Contributory Infringement and Network Innovation

Corinne Langinier* and Philippe Marcoul†

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Abstract

The contributory infringement rule assesses liability to a third party that contributes to the infringement of a patent. Not only are firms that directly infringe liable, those who indirectly contribute are also liable. In the e-commerce world, this rule takes on an important dimension because of the network structure of the Internet. We investigate how the contributory infringement rule affects the creation of a network of members (membership program) and whether this rule is harmful to consumers and firms. We find that whatever the issue of the game (settlement or trial) the enforcement of the contributory infringement rule decreases the network size, and then decreases the social welfare. In the case of a settlement, the network size reduction is smaller than in the case of a trial. Surprisingly we find that if the compensation paid by the indirect infringers is high, the contributory infringement rule does not give enough R&D incentives *en ante*. It is even possible to find a direct compensation for the patentholder that is socially preferable (as it increases the network size).

Keywords: Patents; Internet; Network

JEL classification: K11 (Property Law), K41 (Litigation Process), O34 (Intellectual Property Rights), D62 (Welfare Economics, Externalities)

1 Introduction

Business-method software is one of the fastest-growing categories of new patents. Nowadays, patents exist for methods of accepting credit cards over the Internet, for processing orders and transaction of all types, and for alerting consumers of the status of their orders.[1] These patents are among the most valuable intangible assets of Internet companies. The interconnected architecture of the Internet makes e-commerce patents a powerful tool in the hands of patentholders. Indeed, the network structure of the Internet has an indirect influence on the value of patents, due to the contributory infringement rule that exists in patent laws. This rule states that firms are liable not only if they infringe on a patent, but that they are liable also if they indirectly contribute to the infringement.[2]

To fully capture the effects of this rule, a better understanding of the structure of the relationships on the Internet is needed. The existence of the network induces specific relationships between firms: their web sites are cross-linked, and they advertise other web sites. A given web site of a firm B may use, via hyperlinks or cross promotions, some of the software or some of the resources of another web site created by firm C. Both firms can possibly contract upon the provision of such software or shared resources. Consequently, the Internet can be seen as a network of contracts in which firms are committed to other firms, and thus become liable when the nature of the shared item is altered. Imagine that another firm, say firm A, holds a patent on software that firm B uses; that B has contracted with C, and, furthermore, that firm C derives benefits from this software. What if firm B has infringed upon A's patent? In order to realize the magnitude of such an issue, consider the following example.[3] Amazon.com has about 250,000 members in its associated program. Each of these members receives a payment of between 7 and 15 percent of any book or video sold to consumers that they refer. Imagine now that another firm that holds a specific patent files a lawsuit against Amazon.com for infringement. The contributory infringement rule allows the patentholder to sue the 250,000 members in case of successful trial, because they contribute to the infringement (they appear as a third party in the infringement, but have their share of responsibilities).

Hence, firms can be accused of direct infringement if they illegally use a method-of-doing-business protected by a patent. But they can also be accused of indirect infringement as soon

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[1] Patents owned by Amazon.com, Priceline.com, eBay.com among others.

[2] "Contributory infringement... imposes liability where one person knowingly contributes to the infringing conduct of another" Fonovisa, Inc. v. Cherry Auction, Inc., 76 F.3d at 263 (9th Cir. 1996).

[3] See Rivette and Kline (2000).

as they help to sell or promote products or services of a company that infringes upon a patent.[4] Formally, patent law also makes liable someone who actively induces infringement of a patent, or someone who contributes to the infringement by another if he "offers to sell or sells a component of a patented machine, manufacture, combination or composition, or a material or apparatus for use in practicing a patented process."[5]

A recent lawsuit has been lost by British Telecommunications that sued Prodigy for patent infringement.[6] The Sargent patent (hyperlink patent) describes a system in which multiple users, located at remote terminals, can access data stored in a central computer. BT has argued that the Internet infringes the Sargent patent and that Prodigy facilitates infringement by its subscribers by providing them with access to the Internet. BT wanted to have all the Internet service providers pay a license fee for hosting pages that use hyperlinks (the building blocks on the web). In the case of a successful trial, BT would have sued all Internet service providers. This real-life example gives an idea of the magnitude of such a rule and what could have been the consequences of it. The recent surge of software patents makes the possibility of contributory infringement among Internet actors more likely.

In this paper we investigate the effects of the contributory infringement rule on the creation and the size of an e-commerce network. The existence of this rule introduces a strong (positive) correlation between the risk of legal lawsuits of the different members. The members are willing to be part of this network only when they can cover the costs of legal lawsuits linked to the possibility of indirect infringement. However, in many situations, disputes over intellectual property rights are not settled in court. In our framework, we allow for the possibility of an out of court negotiation in which a license fee can be negotiated between the direct infringer and the patentholder; therefore trial needs not to be always the outcome of the game.

Our main focus is to determine whether and how this rule affects the creation of a network, and whether or not this rule is socially harmful. We wonder whether patentholders will go to court more often or if, on the contrary, they will settle out of court. Our central result is that the enforcement of the contributory infringement rule is harmful to consumers and firms, as it induces a smaller size of network whether or not firms settle out of court. This result still holds even if the patentholder receives the same compensation in case of successful trial under the

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[4] For instance, on March 23, 1999, the on-line auction eBay was sued by Network Engineering Software (NES) for "using third party software packages that infringe NES' patent," Bloomberg news; "NES sues eBay, alleges Patent Infringement," CNET news.com.

[5] 35 USC section 271 (c).

[6] "Hyperlink patent case fails to click," Matt Loney, CNET, News.com, August 23, 2002. See also Rivette and Kline (2000) at the beginning of the lawsuit.

contributory infringement regime and the no-contributory infringement regime.

The economic literature on intellectual property rights is mainly concerned with the liability issues of an infringer and the protection of the patentholder. Schankerman and Scotchmer (2001) study the value of the protection that a patentholder can get when different doctrines of damages are available. More precisely, they analyze the two U.S. doctrines of damages, "lost profit" and "unjust enrichment," and discuss under what circumstances one doctrine is superior to the other. They argue that when the innovator holds a patent on a research tool and is unable to develop it, he is better off when the doctrine of damages is "unjust enrichment." This happens because this doctrine does not completely prevent entry from infringers and put the patentholder in a stronger position to bargain over a license, once entry has occurred.[7] In our setup, we do not consider the possibility of injunctions but we assume that the patentholder observes entry and then decides to threaten the infringer and eventually bargain over a license.

Several other papers study how patentholders make their decision about settling out of court or suing for damages. Aoki and Hu (1999), using a cooperative approach to litigation and settlement, show that a trial can be Pareto optimal and that the threat of liquidation can be effective to prevent entry. Related, Crampes and Langinier (2002) also adopt a cooperative approach to study a setting in which monitoring is used as a tool to prevent entry of infringers.

Other contributions on litigation issues about infringement include, among others, Meurer (1989) who shows that a patentholder may decide to award a license to an infringer to avoid litigation of the issue of patent validity.

To the best of our knowledge, our paper is the first, in the economic literature, to analyze the contributory infringement rule and its consequences. We discuss the importance of this rule in the setup of a commercial network formation within the Internet.

Due to some specific characteristics, the Internet has been the center of interest of economists.[8] The particular infrastructure of the Internet allows everybody access. Our Internet network is a hierarchical one in which joining the network gives the customer the opportunity to buy a good; an opportunity he did not have before joining. Therefore, when one additional member joins the network, our measure of social welfare does not encompass the so-called network effects of this new entry. However, it is straightforward that our welfare result on the inefficiency of the contributory infringement rule would be magnify if we were to retain those

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[7]On the same topic, Kaplow and Shavel (1996), and Blair and Cotter (1998) discuss the appropriateness of doctorine of damages in different contexts.

[8]See Crémer, Rey and Tirole (2000), Crémer (2000)), Shapiro and Varian (1999) for different analysis of the network effects of the Internet.

effects.

From the intellectual property rights viewpoint, there exists debate about the necessity of the existence of software patents, in particular some scholars have argued that this kind of innovation are not very costly to produce and that licensing is just a rent-seeking activity. Several studies have pointed out the necessity of tailoring the patent system to this specific kind of innovation (Mergers (1999), Shapiro (2001)). In our paper, we do not address the problem of whether these patents should be granted, we just consider that they exist as they actually do, and that they can eventually be invalidated in court.

We propose a three-stage game. In the first stage, the potential infringer creates a network of members. He makes a "take-it-or-leave-it" offer to potential members. They all accept or refuse it. In the second stage, an innovator patents his business-method innovation or new software. The infringer decides whether or not to enter the protected market. If he enters, the infringement is detected and the patentholder decides whether to go to court or to settle out of court. When a settlement is reached, the infringer pays a license fee to the patentholder that is determined as a Nash Bargaining Solution. In the third period, if a trial occurs, with a certain probability the patentholder wins the case and can then sue all the members for contributory infringement if the rule is enforced.

We show that the network size is affected by the infringement contributory rule. We find that whatever the issue of the game (settlement or trial) the enforcement of the contributory infringement rule decreases the network size, and then decreases the social welfare. In the case of a settlement, the network size reduction is smaller than in the case of a trial. In the case of a trial, members of the network anticipate that there is a risk of being sued and need to be compensated enough to be part of the membership program. As a result, fewer members will enter. Moreover, we find that even if the patentholder can be equally compensated under both regimes (with and without contributory infringement), *ex ante* the regime without is better for society in general. We study the case of a patentholder whose revenue comes from licensing or damages. We show, in such a situation, that if society's goal is to maximize the *ex ante* incentives for R&D of the patentholder, then, there exists a level of contributory damage per member that maximizes the expected amount of damages (or expected license fee). The existence and the relevance of such a legal rule can thus be justified on that ground.

The paper is organized as follows. In section 2 we introduce the model. After presenting the timing of the game, we detail the structure of the network and the demand for the Internet good. We then present the expected payoffs of the firms under settlement and trial. Section 3 is devoted

to the determination of the license fee that the infringer has to pay in case of infringement when both patentholder and infringer settle out of court. In section 4 we derive the optimal size of the network as defined by the potential infringer when the contributory infringement rule is enforced and when it is not. We thus compare the optimal network size in the two different settings. In section 5 we characterize for which size of the network the patentholder prefers a settlement over a trial in the two different settings. We then define the equilibrium in section 6, the size of the network as well as the decision on whether to settle or to go to court are therefore derived. In section 7 we investigate the implications of the contributory infringement rule on the total welfare. Section 8 is concerned with the patenting and infringement decisions. Section 9 concludes and presents our future research agenda.

2   The Model

We consider a model in which a potential infringer creates a network of members, as is the case with the Amazon.com example presented in the introduction. This network already exists at the time the infringement occurs. In order to simplify, we consider three periods. In the first period the potential future infringer creates his network. In the second period, another firm patents an innovation that can be used in an obvious way by the potential infringer.[9] The latter then decides whether to use the innovation or not, knowing that a patent has been granted. If he infringes, the patentholder immediately detects the infringement and decides to go to court or to settle out of court. In the third period, if the infringer and the patentholder fail to reach an agreement, they go to court. We consider a regime in which contributory infringement is enforced and one in which it is not.

   We devote the rest of this section to first present the timing of the game. Second we detail the structure of the network of members, and we derive the demand for the infringer. Finally we present the payoffs of all the players.

2.1   Timing of the Game

The timing of the game is the following:

   1. In the first period, a network is created by the future potential infringer. He makes a

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[9]One of the patents granted to Amazon.com, number 5,960,411 entitled "method and system for placing a purchase order via a communication network patent" issued in 1999, is an example of such a method that was already used in-house by many firms.

"take-it-or-leave-it" offer to the potential members of his network. The members decide whether to accept or to refuse the offer made by the infringer.

2. In the second period, an innovator patents an innovation that can potentially be used by the infringer.[10] The infringer then decides whether to enter the protected market or not.[11] The patentholder detects immediately the infringement and observes the size of the network as well as the contracts proposed to the members by the infringer. He then decides whether to settle or to go to court.[12] If he decides to settle, then the patentholder and the infringer choose the level of license fee (Nash Bargaining Solution) and the commercial network is exploited for two periods, the second and the third period.

3. In the third period, if the patentholder has chosen to go to court in the second period, with a certain probability he wins the trial and the damages are paid according to the outcome of the trial. If the issue of the lawsuit is in favor of the patentholder then he is entitled to sue the members for contributory infringement if this rule is enforced.[13]

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[10]We can also consider that the patenting decision is a variable of decision. However, to simplify we assume that the parameters of the model are such that it is always worthwhile to patent. A decision not to patent would make the knowledge of the innovation not available to the potential infringer, and thus it would be the end of the game.

[11]We assume that the infringer cannot infringe if he does not have access to the information contained in the patent files of the patentholder.

[12]Crampes and Langinier (2002) consider a model of infringement in which the patentholder must first incur a cost to identify the infringer before deciding whether to go to court, to settle on an agreement or to renunciate any pursuit. Here for the sake of simplicity, we assume that detection is costless. Assuming a cost of detecting infringement would not change the results.

[13]We make the assumption that the success at the first trial insures the success against the members. What is in fact crucial for our results is that the first success makes the second success more likely. To establish a contributory liability, there is the requirement that the defendant has "the knowledge of the infringing activity, she (or he) induces, causes, or materially contributes to the infringing activity of another." The knowledge requirement is satisfied where the defendant knows or has reason to know of the infringing activity" (citing Casella v. Morris, 820 F2d 362, 365 11th Cir. 1987). This definition suggests that, for instance, an Online Service Provider should check whether the materials it diffuses are not copyrighted. The *Napster* case (i.e., A&M Records, Inc. v. Napster, Inc.) in which major recording companies filed a complaint for contributory infringement against Napster shows that judges may not want to encourage "willful blindness" and that Online Service Provider cannot wait the notice of copyrighted plaintiffs who detect the (contributory) infringement before stopping any illegal activity. In the *Napster* case, the judges ruled that *Napster* "has a duty to police its system in order to avoid vicarious infringement" (n175 *Id.* at 1096 –1097). On the Napster case see Boldrin and Levine (1999).

Before solving the game, we first determine the demand that the infringer faces and the payoffs of each firm.

2.2 Structure of the Network and Demand

We first describe the structure of the membership program. The infringer, called firm I, has a program with m members. For the sake of simplicity we will call this program the network of the infringer.

Each member i has n end-users. There is a possibility of overlapping. An end-user who is connected to member 1 can also be connected to member 2, and so on and so forth. Let N ($> n$) be the total fixed number of end-users that represents the size of the total network.

The infringer chooses to have as many end-users (i.e., potential buyers) as possible. Every time he accepts a new member, he will have at most n new end-users; at most, because among the new customers (i.e., end-users) some may already be connected to another member of the network. Consider the following trivial situation. The day he creates his membership program, the infringer does not have any members, consequently there are no end-users from his program. He accepts a new member (member 1) with n new end-users.[14] Then he accepts another member (member 2) with new end-users, as well. Some, if not all, of the end-users of member 2 can also be connected to member 1. Therefore the number of new[15] end-users will be smaller or equal to n. Formally, let G_i be the set of end-users that are not yet connected to a member that belongs to the network of the infringer when the member i joins the program. First, the infringer chooses the member 1 with n end-users. Second, he chooses another member (member 2) with $n\frac{G_2}{N}$ new end-users, where $G_2 = N - n$. The third member will bring fewer new end-users, namely $n\frac{G_3}{N}$ where $G_3 = N - n - n\frac{N-n}{N}$, and consequently the number of new end-users the member 3 brings

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[14]This is in fact equivalent to a sampling without replacement. Indeed, it is like if the infringer "draws" the first member from a set of members. This first member brings n new end-users; i.e., n times the proportion of end-users not yet connected to a member $((N - 0)/N)$, which is 1 for the first member.

[15]New meaning end-users not yet connected to the network of the infringer.

is $n\left(\frac{N-n}{N}\right)^2$, and so on and so forth. To simplify the notation, let us denote $A = \frac{N-n}{N}$. With m members in his network, the number of end-users will be[16]

$$S(m) = n\frac{1 - A^m}{1 - A}.$$

The number of end-users increases with the number of members at a decreasing rate ($S'(m) > 0$, and $S''(m) < 0$).

We now consider the end-users' side. We assume that each consumer can consume one or zero units of the good per period. A consumer has the following utility function:

$$U = \begin{cases} v - p & \text{if he buys the good at price } p \\ 0 & \text{otherwise} \end{cases}$$

where v represents the taste parameter of the consumer and is distributed according to some density $f(v)$, and with a cumulative distribution function $F(v)$, such that $F(0) = 0$ and $F(\infty) = 1$. Thus, $F(v)$ is the fraction of consumers with a taste parameter smaller than v. We can easily derive the total demand at price p

$$D(p, m) = [1 - F(p)]S(m), \tag{1}$$

and the consumers' surplus

$$CS(m) = \int_p^\infty [1 - F(p)]S(m)dp$$

increases at a decreasing rate with the number of members in the network.

2.3 Expected Payoffs Under Settlement or Trial

Each firm earns a payoff during the two periods after the creation of the network (i.e., period two and period three). To simplify, we assume that there is no discounting. In the first period, the infringer constitutes his network of members. Then, in the second period, once the patent has been granted and the infringer has decided to enter the market, the patentholder observes the size of the network and decides whether to settle or to go to court. If both agree upon a settlement, the optimal level of the license fee is immediately determined and the infringer pays the optimal license fee to the patentholder during each of the two remaining periods. If they

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[16]It is easy to check that $S(m) = n + n\left(\frac{N-n}{N}\right) + n\left(\frac{N-n}{N}\right)^2 + ... + n\left(\frac{N-n}{N}\right)^{m-1}$ is equivalent to $S(m) = n\frac{1-\left(\frac{N-n}{N}\right)^m}{1-\left(\frac{N-n}{N}\right)}$.

go to court, the outcome of the trial will only be known in the third period, and consequently will determine the payoffs of that period. The members' payoffs are also affected by the trial or settlement decision.

We first determine the gross payoffs of the infringer and the members. From the demand function (1), we determine the gross payoff of the infringer as

$$\Pi_I(\alpha, m) = (1 - \alpha)\mu[1 - F(p)]S(m) \tag{2}$$

where μ is the mark-up,[17] and $\alpha \in [0, 1]$ the fraction of the payoff that each member will get while he participates in the sell of the good at price p.

Each member obtains the following gross payoff[18]

$$\pi_i(\alpha, m) = \alpha\mu[1 - F(p)]n_i, \text{ for } i = 1, 2, ..., m,$$

where $n_i = nA^{i-1}$ represents the number of new end-users brought by member i.

In the second period of the game we determine the expected payoffs of each player depending on the issue of the game. First we consider that the patentholder and the infringer do agree on a settlement. The patentholder gets an expected payoff of

$$2\Pi_H - c_H^s + L^{NBS}, \tag{3}$$

where c_H^s is the cost associated with a settlement (transaction cost of patent licensing), Π_H the payoff earned by the patentholder and L^{NBS} the total negotiated license fee issued from a Nash Bargaining Solution (that we derive in Section 3). The expected payoff of the infringer is

$$2\Pi_I(\alpha, m) - c_I^s - L^{NBS}, \tag{4}$$

where c_I^s is the cost associated with a settlement paid by the infringer. Each member gets $2(\pi_i(\alpha, m) - c)$ where c represents the cost of maintaining the connection to the network. We assume, without loss of generality, that this cost is borne by the members.

If the patentholder prefers to go to court, his expected payoff is

$$\Pi_H - c_H^t + p_H(\Pi_H^{t,w} + R_H) + (1 - p_H)\Pi_H, \tag{5}$$

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[17]Note that μ depends on p, as $\mu = p - C$ where C is the marginal cost of production. However, to keep the model simple, and because we do not consider price setting, we simply denote by μ the mark-up.

[18]We can rewrite $S(m) = n + n\left(\frac{N-n}{N}\right) + n\left(\frac{N-n}{N}\right)^2 + ... + n\left(\frac{N-n}{N}\right)^{m-1}$ as $S(m) = n_1 + n_2 + n_3 + ... + n_m$.

where c_H^t is the cost incurred by the patentholder in the case of a trial, p_H the probability that he wins the trial, $\Pi_H^{t,w}$ ($\geq \Pi_H$) the associated payoff, and R_H the penalty that the patentholder receives if he wins the case.[19] This penalty depends crucially on the existence of the contributory infringement rule. If it is enforced, the patentholder will first receive a compensation from the infringer for direct infringement before launching a lawsuit against the members of the network. We assume that once the infringer loses the lawsuit, all the members are liable, and the patentholder is entitled to receive a compensation from all of them.[20] Hence, $R_H = R_{H,I} + \sum_{i=1}^{m} R_{H,i}$, where $R_{H,I}$ is the penalty paid by the infringer to the patentholder and $R_{H,i}$ the penalty paid by member i. The expected payoffs of the infringer can be stated as

$$\Pi_I(\alpha, m) - c_I^t + (1 - p_H)\Pi_I(\alpha, m) + p_H(\Pi_I^{t,l} - R_{H,I}),$$

and each member gets

$$\pi_i(\alpha, m) - c + (1 - p_H)(\pi_i(\alpha, m) - c) + p_H(\pi_i^l(\alpha, m) - c_i^t - R_{H,i}), \text{ for } i = 1, 2, ..., m.$$

Without loss of generality, we posit that $\Pi_I^{t,l} = 0$, $\pi_i^l(\alpha, m) = 0$, and we normalize $c_i^t = 0$. Indeed, if the infringer loses the case, he will be prevented from using the protected innovation, and thus will be forced to use a less profitable one that may drive the payoff down to zero. Once the infringer gets zero profit, each member will get zero profit, as well. Therefore, we can rewrite the expected payoff of the infringer as

$$(2 - p_H)\Pi_I(\alpha, m) - c_I^t - p_H R_{H,I}, \tag{6}$$

and of each member as

$$(\pi_i(\alpha, m) - c)(2 - p_H) - p_H R_{H,i}.$$

We now define more precisely the penalty rule. The law enunciates two doctrines of damages, "unjust enrichment" and "lost profit and reasonable royalty." Each doctrine has very distinctive purposes and is directed towards a specific target. The former doctrine states that the infringer is

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[19] We make the assumption that each party pays its own legal costs. In the United States, each party bears its own legal costs of trial unless it can be proved that there was a willful infringement (See Meurer (1989) or Aoki and Hu (1999)).

[20] This is a simplifying assumption and a shortcut. In practice, although infringement liability is a necessary condition for contributory infringement, the members will have to be sued for contributory infringement by the patentholder and each member's liability still has to be established by the court. Our result would not change qualitatively if we assumed that the chances of winning the trial for contributory infringement were strictly less than one.

required to pay back the profits from infringement to the patentholder. The latter compensates the patentholder for the foregone profit due to the infringement. This doctrine of damages is rather designed to maintain the patentholder's incentives to invest in R&D activities. We do not make any specific assumptions with respect to the doctrine of damages that is used by the court. Rather, we assume that the penalty paid to the patentholder will represent a fraction of the gross payoff of the infringer and, if applicable, of the indirect infringers. Consequently,

$$R_{H,I} = \beta_I \Pi_I(\alpha, m) \text{ and } R_{H,i} = \beta \pi_i(\alpha, m), \tag{7}$$

where $\beta_I, \beta \in [0, 1]$.

This assumption, consistent with Schankerman and Scotchmer (2001), may encompass the two doctrines of damages. For instance, $\beta_I = \beta = 1$ corresponds to the "unjust enrichment" doctrine whereas, presumably, $\beta_I < 1$ and $\beta < 1$ corresponds to the "lost profit" one.[21] It is also possible to have $\beta_I > 1$ when the patentholder can prove that there was willful infringement.

In section 7, we discuss the magnitude of the parameter β in the model. A high β stands for a high level of liability of the secondary infringers while a β close to 0 stands for a situation in which the contributory infringement rule is not enforced.

3   Negotiated License

To complete the description of the payoffs, we need to specify the negotiated license fee.

At the second stage of the game, if a settlement occurs, the patentholder and the infringer determine the level of royalty fee that the infringer will pay to the patentholder. We compute this level as the solution of a Nash Bargaining game.[22] The optimal level of the fee L is solution of the following program

$$\max_L \quad \left[2\Pi_H - c_H^s + L - (\Pi_H - c_H^t) - p_H(\Pi_H^{t,w} + R_H) - (1 - p_H)\Pi_H \right]^\rho \times$$
$$\left[2\Pi_I(\alpha, m) - c_I^s - L - ((2 - p_H)\Pi_I(\alpha, m) - c_I^t - p_H R_{H,I}) \right]^{1-\rho}$$

where ρ represents the bargaining power of the patentholder, and $(1 - \rho)$ the bargaining power of the infringer. The first bracket represents the difference between the profit of settlement and the profit of trial for the patentholder and the second bracket represents the difference between

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[21] The doctorine of "unjust enrichment" was used in the famous of Kodak versus Polaroid. See, Warshofsky (1994) for a detailed explanation of this case.

[22] This is in the same vein as Aoki and Hu (1999), or as Crampes and Langinier (2002).

the settlement payoff and the trial payoff for the infringer. If the contributory infringement rule is enforced, the optimal two-period license is

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\begin{aligned}
L_{with}^{NBS}(\alpha, m) \;=\; & \mu[1 - F(p)]S(m)p_H\left[(1 - \alpha)(\rho + \beta_I) + (1 - \rho)\alpha\beta\right] \\
& + (1 - \rho)p_H(\Pi_H^{t,w} - \Pi_H) + \rho(c_I^t - c_I^s) - (1 - \rho)(c_H^t - c_H^s).
\end{aligned} \tag{8}
$$

In the absence of the enforcement of the contributory infringement rule, the license is

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\begin{aligned}
L_{without}^{NBS}(\alpha, m) \;=\; & \mu[1 - F(p)]S(m)p_H(1 - \alpha)(\rho + \beta_I) \\
& + (1 - \rho)p_H(\Pi_H^{t,w} - \Pi_H) + \rho(c_I^t - c_I^s) - (1 - \rho)(c_H^t - c_H^s).
\end{aligned} \tag{9}
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For any m and α, it is easy to check that when the contributory infringement rule is enforced the optimal license fee is bigger than in the absence of such rule $(L_{with}^{NBS}(\alpha, m) > L_{without}^{NBS}(\alpha, m))$. Even though firms settle out of court, the threat point is the trial outcome, and therefore, if the rule is enforced, the license fee includes a fraction of the profit of the members that the patentholder can claim in case of infringement. Whether or not the outcome is a trial, the threat of the trial affects the members' payoffs. Therefore, the license fee increases with the penalty paid by the infringer(s), R_H. It also increases with the probability of winning for the patentholder.

4 Optimal Size of the Network

We now determine the optimal size of the network that the infringer chooses in the first period. For the moment, we do not consider explicitly the decision of the patentholder to settle or not, and the following analysis is conditional on the entry decision of the infringer. We assume that the infringer anticipates correctly what the outcome will be.

The infringer makes a take-it-or-leave-it offer to the members, and this offer consists of the share of profit made on each item sold by the member.

The infringer decides the size of his network by maximizing his payoff, subject to the participation constraint of the members. The members will accept being part of the membership program as long as they get a non-negative payoff. They have neither the same number of end-users nor the same payoff from their participation in the network. Furthermore, the constraint will be different depending on whether the infringer anticipates a settlement or a trial.

If the contributory infringement rule is enforced, and a settlement is anticipated, the participation constraint of each member is

$$
\pi_i(\alpha, m) - c \geq 0 \text{ for } i = 1, 2, ..., m.
$$

Only one constraint will be binding, for the last member that will enter the program with n_m end-users. Therefore, we can rewrite the bidding constraint as

$$\alpha_s = \frac{c}{\mu[1 - F(p)]n_m}. \tag{10}$$

If the infringer anticipates a trial, the participation constraints become

$$(\pi_i(\alpha, m) - c)(2 - p_H) - p_H R_{H,i} \geq 0 \text{ for } i = 1, 2, ..., m.$$

Again, just one constraint will be binding, and is represented by[23]

$$\alpha_t = \frac{c}{\mu[1 - F(p)]n_m} \times \frac{2 - p_H}{2 - p_H(1 + \beta)}. \tag{11}$$

If the contributory infringement is not enforced, whether a trial or a settlement is anticipated, the participation constraint of each member is simply

$$\pi_i(\alpha, m) - c \geq 0 \text{ for } i = 1, 2, ..., m,$$

and thus the only binding participation constraint is (10).

The fraction that the members get from participating in selling the good is higher when the anticipated outcome is a trial rather than a settlement ($\alpha_t > \alpha_s$) for a given number of members m. Indeed, they need to be compensated for a potential trial. On the other hand, the total number of members that will be in the network is affected by the outcome of the game. We now determine the different sizes of networks.

4.1 Without Contributory Infringement

We first determine the size of the network when the contributory infringement rule is not enforced.

If the infringer anticipates that there will be a settlement, his maximization program is

$$\begin{cases} \underset{m}{Max} & \{2\Pi_I(\alpha, m) - c_I^s - L_{without}^{NBS}\} \\ \text{s.t.} & (10) \end{cases}$$

---

[23] We make the simplifying assumption that α is identical for every member. Obviously, the infringer could obtain all the profit by proposing (optimally) a different α to every members and leave them with no profit. This assumption does not affect the results.

where the payoff $\Pi_I(\alpha, m)$ is defined by (2) and the optimal license fee by the appropriate level (9). This yields the following optimal network size (see appendix for all of the calculations)

$$m^*_{without} = \frac{\ln cA - \ln \mu[1 - F(p)]n}{2 \ln A}. \tag{12}$$

This optimal network size is, in fact, exactly the same as if there were no threat from the patentholder, and therefore no license fee to pay. In order to get positive solutions we need to restrict the set of parameters, and we thus assume that the connection cost of each member must be small enough; i.e., we must have $c < \mu[1 - F(p)]n/A$ if we want at least one member.[24]

If the infringer anticipates a trial, his program becomes

$$\begin{cases} \underset{m}{Max} & \{(2 - p_H)\Pi_I(\alpha, m) - c_I^t - p_H R_{H,I}\} \\ s.t. & (10) \end{cases}$$

We obtain the same optimal network size

$$m^{trial}_{without} = m^*_{without}. \tag{13}$$

Without contributory infringement, the optimal network size is not influenced by the possibility of indirect infringement. Indeed, the members' decision to enter the network is not affected by the occurrence of a trial. The optimal network size is an increasing function of N, the total number of end-users available, and a decreasing function of the cost of maintaining the connection to the network for the members, c.

4.2 With Contributory Infringement

We then determine the size of the network when the contributory infringement rule is enforced. The infringer must anticipate correctly if his decision will be followed by a settlement or a trial. We consider both cases, and find the optimal network size in these two settings is different.

If the infringer anticipates a settlement, his maximization program becomes

$$\begin{cases} \underset{m}{Max} & \{2\Pi_I(\alpha, m) - c_I^s - L^{NBS}_{with}\} \\ s.t. & (10) \end{cases}$$

Once we replace the payoff $\Pi_I(\alpha, m)$ with the equation (2) and the optimal license fee with the appropriate level (8), it yields the following optimal network size,

$$m^*_{with} = \frac{\ln cA(\theta + P) - \ln \mu[1 - F(p)]n\theta}{2 \ln A} \tag{14}$$

[24]Formally $m^*_{without}$ is equal to the smaller integer. Therefore, if $0 < m^*_{without} < 1$, then $m^*_{without} = 0$.

where $\theta = 2 - p_H(\beta_I + \rho)$ and $P = p_H(1 - \rho)\beta$.

The optimal size is a decreasing function of the cost of maintaining the connection to the network for the members, c, and of the bargaining power of the patentholder, ρ. It increases with the total number of end-users, N, the probability of winning the trial for the patentholder, p_H, and the fraction of the payoff of the infringer, β_I. It decreases with the level of damages β paid by the member in case of a successful trial for the patentholder.

If the infringer anticipates a trial, his maximization program is

$$
\begin{cases}
\underset{m}{Max} & \{(2 - p_H)\Pi_I(\alpha, m) - c_I^t - p_H R_{H,I}\} \\
\text{s.t.} & (11)
\end{cases}
$$

Once we replace all the appropriate terms with (2), and (7), we obtain

$$
m_{with}^{trial} = \frac{\ln cA(2 - p_H) - \ln \mu[1 - F(p)]n\theta_T}{2\ln A}, \tag{15}
$$

where $\theta_T = 2 - p_H(1 + \beta)$.

In the case of a trial, the optimal size of the network decreases with c and increasing with N. Furthermore, it decreases with p_H and β.

With contributory infringement, the optimal size of the network is influenced by the possibility of direct infringement, and depends on the outcome of the game if infringement occurs. It is important to notice that an increase in the probability that the patentholder wins the trial also increases the network size. An implication of the results of this section is that if we assume that p_H is positively correlated with the value of the innovation, then an increase of p_H when a settlement is the outcome of the game, is socially beneficial. This is true for two reasons. First, an increase in p_H increases the level of the license received by the patentholder and is likely to give him the right incentives to innovate *ex ante*. Second, as shown by expression (14), an increase in p_H also increases the size of the network which is, of course, socially beneficial as it increases the number of exchanges. We now compare the network sizes.

4.3 Comparison of Optimal Network Sizes

The comparison of all these network optimal sizes is straightforward and leads to the following inequalities $m_{with}^{trial} \leq m_{with}^* \leq m_{without}^{trial} = m_{without}^*$. We can posit the following lemma:

Lemma 1 *The enforcement of the contributory infringement rule decreases the optimal network size.*

When the contributory infringement rule is enforced, the infringer decreases the size of his network, whatever the outcome of the game. As the members become liable in the case of a successful trial for the patentholder, the formers are more reluctant to enter the network *ex ante* and the size of the network is smaller compared to the case without contributory infringement. When a settlement is the outcome of the game, the network also tends to become smaller. Indeed, when the contributory infringement rule is enforced, the cost of an extra member is in fact the marginal license fee that the infringer has to pay to recruit another member. However, in the case of contributory infringement, the marginal license fee entails some of the payment made by the member in case of successful trial and, as a result, the marginal license fee is higher than without contributory infringement; therefore fewer members will join the membership program.

When the contributory infringement rule is not enforced, the size of the network is not affected by the outcome of the game.

5   To Settle or Not to Settle

We now turn to the second stage of the game, wherein we describe the decision of the patentholder whether to go to court or to settle, in the two settings: when the contributory infringement rule is enforced and when it is not.

5.1   Without Contributory Infringement

The patentholder chooses whether to go to court, or to settle out of court. We define the payoff of the patentholder as a function of the size of the network. Even if the contributory infringement rule is not enforced, the patentholder benefits from the network through the infringer's penalty, or the license. Indeed, the profit of the innovator is a direct function of the size of the network. As the size of the network increases, the profit of the patentholder first increases and then decreases. First, he prefers to go to court, and get damages in the case of infringement. Then, as the network expands, and for the medium-sized network, the patentholder prefers to settle out of court and benefits from the infringement through the license. If the network becomes very large, the patentholder prefers to go to court.

To summarize these results, it is useful to discuss the decision of the patentholder according to the value of $\Delta = (\Pi_H^{t,w} - \Pi_H) - \frac{1}{p_H}(c_I^t - c_I^s + c_H^t - c_H^s)$. Recall that $\Pi_H^{t,w}$ is the profit of the patentholder whenever he wins the trial. This profit level is independent from any license or damages that the patentholder would obtain. It may represent, for instance, the gains that

the patentholder can derive from a "better reputation" after he wins the trial. We obtain the following lemma:

Lemma 2 *If the contributory infringement rule is not enforced (or equivalently if $\beta = 0$)*

- *and if $\Delta < \Pi_I(\alpha_s, m^*_{without})$*

  - *For a small network ($m < \underline{m}_{without}(\Delta)$) or for a very large network ($m > \overline{m}_{without}(\Delta)$), the patentholder prefers to go to court.*
  - *For intermediate values of the network ($m \in [\underline{m}_{without}(\Delta), \overline{m}_{without}(\Delta)]$), he prefers to settle out of court.*

- *and if $\Delta \geq \Pi_I(\alpha_s, m^*_{without})$, he prefers a trial over a settlement.*

Proof. We compare equations (3) and (5), in which we replace the optimal license by (9), α is defined by equation (10) and the penalty by equation (7). Note that here $R_{H,I} = \beta_I \Pi_I(\alpha, m)$ and $R_{H,i} = 0$, as the contributory infringement rule is not enforced. Independently of the issue of the game (trial or settlement), the share of each member will be the same under the no contributory infringement rule. Thus, it is easy to compare the expected payoffs of the patentholder in the case of trial and settlement. A trial will be preferred to a settlement as long as $p_H \rho(\Delta - \Pi_I(\alpha, m)) > 0$. We will discuss the variation of Δ in section 6.4. However we can represent the different areas (Trial and Settlement) in a graph (m, Δ) that we will study in depth in the next section. It is straightforward to note that for a network size of 0, the profit from a trial is higher that the profit from a settlement as long as $\Delta > 0$, otherwise the converse is true. As the network size increases, if $\Delta \leq 0$, a settlement is preferred to a trial. If $\Delta > 0$, a trial will be preferred to a settlement if $\Delta - \Pi_I(\alpha, m) > 0$. Therefore, for any values of $\Delta < \Pi_I(\alpha_s, m^*_{without})$, there exist two values of m that make the innovator indifferent between going to court or settling out of court (see appendix A.2.1 for these values). For all values of $m \in [\underline{m}_{without}(\Delta), \overline{m}_{without}(\Delta)]$ the outcome is a settlement. For a value smaller than $\underline{m}_{without}(\Delta)$ or bigger than $\overline{m}_{without}(\Delta)$, the outcome is a trial. Figure 3 gives a graphical representation of the function Δ. ∎

This lemma shows that, without contributory infringement, as long as Δ is not too high, the outcome of the game will always be a settlement as the size $m^*_{without}$ is always chosen by the infringer. Only when settlement costs are very high compared to trial costs and / or $\Pi_H^{t,w}$ is very high compared to Π_H, the patentholder decides to go to court.

We can also posit the following result:

Lemma 3 *The profit of the patentholder first increases and then decreases with the size of the network.*

Proof. From equation (5), the derivative of the total payoff is $p_H \rho \frac{\partial \Pi_I(\alpha_s, m)}{\partial m}$ and the derivative of (3) gives $p_H(\rho + \beta_I) \frac{\partial \Pi_I(\alpha_s, m)}{\partial m}$. Thus, the shape of the payoff function of the patentholder depends on the shape of the payoff function of the infringer. The derivative $\frac{\partial \Pi_I(\alpha_s, m)}{\partial m}$ is positive for values of $m < m^*_{without}$ and negative otherwise. Consequently, the expected profit of the patentholder first increases, and then decreases. ∎

This last result is due to the "inverted U" shaped license fee function that is paid by the infringer. It reaches a maximum at the optimal size of the network, as does the profit of the patentholder.

5.2   With Contributory Infringement

If the contributory infringement rule is enforced, the patentholder's decision will depend on the existing contract between the infringer and the members. Indeed, whether the infringer anticipates a trial or a settlement, he will offer a contract in which the fraction that each member gets is different. While anticipating a trial, the infringer offers α_t as defined by equation (11), whereas he offers α_s, as defined by equation (10), if the anticipated outcome is a settlement. Then, depending on the existing contract, the patentholder decides whether or not to settle.

Consider first that the share of profit proposed in the contract is α_s (a settlement is anticipated). The determination of the settlement's decision versus trial's decision is similar to the one defined in the case of no contributory infringement, except that here the optimal license is no longer (9), but is (8), α is defined by equation (10) and the penalty is (7) where $R_{H,i} > 0$. We find similar results, but with different boundaries $\underline{m}^s_{with}(\Delta)$ and $\overline{m}^s_{with}(\Delta)$. Indeed, the patentholder prefers a trial for values of m such that $\Delta \geq f_s(m) = (1 - \alpha_s(1 + \beta))\mu(1 - F(p))S(m)$. If we denote m_s the $\arg\max f_s(m)$, and if $\Delta < f_s(m_s)$, for values of m that belong to the interval $[\underline{m}^s_{with}(\Delta), \overline{m}^s_{with}(\Delta)]$ the patentholder prefers a settlement. If $\Delta > f_s(m_s)$ no settlement occurs. All of the values are derived in the appendix.

Consider now that $\alpha = \alpha_t$ (trial is anticipated). As previously, we define the areas in which the patentholder prefers a trial over a settlement; i.e., if $\Delta \geq f_t(m) = (1 - \alpha_t(1 + \beta))\mu(1 - F(p))S(m)$. If we denote m_t the $\arg\max f_t(m)$, and if $\Delta < f_t(m_t)$, for values of m that are smaller than $\underline{m}^t_{with}(\Delta)$ and bigger than $\overline{m}^t_{with}(\Delta)$, the patentholder prefers a trial over a settlement. If $\Delta > f_t(m_t)$, a trial is always chosen.

19

We show that $\underline{m}^s_{with}(\Delta) < \underline{m}^t_{with}(\Delta) < \overline{m}^t_{with}(\Delta) < \overline{m}^s_{with}(\Delta)$ (see appendix A.2.4. for the proof). We can posit the following result:

Lemma 4 *If the contributory infringement rule is enforced,*

- *and if $\Delta < f_j(m_j)$, where $j = s, t$, then*

   - *for small sizes of the network ($m < \underline{m}^j_{with}(\Delta)$) and big sizes ($m > \overline{m}^j_{with}(\Delta)$), the patentholder prefers a trial over a settlement.*
   - *for intermediate size of the network size ($m \in [\underline{m}^j_{with}(\Delta), \overline{m}^j_{with}(\Delta)]$), the patentholder prefers to settle out of court.*

- *and if $\Delta \geq f_j(m_j)$, where $j = s, t$, the patentholder prefers to go to court.*

According to the contract offered by the infringer to the members, we have defined the size ranges of networks for which the patentholder decides to settle or to go to court.

5.3 Comparison of the Regimes

Under contributory infringement trials are more likely to occur than without contributory infringement rule.

Lemma 5 *For $\Delta \in [0, f_s(m_s)]$, and for a network of any size, more trials occur under a contributory infringement regime than under a no contributory infringement regime.*

Proof. We check that $f_s(m) < \Pi_I(\alpha_s, m)$. Therefore, for any $\Delta \in [0, f_s(m_s)]$, where m_s is the size of network that maximizes $f_s(m)$, $\underline{m}_{without}(\Delta) < \underline{m}^s_{with}(\Delta) < \underline{m}^t_{with}(\Delta) < \overline{m}^t_{with}(\Delta) < \overline{m}^s_{with}(\Delta) < \overline{m}_{without}(\Delta)$. So for values of $m \in [\underline{m}_{without}(\Delta), \underline{m}^s_{with}(\Delta)]$ and $m \in [\overline{m}^s_{with}(\Delta), \overline{m}_{without}(\Delta)]$ a settlement occurs when the contributory infringement rule is not enforced; whereas there is a trial when the rule is enforced. ∎

Thus, for a given Δ, certain sizes of the network will induce a trial if the rule is enforced. However this is only true for certain sizes, and as a result, the equilibrium sizes are not necessarily in this range of network sizes. We now determine the equilibrium.

6 Size of Network and Settlement or Trial Decision

In the first period, the infringer determines the size of his network. In the second period, once a patent has been granted and infringement occurs, the patentholder observes the size of the network and then decides whether or not to settle. Consequently, we look for a Nash Perfect equilibrium. By backward induction we first determine the decision of the patentholder to settle or not, and then we define the size of the network. We first determine the Nash Perfect equilibrium when the contributory infringement is enforced, then when it is not. We then compare the two regimes.

6.1 Contract and Network Size without Contributory Infringement

The equilibrium outcome depends on the infringer's choice of network size in the first place. When he decides the contract to offer and the size of the network, he correctly anticipates the issue of the game.

If the infringer chooses a network size such that there will be a settlement, using the result established in Lemma 2, we can write his program as

$$\begin{cases} \underset{m}{Max} & \{2\Pi_I(\alpha, m) - c_I^s - L_{without}^{NBS}\} \\ \text{s.t.} & (10) \\ \text{and} & m \in [\underline{m}_{without}(\Delta), \overline{m}_{without}(\Delta)] \end{cases}$$

where the second constraint represents the range of network sizes over which the patentholder will choose to settle. We will discuss all of the results in function of Δ and m and provide an analysis in the space (m, Δ). In this problem, the solution can either be $m_{without}^*$, $\underline{m}_{without}(\Delta)$, or $\overline{m}_{without}(\Delta)$, depending on whether a corner solution is obtained.

The infringer can choose to trigger a trial through the choice of network size, in this case the program of the infringer can be written as

$$\begin{cases} \underset{m}{Max} & \{(2 - p_H)\Pi_I(\alpha, m) - c_I^t - p_H R_{H,I}\} \\ \text{s.t.} & (10) \\ \text{and} & m \in [0, \underline{m}_{without}(\Delta)[\cup]\overline{m}_{without}(\Delta), \overline{m}] \end{cases}$$

where $\overline{m}$ is the maximum network size, and the solution again will be either $m_{without}^*$, $\underline{m}_{without}(\Delta)$, or $\overline{m}_{without}(\Delta)$.

Whatever the value of m, we compare the profit of the infringer when the issue is a trial (it is given by (6)) with the profit when the issue is a settlement (it is given by (4)) for $\alpha = \alpha_s$.

Therefore, is it easy to verify that he prefers a trial for $\Delta \geq \Pi_I(\alpha_s, m)$, and that $m^*_{without}$ is the solution of $\max \Pi_I(\alpha_s, m)$. Therefore, $m^*_{without} \in [\underline{m}_{without}(\Delta), \overline{m}_{without}(\Delta)]$ is always satisfied for values of $\Delta < \Pi_I(\alpha_s, m^*_{without})$. For values of $\Delta > \Pi_I(\alpha_s, m^*_{without})$, the only issue is a trial. As a result, for values of $\Delta < \Pi_I(\alpha_s, m^*_{without})$ the outcome is a settlement, and for values of $\Delta > \Pi_I(\alpha_s, m^*_{without})$, a trial occurs.

Lemma 6 (No contributory infringement) *In the game in which members are not liable for contributory infringement ($\beta = 0$), the following constitutes Nash Perfect equilibria;*

- *if $\Delta < \Pi_I(\alpha_s, m^*_{without})$, the infringer offers $(\alpha_s, m^*_{without})$ to the members who all decide to accept it, and the patentholder proposes a settlement;*

- *if $\Delta \geq \Pi_I(\alpha_s, m^*_{without})$, the infringer offers $(\alpha_s, m^*_{without})$ to the members who all decide to accept it, and the patentholder decides to sue the infringer.*

In the space (m, Δ), we represent for which values of Δ and m the infringer prefers a trial over a settlement when we consider all the other parameters of the model (p_H, ρ, β, β_I) as given. We represent $\Pi_I(\alpha, m)$ and we compare this function with Δ.

$$\boxed{\text{Insert Figure 3}}$$

In the absence of contributory infringement, the patentholder and infringer prefer to settle or to go to court for the same values of the parameters. The infringer chooses $m^*_{without} \in [\underline{m}_{without}(\Delta), \overline{m}_{without}(\Delta)]$.

6.2 Contract and Network Size with Contributory Infringement

We now consider that the contributory infringement rule is enforced. The size chosen by the infringer given that there will be a settlement, is solution of the following program

$$\begin{cases} \underset{m}{Max} & \{2\Pi_I(\alpha, m) - c_I^s - L_{with}^{NBS}\} \\ \text{s.t.} & (10) \\ \text{and} & m \in [\underline{m}_{with}^s(\Delta), \overline{m}_{with}^s(\Delta)] \end{cases}$$

If the infringer anticipates that there will be a trial, we can rewrite his problem as

$$\begin{cases} \underset{m}{Max} & \{(2 - p_H)\Pi_I(\alpha, m) - c_I^t - p_H R_{H,I}\} \\ \text{s.t.} & (11) \\ \text{and} & m \in [0, \underline{m}_{with}^t(\Delta)] \cup [\overline{m}_{with}^t(\Delta), \overline{m}] \end{cases}$$

22

For any value of m, we compare the profit of the infringer when the issue is a trial (6) and $\alpha = \alpha_t$ with his profit when the issue is a settlement (4) and $\alpha = \alpha_s$. He prefers a trial for

$$\Delta \geq g(m) = \mu[1 - F(p)]S(m)[1 - \alpha_s(1 + \beta) + \alpha_s \frac{(2 - p_H(1 + \beta_I))\beta}{(1 - \rho)(2 - p_H(1 + \beta))}]. \tag{16}$$

To represents the different values of m for which the patentholder prefers a trial, we compare the profit of the patentholder in case of a trial (5) and in case of a settlement (3) for $\alpha = \{\alpha_s, \alpha_t\}$. Recall that the patentholder prefers a trial for values of m such that

$$\Delta \geq f_j(m) = (1 - \alpha_j(1 + \beta))\mu(1 - F(p))S(m),$$

where $j = s, t$. As $\alpha_t = \alpha_s \times (2 - p_H)/(2 - p_H(1 + \beta))$, then for any m, we have $f_s(m) > f_t(m)$. Furthermore, a comparison of $f_s(m)$ and (16) shows that $g(m) > f_s(m) > f_t(m)$.

In a graph (m, Δ), we represent for which values of Δ and m the infringer and the patentholder prefer a trial over a settlement.

Insert Figure 4

For $\Delta \geq g(m)$ the infringer prefers a trial over a settlement, meaning that he prefers to propose a contract α_t to the members. However, the patentholder prefers a trial for $\Delta \geq f_j(m)$.

Therefore, for $\Delta < f_s(m)$ (Area 1 in figure 4), the outcome is a settlement. Indeed, the infringer proposes α_s, and the patentholder prefers a settlement over a trial.

For $\Delta \geq g(m)$ (Area 3 in figure 4), the outcome is a trial. The infringer proposes α_t and the patentholder prefers a trial over a settlement.

In the area between $f_s(m)$ and $g(m)$ (Area 2 in figure 4), the outcome is not clear. Indeed, the infringer prefers a settlement, but he knows that even if he proposes α_s, the patentholder will bring him to court. In order to be able to conclude in this area, we now define more precisely where the optimal network sizes are. Recall that m_j is the value of m that maximizes the function $f_j(m)$ for $j = s, t$. We can show that $m_t < m_{with}^{trial}$ and $m_s < m_{without}$ (see appendix).

In Area 2 it can be the case that the payoff of the infringer, if the issue is a trial where he has proposed α_s to the members, is even bigger than the payoff he can get if he proposes α_t as he anticipates a trial. As a result, he may prefer to offer (α_s, m_{with}^*), even if a trial follows. Nevertheless, this cannot be an equilibrium, as the members of the network refuse this contract

in the first stage of the game. Indeed, at the time the infringer decides the size of his network and the rent he will leave to each member, the last member that enters the network has a null profit. If the contract is (α_s, m), the mth member is in fact indifferent between entering and not. But as $m_{with}^{trial} \leq m_{with}^*$, the last member that enters the network if a settlement is anticipated will get a negative payoff in case of trial. Thus, the contract will not be accepted by the members in the first stage. Therefore, the infringer has no choice but to propose α_t to the members (point A in figure 4), and the network size will be reduced in this area.

We define a cut-off value, $f_s(m_{with}^*)$. For values of Δ such that $\Delta < f_s(m_{with}^*)$ the outcome will be a settlement and the optimal size m_{with}^*, and for values of Δ such that $\Delta > f_s(m_{with}^*)$ the outcome is a trial and the optimal size is m_{with}^{trial} (in bold on figure 5).

$$\boxed{\text{Insert Figure 5}}$$

Lemma 7 (Contributory Infringement) *In the game in which members are liable for contributory infringement ($\beta > 0$), the following constitutes Nash Perfect equilibria;*

- *if $\Delta < f_s(m_{with}^*)$, the infringer offers the contract (α_s, m_{with}^*) to the members who decide to accept it, and the patentholder decides to settle;*

- *if $\Delta \geq f_s(m_{with}^*)$, the infringer offers the contract $(\alpha_t, m_{with}^{trial})$ to the members who decide to accept it, and the patentholder decides to go to court.*

6.3   Equilibrium: Contributory Infringement and Network Size

We now compare the two regimes, without contributory infringement and with contributory infringement at the equilibrium values. In figure 5, the dash curve represents $\Pi_I(\alpha_s, m)$. We determine a second cut-off value, $\Pi_I(\alpha_s, m_{without}^*)$. The optimal size of the network if the contributory infringement is not enforced lies just between the two optimal sizes in the case of contributory infringement.

Consider first that $\Delta \leq 0$. We will discuss the values of Δ in the next section. If $\Delta = 0$, $\underline{m}_{with}^s(\Delta) = \underline{m}_{with}^t(\Delta) = 0$, and therefore as long as $m_{with}^* < \overline{m}_{with}^t(0)$ the Nash Perfect equilibrium is $((\alpha_s, m_{with}^*), \text{settlement})$. If $\Delta < 0$, then $\underline{m}_{with}(\Delta) < 0$ and $\underline{m}_{with}^t(\Delta) < 0$, and thus as long as $m_{with}^* < \overline{m}_{with}^t(\Delta)$ the Perfect Nash equilibrium is $((\alpha_s, m_{with}^*), \text{settlement})$. We consider any value of Δ, and we compare Δ to the two cut-off values $f_s(m_{with}^*)$ and $\Pi_I(\alpha_s, m_{without}^*)$. We find that:

Proposition 1 (Network size and Contributory Liability)

- *For $\Delta < f_s(m^*_{with})$, the outcome is to settle out of court and the network size is smaller under the contributory infringement rule than without.*

- *For $f_s(m^*_{with}) \leq \Delta < \Pi_I(\alpha_s, m^*_{without})$, if the contributory infringement rule is enforced, a trial occurs and the size of the network is smaller than without. Without contributory infringement, the outcome is to settle.*

- *For $\Delta \geq \Pi_I(\alpha_s, m^*_{without})$, the outcome is a trial and the size of the network is smaller.*

Proof. We put together Lemmas 5 and 6 and we use the fact that $m^{trial}_{with} < m^*_{with} < m^*_{without}$.
∎

We represent these values in a graph (m, Δ).

$$\boxed{\text{Insert Figure 6}}$$

For low values of Δ, the contributory infringement rule allows a decrease in the size of the network, even though firms settle out of court. For intermediate values, the contributory infringement rule induces firms to go to court, and thus decreases the network size. And for high values of Δ, firms will go to court even in the absence of such a rule, but the size of the network is smaller.

6.4 Variation of Δ

All of the above results depend on the values of Δ where $\Delta = (\Pi_H^{t,w} - \Pi_H) - \frac{1}{p_H}(c_I^t - c_I^s + c_H^t - c_H^s)$. We assume that $\Pi_H^{t,w} - \Pi_H \geq 0$, as it is possible that the patentholder will benefit from a successful trial. If we consider that both $\Pi_H^{t,w}$ and Π_H represent discounted payoffs, we can imagine that a successful trial for the patentholder may generate more profits in the future, as he may settle with other firms. This is due to a reputation effect. Hence Δ can be positive even if we consider that the second part of Δ is negative or null. Indeed, the overall cost of a trial $c_I^t + c_H^t$ may be higher than the overall cost of a settlement $c_I^s + c_H^s$.

If we assume that a trial generates more legal costs than a settlement, i.e., $c_I^t + c_H^t \geq c_I^s + c_H^s$, and $\Pi_H^{t,w} = \Pi_H$, then $\Delta \leq 0$. If we allow the legal costs to be identical whether a settlement is reached or a trial occurs, and $\Pi_H^{t,w} > \Pi_H$, or if we allow the legal costs of a settlement to be higher than the legal costs of a trial with $\Pi_H^{t,w} \geq \Pi_H$, then $\Delta > 0$. Hence, we do not want to

restrict the set of parameters, and we believe that most of the configurations can be defendable; that is why we keep our model as general as possible and let Δ be positive or negative.

However, we also have to take into account that Δ depends on p_H, and that some of the functions characterized earlier (for instance $g(m)$ or $f_t(m)$) also depend on p_H. So our graphical analysis is correct for given values of p_H when we allow costs and profits to change and thus to have an impact on Δ.

7   Welfare Analysis of Contributory Liability

In this section, we investigate the implications of the contributory infringement rule on total social welfare. We compare total welfare at the equilibrium when the rule is enforced, and when it is not enforced.

The total social welfare $W(\alpha, m)$ is the sum of the consumers' surplus and the payoffs of all the firms.

We consider the profits and consumers' surplus when a settlement occurs, and when the optimal size of the network is $m^*_{without}$ under no contributory infringement rule, and m^*_{with} under the contributory infringement rule.

The sum of the profits of the infringer and patentholder is $2\Pi_H + 2\Pi_I(\alpha_s, m^*_{without}) - (c^s_H + c^s_I)$ under the no contributory infringement regime and $2\Pi_H + 2\Pi_I(\alpha_s, m^*_{with}) - (c^s_H + c^s_I)$ under the contributory infringement regime. Note here that the license fee is just a transfer from one firm (infringer) to the other firm (patentholder) and it has no impact on the social welfare. The sum of the profits of the members of the network is $2(S(m)\mu[1 - F(p)]\alpha_s - cm)$ with the corresponding m under each regime. And finally the consumers' surplus is $\int_p^\infty [1 - F(p)]S(m)dp$ with the appropriate m.

Consequently, we can write the total welfare with no contributory infringement rule

$$
\begin{aligned}
W_{without} \;=\;& 2\Pi_H + 2\Pi_I(\alpha_s, m^*_{without}) - (c^s_H + c^s_I) + 2(S(m^*_{without})\mu[1 - F(p)]\alpha_s - cm^*_{without}) \\
& + 2\int_p^\infty [1 - F(p)]S(m^*_{without})dp,
\end{aligned}
\tag{17}
$$

and with contributory infringement

$$
\begin{aligned}
W_{with} \;=\;& 2\Pi_H + 2\Pi_I(\alpha, m^*_{with}) - (c^s_H + c^s_I) + 2(S(m^*_{with})\mu[1 - F(p)]\alpha_s - cm^*_{with}) \\
& + 2\int_p^\infty [1 - F(p)]S(m^*_{with})dp.
\end{aligned}
\tag{18}
$$

26

Note that α_s does depend on the chosen size of the network. As a result, the difference between the total welfare functions is

$$2[\Pi_I(\alpha_s, m^*_{without}) - \Pi_I(\alpha_s, m^*_{with})]$$

$$+2\mu[1 - F(p)](\alpha_s(m^*_{without})S(m^*_{without}) - \alpha_s(m^*_{with})S(m^*_{with})) - 2c(m^*_{without} - m^*_{with})$$

$$+2\int_p^\infty (S(m^*_{without}) - S(m^*_{with}))[1 - F(p)]dp$$

Recall that the profit function $\Pi_I(\alpha_s, m)$ reaches its maximum for $m^*_{without}$, and therefore both patentholder and infringer are better off under the no contributory infringement rule. Surprisingly the contributory infringement rule does not benefit the two firms together, as the only advantage of the rule shows up in the license fee, as just a transfer. From the members' viewpoint, increasing the network size increases the gross profit, as $\alpha_s(m^*_{without})S(m^*_{without}) - \alpha_s(m^*_{with})S(m^*_{with}) > 0$. On the other hand, it increases the cost of being part of the network, as $m^*_{without} > m^*_{with}$. Therefore, it is not clear which effect is greater. And lastly, from the consumers' viewpoint, increasing the size of the network, at a given price, increases their surplus. End-users are better off without the rule, because more of them will be able to consume. Therefore, the only benefit of this rule is the saving cost from the connection, $2c(m^*_{with} - m^*_{without})$. The enforcement of the contributory infringement rule decreases the consumers' surplus, decreases the sum of the profits of the patentholder and the infringer, and has a mitigated effect on the members.

As $\Pi_I(\alpha, m) = (1 - \alpha)\mu[1 - F(p)]S(m)$, we can rewrite the difference of welfare as

$$\mu[1 - F(p)](S(m^*_{without}) - S(m^*_{with}))$$

$$-c(m^*_{without} - m^*_{with})$$

$$+\int_p^\infty (S(m^*_{without}) - S(m^*_{with}))[1 - F(p)]dp$$

and we study the function $\mu[1 - F(p)]S(m) - cm$. This function reaches a maximum for $m^* = (\ln \frac{-(1-A)}{\ln A} + \ln \frac{c}{\mu[1-F(p)]n})/\ln A$. If we compare this value with $m^*_{without}$ and m^*_{with}, as $\ln \frac{-(1-A)}{\ln A} < 0$, we find that $m^* > m^*_{without}$ if c is small enough; i.e., if $c < \mu[1 - F(p)]nA$. Therefore, for low values of c, the function $\mu[1 - F(p)]S(m) - cm$ is increasing for $m < m^*_{without}$. This implies that $\mu[1 - F(p)]S(m^*_{without}) - \mu[1 - F(p)]S(m^*_{with}) - c(m^*_{without} - m^*_{with}) > 0$, and thus, the total welfare decreases when the contributory infringement rule is enforced.

For bigger values of Δ, namely $\Delta \in [f_s(m^*_{with}), \Pi_I(\alpha_s, m^*_{without})]$, at the equilibrium, a settlement will occur under the no contributory infringement rule, whereas a trial occurs under

the contributory infringement rule. The difference in the total welfare is now

$$2\mu[1 - F(p)](S(m^*_{without}) - S(m^{trial}_{with})) + \mu p_H[1 - F(p)]S(m^{trial}_{with})$$
$$+ \int_p^\infty (S(m^*_{without}) - S(m^{trial}_{with}))[1 - F(p)]dp$$
$$-c(2m^*_{without} - (2 - p_H)m^{trial}_{with}) - p_H\Delta.$$

If we add $p_H\Pi_I(\alpha_s, m^*_{without}) - p_H\Pi_I(\alpha_s, m^*_{without})$, we can rewrite the difference as

$$(2 - p_H)\mu[1 - F(p)](S(m^*_{without}) - S(m^{trial}_{with})) + \mu p_H[1 - F(p)]\alpha_s S(m^*_{without})$$
$$+ p_H(\Pi_I(\alpha_s, m^*_{without}) - \Delta) + \int_p^\infty (S(m^*_{without}) - S(m^{trial}_{with}))[1 - F(p)]dp$$
$$-c(2m^*_{without} - (2 - p_H)m^{trial}_{with}),$$

where only the last term is negative. Therefore, for low values of the connection cost, the contributory infringement rule decreases the total welfare.

For values of $\Delta > \Pi_I(\alpha_s, m^*_{without})$, the only issue is a trial. By the same token we define the difference between the total welfare without and with contributory infringement

$$(2 - p_H)(S(m^*_{without}) - S(m^{trial}_{with}))$$
$$+ 2\int_p^\infty (S(m^*_{without}) - S(m^{trial}_{with}))[1 - F(p)]dp$$
$$-c(2m^*_{without} - (2 - p_H)m^{trial}_{with}).$$

In this last case, consumers, the patentholder and the infringer are better off without contributory infringement, as $m^{trial}_{with} < m^*_{without}$. On the other hand, the members save on connection costs. Therefore, for a low connection cost, the no contributory infringement increases welfare.

We can thus posit the following Proposition that holds for low connection costs,

Proposition 2 (Welfare Effect) *Conditionally on entry by the infringer, the contributory infringement rule decreases the total welfare.*

This Proposition shows that, once the innovation is patented, the contributory infringement rule has only a negative impact on the total social welfare as defined in (17) and (18).

Our analysis of welfare shows that the welfare is increased by simply removing contributory liability. However, we have been silent on who benefits when the degree of contributory liability β is altered. Whenever entry is not prevented, it is of interest to study how the patentholder's payoffs are affected. Indeed, assuming that these payoffs are a good proxy for the patentholder's *ex ante* incentives to invest in R&D, we shall now discuss how sensitive these payoffs are to a variation of β.

Proposition 3 (R&D Incentives) *Conditionally on entry and trial (respectively settlement), the contributory infringement rule is preferred by the patentholder only if $0 < \beta < \beta_{0t}$ (respectively $0 < \beta < \beta_{0s}$). Moreover, there exists a unique β_t^* (respectively β_s^*) such that the private incentives for R&D are maximum. This level is such that $0 < \beta_t^* < \beta_{0t}$ (respectively $0 < \beta_s^* < \beta_{0s}$), where β_{0t} and β_{0s} are the values of β that make the patentholder indifferent between the two regimes.*

Proof. See appendix. ∎

This result may seem counterintuitive. Indeed, raising the level of damages that the patentholder can obtain when he wins the trial can make him worse off.

A change in the value of β has essentially two contradictory effects for the patentholder's payoffs. A higher β increases the level of damages per member obtained by the patentholder *ex post* but it also tightens the participation constraint of the members. This results in a smaller size of the infringer's network and damages will be collected from fewer members.

The reasoning for maximizing the patentholder's amount of damages is formally identical to setting a monopoly price. A regulator or a judge willing to maximize the expected amount of damages (respectively the license fee) would set $\beta = \beta_t^*$ (respectively $\beta = \beta_s^*$) such that the increased benefit of more damages (i.e., a higher price) is equal to the foregone profit of fewer members (i.e., of having fewer buyers).

It is also interesting to notice that when $\beta > \beta_{0t}$ (respectively $\beta > \beta_{0s}$), everyone (except the judge!) would prefer *ex ante* to waive the contributory liability. In such a case, not only no contributory liability is socially optimal (see Proposition 2) but it is also Pareto optimal for all the players. The next Corollary completes Proposition 3,

Corollary 1 *In the case of a trial (respectively a settlement), any level of contributory damages greater than β_t^* but smaller than β_{0t} (respectively greater than β_s^* but smaller than β_{0s}) is suboptimal.*

Proof. See appendix. ∎

The amount of damages received depends on the parameter β. Our point is that any optimal level of β set by a policy-maker should lie strictly in the interval $(0, \beta_t^*)$. A policy-maker may want to foster the *ex ante* incentives of the patentholder to do research and in this case a β close but smaller than β_t^* would be optimal. Conversely, the policy-maker may want to favor network end-users (i.e., consumers) and then he would set β close to 0 to maximize the network size. However, setting $\beta \in (\beta_t^*, \beta_{0t})$ would decrease the network size and the total amount of

damages received by the patentholder. This result is interesting because it shows formally that a tighter intellectual property protection *can strictly decrease the incentive to innovate* in the framework of a network. It is consistent with the analysis of Bessen and Maskin (2001) who argue that "moderately weak intellectual protection is optimal." However, they advocate weaker protection because it favors innovation through imitation. Our point is different since we argue that the network structure helps to "transmit" infringement liability to all the members, and makes them less incline to join the network.

The damages or the license awarded to the patentholder are important to judge about his incentives to invest *ex ante*. When contributory liability exists, the amount of damages received by the patentholder is described by the parameters β_I and β. Thus, the "weight of liability" is split between the infringer and the members. It is interesting to analyze whether one can generate the same amount of damages without contributory liability. The next corollary develops a result along these lines.

Corollary 2 *Consider a given structure B of direct and contributory damages, with $\beta_I > 0$ and $\beta > 0$. If the outcome is a settlement (respectively a trial), there exists another structure B' characterized by*

$$\beta'_I = \frac{S(m^*_{with})}{S(m^*_{without})} \frac{(\rho+\beta_I)+\alpha_s(m^*_{with})(\beta(1-\rho)-(\rho+\beta_I))}{1-\alpha_s(m^*_{without})} - \rho,$$

$$\beta' = 0.$$

$$\left(respectively \; \beta'_I = \frac{S(m^{trial}_{with})}{S(m^*_{without})} \left(\frac{\beta_I}{1-\alpha_s(m^*_{without})} + \frac{(\beta-\beta_I)\alpha_s(m^{trial}_{with})}{1-\alpha_s(m^*_{without})} \frac{2-p_H}{2-p_H(1+\beta)} \right), \beta' = 0 \right)$$

If, under this structure of damages B', entry by the infringer is not prevented, then this structure is socially better than the structure B.

Proof. See appendix. ∎

Therefore over some range of the parameters it is possible to give the same incentive to invest in R&D *ex ante* with and without the contributory infringement rule, and a bigger size of network is obtained *ex ante*. More generally, this result and the previous ones rather plaid for minimizing the liability of contributory infringers and aggravating the liability of direct infringers when this is possible.

8   Entry and Trial or Settlement Decisions

The above analysis is conditional on the entry by the infringer. Even if assume that the costs c^t_I and c^s_I are low enough, it is not enough to insure entry. Indeed, the decision of entry depends

crucially on the level of damages that the members of the network will have to pay. We can discuss it as a function of β, and we have the following result,

Proposition 4 *When the outcome is a trial, no network will exist if $\beta > \overline{\beta}_t$, where $\overline{\beta}_t = \frac{2-p_H}{p_H}(1 - \frac{c}{\mu(1-F(p))nA})$ and, when the outcome is a settlement, no network will exist if $\beta > \overline{\beta}_s$, where $\overline{\beta}_s = \frac{2-p_H(\beta_I+\rho)}{p_H(1-\rho)}(\frac{\mu(1-F(p))nA}{c} - 1) > 0$.*

Proof. See appendix. ∎

The case where $\beta = \overline{\beta}_t$ corresponds to a situation in which exactly one member will be recruited. Therefore, any $\beta > \overline{\beta}_t$ will deter infringement whenever the outcome is a trial. It should be noticed that when $p_H = 1$ (i.e., the patentholder wins the trial), then we have $\overline{\beta}_t < 1$ and there is no need to set $\beta = 1$ to avoid entry. In other words, awarding damages according to the "unjust enrichment" doctrine is not necessary to deter entry.

When the innovator does not intend to develop and exploit himself the innovation, then he essentially relies on licensing (and eventually trial) to obtain rewards from his innovative activity. In case of trial, entry may be desirable and the parameter β should be set at a low level if one wants to insure entry by the infringer.

When the outcome is a settlement, a level of damages higher than $\overline{\beta}_s$ will make impossible the formation of an infringing network. The level of $\overline{\beta}_s$ varies according to the parameters. It is interesting to consider two extreme cases depending on the bargaining power of the patentholder. When the patentholder has all the bargaining power during the negotiation of the license fee ($\rho \to 1$), the level of damages β has no impact on the infringer decision to enter and the size of the network m^*_{with} is equal to $m^*_{without}$. When the patentholder has a small bargaining power (this could be the case when he cannot develop himself the product), then $\overline{\beta}_s$ decreases and may be strictly lower than 1.

9 Conclusion

In this paper we consider an Internet innovation, and we study the effects of the contributory infringement rule on the size of a network of members, on the total social welfare, and on the infringement decisions. We do not address the problem of whether e-commerce patents should be granted; rather, we investigate the impact of the contributory infringement rule for this particular kind of patent. We show that whether firms settle out of court or go to trial, the optimal size of the network is smaller when the contributory infringement rule is enforced. This decreases the total social welfare. Furthermore, we show that even if the patent-holder can receive the same

compensation under both regimes (with and without contributory infringement), the network size is still smaller under the contributory infringement rule. This rule is harmful to society. We thus question the relevance of such a rule in the case of e-commerce patents.

We have made several assumptions concerning the contracts between the infringer and the members. First, the contract as defined in this model is not optimal. We could propose a contract in which the infringer just gave ε to each member. However, here our aim is to capture the effect of indirect infringement, and therefore we do not restrict ourselves to an optimal contract. Second, we have assumed that the size of the network is determined *ex ante*, and thus the members of the network cannot decide to quit the program at a certain point. We then plan to investigate what would happen if members were allow to exit the program after the infringement has occurred. Or alternatively, we plan to see what the effect would be of a renegotiation of the contracts in the second period of the game.

We have not considered, either, what the outcome would be if the patentholder decided to settle out of court with each member.

Last but not least, our study focuses on e-commerce patents, and we do not consider the investment in R&D in our analysis of the R&D incentive. In fact, we believe that for this special kind of innovation, the investment in R&D is not that important. However, if we consider a more general innovation, for instance in biotechnology, the investment in R&D must be included in the study to fully capture the effects on social welfare. The effects of the contributory infringement rule would be ambiguous, and we plan to investigate this issue further.

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Appendix

A1. Optimal size of the network

A1.1. Without contributory infringement

If the infringer anticipates a settlement, his maximization program is

$$
\begin{cases}
\underset{m}{Max} & \{\mu[1-F(p)]n\frac{1-A^m}{1-A}(1-\alpha_s)(2-p_H(\rho+\beta_I))-(1-\rho)p_H\Delta-c_I^t\} \\
\text{s.t.} & \alpha_s = \frac{c}{\mu[1-F(p)]nA^{m-1}}
\end{cases}
$$

after having replaced α by (10), n_m by nA^{m-1}, the payoff $\Pi_I(\alpha,m)$ by (2), $S(m)$ by $n\frac{1-A^m}{1-A}$, the license by (9) and where we define $\Delta = (\Pi_H^{t,w}-\Pi_H)-\frac{1}{p_H}(c_I^t-c_I^s+c_H^t-c_H^s)$. The first order condition gives $m^*_{without} = \frac{1}{\ln A}(\ln\frac{1}{\mu[1-F(p)]n}\sqrt{\mu[1-F(p)]ncA})$.

If the infringer anticipates a trial, his maximization program is

$$
\begin{cases}
\underset{m}{Max} & \{\mu[1-F(p)]n\frac{1-A^m}{1-A}(1-\alpha_s)(2-p_H(1+\beta_I))-c_I^t\} \\
\text{s.t.} & \alpha_s = \frac{c}{\mu[1-F(p)]nA^{m-1}}
\end{cases}
$$

and the solution of this program gives the same optimal value $m^*_{without}$.

A1.2. With contributory infringement

If the infringer anticipates a settlement, the maximization program is

$$
\begin{cases}
\underset{m}{Max} & \{\mu[1-F(p)]n\frac{1-A^m}{1-A}((1-\alpha_s)(2-p_H(\rho+\beta_I))-(1-\rho)\alpha_s\beta)-(1-\rho)p_H\Delta-c_I^t\} \\
\text{s.t.} & \alpha_s = \frac{c}{\mu[1-F(p)]nA^{m-1}}
\end{cases}
$$

Solving for m gives m^*_{with} as defined by equation (14).

If the infringer anticipates a trial his maximization program is the following

$$
\begin{cases}
\underset{m}{Max} & \{\mu[1-F(p)]n\frac{1-A^m}{1-A}(1-\alpha_t)(2-p_H(1+\beta_I))-c_I^t\} \\
\text{s.t.} & \alpha_t = \frac{c}{\mu[1-F(p)]n_m} \times \dfrac{2-p_H}{2-p_H(1+\beta)}
\end{cases}
$$

Solving for m gives m^{trial}_{with} as defined by equation (15).

A2. Decision of the patentholder to settle or not

A2.1. Without contributory infringement

There exist two values of m that make the innovator indifferent between going to court or settling out of court,

$$\underline{m}_{without}(\Delta) = \frac{\ln \frac{1}{2\mu[1-F(p)]n}[\mu[1-F(p)]n+A(\Delta+c)-\Delta+\sqrt{\Phi}]}{\ln A}$$

$$\overline{m}_{without}(\Delta) = \frac{\ln \frac{1}{2\mu[1-F(p)]n}[\mu[1-F(p)]n+A(\Delta+c)-\Delta-\sqrt{\Phi}]}{\ln A},$$

where $\Phi = (\Delta + c)^2 A^2 - 2A\Delta(\Delta + c) + 2A(\Delta - c)\mu[1 - F(p)]n + (\mu[1 - F(p)]n - \Delta)^2$. Thus, for any values of $\Delta < \Pi_I(\alpha_s, m^*_{without})$, and for all values of $m \in [\underline{m}_{without}(\Delta), \overline{m}_{without}(\Delta)]$ the outcome is a settlement.

A2.2. With contributory infringement

We compare the expected payoffs of the patentholder if a trial or a settlement occurs. Equation (5) gives the payoff in the case of a trial, whereas (3) gives the payoffs in the case of settlement. For any values of α and m, a trial is preferred to a settlement as long as $p_H \rho[\Delta - \mu[1 - F(p)]S(m)(1 - \alpha(1 + \beta))] > 0$ where $\Delta = (\Pi_H^{t,w} - \Pi_H) - \frac{1}{p_H}(c_I^t - c_I^s + c_H^t - c_H^s)$. Therefore, if $\alpha = \alpha_s$ as is the case if a settlement occurs, for values of $\Delta < f_s(m)$ where $f_s(m) = \mu[1 - F(p)]S(m)(1 - \alpha_s(1 + \beta))]$, the patentholder prefers to settle. On the other hand, if $\alpha = \alpha_t$, for values of $\Delta > f_t(m)$ where $f_t(m) = \mu[1 - F(p)]S(m)(1 - \alpha_t(1 + \beta))]$, the patentholder prefers to go to court. There exist two values of m such that $\Delta = f_j(m)$, $\underline{m}^j_{with}(\Delta)$ and $\overline{m}^j_{with}(\Delta)$ for $j = t, s$.

Furthermore, as $\alpha_t > \alpha_s$, we can easily show that $f_t(m) < f_s(m)$ for any value of m. Thus, for values of m such that $\Delta < f_t(m)$ (or in other terms for $m \in [\underline{m}^t_{with}(\Delta), \overline{m}^t_{with}(\Delta)])$, then it implies that $\Delta < f_s(m)$; i.e., that $m \in [\underline{m}^s_{with}(\Delta), \overline{m}^s_{with}(\Delta)]$. And therefore, the interval $[\underline{m}^t_{with}(\Delta), \overline{m}^t_{with}(\Delta)]$ is included in the interval $[\underline{m}^s_{with}(\Delta), \overline{m}^s_{with}(\Delta)]$. Or $\underline{m}^s_{with}(\Delta) < \underline{m}^t_{with}(\Delta) < \overline{m}^t_{with}(\Delta) < \overline{m}^s_{with}(\Delta)$. With

$$\underline{m}^s_{with}(\Delta) = \frac{\ln \frac{1}{2\mu[1-F(p)]n}(\mu[1-F(p)]n+c(1+\beta)A-\Delta(1-A)+\sqrt{\Upsilon})}{\ln A}$$

and

$$\underline{m}^s_{with}(\Delta) = \frac{\ln \frac{1}{2\mu[1-F(p)]n}(\mu[1-F(p)]n+c(1+\beta)A-\Delta(1-A)-\sqrt{\Upsilon})}{\ln A}$$

where $\Upsilon = A^2(\Delta + c(1 + \beta))^2 - 2A(\Delta^2 - \mu[1-F(p)]n(\Delta - c(1+\beta)) + \Delta c(1+\beta)) + (\mu[1 - F(p)]n - \Delta)^2$, and

$$\underline{m}^t_{with}(\Delta) = \frac{\ln \frac{1}{2\mu[1-F(p)]n}\left(\mu[1-F(p)]n-\Delta(1-A)+c\frac{2-p_H}{2-p_H(1+\beta)}(1+\beta)A+\sqrt{\Psi}\right)}{\ln A}$$

and

$$\overline{m}^t_{with}(\Delta) = \frac{\ln \frac{1}{2\mu[1-F(p)]n}\left(\mu[1-F(p)]n - \Delta(1-A) + c\frac{2-p_H}{2-p_H(1+\beta)}(1+\beta)A - \sqrt{\Psi}\right)}{\ln A}$$

where $\Psi = \Delta^2(1-A)^2 - 2\Delta(1-A)(c\frac{2-p_H}{2-p_H(1+\beta)}(1+\beta)A + \mu[1-F(p)]n) + (c\frac{2-p_H}{2-p_H(1+\beta)}(1+\beta)A - \mu[1-F(p)]n)^2$.

A3. Comparison of the sizes of networks

We show that $m_t < m^{trial}_{with}$ and $m_s < m_{without}$. Recall that $m_j = \arg\max f_j(m)$, for $j = s,t$ and $m_I = \arg\max g(m)$ where $g(m) = \mu[1-F(p)]S(m)[1-\alpha_s(1+\beta) + \alpha_s\frac{(2-p_H(1+\beta_I))\beta}{(1-\rho)(2-p_H(1+\beta))}]$ and $f_j(m) = (1-\alpha_j(1+\beta))\mu(1-F(p))S(m)$. Hence,

$$m_t = \frac{\ln\frac{Ac}{\mu[1-F(p)]n}(1+\beta)\frac{2-p_H}{2-p_H(1+\beta)}}{2\ln A}$$

$$m_s = \frac{\ln\frac{Ac}{\mu[1-F(p)]n}(1+\beta)}{2\ln A}$$

As $\frac{2-p_H}{2-p_H(1+\beta)} > 1$, it is easy to check that $m_t < m_s$. By the same token, as $1+\beta > 1$, $m_s < m^*_{without}$ and also $m_t < m^*_{with}$.

Proof of Proposition 3 and Corollary 1

Let us denote by ΔB^j_H for $j = s,t$ the patentholder's profit difference when there is contributory liability and when there is not. When the outcome is a trial, we have

$$\Delta B^t_H = p_H[\beta_I\Pi_I(\alpha_t, m^{trial}_{with}) + \sum_{i=1}^{m^{trial}_{with}} R_{H,i} - \beta_I\Pi_I(\alpha_s, m^*_{without})].$$

This expression reduces to

$$\Delta B^t_H = p_H[1-F(p)]\mu[S(m^{trial}_{with})[\beta_I(1-\alpha_t) + \beta\alpha_t] - \beta_I(1-\alpha_s)S(m^*_{without})] \qquad (19)$$

where m^{trial}_{with}, $m^*_{without}$, α_t and α_s are defined by equations (15), (12), (10) and (11).

The case $\beta = 0$ corresponds to the non-contributory liability, and therefore $\Delta B^t_H = 0$ for $\beta = 0$. Moreover, the derivative of ΔB^t_H with respect to β corresponds in fact to the derivative of the first term, as $\beta_I(1-\alpha_s)S(m^*_{without})$ is independent of β. For $\beta = 0$ it is

$$\frac{\partial\Delta B^t_H}{\partial\beta} = \frac{\beta_I(n([1-F(p)]\mu(2-p_H)\sqrt{n} - 2\sqrt{c[1-F(p)]\mu A}) + \sqrt{n}cAp_H) + (2-p_H)(\sqrt{[1-F(p)]\mu Acn} - \sqrt{n}cA)}{\sqrt{n}[1-F(p)]\mu(1-A)(2-p_H)} \geq 0$$

whenever $c \leq \frac{n[1-F(p)]\mu}{A}\frac{(2-p_H)^2}{4}$.

Thus, starting from 0 and increasing β yields a higher benefit for the patentholder when the contributory liability exists. Using the analytical expression of m_{with}^{trial} and considering $S\left(m_{with}^{trial}\right)$, then, we have

$$S\left(m_{with}^{trial}\right) = n\frac{1 - A^{m_{with}^{trial}}}{1 - A} = 0 \text{ when } m_{with}^{trial} < 1,$$

that is when

$$\beta > \overline{\beta}_t = \frac{2 - p_H}{p_H}(1 - \frac{c}{[1 - F(p)]\mu n A}).$$

In such a case, we have $\Delta B_H^t < 0$ because $\beta_I(1 - \alpha_s)S\left(m_{without}^*\right) > 0$ and is independent of β. Therefore, there exists a value of β, β_{0t} that satisfies $\beta_{0t} > \beta_t^* > 0$ and such that $\Delta B_H^t = 0$ for $\beta = \beta_{0t}$, and ΔB_H^t is maximum for $\beta = \beta_t^*$.

In the case of a trial, the first order condition gives the optimal β_t^*, it is computed as follows

$$\frac{\partial}{\partial\beta}\left(S(m_{with}^{trial})\left[\beta_I\left(1 - \alpha_t\right) + \beta\alpha_t\right]\right) = 0$$

It is easy to show that the first order condition admits only one real positive root.

When the outcome is a settlement, the difference in profit can be written as

$$\Delta B_H^s = 2\Pi_H - c_I^s + L_{with}^{NBS} - \left(2\Pi_H - c_H^s + L_{without}^{NBS}\right)$$

and it reduces to

$$\Delta B_H^s = L_{with}^{NBS} - L_{without}^{NBS}.$$

We know that $\Delta B_H^s = 0$ when $\beta = 0$. We can compute the derivative of ΔB_H^s with respect to β. It is

$$\frac{\partial\Delta B_H^s}{\partial\beta} = \frac{\partial L_{with}^{NBS}}{\partial\beta} = Ac\left(1 - \rho\right)\frac{p_H\left((2 - p_H\beta_I - p_H\rho)\left(\mu\phi n - \sqrt{\mu\phi ncA}\right) + \mu\phi(2n - p_H\beta_I - p_H\rho) - (2 - p_H\beta_I - p_H\rho)\sqrt{\mu\phi ncA}\right)}{2(2 - p_H\beta_I - p_H\rho)\sqrt{cA\mu\phi n}(1 - A)}$$

where $\phi = [1 - F(p)]$. This expression is positive since c is at most $\mu[1 - F(p)]nA$, and then this expression is at most

$$\frac{\partial\Delta B_H^s}{\partial\beta} > Ac\left(1 - \rho\right)\frac{p_H((2 - p_H\beta_I - p_H\rho)\mu\phi n(1 - A) - \mu\phi(p_H\beta_I + p_H\rho) + \mu\phi n(2(1 - A) + (p_H\beta_I + p_H\rho)A))}{2(2 - p_H\beta_I - p_H\rho)\sqrt{cA\mu\phi n}(1 - A)} > 0$$

for any $n \geq 1$. Moreover, there exists a level of $\beta > 0$ such that ΔB_H^s is strictly negative. For instance when

$$\beta \to \overline{\beta}_s = \frac{2 - p_H\left(\beta_I + \rho\right)}{p_H\left(1 - \rho\right)}\left(\frac{\mu\left(1 - F\left(p\right)\right)nA}{c} - 1\right) > 0,$$

we have

$$S\left(m_{with}^*\right) = n\frac{1 - A^{m_{with}^*}}{1 - A} \to 0, L_{with}^{NBS} \to 0 \text{ and } \Delta B_H^s = -L_{without}^{NBS} < 0.$$

Then, we have the existence of β_s^* such that ΔB_H^s is maximum and the existence of $\beta_{0s} > 0$ such that $\Delta B_H^s (\beta_{0s}) = 0$. In case of settlement, the following first order condition

$$\frac{\partial}{\partial \beta}[\mu\phi\frac{1 - A^{m_{with}^*}}{1 - A}(p_H((1 - \frac{c}{\mu\phi A^{m_{with}^* - 1}})(\rho + \beta_I) + \frac{(1 - \rho)c}{\mu\phi A^{m_{with}^* - 1}}\beta))] = 0$$

admits only one real positive root, β_s^*.

Proof of Corollary 2

The structure B' is such that the compensation received by the patentholder under both regimes is identical. When the outcome is a settlement, the optimal level of license fee received under the non-contributory infringement rule, $L_{without}^{NBS}$ must be equal to the level of the license fee under the contributory infringement rule, L_{with}^{NBS}. Furthermore, we denote β_I' the value of β under non-contributory infringement rule. Thus,

$$S(m_{without}^*)[1 - \alpha_s(m_{without}^*)](\rho + \beta_I') = S(m_{with}^*)[(1 - \alpha_s(m_{with}^*))(\rho + \beta_I) + \beta(1 - \rho)\alpha_s(m_{with}^*)]$$

Solving for β_I' yields the announced result.

When the outcome is a trial, the amount of damages received by the patentholder under structure B' is

$$R_H' = \beta_I'(1 - \alpha_s(m_{without}^*))\mu[1 - F(p)]S(m_{without}^*)$$

and it must be equal to

$$R_H = \left[\beta_I\left(1 - \alpha_s(m_{with}^{trial})\frac{2 - p_H}{2 - p_H(1 + \beta)}\right) + \alpha_s(m_{with}^{trial})\frac{(2 - p_H)}{2 - p_H(1 + \beta)}\beta\right]\mu[1 - F(p)]S(m_{with}^{trial})$$

Solving for β_I' yields the announced result.

Proof of Proposition 4

If $m < 1$, there is no membership program, and the infringer does not enter the market. If a trial is the issue of the game, $m_{with}^{trial} < 1$ is satisfied for $\beta > \overline{\beta}_t$. On the other hand, if the issue of the game is a settlement, $m_{with}^* < 1$ if $\beta > \overline{\beta}_s$.
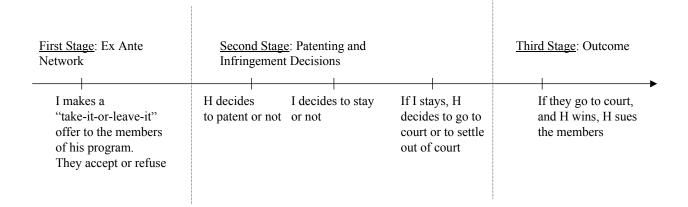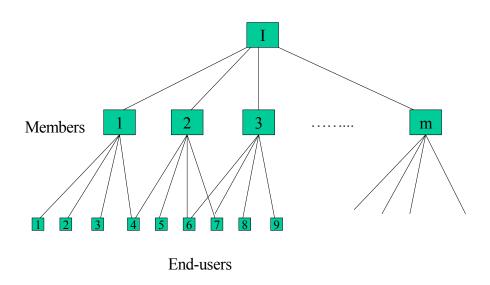
First Stage: Ex Ante Network	Second Stage: Patenting and Infringement Decisions			Third Stage: Outcome
I makes a "take-it-or-leave-it" offer to the members of his program. They accept or refuse	H decides to patent or not	I decides to stay or not	If I stays, H decides to go to court or to settle out of court	If they go to court, and H wins, H sues the members

Figure 1: Timing of the game

Figure 2: Network structure
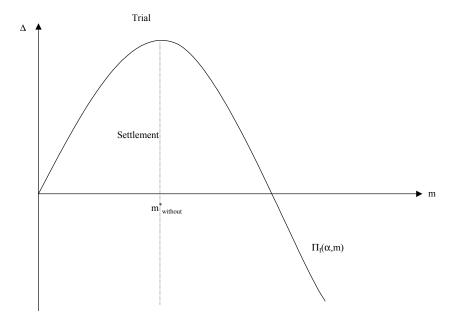
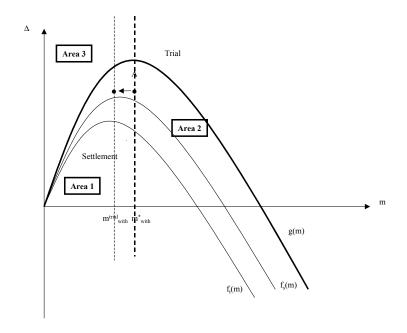Figure 3: Without Contributory Infringement
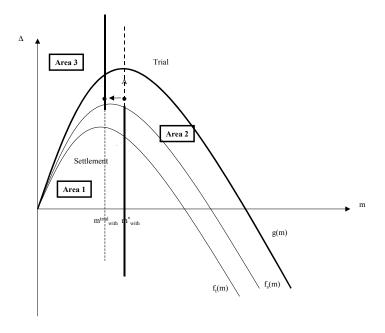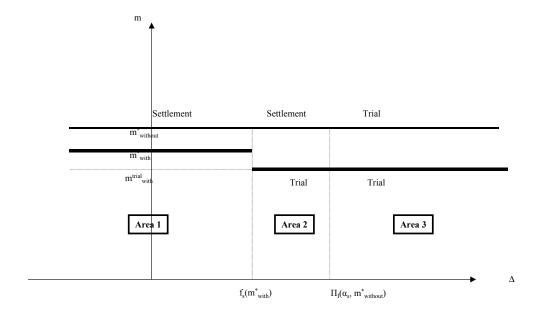

Figure 4: With Contributory Infringement

41

Figure 5: With Contributory Infringement

Figure 6: Optimal Network Sizes