Defensive and offensive acquisition services in the market for patents

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Abstract

We theoretically and empirically examine recent business models of defensive and offensive patent trading by specialized service firms also called non-practicing entities (NPEs). We develop a theoretical model of competition between NPEs and operating firms to win a patent auction, wherein operating firms have private information on their exposure to infringement. We show that an offensive NPE can nevertheless outbid operating firms due to a greater ability to extract damages from infringers. Defensive acquisition services yet obtain even better results by using a combination of private information aggregation and "catch-and-release" strategy to preempt the most valuable patents. Using patent reassignment and litigation data, we then provide evidence that patents acquired by defensive entities are significantly more valuable than patents acquired by offensive NPEs (patent assertion entities). We also find clear evidence that defensive NPEs do implement the catch-and-release policy in practice.

Keywords: Patent; Non-practicing entity; Patent assertion entity; Defensive patent aggregator; Patent auction; Market for patents; Catch-and-release

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1 Introduction

We theoretically and empirically examine recent business models of defensive and offensive patent trading by specialized service firms also called non-practicing entities. Defensive patent acquisition services may "aggregate" (accumulate) patents or simply buy and later sell patents having provided licenses for their members. Offensive patent acquisition services, also called patent assertion entities, acquire patents with the intent to monetize them either through licensing or litigation (cf. Scott Morton and Shapiro, 2013). Patent acquisition services are different from patent pools and intellectual property (IP) exchanges that have previously been extensively studied. In contrast to pools, the goal of patent acquisition services is not to provide consistent package licenses for patents related to a particular technology (e.g. an IT standard), but to share risks, costs of, and possibly returns to, patent litigation and associated patent transactions whenever this is possible.

We argue that patent acquisition services have introduced novel and important business models; organizational responses to the legal and competitive problems posed by the evolving and extremely aggressive market for technology. According to venture capitalist Izhar Armony, "the most sophisticated [technology companies] are inventing more and filing more patents. They buy more defensively, assert more patents, do more cross-licensing deals, and participate in defensive groups like RPX"[1](see also Chien, 2010). Whereas offensive non-practicing entities have been studied in some detail (e.g., Reitzig, Henkel, and Heath, 2007; Scott Morton and Shapiro, 2013), defensive patent acquisition is an emerging cooperative strategy for technology companies, and its internal functioning and competitive implications are not yet well understood. We attempt to address this research gap.

The goal of our research is to theoretically highlight fundamental facts about and empirically generate basic insights into new patent acquisition business models and their implications for the market for patents. We theoretically describe how patent acquisition

[1] Xconomy (2012). Retrieved from http://www.xconomy.com/boston/2011/05/04/charles-river-vc-a-300m-investor-in-intellectual-ventures-says-patents-are-huge-market-not-a-%E2%80%9Cdirty-world%E2%80%9D/?single_page=true on May 8, 2012.

services work. We also empirically examine associated behavior in patent trading and litigation and discuss their potential impact on the IP marketplace. In particular, we highlight the fine line between defensive and offensive models and consider the commitment of defensive aggregators not to litigate their patents. The quantitative patent reassignment (trading) and litigation data are helpful to distinguish how defensive and offensive patent acquisition services operate in the market and in litigation, and how their strategies differ from and complement those of major technology companies. We finish by discussing the longer-term implications of cooperative ownership of IP assets for innovation strategies of operating technology companies.

2 Business models in intellectual property markets

2.1 Innovation in intellectual property intermediation

An early wave of innovation in the market for technology concerned the intellectual property licensing model that challenged the traditional production model (Gans and Stern, 2003). The licensing model commercialized inventions through the market for intellectual property rather than through the market for products. A very different competitive dynamic follows from this strategic choice. In the IP licensing model, revenues are generated from one-off licensing fees and/or royalty revenues based on subsequent product sales by clients; costs are primarily fixed and related to R&D and marketing rather than actual production or service - there is no need to build in-house production facilities or distribution networks - and primary customers are product suppliers rather than product users. This innovation was arguably enabled by the strengthening of the patent regimes, particularly in the United States (Maskus, 2000). E.g., the creation of the United States Court of Appeals of the Federal Circuit in 1982 significantly reduced the probability that challenged patents were invalidated (Henry and Turner, 2006). Relatedly, Branstetter, Fisman and Foley (2006) find that stronger patent regimes have been associated with increasing international technology transfer.

The stronger IP rights also ushered in the next wave of innovation in IP markets, namely the Non-Practicing Entity model, NPEs. These are firms that acquire intellectual property rights without using them to produce a final good, i.e., they do not "practice" the patents. Some NPEs have also been called patent-assertion entities (PAEs) because of their focus on acquiring and enforcing patent rights (Layne-Farrar, 2012). The novelty of this IP licensing business model is to expand into legal competition through patent enforcement rather than simply market competition to license inventions. PAEs also typically do not invest in R&D to develop the inventions themselves, but instead acquire patents in the IP market. These types of "offensive" IP intermediaries have become a tremendous market force that has altered innovation competition in many high-technology markets. The Obama administration in the United States explicitly viewed them as a net negative force on high-tech innovation (Executive Office of the President, 2013)[2].

Because strong patent rights create opportunities to develop and trade intellectual property rights, the market for technology has become more lucrative and allowed entry by new types of IP intermediaries with innovative business models. However, because of the non-rival and only partially excludable nature of intellectual assets (Romer, 1990), unintended flows of technological knowledge must be resolved through the legal system. As a result, the necessary complement to a vibrant IP marketplace is a vibrant litigation scene. Moreover, it has been argued that a patent's intrinsic (technological) value may differ from its exclusion value (its power to exclude rivals from the marketplace, see Chien, 2010: 325), which would make it possible that marginal inventions, from a technological viewpoint, obtain exorbitant valuations in lawsuits and settlements, depending on their strategic implications within complex technical systems.

2.2 Offensive NPEs

Patent assertion entities (PAEs) - NPEs with an explicit strategy to enforce patents through litigation - have become a force to be reckoned with. According to industry estimates, there were 550 IP lawsuits in the United States in 2010 against 3000 defen-

[2] Executive Office of the President. 2013. Patent Assertion and U.S. Innovation. Report released on June 4, 2013. Available at http://www.whitehouse.gov/sites/default/files/docs/patent_report.pdf

dants, that is, over 2000 unique companies (some of which were sued more than once)[3]. It appears that PAE litigation is particularly vibrant in novel and complex technology areas (cf. Cohen et al., 2000).

Steiner and Guth (2005) observe that PAEs, often buy patents and then wait until the associated product market takes off. Once irreversible investments in manufacturing assets have been made, operating companies are not easily able to stop using the technology. Then, PAEs are able to obtain compensations that are higher than what potential licensees would have been willing to pay ex ante (Reitzig, Henkel, and Heath, 2007). Non-practicing entities are also able to extract higher settlement fees than operating companies would in a similar context. Having no R&D or production activity, they are indeed unexposed to patent suits – which deprives the defendant from wielding the threat of counter-suit as a bargaining argument. More generally, they are not bound by the broad cross-licensing agreements or reputation concerns that may prevent patent disputes between operating companies (Shapiro, 2001; Galasso, 2012).

There are relatively few empirical studies of NPEs' acquisition and litigation strategies. Fischer and Henkel (2012) suggest that the probability that a traded patent is acquired by an NPE rather than a practicing entity (operating company) increases in the scope of the patent, in the patent density of its technology field, and in the patent's technological quality. Many other empirical analyses confirm these findings and indicate that NPEs in fact hold patents of similar or even higher quality than operating companies and do not generally engage in "flighty" litigation as it has sometimes been described by critics (e.g., Shrestha, 2012; Risch, 2012). Levko et al. (2009) suggest that NPEs differ from practicing entities primarily in terms of litigation strategies. For instance, they tend to name multiple defendants to maximize settlement revenues and minimize legal costs. NPEs also seem to be less successful in their litigation than practicing entities (29% rate of success compared with 41% for practicing entities, ibid.).

[3]RPX (2011). Annual Report. Retrieved from www.rpx.com on May 7, 2012. P. 2.}. Many of these legal cases were concentrated in the communication technology industry, particularly smart phones, and an estimated 17% of lawsuits were brought by NPEs in 2008\footnote{TechCrunch (2008). Retrieved from http://techcrunch.com/2008/11/24/is-rpxs-defensive-patent-aggregation-simply-patent-extortion-by-another-name/ on May 1, 2012.

2.3 Defensive patent acquisition services

Our focus in this paper is to examine in detail the most recent innovation in the IP market: defensive patent acquisition services. These are cooperative organizations that respond to the competitive and legal challenge presented by PAEs by pooling information about and resources to acquire problematic patents.

Fuelled by the emergence of NPEs and furious patent litigation among practicing entities themselves, technology manufacturers have come up with novel organizational strategies to fend off legal threats (McDonough, 2006; Wang, 2010; Hagiu and Yoffie, 2013). Defensive patent acquisition involves collectively acquiring patents so that they do not end up in the hands of parties that are likely to assert them. The service provider then extends member companies licenses to the patents in exchange for a fee. Defensive NPEs thus provide freedom of operation and safety from litigation for their operating company members or partners (firms that also manufacture goods for the product market).

The two most advanced defensive NPEs are companies called RPX Corporation and AST (Allied Security Trust). Whereas certain offensive NPEs, such as Intellectual Ventures or Mosaid, also provide defensive services, RPX and AST are the most purely defensive in their stated objectives. Their stated foci are on pooling risks, costs, and transaction activities related to acquiring or licensing problematic patents in high-technology industries. However, the business models of these two companies are quite distinct in terms of their bidding mechanisms and post-acquisition monetization.

Defensive NPEs pool the licensing contracting related to external patents. For example, RPX may negotiate licenses with external PAEs to license or acquire their IP that is alleged to be infringed by RPX members. Thus, RPX pools the bargaining power of its members to obtain licenses to relevant IPRs. This may reduce the licensing or acquisition prices paid to IP sellers. Their core service offering involves pooling information about threatening patents to acquire while at the same time disguising the identities and needs of clients in such negotiations.

However, RPX and AST are structured rather differently from one another. AST is a non-profit company that attempts to return as much of the value back to its clients. In a stark contrast, RPX as a publicly-traded entity attempts to capture as much of the created value as possible and utilize it to grow its businesses and at the same time generate reasonable benefits for members. AST engages in patent acquisition based on (confidential) ex-ante bids by its individual members. It is therefore likely that this mechanism suffers from free riding of the members, and as a result, AST probably buys fewer patents than is optimal for its members. Meanwhile, RPX also pools information from its clients regarding patent threats and litigation exposures, but its clients do not need to commit to bidding ex ante. RPX can thus operate more independently in negotiations with problem patent holders.

All in all, it appears that AST is more distinct from offensive NPEs such as Intellectual Ventures and Mosaid than RPX. It buys, licenses, and sells patents but does not enforce them. In contrast, and aligned with PAEs, RPX aggregates and enforces patents, but is committed to litigation only indirectly through holding companies. AST's main orientation appears to be to solve the PAE problem for its members, whereas RPX appears to intend to position itself as the trading platform for valuable patents between its members and patent holders (often NPEs). They thus have fundamentally different approaches, although they both attempt to provide defensive patent services to their clients or members.

3 A model of patent acquisition

3.1 Setup

We first consider the auction of a patent which, once bought out, may threaten a continuum of mass one of operating firms if enforced. Bidders include operating firms, but also a patent assertion entity (PAE), and we denote by $\mathcal{B}$ this set of risk neutral bidders (common knowledge).

Each operating firm is characterized by a different degree of exposure to the patent θ, which can be thought as the probability that a court deems the patent valid and infringed by the firm. Types are assumed to be identically and independently drawn from an absolutely continuous distribution F (common knowledge) over full support $\Theta = [0, 1]$, with associated density f (*i.e.* firms are *ex ante* symmetric). We restrict our attention to a class of distributions satisfying the following assumption[4]:

Assumption 1. $f(\theta) \leq 1 \; \forall \theta \in \Theta$

Importantly, we posit that a firm *privately* knows her type once confronted with the patent, but remains uninformed about others' precise degree of exposure. In contrast, the PAE does not hold any private information about the true patent threat. Therefore the PAE has an information disadvantage in the auction as compared with operating firms.

The patent is auctionned through a second-price sealed-bid auction, where it is assigned to the highest bidder who pays the second highest bid. In case of a tie, we assume that the patent is randomly reassigned to one of the highest bidders. We do not endogenize the patent seller's behavior. The seller exogenously sets a reserve price which does not exclude any bidder from participating in the auction. Finally, the winner of the aution may enforce his rights against all potential infringers.

For the PAE, the expected benefit of buying the patent is obviously to assert it against operating firms so as to collect damage fees. In that case, litigation entails a cost $L > 0$ only borne by the plaintiff, and results in expected damages $d(\theta) = d.\theta \geq 0 \; \forall \theta \in \Theta$. We posit for simplicity that the litigation process quickly reveals the true type of the alleged infringer to the plaintiff, so that both parties are thus better off by reaching a settlement agreement. More specifically, the type of the defendant is assumed to be truly revealed to the plaintiff after the latter incurred a share $\alpha \in (0, 1)$ of the litigation cost L. We denote by $l \equiv \alpha L$ this reverse engineering cost, necessary to reach a settlement agreement between parties, with $0 < l < d < 1$.

For operating firms, the benefits of winning the auction are twofold. First, this makes it possible to save the cost of paying damages to another firm. Second, this also allows the new patent owner to sue the other operating firms. In that case, damages are however

[4] Distributions satisfying this assumption include for instance the Uniform, the Standard Normal, the Exponential for $\lambda \leq 1$, the Logistic, the Laplace, the Gamma ...

discounted by a factor $\delta \in (0,1)$ with $\delta d \geq l$, reflecting the potentially lesser capability of operating entities to extract damages from each other (due to e.g., the risk of countersuing or reputation concerns in a context of repeated interactions). Conversely, one can think of $(1-\delta)$ as the *damage premium* of the NPE.

The timing of the game is as follows:

t=0 Each firm's type is simultaneously and randomly drawn by Nature from the distribution F over full support $\Theta = [0,1]$, and each firm privately learns her type.

t=1 The patent is auctionned through a second price sealed bid auction.

t=2 The patent reassignee may enforce its rights.

3.2 Auction for patent buyout without intermediation

Let us first characterize the players' optimal bidding strategies during the patent acquisition process. The patent value for any bidder is equal to the benefit he can get from owning that patent. Thus, the PAE's value is equal to the expected damages net of reverse engineering cost that he can get when asserting the patent against the whole set of firms' types:

$$v_{AE} = (d-l)\int_0^1 \theta f(\theta)\mathrm{d}\theta = (d-l)\mu$$

where μ denotes the expected exposure to the patent, that is the patent's expected threat. Instead, the patent value of a type $\tilde{\theta}$ firm has two components. The first one equals the damages she would have to pay if the patent were to be enforced, which depends on her type. The second component instead reflects the value of holding a patent that she could enforce against the mass $F\left(\tilde{\theta}\right)$ of operating firms, net of the associated reverse engineering costs:

$$v(\tilde{\theta}) = d\tilde{\theta} + (\delta d - l)F\left(\tilde{\theta}\right)\mathbb{E}\left(\theta|\theta \leq \tilde{\theta}\right) = d\tilde{\theta} + (\delta d - l)\int_0^{\tilde{\theta}} \theta f(\theta)\mathrm{d}\theta$$

It can be easily checked[5] that bidding one's true valuation is a dominant strategy for any bidder, so that the profile of bids $b^* = (v(\theta), v_{AE})\ \forall \theta \in \Theta$ constitutes a Bayesian Nash

[5]The proof is provided in Appendix 1.1.

Equilibrium of the patent auction game. Let $\theta^{max} \leq 1$ denote the highest *realized* type. The PAE then succeeds to acquire the patent if and only if[6]

$$\theta^{max} \leq \left(\frac{d-l}{d}\right)\mu - \left(\delta - \frac{l}{d}\right)\int_0^{\theta^{max}} \theta f(\theta)\mathrm{d}\theta \tag{C1}$$

When the PAE benefits from a positive damage premium ($\delta < 1$), the right hand side of (C1) goes up, thereby increasing its chances to win the patent. However, the PAE succeeds if the patent for sale does not strongly threaten one operating firm in particular. Conversely, there are two conditions for an operating firm to be able to purchase a patent. First, she must be strongly exposed to this patent (that is, highly threatened); second, her ability to extract damages must be close to that of the PAE.

However, any firm with a type realization in $[0, \theta^{max})$ has no means to avoid costly litigation. In the next section, we therefore study whether an intermediary may offer a better protection against litigation initiated by a PAE for at least a subset of types in the industry. Put differently, we analyze whether the intervention of an intermediary in the patent acquisition process permits to achieve a better outcome from firms' perspective. Hence, in the sequel, we assume that (C1) holds to focus on the competition between the intermediary and the PAE at the auction for patent buyout.

4 Intermediation in the market for patents

4.1 Augmented model of patent acquisition

We now turn to an auction whereby a PAE competes with a defensive aggregator (the intermediary) to purchase the patent. In exchange of an up-front fixed membership fee, the intermediary offers first to search for patents that might threaten its set of clients, and participates in the auction for patent buyout. Then, it provides its whole set of clients with licenses to its acquired patents, thereby annihilating risks of patent infringement.

Our goal is to study the role of private information and catch-and-release strategy in

[6]Note that, $F(\theta^{max}) = 1$ by definition of θ^{max}.

the viability of the intermediary's business model. Once a patent has been identified, we indeed assume that the intermediary is able to collect and aggregate private information on its clients' true types before the auction takes place. Accordingly, it enjoys an information advantage in the auction with respect to the PAE. Another key parameter of the intermediary's business model is the use of "catch-and-release" strategy. Once a patent has been purchased, this strategy denotes the option to derive an extra revenue from asserting the patent against non-clients, either by suing them directly, or by reselling to others the right to sue non-clients. Available evidence suggests that catch-and-release is an explicit part of the business model of defensive aggregators (see next section). To simplify the analysis, we posit that the intermediary systematically resorts to this strategy.

Timing.

t=0 Each firm's type is simultaneously and randomly drawn by Nature from the F over full support $\Theta = [0, 1]$, and each firm privately learns her type.

t=1 The intermediary proposes a menu of subscription fees.

t=2 Firms either accept or reject the offer[7], and the intermediary learns its mass of clients' types.

t=3 The patent is auctionned through a second-price sealed-bid auction.

t=4 The patent reassignee may enforce its rights.

Restriction on the set of feasible subscription fees. Following the descriptive section on defensive aggregators' business models, we impose the following restriction on the class of menus of contracts available to the intermediary:

$$\mathcal{T} = \{t : t \in \mathbb{R}_+\} \tag{R}$$

[7]Throughout the paper, we adopt the conventional assumption that, when indifferent, firms accept the intermediary's offer.

The intermediary has only one contracting variable available: the up-front subscription fee. Notably, (R) excludes any type of transfer from the intermediary to its clients in case of failure at the auction for patent buyout.

Commitment of the intermediary towards its clients. We assume that the intermediary *ex ante* commits to bid the *true* aggregate value of its clients for the patent at the auction stage. Letting $\Theta_a \subseteq \Theta$ denote the set of types subscribing to the intermediary, the true aggregate value of its mass of clients for the patent is simply their opportunity cost of being sued for patent infringement, that is

$$\int_{\Theta_a} v(\theta)\mathrm{d}\theta = \int_{\Theta_a} d(\theta)\mathrm{d}\theta = d\int_{\Theta_a} \theta\mathrm{d}\theta$$

Catch-and-release strategy. Finally, we assume that the intermediary systematically enforces its rights against non-clients upon patent reassignment. Since the intermediary *only* knows its clients' true type, the benefit from using the catch-and-release strategy is simply the expected damages it can get, net of reverse engineering costs, from asserting the patent against the subset of non-clients' types. Let Θ_r denote the set of types remaining non-clients, with $\Theta_a \cup \Theta_r = \Theta$ and $\Theta_a \cap \Theta_r = \emptyset$, the use of catch-and-release strategy yields the following benefit to the intermediary:

$$(d-l)\int_{\Theta_r} \theta f(\theta)\mathrm{d}\theta$$

Therefore, the intermediary's valuation for the patent is

$$v_I = d\int_{\Theta_a} \theta\mathrm{d}\theta + (d-l)\int_{\Theta_r} \theta f(\theta)\mathrm{d}\theta$$

and since bidding one's true valuation is a dominant strategy at the auction, $b_I = v_I$.

4.2 Optimal subset of clients' types and subscription fees

We first consider a menu of subscription fees targeting the whole industry, *i.e.* bunching the whole set of types Θ, and show that it is unprofitable for the intermediary to attract all types. Finally, we show that the intermediary finds it instead optimal to restrict its offer to only attract a subset of types in the industry.

Bunching over the whole set of types. Suppose first that the intermediary chooses a subscription fee that attracts the whole set of types, *i.e.* $\Theta_a = \Theta$. Again, θ^{max} denotes the realization of the highest type (with $\theta^{max} \leq 1$), and we assume that the realization of the lowest type $\theta^{min} = 0$ for simplicity. At the patent auction, the intermediary wins if and only if

$$d \int_0^{\theta^{max}} \theta \mathrm{d}\theta \geq (d-l) \int_0^1 \theta f(\theta) \mathrm{d}\theta$$

This condition states that the intermediary uses private information on the industry's *true* exposure to preempt the patents that are the most valuable (that is, most dangerous) for the industry. By contrast, it cannot prevent the PAE from buying patents that are less dangerous for the industry. Note that the intermediary's information advantage also enters the right-hand side of this condition through the reverse engineering cost l that the PAE needs to incur in order to retrieve damages due to his lack of information about the true threat of the patent. Rearranging, we get

$$\theta^{max} \geq \left[2\mu \left(\frac{d-l}{d} \right) \right]^{\frac{1}{2}} \tag{C2}$$

When offering its menu of subscription fees, the intermediary does not know the industry's true exposure to the patent for sale. Therefore, from an ex ante perspective, the prior probability that the intermediary succeeds to acquire the patent is given by

$$P_I \equiv \Pr \left(\theta^{max} \geq \left[2\mu \left(\frac{d-l}{d} \right) \right]^{\frac{1}{2}} \right) = 1 - F \left(\left[2\mu \left(\frac{d-l}{d} \right) \right]^{\frac{1}{2}} \right)$$

since we have a continuum of firms over the unit interval. Hence, ex ante, the problem of the intermediary is to choose a menu of subscription fees that maximizes its ex ante expected profit subject to firms' participation and incentive compatibility constraints, that is

$$\max_{t(.)} \int_0^1 t(\theta)f(\theta)\mathrm{d}\theta - P_I b_{AE} = \int_0^1 t(\theta)f(\theta)\mathrm{d}\theta - P_I(d-l)\mu$$

subject to

$$t(\theta) + [1 - \mu_I(\theta)]\, d(\theta) \leq d(\theta) \quad \forall \theta \in \Theta \tag{PC}$$

and

$$t(\theta) + [1 - \mu_I(\theta)]\, d(\theta) \leq t(\theta') + [1 - \mu_I(\theta)]\, d(\theta) \quad \forall \theta, \theta' \in \Theta \tag{IC}$$

where $\mu_I(\theta)$ denotes a type-θ firm's updated belief that the intermediary will win the patent auction. (PC) states that, in order to induce a type-θ firm to accept its offer, the intermediary's subscription fee plus the damages to pay if the PAE acquires the patent must be lower than the damages she has to pay when not subscribing[8]. Instead, (IC) ensures that a type-θ firm does not have incentives to pick a different type tariff so as to benefit from a lower subscription fee. Rearranging, these constraints simply reduce to

$$t(\theta) \leq \mu_I(\theta)\, d(\theta) \quad \forall \theta \in \Theta \tag{PC}$$

$$t(\theta) \leq t(\theta') \quad \forall \theta, \theta' \in \Theta \tag{IC}$$

Proposition 1. *The intermediary finds it unprofitable to attract the whole set of types. The corresponding incentive feasible menu of subscription fees bunches types:*

$$\mathcal{T}_b = \{t_b^* = t_b^*(\theta) = 0 \; \forall \theta \in \Theta\}$$

Proof. See Appendix 1.2. □

[8] Note that, when rejecting the offer, a type-θ firm faces patent litigation for sure, independently of the patent reassignee's identity, since the intermediary systematically resorts to the catch-and-release strategy.

The intermediary cannot discriminate among firms as proposing a menu of type-contingent subscription fees is not incentive compatible: it fails to have firms self-selecting properly within this menu. Because of the restriction on the set of feasible fees (R), the only incentive feasible menu of fees bunches types. Thus, in order to attract the whole set of types in the industry, the intermediary would have to set a unique subscription fee to $t_b^* = 0$, yielding

$$\mathbb{E}(\Pi_I) = -P_I b_{AE} \leq 0$$

Exclusion of a subset of types. We now analyze the impact of excluding part of the industry on the profitability of the intermediary's business model. From Proposition 1, since attracting the whole set of types is unprofitable, the intermediary instead chooses a fee targeting a subset of types, leaving aside part of the industry even though all types face litigation. Namely, it now chooses both a "limit type" $\underline{\theta}$ and a menu of subscription fees satisfying (PC) and (IC) for all $\theta \in [\underline{\theta}, 1]$ that maximize its ex ante expected profit, and such that:

- types in $\Theta_a = [\underline{\theta}, 1]$ accept the intermediary's offer and become clients,
- types in $\Theta_r = [0, \underline{\theta})$ do not subscribe and face litigation independently of the patent reassignee's identity.

Suppose first that there exists $\underline{\theta}^* \in (0,1)$ solving the intermediary's problem. At the patent auction, its condition to win is

$$d \int_{\underline{\theta}^*}^{\theta^{max}} \theta \mathrm{d}\theta + (d-l) \int_0^{\underline{\theta}^*} \theta f(\theta) \mathrm{d}\theta \geq (d-l) \int_0^1 \theta f(\theta) \mathrm{d}\theta \tag{C3}$$

Besides the intermediary's information advantage over the PAE, condition (C3) also shows that for $\underline{\theta}^* > 0$, the systematic use of catch-and-release increases the intermediary's likelihood to win the auction, and all the more so as the mass of non-client firms is large.

Rearranging this condition, we get:

$$\theta^{max} \geq \left[2\left(\frac{d-l}{d}\right)\int_{\underline{\theta}^*}^{1}\theta f(\theta)\mathrm{d}\theta + (\underline{\theta}^*)^2\right]^{\frac{1}{2}} \equiv x\left(\underline{\theta}^*\right) \tag{C3}$$

Proposition 2. *Ex ante, the prior probability that the intermediary acquires the patent for sale decreases with the limit type* $\underline{\theta}$.

Proof. See Appendix 1.3. □

This result states that excluding a subset of types through the choice of a limit type negatively impacts the intermediary's perceived probability to win the auction. The intuition is that having a lower mass of clients, and therefore less information about the patent threat at the industry level, is not compensated by the benefit retrieved from the use of the catch-and-release strategy against the mass of non-clients. This is because the intermediary needs to incur a cost l to acquire information on non-clients' exposure to the patent in order to collect damages from them.

The intermediary faces a trade-off when choosing the subset of types to target. On the one hand, choosing a strictly positive limit type decreases the mass of clients but allows the intermediary to extract a positive subscription fee. On the other hand, the probability to win at the patent auction decreases, which negatively affects firms' incentives to become client, and their willingness-to-pay for the intermediary's services. Hence, ex ante, the intermediary solves

$$\max_{\{t(.),\underline{\theta}\}_{\theta\in\Theta}} \int_{\underline{\theta}}^{1} t(\theta)f(\theta)\mathrm{d}\theta - P_I\,(d-l)\left(\mu - \int_{0}^{\underline{\theta}}\theta f(\theta)\mathrm{d}\theta\right)$$

subject to

$$t(\theta) \leq \mu_I\,(\theta)\,d(\theta) \quad \forall\theta \in [\underline{\theta}, 1] \tag{PC}$$

$$t(\theta) \leq t(\theta') \quad \forall\theta, \theta' \in [\underline{\theta}, 1] \tag{IC}$$

where the prior probability is now $P_I = 1 - F\left(x(\underline{\theta})\right)$.

Proposition 3. *The intermediary finds it optimal to exclude a subset of types by setting* $\underline{\theta}^* \in (0,1)$ *such that:*

1. $\underline{\theta}^*$ *is defined by the following implicit equation:*

$$\underline{\theta}^* = \left\{ \frac{d-l}{d} \mathbb{E}\left(\theta | \theta \geq \underline{\theta}^*\right) - P_I \left(\frac{\partial P_I}{\partial \underline{\theta}} \right)^{-1} \right\} \left\{ 1 - P_I \left(\frac{\partial P_I}{\partial \underline{\theta}} \right)^{-1} \frac{l}{d} \gamma(\underline{\theta}^*) \right\}^{-1} \tag{1}$$

2. *Types in* $\Theta_a = [\underline{\theta}^*, 1]$ *become clients, and types in* $\Theta_r = [0, \underline{\theta}^*)$ *remain non-clients and face litigation with probability one*

3. *The optimal incentive feasible menu of subscription fees is:*

$$\mathcal{T}_e = \{ t_e^* = t_e^*(\theta) = P_I d \underline{\theta}^* \ \forall \theta \in \Theta_a \}$$

Proof. See Appendix 1.4. □

The intermediary finds it optimal to restrict its offer so as to exclude a subset of types in the industry. Specialization allows to attract a mass $1 - F(\underline{\theta}^*)$ of the industry at a strictly positive subscription fee, while still having the option to derive revenue by enforcing the acquired patent against a mass $F(\underline{\theta}^*)$ of the industry, through the systematic use of the catch-and-release strategy. However, note that the subscription fee t_e^* is lower than the expected damages a type-$\underline{\theta}^*$ firm faces when not subscribing to the intermediary's acquisition services to account for the *imperfect* insurance policy provided against litigation brought by PAEs. By excluding a subset of types in the industry, the intermediary gets

$$\mathbb{E}(\Pi_I^*) = [1 - F\left(x\left(\underline{\theta}^*\right)\right)] \left\{ [1 - F(\underline{\theta}^*)]\, d\underline{\theta}^* - (d-l) \int_{\underline{\theta}^*}^1 \theta f(\theta) \mathrm{d}\theta \right\}$$

which is positive if

$$\underline{\theta}^* \geq \frac{d-l}{d} \frac{1}{1 - F(\underline{\theta}^*)} \int_{\underline{\theta}^*}^1 \theta f(\theta) \mathrm{d}\theta = \frac{d-l}{d} \mathbb{E}\left(\theta | \theta \geq \theta^*\right) \tag{2}$$

Corollary 1. *The intermediary's ex ante expected profit is positive for* $\underline{\theta}^*$ *as defined by Eq. (1). Furthermore, the optimal limit type* $\underline{\theta}^*$ *is indeed a maximum.*

Proof. See Appendix 1.5. □

As for firms, the expected benefit derived from the intervention of an intermediary in the patent acquisition process depends on their degree of exposure to the patent, that is their likelihood of infringement. Firms facing a moderate threat, *i.e.* types in $[0, \underline{\theta}^*)$, get the same expected disutility since they are not enough threatened by the patent to join the intermediary, and they face litigation independently of the patent reassignee due to the systematic use of catch-and-release. Instead, highly exposed firms, *i.e.* types in $[\underline{\theta}^*, 1]$ are better off when an intermediary offers its acquisition services since it allows to partially protect them against litigation. Notably, by gathering its clients' interests, the intermediary can succeed in acquiring patents that could not be bought out by firms at the individual level. Finally, because of the impossibility to discriminate among types through subscription fees, highly threatened firms benefit from a low tariff. The following Lemma summarizes these findings.

Lemma 1. *When an intermediary takes part in the auction for patent buyout, firms with types in* $[\underline{\theta}, \theta^{max}]$ *are better off and those with types in* $[0, \underline{\theta}^*)$ *are as well off.*

Proof. See Appendix 1.6. □

4.3 Implications for empirical analysis

We have shown first that operating firms are unlikely to prevent patent assertion entities from preempting dangerous patents unless they face a really high degree of exposure to infringement and/or when he is able to leverage a damage premium. Against this background, our analysis also suggests that a defensive aggregator is able to perform better by aggregating private information from its clients to preempt the patents that put them the most at risk. Conversely, the PAE still manages to purchase patents that represent a lesser risk for the defensive aggregator's clients. The use of a catch-and-release strategy and the number of clients enable the latter to preempt a larger set of patents. In other words, they change the threshold of aggregate exposure above which the intermediary preempts, but the threshold still exists in any case.

A key implication of this result is that the set of patents “for sale” is eventually split in two subsets - those purchased by PAEs and by defensive aggregators - with respectively lower and higher threat of infringement. Since in our model, the probability of exposure to a particular patent is the same for all operating firms, it follows that the subset of patents preempted by preemptive aggregators are expected to also be more "valuable" at the entire industry scale.

5 Quantitative evidence of the different NPE business models

In this section we compare the patent acquisition strategies of defensive and offensive services and other types of companies engaged in patent acquisition through analyses of patent reassignment data. These descriptive analyses complement the theoretical model by providing information about how the different models work in practice.

5.1 Description of the patent reassignment data

We gathered data on patents reassigned to the defensive and offensive NPEs and created a matched sample of patents having the same characteristics in terms of grant year, reassignment year and type of assignee that were reassigned to practicing entities. This approach sheds light on those patents that were acquired by defensive services, as most of these firms do not file their own patents.

In total, our database contains 2608 patents that were reassigned to NPEs between 1988 and 2012. 865 of these were bought by the purely defensive entities Allied Security Trust and RPX Corporation, and the rest by PAEs including 1st Technology, Acacia Patent Acquisition, Arrival Star, Cheetah Omni, Innovation Management, Innovative Sonic Limited, Intellectual Ventures, IPG Healthcare 501, Mosaid Technologies, Papst Licensing, Rembrandt IP Management, Scenera Research, Tessera Technologies, Trontech Licensing, Wi-Lan Inc., and Wisconsin Alumni Research[9]. In the matched sample, 2608 patents with the same general characteristics reassigned to practicing entities, consisting mostly of large technology companies[10].

Based on this database of 5216 reassigned patents, we gathered data on litigation involving these patents using the Stanford IP Litigation database. From our matched samples of reassigned patents, 284 were litigated during the period 1999-2010. 52 of these litigated patents were reassigned to defensive NPEs, 111 to offensive NPEs, and 121 were reassigned to practicing entities, in other words, technology companies operating in product markets.

5.2 Characteristics of reassigned patents

Table 1 summarizes the main characteristics of the patents in our three samples. There are a few interesting differences between the defensive, offensive and practicing entities. Defensive entities tend to acquire patents that are significantly older and more highly cited than those of offensive and practicing entities. Although the average ages of patents reassigned to defensive and offensive entities differ by less than a year, this statistically significant age difference may reflect that defensive organizations acquire patents that are already known to be problematic or valuable, whereas offensive organizations and practicing entities might acquire patents on a more speculative basis.

[9]However, we were unable to reliably distinguish the reassignments to Intellectual Ventures, because the company appears to operate through so many different funds, subsidiaries, and limited liability companies that this would require substantial amount of detective work to compile (cf. Avancept. 2011. The Intellectual Ventures Report. Second Edition. Retrieved from http://avancept.com/iv-report2Ed.html on May 8, 2012).

[10]The most represented practicing entities in our database are: NEC (211 patents), Infocus Corporation (44 patents), Nortel Networks (36 patents), Siemens AG (28 patents), Harris Corporation (27 patents), Infineon Technology (27 patents), Electronic Data System Corporation (19 patents), Legerity Inc. (19 patents), AT&T Corporation (15 patents) and Fujitsu (15 patents).

	Defensive NPEs	Offensive NPEs	Practising entities
Number of patents	865	1743	2608
Mean application year (SD)	1996,51 (4,83)	1997,28 (5,42)	1997.54 (3.93)
Mean forward citations (SD)	17,07 (28,49)	14,96 (23,05)	16.97 (25.66)
Likelihood of litigation (SD)	0,060 (0,24)	0,050 (0,22)	0.046 (0.21)
Average number of cases / litigated patents (SD)	12,73 (21,57)	10,17 (17,81)	8,98 (15,66)

Table 1: Characteristics of the reassigned patents

Regarding the number of forward citations, the patents bought by practicing entities and defensive NPEs are indistinguishable in terms of citations, whereas PAEs have bought significantly less-cited patents than the other two groups. Forward citations are usually interpreted to reflect patent quality; hence it seems that PAEs tend to acquire lower quality patents.

The likelihood of litigation is the highest for patents reassigned to defensive NPEs and the lowest for those reassigned to practicing entities. The number of lawsuits per litigated patent is also the highest for defensive NPEs, and lowest for practicing entities. This reinforces the previous result and suggests that defensive acquisition services are able to identify the most problematic or valuable patents. However, the differences in litigation rates are not statistically significant, because of the large variation around the means. Overall, these statistics suggest that the defensive NPEs RPX and AST acquire high-quality patents that are highly valuable, i.e. likely to be problematic or litigated.

5.3 Early value indicators of patents reassigned to defensive and offensive NPEs

The theoretical model predicts that defensive NPEs should be able to preempt more valuable patents than PAEs. Whereas there is no objective way to assess the value of reassigned patents, we will use the number of forward-citations[11] that is often considered

[11] Excluding self-citations. The results remain stable if we use the number of forward citations including self-citations.

as a proxy of patents' value[12]. Of course, using the number of forward-citations for patents of different ages and reassignment years has problems. First of all, the number of citations is correlated with the age of the patent. Second, citations and reassignments could be subject to reverse causality (reassignments causing subsequent citations). Thus, any difference in the number of citations between PAEs and defensive aggregators could just be generated by a higher number of reassignments or a different timing of reassignment between patents reassigned to offensive and defensive NPEs. To overcome this difficulty, we chose to use the number of self forward citations that occurred during the first five years of the patents excluding all patents that were reassigned during these years (365 out of the 2,608 patents eventually reassigned to NPEs)[13]. As the theoretical model predicts a significant difference in the value of the patents reassigned to defensive and offensive entities, and as patent value is related to the number of potential infringers, we derived two other indicators of from the number of forward citations within the first five years of the patent's life: (1) the number of different assignees for the citing patents, (2) the number of different technological classes of the citing patents.

	Citations that occured during the first 5 years of the cited patents			
	Number of observations	Total number of forward citations (SD)	Number of different assignees for the citing patents (SD)	Number of different technological classes for the citing patents (SD)
Offensive NPEs	1591	6,62 (0,21)	3,89 (0,10)	2,07 (0,04)
Defensive NPEs	652	7,37 (0,46)	4,33 (0,18)	2,35 (0,08)
Significant difference at 10%		Yes (9,1%)	Yes (2,9%)	Yes (0,01%)

Table 2: Characteristics of the reassigned patents

As we can see in Table 2, there are significant differences between the patents that are reassigned to offensive and defensive NPEs. Patents reassigned to defensive entities are

[12]This number is one of the measures needed to assess the economic and technological significance of a patent. These citations allow for the identification of prior art for an invention. They are thus carefully controlled by patent offices because they help to define the scope of the claims of the patent. For a discussion of this indicator, see for instance: Harhoff et al. (1999), Giummo (2003), and Hall et al. (2005).

[13]For a discussion of this indicator, see : Hall, B. H., A. B. Jaffe, and M. Trajtenberg (2001). "The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools." NBER Working Paper 8498.

more highly cited, are cited by a greater number of assignees of the citing patents (are more broadly cited within the industry) and are cited by patents in a greater number of technology classes (are cited more broadly in the technology space), all within the first five years of the patents life, and before the patent was reassigned. All indicators thus suggest that defensive entities acquire more valuable patents than offensive entities do.

In order to control for observable differences among reassigned patents, we also carried out simple regression analyses. These further explore whether the characteristics of reassigned patents to PAEs and defensive aggregators systematically differ. In the regression framework, we were able to control for basic characteristics of patents and distinguish the types of NPEs involved. We thus regress the three value indicators presented in Table 2 on the types of patent reassignees. We controlled for the age of the cited patent.

The results of these regressions are presented in appendix 2 and confirm that the value of reassigned patents differ according to the type of NPEs acquiring the patents even if we control for the age of the cited patent. In summary, our empirical evidence reinforces the theoretical claim that a distinct defensive subgroup exists among NPEs and that these defensive entities are able to identify more valuable patents on the markets.

5.4 Do "catch and release" strategies exist?

One of the key predictions of the theoretical model is that defensive NPEs' ability to preempt the most valuable patents depends on their use of catch-release strategies. These strategies are not easy to confirm empirically, especially given the timing of patents' reassignment to defensive entities[14]. In order to confirm the existence of such strategies, we explore (1) if some of the patents reassigned to RPX or AST were subsequently reassigned to another entity (2) if some of the patents reassigned to RPX or AST were subsequently litigated.

Regarding the existence of subsequent reassignment, our sample suggests that 32% of patents reassigned to RPX Corporation were subsequently reassigned to another entity. However, we are not able to precisely identify, for all reassignments, if the second reassignee

[14] The majority of patents reassigned to RPX or AST were reassigned in 2009 or later.

was a member of RPX at the time of reassignment[15]. Appendix 3 presents a list of patents that were subsequently reassigned with detailed information on the timing of reassignment and the estimated status of the second assignee. The percentage of secondary reassignments seems to be much higher for AST, around 80%. However, as AST organizes itself through subsidiaries, we do not yet have comprehensive data on the history of its subsequent reassignments.

Regarding the existence of subsequent litigation, our sample suggests that out of those 100 patents that were reassigned to RPX or AST and litigated, 22 patents were part of a litigation that was filed *after* the reassignment to RPX or AST[16]. We are not yet able to identify the parties involved in these lawsuits or to confirm whether these patents were part of a litigation initiated by RPX, AST or by subsequent reassignees. However, these cases imply subsequent monetization of the patent through enforcement, which is consistent with a broad definition of the catch-and-release strategy. Note, moreover, that going to court may not be necessary in all cases before reaching a settlement. Accordingly, the number of litigated patents should be seen as a lower bound for the actual use of catch-and release.

6 Conclusion

This paper examines how defensive and offensive non-practicing entities (NPEs) operate in the patent market. We theoretically model patent auctions with practicing and non-practicing entities and find that, despite lacking information on the true exposure of potential targets, offensive NPEs are able to win patent auctions by leveraging their ability to obtain greater damages on a large number of target companies. Defensive acquisition services, in turn, perform better against offensive NPEs by aggregating private information about their members' value at stake (exposure to the auctioned patent) and using it to preempt the most valuable patents. We also find that defensive NPEs will be the most effective in the auction markets when they have a policy of full catch and release, in

[15]This analysis would need historical information on RPX's membership.
[16]11 of these patents were initially reassigned to RPX and 11 to AST.

other words, all the patents that they acquire are subsequently sold back into the IP marketplace. In fact, catch-and-release enables the defensive organization to expand the set of patents it can preempt, because it has monetization opportunities beyond the initial auction and membership fees. It is also an effective substitute for private information when the defensive NPE has a small base of clients. Moreover, the catch-and-release policy incentivizes exposed practicing entities to join the defensive entity as they are threatened by the subsequent release. As a result, defensive NPEs will win more valuable patents than do offensive NPEs.

We explore the validity of these claims with tentative analyses using patent reassignment and litigation data. Using a number of different indicators of patent value, we find that defensive and offensive NPEs have significantly different acquisition strategies. Defensive entities acquire patents that are more highly cited, cited by patents held by a larger number different companies, and cited by patents in a larger number of technology classes, within the first five years of the patent's life and even before they were reassigned to the defensive entity. These data thus suggest that patents acquired by defensive entities are significantly more valuable, and more likely to be litigated, than patents acquired by offensive NPEs (patent assertion entities). We also present preliminary evidence that defensive NPEs indeed utilize the catch-and-release policy that helps them acquire high-quality patents, and that patents previously held by defensive entities are sometimes subsequently litigated by other entities.

Our analyses attempt to highlight key features of defensive and offensive strategies in the patent marketplace by focusing on the information and bidding advantages of different types of NPEs. Our empirical analyses, however, are based on the behavior of just two defensive entities, RPX Corporation and Allied Security Trust. Only these two companies are thus far known to be purely defensive in their stated missions and actual operations. Our empirical base is thus rather limited, even though these companies are major players in the patent market. We find that these two companies indeed provide services to defend their members or clients against patent assertion entities, but also subsequently monetize their patents by selling them to their own members/clients, other practicing entities, or even patent assertion entities for further monetization and possibly litigation. Thus, what makes them "defensive" is the fact that they enable sharing of risks, costs, and information related to patent threats among the members. The defensive business model thus does not necessarily mean that patents are frozen and left "unmonetized" on the shelf. As of early 2014, AST and RPX have not engaged in significant litigation themselves, but it would not be surprising if RPX decided to do so in the future, as it is holding a large and growing portfolio of unmonetized assets. Otherwise, its limited catch-and-release of the acquired patents may prevent it from acquiring some valuable targets, and hence from providing the best defensive services.

Although our results are tentative, they provide new insights on the distinct patent acquisition strategies of defensive and offensive non-practicing entities, and how they are changing the nature of patent competition. We hope our preliminary ideas and evidence will inspire further research on this topic.

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Appendix

Appendix 1: Theoretical proofs

1.1. Truthful bidding in the patent auction

Proof. When bidding $b_i = v_i$, bidder $i \in \mathcal{B}$ wins the patent whenever $b_i \geq b_{-i} \equiv \max_{\substack{j \in \mathcal{B} \\ j \neq i}} b_j$. In this case, bidder i gets $u_i = v_i - b_{-i}$. Bidding instead $b_i > v_i$ changes the outcome only if $v_i < b_{-i} \leq b_i$, and in this case bidder i receives $u_i = v_i - b_{-i} < 0 = u_i(b_i = v_i)$. Finally, bidding instead $b_i < v_i$ changes the outcome only if $b_i \leq b_{-i} < v_i$, and in this case bidder i receives $u_i = 0 < u_i(b_i = v_i)$. Hence, in the patent auction, bidding one's true valuation, *i.e.* $b_i(v_i) = v_i \; \forall i \in \mathcal{B}$, is a weakly dominant strategy. □

1.2. Proposition 1

Proof. First note that, to satisfy (IC) for all types, one must have

$$t(\theta) = t(\theta') \quad \forall \theta, \theta' \in \Theta$$

Since damages d are strictly increasing in the degree of exposure to the patent, all types are willing to join the intermediary's set of clients whenever the lowest possible type is willing to do so. It follows that the participation constraint must bind for the lowest possible type. Hence, the intermediary sets its unique subscription fee to:

$$t^* = 0$$

yielding a negative ex ante expected payoff

$$\mathbb{E}(\Pi_I) = -\left[1 - F(\hat{\theta})\right] b_{AE} \leq 0$$

□

1.3. Proposition 2

Proof. The prior probability that the intermediary wins the patent auction is given by

$$P_I = 1 - F\left(\left[2\left(\frac{d-l}{d}\right)\int_{\underline{\theta}}^{1}\theta f(\theta)\mathrm{d}\theta + (\underline{\theta})^2\right]^{\frac{1}{2}}\right) \equiv 1 - F\left(x(\underline{\theta})\right)$$

We have that

$$\frac{\partial P_I}{\partial \underline{\theta}} = -f\left(x(\underline{\theta})\right)\frac{\partial x}{\partial \underline{\theta}}$$

Using Leibniz's rule for differentiating an integral, we get

$$\frac{\partial x}{\partial \underline{\theta}} = \frac{1}{2}\left[2\left(\frac{d-l}{d}\right)\int_{\underline{\theta}}^{1}\theta f(\theta)\mathrm{d}\theta + (\underline{\theta})^2\right]^{\frac{-1}{2}}\left[-2\frac{d-l}{d}\underline{\theta}f(\underline{\theta}) + 2\underline{\theta}\right] \geq 0$$

$$\Leftrightarrow \frac{d-l}{d}f(\underline{\theta}) \leq 1$$

Since the probability density function $f\left(x(\underline{\theta})\right)$ is always non negative, we find that

$$\frac{\partial P_I}{\partial \underline{\theta}} \leq 0 \Leftrightarrow \frac{d-l}{d}f(\underline{\theta}) \leq 1$$

which holds by Assumption 1. □

1.4. Proposition 3

Proof. In order to satisfy (IC) for any $\theta \in [\underline{\theta}, 1]$, one must have

$$t(\theta) = t(\theta') \quad \forall \theta, \theta' \in [\underline{\theta}, 1]$$

Since damages d are strictly increasing in the degree of exposure to the patent, all types are willing to join the intermediary's set of clients whenever the limit type $\underline{\theta}$ is willing to do so. It follows that the participation constraint must bind for the limit type. Hence, the intermediary sets its unique subscription fee to:

$$t(\underline{\theta}) = \mu_I\left(\underline{\theta}\right) d\underline{\theta}$$

where $\mu_I(\underline{\theta}) = P_I$. Thus, the intermediary's problem reduces to

$$\max_{\underline{\theta}\in\Theta} [1 - F(x(\underline{\theta}))] \left\{ [1 - F(\underline{\theta})]\, d\underline{\theta} - (d - l) \left(\int_{\underline{\theta}}^{1} \theta f(\theta) \mathrm{d}\theta \right) \right\}$$

The first order condition for an interior solution yields:

$$\left[1 - P_I \left(\frac{\partial P_I}{\partial \underline{\theta}} \right)^{-1} \frac{l}{d} \gamma(\underline{\theta}^*) \right] \underline{\theta}^* = \left[\frac{d-l}{d} \mathbb{E}\left(\theta | \theta \geq \underline{\theta}^*\right) - P_I \left(\frac{\partial P_I}{\partial \underline{\theta}} \right)^{-1} \right]$$

Rearranging, we get the following implicit equality

$$\underline{\theta}^* = \left\{ \frac{d-l}{d} \mathbb{E}\left(\theta | \theta \geq \underline{\theta}^*\right) - P_I \left(\frac{\partial P_I}{\partial \underline{\theta}} \right)^{-1} \right\} \left\{ 1 - P_I \left(\frac{\partial P_I}{\partial \underline{\theta}} \right)^{-1} \frac{l}{d} \gamma(\underline{\theta}^*) \right\}^{-1}$$

where $\gamma(\underline{\theta}^*)$ denotes the hazard rate, that is:

$$\gamma(\underline{\theta}^*) = \frac{f(\underline{\theta}^*)}{1 - F(\underline{\theta}^*)}$$

Hence, the optimal incentive feasible menu of subscription fees is

$$\mathcal{T}_e = \{ t_e^* = t_e^*(\theta) = P_I d \underline{\theta}^* \ \forall \theta \in \Theta_a \}$$

From (PC), it follows that types in $[\underline{\theta}^*, 1]$ become clients, and types in $[0, \underline{\theta}^*)$ remain non-clients. □

1.5. Corollary 1

Proof. The intermediary's ex ante expected profit

$$\mathbb{E}(\Pi_I^*) = [1 - F\left(x\left(\underline{\theta}^*\right)\right)] \left\{ [1 - F(\underline{\theta}^*)]\, d\underline{\theta}^* - (d - l) \int_{\underline{\theta}^*}^{1} \theta f(\theta) \mathrm{d}\theta \right\}$$

is positive if

$$\underline{\theta}^* \geq \frac{d-l}{d} \mathbb{E}\left(\theta | \theta \geq \theta^*\right)$$

From the proof of Proposition 3, we know that $\underline{\theta}^*$ is defined by

$$\underline{\theta}^* = \left\{ \frac{d-l}{d}\mathbb{E}\left(\theta|\theta \geq \underline{\theta}^*\right) - P_I \left(\frac{\partial P_I}{\partial \underline{\theta}}\right)^{-1} \right\} \left\{ 1 - P_I \left(\frac{\partial P_I}{\partial \underline{\theta}}\right)^{-1} \frac{l}{d}\gamma(\underline{\theta}^*) \right\}^{-1}$$

and we showed that

$$\frac{\partial P_I}{\partial \underline{\theta}} \leq 0 \; \forall \theta \in \Theta$$

Hence,

$$\mathbb{E}(\Pi_I^*) \geq 0 \Leftrightarrow \frac{l}{d}\gamma(\underline{\theta}^*)\mathbb{E}\left(\theta|\theta \geq \underline{\theta}^*\right) \leq 1$$

which holds for any $\underline{\theta}^* \in (0,1)$. Finally, note that if $\underline{\theta} = 0$, then $\mathbb{E}(\Pi_I) \leq 0$ from Proposition 1. Likewise, it is easy to see that if $\underline{\theta} = 1$, then $\mathbb{E}(\Pi_I) = 0$ since no type is willing to accept the intermediary's offer. Hence, $\underline{\theta}^*$ as defined by Eq. (1) maximizes the intermediary's problem. □

1.6. Lemma 1

Proof. Without market intermediation, any firm with a type $\theta \in \Theta$ gets $-d\theta$. Instead, when an intermediary intervenes in the patent acquisition process, Proposition 2 stresses that any $\theta \in [0, \underline{\theta}^*)$ remains non-client, thereby getting the same negative payoff $-d\theta$. Instead, any $\theta \in [\underline{\theta}^*, \theta^{max}]$ joins the intermediary and gets $-t(\underline{\theta}^*) - (1-P_I)d\theta$ which is greater than the status quo disutility $-d\theta \; \forall \theta \in [\underline{\theta}^*, \theta^{max}]$. □

Appendix 2: Regression Analyses

We estimate as a baseline model the following cross-sectional model:

$$reassigned\_defensive_p = \alpha_0 + \alpha_1 value_p + \alpha_3 grant\_year_p + \epsilon_p \tag{1}$$

with:

$reassigned\_defensive_p$: Dummy that equals 1 if the patent has been reassigned to a defensive aggregator, 0 if the patent has been reassigned to a PAEs

$value_p$: Indicators of value of the reassigned patent approximated by the number of citations of the citing patents, the number of different assignees/private assignees and technological classes of the citing patents

$grant\_year_p$: Set of dummies for grant years of the reassigned patent

ϵ_p =Error term

Table 3 presents the results concerning the likelihood of reassignment to a defensive aggregator.

	(1)	(2)	(3)	(4)
	Coef.	Coef.	Coef.	Coef.
	(Robust SE)	(Robust SE)	(Robust SE)	(Robust SE)
	DV= Reassigned to a defensive aggregator			
Number of forward citations	0,006*			
	(0,003)			
Number of different assignees		0,018*		
		(0,011)		
Number of different private assignees			0,009**	
			(0,004)	
Number of different technological classes				0,064***
				(0,020)
Dummy grant year_cited patent	Y	Y	Y	Y
Constant	-1.006***	-0,946***	-1.024***	-1.141***
	(0,072)	(0,089)	-0,072	(0,088)
Observations	2167	2167	2167	2167
Log likelihood	-1309.24	-1028.01	-1308.27	-1305.68

Notes: Estimation method is logit with robust standard errors. * p<.10; ** p<.05; *** p<.01

Table 3: Results on likelihood of reassignment

Results in table 3 suggest that the likelihood of being reassigned to a defensive aggregator increases with the value of the reassigned patent even if we control for the age of the cited patent. We chose not to control for the technological class of the cited patent as this variable is probably correlated with the ability of the NPEs to identify good value patents.

Appendix 3: Examples of patents reassigned to RPX Corporation

US Patent number	Initial assignor	Date of reassignment to RPX Corporation	Subsequent reassignment to:	Date of the subsequent reassignment	Estimated status of the subsequent assignee at the time of reassignment
5450085	SAXON INNOVATIONS, LLC	04/08/2010	SAMSUNG ELECTRONICS CO., LTD.	04/21/2010	Not member
5459484	INFOCUS CORPORATION	11/19/2009	SEIKO EPSON CORPORATION	11/19/2009	Member[1]
5481690	SAXON INNOVATIONS, LLC	04/08/2010	SAMSUNG ELECTRONICS CO., LTD.	04/21/2010	Not member
5793236	HUPPER ISLAND LLC	05/02/2012	HTC CORPORATION	07/18/2013	Member[2]
5828850	OAR ISLAND LLC	05/02/2012	HTC CORPORATION	08/01/2013	Member[2]

[1] Epson joined RPX on January 2009.
[2] HTC joined RPX on December 2009.