PATENT TROLL LITIGATION: EFFECTS ON WELFARE AND INNOVATION

By

Christopher Heschl

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1. Introduction

The patent system is designed to protect intellectual property (IP) rights and to promote innovation and inventive activity. Specifically, firms require sufficient incentives to conduct research and development (R&D). Patents bestow exclusive rights of sale and monopoly profits to the producing firm for a limited period of time in order to cover extensive R&D costs. In the classical model of the patent system, patent litigation is brought by the company that invented and sells the new technology against infringing competitors that copy the innovation. However, patent law does not require that the plaintiff have proof that the defendant copied the technology, nor does it require that the plaintiff actually commercialize or produce the product. In addition, patent law does not state that only the inventor can enforce the patent, as patent rights can be bought and sold.[1] The rise in the number of firms that license patents without producing goods, know as non-practicing entities (NPEs),[2] have sparked an extensive debate about their role in the patent system and their effect on welfare and innovation. Many refer to NPEs as "patent trolls" because these firms' sole purpose is to use patents to primarily acquire license fees from practicing entities (PEs). Essentially, patent trolls build patent portfolios to litigate against other firms and demand licensing fees rather than commercialize their own products.

[1] Mark Lemley and A. Douglas Melamed, "Missing the Forest for the Trolls," *Columbia Law Review*
[2] They are also known as patent assertion entities (PAEs).

There is an ongoing debate about whether NPEs play a positive or negative roll in the market for innovation. Proponents of NPEs argue that they protect the IP rights of small firms from larger, more well-funded firms who would otherwise infringe at will because of the substantial costs of patent litigation.[3] This protection option, therefore, would encourage more innovation by small inventors. In contrast, opponents argue that NPEs act as trolls and raise the cost of innovation by exploiting the fact that an imperfect legal system will rule in their favour sufficiently often, even if no infringement had actually occurred. The NPE's, and hence the troll's, business model is to pursue the "freedom to litigate" rather than the "freedom to operate." Therefore, the value of patents for trolls can be based on their "exclusion value" rather than their "intrinsic value."[4]

From 2010 to 2013, it has been shown that the share of patent litigation brought forth by NPEs as a share of all patent lawsuits has increased from 30 percent to 67 percent.[5] In addition, one study found that $500 billion was lost in patent troll litigation from 1990 to 2010, averaging $80 billion from 2007 to 2011.[6] Most of this litigation took place in the IT industry. It has been found that when trolls are involved in patent litigation, they are awarded more in damages and settlements relative to litigation involving only PEs, even though there is evidence that troll-

[3] Lauren Cohen, Umit G. Gurun, and Scott Duke Kominers, "Patent Trolls: Evidence from Targeted Firms," *Harvard Business School Working Paper* No. 15-002 (August 7, 2014): 1, accessed on August 15, 2015, http://www.hbs.edu/faculty/Publication%20Files/15-002_6806e22c-a7a6-45d8-bf1a-78cad85f20f5.pdf.
[4] Jay Pil Choi and Heiko Gerlach, "A Model of Patent Trolls," *Working Paper* (April 13, 2015): 1, accessed on August 15, 2015, http://econ.msu.edu/seminars/docs/A%20Model%20of%20 Patent%20Trolls-April%2013-2015.pdf.
[5] Fiona Scott Morton and Carl Shapiro, "Strategic Patent Acquisitions," *Antitrust Law Journal* 79.2 (2014): 465-466.
[6] James Bensen, Jennifer Ford, and Michael J. Meuer, "The Private and Social Costs of Patent Trolls," *Boston University School of Law Working Paper* No. 11-45 (2011): 2.

owned patents are more likely to lose than PE-owned patents when they go to court.[7] There is evidence that the rise in troll litigation activity has a negative effect on innovative activity. One study shows that litigation conducted primarily by patent trolls was responsible for a 14 percent decline in venture investing over a five-year period (a loss of $22 billion). Another study found that R&D spending by small firms decreased by 19 percent in the years following infringement litigation.[8] While proponents argue that NPEs can benefit the patent system by assisting smaller firms enforce their patents, there is a growing body of evidence that suggests a large number of these NPEs are exhibiting harmful troll behaviour.

In my paper I seek to provide a simple theoretical model to examine the effects of patent troll litigation on welfare and the market for innovation. According to Lemley and Melamed (2013), there are three types of trolls: "lottery-ticket" trolls that target large established firms with an uncertain shot at a large payout, "bottom-feeder" trolls that rely on the high costs of patent litigation to obtain rents from PEs, and "patent aggregators" who build extremely large patent portfolios to settle with defendants who are reluctant to challenge the entire portfolio.[9] I will focus on "bottom-feeder" troll for my study. First, I provide a model of patent litigation with asymmetric information. Litigation is costly for both parties in an infringement suit. Since troll firms are comprised of highly-skilled and specialized lawyers with significant expertise in patent litigation, their legal counsel could be expected to be more effective than the defendant's legal counsel. This could result in more victories

[7] Lemley and Melamed, "Missing the Forest for the Trolls," 2119-2120.
[8] James Bensen, "The Evidence is in: Patent Trolls do Hurt Innovation," *Harvard Business Review*, November 2014.
[9] Lemley and Melamed, "Missing the Forest for the Trolls," 2126-2127.

for the troll, even if the patents they assert are weaker on average. Knowing this, more PEs will settle before going to court to avoid costly litigation. I find that more PEs settle as the relative effectiveness of the troll's legal counsel increases. Second, I provide a simple overview of how firms make R&D investment decisions when they receive a temporary monopoly on their newly invented product and how innovation improves social welfare. And finally, I observe how patent troll litigation can have a strictly negative effect on welfare and create disincentives to innovate greater than if the infringement suit involved only PEs. Overall, my model shows that patent trolls, if left unchecked, can significantly reduce social welfare and the creation of new innovation.

2. Related Literature

The body of literature examining patent trolls, their litigation strategies, and the effect that both can have on innovation and welfare is small but growing. My paper contributes a straightforward theoretical understanding of how litigation by patent trolls can affect innovation and welfare, a topic that is less common in the current literature.

Haus and Juranek (2014) examine the role of NPEs in patent litigation, presenting a theoretical model that predicts that patent infringement cases involving NPEs or trolls resolve faster. Their model is a modification of Galasso and Schankerman's (2010) model of patent litigation and settlement with asymmetric information, adding an additional stage in the litigation game where both the

patentee and infringer invest in legal counsel. Haus and Juranek (2014) builds on the idea that NPEs are highly specialized firms that employ patent professionals and lawyers with significant expertise in patent law and litigation.[10] To represent this, they assume that NPEs have a lower marginal cost of legal investment than do the alleged infringing PEs. They test their model empirically using a hand-collected data set of US patent litigation cases filed between 2004 and 2008. What they find is that NPE patent litigation differs from standard patent cases, and that after controlling for these differences observe that NPE cases do indeed resolve faster. In particular, they find that their results support the hypothesis that NPEs assist small innovators with exploiting the full value of their patents since they lack the necessary legal expertise to do so on their own. They conclude that NPEs help increase the speed of diffusion of technology into the economy through faster licensing, therefore increasing the effectiveness of the market for innovation.[11] In my paper I use their theoretical model of litigation to describe patent troll litigation while excluding the analysis of case duration. I take their analysis a step further and examine how patent troll litigation affects initial investment in innovation R&D and its welfare implications. In contrast to Haus and Juranek (2014), I find that patent trolls can have a negative impact on innovation and welfare.

Choi and Gerlach (2015) develops a theoretical model of patent trolls to understand various NPE litigation strategies, in particular when there are multiple potential infringers who use related technologies. They do not examine the case of

[10] Axel Haus and Steffen Juranek, "Patent Trolls, Litigation, and the Market for Innovation," *Discussion Papers, Department of Business and Management Science, Norwegian School of Economics* 24 (2014): 2.
[11] Ibid., 1.

asymmetric information between infringer and NPE but rather the case where there is "an information externality generated by earlier litigation outcome for subsequent litigation outcomes."[12] They show that in the case of bottom-feeder trolls that may have a weak patent portfolio not strong enough to make litigation credible when suing only one infringer, litigation may become credible in the case of multiple potential defendants. The value created by potential successful litigation against subsequent defendants through Bayesian updating provides the troll with a sufficiently high expected value of litigation that it renders a credible litigation threat against the initial defendant. Given the high costs of litigation for both parties, their model helps to explain why PE defendants accept settlement offers and consider litigation credible even though many trolls assert weak patents. Choi and Gerlach (2015) also discusses policy implications, in particular the introduction of the British "loser-pays" system of fee shifting, where the losing party must also bear the legal costs of the winning party. While their model is thorough and examines many different cases, it does not include an examination of the innovation and welfare effects of patent troll litigation. My paper simplifies the troll's litigation strategy because I am more interested in identifying how increasing patent troll litigation affects welfare and the incentives to innovate.

Cohen, Gurun, and Kominers (2014) provide theoretical and empirical evidence to inform the evolution of NPEs and their impact on innovation. They first derive a theoretical model where NPEs can endogenously emerge as patent trolls, which they define as "agents that sue opportunistically in hopes that an imperfect

[12] Choi and Gerlach, "A Model of Patent Trolls," 2.

legal system will rule in their favour, maximizing expected proceeds rather than maximizing penalties to infringing behaviour."[13] Assuming heterogeneous quality across innovations, Cohen et al. (2014) claim that some patent holders will endogenously decide to litigate commercializing firms instead of producing and commercializing their own innovation. They do so because of the high cost of commercialization and the existence of a legal system that imperfectly enforces patent infringement. Essentially, the patenting firm compares the expected profitability of litigation against the expected profitability of commercializing. They find that firms with low-value innovations will nearly always litigate while firms with high-value innovations will commercialize but will be litigated against more often. Their model predicts trolls target firms with high-value innovations that are cash-rich. One interesting implication of their model is that some welfare-increasing innovations are not produced because of the threat of troll litigation or because it is simply more profitable to be a troll instead of commercialize. Using proprietary data, Cohen at al. (2014) provide strong empirical evidence that trolls indeed target firms that are cash-rich or have recently received a positive cash shock, as well as firms that are occupied with other nonrelated lawsuits or that are more likely to settle. Overall, they show that patent troll litigation has a negative impact on innovation, providing data that shows decreased future innovative activity for targeted firms. My paper also examines the negative impact of patent troll litigation on innovation incentives but in a different manner and more explicitly addresses the social welfare aspects of stifled innovation.

[13] Cohen et al., "Patent Trolls: Evidence from Targeted Firms," 2.

Turner (2011) introduces a model invention, patenting, and infringement under monopolistic competition, where the profitable use of an invention requires that it adapt to complementary inventions. In contrast to previous papers that I have mentioned, Turner introduces trolling behaviour to the analysis of patent thickets.[14] He shows that invention is taxed and welfare is reduced in the presence of conflicting patent rights that could lead to costly infringement litigation. When a patentee is a troll, the rate of invention falls because it is more profitable for a firm to avoid the cost of production of their innovation and instead rely on earning damages from inadvertent infringement. In addition, assuming that if being a troll were not an option then some firms would be willing to invent, the rate of invention falls further in a world with trolls. Here, trolls do not produce useful inventions but contribute to the growing patent thicket of conflicting rights that increases infringement litigation costs. Therefore, Turner (2011) finds that trolls are indeed welfare reducing. My paper also addresses the welfare effects of patent trolls but focuses on how more productive troll legal counsel can affect litigation outcome against PEs.

Finally, Robledo (2005) examines the effect of patent litigation between two PEs on intellectual property, innovation, and welfare. In order to create an incentive to innovate in the face of high R&D costs, firms are granted temporary monopoly power in the market for that invention. However, if innovative firms could be sued for patent infringement after inventing then costly litigation would decrease the rent

[14] A patent thicket is essentially an overlapping set of patent rights, where multiple patents are interconnected and potentially complementary components of a given technology. Because there are multiple patents, individual patent holders can exclude each other from using a technology because it is difficult to determine when one patent potentially infringes on another.

they would earn from patenting, thus reducing the incentive to innovate. Even if a useful invention is brought to market, the new monopoly still creates the standard monopoly deadweight loss. Robledo (2005) introduces a model where patent litigation by a producing firm suing for infringement could increase welfare despite the welfare loses generated by litigating. Since we are looking at two producing firms, if the challenging firm wins the infringement case then the market for that good now becomes a Cournot duopoly, thus decreasing the deadweight loss created by the previous monopoly. His paper does not, however, cover the case where the challenging firm is a troll that will not produce after winning the infringement suit. Therefore, potential welfare gains from reducing the monopoly deadweight loss are no longer observed. I will use the model presented in Robledo (2005) to frame my examination of how patent troll litigation affects welfare and the incentives to innovate.

3. Theoretical Model

3.1 Basic Litigation Framework

I am using the settlement model from Haus and Juranek (2014) to describe the litigation behaviour of patent trolls and PEs when the later is sued for patent infringement by the former. The general form of their model is common in the

literature.[15] To show that the expected case duration is lower when a troll is a litigant, Haus and Juranek assume that patent trolls have more efficient legal counsel, lowering the marginal costs of legal investment. I will emphasize the importance of this assumption to derive the welfare effects of patent troll litigation in Section 3.3. I set up their model and results in the remainder of this section while including some of my own extensions.[16]

This litigation game has two stages and involves two risk-neutral agents: a patent troll and a PE. In $t = 0$, the patent troll accuses the PE of patent infringement. It is assumed that the PE has private information about the validity of its patent, including knowledge about how likely their patent is infringing on the troll's patent. In the model, the PE then knows that they have some base probability *p* of losing the infringement case. The troll does not know the type of the PE but knows that it is uniformly distributed over $[\underline{p} = \phi(1-\lambda), \overline{p} = \phi(1+\lambda)]$. Haus and Juranek assume that $\phi = \frac{1}{2}$ so that, on average, the PE has a 50% chance of losing the case. However, since there is evidence that patents belonging to trolls tend to lose more often than other patents in court,[17] I assume that $0 < \phi < \frac{1}{2}$ to indicate that, on average, the PE is less likely to be infringing on the troll's patent.

At this stage, the troll makes a take-it-or-leave-it settlement offer A to the PE in order to avoid a trial in $t = 1$, possibly in the form of a license agreement. The PE

[15] See Kathryn E. Spier, "Chapter 4: Litigation," in Volume 1 of *Handbook of Law and Economics*, ed. A. Mitchell Polinsky and Steven Shavell (San Diego: North Holland, 2007), 259-342; Alberto Galasso and Mark Schankerman, "Patent Thickets, Courts, and the Market for Innovation," *The RAND Journal of Economics* 44.2 (2010): 472-503; and Lucien Arye Bebchuk, "Litigation and Settlement Under Imperfect Information," *The RAND Journal of Economics* 15.3 (Autumn 1984): 404-425.
[16] I will explicitly mention any extensions or assumptions that I apply to their model. Otherwise, the content of Section 3.1 is from Haus and Juranek (2014).
[17] Lemley and Melamed,"Missing the Forest for the Trolls," 2120.

can only choose to accept or reject the offer. If they accept, then they pay the troll an amount A and the game ends. If they reject, then both parties go to trial in $t = 1$. For the trial stage, both parties are individually responsible for their own litigation costs and invest in legal counsel $x_T, x_P \geq 0$ (subscript T for troll and P for PE) to increase their probabilities of winning at trial. The troll's probability of winning becomes $p + x_T - x_P$. The cost functions for legal counsel investment for trolls and PEs are $h_T \frac{{x_T}^2}{2}$ and $h_P \frac{{x_P}^2}{2}$, respectively, where h_T and h_P are cost parameters known by both parties. We assume $h_T < h_P$ to account for the troll's relatively more specialized and efficient legal counsel given that trolls spend the majority of their time and resources litigating patents. In addition to these variable legal costs there are also fixed legal costs L_T and L_P that the respective parties have to bear in the litigation stage. If the troll wins the case they are awarded damages by the court equal to Z. We will also assume that the troll's threat to litigate is always credible so that if the PE rejects a settlement offer in $t = 0$ both parties will still go to court in $t = 1$.

Since the PE knows how much it expects to pay in litigation fees and damages if the case goes to trial it will accept the troll's settlement offer A in $t = 0$ if it is less than the expected trial reward to the troll plus the PE's own litigation costs. Therefore, when a troll makes a settlement offer it screens the PE into one of two groups: one who accepts the offer and one who rejects and proceeds to trial. This is essentially the same as the troll determining a cutoff value $\tilde{p}$ where if the PE is of type $p \geq \tilde{p}$ they accept the offer (i.e. the PE knows it has a higher probability of losing) and if they are of type $p < \tilde{p}$ they reject the offer (i.e. the PE believes it has a lower base probability of losing). Taking the PE's decision into account at the

litigation stage, the troll takes maximizes its expected payoff, V, conditional on the PE rejecting the settlement, with respect to legal investment, x_T:

$$\max_{x_T} E(V_T | \, p < \tilde{p}) = \frac{1}{\tilde{p} - \underline{p}} \int_{\underline{p}}^{\tilde{p}} \left((p + x_T - x_P)Z - L_T - \, h_T \frac{{x_T}^2}{2} \right) dp. \qquad (1)$$

It should be noted that if the troll loses at trial it receives no damages but it also does not have to pay the winning PE any compensation fees.

The PE enters the litigation stage knowing its base probability of losing at trial. They then maximize their payoff with respect to legal investment, x_P:

$$\max_{x_P} V_P = -(\, p + x_T - x_P)Z - L_P - \, h_P \frac{{x_P}^2}{2}. \qquad (2)$$

Even if the PE wins the case they receive no compensation from the troll, implying that their payoff will always be negative as a result of litigation fees and legal investment. Taking derivatives of the previous payoff functions with respect to x, we have the following first order conditions for (1) and (2), respectively:

$$\frac{1}{\tilde{p} - \underline{p}} \int_{\underline{p}}^{\tilde{p}} h_T x_T dp - \frac{1}{\tilde{p} - \underline{p}} \int_{\underline{p}}^{\tilde{p}} Z dp = 0,$$

$$h_P x_P - Z = 0.$$

In equilibrium, the troll invests $x_T^* = \frac{Z}{h_T}$ in legal counsel. Similarly, the PE invests $x_P^* = \frac{Z}{h_P}$. Since $h_T < h_P$ we observe that trolls spend more on legal counsel than PEs. Plugging these values into the payoff functions (1) and (2) we get the following expected equilibrium profits if the parties go to trial:

$$E(V_T^* | \, p < \tilde{p}) = \frac{1}{\tilde{p} - \underline{p}} \int_{\underline{p}}^{\tilde{p}} (pZ - L_T - K_T) dp. \qquad (3)$$

$$V_P^* = -pZ - L_P - K_P. \qquad (4)$$

For Equations (3) and (4) the K_i parameters (for $i = T, P$) are defined as $K_T = \frac{2h_T - h_P}{2h_T h_P} Z^2$ and $K_P = \frac{2h_P - h_T}{2h_T h_P} Z^2$. Haus and Juranek (2014) show that these equilibrium payoff functions identify the rent-seeking characteristics of the game.[18] If marginal costs are the same then any investment by one player is directly offset by investment by the other player, making both parties worse off in equilibrium than if they had not invested in legal counsel at all. From a social welfare perspective, then, any investment in legal counsel to affect the probability of winning the case is wasteful. In this classic Prisoner's Dilemma, both parties would be better off if they cooperated to reduce their litigation costs. They refuse to do so, however, because the potential payoff from deviating is greater than from cooperating. Therefore, litigation expenditure is a negative-sum game. However, when it is assumed that $h_T < h_P$, trolls can have a higher expected payoff due to more productive legal counsel through K_T, as evidenced by taking the derivative of K_T with respect to h_T:

$$\frac{\partial K_T}{\partial h_T} = \frac{Z^2}{2h_T^2} > 0, \tag{5}$$

where K_T is increasing in h_T.[19] We find that payoffs for both parties decrease with their respected marginal cost of variable litigation expenses. Regardless, any investment in litigation is socially wasteful, as investment by one party at least partially offsets investment by the other. I will go into further detail about the welfare effects of patent troll litigation in Section 3.3.

[18] Haus and Juranek, "Patent Trolls, Litigation, and the Market for Innovation," 6.
[19] We find the same result when we take the derivative of K_P with respect to h_P. However, for the purposes of my paper this result is not strictly relevant.

Since PEs are rational and forward-looking, they take into account litigation stage results when deciding whether or not to accept the settlement offer in $t = 0$. They will accept to pay a settlement offer $A \leq pZ + L_P + K_p$, which is essentially what the PE expects to lose when it goes to trial, minus a penny. Equivalently, we have $p > \tilde{p} = \frac{A - L_P - K_p}{Z}$. The PE will only accept the settlement if it believes that its probability of losing is greater than the cutoff value $\tilde{p}$. Given this, the troll determines the optimal cutoff type $\tilde{p} \in [\underline{p}, \overline{p}]$ in order to maximize their payoff:

$$\max_{\tilde{p}} \frac{1}{\overline{p} - \underline{p}} \left(\int_{\underline{p}}^{\tilde{p}} (pZ - L_T - K_T) dp + \int_{\tilde{p}}^{\overline{p}} A dp \right) dp$$

$$= \max_{\tilde{p}} \frac{1}{\overline{p} - \underline{p}} \left(\int_{\underline{p}}^{\tilde{p}} (pZ - L_T - K_T) dp + \int_{\tilde{p}}^{\overline{p}} \left(\tilde{p}Z + L_P + K_p \right) dp \right). \quad (6)$$

After integrating and taking derivatives with respect to $\tilde{p}$ we get the first-order condition:

$$0 = \tilde{p}Z - (L_T + K_T) - \tilde{p}Z^2 - \left(L_P + K_p \right) + \overline{p}Z.$$

Solving for $\tilde{p}$, Haus and Juranek get the optimal cutoff type:

$$p^* = \bar{p} - \frac{L}{Z} - \frac{K}{Z}. \quad (7)$$

Substituting for $\bar{p}$ and including my mean probability parameter ϕ, I get the equivalent statement:

$$p^* = \phi(1 + \lambda) - \frac{L}{Z} - \frac{K}{Z}, \quad (8)$$

where $L = L_T + L_P$ and $K = K_T + K_p = \frac{h_T + h_P}{2 h_T h_P} Z^2$.

The cutoff type p^* distinguishes between PEs who settle and PEs who go to trial. Haus and Juranek show that since we know PEs will settle when $p \geq \tilde{p}$ and go

to trial when $p < \tilde{p}$, the fraction $\frac{\bar{p}-p^*}{\bar{p}-\underline{p}}$ of PEs settle in $t = 0$ and the fraction $\frac{p^*-\underline{p}}{\bar{p}-\underline{p}}$ of PEs go to trial in $t = 1$. The first derivative of *K* with respect to h_T is:

$$\frac{\partial K}{\partial h_T} = -\frac{Z^2}{2h_T^2} < 0. \tag{9}$$

This implies that as h_T decreases, *K* increases which, in turn, causes p^* in Equation (8) to decrease. Haus and Juranek state that since we know PEs will accept a settlement offer *A* when $p \geq \tilde{p}$, as the cutoff p^* decreases the proportion of PEs that settle increases. In effect, when trolls have more productive or less expensive legal counsel than that of the PE, more PEs will settle in $t = 0$ since they believe that they are less likely to win if they enter the litigation stage in $t = 1$. Based on Haus and Juranek's results,[20] I have the following lemma:

Lemma 1. *The proportion of PEs that settle increases as the marginal cost of litigation of the patent troll decreases.*

Using Lemma 1 and Equation (8) I show that the PE will accept a settlement offer equal to:

$$A \leq p^* Z + L_P + K_p$$

$$\Rightarrow A \leq \left(\phi(1+\lambda) - \frac{L}{Z} - \frac{K}{Z}\right) Z + L_P + K_p$$

$$\Rightarrow A \leq \phi(1+\lambda)Z - L_T - K_T. \tag{10}$$

Assuming that PEs tend to have patents that are less likely to infringe the troll's patent(s) than patents belonging to other PEs, I would expect PEs to accept larger

[20] Haus and Juranek, "Patent Trolls, Litigation, and the Market for Innovation," 7.

settlement payments from trolls less often. Since I defined ϕ as taking a value between 0 and $\frac{1}{2}$, as ϕ decreases A decreases. More important to my model, however, is the assumption that since $h_T < h_P$ and we know that K_T is increasing in h_T from the first derivative of K_T with respect to h_T, I show that lower marginal costs of legal counsel increases the settlement agreement amount. Since PEs only settle when the settlement is slightly less than their expected litigation costs plus damages (see Equation (2)), this also decreases their expected profit when they enter the litigation stage. Based on Haus and Juranek's results I introduce the following lemma that I will use in Section 3.3 to discuss the welfare effects of patent troll litigation:

Lemma 2. *At the litigation stage, expected profits by PEs decreases with the decreasing marginal costs of legal counsel of the patent troll. Therefore, PEs will also accept higher settlement payments.*

3.2 R&D and Innovation Framework

In order to investigate the welfare effects of patent troll litigation I must first provide a model to identify how firms invest in R&D and how new innovation can be welfare improving. I will use the model presented in Robledo (2005) to inform this discussion. In his paper, he examines how R&D investment decisions are affected if a firm expects to be sued by a challenger in the future. He takes the case where both firms are producers and finds that litigation can be welfare improving when it removes the sued firm's monopoly over the innovation and replaces it with a

Cournot duopoly. However, when we encounter patent troll litigation we will not see any increase in production of the innovated good since trolls do not produce. I will apply my results from Section 3.1 to his model in Section 3.3.

Before being sued for patent infringement by a troll, the PE must invest in R&D to develop a new innovation. Robledo (2005) supposes that there is a risk-neutral PE that spends an amount R on research to invent a new product. The probability of the PE successfully innovating is given by $\rho(R)$, where we assume that $\rho'(R) > 0$ and $\rho''(R) < 0$ so that the probability of success is increasing with research investment but at a diminishing rate. The more a firm spends on research the more likely they are to discover a new innovation. Once the innovation is discovered it can be manufactured with a per-unit cost of c.

After invention, the PE will produce quantity q of the new product. Consumers' demand for the new product is given by the inverse demand curve $d(q)$, where $d'(q) < 0$. It is assumed that this invention is worthwhile and cheap enough to produce that the PE will invest in R&D and consumers will purchase it, providing a positive social surplus when the price is less than the consumer's maximum willingness-to-pay. The following gives us the social surplus $S(q)$:

$$S(q) = \int_0^q (d(\tilde{q}) - c)d\tilde{q}, \tag{11}$$

After maximizing Equation (11), let $S^* = S(q^*)$ be the maximum social surplus for the first-best socially optimal quantity q^*. Robledo (2005) defines social welfare W of the new product as the expected value of the innovation minus production costs minus the cost of R&D investment:

$$W = \rho(R)S^* - R. \tag{12}$$

R^* is the first-best socially optimal level of investment that maximizes welfare in Equation (12). The socially optimal level of investment is implicitly defined when you take the derivative of Equation (12) with respect to R:

$$\rho'(R)S^* = 1, \tag{13}$$

where the left-hand side of the equation gives us the marginal increase in social welfare for an increase in one unit of research investment and the right-hand side shows the marginal cost of this one-unit increase in investment. In addition, this equation defines an investment level that depends on social surplus S^*, so we can redefine R as a function of S^*: $R(S^*)$. After he redefines Equation (13) to be $\rho'\big(R(S)\big)S = 1$ and implicitly differentiates, he gets the following:

$$R'(S) = -\frac{-\rho'(R)}{\rho''(R)\cdot S} > 0. \tag{14}$$

This implies that as social surplus S increases research investment R increases. If an invention generates greater social surplus then the innovating PE will invest more in R&D. Given the first-best social surplus S^* and the first-best investment level R^*, the first-best social welfare W^*can then be defined as:

$$W^* = \rho\big(R(S)\big)S^* - R(S^*). \tag{15}$$

After successfully researching their innovation, it is assumed that the PE acquires a patent and enjoys a temporary monopoly on their invention in exchange for the high costs of R&D for innovation. When the PE is a profit-maximizing monopolist, social surplus and R&D investment will be lower than their first-best levels. Let d_m be defined as the quantity chosen by the monopolist PE to maximize

profit Π_m. Now the innovator chooses the investment level R to maximize their expected payoff:

$$\rho(R)\Pi_m - R. \tag{15}$$

Taking the derivative of Equation (15) with respect to R at setting it equal to 0 we get the first-order condition:

$$\rho'(R_m)\Pi_m = 1. \tag{16}$$

Similar to the interpretation of Equation (13), the left-hand side of the equation gives us the marginal increase in monopoly profit for an increase in one unit of research investment and the right-hand side reflects the marginal cost of this one-unit increase in investment. R_m is implicitly defined as the profit maximizing level of research investment. Since we assume that $\Pi_m < S^*$, when we compare the first-order conditions (13) and (16) we find that $\rho'(R_m) > \rho'(R^*)$. Because of the diminishing marginal returns of research, this implies that profit-maximizing PEs with a monopoly on their innovated product invest less in R&D than the socially optimal level: $R_m < R^*$.

In addition, the monopolist PE's output q_m is less than the socially optimal level of output q^*. As such, we observe the common deadweight welfare loss associated with monopoly power:

$$DWL_m = \int_{q_m}^{q^*} (d(\tilde{q}) - c)d\,\tilde{q} > 0. \tag{17}$$

From this, Robledo (2005) gets the social welfare W_m that would be observed under a patent regime. Subtracting the deadweight welfare loss in Equation (17) from the first-best social surplus in Equation (11) defines the social welfare function:

$$W_m = \rho\big(R(\Pi_m)\big)[S^* - DWL_m] - R(\Pi_m). \quad (18)$$

Since PEs with monopoly power both invest in research and produce less than the socially optimal level, then $W_m < W^*$. Therefore, Robledo (2005) identifies the following difference:

$$W^* - W_m = \rho(R^*)S^* - R^* - \rho(R_m)[S^* - DWL_m] - R_m > 0. \quad (19)$$

Under a patent regime, there are welfare losses associated with monopoly power as well as welfare losses resulting from underinvestment in R&D. Robledo (2005) goes on to identify how social welfare can increase from the monopoly level when a challenger sues the PE for infringement and wins. When the challenger successfully litigates the market for the new good moves from being a monopoly to a Cournot duopoly. The increased production of the new good increases social welfare. However, when a patent troll is the challenger you will not observe an increase in q since trolls do not produce. Instead, when a PE loses there is no increase in production. They pay their litigation fees and potential damages when they lose, or they settle before going to trial (see Section 3.1). In either case, this legal transaction has negative effects on social welfare, which I discuss in the next section.

3.3 Welfare Effects

Excessive litigation by trolls can cause a negative welfare effect. This is observable beginning at the research investment stage. Modifying the framework presented in Robledo (2005) using my results from Section 3.1, we can observe how research and welfare levels are affected by troll litigation.

I will assume that an innovating PE could expect to be sued for infringement by a troll once they begin production. While this may not be entirely realistic as not every patent is going to be sued for infringement by a troll, for the purposes of this paper the PE expects to be litigated against in the future. Given that litigation by trolls and NPEs has more than doubled in the past three years, firms are likely more aware of the possibility of being targeted. However, introducing uncertainty about being sued in the model will not affect my general results. Any decrease in the probability of being sued by a troll will simply increase welfare.

From Equation (4), we know that PEs receive an expected payoff from litigation equal to:

$$V_P^* = -pZ - L_P - K_P.$$

Since we know that PEs will pay for a settlement that is no greater than the expected damages plus the fixed and variable litigation fees, that is, $A \leq p^*Z + L_P + K_P$, we can redefine the expected value function by substituting p^* for p to get:

$$V_P^{**} = -\phi(1+\lambda)Z + L_T + K_T. \tag{20}$$

Intuitively, Equation (20) must be less than 0, since even if the PE wins at trial they nonetheless must pay their fixed and variable litigation costs, L_P and K_P. From the derivative of K_T obtained in Section 3.1, K_T is increasing in h_T, as shown in Equation (5). Therefore, the expected value of going to trial for the PE, V_P^{**}, decreases when the patent troll has a lower marginal cost of variable litigation costs, h_T. In addition, when the base probability of the PE losing the case, ϕ, decreases, their expected value of litigation increases; if a PE's patent is less likely to be infringing then they

are less likely to pay damages at the litigation stage. This also decreases the settlement offer they will accept in $t = 0$.

Taking into account monopoly profits and the expected value of future litigation stage results, the PE decides how much money it intends to invest in R&D to innovate a new product. They choose a research investment level R that maximizes the following:

$$\rho(R)V_l - R, \tag{21}$$

where the PE's expected profit of innovating under troll litigation is given by:

$$V_l = \Pi_m + V_P^{**} = \Pi_m - \phi(1+\lambda)Z + L_T + K_T.$$

Taking the first order condition of Equation (21) with respect to R yields:

$$\rho'(R_l)V_l = 1, \tag{22}$$

where R_l gives us the profit maximizing research expenditure when they expect to enter litigation with a troll, implicitly defined in Equation (22). Since we know that $V_P^{**} < 0$ then we also know that $V_l < \Pi_m < S^*$. As such, given the marginal diminishing probability returns of research and the results from Section 3.2 we know the following:

$$\rho'(R_l) > \rho'(R_m) > \rho'(R^*) \iff R_l < R_m < R^*. \tag{23}$$

Therefore, patent troll litigation when patent trolls have more productive or less costly legal counsel lead to even lower levels of research investment below the monopoly and socially optimal levels. Patent troll litigation causes further deviation from the socially optimal level.

While Robledo (2005) then goes on to show that litigation is welfare increasing in the case where the challenger wins because the monopoly becomes a

Cournot duopoly competing in quantity, in the case where the troll is a challenger I observe only greater welfare loss since there is no increase in production. I will assume that the PE will remain a monopolist in the market for their innovation after litigation, though it pays the troll a one-time licensing fee as damages. Therefore, letting $q_m = q_l$ defines the deadweight loss function under monopoly and litigation as:

$$DWL_m = DWL_l = \int_{q_l}^{q^*} (d(\tilde{q}) - c) d\,\tilde{q} > 0. \tag{24}$$

However, since the PE expects to be sued by a troll in the future it will take into account the loss in profit that will result when it must pay litigation fees and damages if the patent is found to be infringing. Including Equation (20) in our welfare equation, I now define social welfare under litigation as:

$$W_l = \rho\big(R(\mathrm{V}_l)\big)[S^* - DWL_l + V_P^{**}] - R(\mathrm{V}_l), \tag{25}$$

where $V_P^{**} = -\phi(1+\lambda)Z + L_T + K_T < 0$. Comparing a world with patent trolls to one without patent troll, I subtract Equation (18) from Equation (25) to get:

$$\begin{aligned} W_l - W_m = {} & \rho\big(R(\mathrm{V}_l)\big)[S^* - DWL_l + V_P^{**}] - R(\mathrm{V}_l) - \\ & \rho\big(R(\Pi_m)\big)[S^* - DWL_m] + R(\Pi_m) \\ = {} & \underbrace{\Big[\Big(\rho\big(R(\mathrm{V}_l)\big)S^* - R(\mathrm{V}_l)\Big) - \Big(\rho\big(R(\Pi_m)\big) - R(\Pi_m)\Big)\Big]}_{<0} \\ & + \underbrace{\big[\rho\big(R(\Pi_m)\big) - \rho\big(R(\mathrm{V}_l)\big)\big]}_{>0} DWL_m + \underbrace{\rho\big(R(\mathrm{V}_l)\big)V_P^{**}}_{<0} \end{aligned}$$

$$\begin{aligned} & W_l - W_m \\ = {} & \underbrace{[(\rho(R_l)S^* - R_l) - (\rho(R_m) - R_m)]}_{<0} + \underbrace{\rho(R_l)V_P^{**}}_{<0} + \underbrace{[\rho(R_m) - \rho(R_l)]}_{>0} DWL_m. \end{aligned} \tag{26}$$

The first term of the right-hand side of the equation is negative because litigation is a disincentive to research. When firms know that they could be sued for infringement in the future, they take this into account when investing in R&D. In the case of low or medium quality inventions, firms may choose not to conduct R&D because their expected future profit is too low in the face of costly litigation, even if their invention is beneficial to consumers. The second term of the right-hand side of the equation is negative because $V_P^{**} < 0$. Any expenditure on litigation is socially wasteful. Finally, the third term is positive because the probability of successfully innovating is lower under litigation. Since these PEs will invent less often they will also acquire patents less often. Therefore, society faces less deadweight loss because fewer firms exert monopoly power with their patented inventions, since there are simply fewer new inventions. However, this effect should be strongly dominated by the other two, as useful, quality inventions are beneficial enough to consumers to outweigh the classic monopoly welfare losses.

Therefore, patent troll litigation is strictly welfare reducing. If a troll possesses legal counsel that is either more productive or has lower marginal cost then PEs have a lower incentive to invest in researching new innovations if they expect to be sued by a troll in the future. Even though patent troll infringement suits are less likely to win at court, their more productive legal counsel could increase their probability of winning their case regardless, or at least induce the PE to settle in the face of higher litigation costs on part of the PE.

Proposition 1. *Social welfare under litigation by a patent troll is welfare reducing when trolls have a lower marginal cost of legal counsel. Practicing entities spend less than the optimal amount of expenditure on R&D towards beneficial innovations when they encounter litigation by a patent troll.*

4. Conclusion

I have presented a straightforward set of models to examine the effects of patent troll litigation on the incentives to innovate and social welfare. I show that NPEs possessing greater legal expertise than PEs will win more often at court and lead more PEs to settle even though NPE infringement claims tend to be weaker. Litigation is a negative-sum game, where legal investment by one party offsets legal investment by the other, which is considered socially wasteful. One study found that "the median cost of defending a troll case ranges from $1.25 million for cases with $10 million or less at stake, to $2.4 million for cases with $10 to $25 million at stake, to $4 million for cases with $25,000,000 or more at stake."[21] Firms make R&D investment decisions in order to maximize their profit on a new invention. When they expect to be sued by trolls in the future, the high cost of litigation and settlement could lead to less innovative activity since some lower quality, but still socially beneficial, inventions may not be researched since they are not sufficiently

[21] Christopher Hu, "Some Observations on the Patent Troll Litigation Problem," *Intellectual Property and Technology Law Journal* 26.8 (2014): 10-11.

profitable. Therefore, excessive litigation by patent trolls results in less innovation and reduced social welfare.

While proponents argue that NPEs can help small innovators enforce their patent rights, there is an increasing amount of theoretical and empirical evidence that many NPEs behave maliciously, acting as trolls. These rent-seeking firms successfully profit from productive firms because of the imperfect nature of the legal system and the high costs of litigation. One potential extension of my model could be the inclusion of policy options. One such policy could be the adoption of the British "loser-pays" fee shifting system, where the loser of the suit must pay the winner's litigation costs. In my model, even if a PE wins the infringement suit their payoff is still negative because they receive no damages to cover their legal fees. If trolls were forced to pay the defendant's legal fees then trolls would not likely litigate unless their case had sufficient merit.[22] Given how the number of troll-related infringement suits has doubled in the past three years alone, policy makers should be aware of the long-term welfare effects of trolling behaviour. In order to secure the future of a strong market for innovation, the power of NPEs must be carefully monitored and limited so that firms are free to research and develop new and beneficial technology.

[22] Choi and Gerlach, "A Model of Patent Trolls," 19.

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