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CHASING PATENTS*

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Abstract

We examine the problem faced by a company that wishes to purchase patents in the hands of two different patent owners. Complementarity of these patents in the production process of the company is a prime efficiency reason for them being owned (or licenced) by the company. We show that this very same complementarity can lead to patent owners behaving strategically in bargaining, and delaying their sale to the company. When the company is highly leveraged, such inefficient delay is limited. Comparative statics results are also obtained. Relevant applications include assembly of patents for drug treatments from the human genome, and land assembly.
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1 Introduction

The literature on asset ownership (Hart and Moore (1990) and Hart (1995)), predicts that complementary assets should be owned by the same party. While seemingly simple, the reason behind this result is quite subtle: Two assets are complementary if the marginal product of asset-speci…c investments by any one party is zero if the assets are not used together. Separate ownership of these assets weakens each party's outside value of the asset, and this increases the surplus that is extracted by the opposing party. Anticipating such a problem, each party will invest less in the speci…c project than is desirable. In contrast, if the assets are owned together, then the owner's outside value of the combination is high. Such an owner has greater incentive to invest ex-ante.

This result assumes that there is a competitive market in assets prior to parties agreeing to do business with one-another. However, there are many cases in which markets for assets can be quite thin. Two (or more) completely separate owners will often make separate discoveries that would – purely through chance – generate higher value if they were combined. Combining such discoveries takes on an importance of its own when markets are thin: An interesting example of this was the development of a virus-resistant papaya in Hawaii. To be able to produce and distribute transgenic seeds resistant to the papaya ring spot virus, it was necessary to obtain the legal rights of other patents that would be infringed. Four relevant patents had to be identi…ed and their owners contacted for negotiations. It turned out that "the process of obtaining agreements from the patent holders was long and arduous. Each patent holder had his own agenda for licensing, ranging from having little interest in protecting a patent to placing a very high priority on negotiating the most favorable deal." [1]

The problems encountered with papaya are likely to be minor when compared to the recently-mapped human genome. Many DNA sequences have already been patented. In fact, the U.S. Patent and Trademarks Office had issued more than 2,000 patents covering gene sequences by the end of 1999. New applications will almost certainly require multiple DNA sequences whose patents are held by different owners. Will this patent assembly be accomplished efficiently or will it hinder innovation and the discovery of new drugs or treatments? This question is the basis of our paper.[2]

We develop a model to capture the problem of combining separate patents (or other assets such as land) when owners can delay sale for strategic advantage. Our main result is that complementarity – while a major reason for assets to be owned together – is also more likely to lead to costly delay in patent purchase. Grossman and Hart (1980) analyze a similar problem; a raider will not takeover a corporation because the returns from any corporate management improvements introduced by the raider will be captured by existing shareholders. The reason for such inefficiency is the public goods nature of managing a corporation. Grossman and Hart then examine several devices that are meant to avoid this nonexcludibility problem. In contrast, inefficiency in our setting arises from strategic behavior by patent owners.

The land assembly problem has also some common features with the chasing patents game we analyze; a developer wants to assemble several

[1] As cited in "Virus-Resistant Papaya in Hawaii: A Sucess Story," ISB News Report, January 1999, available at www.plant.uoguelph.ca/safefood/archives/agnet/ 1999/1-1999/ag-01-09-99-01.txt.

[2] The problem of patent assembly has been recognized in many areas. Lowe (2000), for example, suggests that "for inventions involving multiple patents held by different parties, there are high transaction costs associated with bargaining over rights, which can lead to blocking of commercial development " in the health care industry. His example is the recombinant hepatitis B vaccine, which requires fourteen different patents to be produced.

parcels of land to undertake a project that delivers positive externalities to surrounding land owners. When the developer cannot make a credible all-or-nothing o¤er, ine¢ciency is likely to occur: Existing owners will wait in order to capture the rents resulting from the completion of the project. [3] In our model the source of ine¢ciency is the bargaining process, not the existence of positive externalities from project completion.

While the standard literature on patents[4] focuses on the link between R&D and patents, we abstract from the development stage. This captures value of combining patents that may be generated purely through serendipity – and unanticipated by the separate developers. Our goal is to study the mechanism by which multiple patents are acquired and investigate its implications for e¢ciency. In our model there are two patent owners, and a third party who wishes to combine them. Each patent owner can choose to negotiate sale of the patent to the third party immediately, or delay negotiation in the hope of a better deal. The model is described in detail below.

2 The Model

There are three players in the model. A pharmaceutical company (player 0) wants to buy two patents, and realize a value v from owning the entire set. However, each of these patents are owned by players – two patent owners –

[3] Grossman and Hart argue that these externalities could be avoided if the developer could hide his intentions from the lot owners. There is however a large literature on land assembly. Recent papers eliminate the externality problem either by assuming that lot owners can make …nal o¤ers above their reservation prices, as in Eckart (1985), or by taking a cooperative approach, as in Asami (1988). O'Flaherty (1994) studies urban renewal – when a public authority has the power to buy the lots and resell them to the developer – and shows that it is not a good remedy for the externality problem.

[4] Arrow (1962) is a classical reference on analyzing inventions that reduce production costs. Kamien (1992) surveys the extensive theoretical literature on patent licensing. Mazzoleni and Nelson (1998) provide a more recent review of the theoretical literature on patents.

1 and 2 respectively. Player $i = 1,2$ values its patent at w_i. The pharmaceutical company values the individual patent of i at $v_i, i = 1,2$. We assume that the value of the two assets together exceeds the sum of the individual valuations, i.e.

$$v > v_1 + v_2,$$

and that the pharmaceutical company values the individual patents at least as much as the owners, i.e.

$$v_i \geq w_i.$$

Ideally, the pharmaceutical company would like to engage each of the owners together, make a take-or-leave-it offer $w_i, i = 1,2$, and realize the value $v - w_1 - w_2$. This may not be possible. A patent owner may perceive an advantage from not going to the bargaining table when the other owner is present. In other words, it might be advantageous for an owner to delay sale, perhaps hoping for a higher price later on.

To model this possibility, we assume there are two possible times at which each party can go to the bargaining table, $t_i = n$ ("now") and $t_i = l$ ("later"), $i = 1,2$. We assume that the patent owners $i = 1,2$ simultaneously and non-cooperatively choose p_i the probability of going to the bargaining table now, with probability $(1 - p_i)$ of going later. This choice leads to four possible events: Both parties are at the bargaining table now, probability $p_1 p_2$; party 1 is at the table now, and party 2 later and vice-versa, probabilities $p_1(1 - p_2)$ and $p_2(1 - p_1)$, and; both parties are at the bargaining table later, probability $(1 - p_1)(1 - p_2)$.

We assume that once players are at the table, they bargain efficiently over the exchange of patents. This allows us to examine the pure question of how strategic avoidance of bargaining affects welfare, without biasing results by assuming inefficient bargains. To this end, we adopt a generalized form of

Nash bargaining to determine the payoffs to each player in each event. We assume that the payoff to an individual in a bargain is generically as follows:

$$\text{payoff} =$$

$$\text{(threatpoint payoff)} + \text{(bargaining share)} \cdot [\text{available surplus - sum(threatpoint payoffs)}]. \quad (1)$$

Our interpretation throughout of the threatpoint payoff of a bargainer is standard: it is the payoff if bargaining breaks down completely, with no possibility of reconciliation. Thus, the overall payoff is the sum of the threatpoint payoff, and a share of the gains from trade.

We assume that the pharmaceutical company is unable to commit to leave the bargaining table at time n. To do so would not be subgame perfect: Specifically, suppose that the company purchased a patent from one owner at date n. This agreement yields a positive payoff, and becomes sunk. The time l agreement also yields a positive payoff, and the pharmaceutical company has an incentive to stay at the table. Therefore, we only need to focus on the payoffs of the two patent owners, since only these players are able to make strategic choices in the model.

Let the notation $s(t_j; t_k)$ denote the payoff to either player $j \in \{1; 2\}$ or $k \neq j \in \{1; 2\}$, when the outcome of their choices of p_j and p_k are $t_j \in \{n; l\}$ and $t_k \in \{n; l\}$ respectively. If all three players are at the bargaining table at time n, so that $t_1 = t_2 = n$, then $i = 1; 2$ receive

$$s(n; n) = w_i + \alpha_i \cdot (v - w_1 - w_2)$$

in present value dollars, where $\alpha_j \geq 0$, $\Sigma_{j=0}^{2} \alpha_j = 1$, is the bargaining share of the gains from trade $v - w_1 - w_2$ of player $j = 0; 1; 2$, in a three player bargain. For $i = 1; 2$, value w_i is i's bargaining 'threatpoint', being the value placed on the next best use of the patent. We assume that date l payoffs are discounted by the factor $\delta \in (0;1)$, so that the payoff to player $i = 1;2$ in present value terms from the three player bargain is

$$s(l;l) = \delta \cdot (w_i + \alpha_i \cdot (v - w_1 - w_2)).$$

We can interpret a higher δ as a longer period of delay between dates n and l, or directly as a stronger time preference for all players.

Determination of the payoffs for situations where there is only one patent holder at the table at any given time, requires some careful thought. Suppose patent holder j is at the table at date l. At this time, patent holder $k \neq j$ has made a bargain with the pharmaceutical company. Therefore the total available surplus at date l is v. However, the company can threaten not to purchase j's patent, and just use the first owner's patent, i.e. the company's threatpoint payoff is v_1. Applying the Nash bargaining formula (1) above, yields a present value payoff to player j of

$$s(l;n) = \delta \cdot (w_j + \beta_j \cdot (v - v_k - w_j)),$$

where $\beta_j \in (0;1)$ is the bargaining share of player j vis-a-vis the company. Note that the company is potentially advantaged because it can extract a threatpoint payoff of $v_k > 0$ in this bargain, due to the fact that it now holds patent k.

Now suppose j is at the bargaining table at date n, and k negotiates at date l. Consider the agreement between owner j and the company at date n. The company's threat – should bargaining break down – is not to deal with player j, wait until date l, and receive payoff $(1 - \beta_k) \cdot (v_k - w_k)$, being its share $1 - \beta_k$ of the gains from trade $v_k - w_k$ in the deal with the other player k. Owner k's threatpoint payoff is w_k. We assume that both players anticipate that efficient bargaining will yield the total value v.[5] This yields a payoff at date n to player l of

$$s(n;l) = w_j + \beta_j \cdot [v - w_j - \delta \cdot (1 - \beta_k) \cdot (v_k - w_k)].$$

The important point to note is that the pharmaceutical company's future payoff from dealing with player k alone, affects the surplus in the bargain at date n with player j. Thus, the payoffs capture –in a rigorous way– intertemporal competition between the two patent-holders.

Now consider patent owner j's choice of p_j at the beginning of the game. The owner's expected payoff is calculated by weighting the payoffs derived above with the probabilities of each event:

$$\begin{aligned}\pi_j &= p_j \cdot p_k \cdot [w_j + \alpha_j \cdot (v - w_j - w_k)] \\ &+ p_j \cdot (1 - p_k) \cdot [w_j + \beta_j \cdot (v - w_j - \delta \cdot (1 - \beta_k) \cdot (v_k - w_k))] \\ &+ (1 - p_j) \cdot p_k \cdot [\delta \cdot (w_j + \beta_j \cdot (v - v_k - w_j))] \\ &+ (1 - p_j) \cdot (1 - p_k) \cdot [\delta \cdot (w_j + \alpha_j \cdot (v - w_j - w_k))]\end{aligned} \tag{2}$$

3 Solution and Results

We can derive Nash equilibria in the model by examining the derivative of (2). After some simplification, the derivative becomes:

$$\frac{d\pi_j}{dp_j} = p_k \cdot X + (1 - p_k) \cdot Y \tag{3}$$

where

$$\begin{aligned}X &= s(n;n) - s(l;n) \\ &= (1 - \delta) \cdot w_j + (\alpha_j - \delta\beta_j) \cdot (v - w_j - w_k) + \delta \cdot \beta_j \cdot (v_k - w_k),\end{aligned} \tag{4}$$

[5] That is, both players know that bargaining is efficient, and that bargaining at date 2 will lead to an agreement that gives gross payoff v.

and

$$
\begin{aligned}
Y &= s(n,l) - s(l,l) \qquad (5)\\
&= (1-\delta)\cdot w_j + (\beta_j - \delta\cdot\alpha_j)\cdot(v - w_j - w_k)\\
&\qquad + \beta_j(w_k - \delta\cdot(2-\beta_k)\cdot(v_k - w_k))
\end{aligned}
$$

Proposition 1 *There is inefficient delay in equilibrium if $X < 0$ and $Y > 0$ in the form of multiple equilibria $(p_1, p_2) \in \{(1,0), (0,1), (\bar{p}_1, \bar{p}_2)\}$ with*

$$\bar{p}_k = \frac{(1-\delta)\cdot w_j + (\beta_j - \delta\alpha_j)\cdot(v - w_j - w_k) + \beta_j\cdot(w_k - \delta\cdot(1-\beta_k)\cdot(v_k - w_k))}{(1+\delta)\cdot(\beta_j - \alpha_j)\cdot(v - w_j - w_k) + \beta_j\cdot(w_k - \delta(2-\beta_k)\cdot(v_k - w_k))} \qquad (6)$$

$j \neq k = 1, 2$.

Proof. >From equation (3), we have $\frac{d\pi_j}{dp_j} = 0$ where $p_k = \bar{p}_k = \frac{Y}{Y-X} \in (0,1)$ as $X < 0$, $Y > 0$. On substitution, $\bar{p}_k$ is given by equation (6). The best response correspondences of the owners are given by

$$p_j = \begin{cases} 0 \text{ for } p_k > \bar{p}_k \\ [0,1] \text{ for } p_k = \bar{p}_k \\ 1 \text{ for } p_k < \bar{p}_k \end{cases} \quad j \neq k = 1, 2.$$

This is because if $p_k > \bar{p}_k$, $\frac{d\pi_j}{dp_j} = p_k \cdot X + (1 - p_k)\cdot Y < 0$, as $X < 0, Y > 0$. Similarly, if $p_k < \bar{p}_k$, $\frac{d\pi_j}{dp_j} > 0$ as $X < 0, Y > 0$. To calculate equilibria, suppose first that $p_2 = 0 < \bar{p}_2$. Owner 1's best response is $p_1 = 1$. Owner 2's best response to $p_1 = 1 > \bar{p}_1$ is $p_2 = 0$. Thus, $(1, 0)$ a Nash equilibrium, as is $(0, 1)$ by a symmetrical argument. Consider the point $(\bar{p}_1, \bar{p}_2)$. Neither owner increases their payoff from deviating, so that this point is also a Nash Equilibrium. There are no other Nash equilibria, since owner 2 will deviate from any point $(p_1, \bar{p}_2)$ if $p_1 \neq \bar{p}_1$. ■

First note that delay is always inefficient, because the total available surplus $v - w_1 - w_2$ is discounted. The intuition for proposition 1 is made easier by noting that owners 1 and 2 are playing an intertemporal coordination game. The term X is the difference between owner j's payoff from bargaining now and bargaining later, conditional on owner k bargaining now (i.e. $X = s(n;n) - s(l;n)$). Since $X < 0$, owner j prefers to be absent now when owner k is present. The term Y is the difference between j's payoff from bargaining now and bargaining at time l when owner k bargains at time l (i.e., $Y = s(n;l) - s(l;l)$). Owner j prefers to bargain now in this case. In summary, both owners would prefer to be absent from the table if the other player is present; they wish to coordinate to be apart.

The proposition as it stands does not give us sufficient insight into the basic motivation for equilibrium delay; we need to examine the structure of payoffs more carefully:

Proposition 2 Suppose that discounted bilateral bargaining yields a larger share of surplus than trilateral bargaining (i.e. $\delta\beta_i > \alpha_i$, $i = 1;2$). Then there is inefficient delay in the equilibrium outcome if patents are (sufficiently) complementary, i.e. if either

(i) $v_i = w_i$, and δ is sufficiently near unity (precisely, $\delta > \frac{w_i + \alpha_i(v - w_i - w_k)}{w_i + \beta_i(v - w_i - w_k)}$, $i \neq k = 1;2$); or

(ii) v is sufficiently large.

Proof. For case (i), we have X negative for $\delta > \frac{w_i + \alpha_i(v - w_i - w_k)}{w_i + \beta_i(v - w_i - w_k)}$ and Y positive if $\delta\beta_j - \alpha_j > 0$. For (ii), $\alpha_j - \delta\beta_j < 0$ implies from equation (4) that X is monotonic decreasing in v, so that $X < 0$ for v sufficiently large. Since $\beta_j - \delta\alpha_j > 0$, we see from equation (5) that Y is monotonic increasing in v, so $Y > 0$ for sufficiently large v. From Proposition (1), there is delay in all the equilibria for cases (i) and (ii). ■

The intuition for Proposition 2 is as follows. For part (i), the pharmaceutical company's value of a single patent is no greater than the value to the owner ($v_i = w_i$). Thus, the pharmaceutical company does not gain much of an advantage if it purchases a patent. This is true when the company is bargaining with only one owner at either date n or at date l. In the former case – a deal with one owner at date n – the company anticipates that it does not have much intertemporal bargaining power from a future deal. In the latter case – an agreement with one owner at date l – the company holds a patent that doesn't give it much immediate bargaining power. The lack of a strong threatpoint on the part of the company when there is only one owner at the table, means that the owner is negotiating over a larger net surplus. In addition, the anticipated share of this net surplus to an owner (when the other is absent) is larger, even when the owner must delay its going to the bargaining table (i.e. we assumed $\delta\beta_j > \alpha_j$). Consequently, both parties would prefer to be at the table alone. From proposition 1, there is delay in all three equilibria. With part (ii), there is inefficient delay for analogous reasons. The total available surplus v is high, therefore the gains to owners from being alone is also high.

In both cases (i) and (ii), the driving force behind delay is the degree of complementarity and the fact that bilateral bargaining power exceeds trilateral bargaining power. Since $v > v_1 + v_2$, and $\delta\beta_j > \alpha_j$, each patent owner has an increased incentive to not coordinate with the other owner. In this way, the parties can "divide and conquer": By negotiating separately – at least with some probability – there is a sunk component to the date n agreement. The owners seize a larger share $\delta\beta_j > \alpha_j$ of a large gain from trade. For example, if party 1 bargained at date n, and received share β_1, then party 2 bargains at date n and receives share $\delta\beta_2$. Each owner extracts more of an expected pie than if they negotiate at the same date with shares α_1 and α_2.

4 Comparative Statics

In this section we examine the changes in equilibrium behavior resulting from changes in some of the structural parameters. To do so we write the first-order condition as a function of p_k and of the exogenous variables. That is,

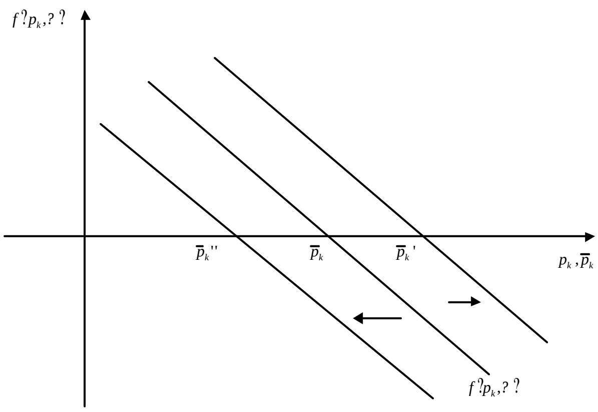
$$\frac{d\pi_j}{dp_j} = f\,(p_k; \Theta)\,;$$

where $\Theta = (\delta; v; v_k; v_j; w_j; w_k)$ is a vector of exogenous parameters.

Note that $f\,(p_k; \Theta)$ is decreasing in p_k under the assumptions in proposition 1, since $f_{p_k} = X - Y < 0$. Thus, the change in the equilibrium value of p_k that results from a change in the parameter $\theta \in \Theta$ depends on how f changes with respect to θ. For example, if we can show that $f\,(p_k; \Theta)$ increases with θ for all values of p_k; then we can argue that the equilibrium value of $\hat{p}_k$ increases with θ as well. This is depicted in figure 1 with some abuse of notation where for convenience we write $f\,(p_k; \theta)$.

In figure 1 if a rise in parameter θ leads to a rise in f, then $\hat{p}_k$ rises to $\hat{p}_k'$, and if it leads to a fall in f, then $\hat{p}_k$ falls to $\hat{p}_k''$. That is, we only need to determine the sign of f_θ to compute the comparative statics effects.

Figure 1: Comparative Statics



As a check on intuition, consider the effect of an increase in δ. We would expect that this leads to an increase in delay. Differentiating f with respect to δ yields

$$f_\delta = -2w_j - (\alpha_j + \beta_j)(v - w_j - w_k) - \beta_j(1 - \beta_k)(v_k - w_k) < 0$$

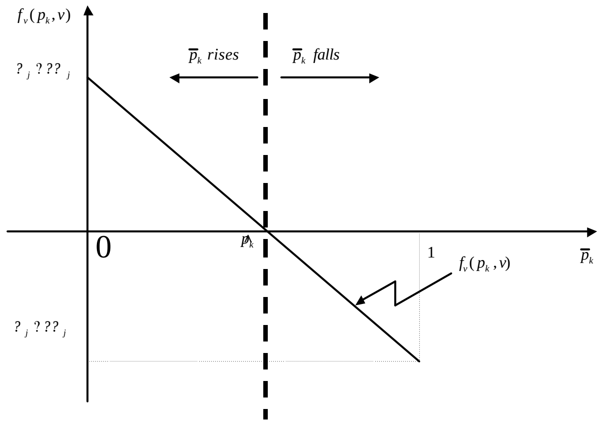
as expected: When δ rises, then not only does the gain from future payoffs rise, but the pharmaceutical company's threatpoint payoff from not to dealing with j at time n is improved (i.e. $s(n; l)$ falls).

The comparative statics of v are not as direct. Differentiating f with respect to v yields:

$$f_v = p_k(1 + \delta)(\alpha_j - \beta_j) + \beta_j - \delta\alpha_j \quad (7)$$

which is of ambiguous sign under the assumption that discounted bilateral bargaining power exceeds trilateral bargaining power ($\delta\beta_j > \alpha_j$). Figure 2 depicts how $\bar{p}_k$ changes with v:

Figure 2: Comparative Statics of v



When $\overline{p}_k = 0$, $f_v = \beta_j - \delta\alpha_j > 0$, and when $\overline{p}_k = 1$, then $f_v = \alpha_j - \delta\beta_j < 0$. Also, f_v is decreasing in p_k. It follows that f_v is increasing below the value $\hat{p}_k$ where $f_v = 0$, and is decreasing above $\hat{p}_k$. Therefore, $\overline{p}_k$ is increasing for $\overline{p}_k < \hat{p}_k$ and decreasing for $\overline{p}_k > \hat{p}_k$. Using the definition of $\hat{p}_k$ allows us to derive the following proposition.

Proposition 3 Suppose that discounted bilateral bargaining yields a larger share of surplus than trilateral bargaining (i.e. $\delta\beta_i > \alpha_i$, $i = 1; 2$). Then inefficient delay decreases (increases) with v if

$$\frac{\beta_j - \delta\alpha_j}{(1+\delta)(\beta_j - \alpha_j)} > (<)$$

$$\frac{(1-\delta)\cdot w_j + (\beta_j - \delta\alpha_j)\cdot(v - w_j - w_k) + \beta_j \cdot (w_k - \delta \cdot (1-\beta_k)\cdot(v_k - w_k))}{(1+\delta)\cdot(\beta_j - \alpha_j)\cdot(v - w_j - w_k) + \beta_j \cdot (w_k - \delta(2-\beta_k)\cdot(v_k - w_k))}$$

Similar comparative statics exercises can be accomplished for the remaining exogenous parameters in order to obtain specific conditions under which increases in any of the variables $\{v_k; v_j; w_j; w_k\}$ may lead to an increase (or decrease) in inefficient delay. We omit the details.

5 Discussion and Extensions

Our aim in this paper is to provide a simple bargaining framework to analyze the problem faced by a company who wants to buy complementary patents from distinct patent owners. Accordingly, several extensions are possible and some are discussed below.

5.1 Wealth Constraints and Efficiency

In the analysis above, it was impossible for the company to commit – at date n – not to negotiate at date l. Being able to commit not to bargain is an extreme version of a commitment to be a tough negotiator. The presence of wealth constraints on the company admits the possibility that it can credibly commit to be a tougher negotiator at date n. We explore this possibility here.

Suppose that the pharmaceutical company has at most wealth $W \in [w_1 + w_2; v]$ to expend on the purchase of the patents. This is possible, for example, if the company is sufficiently highly leveraged. Limited wealth means that the company can offer at most W for the two patents in any agreements with the owners. For illustrative purposes, suppose that wealth is the minimum, at $W = w_1 + w_2$. Consider the bargaining outcome in each event. When both owners negotiate at date n, they can receive no more than $w_1 + w_2$ between them. Since we assume that bargaining is efficient (to focus exclusively on the strategic incentives to delay), the payoff for each party is $s(n; n) = w_i$ $i = 1; 2$.

Now suppose that only owner 1 is present at date n. The company's threatpoint payoff is the amount it will receive from a date l deal with party 2. In this circumstance, 2 receives $\delta \cdot \min\{w_1 + w_2; w_2 + \beta_2(v_2 - w_2)\}$. Therefore, in the date n agreement with the company, party 1 receives

$$s(n; l) = \min[w_1 + w_2; w_1 + \beta_1(v - w_1 - \delta \cdot \min\{w_1 + w_2; w_2 + \beta_2(v_2 - w_2)\})].$$

Consider the case where party 1 bargains at date l – after player 2 reaches agreement at date n. The wealth remaining to the company for bargaining purposes is $w_1 + w_2 - s(l; n) \leq w_1$ (where $s(l; n)$ is defined symmetrically to $s(n; l)$ – with subscripts 1 and 2 switched). It follows that the payoff to 1 is 0. Finally, if both parties bargain at date n, they receive $s(n; n) = w_i$. This gives the following expected profit to player 1:

$$\begin{aligned}\pi_1 &= p_1 \cdot p_2 \cdot w_1 \\ &\quad + p_1 \cdot (1 - p_2) \cdot s(n; l) \\ &\quad + (1 - p_1) \cdot (1 - p_2) \cdot w_1.\end{aligned}$$

Differentiating gives

$$\frac{d\pi_1}{dp_1} = p_2 w_1 + (1 - p_2)(s(n; l) - w_1) > 0.$$

Therefore, there is no inefficient delay in equilibrium. The wealth constraint serves to commit the company to be a hard bargainer.

Clearly from the reasoning in the first part of the paper, if $W = v$, there is inefficient delay. By the continuity of payoffs, there must be some level of wealth such that inefficient delay is eliminated. The presence of a wealth constraint on the company can act as a credible commitment to tough bargaining at date n, and therefore can eliminate the inefficiencies caused by strategic bargaining behavior by owners. This holds true regardless of the degree of complementarity between patents in the company's production process.

5.2 Deterrence

The analysis tells us that in the absence of tight wealth constraints, there will be inefficient delay. This suggests an intriguing possibility. Suppose the pharmaceutical company faces a fixed cost of entering bargaining. The delay problem, and the fact that the parties divide and conquer, could be sufficiently severe that it is not worthwhile for the company to pursue the purchase of patents. This will happen whenever the company's expected payoff falls below the cost of entering into the bargaining process.

5.3 Information Gathering and Renegotiation

Suppose now that each player can find out whether the other player is present at the bargaining table at any given time. With this knowledge, a player can decide whether it wishes to commence bargaining or wait until later to do so. In particular, note that this is only relevant at end of date n: Either player can avoid making a period n agreement, after observing whether the other is present, and wait until period l.

First consider the equilibrium $(p_1; p_2) = (1; 0)$ in the previous model. (In this equilibrium owner 1 chooses to go to the bargaining table at date n when owner 2 chooses to go to the table at date l and vice versa.) Will this continue to be an equilibrium when information gathering is possible? Consider player 1's decision when he arrives at the bargaining table, and finds that player 2 has made the decision not to show up. Will player 1 decide to walk away from bargaining and wait until period l? This will clearly not occur, for the same reason that (1,0) is an equilibrium in the previous model. By a symmetric argument (0,1) will also continue to be an equilibrium. Now consider the mixed strategy $(\rho_1; \rho_2)$. It is trivial to show that there is no incentive to deviate from this strategy. Suppose that both players arrive at the bargaining table at date n. They choose the same probability of exiting, and bargaining at date l, for precisely the same reason $(\rho_1; \rho_2)$ was an equilibrium of the previous game.

A standard device to eliminate inefficiencies in bargaining is to introduce costless renegotiation. In this model, there is no incentive for parties to renegotiate. Once the company has purchased a patent, the prior owner is no longer strategically relevant.

6 Conclusion

We examine the problem faced by a company that wants to purchase two complementary patents from distinct owners. Our model captures the process by which these complementary patents are acquired and shows that inefficient delay can occur as a result of patent owners being strategic. While the ownership literature asserts that complementary patents should be owned together, we show that it is precisely this situation that leads to inefficient delay. Indeed an increase in the degree of complementarity (via an increase in v) will ultimately lead to a higher probability of delay. However when the probability of delay is low, an increase in complementarity leads to a reduction in the chance of delay.

As well as changing the degree of complementarity, we show that delay decreases as the discount factor increases. Extensions include the introduction of wealth constraints, information gathering and renegotiation. In all cases inefficient delay is still a problem. However, with wealth constraints, delay can be eliminated when the company has sufficiently low wealth.

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