat{\theta}_A$ is chosen by the composers with access according to (1).

Maximization of W is the typical welfare objective in models of law enforcement (Kaplow, 2011), as well as in the literature of contracting with externalities (Segal, 1999). More specifically, W captures the extra producer-surplus generated by the second-generation composer. The innovation literature has shown that this construct is crucial to isolate the effects of intellectual property on innovation incentives

in a cumulative setting (Green and Scotchmer, 1995; Llobet et al, 2006). Relative to total welfare, W does not consider static monopoly costs as well as the creation incentives of the original composer. Abstracting away from product market distortions and first-generation investment is natural in our setting, as copyright cases typically focus on the behavior of alleged infringers and the division of profits between the litigants.[4] I will discuss the incentives of first generation composers in Section 4.4, and consumer welfare in Section 3.3 below. Following Segal (1999), I refer to levels of copy and entry that maximize W as 'efficient'.

In the remainder of this section, I describe three conditions required to achieve the efficient outcome. The surplus generated by an independent creation can be re-written as

$$W^I = \int_{E(s\Pi(a,\theta)|I)+c}^{\infty} (b - H - c)\,\phi(b)db$$

where

$$H = \int_0^1 h(\theta)f(\theta)d\theta$$

is the expected harm generated by independent discovery. Notice that entry is below (above) the efficient level if $E(s\Pi(a,\theta)|I) > (<)H$ as the expected sanctions are larger (smaller) than the externality generated. This leads to the first condition required for efficiency:

$$E(s\Pi(a,\theta)|I) = H. \tag{2}$$

The ex-post surplus generated by a creator with access is maximized at

$$\theta^* = \arg\max_\theta b - h(\theta) - c(1-\theta).$$

For most of the analysis, I will assume that $\theta^* \in\ ]0,1[$ so that surplus is maximized with some level of copying, but not complete duplication. The second condition required to maximize W is that the sanctioning rule implements the optimal level of copying:

$$\widehat{\theta}_A = \theta^*. \tag{3}$$

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[4] A similar approach was taken by Schankerman and Scotchmer (2001) in their theoretical analysis of doctrines of patent damages.

Finally, entry of composers with access that copy θ^* will be optimal if only those with

$$b \geq h(\theta^*) + c(1 - \theta^*)$$

compose. This gives the final condition required for an efficient outcome:

$$E(s\Pi(a, \theta^*)|A) = h(\theta^*). \tag{4}$$

3.3 Discussion

My setup builds heavily on the law and economics literature where canonical models of litigation focus on the difference between the individual benefits of committing an act and its external harm, $b - h - c$ (Kaplow, 2011; Siegel and Strulovici, 2022). My setting extends the canonical setup in two dimensions. First, in my model both types of defendants may generate harm ex-post but differ in their ex-ante incentives. Informed (type A) agents commit harmful acts voluntarily and uninformed (type I) agents commit harmful acts accidentally. Second, my setting allows the level of harm generated by the informed types to be chosen strategically, with a reduction in harm leading to an increase in the cost of obtaining private benefits. Below, I provide a discussion of the interpretation of the model and its key assumptions.

Microfoundation. On top of the law and economics interpretation, one can also map the model to a simple industrial organization setting. Let us assume a large pool of consumers with heterogeneous valuations for songs. Each consumer may value or not a song, in the case of positive value the consumer's valuation is set equal to 1. Let us assume that a mass of consumers of measure 1 values the original song. When a new song with overlap θ is composed, a mass $h(\theta)$ of these consumers learns that they value both the old and the new song, whereas the remaining $1 - h(\theta)$ will continue to value only the old song. Moreover, a mass b of the consumers that do not value the original song will value the new song. Under the assumption of Bertrand competition and first-degree price discrimination, the profits of the original composer in the absence of a new song are equal to $\pi_{or}(\theta) = 1$. After the composition of the new song they are $\pi_{or}(\theta) = 1 - h(\theta)$. For the composer of the new song with overlap θ profits are $\pi_{new}(\theta) = b - c(1 - \theta)$ or $\pi_{new}(\theta) = b - c$ depending on whether there is access or not.

Under this simple micro-foundation, the extra-profits generated by the new song are equal to

$\pi_{new}(\theta) + \pi_{or}(0) - \pi_{or}(\theta) = b - c(1-\theta) - h(\theta)$ (or $b - c - h(\theta)$ in the case of independent composition). Notice that the difference between private benefits and harm has the familiar structure of the change in joint profits, which is central to cumulative innovation models a la Green and Scotchmer (1995). Moreover the resulting harm function $h(\theta) = \pi_{or}(0) - \pi_{or}(\theta)$ is consistent with the lost profit doctrine, as transferring $h(\theta)$ to the original composer would restore them to the position 'but for' the infringement (Schankerman and Scotchmer, 2001).

Additional effects of copying. While the model is consistent with the simple micro-foundation presented above, it is important to notice that the analysis relies on the assumptions that copying affects the composition costs of follow-on composers but not their revenues, and that the harm function $h(\theta)$ does not depend on b. It is easy to extend the setting to the case in which θ affects linearly not only the cost but also the revenue of the follow-on composer. This is because $b + \beta\theta - c(1-\theta)$ can be rewritten as $b - c + \tilde{c}\theta$ where $\tilde{c} = \beta + c$.

Less straightforward is to consider the case in which the harm depends both on b and θ, i.e. $h(b,\theta)$. A micro-foundation of this loss function would require a model of duopolistic competition with horizontal and vertical differentiation. These models typically generate a large taxonomy of cases, which make them unsuited to be embedded in a judicial mechanism design problem.

More generally, considering harm functions increasing in b and θ, such as $bh(\theta)$, would lead to optimal cutoffs which are decreasing in b. Intuitively, the planner is more lenient with composers with low b as their copying generates minimal externality while reducing composition costs. Under several parameterizations, there is never excess entry by composers with access. At the same time, it is not clear whether a multiplicative approach is appropriate to model the externality generated by copying in the music industry. As I show in the quantitative analysis of Section 6, the evidence that compositions with large b generate large profit losses is limited.

Consumer welfare. Following the law and economics and contracting with externalities literatures, my framework examines the impact of the actions of the follow-on composer on joint surplus. This definition of welfare is close to the typical objective of the courts, as it focuses on the loss sustained by

right-holders and on the damages required to compensate the harm generated. Section 4.4 extends the framework to include the composition incentives of first-generation composers. Entry and copy decisions may also impact consumer welfare. Their effects will depend on consumer preferences for variety and on the competitive interaction between the two composers. Moreover, the market power generated by copyright may create a temporary deadweight loss, with an increase in consumer surplus at the time of copyright expiration.

In my setting, one may expect composers of new songs not to appropriate all the social benefits generated by their work. Similarly, in the absence of pronounced preferences for variety, the loss sustained by the original composer is likely to exceed the social loss generated by entry and copy, as price competition may increase consumer surplus. In this respect, considering consumer welfare is likely to lead to optimal levels of overlap and entry that are larger than those characterized under maximization of joint surplus. This has implications for the quantitative exercise presented in Section 6 that shows that the damages awarded in a leading case exceeds those required to implement the efficient outcome. The difference with the socially optimal damages is likely to be even larger if we include consumers in the welfare calculation.

4 Sanctioning rules

I now turn my analysis to examining several sanctioning rules used by U.S. courts. I begin with a discussion of the independent creation defense. I then examine inverse ratio sanctioning rules and extend the model to consider the incentives of the original composer and non-statutory damages.

4.1 The independent creation defense

Following Kaplow (2011), I assume that sanctioning rules, $\Pi(a, \theta)$, are based on evidence thresholds which implies that sanctions are applied only if the values of a and θ exceed specific cutoffs. My model departs from Kaplow (2011) as courts observe two distinct signals rather than a unidimensional signal. At the same time, my setting accommodates sanctioning rules which only rely on one signal. In

particular, I define the *similarity-only rule* as the following scheme

$$\Pi(a,\theta) = r(\underline{\theta}) = \begin{cases} 1 \text{ if } \theta > \underline{\theta} \\ 0 \text{ if } \theta \leq \underline{\theta} \end{cases}$$

where sanctions are imposed if θ exceeds $\underline{\theta}$ independently on a. A natural extension of the above sanctioning rule to two signals is the *two-cutoff rule,* which I define as

$$\Pi(a,\theta) = R(\underline{\theta},\underline{a}) = \begin{cases} 1 \text{ if } \theta > \underline{\theta} \text{ and } a > \underline{a} \\ 0 \text{ else} \end{cases}$$

where sanctions are imposed only if both the evidence of similarity and access exceed their specific thresholds. Relative to similarity-only rules, two-cutoff rules do not impose damages on creators when the evidence of access is limited. This property is consistent with the independent creation defense.

Notice that $R(\underline{\theta},\underline{a})$ implies an expected sanction for independent composers equal to:

$$E(sR(\underline{\theta},\underline{a})|I)) = s\int_{\underline{a}}^{1}\int_{\underline{\theta}}^{1} g^I(a)f(\theta)dad\theta$$

$$= s(1 - F(\underline{\theta}))(1 - G^I(\underline{a})).$$

I indicate with $p^I(\underline{a}) = 1 - G^I(\underline{a})$ the probability that the evidence for access exceeds its threshold and with $\delta(\underline{\theta}) = 1 - F(\underline{\theta})$ the probability that the evidence of similarity exceeds its threshold. Independent composition takes place if

$$b \geq sp^I(\underline{a})\delta(\underline{\theta}) + c$$

and the surplus generated by independent creation is:

$$W^I = \int_{sp^I(\underline{a})\delta(\underline{\theta})+c}^{\infty} (b - H - c)\,\phi(b)db.$$

A composer with access will choose $\widehat{\theta}_A$ optimally given that the sanction she faces is equal to

$$E(sR(\underline{\theta},\underline{a})|A) = \begin{cases} sp^A(\underline{a}) \text{ if } \widehat{\theta}_A > \underline{\theta} \\ 0 \text{ if } \widehat{\theta}_A \leq \underline{\theta} \end{cases}.$$

Under this sanctioning scheme, the composer with access faces the choice of fully copying the song or limiting the copy at $\underline{\theta}$. Any level of copying below $\underline{\theta}$ and 1 is not optimal as it can be increased without cost. The choice of the composer will depend on whether $b - sp^A(\underline{a})$ exceeds $b - c(1 - \underline{\theta})$. In other words

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$\widehat{\theta}_A$ will be equal to 1 if $sp^A(\underline{a}) \leq c(1 - \underline{\theta})$ and will be equal to $\underline{\theta}$ if $sp^A(\underline{a}) > c(1 - \underline{\theta})$. New songs will be created if $b - \min\left\{sp^A(\underline{a}), c(1 - \underline{\theta})\right\} \geq 0$ with corresponding surplus

$$W^A = \begin{cases} \int_{sp^A(\underline{a})}^{\infty} \left(b - h(1)\right) \phi(b)db & \text{if} \quad sp^A(\underline{a}) \leq c(1 - \underline{\theta}) \\ \int_{c(1-\underline{\theta})}^{\infty} \left(b - h(\underline{\theta}) - c(1 - \underline{\theta})\right) \phi(b)db & \text{if} \quad sp^A(\underline{a}) > c(1 - \underline{\theta}). \end{cases}$$

I will refer to the case in which $sp^A(\underline{a}) > c(1 - \underline{\theta})$ as *deterring sanctions*, as in the other case the composer fully copies the original composition.[5] I am now ready to state my first result.

Proposition 1 *For any $\underline{\theta}$ such that $s > \max\left\{c(1 - \underline{\theta}); H/\delta(\underline{\theta})\right\}$, then there is an $\underline{a} > 0$ such that $R(\underline{\theta}, \underline{a})$ generates higher joint surplus than $r(\underline{\theta})$.*

Proof. To begin, notice that with $r(\underline{\theta})$ there is too little entry by independent composers as $s\delta(\underline{\theta}) > H$ and sanctions are deterring full copy by the composer with access as $s > c(1 - \underline{\theta})$. Now take any $\underline{a} > 0$ such that $sp^I(\underline{a})\delta(\underline{\theta}) > H$ and $sp^A(\underline{a}) > c(1 - \underline{\theta})$. The fact that $p^I(0) = p^A(0) = 1$ and the continuity of $G^i s$ imply that such $\underline{a}$ exists. This will increase entry of independent composers as $p^I(\underline{a}) < 1$ which increases surplus. At the same time this will not affect the behavior of composers with access as the sanction is still deterring. ∎

A key feature of the model is that the externality generated by copying only depends on θ and not on whether the composer has access or not. This may give the impression that similarity-only sanction rules $r(\theta)$ may be as effective as $R(\theta, \underline{a})$. The above proposition shows that this is not the case when statutory damages are large enough. The intuition for this result is that when sanctions are large enough to be deterring, only independent composers will be found infringing and required to pay s. While this property is useful to discipline the creator with access and avoid a complete copy of the original composition, it may discourage entry by independent composers. By conditioning the sanction not only on similarity but also on the evidence of access the two-cutoff rule increases innovation incentives for independent creator, as s will be paid will lower probability. This increases joint surplus. The proposition shows that this can be done without affecting the behavior of composers with access.

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[5]The observed θ provides information about the type of composer, as $\theta > \underline{\theta}$ only for independent composers when sanctions are deterring. At the same time, it is important to notice that if the court would use this information and be more lenient when the observed θ is high, this would induce composers with access to mimic independent composers and copy more. Section 5 takes these information revelation issues into account with a mechanism design analysis.

The result in Proposition 1 provides a new economic rationale for the independent creation defence in copyright law. Maurer and Scotchmer (2002) show that in the case of patents the independent invention defence can induce greater licensing of the technology and lower market prices. They also show that it can generate ex-ante reluctance to enter a patent race, which reduces the duplication of R&D costs. My analysis points to a different rationale for independent invention defence, which applies to patents and copyrights alike. The innovation incentives for inventors with knowledge of the prior art differ from those without knowledge, so the independent invention defence is beneficial because it allows for a differential policy treatment of these two groups of innovators.

The key requirement for an increase in surplus is that statutory damages, s, are large enough that similarity only rules deter full copy by the composers with access and lead to less than efficient entry by independent composers. Intuitively, in this situation the independent creation defense can reduce the expected damages for fortuitous infringement without changing the behavior of composers with access. An implication of this is that two-cutoff rules may actually reduce surplus in the case in which sanctions are too low, and generate excess entry by independent composers. Specifically, when $H/\delta(\underline{\theta}) > s$ independent creators pay damages very rarely even with $r(\underline{\theta})$, and their expected payment does not compensate the expected externality they create. In this case, two-cutoff rules will exacerbate excess entry and reduce the surplus generated by these composers. This leads to an unambiguous decrease in surplus if the behavior of the independent creators does not change. The following proposition makes this point more formally.

Proposition 2 *For any $\underline{\theta}$ such that $H/\delta(\underline{\theta}) > s > c(1-\underline{\theta})$, then replacing $r(\underline{\theta})$ with $R(\underline{\theta}, \underline{a})$ where $\underline{a} > 0$ has an ambiguous effect on joint surplus. Joint surplus decreases if sanctions deter full copy.*

Proof. $H/\delta(\underline{\theta}) > s$ implies excessive entry by independent composers. With $R(\underline{\theta}, \underline{a})$ inefficient entry by independent composers will increase as expected sanctions become $sp^I(\underline{a})\delta(\underline{\theta})$. With $r(\underline{\theta})$ sanctions are deterring full copy by the composer with access as $s > c(1-\underline{\theta})$. If $sp^A(\underline{a}) > c(1-\underline{\theta})$ there will be no change in the behavior of composers with access as the sanction is still deterring. This implies that joint surplus decreases. If $sp^A(\underline{a}) \leq c(1-\underline{\theta})$ sanctions are no longer deterring and $\widehat{\theta}_A = 1$. Entry by composers with access increases, which may have a positive impact on joint surplus if $c(1-\underline{\theta}) > h(1) - h(\underline{\theta})$. ∎

4.2   Second best with two-cutoff rules

Above I showed that, when damages are large enough, two-cutoff rules perform better than similarity only rules. The next result shows that, despite this property, they cannot implement the efficient outcome.

Proposition 3 *Two-cutoff rules cannot implement the efficient outcome.*

Proof. When sanctions are not deterring, the optimal outcome is not achieved as $\widehat{\theta}_A = 1 > \theta^*$. Consider now the case of deterring sanctions and $\underline{\theta} = \theta^*$ so that condition (3) is satisfied. Notice that condition (4) cannot hold because with deterring sanctions we have that $E(sR(\underline{\theta}, \underline{a})|A) = 0 < h(\theta^*)$. ∎

The result highlights a key limitation of two-cutoff rules in disciplining the behavior of composers with access. The rule can induce the optimal level of copying by setting $\underline{\theta} = \theta^*$ but no sanctions will be imposed on the composer, which implies that entry is above the efficient level as it takes place when $b \geq c(1 - \theta^*)$ rather than $b \geq h(\theta^*) + c(1 - \theta^*)$.

I now look at the case in which a policy maker can set $\underline{\theta}, \underline{a}$ and s and ask what the optimal policy is in this case. To develop some intuition, notice that with deterring sanctions an increase in $\underline{\theta}$ has an ambiguous effect on the surplus generated by a creator with access:

$$
\begin{aligned}
\frac{dW^A}{d\underline{\theta}} &= c\left(c(1 - \underline{\theta}) - h(\underline{\theta}) - c(1 - \underline{\theta})\right)\phi(c(1 - \underline{\theta})) \\
&\quad + \int_{c(1-\underline{\theta})}^{\infty} (-h'(\underline{\theta}) + c)\phi(b)db \\
&= -ch(\underline{\theta})\phi(c(1 - \underline{\theta})) + (c - h'(\underline{\theta}))(1 - \Phi(c(1 - \underline{\theta}))) \gtrless 0.
\end{aligned}
\tag{5}
$$

There are two opposite effects. Higher overlap thresholds lead to more compositions as composers copy more of the original song and this reduces entry costs. At the same time, the new songs have higher overlap, which reduces the joint surplus. Notice that the first part of the equation is negative, which implies that joint surplus is maximized when $c > h'(\underline{\theta})$. The idea is that the planner needs to be harsher with inframarginal creators relative to the efficient level to avoid excessive entry of creators with low levels of b. This is required because deterring two-cutoff schemes induce excess entry of composers with

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access if $\underline{\theta} = \theta^*$. Setting $\underline{\theta} < \theta^*$ increases the entry cost for composers with access, which reduces their propensity to enter. The next result provides a sufficient condition under which the two-step sanctioning scheme leads to optimal behavior by independent composers.

Proposition 4 *If the likelihood ratio $\frac{g^A(a)}{g^I(a)}$ is monotone increasing and unbounded, the second best two-cutoff policy features $\underline{\theta} < \theta^*$ and optimal entry by independent composers.*

Proof. The proof is in Appendix 1. ∎

The assumption of unbounded monotone likelihood ratio property (MLPR) guarantees the existence of a deterring sanctioning scheme that implements efficient behavior by the independent creator and (5) holds with equality. Intuitively, optimal behavior by the independent composer occurs when $sp^I(\underline{a})\delta(\underline{\theta}) - H = 0$. This can be implemented by multiple pairs of $(s, \underline{a})$ as an increase in $\underline{a}$ can be compensated by an increase in s. The unbounded nature of the MLRP assures that for levels of $\underline{a}$ that are large enough, one can find sanctions that are large enough to deter informed composers from copying more than $\underline{\theta}$.

The assumption of strict MLRP is common in the literature and implies that as the observed signal a gets higher, the inferred likelihood that the composer is of type I declines. The assumption that MLRP is unbounded is satisfied when the support for a is $\mathbb{R}$. More generally, this assumption implies that signals are unboundedly informative so that sufficiently high signals provide very strong news about access. The unboundedness assumption is used in the observational learning (Smith and Sorensen, 2000), bargaining (Wolitzky, 2023) and reputation building (Pei, 2022) literatures. In my case, the unbounded nature of MLRP is sufficient, and simplifies the proof of the proposition, but it is not necessary and it may be replaced with a weaker condition requiring the upper limit of $p^A(\underline{a})/p^I(\underline{a})$ to be large enough.

4.3 Inverse ratio sanctioning rules

This section examines 'inverse ratio' (IR) sanctioning rules. These are sanctioning schemes for which *"the stronger the evidence of access, the less compelling the similarities between the two works need be in order to give rise to an inference of copying"* (Rentmeester, 883 F.3d). I begin with a simple extension

of the two-cutoff sanctioning rule examined above:

$$IR(\overline{\theta}, \underline{\theta}, \overline{a}, \underline{a}) = \begin{cases} 1 \text{ if } a > \overline{a} \text{ and } \theta > \underline{\theta} \\ 1 \text{ if } \underline{a} < a \leq \overline{a} \text{ and } \theta > \overline{\theta} \\ 0 \text{ else} \end{cases}$$

where $\overline{\theta} > \underline{\theta}$ and $\overline{a} > \underline{a}$. This scheme adds two cutoffs, and requires higher similarity when evidence of access is weak. For simplicity, let us consider the case in which $\underline{a} = 0$. A composer with access will choose $\widehat{\theta}_A$ optimally given that the sanction she faces is equal to

$$E(sIR(\overline{\theta}, \underline{\theta}, \overline{a}, 0)|A) = \begin{cases} 0 \text{ if } \widehat{\theta}_A \leq \underline{\theta} \\ s(1 - G^A(\overline{a})) \text{ if } \widehat{\theta}_A \in \,]\underline{\theta}, \overline{\theta}] \\ s \text{ if } \widehat{\theta}_A > \overline{\theta}. \end{cases}$$

The creator with access will choose to copy $\overline{\theta}$ if $b - sp^A(\overline{a}) - c(1 - \overline{\theta}) \geq \max\{b - s; b - c(1 - \underline{\theta})\}$. This implies that by setting $\overline{\theta} = \theta^*$ the planner can implement the optimal level of copying by the composer with access as long as the following condition is satisfied:

$$\frac{s(1 - p^A(\overline{a}))}{1 - \theta^*} \geq c \geq \frac{sp^A(\overline{a})}{\theta^* - \underline{\theta}}. \tag{6}$$

Moreover, there will be efficient entry by composers with access if

$$s = \frac{h(\theta^*)}{p^A(\overline{a})}. \tag{7}$$

Consider now the uninformed independent composer. The expected sanction for the independent composer will be

$$E(sIR(\overline{\theta}, \underline{\theta}, \overline{a}, 0)|I) = sp^I(\overline{a})\delta(\underline{\theta}) + s(1 - p^I(\overline{a}))\delta(\theta^*).$$

The condition for efficient entry is $E(sIR(\overline{\theta}, \underline{\theta}, \overline{a}, 0)|I) = H$ which requires

$$s = \frac{H}{p^I(\overline{a})\delta(\underline{\theta}) + (1 - p^I(\overline{a}))\delta(\theta^*)}.$$

Together the conditions for the efficient entry of the two types of composers combine to

$$\frac{h(\theta^*)}{p^A(\overline{a})} = \frac{H}{p^I(\overline{a})\delta(\underline{\theta}) + (1 - p^I(\overline{a}))\delta(\theta^*)}. \tag{8}$$

The above discussion leads to the following result.

Proposition 5 *The sanctioning rule $IR(\overline{\theta}, \underline{\theta}, \overline{a}, 0)$ implements the efficient outcome if conditions (6), (7) and (8) are satisfied.*

This result is in stark contrast with the impossibility of first best obtained for the two-cutoff rule. The key insight is that with two-cutoff sanctioning rules the only way to implement the optimal level of copying is to have no sanctions imposed on the informed composer in equilibrium. This induces excess entry. In contrast, the IR rule provides the flexibility to the court of imposing sanctions to the creators with access even when their level of copying is optimal, which can correct excessive entry.

The above discussion indicates that, under conditions (6)-(8), IR schemes can attain efficiency which implies that they can generate greater joint surplus than simpler two-cutoff rules. I now ask the question of whether IR rules preform better than two-cutoff schemes more generally. The next proposition shows that, under unbounded MLRP, this is the case, as the optimal second-best two-cutoff scheme can be improved by a slight perturbation which generates an IR scheme.

Proposition 6 *Suppose $\frac{g^A(a)}{g^I(a)}$ is monotone increasing and unbounded. Then, there is a inverse ratio sanctioning scheme that generates more surplus than the second best two-cutoff sanctioning scheme.*

Proof. The proof is in Appendix 1. ∎

The intuition for this result is the following. A property of two-cutoff rules with deterring sanctions is that informed composers copy up to the maximum level for which they face no sanctions. This leads to excessive entry, as they do not internalize the externality they generate. The proposition shows that one can perturbate the second best two-cutoff rule to generate an IR rule in which composers with access perceive a small positive expected sanction when they copy at the level of the second best policy. The perturbation is small enough such that the amount of copying conditional on entry does not change relative to the second best two-cutoff rule. At the same time, at the extensive margin, some of the composers with access will no longer find profitable to enter given the expected sanction, and this increases welfare by reducing excessive entry. The proof also shows that the perturbation can be constructed in a way that does not change the expected sanctions for independent composers, and thus does not affect their behavior relative to the second best two-cutoff rule.

There are two important implications that arise from this result. The first is that inverse ratio rules may provide greater flexibility to discipline the behavior of composers with access. The second implication relates to the level of damages that should be awarded in the two regimes. To provide some intuition, Figure 1 shows a graphical example of a two-cutoff rule and of an IR rule. Notice that the IR rule increases the likelihood that independent composers are sanctioned. Specifically, the figure suggests that when the behavior of courts does not change when evidence of access is not strong ($a < \bar{a}$), switching from a two-cutoff rule to an IR rule increases the expected sanctions for independent composers. To avoid reducing their composition incentives relative to the two-cutoff rule, the IR rule requires lower sanction levels (lower s), or more leniency in the case of lower evidence of access (increase in $\underline{a}$). I will provide an additional discussion of this propensity of inverse ratio rules to 'overpunish' in Section 6.

4.4   Incentives of first generation composers

Thus far, my analysis has only considered the composition incentives of follow-on composers. This is consistent with the typical approach in the law and economics literature, which focuses on the effect of judicial rules on the incentives to commit harmful acts. In the context of intellectual property, one may expect copyright enforcement to also affect the composition incentives of the original composer. Indeed, in standard cumulative innovation models a la Green and Scotchmer (1995), first generation innovators tend to benefit from stronger intellectual property rights. It is possible to extend the model to consider the effect of copyright enforcement on first generation composers. In particular, we can assume that independent composers are first generation composers, and that they take into account both the possibility of unintentionally infringing someone else's copyright, and the possibility that follow-on composers will infringe their copyrights.

To facilitate the intuition, let us assume that composers with access behave efficiently, so that $\widehat{\theta}_A = \theta^*$ and their entry occurs only if $b \geq \underline{b}^A = h(\theta^*) + c(1 - \theta^*)$. As I show in Section 5, the optimal mechanism implements this behavior. In this extended model, independent composers behave efficiently if

$$b - H - c + (1 - \gamma)(1 - \Phi(\underline{b}^A))c\theta^* > 0.$$

As in the baseline setting, the formula indicates that the benefits generated by the composition, b,

need to exceed the composition cost, c, and the externality created by inadvertent infringement, H. The extra term $(1-\gamma)(1-\Phi(\underline{b}^A))c\theta^*$ captures the positive externality that independent composers generate by facilitating composition by second generation composers with access. Let us call $\underline{b}^I$ the efficient entry threshold for independent composers in this extended model. Notice that $\underline{b}^I$ is lower than the threshold of the baseline model as entry by independent composers with low values of b may become efficient once we take into account their beneficial effect on follow-on composers.

From a private perspective, independent composers find profitable to compose if

$$b - E(s\Pi(a,\theta)|I) - c - (1-\gamma)(1-\Phi(\underline{b}^A))h(\theta^*) - \gamma(1-\Phi(\underline{b}^I))H +$$

$$(1-\gamma)(1-\Phi(\underline{b}^A))E(s\Pi(a,\theta^*)|A) + \gamma(1-\Phi(\underline{b}^I))E(s\Pi(a,\theta)|I).$$

In this extended formulation, independent composers consider not only the damages that they are expected to pay for inadvertent infringement, $E(s\Pi(a,\theta)|I)$, but also the harm that follow-on composers cause them, and the damages that they will receive as compensation. Notice how the damages have two opposite effects on composition incentives of independent composers. On one hand, higher damages increase the incentives to compose, as they increase the transfers obtained from infringing follow-on composers. On the other hand, higher $E(s\Pi(a,\theta)|I)$ reduces innovation incentives as it increases the damages paid in the case of inadvertent infringement.

In the optimal mechanism described in Section 5, the damages paid by composers with access fully compensate their externality, i.e. $E(s\Pi(a,\theta^*)|A) = h(\theta^*)$. Focusing on this case, it is possible to see that efficient entry can be implemented by setting

$$E(s\Pi(a,\theta)|I) = H - \frac{(1-\gamma)(1-\Phi(\underline{b}^A))}{1-\gamma(1-\Phi(\underline{b}^I))}c\theta^*.$$

The above formula shows that in a cumulative innovation setting the damages required to implement the efficient behavior by independent composers are lower than H. This implies that the 'discouragement effect' due to unintentional infringement dominates the 'encouragement effect' of the transfers from follow-on generations.

This finding relates to the literature on 'patent thickets', which are technology areas in which the number of granted patents is very large and firms face high risk of unintentionally infringement (Galasso

and Schankerman, 2010; 2015). Several scholars, including Shapiro (2001), have argued that in these settings stronger patent rights may slow-down rather than encourage innovation. My model emphasizes that similar forces may be at play with copyrights, where uncertainty over existing rights is substantial and the risk of unintentional infringement likely exceeds the one faced by most patentees.

4.5 Non-statutory damages

The previous analysis has focused on the case in which an infringer pays statutory damages, which are pre-specified by the law rather than calculated based on the harm to the plaintiff. While statutory damages are common in copyright litigation, a plaintiff in an infringement action may opt for actual damages suffered as a result of the infringement. Specifically, 17 U.S. Code § 504, states that "*the copyright owner is entitled to recover the actual damages suffered by him or her as a result of the infringement, and any profits of the infringer that are attributable to the infringement and are not taken into account in computing the actual damages.*" Law scholars have noticed how these guidelines are quite vague and that, in practice, it is very challenging to determine the precise amount of profits lost by the copyright holder because of the infringing activity and the fraction of the infringer profits due to the infringing activity (Bell and Parchomovsky, 2019). Typically this is established through expert testimony, where damages are computed as a percentage of the revenue generated by the infringing song. For example, in the case *Pharrell Williams, et al. v. Bridgeport Music, et al. (C.D. Cal. Dec. 2, 2015)* monetary damages were calculated as "*the percentage of the new musical composition that the owner of the older composition should receive for the use.*"

In the context of my model, the extra-surplus generated by a new song with overlap θ by a composer with access relative to a new song with zero overlap is equal to $-h(\theta) + c\theta$. A natural interpretation of this formula is that the welfare change generated by copying is a combination of the loss in profits by the original composer $(-h(\theta))$ and the cost saving $(c\theta)$ experienced by the infringer with access. This discussion illustrates the tension between the externality generated by infringement and the common approach used by courts of specifying monetary damages as a fraction of b, which is centered around the idea that copyright holders should be compensated for lost licensing revenues they would have received in the case of pre-release licensing. There are a number of problems with the focus on lost royalties.

First, as discussed in Scotchmer and Schankerman (2001) it is natural to expect market royalties to depend on the expected damages faced in the case of litigation. If, in addition, damages are themselves determined by the expected royalties, the doctrine involves a circularity, with the consequence that a whole range of damages consistent with it (i.e., the game display a large multiplicity of equilibria). Moreover, pre-release licensing deals will also vary depending on the bargaining power of the two parties, which is conceptually distinct from the actual harm generated by the infringement.[6] In this respect, an important implication of my model is that the appropriate approach to determine actual damages is to rely on profit changes $(h(\theta))$ and cost savings $(c\theta)$ rather than on potential licensing counterfactuals.

Notwithstanding the above discussion, one can introduce actual damages in the model by replacing the fixed damage awards, s, with the payment of a fraction of the creator's revenue, $b\tau$. The policy parameter in this case becomes $\tau > 0$. In Appendix 2 I show that the main results presented above are robust to using this alternative form of damages. Intuitively, one can pin down values of τ for which the marginal entrants are the same as in the case of statutory damages s. At the intensive margin, damages equal to $b\tau$ may not be deterring for small values of b. Therefore, to focus on the case of deterring sanctions, we need to assume the existence of a positive lower bound for the infringer revenue, which I label $\underline{b} > 0$. This assumption is natural in my setting as, in practice, plaintiffs select statutory damages when the revenue generated by the infringing composition is small. Despite the different damage functions, rules relying both on access and overlap tend to be superior to those only consider composition similarity, especially when the damages are large fraction of infringer's profits. Moreover, inverse ratio rules appear superior to rules relying on fixed thresholds especially when the informative power of the access signal is high.

5   Optimal judicial mechanisms

Thus far, I used the model to examine the properties of sentencing schemes commonly used by U.S. courts. In this section, I depart from common judicial rules and explore the properties of rules maximiz-

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[6] For example, if the new creator has full bargaining power and negotiation takes place after the song has been created, one may expect a licensing deals in which the copyright holder is only compensated for its lost profits $h(\theta)$ and the new composer appropriates the remaining surplus. If, instead, the bargaining power is entirely on the side of the copyright holder, the licensing deal would lead to full surplus extraction by the original composer.

ing joint surplus. Specifically, I propose a mechanism design approach and model copyright litigation as a direct-revelation mechanism in which the defendant reports whether she had access or not to the original song. The mechanism maps the signals regarding access and overlap and the defendant report to a judgement.

To conduct this exercise, I indicate with $t \in \{I, A\}$ the defendant's type and with $\widehat{t} \in \left\{\widehat{I}, \widehat{A}\right\}$ the report about her type. Following Siegel and Strulovici (2022), I consider direct revelation judicial mechanisms using sentencing schemes $S : (a, \theta, \widehat{t}) \rightarrow S(a, \theta, \widehat{t})$ which map the access signal, the degree of overlap and the defendant's report into a lottery over the available sanctions. As for possible damage awards, Siegel and Strulovici (2022) consider a continuum interval $s \in [0, \bar{s}]$. As I discussed in Section 3, in my setting the optimal mechanism would be trivial under this assumption as the court would set $s(\theta) = h(\theta)$ and implement the first best. To focus on a more interesting case, I assume a countable set of sanctions, $s \in \{0, s_1, s_2, ..., s_N\}$ with $s_N > s_{N-1} > ... > s_1 > 0$, which can be chosen by the court. This is consistent with the idea of designing a set of statutory damages, which provides some discretion on whether to award harsher or lesser penalties. Moreover, as I will discuss below, focusing on mechanisms that rely on a small and finite set of sanctions is more in line with current policy discussions about the introduction of a system of compulsory licensing with statutory terms. Notice that I assume that the defendant cannot be rewarded by the mechanism which is consistent with the law and economics application (i.e., damages cannot be negative).

Consistently with the analysis in the previous sections, I assume that the distribution of access signals is not affected by the report $G^I_{\widehat{I}}(a) = G^I_{\widehat{A}}(a) = G^I(a)$ and $G^A_{\widehat{I}}(a) = G^A_{\widehat{A}}(a) = G^A(a)$. Similarly, I assume that the distribution of overlap for independent composers is not affected by the report $F_{\widehat{I}}(\theta) = F_{\widehat{A}}(\theta) = F(\theta)$. I also assume that submitting the report is costless.

A sentencing scheme is truthful if truth-telling is optimal for the defendant given S. This requires the following two conditions to be satisfied:

$$b - E(S(a, \theta, \widehat{t} = \widehat{I})|t = I) - c \geq b - E(S(a, \theta, \widehat{t} = \widehat{A})|t = I) - c \tag{9}$$

$$\max_{\theta} \left[b - E(S(a, \theta, \widehat{t} = \widehat{A})|t = A) - c(1 - \theta) \right] \geq \tag{10}$$
$$\max_{\theta} \left[b - E(S(a, \theta, \widehat{t} = \widehat{I})|t = A) - c(1 - \theta) \right].$$

These conditions ensure that independent composers do not prefer to report access, and that composers with access do not gain by reporting independent creation. My next result describes properties of the optimal mechanism.

Proposition 7 *If the likelihood ratio $\frac{g^A(a)}{g^I(a)}$ is monotone, increasing and unbounded, truthful sentencing schemes can achieve the efficient outcome. There is an optimal mechanism in which defendants with access copy θ^* and face a deterministic sanction $\underline{s} = h(\theta^*)$. The sanction for the independent creators is a step function of the access signal which jumps at some cutoff $\underline{a}$ from 0 to $\overline{s} = \frac{H}{p^I(\underline{a})}$.*

Proof. The proof is in Appendix 1. ∎

Intuitively, under the unbounded MLRP assumption, the court can set the burden of proof at a level which generates a large difference in the expected sanction for composers of type I and type A. In the case of reporting type I, defendants face a high sanction if the access signal exceeds a threshold. For independent composers the probability of conviction is very low, and it leads to the socially optimal expected sanction H. For composers with access reporting type I, the expected sanction is much higher which induces truthful reporting. Moreover, in the case of a report of type A and overlap below or equal to θ^*, the composer faces a non-stochastic judgement and payment equal to $h(\theta^*)$. This induces optimal overlap and entry decisions by composers with access.

Proposition 7 implies that the optimal judicial mechanism can be implemented by a system in which compulsory licenses are available and trials end in one of two verdicts. If the overlap between the compositions is relatively modest, the defendant revealing access can forgo the trial by entering a compulsory license. This resembles a plea bargain in criminal cases in which defendants pleading guilty receive lower sentences. Composers claiming independent creation face a trial, in which they may be acquitted or convicted, and pay high damages if the evidence of access is above a specific threshold. As in Siegel and Strulovici (2022), compulsory licensing, the binary verdict and the absence of damages following acquittal emerge as features of one of the optimal mechanisms and are not assumed elements of the judicial policy. More broadly, the fact that the optimal mechanism relies on the informative content of the access signal provides additional support to the idea that the independent creation defense is a valuable feature of copyright law.

A feature of the optimal mechanism is that it requires independent composers to pay high damages with some probability, even though there is complete separation between the two types. This feature, which is also shared by the optimal judicial mechanism developed by Siegel and Strulovici (2022), is in line with standard commitment assumption in the mechanism design literature and highlights the value of commitment in IP legal settings.[7]

While the optimal mechanism that I characterize resembles the one derived by Siegel and Strulovici (2022), it is important to notice the differences between their setting and the one of this paper. Siegel and Strulovici (2022) study an environment in which courts aim to punish guilty defendants and to avoid punishment for innocent defendants. In their model only guilty individuals can generate a social harm and, following a long standing tradition in the law and economics literature, they assume that courts minimize the sum of the expected social losses from type 1 errors and type 2 errors. My setting instead builds on the economics of innovation literature, which assumes that courts maximize surplus trading-off ex-ante composition incentives with ex-post welfare losses. Crucially, I assume that both types of composers generate the same externality in the case of identical composition overlap. The optimal sentencing scheme separates independent composers from those with access not because of pre-specified welfare losses from type 1 and type 2 errors, but because of the efficiency gains obtained from tailoring the sanctions to the composition incentives of the two group of composers.

The result provides support to the idea of extending the use of compulsory license in music copyright. Menell (2022) advocates for this approach, especially in the case of mash-up artists which overlay an instrumental track with a vocal track from a different recording. In the context of the mechanism described above, the cumulative creator (mash-up artist) would obtain a compulsory license from the copyright owner in the case she reveals the use of the copyrighted work and the overlap is not substantial. In the case of large overlap or when the cumulative creator claims independent creation, infringement will be assessed at a trial where damages awarded are potentially larger than the licensing fee.

Compulsory licensing or buyouts have been proposed in the economics of innovation literature as a mechanism to encourage cumulative innovation. In particular, Hopenhayn et al (2006) show that a

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[7]An important difference with models focused on the criminal justice system, is that in my model independent creators do generate negative externalities to the original composer, which implies that ex-post regret may be less of a concern in copyright litigation.

compulsory patent license scheme allows policy makers to provide heterogeneous rewards to innovations of different quality levels. My setting shows that compulsory licensing can also help to identify independent creators and to discipline the extent of intellectual property right infringement. For the case of digital remix, Gans (2015) shows that compulsory licensing in the form of 'remix rights' can be beneficial in many environments by reducing transaction costs between copyright holders and follow-on creators. The optimal mechanism derived above highlights a different 'screening' effect of compulsory licensing which emerges in a setting without negotiation between the two parties.

6   Quantitative analysis

In this section, I exploit a calibration of the model to evaluate the size of the damages awarded in a leading music infringement litigation case. I proceed in four steps. First, I develop a simplified version of the model which can be mapped to the empirical setting. Second, I use data on music copyright litigation to calibrate the frequencies of access and similarity signals. Third, I provide estimates of the harm generated by copyright infringement using music streaming data from Youtube and mechanical licensing terms. Finally, I compare the damages awarded by the court with those suggested by the calibrated model.

6.1   A simplified version of the model

Consider a simplified version of the model in which the signals of access and overlap are binary $a \in \{1, 0\}$ and $\theta \in \{0, 1\}$. I assume that $a = 1$ with probability p^I for independent creators and with probability $p^A > p^I$ for creators with access. For independent creators I assume that $\theta = 1$ with probability δ. The fraction of independent creators is equal to γ. I also assume that there is no harm without similarity, $h(0) = 0$, and that the harm is positive with overlap, $h(1) > 0$. I also assume that $c = 0$.

Consider a sample of cases in which the court uses a deterring two cut-off rule. Specifically, I assume that sanctions are avoided by the creator with access and paid by the independent creator only if $\theta = 1$ and $a = 1$. This implies that entry occurs for all creators with access. Let us call $\underline{b}$ the entry threshold for independent composers and $\widetilde{\gamma} \equiv \gamma(1 - \Phi(\underline{b}))$ the effective entry fraction of independent composers.

Let us indicate with $\psi(a = x, \theta = y)$ the fraction of sample cases in which signal a has value x and

signal θ has value y. For example, $\psi(a = 1, \theta = 1)$ is the fraction of cases in which the court finds both access and similarity. These fractions can be linked to the parameters of the model in the following way:

$$\delta p^I \widetilde{\gamma} = \psi(a = 1, \theta = 1)$$
$$\delta(1 - p^I)\widetilde{\gamma} = \psi(a = 0, \theta = 1) \tag{11}$$
$$(1 - \widetilde{\gamma})p^A + \widetilde{\gamma}(1 - \delta)p^I = \psi(a = 1, \theta = 0)$$
$$(1 - \widetilde{\gamma})(1 - p^A) + \widetilde{\gamma}(1 - \delta)(1 - p^I) = \psi(a = 0, \theta = 0).$$

Below, I will use data on the outcomes of copyright litigation cases to obtain empirical targets for ψ, and the use equations (11) to calibrate and estimate these parameters of the model. I will then use data on Youtube views and mechanical licensing terms to estimate $h(1)$.

6.2 Calibration of signal probabilities

The main source of data for music copyright cases is the private vendor LexMachina, a leading provider of legal analytics. The LexMachina data offer a complete coverage of US federal cases with one or more claims of copyright infringement (brought under 17 USC § 101) pending between 2009 and 2022. I identified cases involving disputes on music copyright by manually searching for litigation involving leading music companies (e.g. EMI, Sony, UMG...). I further identify cases in which court documents provide an assessment of substantial similarity between the compositions and of access (either in a case decision or in documents filed before settlement). I complement the Lex Machina data with the music copyright infringement case database provided by the George Washington University Law School, which allows me to include cases decided before 2009. LexMachina provides information on whether the plaintiff wins or not and, in the case in which infringement is found, the damages awarded.

I manually examined the documents associated to each case to identify whether the court found evidentiary basis for access or substantial similarity. In total, the sample includes 62 cases decided between 2000 and 2020. Focusing on cases litigated outside the 9th circuit (the circuit which typically uses inverse ratio rules), the data shows that in about 11 percent of the cases the court found the copyright infringed ($a = 1, \theta = 1$). Moreover, in roughly 7 percent of the cases the court found evidence

of substantial similarity but not evidence of access ($a = 0, \theta = 1$); in about 55 percent of the cases there is evidence of access but not of substantial similarity ($a = 1, \theta = 0$); and in approximately 27 percent of the cases there is neither evidence of access nor of similarity ($a = 0, \theta = 0$). I use these frequencies as empirical targets to be matched to their theoretical equivalents from the model described in (11).

Notice that the first two equations in (11) uniquely identify p^I, yielding a value of 0.61. At the same time, because the four equations are not linearly independent, I cannot uniquely identify all the parameters of the model. To obtain the estimates, I assign a value to p^A and recover δ and $\widetilde{\gamma}$ matching the empirical targets to the theoretical equivalents. To reduce the set of possible values, I also rely on the conditions that $p^A > p^I$ and that δ and $\widetilde{\gamma}$ are positive and less than 1. These are requirements are satisfied only when p^A is above 0.68. Table 1 presents the baseline parameter estimates in which I set $p^A = 0.75$. It also presents the value of the parameters for p^A ranging from 0.7 to 0.9 that I will use for robustness analysis.

6.3   Estimating infringement's harm

The next step requires the calibration of $h(\theta)$, which in the simplified set-up is assumed to be zero when $\theta = 0$. As I discussed in Section 3, a natural interpretation of $h(\theta)$ is the revenue lost by the original composer because of the infringing song.

I conduct the quantitative exercise focusing on a leading music infringement case: *Pharrell Williams, et al. v. Bridgeport Music, et al.* (C.D. Cal. Dec. 2, 2015). The case was initially decided by the Central District of California in 2015 then appealed in 2018. The dispute relates to the song *Blurred Lines* by Robin Thicke featuring rapper Pharrell Williams. The song was released in March 2013. The court found that the composition infringed the copyright of *Got to Give It Up*, a song by Marvin Gaye released in 1977. The court documents indicate a damage award of $3,188,527.50 which was computed as 50 percent of Blurred Lines publishing revenues.

Preliminary evidence: YouTube search trends

Ideally, to estimate the loss of profits one would like to track the sales of *Got to Give It Up* before and after the release of *Blurred Lines* and compare them with the counterfactual sales that would

have occurred in the absence of infringement. Because I do not have access to detailed data on sales, I construct a proxy for demand exploiting YouTube data. Specifically, the platform Google Trends provides information on YouTube searches over time from 2008 to present computing a monthly index of popularity of specific search terms on YouTube, which is normalized to 100 at the peak popularity month. To quantify the magnitude of the YouTube searches over time for *Got to Give It Up,* I collect information of the total views for the 5 YouTube videos of the song with the largest number of views (about 65 million views in total), and distribute these views over the period 2008-22 proportionally to the popularity indexes of YouTube searches.[8]

The next step is to construct similar measures of demand for a control group of songs, which are comparable to *Got to Give It Up* in terms of YouTube popularity levels and trends before 2013. To do this, I identified all the songs which featured as a top 5 hit in the Billboard Hot 100 chart in each week of 1977. *Got to Give It Up* featured in one of the top 5 positions for 7 weeks in 1977, together with 58 other songs listed as top 5 in the same year. These control songs include *Hotel California* by the Eagles, *Sir Duke* by Stevie Wonder, and *Dancing Queen* by ABBA. For each of these compositions, I construct a measure of YouTube searches over time with the same approach used for *Got to Give It Up.*

Figure 2 exploits the control sample to construct a synthetic version of *Got to Give It Up* using a data-driven procedure that aims to reproduce the counterfactual trajectory of YouTube searches in the absence of the release of *Blurred Lines* in 2013. This is done with the synthetic control method developed in Abadie et al. (2010). This empirical approach relies on identifying assumptions which are less demanding than those required for difference-in-differences analysis (Kleven et al, 2013).

Results are striking. There is no evidence of a decline in demand for Marvin Gaye's song after the release of *Blurred Lines* in March 2013. Conversely, YouTube searches increased substantially during the litigation. Interestingly, the two spikes in popularity appear to coincide with the date in which the case was filed (August 2013) and decided (December 2015).

Overall, the figure does not support the idea of lost profits because of infringement, if anything it suggests that $h(1)$ is negative in this case! This finding is consistent with accounts in the specialized

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[8]Cabral et al (2022) and Raj (2022) are two other recent papers which measure music demand using popularity on online platforms.

press, which described an increase in digital-sales in 2015 which led *Got to Give It Up* back on song charts. [9]

An alternative explanation for the finding is that the increase in YouTube searches may be driven by marketing investments made by the copyright holders of *Got to Give It Up* in conjunction with the lawsuit, rather than a positive externality from *Blurred Lines*. If this is the case, one may expect to find some evidence of a decline in sales in the short time window after the release of Thicke's song, as the effect of these reactive marketing investments may not be immediate. Figure 3 examines this possibility replicating the synthetic control analysis focusing on a shorter time window five months before and four months after the release of *Blurred Lines*. Here I find some weak evidence of a decline in YouTube searches for *Got to Give It Up* relative to its synthetic version. Below, I will exploit this decline in one of the approaches used to estimate $h(1)$. Because of the stark difference between the long and short term findings, this effect on YouTube searches should be view as an extreme upper bound on the lost profits from infringement.

Approach 1: Mapping YouTube searches to lost sales

My first approach to estimate the infringement's harm uses the YouTube data and is guided by the pattern observed in the synthetic control analysis. Table 2 confirms the findings of the two figures using a standard difference-in-difference regression framework. The treated song is *Got to Give It Up* with treatment period beginning in March 2013 when *Blurred Lines* is released. The control group includes all the other songs listed as top 5 in the Billboard Hot 100 chart in 1977. I include month-year and song effects, and cluster the standard errors at the song level.

Over the longer time period (column 1 of Table 2) I observe an increase in YouTube views of about 580,000 per month for *Got to Give It Up* after March 2013 relative to the other songs. This is statistically significant at the 0.01 percent. In the shorter time window (column 2 of Table 2) there is a decline of 51,229 YouTube views per month, and the estimate is borderline statistically significant at conventional levels.

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[9]This result is also related to studies on the effect of piracy on music sales. Findings in this literature are mixed. My estimates are in line with Oberholzer and Strumpf (2007) who do not find evidence of large declines in sales due to file sharing platforms. At the same time, in my setting the two songs are likely to be differentiated products, which differs from traditional piracy cases in which the products tend to be close substitutes.

As explained above I exploit this second estimate to compute the negative effect of *Blurred Lines* on the sales of *Got to Give It Up*. Specifically, I assume that the YouTube views of Gaye's song decline by 51,229 per month for 24 months after the release of Blurred Lines. This gives a total decline of 1,229,500 views.[10]

Translating the drop in YouTube views into drop in sales is challenging as data on sales are not easily accessible. To this end, I exploit the estimates in Kretschmer and Peukert (2020) which indicate that 9,648,200 million additional video views translates to an increase in music sales of about 92,000 euros (in Germany). With a similar covariation, I would expect a drop in sales of about 11,724 euros in my setting, which is about $13,000 if I use the average exchange rate for 2015 (1 EUR=1.11 USD).

To assess the plausibility of the magnitude of the decline in sales, I also collected information on the certified units sold by each sample song from the Recording Industry Association of America (RIAA) historic Gold and Platinum award database. I then regressed the total certified units sold (approximated at the million) on the YouTube views, using the songs for which RIAA data is available. The estimates show a positive correlation, and the implied marginal effect suggests that an increase of 1 million YouTube views is associated with an increase of 5,200 certified copies sold. This implies that the reduction in YouTube views is consistent with a drop in sales of about 6,400 certified copies. Assuming a revenue per copy of $1.5 (roughly the current price of theMP3 of *Got to Give It Up* on Amazon.com), I obtain a decline in revenue of about $9,600. The estimate is relatively close in magnitude to the value of $13,000 computed above. To focus on the upper bound case, I use $13,000 as an estimate of the drop in sales in my computations below.

Approach 2: Mechanical license and lost royalty

The approach used by the court to compute the damages was to consider lost licensing revenues that *Got to Give It Up*'s copyright owner would have received in the case of pre-release licensing. As I discussed in Section 4.5, this approach is problematic as it involves a logic circularity given that market royalties depend on expected damages (Scotchmer and Shankerman, 2001).

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[10]I focus on a 24 month period because the damages awarded by the court rely on publishing revenue data filed in a document on March 2015 (docket 351). The content of the docket is sealed so I do not know the exact way in which these sales are computed. My approach is to assume that they are based on the time period March 2013 (release of *Blurred Lines*) to March 2015 (date of the docket).

A way to address this issue is to consider the royalties that Thicke and Pharrell would have paid in the extreme case of complete overlap between the two compositions: i.e., if they recorded a cover song. In this case the copyright act of 1976 (17 U.S.C. §115) indicates that they would be entitled to a compulsory licensing at a statutory mechanical royalty rate of 9.1 cents per copy.

According to the RIAA's database, Blurred lines sold between 6 and 7 million certified copies by 2015. Assuming that the actual sales are 6.5 million copies, the corresponding mechanical license would have been 591,500 dollars. I am going to use this value as the lost royalties from infringement.

6.4   Assessing the size of the damages

Building on the calibrations presented above, I use the model to compute the damages that would lead to an ex-ante optimal entry decision by independent composers. I begin with the case of a two-cutoff rule. As I did when I calibrated the signal probabilities, I assume that these damages deter infringement by the composer with access. Expected damages for the independent composer are $\delta p^I s$ whereas the expected harm is $H = \delta h(1)$. Damages that equates these two values are such that $p^I s = h(1)$.

The implied optimal damages are presented in the second column of Table 3. They range from about $21,000 (when I only consider sales to compute harm) to $991,000 (when I use sales and royalties). They are substantially below those awarded in the *Blurred Lines* case, which exceeded 3 million.

Column 3 shows a similar computation considering instead an IR rule, in which damages are avoided by independent composers only if there is no evidence of access and no evidence of similarity. In this case the expected damages for independent creators are $\delta s + (1 - \delta)p^I s$. The computed damages are much lower in this case. The remaining columns of the table show robustness to changing the approach used to assign the parameters of the model associated with the signals of access. Even in the most conservative calibration, damages are about one tenth of those awarded in court. I perform these robustness only for the IR damages, as the implied damages for the two-cutoff rule only depend on p^I, which is uniquely identified by the model.

6.5 Discussion

The calibration exercise presented above quantifies the damages required to implement efficient entry by independent composers. The magnitude of my estimates is substantially lower than the one of the damages awarded by the court in the case. There are several other elements of the quantitative exercise that are worthy of additional discussion.

Difference between harm and damages.   Table 3 shows that the optimal damages differ from the estimated harm. In particular, for the two-cutoff rule, damages exceed lost revenues and royalties by a factor of about 1.5. This departs from the traditional approach used by courts when determining damages, which tends to compensate the copyright holder for the loss incurred because of the infringement. This difference reflects the fact that our computations take into account both the ex-ante and the ex-post effects of damage payments. Specifically, with the two-cutoff rule, not all follow-on composers that generate the externality pay damages, only those for which there is evidence of access. This implies that damages need to exceed the harm as optimal behavior requires equating ex-ante expected damages, rather than ex-post paid damages, to the externality.

Table 3 also shows that damages are higher with the two-cutoff rule relative to those with IR. This relates to the discussion presented in Section 4.3 that highlights the propensity of IR rules to award damages more frequently, which implies that a lower level of sanctions is required to deter entry by inefficient composers. In the specific case estimated, I used an extreme IR rule in which damages are avoided only if $\theta = 0$ and $a = 0$. With this rule, all composers with $\theta = 1$ pay damages. Moreover, some composers not imposing externalities are also sanctioned because they cannot show absence of access (those with $\theta = 0$ and $a = 1$). This implies that ex-post damages need to be below $h(1)$ to avoid over-punishing independent composers. For this reason the damages in columns 3-5 are below the estimated harm reported in column 1. An implication of this empirical finding is that large downward adjustments to damages may be required for courts using IR rules with very low thresholds of similarity in the case of strong evidence of access.

Composers with access   The estimates focus on the behavior of independent composers, because of the key simplifying assumption that $c = 0$. This assumption implies that the optimal level of overlap is zero ($\theta^* = 0$) and that any positive sanction deters entry by composers with access. Combined with the binary nature of the actions and signals, this allows me to interpret the two-cutoff damages presented in column 2 as those implementing the first best, as they are equal to the trial damages of the optimal mechanism derived in section 5.[11] Notice that setting $c = 0$ implies that copying generates only harm and not benefits, which may bias my analysis toward over-estimating the damages required to implement efficient behavior.

Selection into litigation   My model abstracted away from selection of cases into litigation. This raises the concern that the model may overestimate the extent to which (ex-post) awarded damages translate into (ex-ante) expected damages. Intuitively, larger damages may be needed to deter infringement if follow-on composers expect many overlapping songs not to be litigated at all. For example, if litigating a case costs L, the original composer may prefer not to litigate if expected damages are lower than L. While this is a valid concern, it is important to notice that in my baseline model some degree of overlap is efficient, and that sanctioning schemes relying on overlap thresholds typically do not punish follow-on composers that engage in limited amount of copy. In this respect, the ex-ante perceived damages would not change significantly if the cases with small levels of θ are not litigated. More problematic would be the case in which selection induces only the cases with extreme values of θ to be litigated, and several disputes with $\theta > \theta^*$ (but θ not large enough) not be to litigated. In this case many composers generating large externalities would not to be punished, and my computation would under-estimate the damages required to induce efficient behavior. If this type of selection was substantial and only the cases with extreme values of θ were litigated, empirically one would expect to see courts finding evidence of substantial similarity in a large fraction of cases. This is not what I find in my sample, where in more than 80 percent of the cases courts find no evidence of similarity. The fact that substantial overlap between songs is only found in a very small fraction of cases, suggests that 'overconfidence' by original composers may in part explain selection into litigation. If this is the case,

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[11] Given that $\theta^* = 0$ the compulsory licensing fee is zero in the optimal mechanism and all cases with $\theta = 1$ face the trial.

an increase in damages may actually lead to an even higher fraction of cases with low merit.

7   Conclusions

This paper develops a model of judicial copyright enforcement in which the strength of the burden of proof affects the level and direction of creative efforts.

The analysis provides three key insights. First, I show that the independent creation defense in copyright law can be valuable in settings where statutory damages are large, and that sanctioning rules satisfying the inverse ratio property can increase the joint surplus relative to simpler rules. Second, I conduct a mechanism design analysis and show that optimal sentencing schemes allow alleged infringers to choose between a compulsory license and a trial. Finally, a calibration of the model to fit the leading music infringement case *Pharrell Williams v. Bridgeport Music* suggests that the damages awarded by the courts may substantially exceed those required to deter entry by inefficient creators.

Ultimately, the paper suggests that copyright judicial enforcement can have important interactions with the incentives to create and the direction of creative effort.

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Appendix 1: Omitted proofs

Proof of Proposition 4

Notice that W^A is maximized at a value $\underline{\theta}_{SB}$ which satisfies

$$-ch(\underline{\theta}_{SB})\phi(c(1-\underline{\theta}_{SB})) + (c - h'(\underline{\theta}_{SB}))(1 - \Phi(c(1-\underline{\theta}_{SB}))) = 0$$

which implies $h'(\underline{\theta}_{SB}) < c = h'(\theta^*)$ and $\underline{\theta}_{SB} < \theta^*$. Moreover notice that with deterring sanctions we have that $\frac{dW^A}{d\underline{a}} = 0$. The independent creator behave at the optimal level if $sp^I(\underline{a})\delta(\underline{\theta}_{SB}) - H = 0$. This can be enforced by setting an $\underline{a}_{SB}$ such that

$$s_{SB} = \frac{H}{p^I(\underline{a}_{SB})\delta(\underline{\theta}_{SB})}.$$

These sanctions are deterring as long as $sp^A(\underline{a}_{SB}) > c(1-\underline{\theta}_{SB})$ which can be re-written as

$$\frac{H}{p^I(\underline{a}_{SB})\delta(\underline{\theta}_{SB})}p^A(\underline{a}_{SB}) > c(1-\underline{\theta}_{SB})$$

$$\frac{p^A(\underline{a}_{SB})}{p^I(\underline{a}_{SB})} > \frac{c(1-\underline{\theta}_{SB})\delta(\underline{\theta}_{SB})}{H}.$$

The final thing to prove is that there exists at least one $\underline{a}_{SB}$ satisfying this inequality. Notice that the left hand side is equal to

$$\frac{p^A(\underline{a}_{SB})}{p^I(\underline{a}_{SB})} = \frac{1 - G^A(\underline{a}_{SB})}{1 - G^I(\underline{a}_{SB})}$$

which is increasing as long as $\frac{g^I}{1-G^I} > \frac{g^A}{1-G^A}$ which is satisfied when $\frac{g^A(a)}{g^I(a)}$ increases monotonically (Ross et al., 2005; Shaked and Shanthikuma, 2007). Finally notice that

$$\lim_{\underline{a}\to\infty} \frac{1 - G^A(\underline{a})}{1 - G^I(\underline{a})} = \lim_{\underline{a}\to\infty} \frac{g^A(\underline{a})}{g^I(\underline{a})} = +\infty.$$

As the function is continuous this implies that a threshold $\underline{a}_{SB}$ satisfying the inequality exists.

Proof of Proposition 6

Proposition 4 characterized the second best policy s_{SB}, $\underline{a}_{SB}$ and $\underline{\theta}_{SB}$. The proposition shows that $\underline{\theta}_{SB}$ is set to maximize the welfare created by the composer with access

$$\max_{\theta} \int_{c(1-\theta)}^{\infty} (b - h(\theta) - c(1 - \theta)) \phi(b)db$$

and that with increasing and unbounded likelihood ratio it is possible to find s_{SB}, $\underline{a}_{SB}$ which satisfy $s_{SB}p^I(\underline{a}_{SB})\delta(\underline{\theta}_{SB}) = H$ so that independent creators act optimally and $s_{SB}p^A(\underline{a}_{SB}) > c(1 - \underline{\theta}_{SB})$ so that the sanctions are deterring. Consider now the following perturbation:

$$IR(\underline{\theta}_{SB}, \underline{\theta}_{SB} - \varepsilon, 1 - \Delta, a') = \begin{cases} 1 & \text{if } a > 1 - \Delta \text{ and } \theta > \underline{\theta}_{SB} - \varepsilon \\ 1 & \text{if } a > \underline{a}' \text{ and } \theta > \underline{\theta}_{SB} \\ 0 & \text{else.} \end{cases}$$

where Δ and ε are positive and small. We keep the sanctions $s = s_{SB}$ at the same level as in the second best two-cutoff. We choose $\underline{a}' = \underline{a}_{SB} + da$, Δ and ε to keep the expected sanction constant for the independent composer. Specifically, we set

$$H = s_{SB}p^I(\underline{a}_{SB})\delta(\underline{\theta}_{SB})$$
$$= s_{SB}(p^I(\underline{a}_{SB} + da) - p^I(1 - \Delta))\delta(\underline{\theta}_{SB}) + s_{SB}p^I(1 - \Delta)\delta(\underline{\theta}_{SB} - \varepsilon).$$

Notice that, for a fixed ε, da can be made arbitrarily small by reducing Δ, which implies that we can find an $\underline{a}' < 1 - \Delta$ for which the equality holds. This perturbation leads to an IR rule sanctioning where as a increases the threshold for sanctions decreases from above 1 (a below $\underline{a}'$) to $\underline{\theta}_{SB}$ (a between $\underline{a}'$ and $1 - \Delta$) and $\underline{\theta}_{SB} - \varepsilon$ (a above $1 - \Delta$). Because the expected sanction of the independent creator does not change, her behavior will remain the same as in the two-cutoff rule. The creator with access will set $\widehat{\theta}_A = \underline{\theta}_{SB}$ as long as the following two conditions are satisfied

$$b - s_{SB}p^A(1 - \Delta) - c(1 - \underline{\theta}_{SB}) > b - s_{SB}$$
$$b - s_{SB}p^A(1 - \Delta) - c(1 - \underline{\theta}_{SB}) > b - c(1 - \underline{\theta}_{SB} + \varepsilon).$$

The first condition can be re-written as

$$\frac{s_{SB}(1 - p^A(1 - \Delta))}{1 - \underline{\theta}_{SB}} > c$$

which is satisfied for Δ close to zero as $p^A(1) = 0$ and given that in the second best two-cutoff rule we have $s_{SB}p^I(\underline{a}_{SB}) > c(1 - \underline{\theta}_{SB})$. The second condition becomes

$$c > \frac{s_{SB}p^A(1 - \Delta)}{\varepsilon}$$

which again is satisfied for Δ close to zero and fixed ε. This shows that the IIR policy implements the same copying level as the two-cutoff rule for the creators with access. For these creators it generates welfare

$$W = \int_{s_{SB}p^A(1-\Delta)+c(1-\underline{\theta}_{SB})}^{\infty} \left(b - h(\underline{\theta}_{SB}) - c(1-\underline{\theta}_{SB})\right)\phi(b)db.$$

Now we have

$$\frac{dW}{d\Delta} = (\underline{\theta}_{SB}p^A(1-\Delta) + c(1-\underline{\theta}_{SB}) - h(\underline{\theta}_{SB})-$$

$$c(1-\underline{\theta}_{SB}))\phi(\underline{\theta}_{SB}p^A(1-\Delta) + c(1-\underline{\theta}_{SB}))\frac{dp^A(1-\Delta)}{da}$$

$$= (\underline{\theta}_{SB}p^A(1-\Delta) - h(\underline{\theta}_{SB}))\phi(\underline{\theta}_{SB}p^A(1-\Delta) + c(1-\underline{\theta}_{SB}))\frac{dp^A(1-\Delta)}{da}$$

which evaluated at $\Delta = 0$ is $-h(\underline{\theta}_{SB})\phi(c(1-\underline{\theta}_{SB}))\frac{dp^A(1)}{da} > 0$ as $\frac{dp^A(1)}{da} = -g(1) < 0$. Another way to see it is that in the two-cutoff rule the marginal entrant is such that $b = c(1-\underline{\theta}_{SB}) < c(1-\underline{\theta}_{SB}) + h(\underline{\theta}_{SB})$ so the marginal entrant reduces welfare. With the perturbation the marginal entrant is such that $b = s_{SB}p^A(1-\Delta) + c(1-\underline{\theta}_{SB}) > c(1-\underline{\theta}_{SB})$ so welfare increases as long as $s_{SB}p^A(1-\Delta) \leq h(\underline{\theta}_{SB})$ which is satisfied for Δ small enough.

Proof of Proposition 7

I pick a threshold $\underline{a}$ such that

$$\frac{p^A(\underline{a})}{p^I(\underline{a})} > \max\left\{\frac{h(\theta^*) + c(1-\theta^*)}{H}; \frac{H - F(\theta^*)h(\theta^*)}{H(1-F(\theta^*))}\right\}$$

which exists because of the unbounded MLR property. The sentencing scheme uses $\overline{s} = \frac{H}{p^I(\underline{a})}$ and $\underline{s} = h(\theta^*)$ and it is defined as:

$$S(a,\theta,\widehat{t}) = \begin{cases} \underline{s} \text{ if } \widehat{i} = \widehat{A} \text{ and } \theta \leq \theta^* \\ \overline{s} \text{ if } \widehat{i} = \widehat{A} \text{ and } \theta > \theta^* \\ \overline{s} \text{ if } a > \underline{a} \text{ and } \widehat{i} = \widehat{I} \end{cases}.$$

Let us begin with type A.[12] To report truthfully and copy θ^* is optimal if it provides a higher payoff than to report $\hat{i} = \hat{I}$ and copy the entire song. This occurs if

$$b - \underline{s} - c(1 - \theta^*) \geq b - p^A(\underline{a})\overline{s}$$

$$p^A(\underline{a})\overline{s} \geq \underline{s} + c(1 - \theta^*)$$

$$\frac{p^A(\underline{a})}{p^I(\underline{a})}H \geq h(\theta^*) + c(1 - \theta^*)$$

$$\frac{p^A(\underline{a})}{p^I(\underline{a})} \geq \frac{h(\theta^*) + c(1 - \theta^*)}{H}$$

which is satisfied by the threshold chosen. Moreover, the defendant of type A has no incentives to report trutfully and copy more than θ^* as:

$$b - \underline{s} - c(1 - \theta^*) \geq b - \overline{s}$$

$$\frac{1}{p^I(\underline{a})} \geq \frac{h(\theta^*) + c(1 - \theta^*)}{H}$$

which holds because $\frac{1}{p^I(\underline{a})} > \frac{p^A(\underline{a})}{p^I(\underline{a})}$. Consider now the defendant of type I. Truthful reporting occurs because

$$b - \overline{s}p^I(\underline{a}) - c \geq b - F(\theta^*)\underline{s} - (1 - F(\theta^*))\overline{s} - c$$

$$F(\theta^*)h(\theta^*) + (1 - F(\theta^*))\frac{H}{p^I(\underline{a})} \geq H$$

which is satified because

$$(1 - F(\theta^*))\frac{H}{p^I(\underline{a})} \geq H - F(\theta^*)h(\theta^*)$$

$$\frac{1}{p^I(\underline{a})} \geq \frac{H - F(\theta^*)h(\theta^*)}{H(1 - F(\theta^*))}$$

and $\frac{1}{p^I(\underline{a})} > \frac{p^A(\underline{a})}{p^I(\underline{a})}$. Finally notice that the sentencing scheme implements the first best because type A copies at the optimal level and faces a sentence equal to $h(\theta^*)$, whereas the expected sentence for I is H. Moreover $\overline{s} > \underline{s}$ because the threshold $\underline{a}$ is such that $\frac{p^A(\underline{a})}{p^I(\underline{a})} > \frac{h(\theta^*) + c(1 - \theta^*)}{H} > \frac{h(\theta^*)}{H}$ and $\frac{1}{p^I(\underline{a})} > \frac{p^A(\underline{a})}{p^I(\underline{a})}$.

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[12]For simplicity we assume that $\underline{s}$ is paid even if $\theta = 0$. Assuming no payment if $\theta = 0$ does not change our analysis as the convexity of $h()$ and the assumption that $h(0) = 0$ imply that $b - c < b - \underline{s} - c(1 - \theta^*)$ which assures that the composer of type A prefers to copy θ^*.

Appendix 2: Robustness to the use of actual damages

This appendix provides robustness of the main results to the case in which actual, rather than statutory, damages are used. I begin by restating the conditions required to achieve the first best in this alternative modeling in which sanctions s are replaced by a proportion of the creator revenue $b\tau$. The other technical extension required in this model is to impose a positive lower bound on b, which we label $\underline{b} > 0$, as otherwise damages would never be deterring for very low levels of b. This assumption is consistent with the idea that actual damages are chosen over statutory damages only when the revenue generated by the composer is large enough.

In this alternative model the independent creator composes if $b - b\tau E(s\Pi(a,\theta)|I) - c \geq 0$ which implies that

$$b \geq \frac{c}{1 - \tau E(s\Pi(a,\theta)|I)}.$$

This cut-off is identical to the one required for the first best if

$$\frac{c}{1 - \tau E(s\Pi(a,\theta)|I)} = H + c$$

which leads to the condition

$$\tau \int_a \int_\theta \Pi(a,\theta)g^I(a)f(\theta)dad\theta = \frac{H}{H+c}. \tag{12}$$

Damages implement the optimal level of copying by the composer with access if $\widehat{\theta}_A = \theta_A^*$ when:

$$\arg\min_\theta h(\theta) + c(1 - \theta) = \arg\min_\theta b\tau \int_a \Pi(a,\theta)g^A(a)da + c(1 - \theta). \tag{13}$$

Notice that, differently from the case of statutory damages, the optimal choice of the composer depends on b. This dependence can be limited by using a step functions for Π as we do in the proofs below.

Entry of the composers with access that copy θ^* will be optimal if only those with

$$b \geq h(\theta^*) + c(1 - \theta^*)$$

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compose. Entry takes place if

$$b \geq \frac{c(1 - \theta^*)}{1 - \tau \int\limits_a \Pi(a, \theta^*) g^A(a) da}$$

so the first best is obtained if

$$\tau \int\limits_a \Pi(a, \theta^*) g^A(a) da = \frac{h(\theta^*)}{h(\theta^*) + c(1 - \theta^*)}. \tag{14}$$

Levereging these conditions, I show that the main results are robust in this alternative form of damages. We begin with an analysis of the two-cutoff rule $\Pi(a, \theta) = R(\underline{\theta}, \underline{a})$.

Proposition 8 *Two-cutoff rules cannot implement the first best.*

Proof. When sanctions are not deterring, the first best is not achieved as $\widehat{\theta}_A = 1 > \theta^*$. Consider now the case of deterring sanctions and $\underline{\theta} = \theta^*$ so that condition (13) is satisfied. Notice now that the entry condition for composers with access cannot hold because with deterring sanctions we have that $E(b\tau R(\underline{\theta}, \underline{a})|A) = 0 < h(\theta^*)$. ■

The next proposition confirms the idea that two cutoff rules can improve on similarity only rules when sanctions are high enough.

Proposition 9 *If* $\tau > \min \left\{ \dfrac{c(1 - \underline{\theta})}{\underline{b}}; \dfrac{H}{(H + c)\delta(\underline{\theta})} \right\}$*, then for any* $r(\underline{\theta})$ *there exists a* $\underline{a} > 0$ *such that* $R(\underline{\theta}, \underline{a})$ *strictly increases welfare.*

Proof. To begin, notice that with $r(\underline{\theta})$ there is too little entry by independent composers as when $b = H + c$ when have that $b\tau\delta(\underline{\theta}) > H$ and sanctions are deterring full copy by the composer with access as $\underline{b}\tau > c(1 - \underline{\theta})$. Now take any $\underline{a} > 0$ such that $(H + c)\tau p^I(\underline{a})\delta(\underline{\theta}) > H$ and $\underline{b}\tau p^A(\underline{a}) > c(1 - \underline{\theta})$. The fact that $p^I(0) = p^A(0) = 1$ and the continuity of $G^i s$ imply that such $\underline{a}$ exists. This will increase entry of independent composers as $p^I(\underline{a}) < 1$ which increases welfare. At the same time this will not affect the behavior of composers with access as the sanction is still deterring. ■

I now show that the property of the second best policy are similar to those with statutory damages.

Proposition 10 *If the likelihood ratio* $\dfrac{g^A(a)}{g^I(a)}$ *is monotone increasing and unbounded the second best policy features* $\underline{\theta} < \theta^*$ *and optimal entry by the independent composers.*

Proof. W^A is maximized when $\underline{\theta}$ satisfies

$$-ch(\underline{\theta})\phi(c(1-\underline{\theta})) + (c - h'(\underline{\theta}))(1 - \Phi(c(1-\underline{\theta}))) = 0$$

which implies $h'(\underline{\theta}) < c = h'(\theta^*)$ and $\underline{\theta} < \theta^*$. Moreover notice that with deterring sanctions we have that $\frac{dW^A}{d\underline{a}} = 0$. The independent creator behave at the first best level if $(H + c)\tau p^I(\underline{a})\delta(\underline{\theta}) - H = 0$. This can be enforced by setting

$$\tau = \frac{H}{(H + c)p^I(\underline{a})\delta(\underline{\theta})}.$$

These sanctions are deterring as long as $\tau \underline{b}p^A(\underline{a}) > c(1-\underline{\theta})$ which can be re-written as

$$\frac{H}{(H + c)p^I(\underline{a})\delta(\underline{\theta})}\underline{b}p^A(\underline{a}) > c(1-\underline{\theta})$$

$$\frac{p^A(\underline{a})}{p^I(\underline{a})} > \frac{c(1-\underline{\theta})\delta(\underline{\theta})(H + c)}{H}.$$

The proof of the case with statutory damages shows that there exists at least one $\underline{a}$ satisfying this inequality. ∎

We conclude with the comparison between IR and two cutoff schemes.

Proposition 11 *Suppose $\frac{g^A(a)}{g^I(a)}$ is monotone increasing and unbounded. Then, there is a inverse ratio sanctioning scheme that generates more welfare than second best two-cutoff sanctioning scheme.*

Proof. Consider the following perturbation of the second best policy for two cutoff rules. Sanctions are paid if

$$IR(\underline{\theta}_{SB}, \underline{\theta}_{SB} - \varepsilon, 1 - \Delta, a')| = \begin{cases} 1 & \text{if } a > 1 - \Delta \text{ and } \theta > \underline{\theta}_{SB} - \varepsilon \\ 1 & \text{if } a > \underline{a}' \text{ and } \theta > \underline{\theta}_{SB} \\ 0 & \text{else} \end{cases}$$

where Δ and ε are positive and small. We set $\underline{a}' = \underline{a}_{SB} + da$ to keep the expected sanction constant for the marginal independent composer. We keep the sanctions for the marginal entrant at the same level as in the second best two-cutoff. Specifically, we set

$$H = (H + c)\tau_{SB}p^I(\underline{a}_{SB})\delta(\underline{\theta}_{SB})$$

$$= (H + c)\tau_{SB}(p^I(\underline{a}_{SB} + da) - p^I(1 - \Delta))\delta(\theta^*) + (H + c)\tau_{SB}p^I(1 - \Delta)\delta(\theta^* - \varepsilon).$$

Notice that, for a fixed ε, da can be made arbitrarily small by reducing Δ, which implies that we can find an $\underline{a}' < 1 - \Delta$. This perturbation leads to an IR rule sanctioning where as a increases the threshold for sanctions decreases from above 1 (a below $\underline{a}'$) to $\underline{\theta}_{SB}$ (a between $\underline{a}'$ and $1 - \Delta$) and $\underline{\theta}_{SB} - \varepsilon$ (a above $1 - \Delta$) . Because the expected sanction of the independent creator does not change, its behavior will remain the same as in the two-cutoff rule. The creator will access will set $\widehat{\theta}_A = \underline{\theta}_{SB}$ as long as

$$b - b\tau_{SB}p^A(1 - \Delta) - c(1 - \underline{\theta}_{SB}) > b - b\tau_{SB}$$

$$b - b\tau_{SB}p^A(1 - \Delta) - c(1 - \underline{\theta}_{SB}) > b - c(1 - \underline{\theta}_{SB} + \varepsilon)$$

The first condition can be re-written as

$$\frac{b\tau_{SB}(1 - p^A(1 - \Delta))}{1 - \underline{\theta}_{SB}} > c$$

which is satisfied for Δ close to zero as $p^A(1) = 0$ and in the second best two-cutoff rule we have $\underline{b}\tau_{SB} > c(1 - \underline{\theta}_{SB})$. The second condition becomes

$$c > \frac{b\tau_{SB}p^A(1 - \Delta)}{\varepsilon}$$

which again is satisfied at $\underline{b}$ for Δ close to zero and fixed ε. This shows that the IR policy implements the same copying level as the two-cutoff rule for the creators with access. For these creators it generates welfare

$$W = \int_{\frac{c(1 - \underline{\theta}_{SB})}{1 - \tau_{SB}p^A(1 - \Delta)}}^{\infty} (b - h(\underline{\theta}_{SB}) - c(1 - \underline{\theta}_{SB})) f(b)db.$$

Now notice that in the two-cutoff rule the marginal entrant is such that $b = c(1 - \underline{\theta}_{SB}) < c(1 - \underline{\theta}_{SB}) + h(\underline{\theta}_{SB})$ so the marginal entrant reduces welfare. With the perturbation the marginal entrant is such that $b = \frac{c(1 - \underline{\theta}_{SB})}{1 - \tau_{SB}p^A(1 - \Delta)} > c(1 - \underline{\theta}_{SB})$ so welfare increases as long as the increase is not too large which is satisfied for Δ small enough. ∎

Figure 1 - Comparing two-cutoff and inverse ratio rules
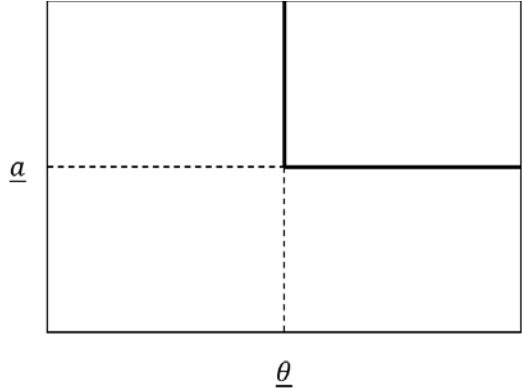
Two-cutoff rule
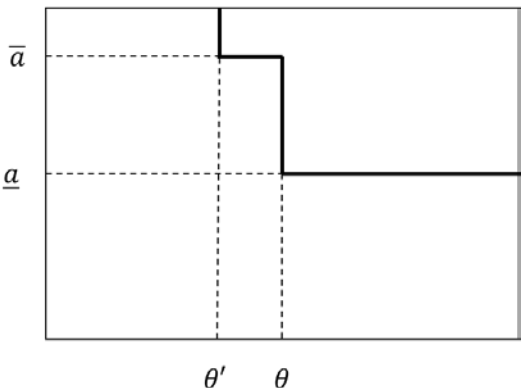
Inverse ratio rule

Figure 2: YouTube views for 'Got to give it up' vs. the synthetic version of the song
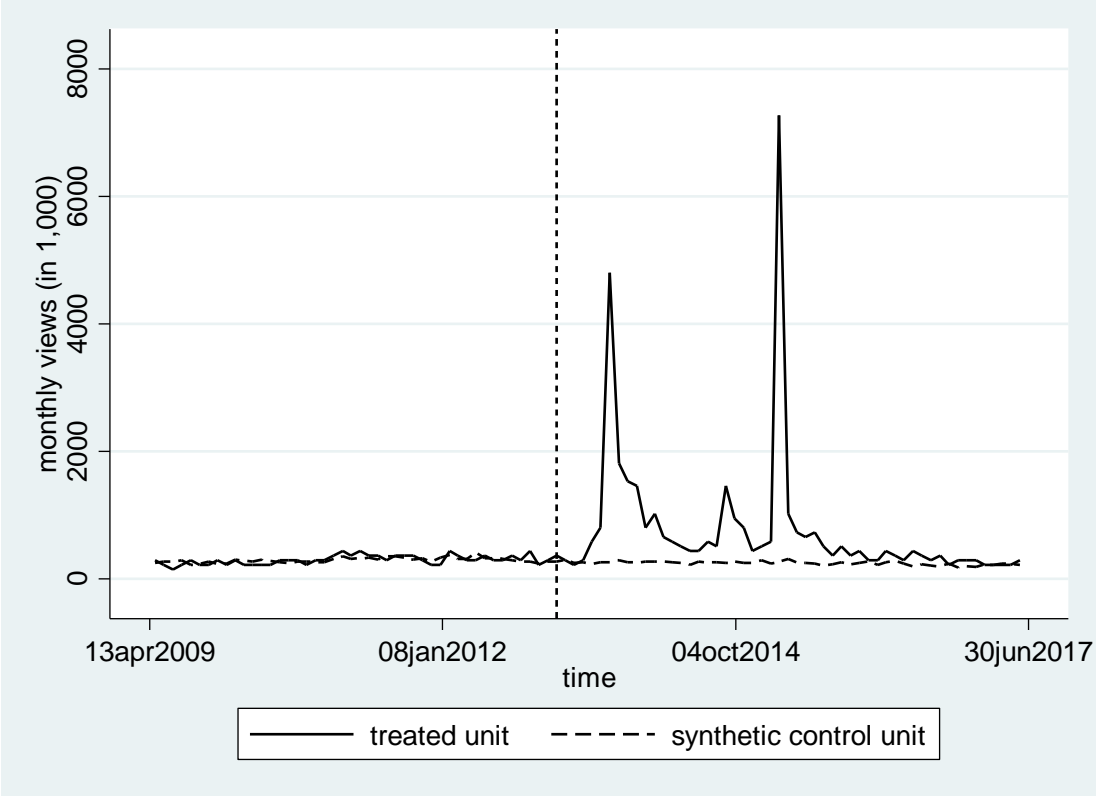
Figure 3: YouTube views for 'Got to give it up' vs. the synthetic version of the song - Shorter time window
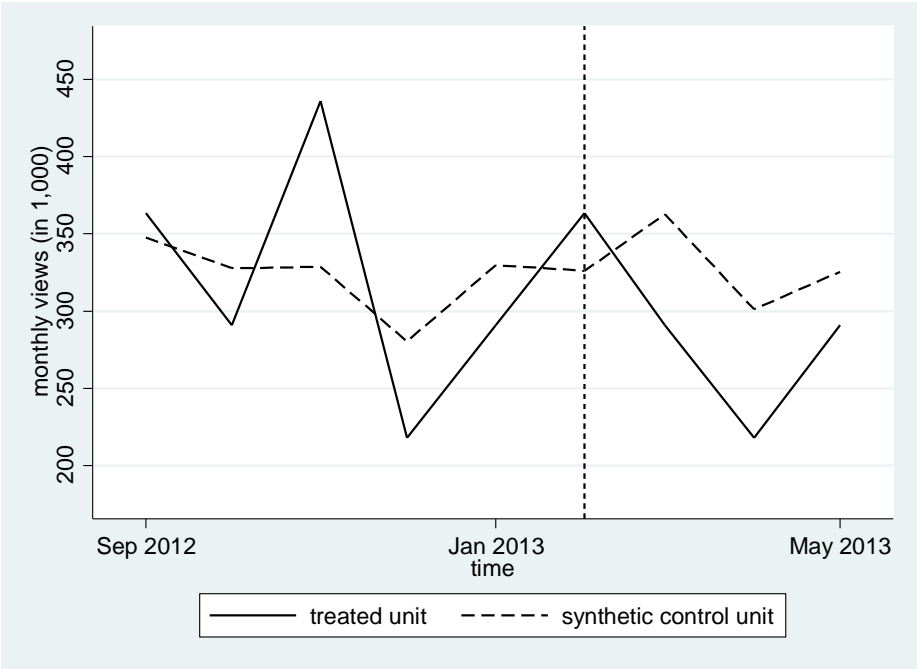
Table 1: Calibrated parameters

Assigned Parameter	Estimated parameters		
	p^I	$\check{\gamma}$	δ
Baseline			
$p^A = 0.75$	0.61	0.65	0.28
Robustness			
$p^A = 0.70$	0.61	0.45	0.40
$p^A = 0.80$	0.61	0.74	0.24
$p^A = 0.90$	0.61	0.83	0.21

Table 2: Release of *Blurred Lines* and YouTube Searches

	(1)	(2)
Got to Give it Up	579.520***	-51.229*
x After Blurred Lines	(65.209)	(26.905)
Month-year effects	YES	YES
Song effects	YES	YES
Time window	January 2008 to June 2017	September 2012 to May 2013
Observations	6042	477

NOTES: Robust standard error clustered at the song level in parenthesis. The unit of observation is a song-month. The dependent variable is the number of YouTube searches for the song assigned to the month. Control group includes 58 songs listed as top 5 in the Billboard Hot 100 weekly charts in 1977.

Table 3 - Estimated Damages

	Estimated harm	Two Cutoffs s if both θ and *a* =1	Inverse Ratio s unless both θ and *a* =0	Inverse Ratio	Inverse Ratio
lost sales	13,000	21,300	5,100	3,900	6,800
lost royalty	591,500	969,700	230,300	179,500	308,900
lost sales + lost royalty	604,500	991,000	235,400	183,400	315,700
Parameter values	Baseline	Baseline	Baseline	$p^A = 0.90$	$p^A = 0.70$

Damages inducing efficent entry behavior of independent composers. In US dollars, rounded at 100.