The Dilemma of Defensive Patenting* (preliminary)

Jing-Yuan Chiou†

November 2013

Abstract

Defensive patenting builds credible threats of infringement countersuit, whereby safeguards the freedom of operation of a firm and raises the incentives of investment. But only operating firms, but not non-practicing entities (NPEs), are subject to infringement risks. Defensive patenting, therefore, cannot offer protections against NPEs. Instead, its positive impact on investment encourages offensive patenting by NPEs. "Defense-only" commitment via the Defensive Patent Licence or defensive patent aggregation may not resolve this "dilemma of defensive patenting."

Keywords: Defensive patenting, Defensive patent license, Defensive patent aggregation.

JEL codes: K19, K41, O34.

*All errors are mine. Comments are welcome.

†Department of Economics, National Taipei University; email: jychioiua@gmail.com.

1. Introduction

Firms often contend that defense is an important reason of building a patent portfolio (Taylor and Silberston, 1973; von Hippel, 1988; Cohen *et al.*, 2000; Hall and Ziedonis, 2001). According to a manager of Microsoft:[1]

> *"At Microsoft, we used to pay little attention to patents... One of these big companies could dig through their patent portfolio, find something close to what we had done, then sue us, and we would have to go through an elaborate defense and possibly lose. So Microsoft did what most big companies do, which is start to build what is called a 'defensive' patent portfolio. So if a big company tried to sue us, we could find something in our portfolio they were afoul of, and countersue. ... since it was intolerable for all parties to engage, it resulted in a state called 'détente', or 'standoff'. This is what you see today for the most part in lots of industries."* (Chris Pratley, 2004)

A powerful patent portfolio creates credible countersuit threats, and helps its owner to settle IP disputes or deter litigation in the first place. Like a sturdy shield, it gives firms "freedom of operation," so that they can navigate through "patent thickets," i.e., a technology "minefield" that is highly fragmented by volumes of patent rights (Shapiro, 2001), and invest in production facilities or further R&D fearless of threats from others' patent attacks.

Defensive patenting, nevertheless, is no panacea. The (initial) intention of defense by no means precludes offensive assertion of patent rights for the purpose of collecting licensing revenues or gaining competitive advantage in the market.[2] In the recent

[1] The blog of Chris Pratley (http://blogs.msdn.com/Chris_Pratley/archive/2004/05/01/124586.aspx; last checked on January 10, 2013). von Hippel (1988) describes strategic patent enforcement in the semiconductor industry: *"Firm A's corporate patent department will wait to be notified by attorneys from firm B that it is suspected that A's activities are infringing B's patents.... Because possibly germane patents and their associated claims are so numerous, it is in practice usually impossible for firm A — or firm B — to evaluate firm B's claims on their merits. Firm A therefore responds — and this is the true defensive value of patents in the industry — by sending firm B copies of 'a pound or two' of its possible germane patents with the suggestion that, although it is quite sure it is not infringing B, its examination shows that B is in fact probably infringing A. The usual result is cross-licensing ..."* Somaya (2003) explicitly considers countersuit and finds that, in most cases, when a suit is countered by a countersuit, the two are disposed of within a day of each other. Without any legal or administrative factor underlying these two legally separated proceedings, it suggests a strong strategic concern for countersuit.

[2] In its Innovator's Patent Agreement, Twitter has publicly committed to a purely defensive stance on April 17, 2012 (http://blog.twitter.com/2012/04/introducing-innovators-patent-agreement.html, last checked on January 10, 2013). The exact promise, however, is to "not use the patents from

battles in the smart phone industry, Microsoft does not shy away from initiating infringement attacks against the Android camp, from core companies like Motorola and Google to manufacturing companies like Foxconn and Inventec. Furthermore, threats of countersuit can only sustain freedom *vis-à-vis* "operating firms," i.e., opponents that carry out potentially infringing activities. Having no products, non-practicing entities (henceforth, NPEs) are not exposed to infringement risks, and defensive patenting becomes toothless. This observation leads to the "dilemma of defensive patenting" (section 2): When defensive patenting does help operating a patent-holder gain more freedom of operation against other operating firms, by boosting investments it also raises the returns of patent enforcement by NEPs and thus incentives to pursue a purely offensive patent portfolio. In other words, defensive patenting can breed offensive patenting.

Defensive patenting is a response to patent thickets at the level of individual firms. At a larger scale, recently there emerge private initiatives beyond traditional collective IPRs arrangements, e.g., patent pools and cross-licenses Shapiro (2001). Legal scholars have proposed the Defensive Patent License (henceforth, DPL), namely, a "truce alliance" with free membership that mandates no patent litigation among members (Schultz and Urban, 2012). A new business model, the defensive patent aggregation (henceforth, DPA), lets for-profit NPEs acquire and then license their patents for defense, and at the same time commit not to offensively enforcing their patent portfolios (Wang, 2010; Hagiu and Yoffie, 2011). However, we show in section 3 and 4, respectively, that these two solutions may fall victim to the same dilemma.

Lastly, the DPA also emphasizes its benefit of "preemptive acquisition" of patents before they fall into the hands of "patent trolls." We conclude this note with some remarks about this practice in section 5.

2. Defensive Patenting and its Dilemma

Two types of continuum firms, type-1 and type-2, engage in a three-stage game; Figure 1 illustrates the timing. At time 1, both types decide whether to acquire a patent

employees inventions in offensive litigation without their permission." In addition, Twitter does not seem to have a significant patent portfolio. In the article of May 10, 2012, "Twitter Gambles on a Patent Plan," *The Wall Street Journal* reported that Twitter has at least two pending applications, but no issued patents (http://online.wsj.com/article/SB10001424052702304363104577392342603822440.html#articleTabs%3Darticle, last checked on November 21, 2013).

Figure 1: Timing

portfolio. At time 2, the investment stage, only type 2 firms, but not type-1 firms, have the ability to build a (downstream) manufacturing facility. In other words, type 1 firms include small, independent inventors, universities, or patent-holding companies that cannot, or do not intend to commercialize their technologies. Time 3 is the stage of patent enforcement.

Ex ante, there are a number of $T_1 > 0$ of type-1 firms, and $T_2 > 0$ of type-2 firms, respectively. At the end of time 2, firms are categorized according to their patenting and investment decisions. Referring to Figure 2, operating firms invest and build manufacturing facilities at time 2. Among operating firms, vertically integrated firms hold a patent portfolio, while pure manufacturing firms do not. On the other hand, patent-holding firms include vertically integrated firms (those with downstream investments) and non-practicing entities (NPEs, those without investments).

For simplicity, we assume that both patenting and investment decisions are observable to other players and take binary forms, and firm heterogeneity only appears at the cost side. Downstream investment creates a value $v > 0$, and its cost is independently distributed among type-2 firms according to $CDF\ K(\cdot)$. The cost of patenting is also independently distributed, with $CDF\ F_i$ for type-i firms, $i \in \{1, 2\}$. This cost consists the expense at preparing and prosecuting patent applications, and the costs of identifying and purchasing (existing) patents from prior owners.

At the patent enforcement stage, for simplicity, we ignore the enforcement cost, and assume that *all* operating firms are exposed to the infringement risk of *all* patents. Each patent has a probability $\alpha \in (0, 1)$ of being valid and infringed by an operating firm. The court's rulings are independently distributed across infringement suits. If the court rules infringement, then the infringed party obtains a benefit $r \cdot v > 0$ and the infringing party incurs a loss $l \cdot v > 0$. We denote

$$L \equiv \alpha \cdot lv \quad \text{and} \quad R \equiv \alpha \cdot rv \tag{1}$$

as the expected loss and gain, respectively, in a unilateral infringement litigation.

Between two vertically integrated firms, there is a probability $t \in [0, 1]$ that they

	patent	no patent	
investment	vertically integrated firms	pure manufacturing firms	operating firms
no investment	non-practicing entities		
	patent-holding firms		

Figure 2: Firm classification

can reach a "truce" and there is no infringement suit. With probability $1-t$, the two firms engage in a litigation war and sue each other for infringement.[3] If there is mutual blocking, i.e., the court rules that both infringe on the other's patent, then both incur a loss $\hat{l} \cdot v \geq 0$.[4] The expected loss of a vertically integrated firm facing another firm of its kind is

$$t \cdot 0 + (1-t)[\alpha^2 \hat{l} + \alpha(1-\alpha)(l-r) + (1-\alpha)^2 \cdot 0]v = \alpha(1-t)[\alpha \hat{l} + (1-\alpha)(l-r)]v. \quad (2)$$

There is no loss when two vertically integrated firms can maintain truce, which occurs with probability t, or when a litigation war breaks out but the court rules no infringement on both sides, which occurs with probability $(1-t) \cdot (1-\alpha)^2$. A firm may come out of a litigation war as a winner (with benefit $r \cdot v$) or loser (with loss $l \cdot v$) in unilateral infringement; both events occur with probability $(1-t) \cdot \alpha(1-\alpha)$. With probability $(1-t)\alpha^2$, there is mutual blocking which causes a loss $\hat{l} \cdot v$. We define

$$W \equiv \alpha[\alpha \hat{l} + (1-\alpha)(l-r)]v \quad (3)$$

as the expected loss in a litigation war.

Let's compare the expected loss when a firm does not hold a patent versus when it does,

$$L - W = \alpha v[\alpha r + (1-\alpha)(l-\hat{l})], \quad (4)$$

which is positive if $l \geq \hat{l}$. Mutual blocking may improve a firm's bargaining position in the post-infringement negotiation relative to the case where it is the only infringer,

[3]Since there is no litigation cost, if a firm is sued for infringement, fighting back with a countersuit is always optimal.

[4]When patents serve some coordination, or collusive, function to help firms alleviate market competition (by choosing appropriate royalties, for instance), a firm may receive a positive benefit in mutual blocking, $\hat{l} < 0$. But in this case, vertically integrated firms would not want to maintain truce. We do not consider this scenario.

hence reduce the loss of infringement. But even if $l < \hat{l}$, we may still have $L > W$ because of the term r, which is associated with the event when the paten-holder becomes the unique "winner," i.e., the only infringed party in a litigation war. The ability of fighting back raises two defensive values of a patent portfolio: the firm can cut back its loss by imposing mutual blocking, or even emerge as the sole winner at the enforcement stage.

2.1. Defensive patenting and investment

Consider the investment stage. Let P_i be the total number of type-i firms, $i \in \{1, 2\}$, that have built a patent portfolio. At time 2, a type-2 firm that does not acquire a patent will expect its investment to infringe on $\alpha(P_1 + P_2)$ firms' patents. The return of investment is $\pi^M = v - (P_1 + P_2)L$. The total number of pure manufacturing firms is the number of non-patenting type-2 firms, $T_2 - P_2$, multiplied by the probability that the investment cost is smaller than π^M:

$$M = (T_2 - P_2) \cdot K(\pi^M). \tag{5}$$

More patents, P_1 or P_2, reduces the number of pure manufacturing firms because a larger share of investment returns will be taken away by patent-holders.

The investment decision of a type-2 firm that has acquired a patent, on the other hand, involves a trade-off between investing under a "defensive patent shield" and not investing in order to keep its patent portfolio purely offensive. By not investing, it becomes a NPE and obtains an expected return $\pi^N = (M + I)R$ by attacking a number of M pure manufacturers and I vertically integrated firms. By investing, it is vulnerable to NPEs of a total number of $P_1 + P_2 - I$, but can still offensively enforce its patent rights against a number M of pure manufacturing firms. Facing other vertically integrated firms, a loss W occurs when truce cannot be maintained; the loss against a number of I vertically integrated firms is $(1 - t)WI$. The expected return of investment is

$$\pi^I = v - (P_1 + P_2 - I)L + MR - (1 - t)WI = \pi^M + \pi^N + ID, \tag{6}$$

where

$$\begin{aligned} D \equiv L - R - (1 - t)W &= \alpha v \left\{ (l - r) - (1 - t)[\alpha \hat{l} + (1 - \alpha)(l - r)] \right\} \\ &= \alpha v[t(l - r) + \alpha(1 - t)(l - r - \hat{l})]. \end{aligned} \tag{7}$$

A patent-holding firm will invest when the investment cost is smaller than $\pi^I - \pi^N = \pi^M + ID$. Having a patent portfolio boosts investment incentives if and only if $D > 0$, so that $\pi^I - \pi^N > \pi^M$. The term D captures a "defensive premium:" *relative to* using its patent portfolio offensively against other vertically integrated firms, the extra benefit the firm can garner from investment, whereby its patent becomes defensive, i.e., the ability to maintain truce or reduce loss in a litigation war . This premium is increasing in l and t, but decreasing in r and $\hat{l}$. Higher r raises the returns of offensively enforcing patent rights, while higher $\hat{l}$ implies a larger loss even after mutual blocking. Both undermines the relative attractiveness of defensive patenting. On the other hand, by higher l, a defenseless firm incurs a larger infringement loss , and by higher t, holding patents can more effectively deter litigation. Both strengthen the defensive value of a patent portfolio.

We assume a positive premium, so that holding a patent portfolio patents raise investment incentives.

Assumption 1. (Defensive premium) $D > 0$.

A necessary condition for this assumption to hold is $l > r$, namely, the loss from unilateral infringement is strictly higher than the gain. For instance, the infringer may suffer non-transferable losses such as reputation or confidences of other stake-holders, including consumers, financing providers, or partners of joint ventures, *etc.*.

Among the type-2 firms that have acquired patents, a number of

$$I = P_2 \cdot K(\pi^M + DI) \tag{8}$$

firms will invest and become vertically integrated firms. Given P_1 and P_2, an equilibrium at the investment subgame is a pair $(\hat{M}, \hat{I})$ such that $\hat{M}$ satisfies condition (5) and $\hat{I}$ satisfies condition (8), respectively. The number of manufacturing firms $\hat{M}$ is uniquely determined by the total number of patents $P_1 + P_2$. By $D > 0$, higher I raises a patent-holder's incentive to invest in downstream facilities. Investment decisions under defensive patenting are strategic complements, and there may be multiple equilibria in $\hat{I}$.[5] Let K' be the pdf of investment cost. We consider only stable equilibria: for all P_2, an equilibrium $\hat{I}$ satisfies

$$P_2 D K'(\pi^M + D\hat{I}) < 1, \tag{9}$$

[5]The existence of equilibrium $\hat{I} \in [0, P_2]$ is ensured by Tarski's fixed point theorem, for $K(\cdot)$ is an increasing function. If $K(\cdot)$ is continuous, then Brouwer's fixed point theorem also applies.

which ensures intuitive comparative statics.

Proposition 1. *(Patents and investment)* $\hat{M}$ *is decreasing in* P_1 *and* P_2*. A stable equilibrium investment* $\hat{I}$ *is increasing in* D *and decreasing in* P_1*. The impacts of* P_2 *on* $\hat{I}$*, and thus on the total investment* $\hat{M}+\hat{I}$*, are ambiguous:*

$$\frac{d\hat{M}}{dP_2} = -K(\pi^M) - (T_2 - P_2)LK'(\pi^M) \text{ and } \frac{d\hat{I}}{dP_2} = \left.\frac{K(c) - P_2LK'(c)}{1 - P_2DK'(c)}\right|_{c=\pi^M+D\hat{I}}. \quad (10)$$

Higher P_2 reduces π^M and discourages investment. But it also implies a larger pool of potential vertically integrated firms. The latter force may outweigh the former, and so $\hat{I}$ may be increasing in P_2. If the response of investment is sufficiently large, i.e., if P_2DK' is sufficiently close to one, which occurs for large values of D, then the impact of P_2 on $\hat{I}$ will dominate its impact on $\hat{M}$. Higher P_2 can raise total investment.

2.2. Offensive *vs.* defensive patenting

Turn to time 1. A type-1 firm bases its patenting decision solely on the offensive value π^N. The number of patent-holding type-1 firms is

$$P_1 = T_1 \cdot F_1(\pi^N) = T_1 \cdot F_1(R(\hat{M}+\hat{I})). \quad (11)$$

For a type-2 firm, a patent portfolio provides an option value. Without a patent portfolio it can only invest as a manufacturing firm at time 2 and obtain a payoff $\pi^M - c$, where c is the investment cost that will be realized at time 2. The expected return of not building a patent portfolio is $\int_0^{\pi^M}(\pi^M - c)dK(c)$. If having a patent portfolio, the firm can either invest under a defensive shield (with a payoff $\pi^I - c$) or remain as a NPE (with a payoff π^N). The expected return of patenting is $\int_0^{\pi^M+D\hat{I}}(\pi^I - c)dK(c) + [1 - K(\pi^M + D\hat{I})]\pi^N$. A type-2 firm will acquire a patent portfolio when patenting cost is smaller than

$$\begin{aligned} f &\equiv \int_0^{\pi^M+D\hat{I}}(\pi^I - c)dK(c) + [1 - K(\pi^M + D\hat{I})]\pi^N - \int_0^{\pi^M}(\pi^M - c)dK(c) \\ &= K(\pi^M)(\pi^N + D\hat{I}) + \int_{\pi^M}^{\pi^M+D\hat{I}}(\pi^I - c)dK(c) + [1 - K(\pi^M + D\hat{I})]\pi^N. \end{aligned} \quad (12)$$

The number of type-2 firms that will build a patent portfolio is

$$P_2 = T_2 \cdot F_2(f). \quad (13)$$

An equilibrium of the whole game is a pair (P_1^*, P_2^*) that satisfies condition (11) and (13), and the equilibrium investment (M^*, I^*) is determined accordingly.[6] Again,

[6]Brouwer's fixed point theorem ensures the existence of equilibrium for continuous *CDF* F_1 and F_2.

we consider only stable equilibria: given P_1, $1 > T_2 F_2'(\partial f/\partial P_2)$, where F_2' is the pdf of type-2 firms' patenting cost.

The strategic relationships of patenting decisions are determined through their impacts on investment. By Proposition 1, an increase in P_1 reduces the aggregate investments $\hat{M} + \hat{I}$, and so the return of NPEs, π^N. Patenting decisions among type-1 firms are strategic substitutes. Higher P_1 also reduces π^M, π^I, and f (see the proof of Proposition 2). The stability condition ensures that, by reducing f, type-2 firms' patenting incentives are decreasing in P_1. On the other hand, if higher P_2 raises total investment $\hat{M} + \hat{I}$, then P_1 is increasing in P_2. In other words, if patenting with defensive motifs boosts investment, then it also encourages purely offensive patenting; hence the dilemma of defensive patenting.

Proposition 2. *(The dilemma of defensive patenting) In a stable equilibrium, higher D raises P_1^* or P_2^* (or both). If total investment $\hat{M} + \hat{I}$ is increasing in P_2, then higher D raises the equilibrium P_1^*.*

Proof. We first show that f is decreasing in P_1. Since $\pi^I = \pi^M + \pi^N + D\hat{I}$, we can ignore the impacts on boundary points and obtain $\partial f/\partial \pi^M = K(\pi^M + D\hat{I}) - K(\pi^M)$, $\partial f/\partial \pi^N = 1$, and $\partial f/\partial \hat{I} = DK(\pi^M + D\hat{I})$. Since higher P_1 reduces π^M and, in turn, $\hat{I}$ and π^N, the threshold f is decreasing in P_1.

We express the strategic interactions between P_1 and P_2 by the best responses: $P_1 = \underset{(?)\ (+)}{\hat{P}_1}(P_2, D)$ and $P_2 = \underset{(-)\ (+)}{\hat{P}_2}(P_1, D)$, where higher D increases both $\hat{P}_1$ and $\hat{P}_2$, higher P_1 reduces $\hat{P}_2$, and the impact of P_2 on $\hat{P}_1$ has the same sign as $d(\hat{M} + \hat{I})/dP_2$. Given D, the equilibrium pair $(P_1^*(D), P_2^*(D))$ satisfies $P_1^*(D) = \hat{P}_1(P_2^*(D), D)$ and $P_2^*(D) = \hat{P}_2(P_1^*(D), D)$. Consider $D > D'$ such that $P_i^*(D) < P_i^*(D')$, $i = 1$ and 2. Since $\hat{P}_2$ is increasing in D and decreasing in P_1, we obtain $P_2^*(D) = \hat{P}_2(P_1^*(D), D) > \hat{P}_2(P_1^*(D), D') > \hat{P}_2(P_1^*(D'), D') = P_2^*(D')$, a contradiction.

By raising $\hat{M} + \hat{I}$, higher P_2 also increases $\hat{P}_1$. If $D > D'$ but $P_1^*(D) < P_1^*(D')$, then $P_2^*(D) > P_2^*(D')$, and so $P_1^*(D) = \hat{P}_1(P_2^*(D), D) > \hat{P}_1(P_2^*(D), D') > \hat{P}_1(P_2^*(D'), D') = P_1^*(D')$, a contradiction. *Q.E.D.*

When the defensive premium D is higher, at least one type of firms will patent more. And if more patents held by type-2 firms, i.e., those with the capacity to develop downstream capacities, encourage aggregate investment, then higher defensive premium will increase the number of patent-holding type-1 firms. In this case, more effective defensive patenting breeds purely offensive patenting.

2.3. Discussion

The dilemma of defensive patenting occurs when (i) defensive patenting alleviates litigation threats and boosts investment incentives, and (ii) higher investment invites more (purely) offensive patenting. We demonstrate this dilemma in a very simple setting, especially at the patent enforcement stage. For instance, we do not consider litigation costs, different validity among patents, or different investment values as well as infringement probabilities among firms. Heterogeneity at these aspects may change the propensity of litigation, including the truce probability t between two vertically integrated firms, and the stakes in a lawsuit (lv, rv, and $\hat{l}v$), but should not affect the two crucial properties. The dilemma may still occur after these complicating factors are introduced.

In our model, an infringing firm would not be shut down and forced to ext the market by the infringed party. Hence pure manufacturer, post infringement, can still obtain a positive payoff π^M.[7] This feature is consistent with the assumption that the value of investment v is independent of other firms' investment behavior.[8] One might argue that there is some tension between this scenario and the assumption that all operating firms may infringe on the same patent, which seems would imply that all operating firms are competing at the same market. However, a patented invention may be applied to different fields that corresponds to independent markets. In addition, only vertically integrated firms, but not NPEs, would have any incentives to shut down a competing infringer. NPEs would rather collect licensing payments. As long as countersuit threats can alleviate shut-down risks from other vertically integrated firms, defensive patenting strategy can still preserve investment incentives. Higher investment by vertically integrated firms, then, would encourage purely offensive patenting, and thus the dilemma ensues.

[7] We implicitly assume that there is no "negative externality" at the enforcement stage. That is, downstream investment is sufficiently valuable such that all infringing parties can receive the same infringement compensation rv, regardless of the number of infringement judgements. This externality would undermine the offensive value of patents. But since type-1 firms' patenting decisions are already strategic substitutes due to the negative impact on investment, we believe that the negative externality would not affect our qualitative results.

[8] The opposite case where investments are complements, namely, one firm's investment raises the value of others' investment, would introduce strategic complementarity into investment decisions even among pure manufacturing firms. But since no patent-holders, NPEs or vertically integrated firms, would want to shut down infringers, this assumption generates the same qualitative result.

3. DPL: The Alliance of Truce

Suppose that, after investment decisions are made but before the enforcement stage, patent-holders decide whether to join an "alliance of truce" and grant a "defensive patent license" (DPL) that ensures no patent litigation among members of the alliance.

Joining this alliance would cut off their sole source of revenues, hence NPEs would surely not grant a DPL. Let $\mu^I \in [0,1]$ be the portion of vertically integrated firms joining the alliance. Suppose that, after participation, a vertically integrated firm will enforce its patent rights against a pure manufacturing firm with probability $\phi^M \in [0,1]$, and against a non-member vertically integrated firm with probability $\phi^I \in [0,1]$. These probabilities ϕ^M and ϕ^I do not necessarily reflect the official rules of the DPL, but rather how the membership of the alliance may change the litigation propensity outside the alliance. In the previous analysis, without a formal alliance we have $\phi^I = 1-t$ and $\phi^M = 1$.

Given (μ^I, ϕ^M, ϕ^I), a vertically integrated firm obtains a payoff $v - (P_1 + P_2 - I)L + RM - [(1-\mu^I)(1-t) + \mu^I\phi^I]WI$ for not joining the alliance, and a payoff $v - (P_1 + P_2 - I)L + RM\phi^M - I(1-\mu^I)\phi^I W$ for joining the alliance. The firm will participate when

$$[\mu^I\phi^I + (1-\mu^I)(1-t-\phi^I)]WI > (1-\phi^M)RM. \tag{14}$$

At the right-hand side, participation entails a cost of a softer stance against manufacturing firms. The left-hand side captures the benefit of participation: it entirely eliminates litigations against other members (with a portion μ^I), and, facing non-member vertically litigation firms (with a portion $1-\mu^I$), it changes the probability of litigation war from $1-t$ to ϕ^I. Note that μ^I and ϕ^I are complementary in encouraging participation. The benefit of participation is increasing in ϕ^I if and only if $\mu^I > 1/2$, and increasing in μ^I if and only if $\phi^I > (1-t)/2$. Hence, a viable alliance requires a sufficiently large number of members, and members have to be sufficiently litigant outside the alliance.

Suppose that $\phi^M = 1$ and $\phi^I \geq 1-t$, i.e., the DPL does not soften litigation propensity against non-members. Both $\mu^I = 0$ and $\mu^I = 1$ are equilibria. For the former, by $1-t-\phi^I \leq 0$, a vertically integrated firm will not join when no other firms participate in the alliance; for the latter, if every other vertically integrated firm grants the DPL, then by $\phi^I > 0$, a vertically integrated firm will do so, too.

Under the equilibrium of $\mu^I = 1$, a manufacturing firm's investment return is $v - [P_1 + P_2 - I + I(1-\mu^I) + I\mu^I\phi^M]L = \pi^M + I\mu^I(1-\phi^M)L = \pi^M$, the same as before. The investment payoff of a vertically integrated firm is $v - (P_1 + P_2 - I)L + RM\phi^M = \pi^M + \pi^N + I(L-R)$. Since $L - R > D$, the impact of DPL, when it is granted in equilibrium, is the same as an increase in D. We can apply Proposition 2 to reproduce the dilemma.

Corollary 1. *(Defensive patent license) NPEs have no incentive to grant a DPL. When $\phi^M = 1$ and $\phi^I \geq 1 - t$, there are multiple equilibria, $\mu^I = 1$ and $\mu^I = 0$, in the participation of the "truce alliance." If the equilibrium $\mu^I = 1$ prevails and higher P_2 boosts total investment, then the DPL also encourages offensive patenting.*

4. DPA: The Defense-Only Commitment

In this section we consider how the "defense-only" commitment of the defensive patent aggregation (DPA) affects investment and patenting decisions. We introduce another group of firms, with size $A \geq 0$, that are clients of a defensive patent aggregator, which, to slightly abuse the terminology, is also called a DPA. These firms only make investment decisions, and use the DPA's patent portfolio in patent countersuit. The DPA lends its patent portfolio to clients under attack, but also commits not to initiating patent litigations against any party, including non-clients.

To single out the effect of this defense-only commitment, we assume that (i) clients of the DPA do not possess any patent, but instead "oursourcing" their patent strategy and relying on the DPA's patent portfolio to fend off patent attacks; and (ii) while (non-client) vertically integrated firms can only maintain truce among themselves with probability t, there is full truce between them and clients of DPA.[9] The second assumption can be justified by DPA's defensive position and large pile of patents, which would render any offensive attack unprofitable. It also gives the DPA the "benefit of

[9] A DPL requires its members not use its own patent portfolio to attack other members. But the DPA only ensures that a firm is immune to patents held by the aggregator, but not to patents held by other members of the aggregator. Members of the DPA very often have their own patent portfolio. One of the major DPA, RPX Corporation, is backed by firms with sizeable patent portfolios such as IBM (http://www.bizjournals.com/seattle/blog/techflash/2008/11/IBM_Cisco_support_RPX_in_defensive_patents34959854.html?page=all; last checked on April 2, 2013). An interesting scenario is a client launches offensive attacks, and then draws on the patent portfolio of the DPA when facing counter attacks. We leave it for future research.

the doubt," i.e., we assume that the DPA can guarantee its clients the maximal freedom of operation defensive patenting can offer.

Given A, P_1, and P_2, at the investment stage, a type-2 firm that does not have a patent (and, by assumption, is not a client of the DPA) obtains an investment revenue $\pi^M = v - L(P_1 + P_2)$. The total amount of investment from these firms is $\widetilde{M} = (T_2 - P_2)K(\pi^M)$. We denote $\widetilde{I}$ as the aggregate investment by vertically integrated firms, and I_A the aggregate investment by clients of DPA. Since now clients of the DPA also becomes its victim, a NPE obtains a return $\widetilde{\pi}^N = R(\widetilde{M} + \widetilde{I} + I_A)$.

A vertically integrated firm's revenue is

$$\begin{aligned}\widetilde{\pi}^I &= v - L(P_1 + P_2 - \widetilde{I}) + R\widetilde{M} - \widetilde{I}\alpha v(1-t)[\alpha\hat{I} + (1-\alpha)(l-r)] \\ &= \pi^M + \widetilde{\pi}^N + D\widetilde{I} - RI_A.\end{aligned} \tag{15}$$

It will invest if the investment cost is smaller than $\widetilde{\pi}^I - \widetilde{\pi}^N = \pi^M + D\widetilde{I} - RI_A$. Comparing with the counterpart in section 2.1, there is a negative term associated with investments by clients of DPA. This negative effect does *not* come from full truce between vertically integrated firms and clients of the DPA. It is due to the defensive commitment of the DPA. To see this point, assume full truce among vertically integrated firms. By $t = 1$, and so $D = \alpha v(l - r) > 0$ as long as $l > r$, investment decisions of patent-holding type-2 firms are still complements. On the other hand, had DPA also allowed its patent portfolio to be used for offensive purposes, then more investments by its clients would imply less exposure to offensive attacks and thus raise incentives of investment. Put differently, any defense is of no value without offensive threats. The defensive commitment of DPA reinforces the relative importance of a patent's offensive use, hence reduces a patent-owner's investment incentives.

Lastly, since a client cannot use the DPA's patent portfolio for offensive purposes, its only source of revenue is investment return $\pi^A = v - L(P_1 + P_2 - \widetilde{I}) = \pi^M + L\widetilde{I}$. Only the aggregate investment of non-clients, $\widetilde{I}$, but not that of other clients, I_A, affects this return. This is also due to the pure defensive stance of the DPA.

The aggregate investment $\widetilde{M}$ is independent of other firms' investment decisions. Suppose that the investment cost of the clients has CDF $K_A(\cdot)$. Given P_1, P_2, and A, the equilibrium at the investment subgame is characterized by aggregate investment $(\widetilde{I}, I_A)$ such that

$$\widetilde{I} \equiv P_2 \cdot K(\pi^M + D\widetilde{I} - RI_A) \text{ and } I_A \equiv A \cdot K_A(\pi^M + L\widetilde{I}). \tag{16}$$

Given stability, i.e., condition (9), higher A raises I_A which in turn reduces $\widetilde{I}$. That is,

a larger client base of the DPA, by increasing investments by this group, will induce more non-clients to use their patent portfolios for purely offensive purposes. If higher A also raises the total investment $\widetilde{I} + I_A + \widetilde{M}$, i.e., if the positive effect ($dI_A/dA > 0$) outweighs the negative effect ($d\widetilde{I}/dA < 0$), then higher A will further increase the incentive of type-1 firms to pursue offensive patenting.

Proposition 3. *(The defensive patent aggregation) The DPA raises incentives of non-clients to pursue an offensive stance for their patent portfolios.*

5. Road Ahead: More on the DPA

The patenting stage in our model suggests a sufficiently large pool of patentable patents, or existing patents, so that a firm can build a non-negligible patent portfolio as long as it is willing to incur the cost. When a patent system is "broken" by the "flooding" of low-quality yet powerful patents (Jaffe and Lerner, 2004), our results show that defensive patenting may offer limited help to curb the damage of patent trolls, or excessive offensive enforcement. The patent office may need to tighten the examination standard and reduce the "supply" of questionable patents.

Alternatively, if there is only limited patent supply, patent acquisition may involve a bidding war in the patent auction.[10] In this regard, proponents of the DPA argue that this model can tackle the problem of patent trolls by "preemptive acquisition," that is, grabbing patents that posit potential threats before they fall into the hand of more aggressive owners. Success of this strategy hinges on how high the willingness, which depends on the defensive *vs.* offensive value of patents, and how deep the pockets of the DPA, which requires a well-crafted licensing strategy. Hagiu and Yoffie (2011) points out that the defensive-only commitment to non-clients of the DPA may create free-riding problem. To mitigate this problem, the DPA adopts the "catch and

[10]The reality may contain both. The average annual growth rate of patent grants in the U.S. between 1983, the year after the creation of the Court of Appeals for Federal Circuit, and 2011 is about 5.5% (The United Stated Patent and Trademark Office patent statistics , http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm, last checked on January 11, 2013). Quillen and Webster (2001) reports that the allowance rate of the USPTO (the number of applications allowed divided by the number filed) in the mid-1990s is 95%, versus 68% and 65% for the European and Japanese patent offices, respectively. On the other hand, the acquisition of Nortel's more than 6,000 patents was conducted in an auction in 2011, and won by a team including Apple, Microsoft, and RIM, beating Google with a price of $4.5 billion (http://www.forbes.com/sites/elizabethwoyke/2011/07/07/an-insider-on-the-nortel-patent-auction-and-its-consequences/, last checked on January 10, 2013).

release" strategy (Hagiu and Yoffie, 2011): to resell acquired patents to other entities that would pursue offensive enforcement against those who previously did not obtain licenses from the aggergator. Put differently, the DPA delays offensive attacks and creates a window during which operating firms can respond to future litigation threats, either by securing a license now from the aggregator, or by modifying their investment behavior, i.e., by inventing around the patents. We leave this as well as other exciting topics about the DPA for future research.

References

Cohen, W., R. Nelson, and J. Walsh (2000). "Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or not)." NBER working paper 7552.

Hagiu, A., and D. Yoffie (2011). "Intermediaries for the IP Market." Working paper.

Hall, B., and R. Ziedonis (2001). "The Patent Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995." *RAND Journal of Economics*, 32: 101-28.

Jaffe, A. and J. Lerner (2004). *Innovation and its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About it*, Princeton University Press.

Quillen, C. and O. Webster (2001). "Continuing Patent Applications and Performance of the U.S. Patent Office." *Federal Circuit Bar Journal*, 11: 1–21.

Schultz, J. and J. Urban (2012). "Protecting Open Innovation: A New Approach to Patent Threats, Transaction Costs, and Tactical Disarmament." *Harvard Journal of Law and Technology,* forthcoming.

Shapiro, C. (2001). "Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard-Setting." *Innovation Policy and the Economy*, Volume I, A. Jaffe, J. Lerner, and S. Stern, eds., MIT Press.

Somaya, D. (2003). "Strategic Determinants Of Decisions Not To Settle Patent Litigation." *Strategic Management Journal*, 24: 17–38.

Taylor, C. and Z. Silberston (1973). *The Economic Impact of the Patent System: A Study of the British Experience*, Cambridge, UK: University Press.

von Hippel, E. (1988). *The Sources of Innovation*, Oxford University Press.

Wang, A. (2010). "Rise of the Patent Intermediaries." *Berkeley Technology Law Journal*, 25: 159–200.