A Tort Model of Open Contents*

Benjamin Chiao. Peking University and University of Michigan.

Jan 6, 2010.

(The full paper is available here when the revision is completed:
http://benjaminchiao.org/papers/opencontentstorts.pdf)

Abstract

In some open contents processes such as open source software or Wikipedia, downstream licensing is royalty-free. Buyers, especially large vendors, can then become resellers to compete with the innovators. The innovators, however, can share the cost with the resellers to obtaining proper copyright permissions before using certain prior code. This is especially important for open contents because there is

*My sincere thanks to Yan Chen, Michael Cohen, Jessica Litman, and Jeffrey MacKie-Mason who advised me on this research. I especially thank Josh Lerner, Mikko Valimaki, and Joel West, who sent me some detailed comments. I am indebted to Mario Rizzo, who has enlightened me on the economic analysis of tort law. Lastly, I benefited from the comments from Angus Chu, Vijay Dakshinamoorthy, Sanjeev Kumar, Mark Madrilejo, Russell Neuman, Xingbai Xu, several software engineers, executives and patent lawyers at IBM, participants of the Academy of Management Open Source Software Research Development Workshop and EURAM conference, and the Incentive-Centered Design Lab (especially Josh Cherry, Greg Gamette, Lian Jian, Kil-Sang Kim, Tapan Khopkar, John Lin, Anya Osepayshvili, Ben Stearns, and Rick Wash). All errors are my own.

seldom dedicated staff to verify possible intellectual property infringements for contributions made by volunteers worldwide. I compare the individual and social optimal levels of distribution, and care taken to avoid monetary losses in open contents. To have efficient quantities distributed, it is necessary for the vendors to bear more liability than the innovators when the marginal spillover effect and the innovators' care cost of the marginal copy are high relative to the vendors' care costs of the marginal copy. In the no liability to users case, efficient care levels cannot be obtained if the litigation costs are too high. In the no liability to the innovators and vendors case commonly used in open content licenses, efficient care levels cannot be achieved if there are non-zero litigation costs.

1 Introduction

Contents, such as software, music, films or books, are defined here to be open if one is free to use, reuse, and redistribute them[1]. The delineation of rights in open contents seems quite unclear to many stakeholders. There is seldom dedicated staff to verify possible intellectual property infringements for contributions made by volunteers worldwide. For some open contents such as Wikipedia and open source software, the production involves many amateur

[1]This is from the Open Knowledge Definition website, which claims this to be the simplest version of their more complete definition available at: http://www.opendefinition.org/, visited December 15, 2009. Other definitions exist, for example, see Newmarch (2000) and Liang (2004) for further references.

innovators whose contributions could decrease when faced with liability for certain damages. Such damages are largely confined here to those related to copyright actual damages and profits[2,3]. For example, the current innovator might not know that the existing work already contains proprietary materials. Vendors who redistribute or add value to open contents, and users who consume the product could be liable as well.

The major research question in this paper is: Given a liability rule, are the individually optimal levels of redistribution and care taken to avoid damages in open contents different from the social optimal levels?

It is well known in the literature (Coase [1960]) that when transaction costs are zero, liability rules are irrelevant and thus care and redistribution will be socially efficient. But transaction costs are not zero in reality, I have derived some necessary conditions for social efficiency and some sufficient conditions for social inefficiency.

The next section presents some copyright infringement risks and measures to avoid them. Section 3 uses injurer-victim tort models to derive some

[2]The owner whose copyright has been infringed can choose between two mutually exclusive choices of damages: i) actual damages and profits ii) statutory damages.

The primary measure of recovery of actual damages is based upon the loss of market value of the copyrighted work due the infringement. Alternatively, the plaintiff could show the defendant's profits from sales of the infringing works.

Statutory damages are outside the scope of this paper because the calculation of such damages greatly increases the complexity of the model. For example, according to the the statute, the damage shall not be less than $750 nor more than $30,000 per work infringed. This range will be changed depending on whether the infringement is committeed willfully.

[3]Some but not all features of the current analysis apply to other intellectual property infringements related to patents or other damages related to product failures. These are, however, outside the scope of this paper.

optimal liability and bargaining arrangements across agents to deal with such risks. The last section concludes.

2 Copyright Infringements

The theory in the next section is about some strategic interactions of the users, innovators, and vendors of open contents. As a motivation, I present in this section the SCO-Linux controversy that highlights some copyright infringement risks and measures to avoid them.

SCO has claimed itself to be the "owner of UNIX" through a chain of sales. In 2003, SCO claimed that there had been misappropriation of its UNIX System V code into Linux SCO has claimed that there is copyright infringing code in Linuxo[4]. SCO began numerous legal claims and threats against many vendors (e.g. IBM, Hewlett-Packard, Microsoft, Novell, Silicon Graphics, Sun Microsystems and Red Hat) and end users[5]. However, on August 10, 2007 Judge Dale Kimball, hearing the *SCO* v. *Novell* case, ruled that "...the court concludes that Novell is the owner of the UNIX and UnixWare Copyrights"[6]. In September 2007, SCO filed for Chapter 11 bankruptcy protection.

Although SCO's claims so far have not been upheld by the courts and the

[4]See *SCO Group, Inc.* v. *Novell, Inc.*, 578 F.3d 1201 (10th Cir. Utah 2009).

[5]See http://www.sco.com/scoip/lawsuits/, accessed Nov 1, 2009.

[6]MEMORANDUM DECISION AND ORDER, Civil Case No.2:04CV139DAK, IN THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF UTAH, CENTRAL DIVISION.

legal impact on both Linux and Unix seems minimal, this episode highlights the possibility that the transaction costs involved in clearing copyrights in open contents ex post is non-trivial. This points to a demand to clarify such rights ex ante. Vendors could assist such clarifications especially when there are more profit motives (e.g. spillover effects to the other markets of the vendors[7]). For instance, IBM has assisted in several efforts to maintain a good code pedigree internally at IBM and externally to much smaller organizations[8]. Vendors could further sponsor more research to avoid damages. For example, more legal measures such as safe-habor provisions, which prevent intellectual property owners from hiding for too long (e.g. until some open contents have been widely adopted) before suing[9], could be further studied.

In short, open contents stakeholders are facing uncertainties surrounding intellectual property rights and care levels have been exercised to limit the scale of such problems ex ante. Given the complicated issues involved in

[7]For example, IBM researchers Capek et al (2005) write, "We also saw in Linux the possibility of having a unified operating system on our platform...A strategy [at IBM] was planned that allowed us to add value for our customers in the areas, [which were] clearly in the broad area of what is called middleware, and not in operating systems." Also, IBM announced in 2001 to spend over $1 billion in the next three years on open source projects (Capek et al [2005]).

[8]Such efforts include the Certificate of Originality for the code developed at IBM, the Developer's Certificate of Origin for the Linux kernel, and the Contributor License Agreement for the Apache Software Foundation. See Capek et al (2005), pp. 251, Open Source Development Lab (2005) and The Apache Software Foundation (2006).

[9] In view of *SCO v. IBM*, Zittrain (2004) argues that copyright law should be "construed in a way that does not permit a poisoned pea of unauthorized code under the mattress of a massive software project to effectively compromise the entire work". He discusses that copyright's statute of limitations might be applied to require those claiming copyright infringement to bring such claims within a three-year (or shorter) window stemming from the targeted software's initial public release of source code.

these episodes, I will only abstract in the next section slices of the episodes to capture certain decision problems in open content production I think are relevant to the research question presented earlier.

3 Theory

3.1 Setup

Consequences not fully specified in a contract can reduce investment (Grossman and Hart [1986] and Hart and Moore [1990]). Unspecified consequences can be thought of as unclear delineation of rights, which results from the absence of right to contract (Cheung [1970]) or the high transaction costs of specification. Without a detailed investigation of the transaction costs involved, it is inconclusive that any reduction in investment is socially inefficient. If it is due to high transaction costs, then one could argue that the status quo is efficient because society otherwise needs to find ways to reduce such transaction costs. If it is due to the absence of rights, then one could argue that the status quo is not efficient if the provision of rights is costless. This is because when property rights are clearly defined, social efficiency will be achieved by subsequent contracting as long as transaction costs are low (Coase [1960]). I will contrast the optimal choices when there is or is not a right to contract.

More specifically, I consider a case in which there are still high transaction costs to contract with Hidden, defined as an agent claiming to be the intellec-

tual property right owner. Hidden, similar to what SCO has done, does not surface until later stages. However, I vary the transaction costs (or equivalently, for our purpose here, the rights) of contracting between innovators, value-adding vendors (resellers or redistributors) and users.

To model overlapping of rights in open contents, I present the decision problems of several active agents in the economy relevant to the open contents landscape: social planner, users, innovators, and vendors. In addition, Hidden is an inactive agent who passively collects receipts from users, innovators, and vendors.

In some bilateral-care accident or product liability models (Landes and Posner [1985, 1987], Miceli [1997] and Shavell [1980]), each agent chooses care and activity levels to adjust damages (or monetary losses). They may or may not have engaged in a market transaction (e.g. a faulty purchased fan causes a house fire, versus an auto accident.) I use such models to incorporate a third party called vendors. Vendors may or may not engage in market exchanges with the innovators or the users but will choose some care and activity levels. The care levels here refer to the efforts, measured in monetary amount, made to avoid some expected damage paid to the inactive agent. The level of activity, Q, is the number of copies of the same information good distributed by the innovators and the vendors.

The damages are due to intellectual property infringements. They are paid to Hidden and thus one form[10] of unclear delineation of rights is in-

[10] Another form arises when innovators, vendors and users cannot contract with each

corporated in the model since it is not possible to enter into contractual arrangements with Hidden[11]. I, therefore, have not explicitly modeled the actions of this inactive agent. Now consider only the representative agent approach in modeling the active agents. Hereafter I use the singular and plural forms of these active agents interchangeably. Also, subscript $j = v, u, i$ stands for the vendor, user, and innovator. Let $K_j(Ql_j)$ be the total care cost of agent j when agent j chooses care level l_j for each of the Q copies of the information goods available in the market. Note that the care applies to all existing stocks of open contents. This captures the case in which all copies of the same information good is free from the liability of an infringing part if it is discovered once and is removed in the current and subsequent copies. Denote $D(l_v, l_i, l_u)$ the unit expected damage for each of the Q copies of the information goods. $D(\cdot)$ is a strictly concave function with $D_j < 0$.

The liability for active agent j, $\bar{s}_j$, is defined to be the fraction of D that j pays in expectation.

Let $b(Q)$ be the marginal consumption benefit for a representative user of the information good. There is diminishing marginal benefit because by assumption $b' < 0$[12]. Let $c_i(\cdot)$ be the total production cost of an innovator.

other. See discussions before Corollary 3.

[11] Since Hidden is by construction hidden, there is no way to contract with them and thus its decision problem is absent in the model. This is not to say that there are no other intellectual property owners that you can contract with. For example, not all trolls are hidden if they jump out of the bush early and negotiate a contract with other agents.

[12] One could argue that for open contents such as open source software, there are network effects because the more copies circulated the higher is the marginal value to the users because they could share files with each other. However, some form of diminishing returns must be showing at some point to rule out infinite sales, which we do not observe in the

R is the price paid to either the innovators or the vendors depending on who delivers the copy to the user.

Before I present the decision problems of the active agents, let us assume that the profit function of Hidden is:

$$\Pi_h = (1-\theta)QD - F_h \tag{1}$$

where θ is the ratio of litigation costs due to intellectual property infringement lawsuits, and F_h is the fixed cost of having the court to rule that Hidden has a claim on the intellectual property with a positive probability. Such fixed cost captures, for example, that Hidden needs to incur a cost to produce part of the open contents[13].

3.2 The Users' Problem

The problem for the users is assumed to be equivalent to the one solved by a representative user. Assume that there is only one piece of information good to be produced, which requires a fixed cost of F_i. Innovators distribute q_i copies of it. Vendors distribute q_v of it. The user buys from either of them. In equilibrium,

$$q_v + q_i = Q \tag{2}$$

real world. For simplicity, I have considered only cases in which diminishing marginal benefit is consistent with the cases that either Q is already expected to be so large that there is no more positive network effects, or there are no intrinsic network effects.

[13] One could further extend this model by allowing Hidden to choose some actions such as the timing of litigation.

The risk-neutral user buys a total of Q copies at a unit price of R each, and chooses a care level l_u to maximize:

$$U = \int_0^Q b(h)dh - Q[R + \bar{s}_u D(l_v, l_i, l_u)] - K_u(Ql_u) \tag{3}$$

where $\frac{\partial R}{\partial Q} = 0$[14], and $\bar{s}_u$ is the expected liability share of the users for the damage. The care level refers to the caution the user takes to ensure that the intellectual property rights are cleared, and that the information good is properly chosen, maintained and operated. The first order conditions are[15]:

$$-\frac{\partial R}{\partial l_u} = \bar{s}_u D_{l_u} + K'_u \tag{4}$$

$$b(Q) = R + \bar{s}_u D + K'_u l_u \tag{5}$$

3.3 The Innovator's Problem

In this model, an information good is not serviceable unless it is thoroughly documented and provided with customer support. For instance, a large q_i increases the need to provide differentiated documentation for different types of users. For each copy sold by the innovator, a marginal cost of $c'_i(\cdot)$ will be incurred by the innovator. The total variable cost of production is $c_i(\cdot)$. In addition, the innovator also chooses a care level l_i for each Q (important, not q_i, because it is open content), to directly adjust the total expected damage

[14] Recall that this user is a representative user, who represents n identical users who are small relative to the whole market. That is why they are price-takers.

[15] The Leibnitz formula is used to derive the result $\frac{d}{dQ}\int_0^Q b(h)dh = b(Q)$.

QD. The total care cost, $K_i(Ql_i)$, increases with Q. This is to capture the case that the innovator needs to patch each of the copies circulated to remove the infringing code.

For simplicity, there is only one innovator who is selected from competition. Thus, the innovator makes zero profit. The problem for the innovator is to choose q_i and l_i to maximize:

$$\Pi_i \equiv q_i R - F_i - c_i(q_i) - Q\bar{s}_i D(l_v, l_i, l_u) - K_i(Ql_i) \tag{6}$$

where $\bar{s}_i$ is the expected liability share of the innovator. The first order conditions are:

$$q_i \frac{\partial R}{\partial l_i} = Q\bar{s}_i D_{l_i} + QK_i' \tag{7}$$

$$R = c_i'(q_i) + \bar{s}_i D + K_i' l_i \tag{8}$$

3.4 The Vendor's Problem

There is one vendor who is selected from competition. Thus, the vendor makes zero profit. The vendor competes with the innovator to resell the open contents since downstream licensing is royalty free. The vendor incurs a cost $c_v(\cdot)$ to redistribute some copies of the good created by the innovator.

On the other hand, this vendor enjoys some net spillover benefits, $\omega(Q)$, of the stock of copies in the economy. For example, the vendor might be selling a complementary product in another market. The vendor's profit

function is:

$$\Pi_v \equiv q_v R - c_v(q_v) + \omega(Q) - Q\bar{s}_v D(l_v, l_i, l_u) - K_v(Ql_v) \tag{9}$$

It implies that even if $q_v = 0$, as long as $q_i > 0$, this vendor might find it beneficial to incur $K_v(Ql_v)$ to adjust the total expected damage QD[16]. The first order conditions are:

$$q_v \frac{\partial R}{\partial l_v} = Q\bar{s}_v D_{l_v} + QK'_v \tag{10}$$

$$R + \omega'(Q) = c'_v(q_v) + \bar{s}_v D + K'_v l_v \tag{11}$$

3.5 The Decentralized Equilibrium

(2), (4), (7) and (10) together with the five equations below characterize the equilibrium given the liability rules. Since $\bar{s}_v + \bar{s}_u + \bar{s}_i = 1$, the decentralized equilibrium level q_i^+ satisfies the following equation, obtained from the combination of (5) and (8)[17]:

$$b(Q) = c'_i(q_i) + (\bar{s}_u + \bar{s}_i)D + K'_i l_i + K'_u l_u \tag{12}$$

[16] The debate (Boldrin and Levine [2002], Klein, Lerner, and Murphy [2002], and Romer [2002]) focuses on the necessity of intellectual property in face of the new sharing technologies such as Napster. This paper fills a gap in the debate by enlarging the scope of analysis to include information goods such as software files. The sharing of software allows resellers to help increase the quality of the software by, for example, sharing the efforts to fix software vulnerabilities.

[17] To be more precise, q_i^+ is still a best response function wrt q_v. But we do not need to explicitly solve for it for comparative statics.

Also, the decentralized equilibrium level q_v^+ satisfies the following equation, obtained from the combination of (5) and (11)[18]:

$$b(Q) = -\omega'(Q) + c_v'(q_v) + (\bar{s}_u + \bar{s}_v)D + K_v' l_v + K_u' l_u \tag{13}$$

Free entry implies these zero profit conditions of the innovator, vendor and Hidden, respectively:

$$q_i R = F_i + c_i(q_i) + Q\bar{s}_i D + K_i(Ql_i) \tag{14}$$

$$q_v R + \omega(Q) = c_v(q_v) + Q\bar{s}_v D + K_v(Ql_v) \tag{15}$$

$$(1-\theta)QD = F_h \tag{16}$$

3.6 The Centralized Equilibrium

The social planner's problem I use here is to choose l_v, l_u, l_i, q_i and q_v to maximize the total welfare in this additive form:

[18] Similarly, q_v^+ is still a best response function wrt q_i.

$$
\begin{aligned}
W &= U + \Pi_i + \Pi_v + \Pi_h && (17)\\
&= \int_0^Q b(h)dh + \omega(Q) - c_i(q_i) - c_v(q_v) - K_v(Ql_v) \\
&\quad -K_u(Ql_u) - K_i(Ql_i) - QD + (1-\theta)QD - F_i - F_h && (18)\\
&= \int_0^Q b(h)dh + \omega(Q) - c_i(q_i) - c_v(q_v) - K_v(Ql_v) && (19)\\
&\quad -K_u(Ql_u) - K_i(Ql_i) - \theta QD - F_i - F_h && (20)
\end{aligned}
$$

Conditional on there being a litigation, $(1-\theta)QD$ is just a transfer between the agents, if the social planner does not care about its distribution among the agents, the role of liability shares is just to induce the most efficient care takers to reduce the damages. That is why only θ portion of the total expected damage is left in the last equation because the social planner still cares about how to reduce the dissipative litigation costs.

Considering interior solutions[19], the first order conditions are:

$$K_v' + \theta D_{l_v} = 0 \tag{21}$$

$$K_u' + \theta D_{l_u} = 0 \tag{22}$$

$$K_i' + \theta D_{l_i} = 0 \tag{23}$$

$$b(Q) = -\omega'(Q) + c_i'(q_i) + K_v' l_v + K_u' l_u + K_i' l_i + \theta D \tag{24}$$

$$b(Q) = -\omega'(Q) + c_v'(q_v) + K_v' l_v + K_u' l_u + K_i' l_i + \theta D \tag{25}$$

The last two equations together imply:

$$c_v'(q_v) = c_i'(q_i) \tag{26}$$

3.7 Efficiency of Decentralization

When the values of the decentralized and centralized equilibrium variables (denoted by $+$ and $*$) coincide, the decentralized choices are efficient.

Quantities

Proposition 1 *Given some strictly positive care levels, the liability rules are irrelevant for q_i^* and q_v^*. But the efficient quantities levels of q_i^* and q_v^* are not necessarily obtained from the decentralized equilibrium. In fact, $q_i^* = q_i^+$*

[19] Here I assume the Inada conditions $\lim_{l_j \to 0} \frac{\partial D(\cdot)}{\partial l_j} = -\infty$ and $\lim_{l_j \to \infty} \frac{\partial D(\cdot)}{\partial l_j} = 0$. These guarantee a unique interior solution for the care levels. For q_v and q_i, we assume that it is strictly positive because we have to start with some strictly positive q_i for vendors to redistribute. $q_v = 0$ is an uninteresting case.

and $q_v^* = q_v^+$ *only if* $K_i' l_i + \bar{s}_i D = K_v' l_v + \bar{s}_v D - \omega'(Q)$

Proof. $\bar{s}_v, \bar{s}_u$, and $\bar{s}_i$ are absent in (24) and (25). Recall that the centralized equilibrium requires that $c_v'(q_v^*) = c_i'(q_i^*)$. For this to hold at the decentralized level, from (12) and (13), we have $c_v'(q_v^+) = c_i'(q_i^+) \iff K_i' l_i + \bar{s}_i D = K_v' l_v + \bar{s}_v D - \omega'(Q)$ ■

The intuition is the following. The marginal revenue of redistribution is constant. For both the innovator and vendor to make zero profit, their total marginal costs should be the same. From (26), the social planner wants the marginal distribution costs to be the same for both the innovator and vendor. This implies that the rest of the marginal costs must be the same. The rest of the marginal costs for the innovator are $K_i' l_i + \bar{s}_i D$ and the rest for the vendor are $K_v' l_v + \bar{s}_v D - \omega'(Q)$[20].

Rewriting the condition $K_i' l_i + \bar{s}_i D = K_v' l_v + \bar{s}_v D - \omega'(Q)$, we have $(\bar{s}_v - \bar{s}_i) D = K_i' l_i - K_v' l_v + \omega'(Q)$. One implication is that to have efficient quantities produced, a necessary condition is that the vendor should bear more liability than the innovator when the marginal spillover effect $\omega'(Q)$ and the innovator's care costs of the marginal copy, $K_i' l_i$, are high relative to the vendor's care costs of the marginal copy, $K_v' l_v$.

Care Levels Now, let us compare the care levels by comparing the equilibrium care levels l_v^+, l_u^+, and l_i^+ that satisfy (10), (4), and (7) with l_v^*, l_u^* and

[20] One can also see it this way. The zero profit condition of the innovator implies that $R = c_i'(q_i) + \bar{s}_i D + K_i' l_i$ and the zero profit condition of the vendor implies that $R = c_v'(q_v) + \bar{s}_v D + K_v' l_v - \omega'(Q)$. Equating these two implications and then apply $c_v'(q_v^+) = c_i'(q_i^+)$, we have $K_i' l_i + \bar{s}_i D = K_v' l_v + \bar{s}_v D - \omega'(Q)$.

l_i^* that satisfy (21), (22), and (23).

Proposition 2 *Efficient care levels can be achieved when these necessary conditions are satisfied:*

$$\bar{s}_i = \theta + \frac{q_i \frac{\partial R}{\partial l_i}}{QD_{l_i}} \tag{27}$$

$$\bar{s}_v = \theta + \frac{q_v \frac{\partial R}{\partial l_v}}{QD_{l_v}} \tag{28}$$

$$\bar{s}_u = \theta - \frac{\frac{\partial R}{\partial l_u}}{D_{l_u}} \tag{29}$$

Proof. Equating (7) with (23), we have: $\bar{s}_i = \theta + \frac{q_i \frac{\partial R}{\partial l_i}}{QD_{l_i}}$. Equating (10) with (21), we have: $\bar{s}_v = \theta + \frac{q_v \frac{\partial R}{\partial l_v}}{QD_{l_v}}$. Equating (4) with (22), we have: $\bar{s}_u = \theta - \frac{\frac{\partial R}{\partial l_u}}{QD_{l_u}}$.

■

Note that for $j = i, v, \bar{s}_j$ is increasing in the litigation cost, j's share of quantity supplied (q_j/Q), and the rate of change of the unit price w.r.t. j's care level. $\bar{s}_j$ is decreasing in the rate of change of the damage function w.r.t. j's care level. The intuition is that j should bear a higher liability share cost if it is supplying relatively more than the other supplier else there will not be zero profits because j has to exercise care to the copies distributed by itself and the other supplier. j should bear an even higher liability share cost if it is compensated more through the unit revenue for more of its care level else its zero condition will be violated. But j should bear a lower liability share cost if D_{l_i} increases, that is, it is becoming less effective in reducing damage through its care. $\bar{s}_u$ can be interpreted in a similar way but with the

direction reversed for the rate of changes.

Recall that in the beginning of this theory section, I want to model some cases when there are high transaction costs or some rights are absent. Now consider the cases if some forms of bargaining are not feasible because of these reasons. Specifically, consider these restrictions:

$$\bar{s}_v, \bar{s}_u, \bar{s}_i \in [0, 1] \tag{30}$$

and

$$\text{For some } j, \frac{\partial R}{\partial l_j} = 0. \tag{31}$$

The lower bound of the first restriction says that one cannot take the liability as a revenue source. Its upper bound implies that one cannot pay more than what the damage is worth. The second restriction says that the price could be independent of either l_v, l_u or l_i.

Here are several corollaries that hold largely because some zero profit condition(s) must be violated otherwise:

Corollary 3

$$\forall j \quad = \quad i, v : \frac{\partial R}{\partial l_j} = 0 \iff \bar{s}_j = \theta \tag{32}$$

$$\forall j, j' \quad = \quad i, v : \frac{\partial R}{\partial l_j} = 0 \iff \bar{s}_{j'} = 0, j \neq j' \tag{33}$$

Proof. The first equation is trivial by Proposition 2 since $q_i, q_v, D_{l_v} \neq 0$. For the second equation, from the zero profit condition of the vendor (15),

$\frac{\partial R}{\partial l_i} = 0 \iff \bar{s}_v = 0$. Similarly, from the zero profit condition of the innovator (14), $\frac{\partial R}{\partial l_v} = 0 \iff \bar{s}_i = 0$. ■

For $Q > 0, \frac{\partial R}{\partial l_j} = 0$ implies that the first order condition of innovator or vendor becomes $\bar{s}_j D_{l_j} = K_j'$. This is a marginal revenue equals marginal cost condition for the individual's optimization problem. Recall that the corresponding marginal revenue equals marginal cost condition for the social planner's optimization problem is: $\theta D_{l_j} = K_j'$. So for the decentralized choices of care levels to be socially optimal, these two conditions need to be equal, giving $\bar{s}_j = \theta$.

Corollary 4 *When the price is invariant to the care levels of the innovator and the vendor, that is,* $\frac{\partial R}{\partial l_i} = \frac{\partial R}{\partial l_v} = 0$, *efficient care levels cannot be achieved if* $\theta \neq 0$.

Proof. By the previous corollary, when $\frac{\partial R}{\partial l_i} = \frac{\partial R}{\partial l_v} = 0, \bar{s}_v = \bar{s}_i = 0$. This violates $\bar{s}_v = \bar{s}_i = \theta$ by the previous corollary since $\theta \neq 0$. ■

Corollary 5 *If* $\theta \geq \frac{1}{2}, \bar{s}_v > 0$ *and* $\bar{s}_i > 0$, *the decentralized choices are efficient only if* $\bar{s}_u < 0$.

Proof. When $\bar{s}_v > 0$, the zero profit condition of the vendor (15) implies that $\frac{\partial R}{\partial l_i} < 0$. Then by Proposition (2), $\bar{s}_i > \theta$. Similarly, $\bar{s}_i > 0$ and the zero profit condition of the innovator (14) implies that $\frac{\partial R}{\partial lv} < 0$ and $\bar{s}_v > \theta$ by Proposition (2). Together with $\bar{s}_v + \bar{s}_u + \bar{s}_i = 1$, we have $\bar{s}_u < 1 - 2\theta \leq 0$ if $\theta \geq \frac{1}{2}$. ■

One implication is that in the no liability to users case ($\bar{s}_u = 0$), efficient care levels cannot be obtained if the litigation costs are too high ($\theta \geq \frac{1}{2}$).

Corollary 6 *If $\bar{s}_v = \bar{s}_i = 0$, efficient care levels cannot be achieved if $\theta \neq 0$.*

Proof. $\bar{s}_v = \bar{s}_i = 0 \implies \frac{\partial R}{\partial l_i} = \frac{\partial R}{\partial l_v} = 0$ by Corollary (3). Then by Corollary (4), efficient care levels cannot be achieved if $\theta \neq 0$. ■

Another implication is that for the no liability to the innovators and vendors case ($\bar{s}_v = \bar{s}_i = 0$), commonly used in open content licenses, efficient care levels cannot be achieved if there are non-zero litigation costs ($\theta \neq 0$).

4 Conclusions

I used a tort model to study the inclusion of value-adding resellers (vendors) who do not need to pay the original sellers (innovators) for production. I modeled after the SCO-Linux controversy to include an agent who receives a positive expected payment in intellectual property lawsuits but it is hard for other agents to contract with this agent ex ante. I then analyzed how the litigation between this agent, vendors, innovators and users affects care levels and quantities distributed.

Some main results here confirm with the standard results that in general efficiency requires the lowest cost agents to engage in activity until their marginal costs equal to that of other agents. The main contributions here are the derivation of some neccessary conditions for efficiency and sufficient conditions for inefficiency in the context of open contents.

For efficient quantities, it is necessary for the vendors to bear more liability than the innovator when the marginal spillover effect and the innovator's care costs of the marginal copy are high relative to the vendor's care costs of the marginal copy. For efficient care, it is necessary for care levels to obey the implicit analytical forms of the optimal liability shares I have derived.

For inefficient care, I have derived some sufficient conditions related to the interaction of liability shares and litigation costs. For example, in the no liability to users case, efficient care levels cannot be obtained if the litigation costs are too high. In the no liability to the innovators and vendors case commonly used in open content licenses, efficient care levels cannot be achieved if there are non-zero litigation costs.

This research is not without limitations. One cannot immediately conclude that the real world values are not optimal when there is a deviation from the theoretical values because the transaction costs associated with one or more variables could simply be too high. Further empirical research could be done to identify what measures, with less transaction costs, are used for adjustment in place of those variables that appear to be deviating from the theoretical values. For example, the theoretical liability shares here could be proxied by several non-mutually exclusive observables in addition to those provisions in the open content licenses. If the liability shares in open content licenses are too rigid, liability adjusting measures such as safe harbor provisions might emerge to clear the market.

5 References

Boldrin, Michele, and David K. Levine (2002). "The Case Against Intellectual Property," *American Economic Review*, May 2002 (Papers and Proceedings), 92(2), pp. 209-12.

Capek P.G., S. P. Frank, S. Gerdt, and D. Shields (2005). "A History of IBM's Open-Source Involvement and Strategy," *IBM Systems Journal*, 44(2), pp. 249-257.

Cheung, Steven N.S. (1970). "The Structure of a Contract and the Theory of a Non-Exclusive Resource," *Journal of Law and Economics,* 3, pp. 1-44.

Coase, Ronald (1960). "The Problem of Social Cost," *The Journal of Law and Economics*, 3, pp. 1-44.

Grossman, Sanford J, and Oliver D. Hart (1986). "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy*, 94(4), pp. 691-719.

Hart, Oliver D., and John Moore (1990). "A Theory of Corporate Financial Structure Based on the Seniority of Claims," National Bureau of Economic Research Working Paper No. 3431.

Klein, Benjamin, Andres V. Lerner, and Kevin M. Murphy (2002). "The Economics of Copyright "Fair Use" in a Networked World," *American Economic Review*, May 2002 (Papers and Proceedings) 92(2), pp. 205-8.

Landes, William, and Richard Posner (1985). "A Positive Economic The-

ory of Products Liability," *Journal of Legal Studies*, 14(3), pp. 535-567.

Landes, William, and Richard Posner (1987). *The Economic Structure of Tort Law*. Cambridge, MA: Harvard University Press.

Liang, Lawrence (2004). *Guide to Open Content Licenses*. Piet Zwart Institute.

Miceli, Thomas J. (1997). *Economics of the Law: Torts, Contracts, Property, Litigation*. New York, NY: Oxford University Press.

Newmarch, Jan (2000). "Open Content Licenses," mimeo, `http://jan.newmarch.name/opendoc/chapter.pdf`, accessed October 6, 2007.

OSDL. "OSDL to Support Enhancements to Linux Kernel Development Process," `http://www.osdl.org/newsroom/press_releases/2004/2004_05_24_beaverton.html`, accessed May 2005.

Romer, Paul M. (2002). "When Should We Use Intellectual Property Rights?" *American Economic Review*, May 2002 (Papers and Proceedings), 92(2), pp. 213-216.

Shavell, S. (1980). "Strict Liability versus Negligence," *Journal of Legal Studies*, 9(1), pp. 1-25.

The Apache Software Foundation. "Licenses: Contributor License Agreements," `http://www.apache.org/licenses/`, accessed February 6, 2006.

Wall Street Journal. "Linux Backers Form Network To Buy Software Patents?" November 10, 2005, `http://online.wsj.com/article/SB113157984994692879.html`, accessed December 1, 2005.

Zittrain, Jonathan (2004). "Normative Principles for Evaluating Free and

Proprietary Software," *University of Chicago Law Review*, 71(1).