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A Comparative Analysis of Patent Assertion Entities in Markets for Intellectual Property Rights

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The patent assertion entity is a relatively new organizational form that neither invents nor commercializes products, but acts as a distributor of intellectual property rights between inventors and commercializing entities. We combine measurement and governance branches of transaction cost theory to compare the efficiency of market intermediation by patent assertion entities to that of bilateral licensing agreements, patent pools, and firm integration. We consider the level of complementarity between patents and the breadth of their commercial applications to develop four general intellectual property configurations that depict distinct relationships between patent supply and patent demand. The costs and benefits of the various governance alternatives are then weighed for each configuration to identify when each alternative is likely to be most efficient. Our analysis suggests that patent assertion entities are most efficient in allocating intellectual property rights when there is substantial patent complementarity such that value is created through patent bundling, and these bundles are applicable across a broad range of product lines such that the costs of measuring infringement and its damages are substantial. We consider how the imperfections of patents as contracts between inventors and society in conjunction with rapid technological evolution contribute to the growth of patent assertion entities. This analysis provides some guidance for managers on how to appropriate value from intellectual property.

Keywords: technology and innovation management; patents and intellectual property rights; transaction cost
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Introduction

Patent protection and efficient markets for allocating intellectual property rights provide both an incentive to innovate and a means for matching inventions with opportunities for their commercialization (Arora et al. 2008). Well-functioning patent markets allow firms to specialize in either discovery or commercialization and form bilateral licensing agreements (Arora et al. 2004). Other types of governance, such as patent pools, are particularly efficient in bundling patents to facilitate the commercialization pursuits of pool members (Shapiro 2001). While bilateral licensing agreements and patent pools have a long history, a relatively recent organizational form used to allocate intellectual property rights is the patent assertion entity (PAE). Pejoratively referred to as patent trolls, PAEs neither invent nor commercialize intellectual property, but rather act as independent distributors, purchasing patents from inventors and licensing the rights to commercializing entities. The evolution of PAEs has been remarkable in terms of their speed of ascendance and influence on business practices. In 2011, PAEs generated licensing revenues of over $29 billion (Bessen and Meurer 2012).

Although the growing influence of PAEs is indisputable, there is much debate as to whether they are beneficial or exploitative. Some argue they destroy value by enforcing frivolous patents and hampering legitimate commercialization (Blumberg and Sydell 2011, Reitzig et al. 2007). Others contend they incentivize innovation by offering inventors remuneration they could not obtain on their own (McDonough 2006). Irrespective of such debate, the growth of PAEs suggests that they fill a void left by other governance alternatives such as bilateral licensing agreements between inventors and commercializing entities, patent pools, and fully integrated ownership of patents and commercializing assets. Nonetheless, questions remain. When are PAEs likely to play a role in markets for intellectual property rights? Why has this relatively new type of organization evolved? What has precipitated their growth? In an attempt to provide some perspective on PAEs, we meld the measurement and governance branches of transaction cost theory to identify measurement challenges specific to intellectual property that lead to contractual difficulties, and compare how well various governance alternatives resolve these challenges. Although we acknowledge the traditional influence of asset specificity on governance efficiency, accurately measuring the value and use of intellectual property assets which can neither be seen nor touched can be particularly challenging and a primary source of transaction costs when contracting for such

assets. Although others have explored the allocation of intellectual property rights through market transactions such as bilateral licensing (Arora and Ceccagnoli 2006) and hybrid structures such as patent pools (Lerner et al. 2007, Shapiro 2001), a comprehensive assessment of the broader set of alternatives including PAE intermediation may provide insight as to when they are likely to be comparatively efficient and why they are playing a larger role in patent markets.

Our analysis takes into account two forms of asset specialization specific to patents, which influence transaction costs and governance efficiency. One form occurs between patents themselves (patent complementarity), and the second occurs between patents and other complementary assets used for commercialization (patent specialization). From this, we derive four general intellectual property configurations for commercialization that depict distinct relationships between the supply of existing patents and their demand. We consider the core activities of patent deployment, enforcement, and commercialization, and reflect on when it is likely to be most efficient for patent ownership to be held by inventors, commercializing entities, or PAEs. In doing so, we take into account how alternative governance arrangements influence transaction and production costs.

With some exceptions (Argyres and Liebeskind 2002, Jacobides 2005), the single transaction has been the typical unit of analysis when using a transaction cost framework. We adopt a system view and consider the incentives of a broader set of potential participants (inventors, commercializing entities, PAEs) attempting to appropriate value from intellectual property. Our analysis suggests that a *lack* of specialization between patents and complementary commercialization assets in conjunction with patent complementarity creates measurement challenges and generates costs that cannot be easily economized through firm integration or hybrid arrangements such as patent pools. In these instances, PAE intermediation can both alter how rents from intellectual property are spread across inventors and commercializing entities, and create an efficient system of intellectual property allocation.

Throughout our inquiry, we assume that all entities operate within a reasonably strong and consistent appropriability regime in terms of patent enforcement, and other than possibly infringing on the property rights of others, conduct themselves within the rules of the game. Once we establish conditions where PAE intermediation is likely more efficient than the alternatives, we consider how the deficiencies in the institutional process by which patents are granted, in conjunction with rapid technological evolution leads to such conditions. Patents are imperfect and incomplete contracts between inventors and society; PAEs can be viewed as either exploiting these imperfections (destroying social welfare) or lessening their influence (preserving social welfare).

We begin laying the groundwork for our analysis by describing property rights, transaction costs, and production specialization within the context of intellectual property.

Property Rights, Transaction Costs and Production Specialization

Formalized property rights are imperative to efficiently create value from combining assets (Barzel 1997). If for example there were no property rights associated with a particular piece of land, it would fall into the public domain and be subject to overuse. Only when ownership of the land and its attributes are defined can a land owner efficiently exchange with other input providers (e.g., labor) to combine assets and create valuable output such as crops.

Nonetheless, even with property rights in place, exchange can be costly when the attributes of the inputs are difficult for those other than their owners to accurately measure. The effort put forth by transacting parties to evaluate the inputs of their counterparts reduces any value created from their combination. Such transaction costs may be minimized by designing contracts that give residual value of the output created from the combination of inputs to the provider whose input is both consequential and costly for transacting counterparts to measure (Barzel 1997). For example, when the efforts of labor are difficult to measure and land quality is relatively easy to evaluate, a rental agreement that grants a fixed amount to the land owner and the residual value of the crop output to a laborer will dissuade the laborer from shirking. By reducing the need for the land owner to measure (at high cost) the laborer's effort, the value from combining land and labor to produce crops is optimized. In contrast, land quality may be misrepresented by self-interested landowners and difficult for others to measure independently. If the efforts of labor are relatively easier for the land owner to measure, a wage contract that grants a fixed payment to a laborer with the residual value of the crop accruing to the landowner may be most efficient. Under these terms, laborers will feel less compelled to expend costly time and energy evaluating land quality, costs that detract from the value of combining land and labor.

How contracts are designed influence not only transaction costs, but also production costs and the potential to realize economies from production specialization. If input providers can easily measure and evaluate the inputs of their counterparts, each provider could then specialize in their respective activity and generate production efficiencies by operating at an efficient scale. For example, landowners may specialize in managing their land holdings and deploy them through rental agreements, whereas their tenants specialize in crop production. If inputs cannot be easily measured by others,

the cost efficiencies from production specialization may be outweighed by the costs of input providers having to vigilantly evaluate the complementary inputs of others. In essence, the activities of land management and crop production are integrated within one economic entity if the sum of management and production costs within that entity are less than the sum of transaction and production costs that occur with a rental arrangement (Williamson 1979). Management costs arise from having to incentivize and measure employee performance, and resolve disputes through fiat. Transaction costs arise from firms having to identify exchange partners, measure the value of their respective inputs to determine equitable prices, and resolve contractual disputes through a court of law.

In an ideal world where it is costless for input providers to evaluate the inputs of their counterparts, economic entities specialize in a narrow activity and rely on market exchanges to secure inputs and to sell output. Multiple independent entities could devote their efforts toward a given solitary activity, conduct it at the optimal scale, and fully realize all efficiencies from production specialization. Market forces alleviate the challenges of pricing inputs; the flexibility to switch exchange partners ensures that downstream firms receive quality input at competitive prices. When there are few transaction costs, organizing transactions within the firm where multiple activities are coordinated by internal management is inefficient because of the inherent benefits of market exchange and production specialization (Williamson 1991).

Such logic also applies when combining *intellectual* property and commercialization assets. By drawing legal boundaries around intellectual property and establishing ownership rights, patents place value that would otherwise be in the public domain into private control. Whether intellectual property is patented determines in part the type of governance that is most efficient for combining intellectual property with complementary commercialization assets. If for example, intellectual property is secured solely through trade secrets, providers of such intellectual property may be reluctant to disclose its innermost details for fear of being taken advantage of and losing the opportunity to fully appropriate value from such intellectual property (Gans et al. 2002, Merges 1994). Similar to prospective tenants trying to measure the quality of land from owners who are not forthcoming regarding its attributes, it is difficult for prospective providers of commercialization inputs to evaluate the quality of intellectual property if its details are not adequately disclosed by its providers. In these cases, the most efficient means of combining such intellectual property with complementary inputs is often through fixed payment wage contracts whereby the providers of intellectual property and commercialization assets are integrated within the same organization.

By codifying intellectual property and establishing ownership, patents facilitate disclosure, making it easier for prospective providers of complementary inputs to evaluate the intellectual property contained within them. In such cases, arms-length licensing agreements may be more efficient than wage contracts. Analogous to rental agreements between landowners and tenants, licensing agreements occur between patent owners and commercializing entities which, for a fixed fee, are granted the majority of residual rights to the value of the combination of assets.

Notably, by alleviating transaction costs caused by measurement challenges, patents enable firms to specialize in either invention or commercialization. Such specialization not only leads to scale efficiencies in production, but also facilitates the use of refined and targeted incentives. Such incentives are particularly consequential for invention; it is often difficult for integrated firms that invent *and* commercialize to maintain dual incentives to motivate both their inventors and those involved in commercialization activities (Milgrom and Roberts 1990). The political sway of those directly involved with commercialization often gives way to uniform incentives that maintain the primacy of commercialization personnel over inventors. Firms that specialize in discovery can provide university-like environments supportive of inventor productivity that large integrated firms, frequently rife with competing interests and internal politics, are unable to duplicate (Argyres and Liebeskind 2002).

Transactional Frictions in Patent Markets

Establishing ownership rights to intellectual property through patenting can encourage its disclosure, diminish the transaction costs of combining intellectual property with commercialization assets, and enable firms to attain production efficiencies through specialization. Nonetheless, patentable discovery and commercialization activities are often integrated within one economic entity, suggesting that measurement challenges persist despite the clarity and protection provided by patents. Dissecting the invention-commercialization value chain, and taking into account intermediary activities associated with owning patents, provide further insight into potential impediments to forging bilateral licensing contracts directly between those that discover patentable inventions and those that commercialize them. *Deploying* patents entails managing how best to appropriate value from them through their legitimate combinations with commercialization assets. *Enforcing* patents entails monitoring for their illegitimate combinations with commercialization assets (i.e., infringement) and all associated litigation. Patent ownership confers discretion over their deployment and enforcement.[1] Similar to the activities of invention and commercialization, costs associated with patent deployment and enforcement can be economized through specialization and scale. The extent to which measurement challenges arise when deploying and enforcing patents depend on their relationship to other patents and complementary commercialization assets.

Patent Complementarity

Although securing ownership over intellectual property through patenting enhances disclosure of the intellectual property contained in the patent, measuring the value of any one patent remains challenging. By design, a patent grants ownership over a relatively unique piece of intellectual property; there are few points of comparison for which to benchmark its value. Unlike commodity products where highly liquid markets signal their fair value, precise pricing signals rarely exist for patents (Hagiu and Yoffie 2013). These measurement challenges are further exacerbated when the value of a given patent depends on whether it is combined with other patents. We refer to highly cospecialized relationships among patents as *patent complementarity*. Commercializing products without rights to all relevant patents in the bundle can lead to claims of infringement by the owners of these complementary patents. Each individual patent holds little independent worth; only the full bundle of complementary patents has value.

The effort that prospective providers of commercialization assets need to expend to accurately evaluate a bundle of complementary patents may be considerable. Simply identifying the full portfolio of patents needed for commercialization pursuits may be difficult, particularly when patent owners are geographically dispersed (Arora et al. 2004). Even if all relevant patents can be identified, transacting with each owner can be costly. Because the marginal contribution of each patent to the bundle is difficult to measure, individual owners are more likely to haggle over the price for their respective patents; coordination and negotiation costs are exacerbated (Hagiu and Yoffie 2013). When two or more patents owned by independent price-setting patent owners are needed to create a product, each owner can apply their own monopolistic markup, inflating the costs of attaining the needed rights (Gilbert 2004).

In general, patent complementarity can make it difficult for providers of commercialization assets to accurately value individual patents. Such measurement challenges and associated transaction costs are likely to hamper the efficiency of bilateral licensing agreements between inventors and commercializing entities, giving rise to alternative arrangements that are more efficient.

Patent Specialization

Regardless of whether patents create value independently or in conjunction with complementary patents, they vary in their commercial breadth. Highly specialized patents have a limited number of commercial applications. For example, a patent covering the use of a molecule to treat heart disease cannot likely be used for any other purpose. Other patents or patent bundles can be applied more broadly, such as those associated with microelectronic technologies (Arora et al. 2004). These patents can be combined with a variety of componentry to create a diverse set of products in multiple industries.

Owning patented intellectual property is profitable only if its use is effectively measured and monetized. Deliberate or unintentional infringement of patented inventions by commercializing entities leads to substantial economic losses for inventors and their noninfringing licensees (Eisenberg 2011). One source of infringement is when current licensees adapt their existing product lines or develop new ones, and use licensed intellectual property beyond the scope of their licensing agreements. To restore the legitimacy of their use, original licensing agreements often need to be renegotiated. Monitoring the behavior of licensees is necessary to limit infringement and losing value to the public domain. When the cost of measuring such infringement and renegotiating licensing agreements are substantial, the value from combining patented intellectual property with commercialization inputs through licensing agreements shrinks. Alternative governance arrangements may become more efficient.

However, acts of infringement are not limited to current licensees. In contrast to physical assets, intellectual property is nonrivalrous in that many individuals may use the same intellectual property unbeknownst to its rightful owners or other legitimate users (Romer 1990). Thus, measuring infringement entails monitoring not only those contractually permitted to use specific patents in a limited way, but also those that have no contractual permission whatsoever. To the degree that the patent in question is broadly applicable to a wide swathe of industries and products, measuring the full extent of infringement becomes costly because of the sheer number of potential infringers. The expense of accurately measuring infringement when there is limited patent specialization is further heightened when patent bundles are involved. In the absence of one-to-one correspondence between patent and product, assessing the range of patent infringement may require specialized personnel to deconstruct a broad array of complex products such as computers or telecom equipment (Ludlow et al. 2008).

Even after infringement is detected, enforcing patent rights and pursuing equitable compensation can be expensive. Measuring the value of the infringed patent in relation to other patents and commercialization assets used to develop the infringing product, and determining damages can be difficult for patent owners. Although they can threaten legal recourse, the high cost of litigation with uncertain outcomes combined with limited resources of many inventors reduces the credibility of such threats. As a result, many patent owners either abandon all hope of patent protection (Rosenkopf and Nerkar 2001), tolerate high levels of infringement (Cohen et al. 2000), or sell their patents to firms that can efficiently enforce them (Galasso et al. 2013).

Table 1 Intellectual Property Configurations for Commercialization

Patent complementarity	Patent specialization	Supply of patents	Commercial demand for patents	Examples
Low	High			Drug molecules
Low	Low			Aerosol spray
High	High			Insect/weed resistant crops
High	Low			Field programmable gate arrays

Note. ◆, patent; •, commercial application.

In general, the *lack* of patent specialization increases the cost of measuring infringement and assessing its damages. As with most activity costs, these enforcement costs can be economized through scale efficiencies in operations.

Intellectual Property Configurations for Commercialization

By taking into account both patent complementarity and patent specialization, we derive four intellectual property configurations (depicted in Table 1) that delineate the relationship between the supply of patents and their demand in terms of commercialization opportunities.

Low Patent Complementarity/High Patent Specialization

In the simplest type of configuration, patent complementarity is low where the value of a patent is not based on bundling opportunities with other patents, whereas patent specialization is high where a patent's potential value is limited to a narrow set of commercialization processes. In essence, the supply-demand relationship involves unbundled patents with a narrow commercialization corridor. Patented molecules used for drug development typically fall under this configuration; the applicability of a molecule used to treat a specific ailment is clearly limited. In addition, the single patent/molecule stands on its own in terms of its value in commercialization.

For example, a therapeutic drug for the treatment of AIDS protected by U.S. Patent No. 7,514,085 (i.e., immune modulating compounds from fungi) is based on an extract of a certain type of mushroom. This drug was developed specifically to control the growth of the AIDS virus and normalize the immune response of a patient. The patent can be deployed only in the production of a class of drugs that have only one use—treating AIDS. The chemical industry yields several similar single-use examples.

Low Patent Complementarity/Low Patent Specialization

Another intellectual property configuration occurs when there is neither patent complementarity nor patent specialization; there is little in the way of bundling of intellectual property, and the knowledge contained in those assets can be used in a broad array of commercialization processes.

A patent related to the method and means for atomizing or distributing liquid or semiliquid materials illustrates the idea of this configuration. Otherwise known as the aerosol spray, U.S. Patent No. 1800156 was granted in 1931. The value generated to date from the aerosol spray does not depend on complementary technologies, whereas its function is applicable to products ranging from fire extinguishers to beverage and pharmaceutical dispensers.

High Patent Complementarity/High Patent Specialization

A third configuration occurs when both patent complementarity and patent specialization is high; a bundle of complementary patents are needed to create a product where its use is restricted to a limited set of commercialization processes and product lines. Crop technologies provide relevant examples of this type of intellectual property. Bayer has developed LibertyLink® technology making crops resistant to pigweed (U.S. Patent No. RE36449), whereas Monsanto's Intacta RR2 Pro™ technology is intended for making crops insect resistant (U.S. Patent No. 6982367). The value of the technologies depends on whether they are used together to make crops resist both weeds and insects (*PRNewswire* 2013). Yet this combination has a limited and specific use of creating pest-resistant soybean and corn.

High Patent Complementarity/Low Patent Specialization

In the final configuration, patent complementarity is substantial whereas patent specialization is minimal; patent

bundling is necessary to create value for commercialization, and such bundles are applicable to a broad array of commercializing entities. For example, dynamic integrated circuits are used in a wide range of product markets. Field Programmable Gate Array (FPGA) technology (U.S. Patent No. 5,687,325) allows an integrated circuit to be configured by a customer or a designer after manufacturing. FPGA technology relies on a bundle of complementary patents. Most manufacturers require energy-efficient programmable logic devices, thus the value of FPGA's is contingent on complementary power control technologies for integrated circuits (e.g., U.S. Patent No. 5,675,808, U.S. Patent No. 6,993,669). Furthermore, FPGA technology has low specialization as it is embedded in products related to the automotive, telecom, wireless, defense, and broadcast industries.

Alternatives for Allocating Intellectual Property Rights

Our analysis considers the organization of value chain activities for patents that have been granted—that is, their deployment, enforcement, and commercialization. Patent ownership, and thus discretion over its deployment and enforcement, may be held by the inventor, an independent distributor, or a commercializing entity. In bilateral licensing arrangements, deployment and enforcement activities conferred through ownership reside with the inventing entity; market contracts mediate the direct relationship between the inventor and the commercializing entity. With firm integration, patent and commercialization assets are owned by one entity responsible for a patent's deployment, enforcement, and commercialization. Patent pools entail shared deployment and enforcement amongst participating pool members. PAE intermediation occurs when PAEs secure patent ownership and specialize in deploying and enforcing them, licensing their rights to commercializing entities.

When deploying and enforcing patents entail few measurement challenges, bilateral licensing agreements between inventors and commercializing entities would yield the most efficient outcome. Market forces provide clear price signals and transaction costs are held in check. However, when there are substantial measurement challenges associated with patent deployment and enforcement, greater efficiency may be derived from governance alternatives that economize these costs. As discussed below, each alternative brings its own set of costs and benefits.

Firm Integration

One means of mitigating the transaction costs associated with bilateral licensing agreements is to integrate patent deployment, enforcement, and commercialization within one entity that purchases outright the patents it needs for its commercialization activity. In such cases, whenever commercializing units within the firm uncover new applications for the patents owned by the firm, there is no need to renegotiate contractual restrictions as would be the case with bilateral licensing arrangements. Those who deploy patent rights and those who commercialize products based on these patents are on the same team. Instead of relying on market contracts to mediate the relationship between patent owners and commercializing entities, internal fiat is used (Masten 1988). Measuring infringement by would-be licensees is a nonissue, and any associated transaction costs can be avoided.

However, there are countervailing costs from integrating patent deployment and commercialization that limits the prevalence of this type of integration; in such cases, high-powered market forces and fine-tuned incentives are attenuated. Similar to the difficulties associated with integrating invention and commercialization activities (Argyres and Liebeskind 2002), efficiently integrating patent deployment and commercialization within one firm can be hampered by competing internal incentives. Managers responsible for product commercialization are typically incentivized to maximize profits from their respective product lines; thus, they are motivated to suppress outside competition by restricting the licensing out of owned patents to others, even if such licensing would enhance profits overall (Fosfuri 2006). Because patent-owning commercializing entities primarily focus on generating revenues from products developed internally, they tend not to vigorously pursue licensing revenues, leaving money on the table by not fully appropriating the value of their patents (Arora et al. 2004, Chien 2010). All else being equal, it is more challenging to motivate those responsible for deploying patents to fully appropriate the value from these patents if they are employed by an integrated firm (those that deploy, enforce, and commercialize) than a specialized firm that depends solely on licensing revenues for survival. Integrated firms either incur the costs of implementing managerial control systems to measure and incentivize patent deployment professionals or accept the lost revenues from not fully appropriating patent value. The net difference in costs between firm integration and bilateral licensing agreements is the transaction cost savings realized from integrating deployment and commercialization minus any costs from compensating for the loss of market incentives by instituting managerial control systems to monitor and incentivize deployment professionals, or the lost revenue from not fully appropriating patent value.

Although integrating patent deployment, enforcement, and commercialization would eliminate the need to measure infringement by those firms that would otherwise have been licensees, it does little to economize the costs of measuring infringement more broadly by those firms who might never have been licensees. Whether patents are owned by an entity specializing in invention or an

integrated firm, the costs of contending with infringement by likely nonlicensees remain.

Patent Pools

Patent pools are collaborative arrangements formed by partner firms that contribute their relevant patents to a jointly owned organization that bundle them together and then license the bundle back to members for commercialization. Thus, responsibility for patent deployment and enforcement is shared among members of the pool. Patent pools benefit member firms by eliminating the need to negotiate multiple contracts or renegotiate them when new commercialization opportunities arise. Measuring the contribution of each patent relative to the bundle is a one-time setup cost for the pool. By offering a standard priced single-bundle license contract (Lerner et al. 2007), patent pools avoid the costs from measuring the value of the bundle relative to each members' commercialization processes or customizing the bundle to individual members' needs. However, similar to the case of integrated firms, the motivation to fully exploit the licensing revenue potential from intellectual property controlled within a patent pool is muted. The primary mission of a patent pool is to provide its members access to the intellectual property within its domain with a single price license to the entire bundle; maximizing returns from licensing arrangements with those outside of the pool is secondary.

As compared to firm integration which eliminates the costs of coordinating and negotiating with multiple owners by fully integrating patent deployment and commercialization within one entity, some coordination challenges remain for patent pool members. To obtain higher revenues from their patents, some pool members may conceal their complete holdings of complementary patents until pools have been formed. To protect the collective membership from opportunistic members, elaborate contractual safeguards need to be established and enforced (Joshi and Nerkar 2011). Thus, although transaction costs associated with patent pools are lower than they would be if each member contracted with each other member bilaterally for patent rights, they are more than what would occur if all patents were owned by one entity.

Patent pools are a hybrid form of governance where transaction costs are at an intermediate level between the costs that occur through bilateral licensing contracts and those through firm ownership of intellectual property. However, similar to firm integration and bilateral licensing arrangements, patent pools do little to limit the costs of monitoring infringement by firms outside the pool. They typically lack specialized capabilities to efficiently detect and litigate infringement.

PAE Intermediation

PAEs are a breed apart from inventors and commercializing entities. They generally operate in a manner similar to venture capital and private equity funds by raising money from both corporate and institutional investors to buy assets from those who would have difficulty monetizing them on their own. However, rather than purchasing equity in early stage companies, PAEs buy patents from individual inventors, corporations, universities, and government research labs, and license them to commercializing entities. Table 2 lists some of the leading PAEs in terms of patent holdings. Notably, none of them existed prior to the year 2000.

PAEs are fluidly structured, mixing and matching personnel to create temporary teams composed of technology and industry specialists, and other functional generalists.[2] Their activities include patent procurement, deployment (licensing), and enforcement (infringement detection, litigation). Procurement professionals are technology specialists who have in-depth expertise in a narrow technological domain, and are responsible for negotiating with inventors and purchasing patents. Licensing professionals have general expertise in crafting and negotiating licensing agreements with commercializing entities for a broad range of technologies. To detect any infringement of their patent holdings, PAEs employ industry specialists who reverse engineer commercial products within their industry of specialization and map patent claims onto these products. Because patented technologies may be used across multiple industries, those responsible for detecting infringement within their designated industry work closely with in-house technology specialists. A team of lawyers is responsible for pursuing suspected infringers in hopes of a settlement, or as a last resort, in a court of law. Although salaries and bonuses for these professionals are based on how well they work together and contribute to PAE revenue, one PAE executive described how his firm relies on a selection process to ensure motivated employees; only true believers in the mission of creating a new and socially beneficial model for patent markets are hired.

Opportunities to share best practices from operations in one technological domain to another are prevalent for licensing and litigation. For example, professionals creating licensing contracts or litigating infringement for telecommunication technologies can apply much of what is learned from licensing and litigating software technologies. Such opportunities are less prevalent in procurement and infringement detection, where expertise is specific to a technology or industry.

PAEs function as distributors that intermediate relationships between inventors and commercializing entities. In general, distributors enhance efficiency by matching the supply of varietal goods from multiple providers to the demand for this variety from individual consumers. Without them, providers and consumers would have to contract directly with each other, resulting in numerous transactions. For example, five consumers contracting individually with five single-good providers

Table 2 Leading Patent Assertion Entities

Entity	U.S. patent holdings[a]	Focus[b]	Year of founding[b]
Intellectual Ventures	25,000	Networking, semiconductors, biomedical, energy, software	2000
Round Rock Research	3,500	Semiconductors	2010
Rockstar Consortium	2,400	Networking, Internet	2011
Conversant Intellectual Property Management	2,200	Semiconductor memory, networking, automotive	2007
Acacia Technologies	1,700	Automotive, medical, networking, computers	2000
Unwired Planet	1,100	Mobile Internet	2000
IPG Healthcare	1,050	Software, electronics	2008
Global OLED Technology	800	Organic light emitting diodes	2009
Scenera Research	350	Software, location based services, Internet, computers	2002

[a]Patentfreedom.com.
[b]Company websites.

would generate a total of twenty-five transactions; a single distributor performing the bundling function would reduce this total to ten—five for the providers and five for the consumers.

Similarly, PAEs can reduce the number of transactions for patent deployment which would otherwise occur through bilateral licensing agreements between inventors and commercializing entities. Within a PAE, industry and technology specialists work closely to identify industry trends, patent clusters, and potential licensing opportunities that drive patent procurement. Licensing professionals can then mix these patents into bundles that meet the needs of licensees. Commercializing entities benefit from one-stop shopping for intellectual property, reducing the costs of locating relevant intellectual property and its owners; inventors benefit from not having to market their patented intellectual property directly to potentially a vast array of commercializing entities (Coughlan 1987).

The bundling function provided by distributors is particularly beneficial when it also economizes transaction costs from having to measure and price hard-to-value goods (Kenney and Klein 1983). De Beers, the primary distributor of raw diamonds, exemplifies how a distributor can diminish such measurement issues through bundling. Although each diamond in a given bundle may be above or below the bundle average for the various attributes (e.g., shape, quality, color), bundle price is based on average attributes. De Beers prevents buyers from disaggregating a bundle into individual diamonds and haggling for lower prices. Although buyers overpay for diamonds of quality below the bundle average, and underpay for those above the bundle average, the purchasing process is simplified.

Measuring patent value can be even more difficult than it is for diamonds because of the potential for complementarity between them. PAEs provide simplifying pricing services similar to De Beers. Following the initial identification of possible distribution opportunities by industry and technology specialists, licensing professionals work closely with reverse engineering teams to spot potential infringers and additional sources of revenue for a prospective patent bundle. By developing relatively precise estimates of the value of these patent bundles, revenue models are generated. With the aid of these models, and working alongside industry experts, procurement professionals assess the marginal contribution of the various patents to their respective bundles, and negotiate sale prices with inventors. Through PAE intermediation, inventors no longer have to coordinate with other inventors of complementary patents or measure the value of their patents for various applications. Likewise, commercializing entities are spared from having to assess the value of each patent within a bundle of desired patents.

Moreover, PAEs economize the costs of patent deployment and enforcement through their scale of operations and any learning that occurs through repeated deployment and enforcement. Because PAEs specialize in patent deployment and enforcement, their efficient scale of operations is determined by these activities; professionals conducting them can be employed at an efficient scale. In contrast, when deployment and enforcement is integrated within firms that also commercialize, the efficient scale of operations is more likely determined by the activity of commercialization, the dominant activity in terms of capital intensity. For example, assume that the efficient scale for the commercialization efforts of a commercializing entity is ten products that are based on a relatively limited number of patents owned by the commercializing entity. In such cases, employing deployment and enforcement professionals at an efficient scale may not be viable with so few patents. The same is likely true for entities specializing in discovery; their efficient scale in terms of producing patentable inventions is not likely to match that which is needed to achieve efficiency in patent deployment and enforcement. Unimpeded by discovery and commercialization pursuits, PAEs have the flexibility to optimally scale their operations.

Although large integrated firms (e.g., IBM) may have the necessary scale of patent holdings to *potentially* achieve patent deployment and enforcement efficiencies

similar to PAEs, their lack of specialization hampers their ability to do so for two reasons. First, the incentive to fully appropriate value from a patent will be somewhat diluted for integrated firms because their survival is buffered by their commercialization pursuits. In contrast, PAE survival rests solely on monetizing patents through licensing revenues by means of effective patent deployment and enforcement; market incentives remain intact. Second, the commercialization activities of integrated firms further weakens their ability to enforce the patents they own because their products render them potential targets of countervailing infringement claims. By not pursuing commercialization, PAEs avoid such dynamics and have greater bargaining power vis-à-vis infringing parties to secure licensing revenues.

The source of PAE efficiencies lies not only in their specialization in patent deployment and enforcement, but also the tight coordination of these appropriately scaled activities. Deployment and enforcement can become mutually fortifying in a virtuous circle. With each deployment of a patent or patent bundle through licensing, licensing professionals broaden their understanding of its commercial breadth and possibly identify ancillary commercial applications. Such information aids patent enforcement professionals in detecting prospective infringers and pursuing additional licensing opportunities, providing further insight into additional commercial applications.

Overall, PAEs convert the costs of patent deployment and enforcement from what would otherwise be viewed as transaction costs associated with licensing agreements between inventors and commercializing entities, into an efficient production function. They enable the most granularity in terms of production specialization; inventors focus on invention, PAEs are responsible for patent deployment and enforcement, and commercializing entities concentrate on commercializing the patents they license.

However, PAE intermediation adds another point of costly bureaucracy between inventors and commercializing entities. PAEs incur management costs to measure employee performance and incentivize them to fully monetize their portfolio of patents—costs that detract from the value of combining intellectual property and complementary inputs for their commercialization. Such costs may not be justified in conditions where PAE intermediation does not generate substantial efficiency gains.

An Analysis of Governance Alternatives

When might each governance alternative dominate the others in terms of efficiently allocating intellectual property rights? Comparative economic organization evaluates the mix of conditions (in our case, intellectual property configurations) and governance alternatives that are most efficient in terms of minimizing total costs including transaction, management, and production (Williamson 1991). Costs associated with patent deployment, enforcement, and commercialization will depend on the intellectual property configuration and the governance alternative used to allocate patent rights.

Low Complementarity/Low Specialization

When patents do not need to be combined with others to create value, and are broadly applicable across a variety of products and industries, bilateral licensing arrangements between inventors and commercializing entities are likely the most efficient means for allocating patented intellectual property. Because patent complementarity is low, commercializing entities do not face the prospect of having to haggle with multiple owners of complementary patents. Moreover, measuring the marginal contribution of each patent to the value of commercialized products is comparatively trivial when there are few complementary patents to account for. Because patents in this configuration are applicable to a broad array of industries and potential licensees, high-powered market forces maintained through bilateral licensing agreements are particularly critical for efficient patent deployment. Integrating patent ownership and commercialization within a firm is likely to lead to money being left on the table because integrated firms emphasize revenues from their own commercialization activities at the expense of pursuing supplementary licensing revenue.

Nonetheless, bilateral licensing agreements for patents in this intellectual property configuration incur transaction costs from inventors having to monitor their licensees for infringement, and renegotiate contracts as licensees uncover unanticipated opportunities to use the intellectual property. Ownership of these patents by commercializing entities tightly integrates their deployment and commercialization, reducing such transaction costs. However, renegotiating with licensees is reasonably straightforward because of a one-to-one correspondence between patent and product (i.e., low complementarity), and the ease of measuring the contribution of these patents to the value of final products. Avoiding these nominal transactions costs by integrating patent ownership and commercialization is not likely worth foregoing powerful market incentives that are maintained through bilateral licensing arrangements, and encourage relatively efficient patent deployment. Unburdened from having to deploy and enforce patents, licensees can focus solely on their commercialization pursuits and scale their operations accordingly.

Because patent bundling is unnecessary, the management costs associated with either patent pools or PAE intermediation are not justified. When patented intellectual property is applicable to a wide range of products and industries, there is an increased risk of infringement by entities other than licensees; PAE intermediation

could potentially economize on the costs of enforcement through scale efficiencies. However, because there is a one-to-one correspondence between patent and product, infringement and its damages will be relatively easy to measure. Potential infringers will be deterred because proving their infringement would be relatively straightforward.

Overall, the costs to deploy and enforce patents in this configuration are a small percentage of total costs and can be borne by inventors, even if conducted somewhat inefficiently (relative to PAE intermediation). In sum, total costs comprising management, transaction and production costs across the three types of entities (i.e., inventor, distributor, commercializing entity) are minimized when patents in a low complementarity/low specialization configuration are owned by inventors and licensed directly to commercializing entities. Recent empirical evidence supports the notion that general purpose technologies with relatively few interdependencies (e.g., software security algorithms) are exploited primarily through bilateral licensing agreements (Gambardella and Giarratana 2013).

Proposition 1. *When both patent complementarity and patent specialization are low, bilateral licensing agreements between inventors and commercializing entities are the most efficient means to allocate intellectual property rights, relative to the alternatives.*

Low Complementarity/High Specialization

Similar to when patents have low complementarity with other patents and have extensive commercial applications (i.e., low specialization), when they have low complementarity and have limited commercial applications (i.e., high specialization), patent pools offer little benefit; avoiding onerous transaction costs associated with measuring the marginal value of complementary patents and negotiating with multiple owners is immaterial. By specializing in enforcement at an efficient operational scale, PAE intermediation could potentially economize on monitoring for their infringement and associated litigation. However, because patent complementarity is low and there is a one-to-one correspondence between patent and product, detecting infringement and determining damages are relatively easy. Moreover, the number of potential infringers is limited due to the patent's narrow applicability. In such cases, the use of PAEs would involve costly intermediation and bureaucracy in exchange for little benefit.

Whether bilateral licensing or firm integration is more efficient for low complementarity/high specialization patents depends on whether there would be mutual dependence between the owners of such patents and the owners of commercializing assets. If the value of a patent asset depends on whether it is combined with a specific set of commercialization assets, and the value of such commercialization assets also depends on whether it is combined with the specific patent asset, none of these assets could easily be reassigned for alternative uses (Teece 1986). Such asset specificity and the mutual dependency it creates between transacting parties exacerbate transaction costs by forcing both parties into a small numbers bargaining situation. If contractual changes become necessary, opportunistic partners can take advantage of those that have few alternative uses for their customized assets, and are locked into the relationship. Any losses suffered by each contracting party from haggling diminish the value created from combining their assets. To keep such opportunistic behavior in check, elaborate ex ante contractual safeguards and contingency clauses may be instituted and expensive ex post monitoring conducted to ensure that one's exchange partner is not being exploitive. At some point, transaction costs become so burdensome that firm integration where disputes are resolved by fiat may be more efficient than market contracts.

Transaction costs resulting from specificity between patents and commercialization assets are a function of *mutual* dependency. If either the patent or commercialization assets can be easily reassigned for alternative uses, the incentive to integrate the ownership of patent and commercialization assets is absent for at least one transacting party. When a patent is applicable to a broad array of product lines and industries as with the previous configuration, opportunities to reassign it to alternative uses are plentiful; the value of the patent will not be dependent on specific commercialization assets and there is little risk of mutual dependency. However this is not the case when a patent has narrow commercial applicability; mutual dependency between patent and commercialization asset owners is a real possibility. Integrating patent ownership with commercialization when there is mutual dependency will squelch the high-powered market incentives that would have existed through bilateral licensing. Yet, because these patents hold little value unless they are combined with a specific set of complementary assets, deployment opportunities beyond the integrated firm's commercialization pursuits are few; the risk of an integrated firm leaving money on the table by underdeploying the patents they own is low, rendering costly internal incentive structures for patent deployment unnecessary. When the value of both low complementarity/high specialization patents and the assets to commercialize such patents are highly dependent on them being combined specifically with each other, integrating patent ownership with commercialization activities is likely to be more efficient than bilateral licensing. Total costs across the three entities potentially involved (i.e., inventor, distributor, commercializing entity) are minimized.

As described above, drug molecules fit within the low complementarity/high specialization configuration.

To avoid small numbers bargaining situations, drug manufacturers that make molecule-specific investments in testing and branding often prefer outright ownership of drug molecule patents prior to commercializing them (Lerner and Merges 1998). Integrated ownership of a patented drug molecule and its dependent commercialization assets will likely occur if the value of the patented molecule is also highly dependent on being combined with such assets. Because of the low cost of detecting infringement and determining damages, these activities can readily be conducted in-house, albeit inefficiently as compared to when done by PAEs.

Proposition 2A. *When there is substantial specificity between low complementarity/high specialization patents and commercialization assets, integrating patent ownership and commercialization is the most efficient means to allocate intellectual property rights, relative to the alternatives.*

When there is no mutual dependence between the owners of low complementarity/high specialization patents and the owners of commercializing assets, bilateral licensing agreements between inventors and commercialization entities are likely to be most efficient.

In such cases, the benefits of maintaining market incentives for the deployment of patent assets and/or their complementary commercialization assets are likely to outweigh any transaction cost savings from integrating patent ownership and commercialization. In the instance where the value of these patents does not depend on them being combined with a specific set of complementary assets, inventors deploying them through bilateral licensing have the flexibility to reassign them to alternative uses if necessary. The contractual challenge of small numbers bargaining is diminished and alternative licensees within the same narrow commercial application can readily be pursued. High-powered market incentives ensure that such patents are deployed efficiently and their full value is appropriated by inventors.

Likewise, if the value of commercialization assets does not depend on them being linked with specific low complementarity/high specialization patents, owners of such assets can easily reassign them to alternative uses if necessary. By contracting for the requisite patent rights as opposed to securing patent ownership, commercializing entities are not saddled with patent deployment and enforcement responsibilities, and can reap the cost benefits from specializing in commercialization. The patent protecting the method for DNA cloning (US4237224) is one example of a patent that has value independent of other patents, and is highly specialized for a narrow application, yet deployed through bilateral licensing. This cloning method is used in conjunction with generic laboratory assets that can easily be reassigned. As a result, inventors and patent owners Stanley Cohen of Stanford and Herbert Boyer of University of California established a licensing program that has led to over 450 license agreements and generated over $255 million in revenues since the patent was granted in 1980.

Proposition 2B. *When there is little specificity between low complementary/high specialization patents and their complementary commercialization assets, bilateral licensing agreements between inventors and commercializing entities are the most efficient means to allocate intellectual property rights, relative to the alternatives.*

High Complementarity/High Specialization

When patents have high complementarity with other patents and such bundles have limited commercial application, patent pools are particularly efficient in allocating intellectual property rights compared with alternatives. In such a configuration, transaction costs associated with bilateral licensing would be extensive because of the need for bundling; each viable commercializing entity would have to identify and transact with individual patent owners. Because accurately measuring the marginal value of each patent to the value of the entire patent bundle is difficult and fraught with error, each patent owner represented in a patent bundle may haggle over price with the other patent owners and commercializing entities in an attempt to extract greater licensing fees.

Patent pools mitigate such costs through bundling. They provide a coordinated pricing mechanism to reduce losses stemming from independent price setting by multiple patent holders. For example, the sewing machine wars that occurred in the early 1850s threatened to stop all sewing machine production because of constant infringement litigation between the major manufacturers (Lampe and Moser 2010). To resolve these disputes, the I.M. Singer Company and three other manufacturers created the first patent pool in 1856 by pooling their nine complementary patents essential to manufacturing a sewing machine. Doing so lowered overall licensing fees and associated transaction costs. Licensing fees that were collected were used to protect this pool of patents from being infringed by nonmembers.

Integrating deployment, enforcement, and commercialization of such patent bundles within a single firm would completely alleviate the costs of coordinating multiple patent owners, but at the expense of relatively stronger market incentives within patent pools to efficiently deploy bundled intellectual property. Relying on the independent distribution capabilities of PAEs offers another alternative for patents that have high complementarity and limited commercial application. Although AEs can coordinate pricing across inventors and efficiently bundle patents, they do so at higher management costs than patent pools. The overhead from relying on specialized deployment and enforcement capabilities

found within PAEs to allocate intellectual property is not likely justified when bundled patents have few commercial applications. The number of potential infringers will be restricted, and the costs of monitoring infringement and any subsequent litigation will be a small percentage of total costs.

Total management, transaction and production costs across the three entities possibly involved (i.e., inventor, distributor, commercializing entity) are minimized when patents associated with a high complementarity/high specialization configuration are allocated through patent pools.

Proposition 3. *When both patent complementarity and patent specialization are high, patent pools are the most efficient means to allocate intellectual property rights, relative to the alternatives.*

High Complementarity/Low Specialization

Scale efficiencies in patent deployment and enforcement provided by PAEs will be most beneficial when these costs comprise a large percentage of total costs. A mismatch between the efficient scale for inventing and the efficient scale for patent deployment/enforcement, as is likely to occur through bilateral licensing agreements between inventors and commercializing entities, will be particularly costly when patents need to be bundled, and these bundles are broadly applicable across a variety of industries and product lines. Under such conditions, patent deployment costs in terms of identifying complementary patents, measuring marginal patent values, and negotiating with multiple parties are likely to be substantial, along with any savings from scale efficiencies. Through unified ownership and patent bundling, PAEs reduce the total number of transactions that would otherwise occur through bilateral licensing; haggling between individual inventors, and between inventors and commercializing entities is inhibited; pricing challenges that plague patent bundles diminish. Employing a cadre of professionals to efficiently create and price customized bundles of patents is viable when their cost can be spread over a large array of patent bundles, commercial applications, and licensees.

Likewise, scale efficiencies in patent enforcement are particularly valuable for patent bundles that have broad commercial applicability. Enforcement costs will be a significant component of total costs when the potential pool of infringers is expansive, and measuring infringement damages for each patent is difficult due to it being one component of a larger bundle. By specializing in enforcement, PAEs can more efficiently enforce broadly applicable patent rights than can individual inventors. It is the combination of high patent complementarity (generating high deployment costs) and low patent specialization (generating high enforcement costs) where the scale efficiencies of PAEs provide the greatest payoff in cost reduction vis-à-vis bilateral licensing. By maintaining separation between patent deployment and commercialization, PAE intermediation preserves the market incentives associated with bilateral licensing to fully deploy patent rights, while shedding the scale inefficiencies associated with bilateral licensing where invention and patent deployment/enforcement activities are integrated.

Integrating patent ownership and commercialization is also likely to be relatively inefficient vis-à-vis PAE intermediation when patents need to be bundled, and these bundles are broadly applicable. Similar to the mismatch in efficient production scales between the activities of invention and patent deployment/enforcement, any mismatch in efficient production scales between commercialization and deployment/enforcement will be relatively costly for patents in this configuration. A commercializing entity could acquire additional patents beyond what is needed for their commercialization in an attempt to establish scale efficiencies in patent deployment/enforcement. Moreover, large-scale commercializing entities with extensive patent portfolios would appear to have the requisite scale to efficiently deploy and enforce any patents they may wish to own. However, combining deployment and commercialization dilutes high powered market incentives that are particularly critical to fully appropriate value from complementary patents that are broadly applicable to a vast array of potential licensees. Furthermore, because such patents could be infringed on by many, the threat of countervailing infringement claims would be excessive, and severely impede commercializing entities from effectively enforcing them.

Although patent pools can quell the inefficient haggling among multiple patent holders that often occurs when there is substantial patent complementarity, they lack the deployment and enforcement efficiencies, relative to PAEs, to adequately customize bundles of patents for a wide array of uses, monitor the diversity of potential infringers, or appropriately price the bundle across varying applications.

In sum, efficiencies in patent deployment and enforcement are particularly beneficial for high complementarity/low specialization patents because patent deployment and enforcement costs are likely to be substantial. Unencumbered by inventing and commercializing activities, PAEs are able to provide efficiencies from specializing in deploying and enforcing such patents, and reduce costs otherwise borne by inventors and commercializing entities; total management, transaction and production costs across the three entities possibly involved (i.e., inventor, distributor, commercializing entity) are minimized.[3]

Proposition 4. *When patent complementarity is high, and patent specialization is low, PAE intermediation is the most efficient means to allocate intellectual property rights, relative to the alternatives.*

Table 3 succinctly summarizes the results of our comparative analysis.

Table 3 Efficient Governance Alternatives

		Patent specialization	
		Low	High
Patent complementarity	Low	Licensing	*Low asset specificity* Licensing / Integration *High asset specificity*
	High	PAE intermediation	Patent pools

Patents as Incomplete Contracts Between Inventors and Society

Our analysis suggests that, when there is substantial complementarity between patents, and these patent bundles are applicable across a broad array of product lines, PAE intermediation is more efficient than other governance alternatives. What then underlies the emergence of these organizations? The growing imperfections in the patenting process in conjunction with rapid technology evolution are creating conditions that promote PAE intermediation in patent markets.

Patent protection is granted only to those claims that are deemed novel. Patents are negotiated contracts between self-interested inventors and United States Patent and Trademark Office (USPTO) patent examiners acting on behalf of society, and responsible for assessing the novelty of inventors' claims. To determine the novelty of a claim, a patent examiner reviews related prior art found in previously granted patents or publications. The USPTO patent examiner then compares this prior art to claims in a new patent application to assess whether the invention is novel (Cotropia 2009). The examiner is ultimately responsible for determining what intellectual property is included within the patent and what is excluded. In contrast to well-defined property rights specified in boilerplate title deeds for physical assets such as land and equipment, the boundaries of intellectual property are often ambiguous.

An inadequate assessment of prior art and future technological trajectories by boundedly rational patent examiners can generate incomplete patent contracts between inventors and society. Patents whose intellectual property overlap that of other patents are often granted when patent examiners have inadequate information on prior art (Mack 2006). For example, Apple's voice recognition patent was rejected nine times before being accepted by an examiner as a valid patent, despite substantial prior art overlapping the same intellectual property claimed in Apple's patent application (Duhigg and Lohr 2012). Such outcomes create patent complementarity; commercializing entities require access to a host of related and overlapping patents to legitimately develop products without infringing on the intellectual property of others. These overlapping patents may be generated by a number of different inventing entities, making it difficult for commercializing entities to search, value, and contract for all the relevant patents. In many technology sectors, overlapping patents have become the norm because of an increase in patent applications, limited USPTO resources for adequately reviewing these applications, and conscious patenting strategies by firms designed to block competitors' product development or artificially gain competitive parity (Somaya 2012).

Uncertainty over how technology is likely to evolve also impedes patent examiners from anticipating exclusions and specifying precise terms when issuing a patent. Because of the inability to anticipate relevant exclusions, patents and patent bundles often become applicable to a broader range of product lines over time. For example, at the time that a patent for physically cutting and pasting photographs of people's faces into cartoons was granted, neither the inventor nor the patent examiner could have envisioned such tasks being conducted electronically through advanced graphics software. Consequently, the claims specified in the patent did not exclude this technological possibility. When a firm eventually developed such software, it was sued for infringement by the owner of the original patent, which could be used to claim infringement because technological advances had essentially broadened its commercial application (Federal Trade Commission and Department of Justice 2012). Rapid technological expansion can broaden the commercial applicability of a patent or patent bundle, and create conditions where PAE intermediation may be more efficient than its alternatives.

To the extent that the technology within various sectors is evolving at an increasing pace, leading to greater patent complementarity and commercial breadth, PAE intermediation within these sectors will also increase.

Proposition 5. *PAE intermediation will be more prevalent within technology sectors that are rapidly evolving.*

Discussion

Our analysis provides insight into when and how PAEs may function in the allocation of intellectual property rights. They are particularly efficient in deploying and enforcing patented intellectual property relative to other governance alternatives when complementarity with other patents is substantial and specialization in terms of commercial application is minimal. Such conditions are especially acute in technology sectors that are rapidly evolving. By taking into consideration these distinctions in patent complementarity and specialization, we address the unique characteristics of intellectual property assets to apply transaction cost considerations more precisely to patent markets. Accounting for the overall management, transaction, and production costs across inventors, PAEs, and commercializing entities

provides a more complete perspective on when various governance alternatives are likely to play a role.

In addition to bilateral licensing, patent pooling, and directly commercializing, PAEs offer another way for firms to appropriate value from the patented intellectual property they develop. Our work provides guidance for firms on when to sell portions of their existing patent holdings to PAEs and when to pursue alternatives. For many firms, their patent holdings are likely to be dispersed across a number of intellectual property configurations (e.g., low complementarity/low specialization) that we have conceptualized. Categorizing patent holdings based on these configurations may provide a starting point for managers responsible for them.

Barring government regulations, PAE intermediation is likely to continue to grow and alter the landscape of how intellectual property rights are allocated. Prior to PAEs coming of age, patent pools were developed to allocate rights to complementary patents applicable to a broad array of product lines. For example, the 3G-mobile communications patent pool was formed in 2001, whereas the digital data transfer interface pool was formed in 1999 (Lerner et al. 2007). Going forward, PAEs provide a viable alternative to patent pool formation (Bekkers et al. 2006). Similarly, PAE intermediation may ultimately reduce the occurrence of technology-driven acquisitions; in some cases, PAEs may provide a more efficient means for divesting patents than integrating patent deployment, enforcement and commercialization through corporate takeovers.

PAE intermediation may also shift the locus of invention and reduce the need for commercializing entities to rapidly expand their own patent portfolios through internal development. To freely commercialize products, firms often need to navigate thickets of complementary intellectual property rights controlled by competitors (Hall and Ziedonis 2001). These competitors can use their patents to allege infringement, impeding the sale of rival products (Shapiro 2001). Targets of such behavior can invent around their competitors' patents by generating their own patents having claims overlapping those of their competitors' patents, and establishing some form of competitive détente through cross-licensing or the formation of patent pools. By reducing transaction costs, PAE intermediation may incentivize the production of such patents by entities specializing in invention. Instead of expanding their own patent portfolios, commercializing entities may be able to license bundled complementary patents from PAEs, and do so at a lower cost than developing them internally.

It is important to note that although inefficient governance alternatives are likely to be rejected by potential participants, in the short run, efficient governance is not necessarily optimal for all parties. PAE intermediation may increase costs for commercializing entities as they incur licensing fees that they would not otherwise. Indeed, this is the side of the story that one is likely to read in the popular press (Blumberg and Sydell 2011). Although rampant infringement may dampen technological progress and hamper commercialization activity in the long run, commercializing entities enjoy lower commercialization costs because of relatively inefficient patent enforcement by individual inventors vis-à-vis PAEs. Nonetheless, these lower costs come at the expense of inventors.

Furthermore, our analysis does *not* suggest that PAE intermediation is necessarily beneficial for economic growth or social welfare, nor addresses its effect on consumers. Economizing transaction costs can generate second-order counterproductive outcomes at the societal level depending on the legal context and other institutional forces (North 1990).[4] Whether PAEs exploit or mitigate the effects of an imperfect patenting process is open for debate. One possible outcome from PAE efficiencies in patent deployment and enforcement is that PAEs extract licensing fees from "frivolous" patents and hamper the commercialization of socially beneficial products. Furthermore, by deploying and enforcing such patents, PAEs may incentivize inventors to waste resources on developing frivolous patents. Commercializing entities would eventually pass on the costs of these frivolous patents to consumers, harming social welfare. Moreover, there are structural differences between when PAEs assert their patents against commercializing entities and when commercializing entities assert their patents against other commercializing entities. In the case of two commercializing entities, each can threaten to block the other's product sales through infringement litigation; this mutual destruction scenario encourages some form of cross-licensing settlement. Such settlements have proliferated due to the abundance of complementary patents being granted to commercializing entities (Hall and Ziedonis 2001). However, because PAEs do not compete in product markets, there is no mutually assured destruction scenario. As some suggest, this structural difference enables PAEs to legally extort commercializing entities through excessive royalties without fear of retribution (Blumberg and Sydell 2011).

Whether a patent or lawsuit is frivolous, or whether certain PAE behavior is coercive is in the eye of the beholder, and ultimately determined by the courts. Our analysis assumes that PAEs operate within the rules of the game. If policy makers wish to quell what they believe to be counterproductive PAE intermediation, they can do so by minimizing conditions where PAEs deploy and enforce intellectual property rights more efficiently than other governance alternatives. Reducing both patent overlap and the granting of overly broad patents would be one means of doing so. Recent changes in how patent applications are assessed may play a role. The *America Invents Act* of 2012 makes it easier for firms to anonymously submit any prior art they believe is relevant to

their competitors' patent applications in hopes of preventing competitors from obtaining overly broad patents. Other changes to the law enable firms to lodge post-grant opposition to newly granted patents.

An alternative conclusion from our analysis may be that PAE intermediation mitigates the effects of inherently imperfect patent contracts between inventors and society by efficiently bundling and enforcing broadly applicable patents with overlapping boundaries. Without the intermediation provided by PAEs, inventors and commercializing entities would be burdened with excessive transaction or management costs, particularly in sectors with rapidly evolving technologies where overlapping and broadly applicable patents are likely to appear. Such cost burdens may discourage innovation. To the extent that the granting of patents naturally entails some imperfection and uncertainty, PAE intermediation may be socially beneficial by efficiently resolving the errors made by the USPTO. Although PAEs have been disparaged in the popular press for being highly litigious (Blumberg and Sydell 2011), this may be a function of the type of patents they are likely to manage; PAE intermediation is more efficient than alternatives in the allocation of intellectual property rights for patent bundles that are broadly applicable. However, the threat of infringement is also substantial for this configuration. The litigiousness of PAEs is likely a natural outcome of conditions where they are the most efficient alternative for allocating intellectual property rights.

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Endnotes

[1]Although responsibilities for patent enforcement can be further disaggregated from their deployment and outsourced, creating efficient market contracts between patent owners and enforcement professionals is often difficult, because of problems in measuring the effort of individuals contracted to detect infringement and enforce patent rights. Thus, it is often most efficient to combine patent deployment and enforcement within a single firm; assuming these activities are integrated simplifies our analysis without unduly limiting inferences.

[2]Information regarding the internal structure of PAE is based on interviews conducted by the authors. We initially identified current and former employees through LinkedIn and alumni databases. Although we were repeatedly told of confidentiality agreements and restricted communications with journalists and academics due to past derision of PAEs in the popular press, we were able to secure interviews spanning 45–90 minutes with five current and former employees from two separate PAEs. Their titles ranged from portfolio architect to senior vice presidents.

[3]The limited empirical evidence available is consistent with the notion that PAEs tend to acquire patents that are broadly applicable (Fischer and Henkel 2012).

[4]For example, in some legal contexts, bribery or other nefarious activities can be used to minimize transaction costs or enforce contracts. However, such activities may have harmful social costs.

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