A Theory of NPEs and Patent Monetization

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This paper develops an economic model of patent monetization to understand how heterogeneity in firms and in patents determines the optimal monetization method of patents. In particular, we compare two methods of patent monetization: the practicing method, where value appropriation occurs in the product market, and the litigating method, where value appropriation occurs via threat of legal action. We show that differences in both the technological strength of the technology and the exclusionary strength of the patent lead to differences in the value that firms can appropriate from practicing and litigating monetization. Although greater technological strength monotonically increases the relative profitability of practicing compared to litigating, the effect of exclusionary strength is curvilinear: The profitability of practicing is convex in exclusionary strength, while the profitability of litigating is convex. So, the relative profitability of practicing compared to litigating is usually greatest for patents with extreme values of exclusionary strength, either very high or very low. The model provides a basic theory of non practicing entities (NPE) by explaining how firms with different monetization methods value the same patent differently and how those valuations affect their patent acquisitions.

Key words: patent monetization, value appropriation, business models, NPEs

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1. Introduction

1.1. Impact of Competing Business Models on Strategic Factor Markets

One of the most interesting strategic phenomena in the twenty-first century economy is competition between firms with different business models (Casadesus-Masanell and Zhu 2010, 2013) e.g., between Amazon and Wal-Mart, or between Craigslist and newspapers. Technologies like mobile computing and artificial intelligence have increased the frequency of disruptive innovations (Bower and Christensen 1995) that pit a conventional business model against a new upstart business model. So far, research on this phenomenon has focused primarily on how it affects competition in the product market, although it is clear that competing business models may also affect the resource market as well (Markman et al. 2009). Existing research provides few clues about how competing business models can affect the valuation of a productive resource, the identity of the firm that ultimately acquires the resource, and the amount of value the acquiring firm can both create with and appropriate from that resource.

In principle, a firm's ability to earn superior returns on acquired resources may depend upon whether the firm can use the resource to create value in a way that competitors cannot. This reality has long been recognized in market for corporate acquisitions, where "only when bidding firms enjoy private and uniquely valuable synergistic cash flows with targets, inimitable and uniquely valuable synergistic cash flows with targets, or unexpected synergistic cash flows, will acquiring a related firm result in abnormal returns for the shareholders of bidding firms" (Barney 1988). For example, "financial buyers" like private equity firms, whose business model creates value by exercising their own superior skills to improve an acquired business and then sell it within a few years, often must bid against "strategic buyers" like the business's competitors, suppliers, or distributors, who create value by keeping the business indefinitely and integrating it into their own operations in order to exploit synergies (Blomkvist and Korkeamaki 2017). A similar type of competition occurs in the market for startup equity, where independent venture capital funds play the role of the financial buyers, while corporate venture capital funds play the role of the strategic buyers (Dushnitsky and Shaver 2009). Indeed, even among strategic buyers, there can be stark differences in the types of synergies that different acquirers seek to obtain. For example, in 1999, Comcast and AT&T engaged in a bidding war for cable television operator MediaOne, with very different synergies in mind. Comcast sought MediaOne as a horizontal merger in order to broaden its geographic scope and thereby increase scale economies in its existing business model, while AT&T sought to create a new business model by vertically integrating with MediaOne in order to reestablish the "last mile" connection that it had lost in the 1982 forced divestiture of its regional operating companies.[1] Even resources as mundane as product inventory may be valued differently by firms, if they obtain different synergies by monetizing that inventory in different ways, such as sales, rentals, leases, or subscriptions. For example, movie DVDs may be valued differently by RedBox, Netflix, and Walmart, since their business models monetize them differently.[2]

1.2. Business Models and Patent Monetization Methods

Patents are another type of resource where firms with different business models may seek to obtain different synergies, according to each firm's capabilities and appropriation/monetization strategy (Steensma et al. 2016, Hsu and Ziedonis 2013). Most research on the market for technology views external acquisition of patents as a substitute for firms' internal development of technologies (Arora and Gambardella 2010, Arora and Nandkumar 2012). Following this logic, the value of the patent, represented in licensing, self-commercializing, or other commercialization methods, primarily depends on the technological strength of the patent (Arora and Gambardella 1994, 2010, Marx and Hsu 2015) and its resulting value as a signal of quality to external stakeholders (Hsu and Ziedonis 2013).

This conventional use of a patent for competitive advantage not only requires that the firm must implement the patent's technology to increase its own economic value creation, but also that it must prevent competitors from doing so as well (Capron and Chatain 2008). So, an important purpose of acquiring patents can be to prevent rivals from using the technology (Bessen and Maskin 2009). Firms that monetize patents in this conventional way are often called "practicing entities" (PEs).

However, a firm can also monetize patents in other ways that do not require it to implement the technology, or even to compete in the product market at all. In particular, "non-practicing entities" (NPEs) or "patent assertion entities" (PAEs), often labeled derisively as "patent trolls" in public policy discourse, represent a relatively new business model (Steensma et al. 2016) that monetize patents purely through litigation, with no intention of either entering the product market themselves or using their patents as a quality signal (Cohen et al. 2016).

So far, research on NPE's has focused on their predatory methods (Cohen et al. Forthcoming), and their implications for public welfare and intellectual property policy (Appel et al. Forthcoming). Little if any research has studied the factor-market competition between PEs and NPEs as they both seek to acquire patents. Consequently, many questions remain unanswered, such as: How does the competition between PE and NPE business models affect the market valuation of patents? How much value can be appropriated from a patent by either PEs or NPEs? What factors determine the amount of value that PEs or NPEs can appropriate from a patent? Under what conditions would one expect NPEs to outbid PEs for a patent, and vice versa?

These questions have economic, strategic, and public policy implications: From an economic perspective, answering them may illuminate how markets for technology work, including how PEs and NPEs differ in the types of patents they buy and sell, and the conditions under which NPEs may acquire patents from PEs, or vice versa. From a strategic perspective, answering these questions may illuminate how strategic factor market competition differs when rival firms pursue different business models. From a public policy perspective, these questions may help to craft precisely targeted policies that would be most effective at reducing the incentive for NPEs to acquire patents in the first place by focusing on the particular types of patents that are most vulnerable to predatory exploitation.

1.3. Technological Versus Exclusionary Strength and Relative Valuation by PEs and NPEs

As a starting point on the path toward answering these questions, this study develops a formal model to analyze the practicing (PE) and the litigating (NPE) methods for patent monetization, comparing the value that each of these methods can capture from a patent with a given set of characteristics. Although patents vary on many characteristics, our model focuses especially on two important ones namely, their technological strength for creating value, and their exclusionary strength for appropriating value. While the value that a PE derives from a patent depends upon both of these characteristics, the value that a NPE derives from it depends only on its exclusionary strength. After all, the NPE does not actually use the patent's technology, so the technology's strength matters little, if at all, to the NPE's valuation of the patent. Hence, it has been observed that NPEs tend to buy lower quality "junk patents" with negligible technological value but high litigation value (Choi and Gerlach 2018, Lemus and Temnyalov 2017, Cohen et al. 2016). Thus, it seems obvious that a PE's valuation for a patent would exceed a NPE's valuation when the patent's technological strength is sufficiently high, while a NPE's valuation would exceed a PE's when the patent's technological strength is sufficiently low. So, between these two extremes, there must be some intermediate "boundary" level of technological strength at which PE's and NPE's would value the patent equally.

What is less obvious, however, is the role of exclusionary strength: How does a patent's exclusionary strength affect its relative valuation by PEs versus NPEs? How do exclusionary strength and technological strength interact to jointly affect a patent's valuation by PEs and NPEs? Does a patent's exclusionary strength affect the "boundary" level of technological strength where PEs and NPEs share the same valuation of the patent? If so, how? To answer these questions, our model starts with the observation that, although greater exclusionary strength increases a patent's value to both PEs and NPEs, it increases at an increasing rate for PEs (i.e., convex) but increases at a decreasing rate for NPEs (i.e., concave). Why this difference? Increasing a PE's ability to exclude competitors from using its patented technology will generally increase both its margin and its market share, and since profit is, roughly speaking, market size multiplied by both margin and market share, exclusionary strength must have a quadratic effect on a PE's profit i.e., increasing marginal returns to exclusion. By contrast, a NPE experiences diminishing marginal returns to exclusionary strength because potential defendants differ in how profitable they are for the NPE to pursue: Some defendants are easier to find, or are easier to prove an infringement case against, or have less motivation or less ability to defend themselves against the infringement claim. So, potential defendants differ in terms of the expected return that a NPE can obtain on its investment in pursuing an infringement case. Naturally, a profit-maximizing NPE would prefer to pursue the "lowest-hanging fruit" first i.e., the defendant from whom they can get the highest expected return. After that, the NPE would pursue the defendant with the second highest expected return, and then the third highest, and so on prioritizing defendants in decreasing order of expected return, until the costs of litigating against the next defendant outweigh the expected benefits. Thus, as exclusionary strength rises, the marginal defendant becomes successively less profitable for the NPE to pursue. This difference between PEs and NPEs with the former having increasing marginal returns to exclusionary strength and the latter having decreasing marginal returns implies that exclusionary strength can have a convex curvilinear effect on the "boundary" level of technological strength where PEs and NPEs share the same valuation of the patent. Depending upon the exact location of this curvilinear boundary and the particular level of technological strength, the model finds that a variety of different scenarios are possible for the main effect of a patent's exclusionary strength on its relative valuation to PEs versus NPEs. We analyze these scenarios and examine the conditions under which each scenario applies.

Finally, we also use our model to analyze one particularly notorious practice of certain NPEs namely, litigation against firms that are merely end users of infringing products, rather than against the producers of those products (Bernstein 2016). NPEs may see end-user firms as more attractive targets than producers of infringing products, for two reasons: First, they may have little resources to mount a legal defense, which can cost millions of dollars in terms of attorney fees, court costs, and diverted attention of managers. Second, end users have less incentive to defend a product in court than its actual producer would have. To capture this phenomenon, we extend the baseline model to include end users who do not compete in the product market as a second category of litigation targets.

The paper proceeds as follows: We first discuss how the monetization methods of NPEs differ from those of other parties in the patent market. Then we present a model of how monetization method affects a patent's valuation. Next, we derive conditions under which each method yields a higher valuation and use comparative statics to study the effects of various parameters. Finally, we discuss the model's empirical implications, and the last section concludes.

2. Alternative Monetization of Patents: PEs, NPEs, and Defensive Aggregators

2.1. NPEs Versus PEs

A firm that owns patented technologies can affect market outcomes via two mechanisms creating value and capturing value. On one hand, by practicing these technologies, it can create value for the economy, and thereby enhance societal welfare. On the other hand, by excluding others from practicing these technologies (or threatening to do so), it can capture value from the economy in a monopolistic way, and thereby diminish societal welfare. So, the institutions of patenting represent an inherent societal compromise between these two effects. The underlying public policy premise of allowing patents in the first place is that, in aggregate and over the long term, their welfare-enhancing effects outweigh their welfare-diminishing effects, because the opportunity to patent provides an incentive for innovators and thereby increases their motivation to innovate. However, this entire premise is predicated on the assumption that the patent's owner is a practicing entity (PE) that both creates value by innovating and then practicing a new technology and captures a substantial part of that value by temporarily monopolizing the practicing of that technology until the patent expires, so that the exclusionary value capture incentivizes the innovative value creation. This compromise between society and the patent holder only makes sense if value is created by practicing the technology. Otherwise, it may be no compromise at all.

By contrast, non-practicing entities (NPEs) monetize only the exclusionary value of patents, not their practicing value. Rather than producing their own products or services or innovating new technologies themselves, NPEs appropriate value from their patents by litigating against defendants who might be perceived as infringing, by licensing to such defendants or to others, or sometimes by arbitraging the patent market (Choi and Gerlach 2018). Due to their exclusive focus on monopolistic value capture without any counterbalancing value creation, the growing activity of NPEs is controversial (Cohen et al. 2016), and might be interpreted as contrary to the social compact underlying the institution of patents. This activity has been shown to hurt innovation and innovative firms' performance (Abrams et al. 2017, Smeets 2014). Even when courts dismiss NPE-initiated lawsuits as frivolous, defendants must expend substantial resources for their defense. Many defendants find it cheaper and easier to settle such lawsuits, even if they are frivolous, than to fight them. These settlements often require defendants to sign nondisclosure and non-disparagement agreements, which makes it difficult for defendants to help each other or to reveal information that might be useful to future defendants. While large firms may have the financial and human resource to defend against NPE lawsuits, small and mid-size firms, which constitute more than half of the defendants of such lawsuits, suffer more due to their limited capital and personnel, as well as reduced external support from venture capitalists or other investors as a result of increased uncertainty about the startup's future performance (Chien 2013, Kiebzak et al. 2016). In general, NPE activities have negative effects on innovation (Tucker 2014b, Penin 2012), entrepreneurial activities (Tucker 2014a, Kiebzak et al. 2016), venture capital investment, and small business employment (Appel et al. Forthcoming). Indeed, the impact of NPEs on small businesses has been poignantly publicized by Austin Meyer's popular and humorous documentary film "The Patent Scam."

In addition to affecting innovation and firm performance, NPEs also disrupt to the market for technology, of which a substantial part is the patent market since patents are relatively clearly defined and have high transferability. NPEs, as firms that specialize in patent monetization that lie between invention and commercialization, claim to help inventors overcome the difficulty of identifying and reaching other potential buyers of their technologies (Luo 2014). However, research indicates that, rather than brokering such transactions, NPEs usually accumulate large portfolios of patents which they select patents not based on their technological value, but on their easiness to assert in court. Thus, NPEs often acquire patents that are in dense technology fields and have wide scope(Fischer and Henkel 2012), issued by lenient examiners (Feng and Jaravel 2017), not critical to a firm's business, and are more litigation-prone (Abrams et al. 2017). Such findings suggest that NPEs buy "low quality" patents with negligible commercial value but high litigation value (Choi and Gerlach 2018, Lemus and Temnyalov 2017, Cohen et al. 2016). When NPEs' acquire patents, it worth noticing that NPEs often create numerous affiliated entities for patent acquisition and patent holding, perhaps in order to hide the identities of the individuals responsible for initiating litigation or to shield themselves from counter-suits. For example, Intellectual Ventures, one of the world's largest NPEs, tops the list with several hundreds of affiliated entities.

As an important caveat to provide a balanced view, none of this discussion should be interpreted to mean that only NPEs use patents in a predatory way, or to mean that no PE ever engages in such predatory behavior. In fact, recent research by Cunningham et al. (2018) indicates that PEs may sometimes acquire patents in order to preclude research that could threaten their business interests (see Capron and Chatain (2008) for a more general theory about this type of strategy). More generally, there is evidence that, due to monopolistic behaviors by PEs, patents may sometimes do more harm than good (Posner 1975, Gilbert and Shapiro 1990) including detrimental effects on innovation (Williams 2013) even in the absence of NPEs.

NPEs have attracted research in fields of law and economics (Hovenkamp 2013, Chien 2013, Cohen et al. 2016), such as the Federal Trade Commission (FTC) survey on PAEs and their practices (Federal Trade Commission 2016). But in strategy, it is yet to be explored how their patent monetization affect the patent market and patent strategies of firms. Extant studies have primarily focused on firms that appropriate value of patents from product market profit (Gans and Stern 2003, Marx et al. 2014, Marx and Hsu 2015, Gans and Persson 2013) rather than through litigating (Cotropia 2008).

2.2. NPEs Versus Other Non-Practicing Patent Holders

In this section, we contrast NPEs from other types of organizations that hold patents without practicing them to profit in the product market. For example, although universities may also litigate infringements of their patents, they do not qualify as true NPEs for several reasons: First, universities innovate the technologies that they patent, while NPEs simply buy patents without undertaking any innovative activity. Second, litigation is not the main way that universities monetize their technology. Instead, the monetization of university-developed technology is more indirect: A university's technology is primarily a tool to boost its research reputation, which enables it to attract more and better students who then pay more tuition, as well as more and better faculty who then are awarded larger research grants from foundations and agencies.

Recently, a new category of patent intermediaries, known as "defensive aggregators" (Hagiu and Yoffie 2013) have emerged in response to NPEs.[3] Like NPEs, they acquire patents rather than developing any technologies themselves, but they do so for the opposite reason. Defensive aggregators buy patents from any party as long as the patent is potentially problematic,[4] and license them to subscribers seeking protection from litigation and harassment by NPEs. Defensive aggregators' revenue comes from licensing fees, subscription fees, litigation insurance, and other business intelligence service fees of their customers. One of the most prominent and famous defensive aggregators is RPX, whose clients include Cisco, IBM, Intel, and Microsoft. Defensive aggregators often acquire and own a large number of patents, but unlike NPEs, their patent acquisitions are defensive, and they do not rely on litigation or the threat of litigation to appropriate value from their patents.[5] The pricing of the services, will depend on both the technological value and the exclusionary value of patents. Naturally, defensive aggregators often distance themselves from NPE's and the derogatory "NPE" label.[6] For example, RPX calls the business model of NPEs is "wasteful and dangerous."[7]

Despite this stigma, positive views of NPEs do exist. For example, Sabattini (2015) defines the NPE business model as a firm "that does not commercialize any product or service, but *fosters innovation* by monetizing intellectual property rights (IPRs) through licensing and technology transfer." Some researchers argue that NPEs are just a type of patent intermediaries (Haber and Werfel 2016) that can improve efficiency in the patent market (Steensma et al. 2016), and that can increase competition, lower downstream prices, enhance consumer choice, and benefit innovation (Geradin et al. 2012). Likewise, Lemus and Temnyalov (2017) theorize that the patent privateering activities reduce the surplus of producing firms, but are in general beneficial to R & D activities.

In this paper, we use the term "NPE" to refer only to offensive patent aggregators who rely on litigation in their business models, and adopt the definition of NPEs as in Hagiu and Yoffie (2013). We are agnostic with respect to the social welfare impact or morality of NPEs and their activities. Rather than making such value judgments, we simply approach the NPE phenomenon from a purely strategic perspective in order to study the conditions under which NPE-style litigation maximizes a patent's value. Accordingly, we present a model that enables us to compare how the valuation of a patent differs according to whether it is monetized via practicing or via litigating.

3. The Model Setup

In the simple model presented below, we discuss the practicing and litigating monetization of patents, with implications for the value of a patent to both PEs and NPEs. Although this model certainly does not capture every detail of the phenomena, it provides a basic broad-brush tool to analyze how the different monetization methods of NPEs and PEs lead to their different valuation of patents, and hence to patent ownership patterns.

3.1. Patent and Firm Heterogeneity

Patents, by definition, consist of a novel, useful, non-obvious invention and the right to exclude others from using the invention (Lemley and Shapiro 2005). Based on this notion, we distinguish two dimensions on which patents can differ their technological strength for creating value, and their exclusionary strength for capturing value. Let us consider each of these dimensions in turn.

In terms of a patent's technological strength for creating value, it is generally understood that value creation can come either in the form of increasing a customer's willingness to pay for a product (i.e., product differentiation) or in the form of decreasing a firm's cost to provide that product (i.e., efficiency) or some combination of these two (Brandenburger and Stuart 1996), and that both forms have similar effects on competitive outcomes (except for a few unusual circumstances, e.g., Schmidt et al. (2016)). For simplicity, we treat a patent's technological strength $v > 0$ as simply the magnitude of cost reduction that the patented technology can provide to firms competing in the product market. Specifically, we treat this as a reduction to the marginal cost of each unit produced, and we leave other possible ways that the technology might create value for future research.

In addition to differing in their technological strength, patents also differ in the exclusionary strength of their right to stop or prevent others from using the technology. Given a set of potential users, a patent with the greatest possible exclusionary strength can prevent all unauthorized users from practicing the technology, while a patent with the least possible exclusionary strength can prevent nobody from practicing the technology. Much research has viewed the exclusionary strength of patents as driven by the institutional and legal environment's "appropriability regime" (Teece 1986, Cohen et al. 2000, Arora and Ceccagnoli 2006, Lerner 2002), a factor that presumably would equally protect all patented technologies from all unauthorized users. By contrast, we assume that a patent's ability to prevent unauthorized use of its technology depends not only on the appropriability regime, but also on characteristics of both the user and the patent itself. For example, some firms may have the right set of technical, financial, and/or legal capabilities either to conceal their unauthorized use of the patented technology, or to circumvent the patent by "inventing around" it in order to practice the technology without technically infringing it (Mansfield 1985, Ziedonis 2004, Lieberman and Montgomery 1998), or to prevent or invalidate an infringement claim. Likewise, even with the same technology, patents can be written in drastically different ways that may differ in related technological classes, and in the number, phrasing, breadth, and precision of claims. Other patent-specific factors may also undermine the legal enforceability of a patent, such as obviousness of the technology, ambiguity about who invented the technology, anticipation of the technology by others, indefiniteness of the patent's language, insufficient disclosure of the technology to enable its replication by others, concealment of other relevant information in the patent application process, or inequitable conduct by the patent's owner. So, let $x \in [0, 1)$ represent the exclusionary strength of a patent, representing the scope of exclusion, and measured as the proportion of potential users that the patent can actually prevent from using the technology. The remaining proportion of users, $(1 - x)$, are assumed to be immune from any infringement claims, perhaps due to concealment of their activities, or circumventing the patent by "inventing around" it, or some legal weakness in the patent itself, or some other reason.

Firms in our theory are categorized into two types: Practicing Entities (or practicing firms, PEs) and Non-Practicing Entities (NPEs). PEs and NPEs differ in their value appropriation mechanism from a patent in that a PE's monetization of the patent will only be adopting the technology and use in the production of a product (or service), while an NPE's monetization of the patent will only be asserting patent rights against the PEs in the market and being paid by PEs through settlement fees or awarded court damages. Acknowledgedly, firms in reality may adopt dual value appropriation mechanisms, but we study representative pure PEs and NPEs shed more light on the mechanisms. There are several important implications from the distinctions of PEs and NPEs. At first, the innovativeness of a patent has little to do with the NPEs' value appropriation, since it rely primarily on the exclusivity of the patent to assert patent rights. However, for PEs who practice the patent, obviously the innovativeness of a patent matter as the invention directly affect product market profit, the degree of exclusivity also matters, not for the potentiality to profit from litigating, but from the right to exclude other competitors in the product market to restrain rivalry and obtain economic rent (Makadok 2010). In addition, we introduce another dimension of heterogeneity among PEs in that each firm have different capability in using the invention. Some firms may be more technologically capable so that they may find ways to invent around, using the technology but not infringe the patented invention, but some other firms may be less capable so that the only way to use the technology is to obtain the right such as acquiring the patent. Firms differ in their capability to appropriate from patents (Reitzig and Puranam 2009), and also in their capability to avoid being appropriated by other patent owners.

Thus, we write the value of a patent from litigating monetization as $\Pi^l(x)$ and the value from practicing monetization as $\Pi^p(x, v)$.

3.2. Decisions

We characterize decisions of firms in a game that proceeds as follows:

1. The technology is invented and patented by an independent inventor who lacks the capability to monetize it in any way neither through practicing nor through litigating. We treat all expenses that the inventor paid in order to be granted the patent in the first place (e.g., research costs, legal costs) as sunk costs and therefore irrelevant to our analysis.

2. The inventor offers the patent for sale, both to a set of NPEs and also to the n PEs in the industry where the patent can create value.
3. However, the patent may not actually be sold, even at a price of zero, because any firm that obtains the patent from the inventor will subsequently have to pay some additional costs in order to maintain the patent. This additional investment may include not only periodic fees for patent maintenance or renewal, but also the possibility of filing for patent extensions, or the possibility of being required to defend the validity of the patent in court if it gets challenged. If the expected value of these patent maintenance costs exceed the expected value that a firm can appropriate from the patent, then that firm's expected net valuation for the patent is negative, in which case that firm will not purchase the patent. If no firm purchases it, then the patent is deemed as dormant and remains the property of the inventor. In this case, all n PE firms will use the technology freely, given how little litigating capability the inventor has. Thus, the patent may not actually be sold, even if its price were zero.
4. We make no particular assumption about the market mechanism by which the patent is offered for sale, nor any particular assumption about the selling price of the patent. We assume only that the patent is sold to whichever type of firm – either PE or NPE – has the highest expected net valuation for it, where a firm's expected net valuation is the difference between the expected amount of value that it will appropriate from the patent and the expected costs that it will pay to maintain the patent.
5. If a PE acquires the patent, then $(1-x)n$ competing PEs have strong enough technical and/or legal capabilities to use the technology without risk of being sued for infringing the patent (e.g., by concealing their activity, "inventing around" the patent, or exploiting some legal weakness in the patent). Only the remaining xn competing PE firms will actually be excluded from using the technology. The patent-owning PE's profit from practicing monetization realized with this partial exclusion is designated as Π^p.
6. If the NPE decides to acquire, it can assert patent rights against multiple PEs. For a given PE j, the NPE will demand a settlement fee S_j, which is determined by the NPE's legal cost L^N, the PE's legal cost L_j, the expectation of winning chance at court (θ_j), and damage awarded (D_j).
7. The threatened PE chooses whether to settle with the NPE or go to court based on the demanded settlement fee (S_j), the NPE's probability of winning (θ_j) and damages awarded by the court (D_j). With the patent being litigated, the NPE realizes profit from litigating monetization Π^l.
8. If PE j chooses to go to court, then depending on whether the case is baseless, the court will decide the case to be a normal case or an exceptional case. If it is a normal case, the NPE

has a positive chance of θ_j of winning and each party is responsible for its own legal fee. But if the case is baseless thus ruled to be exceptional, not only will the NPE lose because $\theta_j = 0$, but the NPE must also reimburse the prevailing PE's legal fee L_j.

We describe the subgame of an NPE threatening a PE in the following game tree, payoffs are written in the order of (V^{NPE}, V^{PE}):

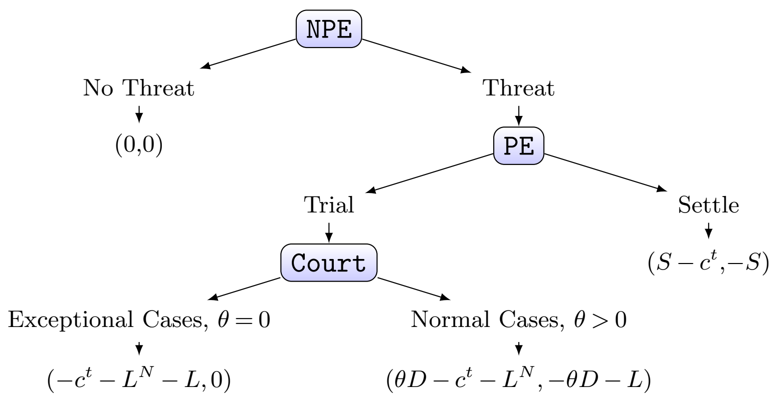


Figure 1 The Litigating Game Tree

Note: The payoff pairs are in the order of (V^{NPE}, V^{PE}).

4. Value Appropriation Mechanisms

With the above setup regarding firm and patent heterogeneity and decisions made by firms, below we discuss different value appropriation mechanisms and how the heterogeneity in the valuation of resources emerges endogenously among firms that differ in their use of resources (Chatain 2014, Schmidt and Keil 2013, Adegbesan 2009).

4.1. Practicing Monetization

4.1.1. Product Market Demand There are n firms competing in the product market with substitutable products and assume that all these firms are potential users of the technology. Let q_i, q_{-i} be the quantity of firm i and all other firms respectively, and define $Q \equiv q_i + q_{-i} \equiv \sum_{i=1}^{N} q_i$. For a firm i, its marginal cost of production is c_i and the price of the product it produces is p_i, and. Then we follow a standard linear demand structure as employed by Singh and Vives (1984) and Zanchettin (2006), and yield the industry's inverse demand function: $p = A - BQ$, where $A, B > 0$.[8]

4.1.2. Baseline Case for Product Market Competition We normalize $B = 1$ and use the special case of Cournot quantity competition (Cournot 1838) with different firms having the same marginal cost, $c_i = c < 1$ and $p_i = p$, $\forall i$. This yields the demand function for one firm: $p = A - q_i - \sum_{j \neq i} q_j = A - Q$. Each firm chooses quantity that maximizes its profit $\pi_i = q_i(p(q_i) - c)$. Then the best response function is given by: $q_i = \frac{1}{2}(A - \sum_{j \neq i} q_j - c)$. Then, summing all i firms' best response functions yields: $2Q = n - (n-1)Q - nc$. Solving for Q and substituting it to the demand function, we obtain the quantity and the equilibrium price are: $Q = \frac{n}{n+1}(A-c)$ and $p = \frac{A}{n+1} + \frac{n}{n+1}c$. Then the output and profit for each firm are:$q_i^* = \frac{A-c}{n+1}$ and $\pi_i^C = \frac{(A-c)^2}{(n+1)^2}$.

In this setting, we can see that all PE firms will earn the same profit so that all firms are active in the industry. If one of the active PE firms possesses the patent, we assume that the PE firm only seeks for profit gain from the product market by using the technology itself to achieve cost reduction, and by acting to block other PE firms from using the technology (Bessen and Maskin 2009, Capron and Chatain 2008). Although PEs can choose practicing while simultaneously licensing the technology to other players (Arora and Fosfuri 2003), we argue that the value from practicing exemplifies the technological strength of the patent, and the value from licensing exemplifies the exclusionary value of the patent. After all, if the patent has no exclusionary strength, then other firms could simply use the technology with impunity and would therefore have no reason to pay to license the patent at all. So, our model still captures these two parts of patents' value.

4.1.3. Strength of PEs and Patents' Imperfect Exclusion Assume that the patented technology can bring a net cost reduction of $v \in (0, c)$ to a practicing firm, which we designate the patent's technological strength. In order to preserve the right to exclude others from using the patented technology, the patent's owner must pay a fixed cost C^p required to maintain the patent. However, patents neither grant perfectly effective protection of the technology nor guarantee the exclusive use of the technology (Cohen et al. 2000). In fact, some firms will be able to imitate or use the technology during the patent period by "inventing around" the patent to avoid infringement (Gallini 1992, Mansfield 1985). Especially with the publication of the technology in the application, the granted patent, or elsewhere, other firms are likely to engage in such imitation if they are capable and find it profitable (Horstmann et al. 1985). So, some firms, other than the patent-owning firm, may also exploit the patented technology with impunity. Of course, firms differ in their capability to exploit the technology while avoiding infringement. Firms with deeper technical and/or legal resources are better able to create solutions (Ziedonis 2004) that bypass the patent and thereby use the patented technology without infringing the patent (Agarwal et al. 2009).

Assume that we can rank all PE firms from the weakest to the strongest according to their capability to bypass and "invent around" the patent. With a patent of exclusivity x, a share of $x \in [0, 1)$ PE firms that are weaker in their capability to bypass and "invent around" are not able to disregard the patent and freely use the technology. We refer to those PE firms as Weak User PE firms. However, the rest $(1-x)n$ firms, knowing the existence of patent as well as the technology, can figure out a way to use the patented technology while still preventing any infringement accusation. We refer to those PE firms as Capable User PE firms. Thus, the sets of Weak and Capable users differ across patents and each patent's x captures its specific exclusionary value (Ordover 1991). If a patent has a high x, i.e., a high exclusionary strength, then even firms with strong capabilities and deep pockets cannot bypass the patent and use the technology without risking an infringement claim. On the other hand, if a patent has a low x, i.e, a low exclusionary strength, perhaps because it was badly written or perhaps because it is difficult to enforce for other reasons (e.g., obviousness, ambiguous inventorship, anticipation by others, indefiniteness, insufficient disclosure, concealment, or inequitable conduct), then even weak firms can bypass it with impunity.

When a firm practices the patent and excludes xn rival firms from using the technology, thus making those excluded firms disadvantaged in the market, [9] the patent-owning firm's profit under Cournot quantity competition is: [10]

$$\tilde{\pi}_i^C = \left(\frac{A-c+(nx+1)v}{n+1}\right)^2 - C^p \tag{1}$$

On the one hand, when the patent is extremely strong so that all other firms, no matter how capable, cannot use the technology without infringing the patent, and only the patent-owning firm use the patented cost-reducing technology, $x = \frac{n-1}{n}$, the profit of the patent-owning PE firm will be the maximal: $\bar{\pi}_i^C = \left(\frac{A-c+nv}{n+1}\right)^2 - C^p$. On the other hand, in the situation where the patent has minimal power protecting the technology such that all firms can use the technology while avoiding the patent, the profit of the patent-owning firm will be: $\underline{\pi}_i^C = \left(\frac{A-c+v}{n+1}\right)^2 - C^p$.

Let Π_i^p be the profit gain of Firm i from practicing the patented technology. For a Weak User PE firm, it will not be able to use the technology without acquiring the right to use, so the value of the patent to such a PE firm will be the difference between $\tilde{\pi}_i^C$ (the profit with patent protection) and π_i^C (the profit without practicing the patented technology):

$$\tilde{\Pi}_i^{pW} = \tilde{\pi}_i^C - \pi_i^C = \frac{(nx+1)^2v^2 + 2(nx+1)(A-c)v}{(n+1)^2} - C^p \tag{2}$$

However, for a Capable User, since it can invent around and will use the technology even without acquiring the right and paying the fixed cost C^p, the value of the patent purely comes in the exclusion of other PEs. Thus, the value of the patent lies in the profit gain between the situation that the Capable User pays no cost to the patent but that every other firm also uses the technology, and the situation where the Capable User obtain $\tilde{\pi}_i^C$. Therefore, for such Capable PE firms:

$$\tilde{\Pi}_i^{pC} = \tilde{\pi}_i^C - (\underline{\pi}_i^C + C^p) = \frac{(n^2x^2 + 2nx)v^2 + 2nx(A-c)v}{(n+1)^2} - C^p \tag{3}$$

Comparing the payoff of the Weak User to that of the Capable User, the difference is the pure benefits brought by the technology: $\Pi_i^t = \Pi_i^{pW} - \Pi_i^{pC} = \frac{v^2+2(A-c)v}{(n+1)^2}$. As we can see, the technological benefit satisfies $\frac{\partial \Pi_i^t}{\partial v} > 0$ and $\frac{\partial^2 \Pi_i^t}{\partial v^2} > 0$.

Up to this point, we have assumed that the patented technology reduces PEs' per unit cost by v, without affecting customers' willingness-to-pay (WTP), but the situation for WTP-enhancing inventions is similar. The difference is that, instead of reducing a PE firm's marginal cost from c to $c-v$, which imposes the constraint that $v<c$ for all firm i, a WTP-enhancing innovation will increase A in consumers' utility function such that A will become $A+\Delta A$. Therefore, the demand function of firms that adopt the innovation will be different from that of firms that do not adopt the innovation. But, ΔA enters the profit function π_i in the same fashion as v. Thus, the discussion above should still hold for WTP-enhancing innovations with a simple replacement of v by $-\Delta A$.

Now that we incorporate both cost-reducing and WTP-enhencing inventions, we can expand v's domain to $v \in (-\infty, c)$. Without loss of generality, further simplifying by normalizing c to zero, the profit gain from practicing a patent for a Weak User and a Capable User are:

$$\Pi_i^{pW} = \frac{(nx+1)^2v^2 + 2A(nx+1)v}{(n+1)^2} - C^p \quad (4) \qquad \Pi_i^{pC} = \frac{(n^2x^2+2nx)v^2 + 2Anxv}{(n+1)^2} - C^p \quad (5)$$

For both Weak and Capable PE firms, defining the exclusivity x as the proportion of product market rivals that a patent can exclude, and the innovativeness v as the relative magnitude of cost reduction (or WTP enhancement), we propose that:

Proposition 1 *As either a patent's exclusivity x or its technological strength v increases, the profit from practicing the patent increases at an increasing rate. In other words, the profit from practicing a patent is both upward-sloping and convex in both x and v.* [11]

Although the rationale for the upward slope in this proposition may be intuitively obvious, the convexity rationale might not seem so intuitive, but can be understood as follows: Increasing either a patent's technological strength or its exclusivity increases the magnitude of the patent holder's competitive advantage in the product market. In most market structures, [12] the optimal way for a firm to exploit such a competitive advantage is by increasing both its margin and its output together, rather than increasing only one individually. Since profit is, roughly speaking, the product of margin and output, the multiplication of the margin and output effects yields a quadratic i.e., convex combined effect on profit. This convexity is indicated by the positive coefficients on the quadratic terms (v^2 and x^2) in Eq. 4 and Eq. 5.

Due to the fixed cost C^p needed to practice the patented technology, there is a minimum requirement on x to make practicing profitable enough to cover the fixed investment. Let x^p be the requirement for profitable practicing monetization in that $x^p = \min\{x|\Pi^p(x) \geq 0\}$. In addition, profitable practicing monetization also requires a sufficiently low fixed cost C^p, a sufficiently valuable technology (v), and a sufficiently small number of firms competing to share the product market profit (n). So, we propose that:

Corollary 1 *When $C^p < v^2 + \frac{2Av}{n+1}$, there exists a unique $x^p \in [0, 1)$ such that when $x \geq x^p$, $\Pi^p(x) \geq 0$, and x^p has below properties:*

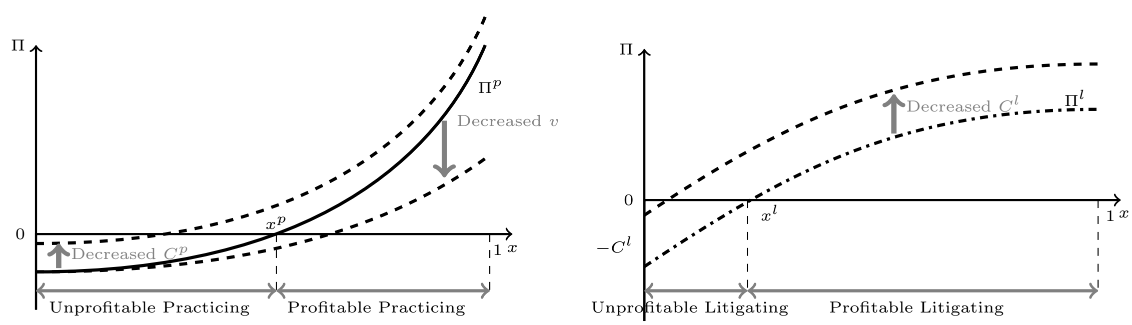
(a) The more innovative the patent is (the higher the v), the lower the exclusivity requirement (lower x^p) for profitable practicing.

(b) The more difficult implementing the patent (the higher the C^p), the higher the exclusivity requirement (higher x^p) for profitable practicing.

(c) The more firms in the industry (the higher the n), the lower the exclusivity requirement (x^p) for profitable practicing.

The corollary above informs us that, when a patent can only reach a low exclusivity and has a low x, the imitation problem from other PEs is severe, which reduces a firm's incentive to practice the patent (Polidoro and Toh 2011). The requirement of minimal exclusivity x^p, however, depends on the innovativeness of the technology itself, and also the cost to implement the patented technology.

Figure 2a plots the relationship between Π^p and x, with dotted lines showing effects of changes in the fixed cost (C^p) and the innovativeness of the patent (v).



(a) Practicing Monetization (b) Litigating Monetization

Figure 2 Values from Practicing and Litigating monetization in x

Note: The x-axis is exclusivity x, the y-axis is value Π. The Blue line is Π^p and the Orange line is Π^l. Regions of profitable and unprofitable monetization are marked below each graph.

4.2. Litigating Monetization

Unlike the practicing profit that comes from the product market, the litigating monetization represents the scenario that a typical NPE can make a profit by threatening legal action against PEs demanding monetary payment in exchange for dropping this threat. After some initial communication and a hearing of initial evidence by the court, if the target PE firm still does not pay, the NPE would proceed with a patent infringement litigation against the firm. [13]

After receiving an initial demand letter asking for a payment of S, the defendant PE's payoff to settle is $-S$. But if the PE choose to go to court, there are two cases. If the case is viewed by the court as normal, the payoff of the defendant to fight at court is $-(\theta_j D_j + L_j)$, where L_j is the defendant firm's legal cost, θ_j is the focal defendant PE firm's probability of losing to the plaintiff, and D_j is the damage the court would order to be paid if it rules in favor of the plaintiff. For the plaintiff NPE, its payoff for taking a normal case to court is $\theta_j D_j - c^t - L^N$, where c^t is the NPE's variable cost to threaten one target, and L^N is the NPE's legal cost to pursue the trial. In the normal case, both party pay their own legal fee.[14] However, if the court rules the case to be exceptional, the losing party must pay for the prevailing party's reasonable legal fee, in which case the payoffs would be 0 for the defendant and $-(c^t + L^N + L_j)$ for the plaintiff. [15] To qualify as an exceptional case, the court must find the lawsuit to be both baseless and filed in bad faith.

We assume that if the defendant is a Capable User e.g., it invented around the patent and used a substitute technology in order to avoid infringing the focal patent its probability of losing to a plaintiff is $\theta_j = 0$ and the case will be regarded as exceptional. Therefore, in cases against a Capable User, not only will the NPE plaintiff have no chance of winning, but will also have to pay the defendant its legal fee, resulting in a negative payoff of $-(L_j + L^N + c^t)$. Thus, an NPE will never take a Capable User to court, and would not even bother paying to threaten a Capable User with a demand letter, because the threat would not be credible. So, a NPE will only target Weak Users. Letting the weak PE and the NPE engage in a Nash Bargaining, the equilibrium settlement fee S will be solved from:

$$\max\{(S - c^t - (\theta_j D_j - c^t - L^N))(-S - (-\theta_j D_j - L_j))\} \tag{6}$$

Further assuming $L_j = L$ such that all PE firms have similar litigation cost, we obtain:

Lemma 1 *An NPE can maximize its expected profit from threatening one PE firm by offer settle the litigation at a fee of* $S_j^* = \theta_j D_j + \dfrac{L - L^N}{2}$.

In reality, NPEs usually seek to settle a litigation.[16] According to the managing director of IP Edge, an NPE firm: "The vast majority of patent lawsuits settle before trial — 95 % to 97 % of them."[17]

4.2.1. Strength of PEs and litigation outcome probabilities. Recall that a patent's scope of exclusion divides PEs into Weak Users and Capable Users. Let κ_j be the strength of a firm's capability to use its own technical and/or legal skills to circumvent the patent, so that firms with higher κ_j, are less likely to lose to the plaintiff in court. Specifically, we rank firms by the strength of their capability to circumvent the patent, from the weakest to the strongest, and define $\kappa_j \in [0, 1)$ as a firm's percentile in the ranking among all the n PE firms. For Weak Users firms with $\kappa_j \in [0, x]$, we assume a linear relationship between the chance of a plaintiff win θ_j and firm capability. Then for Capable Users with $\kappa_j \in (x, 1)$, due to the fact taht they successfully invented around and avoided infringing the patent, we assume that $\theta_j = 0$. Thus, we have:

Assumption 1 *θ_j, the probability of losing to the plaintiff in a patent infringement litigation, decreases with a defendant firm's strength of the capability to invent around (κ_j).*
(a) $\theta_j = \theta_0 - \alpha\kappa_j$, and $\theta_0 \geq \alpha$, for Weak Users with $\kappa_j \in [0, x]$ that cannot avoid the patent.
(b) $\theta_j = 0$, for Capable Users with $\kappa_j \in (x, 1]$ that can avoid the patent.

This assumption also reflects the fact that NPEs as plaintiffs often target firms that are less capable (Cohen et al. Forthcoming). Thus, PEs that are incapable of inventing around but are using the patented technology intentionally or unintentionally will be NPEs' targets for threatening.

4.2.2. Asserting strategy of NPE. Using Assumption 1, we can write a price-discriminating NPE's expected profit from threatening to litigate one PE that use the patent as: $\pi_j^l = S^* - c^t = (\theta_0 - \alpha\kappa_j)D_j + \frac{L-L^N}{2} - c^t$ with c^t being the marginal cost for validly threatening a firm. [18] Most patent litigations settle at the pre-trial hearing stage. For a threat to be profitable, $S^* \geq c^t$. Given the fact that while most PEs are not familiar with patent litigations, NPEs are proficient in handling litigations and their cost sending letters to threat multiple targets are low, we assume that:

Assumption 2 *A PE's cost to defend itself is higher than an NPE's legal cost to assert patent rights at court in that $L \geq L^N + 2c^t$.*

Thus, threatening a Weak User is always expected to be profitable in that $\pi_j^l = (\theta_0 - \alpha\kappa_j)D_j + \frac{L-L^N}{2} - c^t \geq 0$, for all firms with $\kappa_j < x$.

As Choi and Gerlach (2018) discussed, NPEs usually target multiple firms for infringement cases. In particular, we assume that NPEs naturally pursue the "lowest-hanging fruit" first before climbing up to pick fruit from the upper branches. That is, we assume that a NPE first targets the weakest target in order to have the highest probability of winning, and then the second weakest target, and so on until the probability of winning drops too low to justify pursuing the next target. So, the complete set of targets will be all Weak User firms with $\kappa_j \in [0, x]$. Thus, we can obtain an NPE's total expected litigation monetization profit by summing the NPE's expected profit from all eligible Weak firms:

$$\Pi^l = n\int_0^x \pi^l(\kappa)d\kappa - C^l \tag{7}$$

with C^l being the fixed cost for litigating monetization, including costs such as an NPE's patent search, research, and acquisition. For convenience, we let $D_j = D$, meaning that the damage asserted by an NPE at court for infringing a given patent is the same across all defendant PE firms. Thus, the total expected profit of the NPE is:

$$\Pi^l = -\frac{1}{2}\alpha n D x^2 + (D\theta_0 + \frac{L - L^N}{2} - c^t)nx - C^l \tag{8}$$

Notice that the profit from litigating monetization is not related to the innovativeness of the technology itself, but is only a function of a patent's exclusivity. And we propose:

Proposition 2 *As a patent's exclusivity x increases, the expected profit from litigating the patent increases, but at a decreasing rate. In other words, the expected profit from litigating a patent is both upward-sloping and concave in x.*

The rationale for the upward slope part of Proposition 2 is that when exclusivity increases, the patent-owning NPE can validly threaten more target firms. However, because the NPE targets defendants in order from weaker to stronger, every additional defendant targeted is more capable than the previous defendants, so that the NPE's probability of winning in court against the marginal defendant constantly decreases as more defendants are targeted. This diminishing marginal benefit to the NPE implies a concave profit function for litigating monetization. This concavity is indicated by the negative coefficient on the quadratic term (x^2) in Eq. 8.

However, litigating monetization is not guaranteed a positive profit due to the existence of the fixed cost C^l. So in order to cover this fixed cost of maintaining the patent, there must be a significant mass of firms that are potential targets, i.e., firms in the industry that use the technology and potentially infringe the patent. This requirement imposes conditions on the exclusivity of the patent, x, as well as the number of firms in the industry n. In addition to having a significant number of potential targets, profitable litigating monetization also requires a sufficiently plaintiff-friendly legal regime, e.g., the court tends to reward sufficiently large damages to the plaintiff, or has a sufficiently high probability to rule in favor of the plaintiff.

Let x^l be the requirement for profitable litigating monetization in that $x^l = \min\{x|\Pi^l(x) \geq 0\}$.

Corollary 2 *When $n > \frac{C^l}{D(\theta_0 - \frac{\alpha}{2}) + \frac{L-L^N}{2} - c^t}$, there exists a unique $x^l \in [0,1)$ such that when $x \geq x^l$, $\Pi^l(x) \geq 0$, and x^l has below properties:*

(a) The lower the fixed cost to assert the patent rights (the lower the C^l), the lower the exclusivity requirement (lower x^l) for profitable litigating monetization.

(b) The more firms that are potential users of the technology (the higher n), the lower the exclusivity requirement (lower x^l) for profitable litigating monetization.

(c) The more friendly the legal regime to the plaintiff, represented by a low plaintiff legal cost (the lower L^N), a high defendant cost (the higher L), a high damage award ordered by the court (the higher D), or a high probability for a plaintiff win (the higher θ_0), the lower the exclusivity requirement (lower x^l) for profitable litigating monetization.

Figure 2b shows the relationship between Π^l and x and the position of x^l, where the exclusivity makes litigating monetization profitable enough to justify the threatening and litigating costs.

For tractability, we make the simplifying assumption that $\alpha = \theta_0 = 1$,meaning that the NPE will always win against the weakest defendant and always lose against strongest defendant. Moreover, we assume that $L = L^N + 2c^t$ to indicate that the PE defendant has a similar legal fee compared to the NPE plaintiff. This yields the simplified expression below for litigating monetization:

$$\Pi^l = -\frac{1}{2}nDx^2 + nDx - C^l \tag{9}$$

Notice that now for litigating monetization, we have that $\frac{\partial \Pi^l}{\partial x}|_{x=1} = 0$, meaning

5. Equilibrium

5.1. Equilibrium Monetization Method as a Function of Technological and Exclusionary Strength

Based on the technological and exclusionary strengths of a patent, we determine PEs' and NPEs' respective valuations for the patent, and these valuations in turn determine the equilibrium ownership and use of the patent. There are three possible mutually exclusive outcomes – The patent may be acquired and practiced by a PE (outcome P for "practicing"), acquired and monetized litigatively by a NPE (outcome L for "litigating"), or retained by the inventor and kept unused or dormant (outcome D for "dormancy").

For the relevancy of the technological value of the patent to our analysis, we use the Weak User's profit in Eq.**??** as the payoff for practicing monetization and compare it with that of litigating monetization in Eq.9. Define the strategy space $S = \{D, P, L\}$, $s \in S$, and indicator functions $\mathbb{1}_D(s) = 1$ if $s = D$, $\mathbb{1}_P(s) = 1$ if $s = P$, and $\mathbb{1}_L(s) = 1$ if $s = L$. Let σ be the optimal strategy, then the optimal monetization strategy of a patent is given by: $\sigma(x, v) \equiv \arg\max_s\{\mathbb{1}_D 0 + \mathbb{1}_P \Pi^p(x) + \mathbb{1}_L \Pi^l(x)\}$, or simply:

$$\sigma(x, v) \equiv \arg\max_s\{\mathbb{1}_P(s)\Pi^p(x, v) + \mathbb{1}_L(s)\Pi^l(x)\} \tag{10}$$

Thus, on the two-dimensional plane of x and v, we derive regions on which each of the three strategy options will prevail.

Proposition 3 *With patents that differ in their exclusivity x and innovativeness v, there exist $\underline{x}^l$, $\underline{v}^p$, and v^* such that $\sigma(x, v)$, the optimal monetization strategies for patents are:*

(a) Dormancy (D), for patents with $x \leq \underline{x}^l$ and $v \leq \underline{v}^p$;

(b) Litigating Monetization (L), for patents with $x > \underline{x}^l$ and $v \leq v^*$;

(c) Practicing Monetization (P), for patents with (1) $x \leq \underline{x}^l$ and $v > \underline{v}^p$ or (2) $x > \underline{x}^l$ and $v > v^*$.[19]

As an example, Figure 3 graphically shows a special case of Proposition 3 for a particular set of values for the other parameters. The horizontal axis is the exclusivity of a patent x and the vertical axis is the innovativeness of the patented invention v. The three regions, i.e., D region, P region, and L region, are regions that each strategy dominates. It is worth noticing that the relative size of regions in Figure 3 does not imply the relative amount of patents in each region. In order to do so, we need a distribution of all patents on the two-dimensional plane of $\{x, v\}$. To help illustrating the figure, we define several points in Figure 3: Z_1, Z_2, Z_3, and Z_4. Z_1 is point that at the edge of for the D-P boundary, Z_2 is the D-P-L intersection point, Z_3 is the peak point of the P-L boundary, and Z_4 is the edge point for the P-L boundary.

Intuitively speaking, patents that have neither technological nor exclusionary strength (the lower left region with $x \leq x_{Z_2} = \underline{x}^l$, and v below $\underline{v}^p$, which is represented by the Z_1Z_2 curve) remain dormant in the possession of the inventor. Patents that reach a sufficient level of exclusivity ($x > x_{Z_2} = \underline{x}^l$), but are weaker technically (orange region where v is below v^*, as represented by the $Z_2Z_3Z_4$ curve) are acquired by a NPE and monetized via litigation. Only the technically strong patents (blue region where v is above both the Z_1Z_2 curve and the $Z_2Z_3Z_4$ curve). However, depending on the patent's exclusivity, the thresholds of minimum technological strength for practicing monetization differ ($\underline{v}^p$ for the P-D boundary shown as the Z_1Z_2 curve , and v for the P-L boundary shown as the $Z_2Z_3Z_4$ curve), with patents of medium exclusivity having the highest minimum technological strength required for practicing to be the equilibrium outcome (Point Z_3).

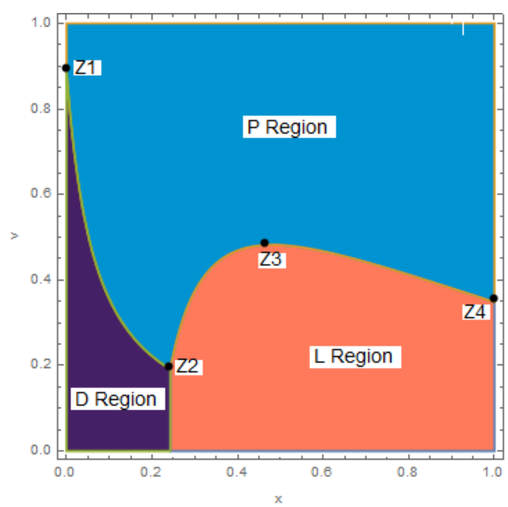


Figure 3 Optimal Monetization Method

Note: The horizontal axis is exclusivity x, the vertical axis is innovativeness v. The Purple region is the Dormancy region (D Region), the Blue region is the Practicing region (P Region), the Orange region is the Litigating region (L Region).

Depending on different parameter configurations, there can be multiple scenarios for optimal monetization methods. Figure 4 shows those scenarios on the two-dimensional plane characterized by x and v. When the number of firms n increases, the L region expands with the P-L boundary shifts up and the D-L boundary shifts left. If the cost of implementing the patent (C^p) decreases, the P region expands with the D-P boundary shifts down and the P-L boundary shifts down. A combination of the above two effects result a shift from Figure 4a (which replicates the same scenario in Figure 3) to a graph that is similar to Figure 4b in which the L region significantly enlarged and the P region mainly concentrates on areas with patents of either extremely high or extremely low exclusionary strength. As the NPE's expected damage from winning in court (D) decreases or the cost for initiating a campaign against multiple defendant (C^l) increases, the L region shrinks with the P-L boundary shifts down, and the D-L boundary shifts right. The result is a shift from Figure 4b to Figure 4c. But if D is sufficiently low or if C^l is sufficiently high (or as an extention, the NPE's chance of winning at court (θ_0) decreases), Figure 4c gets transformed into a graph that looks like Figure 4d in which the L region completely disappear and there is no room for litigating monetization to prevail.

5.2. Equilibrium Monetization Method as a Function of Exclusivity Alone

The dotted horizontal lines in Figure 4 illustrate all possible scenarios for the effect of patent exclusivity on the equilibrium monetization method. Depending on the values of the other parameters, there are a total of nine sequences for how the equilibrium monetization method changes as x increases from 0 to 1. We denote each equilibrium sequence as an ordered list of the equilibrium monetization methods in the order that appear as x increases from 0 to 1. For example, the equilibrium sequence (D,L,P) means that the equilibrium monetization method is Dormancy, Litigating, and Practicing for patents in regions $x \in [0, x^a)$, $[x^a, x^b)$, and $[x^a, 1)$ respectively - i.e., starting with D, shifting to L, and ending with P.

Proposition 4 *There are nine possible sequences for how the equilibrium monetization method changes as a function of the patent exclusionary strength x. These nine scenarios are determined by the relative positions of x^l, x^p, x^{*1}, and x^{*2}, as shown below in Table 1.*

Table 1 Summary of Nine Equilibrium Sequences

#	Notation	Optimal Strategies $\sigma(x)$	Conditions
i	(D)	D for $x \in [0,1)$	$\{x^p > 1\} \bigcap \{x^l > 1\}$
ii	(P)	P for $x \in [0,1)$	$\{x^p < 0\} \bigcap \{\{x^{*1} > 1\} \bigcup \{x^{*2} < 0\} \bigcup \{dx < 1\}\}$
iii	(D,P)	D for $x \in [0, x^p)$ and P for $x \in [x^p, 1)$	$\{x^p \in (0,1)\} \bigcap \{\{x^{*1} > 1\} \bigcup \{x^{*2} < x^p\} \bigcup \{dx < 1\}\}$
iv	(D,L)	D for $x \in [0, x^l)$ and L for $x \in [x^l, 1)$	$\{x^l \in (0,1)\} \bigcap \{x^{*1} < x^l\} \bigcap \{x^{*2} > 1\}$
v	(P,L)	P for $x \in [0, x^{*1})$ and L for $x \in [x^{*1}, 1)$	$\{x^p < 0\} \bigcap \{x^{*1} \in (0,1)\} \bigcap \{x^{*2} > 1\}$
vi	(P,L,P)	P for $x \in [0, x^{*1})$, L for $x \in [x^{*1}, x^{*2})$ and P for $x \in [x^{*2}, 1)$	$\{x^p < 0\} \bigcap \{x^{*1} > 0\} \bigcup \{x^{*2} < 1\}$
vii	(D,L,P)	D for $x \in [0, x^l)$, L for $x \in [x^l, x^{*2})$, and P for $x \in [x^{*2}, 1)$	$\{x^l \in (0,1)\} \bigcap \{x^{*1} < x^l\} \bigcap \{x^{*2} \in (0,1)\}$
viii	(D,P,L)	D for $x \in [0, x^p)$, P for $x \in [x^p, x^{*1})$, and L for $x \in [x^{*1}, 1)$	$\{x^p \in (0,1)\} \bigcap \{x^{*1} > x^p\} \bigcup \{x^{*2} > 1\}$
ix	(D,P,L,P)	D for $x \in [0, x^p)$, P for $x \in [x^p, x^{*1})$, L for $x \in [x^{*1}, x^{*2})$, and P for $x \in [x^{*2}, 1)$	$\{x^p \in (0,1)\} \bigcap \{x^{*1} > x^p\} \bigcap \{x^{*2} < 1\}$

When will each of the equilibrium sequence appear depends on the positions of x^l, x^p, x^{*1}, and x^{*2}. [20] Detailed conditions for each scenario are also given in Table 1. The nine plots in Figure 5 show the relative positions of Π^p, Π^l, and relevant intersections.

We highlight three critical conditions that differentiate the above nine equilibrium sequences. First, when C^p and C^l are sufficiently large, meaning the maximal value appropriation from the patent cannot justify the cost to either practicingly or litigatingly monetize the patent, the equilibrium sequence will be (D).[21] Second, when the technology is sufficiently valuable,[22] and fixed cost of practicing (C^p) or the number of firms in the market (n) is sufficiently small in that $C^p(n+1)^2 \leq 4$, which results $x^p < 0$, then the equilibrium sequences will have no D region and start from P. This means for patents with strong technological strength, practicing them would be preferred even with even zero scope of exclusion, which is the case similar to open knowledge.

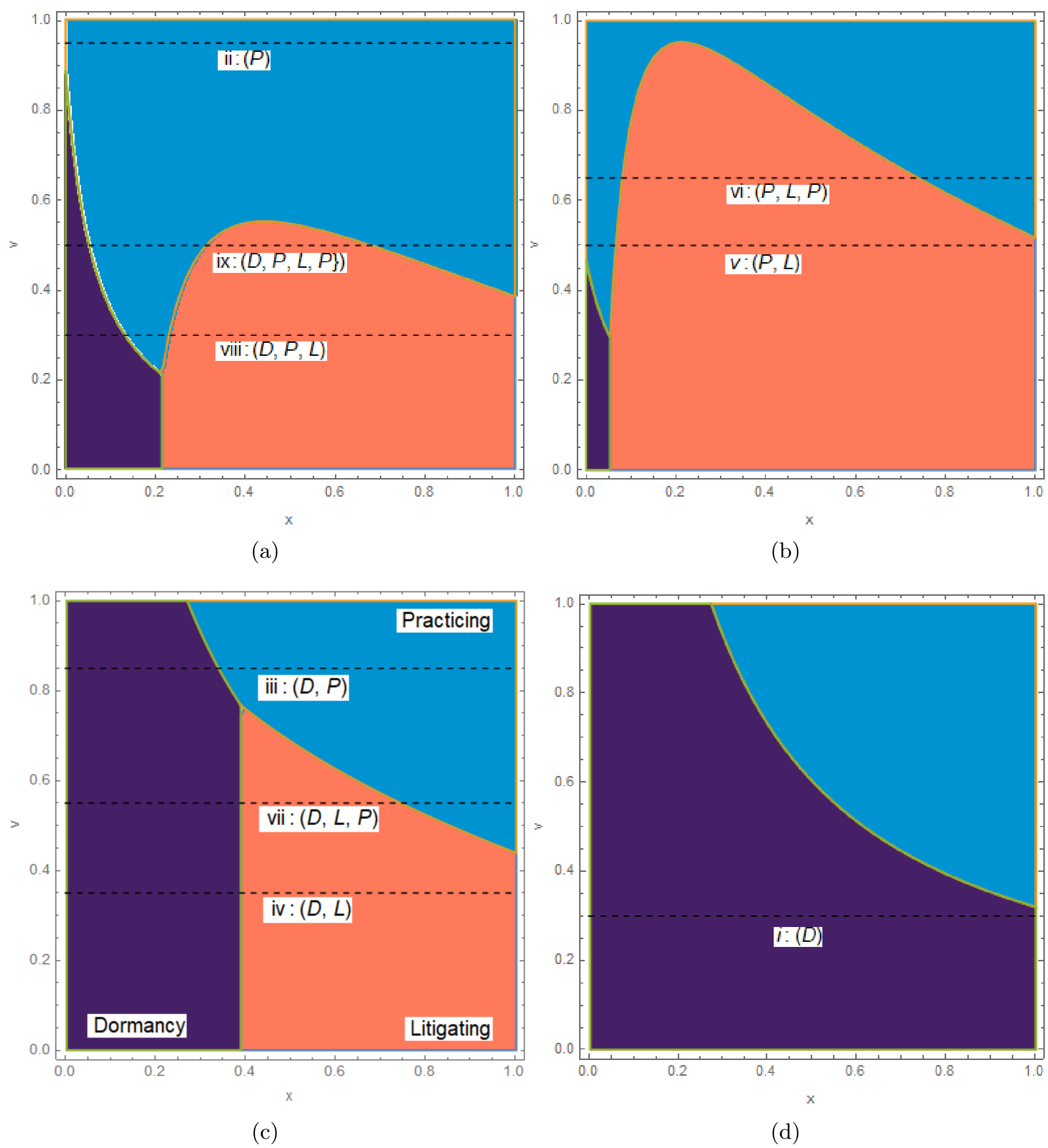


Figure 4 Region of Optimal Monetization Method

Note: The x-axis is exclusionary strength x, the y-axis is technological strength v. The Purple region is the Dormancy region (D Region), the Blue region is the Practicing region (P Region), the Orange region is the Litigating region (L Region). Letters in the graphs indicate the index of equilibrium sequences as in Figure 5.

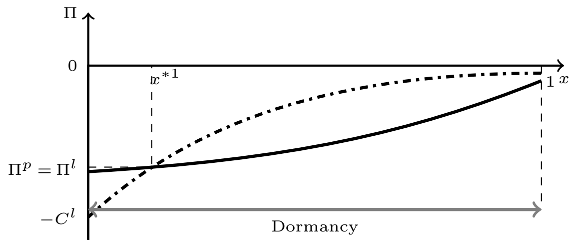
Third, when the technological value v or the NPE's litigating cost C^l is sufficiently large, or when n, C^l, and the damage awarded to te NPE (D) are sufficiently small, in that they altogether satisfy $\frac{v(2A+v+nv)}{1+n} - C^p > \frac{Dn}{2} - C^l$, the equilibrium sequences will end with P, which means patents with the widest scope of exclusion will be optimally acquired by an PE to practice.

Also in Figure 4, we give example lines and show the index for each of the nine situations in Table 1. Notice that the horizontal axis in Figure 4 is x, so the horizontal lines in Figure 4 capture the optimal strategy on x given a fixed level of v.

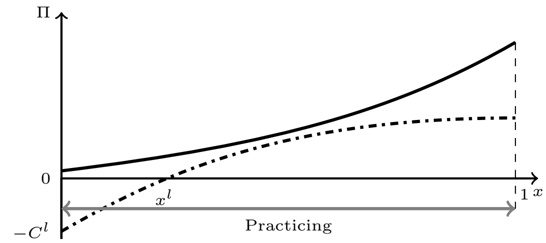
We now explain insights derived from the different equilibrium sequences. At first, in some scenarios, in addition to the P region when the patent has high exclusivity on $x > x^{*2}$, the existence of another P region on $x \in [x^p, x^{*1})$. This reflects the fact that a part of the practicing profit gain comes from the pure technological value of the invention which is not related to exclusivity. Some good inventions with bad patents, may still be practiced, but due to the low exclusivity, will be out of NPEs' radar. Second, regarding the thresholds for profitable monetization, x^l is always greater than zero since when $x = 0$, $\Pi^l = C^l < 0$. When the patent has no exclusivity, then the patent would be completely useless for litigating monetization. When litigating is profitable, there is always $x^l > 0$. However, the threshold for profiting practicing monetization, x^p can be smaller than zero since even when $x = 0$, $\Pi^p = \frac{v^2+2v}{(n+1)^2} - C^p$, which is not necessarily negative. This captures the pure value of the technology, even without any exclusion power of the patent, or without a patent at all. Third, when $x^{*2} \in (0,1)$, the most exclusive patents, i.e., patents with $x \in [x^{*2}, 1)$, will always more profitable monetized via practicing. This means that the profit from excluding other PE rivals, together with the profit from the technology itself, dominate the profit from litigating. Fourth, the least exclusive patents $x < \min\{x^p, x^l\}$, will be unprofitable either through litigating or practicing monetization, thus will stay in dormancy, due to the existence of the fixed costs, C^p and C^l, to initiate either monetization strategy. Fourth, patents that will be litigated will always be patents with medium exclusivity range, i.e., $x \in \{x^{*1}, x^{*2}\}$ and $x > x^l$.

6. Extension: End Users as Litigation Targets

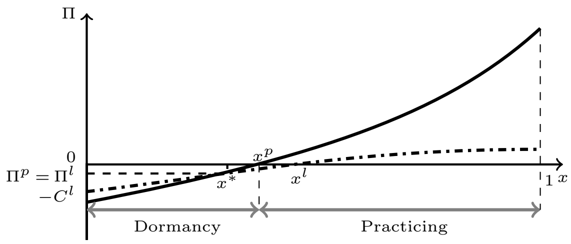
One notorious practice of litigating patent monetization is targeting end users of infringing products, rather than against the actual producers of those products (Bernstein 2016). NPE's target end users may have little, if anything, to do with each other, and these end users do not participate in the competition among producers in the product market. Therefore, being able to target end users in patent litigations additionally incentivizes litigating monetization. For a product whose end users are in large number, NPEs may have relatively more to gain from owning a patent than PEs. In this scenario, we use $\Pi^l(n^U)$ and $\Pi^p(n)$ to denote the profit from litigating monetization and practicing monetization as a function of number of targets n^U, and number of active producers in the industry n respectively.



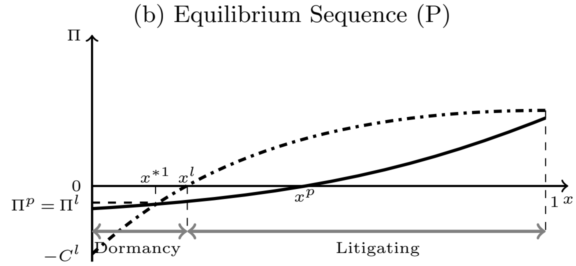
(a) Equilibrium Sequence: (D)



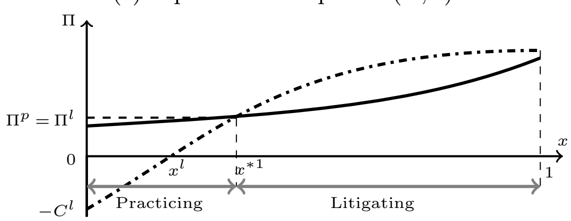
(b) Equilibrium Sequence (P)



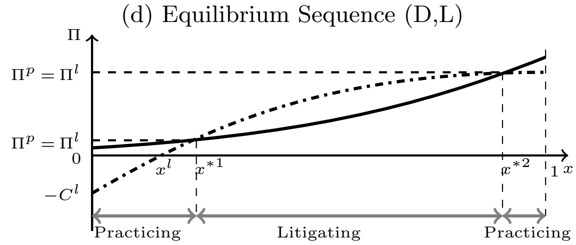
(c) Equilibrium Sequence (D,P)



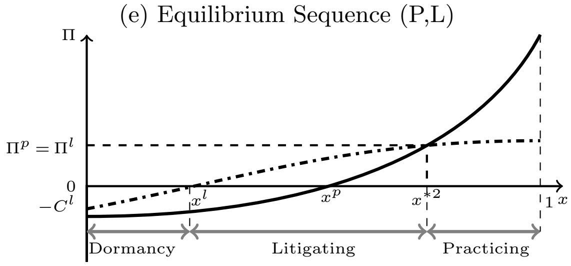
(d) Equilibrium Sequence (D,L)



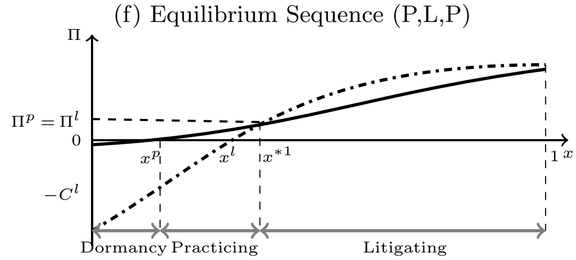
(e) Equilibrium Sequence (P,L)



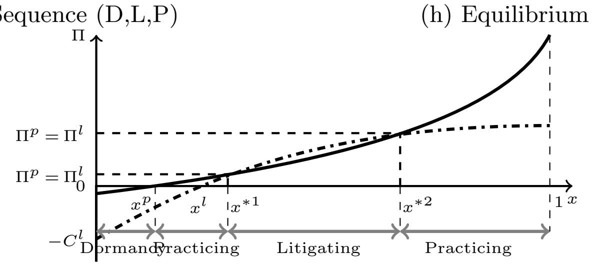
(f) Equilibrium Sequence (P,L,P)



(g) Equilibrium Sequence (D,L,P)



(h) Equilibrium Sequence (D,P,L)



(i) Equilibrium Sequence (D,P,L,P)

Figure 5 Equilibrium Monetization Method as a function of x

Note: The horizontal axis is the exclusionary strength of patents x, the vertical axis is value Π. In each graph, Solid curves plots the value from practicing monetization (Π^p) and Dash dot curves plots the value from litigating monetization (Π^l). Dormancy, Practicing, and Litigating regions, as well as positions of x^l, x^p, x^{*1}, and x^{*2}, are marked in each graph.

Proposition 5 *The more end users relative to producers in an industry (i.e., higher n^U/n ratio), the more profitable litigating monetization becomes, relative to practicing monetization.*

7. Empirical Implications

Our propositions suggest several avenues for future empirical research, provided that a patent's practicing value can be distinguished from its litigating value. It may be possible to proxy for these values at the patent class level, since certain patent classes are known to have, on average, relatively higher exclusionary strength and/or practicing value than others. For example, regulations requiring clinical trials make pharmaceutical patents especially difficult to "invent around," while patents for computer hardware are relatively easier to circumvent because the possibility of recombining electronic components in multiple configurations offers "more than one way to skin a cat." It may also be possible to find proxies that distinguish patents according to their practicing value. For example, among pharmaceutical patents, some drugs are slight variations on existing molecules in longstanding therapeutic classes and are therefore likely to have relatively low practicing value, while other drugs pioneer entirely new types of molecules or entirely new therapeutic classes and are therefore likely to have much higher practicing value.

It may be possible to test our propositions in situations where natural experiments suddenly shift the litigating and/or practicing value of patents in ways that precipitate observable sales of patents from PEs to NPEs or vice versa. For example, as one possible natural experiment, the U.S. Food and Drug Administration's 1997 deregulation of direct-to-consumer advertising and the 1983 Orphan Drug Act both increased the practicing value of pharmaceutical patents. Likewise, court rulings like the 2010 *Bilski v. Kappos* and 2014 *Alice v. CLS* decisions on software and business-process patents can suddenly shift the exclusionary value of specific patent classes. Broader changes to the exclusionary value of patents across many classes may result from patent reform legislation, such as the 2011 America Invents Act (AIA). Specifically, the Act increased the cost for litigating by banning combining cases based on infringing the same patent, thus increases the fixed cost that the plaintiff has to pay to initiate a series litigations – i.e., our parameter C^l. Second, the AIA paved ways for easier patent invalidation by the defendants, thereby decreasing NPEs' likelihood of successfully extorting a PE firm – i.e., our parameter θ_j.

8. Concluding Remarks, Caveats, Limitations, and Opportunities

In this paper, by decoupling the technological and exclusionary strength of the patent, we study how firms' value appropriation mechanisms relate to patent monetization methods and implications in the market for patents and technologies. Relationships among concepts are summarized below in Figure 6.

Different firms, with their different monetization mechanisms and different synergies, have heterogeneous valuations for resources. Inspired by the NPE phenomenon, this study contributes to resource-based theory by examining the role that differing monetization mechanisms plays as a

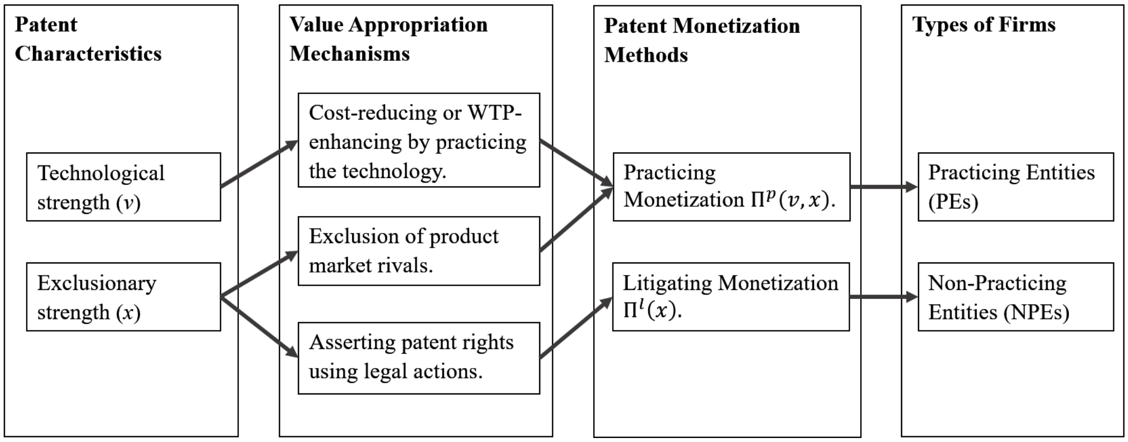


Figure 6 **Value Appropriation and Patent Monetization Framework**

source of firms' valuation of resources (Asmussen 2015), and highlighting the resulting implications for the trading of resources (in this case, patents) in a strategic factor market (Barney 1986). Since the monetization mechanism is one of the most important dimensions on which business models usually differ, our model also contributes to research on competing business models (e.g., Casadesus-Masanell and Zhu 2010, 2013) by shifting the focus of competition from the product market to the resource market. We believe that the impact of competing business models and differing monetization methods on the resource market, and not just on the product market, is a topic that is ripe for future research.

This study also contributes to the literature in market for technology by analyzing monetization methods based on differentiating the value of exclusion from the practicing value of the technology itself. Most extant research studies the value of patents in general while not separating the two (Bessen 2008, Harhoff et al. 2003, Lanjouw et al. 1998). We argue that the technological value matters for firms that commercialize the patented technology, whereas the exclusionary value of patents matters for both practicing monetization and litigating monetization (Lemley and Shapiro 2005). Moreover, our theory highlight firms' difference in monetizing the exclusionary value of patents. The exclusion in practicing monetization means excluding other firms from using the technology in their products and services; but in litigating monetization, it means being able to assert patent rights and profit from litigating (Chien 2013). Thus, while firms that use practicing monetization prefer less infringement to maximize their competitive advantage, firms that exploit litigating monetization prefer more infringement in order to maximize the set of potential defendants. Extensions of the model may incorporate characteristics of the industry and the product market overlapping among PEs. Studying how they affect the competitive rivalry among firms (Ross 2014) in the factor market can also be fruitful.

In addition, given the significant attention given by other fields on the non-practicing monetization of patents, we join the current discussion on Non-Practicing Entities (NPEs) and shed light on their patent acquisition behavior. Existing studies presented mixed findings regarding whether NPEs acquire high or low quality patents (Feng and Jaravel 2017, Abrams et al. 2013).In an effort to solve the puzzling mixture of findings, we propose that the value of technology is only reflecting one facet of patent quality, and NPEs make their acquisition based on the exclusionary value of patents, which may not necessarily related to the technological value. For instance, a valuable technology that is written badly into a patent may still be highly valuable for practicing monetization, but it may have no value in eyes of NPEs for litigating monetization. We found while practicing monetization is convex, litigating monetization is concave in patent's exclusionary strength. This difference in value functions have substantial implications for the optimal resource monetization, since it implies a curvilinear boundary between the patents that are practiced by PEs and the patents that are litigated by NPEs.

Although our model provides a starting point for understanding NPEs and competing patent monetization methods, it certainly does not represent a complete theory of these phenomena. We hope that future research will extend our model in ways that overcome its limitations and omissions. One such limitation is that there are more patent monetization methods than the two we considered (practicing and litigating), such as licensing that does not involve threat of litigation (Fosfuri 2006). However, licensing is a form of contract whose value (represented in licensing fee) will hinge on whether the ultimate value appropriation mechanism is from the product market or from the threat to litigate. In this regard, licensing might be expected to behave like an intermediate blend of practicing and litigating. So, it would be interesting to extend the model and discusses various scenarios of licensing. A second limitation is that we use a static model and assume that all uses of the patent and its underlying technology happen instantaneously. However, in reality, litigation, technology adoption, and inventing around patents are dynamic processes that take time (Gort and Klepper 1982). In an explicitly dynamic model, differences in the speeds with which these different processes occur might generate different results. Finally, although our model focuses on the two specific aspects of patents their technological strength and their exclusionary strength that seem to us to be the most important determinants of monetization methods, these are certainly not the only two dimensions on which patents differ, and may not be the only drivers of monetization decisions. Accordingly, future theories of patent monetization may incorporate a broader range of independent variables.

Appendix A: Proofs

A.1. Proof of Lemma 1

It is clear that for the target PE firm, since $S^* \leq \theta_j D_j + L_j$, which is the expected payoff had it choose to fight at court, the PE is willing to settle with the NPE. We let $D_j \leq \tilde{\pi}_j^C$, meaning the court will not award a damage larger than the defendant firm's profit to the plaintiff.

Then from the perspective of the NPE, if the defendant PE decides to fight, even when the plaintiff NPE wins at the court, the payoff of the NPE will only be $\mathbb{E}(\pi_j^{court}) = \theta_j D_j - L^N < S_j^*$. The difference is the legal fee that the defendant has to pay under the American court rule that let each party bear their own legal fee.

This indicates that fighting at court is not to the plaintiff NPE's best profit either. So NPEs, with knowledge about the litigation cost of PEs and their odds at court, would demand the maximal monetary payment S^* such that it can expect a PE to agree to settle other than fight.

A.2. Proof of Proposition 1

Signs of relevant first-order and second-order derivatives are given below: $\frac{\partial \Pi_i^{pW}}{\partial v} = \frac{2(nx+1)^2 v + 2A(nx+1)}{(n+1)^2} > 0$, $\frac{\partial^2 \Pi_i^{pW}}{\partial v^2} = \frac{2(nx+1)^2}{(n+1)^2} > 0$, $\frac{\partial \Pi_i^{pC}}{\partial v} = \frac{2(n^2x^2+2nx)v+2Anx}{(n+1)^2} > 0$, $\frac{\partial^2 \Pi_i^{pC}}{\partial v^2} = \frac{2(nx+1)^2-2}{(n+1)^2} > 0$, $\frac{\partial \Pi_i^{pC}}{\partial x} = \frac{\partial \Pi_i^{pW}}{\partial x} = \frac{2n^2v^2x+2nv(v+A)}{(n+1)^2} > 0$, $\frac{\partial^2 \Pi_i^{pC}}{\partial x^2} = \frac{\partial^2 \Pi_i^{pW}}{\partial x^2} = \frac{2n^2v^2}{(n+1)^2} > 0$.

A.3. Proof of Corollary 1

Using Proposition 1, we know that $\max\{\Pi^p\} = \Pi^p|_{x=1} = v^2 + \frac{2Av}{n+1} - C^p$. To guarantee that $\max\{\Pi^p\} > 0$ such that $x^p < 1$, we obtain: $C^p < v^2 + \frac{2Av}{n+1}$.

Let $\Pi^p = 0$, then we can solve for the minimum level of exclusivity that support profitable practicing monetization x^p:

$$x^p = \frac{-A - v + \sqrt{C^p(n+1)^2 + A^2}}{nv}$$

Thus we can obtain the signs of relevent first-order derivatives: $\frac{\partial x^p}{\partial v} = -\frac{\sqrt{C^p(n+1)^2+A^2}-A}{n} v^{-2} < 0$, $\frac{\partial x^p}{\partial C^p} = \frac{1}{2nv}\frac{(n+1)^2}{\sqrt{C^p(n+1)^2+A^2}} > 0$, $\frac{\partial x^p}{\partial n} = \frac{(v+1)\sqrt{C^p(n+1)^2+A^2} - C^p(n+1) - A}{vn^2\sqrt{C^p(n+1)^2+A^2}} < 0$.

A.4. Proof of Proposition 2

The proof is straightforward by taking the derivative of Π^l with respect to x. When the damage is positive ($D > 0$), the chance of a plaintiff win is positive ($\theta_0 - \alpha x > 0$), and the cost of the defendant to defend itself is sufficiently large in that $L \geq L^N + 2c^t$, we have $\frac{\partial \Pi^l}{\partial x} = (D(\theta_0 - \alpha x) + \frac{L-L^N}{2} - c^t)n > 0$ and $\frac{\partial^2 \Pi^l}{\partial x^2} = -\alpha D n < 0$.

A.5. Proof of Corollary 2

From Proposition 2, we know that $\max\{\Pi^l\} = \Pi^l|_{x=1} = -\frac{1}{2}\alpha n D + (D\theta_0 - c^t + \frac{L-L^N}{2})n - C^l$. To guarantee $\max\{\Pi^l\} \geq 0$ such that $x^l \leq 1$, we obtain the necessary condition that: $n \geq \frac{C^l}{D(\theta_0 - \frac{\alpha}{2}) + \frac{L-L^N}{2} - c^t}$. The condition is also sufficient because the numerator is greater than zero by assumptions. In addition, the condition above is a sufficient condition that guarantees the existence of real colutions of x^l. Letting $\Pi^l = 0$, we can solve for the minimum level of exclusivity that support profitable litigating monetization x^l:

$$x^l = \frac{\theta_0}{\alpha} + \frac{L - L^N - 2c^t}{2\alpha D} - \frac{1}{\alpha}\sqrt{\left(\theta_0 + \frac{L - L^N - 2c^t}{2D}\right)^2 - \frac{2\alpha C^l}{nD}} \tag{11}$$

To prove properties of x^l, we define and use a tool $\Psi = \frac{\theta_0 + \frac{L-L^N-2c^t}{2D}}{\sqrt{\left(\theta_0 + \frac{L-L^N-2c^t}{2D}\right)^2 - \frac{2\alpha C^l}{nD}}} > 1$. Then the corollary is straightforward by calculating $\frac{\partial x^l}{\partial D} < 0$, $\frac{\partial x^l}{\partial C^l} > 0$, $\frac{\partial x^l}{\partial n} = -\frac{C^l}{n}\frac{\partial x^l}{\partial C^l} < 0$, $\frac{\partial x^l}{\partial \theta_0} = \frac{1-\Psi}{\alpha} < 0$, $\frac{\partial x^l}{\partial c^t} = -\frac{1}{D}\frac{\partial x^l}{\partial \theta_0} > 0$, $\frac{\partial x^l}{\partial L^N} = \frac{1}{2}\frac{\partial x^l}{\partial c^t} > 0$ and $\frac{\partial x^l}{\partial L} = -\frac{\partial x^l}{\partial L^N} < 0$. The results also match with intuitions regarding variables that affect patent litigations and with findings in Lanjouw (1998) about the value of patent protection.

After simplifying by letting $L = L^N + 2c^t$, we obtain $\Pi^l = -\frac{1}{2}\alpha n D x^2 + D\theta_0 n x - C^l$. When $\Pi^l = 0$, we can solve for the minimum requirement for a patent's exclusivity: $x^l = \frac{\theta_0 - \sqrt{\theta_0^2 - \frac{2\alpha C^l}{nD}}}{\alpha}$.

A.6. Proof of Proposition 3

(a) When $\Pi^p = 0$, we have $\underline{v}^p = \frac{\sqrt{1+C^p(n+1)^2}-A}{1+nx}$. Also, notice that $\underline{x}^l$ is x^l after we made simplifications of $\theta_0 = 1$, $\alpha = 1$, and $L = L^N + 2c^t$. So we have $\underline{x}^l = 1 - \sqrt{1 - \frac{2C^l}{Dn}}$. When $x > \underline{x}^l$, $\Pi^l > 0$. Thus, when $x \leq \underline{x}^l$ and $v \leq \underline{v}^p$, a patent is in D region with $\Pi^l \leq 0$ and $\Pi^l \leq \Pi^p$.

(b) Solving $\Pi^p = \Pi^l$ for v, we obtain: $v^* = \frac{-A+\sqrt{1+(1+n)^2[(C^p-C^l)+nD(x-\frac{x^2}{2})]}}{1+nx}$. Thus, when $x > \underline{x}^l$ and $v < v^*$, a patent is in L region with $\Pi^l > 0$ and $\Pi^l > \Pi^p$.

(c) After specifying the L and D region, then what remains on the plane is the P region with is to the right of the D region and to the up of the L region, with $v > \underline{v}^p$ when $x \leq \underline{x}^l$ and $v > v^*$ when $x > \underline{x}^l$. It worth noticing that when solving $\Pi^p = \Pi^l$ for x, we obtain two solutions:

$$x^{*1} = \frac{D - \frac{2v(v+A)}{(n+1)^2} - \sqrt{\Lambda}}{\left(D + \frac{2v^2 n}{(n+1)^2}\right)} \qquad (12) \qquad\qquad x^{*2} = \frac{D - \frac{2v(v+A)}{(n+1)^2} + \sqrt{\Lambda}}{\left(D + \frac{2v^2 n}{(n+1)^2}\right)} \qquad (13)$$

where $\Lambda = \left(D - \frac{2v(v+A)}{(n+1)^2}\right)^2 - 2\left(\frac{D}{n} + \frac{2v^2}{(n+1)^2}\right)\left((C^l - C^p) + \frac{v(v+2A)}{(n+1)^2}\right)$.

There are two real solutions to x^* while there is only one solution to v^*, this is represented in Figure 4 by the fact that for each x value on the curve that splits the P region and the L region, there is only one v^*; while for a v value, it can have two intersections with the P-L boundary, corresponding to the two x^* solutions.

A.7. Proof of Proposition 4

Recall that: $x^{*1} = \frac{D-\frac{2v(v+A)}{(n+1)^2}-\sqrt{\Lambda}}{\left(D+\frac{2v^2n}{(n+1)^2}\right)}$, $x^{*2} = \frac{D-\frac{2v(v+A)}{(n+1)^2}+\sqrt{\Lambda}}{\left(D+\frac{2v^2n}{(n+1)^2}\right)}$, $x^l = 1 - \sqrt{1-\frac{2C^l}{Dn}}$, and $x^p = -\frac{1}{n} - \frac{A}{nv} + \frac{\sqrt{C^p(n+1)^2+A^2}}{nv}$. In addition, from $\Pi^l \geq \Pi^p \iff x \in [x^{*1}, x^{*2}]$ and $x^l > 0$, we know that the Litigating region is a convex set on $\{x|0 \leq x < 1\}$, meaning there is only one segment on $[0,1)$ that the optimal monetization will be Litigating. Also, as $\frac{\partial \Pi^p}{\partial x} > 0$ and $\frac{\partial \Pi^l}{\partial x} > 0$ $\forall x \in [0,1)$, we know that if there exists a Dormancy region, it must be the first segment on $[0,1)$, before Litigating region or Practicing region. Therefore, exhausting all combinations of D, L, P giving the constraints yields nine possible equilibrium sequences in terms of patnets' exclusionary strength x: (P), (L,P), (P,L), (P,L,P), (D), (D,P), (D,L,P), (D,P,L), and (D,P,L,P).

A.8. Proof of Proposition 5

The proof is straightforward by replacing n^U in Π^l with $\rho = \frac{n^U}{n}$. Then it is easy to find that $\frac{\Pi^l}{\Pi^p} \propto \rho$.

Endnotes

[1]Such differences in the types of synergies sought from an acquired resource also occur in the labor market, where some firms pursue an exploration strategy of hiring new employees to initiate new activities, while other firms pursue an exploitation strategy of hiring new employees to expand or enhance its existing activities, and these differences have been shown to affect the amount and type of value created (Groysberg and Lee 2009).

[2] Similarly, commercial real estate is valued differently by companies according to the type of synergies they can obtain from a property, as evidenced by the recent trend of U.S. shopping malls replacing defunct department stores with hotels (Frankel 2018, Gose 2018).

[3]Hagiu and Yoffie (2013) also mentioned other types of patent intermediaries. First, patent brokers who do not buy patents but only connect patent sellers and buyers. Brokers can improve the social welfare by using their expertise to reduce the search cost and transaction cost in the market of patents. Some examples are Thinkfire and IPValue.

Second, patent pool, which is a pool of patents that practicing company put together and license to each other. Third, standard setting organizations which are two-sided patent platforms but are already a failed trial. Fourth, super aggregators that combines the properties of defensive aggregators and offensive aggregators.

[4]As written on the website of RPX(one of the largest defensive aggregators) website: “We welcome inquiries from individual inventors/owners, academic institutions, brokers, technology transfer offices, corporate sellers, and non-practicing entities.”

[5]See the article *Patent Sales* at http://www.rpxcorp.com/rpx-services/rpx-patent-sales/.

[6]In some articles, “NPE” is a neutral term (Lemley and Feldman 2016), but the other two names, “Non-practicing Assertion Entities” (NAE) and “patent troll” are always used derogatorily.

[7]See http://www.rpxcorp.com/network/patent-risk/

[8]Derived from a representative consumer’s quadratic utility function: $U = AQ - \frac{B}{2}\left(\sum_{i=1}^{N} q_i^2 + \sum_{\substack{i=1 \\ i\neq j}}^{N}\sum_{j=1}^{N} q_i q_j\right) + m$, where m is a numeraire good and $A, B > 0$.

[9]When some firms have adopted the technology, the other firms that have not are in a disadvantage. In our model, we assume that those disadvantaged firms will not be driven out of the market, i.e., the optimal quantity $\tilde{q_i}$ is non-positive, because they did not use that specific technology. Formally, this means that we assume the Nash Equilibrium output and profit margin of the disadvantaged firms are still positive, or formally:

$$\tilde{q_i}^{Cdis} = \tilde{p} - c = \frac{A - c - (1-x)nv}{n+1} > 0 \Rightarrow \frac{A-c}{n} > (1-x)v$$

notice that when the patent is WTP-enhancing instead of cost-reducing ($v < 0$, as will be specified in the text later), the assumption automatically holds.

[10]The focal firm’s quantity: $\tilde{q}_i^C = \frac{A-c+(1+nx)v}{n+1}$, and the price: $\tilde{p} = \frac{A+n(c-(1-x)v)}{n+1}$.

[11]It worth noticing that although $\frac{\partial \Pi_i^{pW}}{\partial x} = \frac{\partial \Pi_i^{pC}}{\partial x}$ and $\frac{\partial^2 \Pi_i^{pW}}{\partial x^2} = \frac{\partial^2 \Pi_i^{pC}}{\partial x^2}$, which means x the exclusivity of the patent has the same marginal effect on the profit of both types of PEs, $\frac{\partial \Pi_i^{pW}}{\partial v} > \frac{\partial \Pi_i^{pC}}{\partial v}$ and $\frac{\partial^2 \Pi_i^{pW}}{\partial v^2} > \frac{\partial^2 \Pi_i^{pC}}{\partial v^2}$, which reflect the fact that the technology itself has larger impact on firms that cannot invent around and need the patent to adopt technology than firms that can find other ways to use the technology.

[12]The exception is the Bertrand price competition with perfectly undifferentiated products.

[13]NPEs often acquire patents from individual patent holders, since individuals often have neither the skills nor the financial resources to finance the costs of such litigation (Haber and Werfel 2016).

[14]Under the British court rule, however, the prevailing party will always be awarded the legal fees by the losing party.

[15]35 U.S.C. §285: ”The court in exceptional cases may award reasonable attorney fees to the prevailing party.”

[16]However, if the plaintiff of a litigation is a PE, since they are evaluating the damage it experiences in the product market, its likelihood to settle a litigation decreases with the increase in the value and its strategic stake of the litigated patent (Somaya 2003).

[17]Source: https://www.iam-media.com/litigation/why-plaintiffs-us-patent-cases-who-understand-odds-victory-are-almost-always-best.

[18]To validly threaten a firm requires initial research, sending a demand letter, and appearing at a pre-trial hearing.

[19] $v > v^*$ can also be written as $x \in (0, x^{*1}) \cup (x^{*2}, 1)$, where $x^{*1} < x^{*2}$ are the two solutions to $\Pi^p - \Pi^l = 0$. Similarly, the condition of $v \leq \overline{v}^*$ can also be written as $x \in [x^{*1}, x^{*2}]$.

[20]When $\frac{\left(D - \frac{2v(v+1)}{(n+1)^2}\right)^2}{2\left(\frac{D}{n} + \frac{2v^2}{(n+1)^2}\right)\left((C^l - C^p) + \frac{v(v+2)}{(n+1)^2}\right)} > 1$, there exists $x^{*1}, x^{*2} \in \mathbb{R}$ such that when $x \in (x^{*1}, x^{*2})$, $\Pi^l > \Pi^p$. So, on the patent exclusivity dimension, there will be a convex region that the value from litigating monetization surpasses that of practicing monetization.

[21]The conditions for the equilibrium sequence (D) are $C^p > v^2 + \frac{2Av}{n+1}$ and $C^l > \frac{nD}{2}$.

[22]To be specific, when $v > \sqrt{C^p(n+1)^2 + 1} - A$.

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