To Share or to Hoard?

Inventor Commitment and the Strategic Incentives to Share Knowledge*

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A prolific inventor is one of the high technology firm's most valuable strategic assets. But it is also one of the easiest to lose to an aggressive competitor willing to bid for his talents. Data on the company affiliation of an inventor's patents provides a record of his movements. Given desirable productivity, frequent job changes may be indicative of an inventor's lack of commitment to his employer. But it is also a proxy for the uncertainty a given company may have about the commitment, or lack thereof, of a member of their research and development team. A company's response to inventor mobility can be aggressive or cooperative. One option is to aggressively pursue an attractive potential recruit, outbidding the incumbent employer and hiring the prolific inventor. Another, more cooperative option is to seek alliance with the incumbent so as to share in at least some of the proprietary knowledge produced by the inventor. The strategic game is played by three parties: the incumbent employer, his research and development team and the competition. The stakes are profits for the firms, compensation and bargaining power for the inventors. What course of action is best for each of the parties given what the others are going to do? What would simple game theoretic constructs have to contribute here? As a first level of analysis we present a simple game theoretic model of this situation.

1. A Game Theoretic Analysis

Construction of a game theoretic model requires specifying the players, the moves available to them and the resulting payoffs.

1.1 The Players and their Moves:

There are three players: the inventor, the incumbent employer Firm 1 and the competitor Firm 2. The inventor can commit to Firm 1 or not. If he commits, then a bid by Firm 2 would lead to a matching compensation increase by Firm1 but the inventor would not leave. If the inventor does not commit to Firm 1, a bid by Firm 2 will be accepted, and the inventor will leave the incumbent employer. Firm 2 also has two possible courses of action: offer to enter a strategic alliance with Firm 1 or bid for the inventor. Firm 1 in turn can accept or turn down the alliance proposal.

1.2 Strategy and Payoffs.

The strategic problem faced by the incumbent employer and his competitor, Firm 2, is the result of uncertainty over the inventor's commitment to his employer. A committed inventor stays with the incumbent and Firm 2 then wants to encourage alliance. But only an uncommitted inventor encourages the incumbent employer to accept an alliance offer. The inventor needs to signal his level of commitment.

1.2.1 The Inventor's Strategic Problem

The inventor loses from a strategic alliance. While this may not reflect a literal compensation loss, an alliance reduces the inventor's bargaining power and his payoff is presumed to reflect that loss. He does best if Firm 2 bids for his services. Firm 2's bid depends on his belief about the inventor's availability. If Firm 2 thinks the inventor is not very committed to the incumbent a low bid should attract him. Otherwise a high bid is necessary. If Firm 2 bids,

Firm 1 must match the high bid but only keeps a committed inventor. There are, altogether, six possible outcomes for the inventor. Three are the result of a signaled lack of commitment to the incumbent while the others obtain if the inventor decides to commit. The table below provides a numerical example for these payoffs:

Inventor Payoffs

Payoffs if Inventor Signals Commitment		
Firm 2 Bids, Firm 1 Keeps	Firm 1 Keeps, No Alliance	Alliance
A1=3	A2=2.5	A3=1.5
Payoff if Inventor Signals that He is Not Committed		
Firm 2 Bids, Firm 1 Loses	Firm 2 Bids if No Alliance	Alliance
A4=2.5	A5=3	A6=2

The particular numbers chosen for the above table reflect the following strategic situation for the inventor: Alliance means a loss of bargaining power. So A3 and A6 need to be less than any other payoffs and they may or may not be equal. In this example, a higher payoff under alliance when the inventor has signaled a lack of commitment could be interpreted as a desire on the part of the firms to encourage the inventor to stay with the alliance by offering to compensate in part for the inventor's loss of bargaining power. It turns out that the difference between A3 and A6 changes the strategic character of the game prompting the inventor to favor lack of

commitment over commitment if A6>A3 while a reversal of the inequality leads the inventor to be more likely to commit.

Most importantly, the game is structured in such a way that the inventor would never wholeheartedly choose one attitude or the other, and this ends up prompting the firms to form alliances most of the time with dire consequences for the inventor. But to understand this dilemma we need to introduce each firm's priorities and possible courses of action.

1.2.2 The Strategic Problem Faced by the Firms .

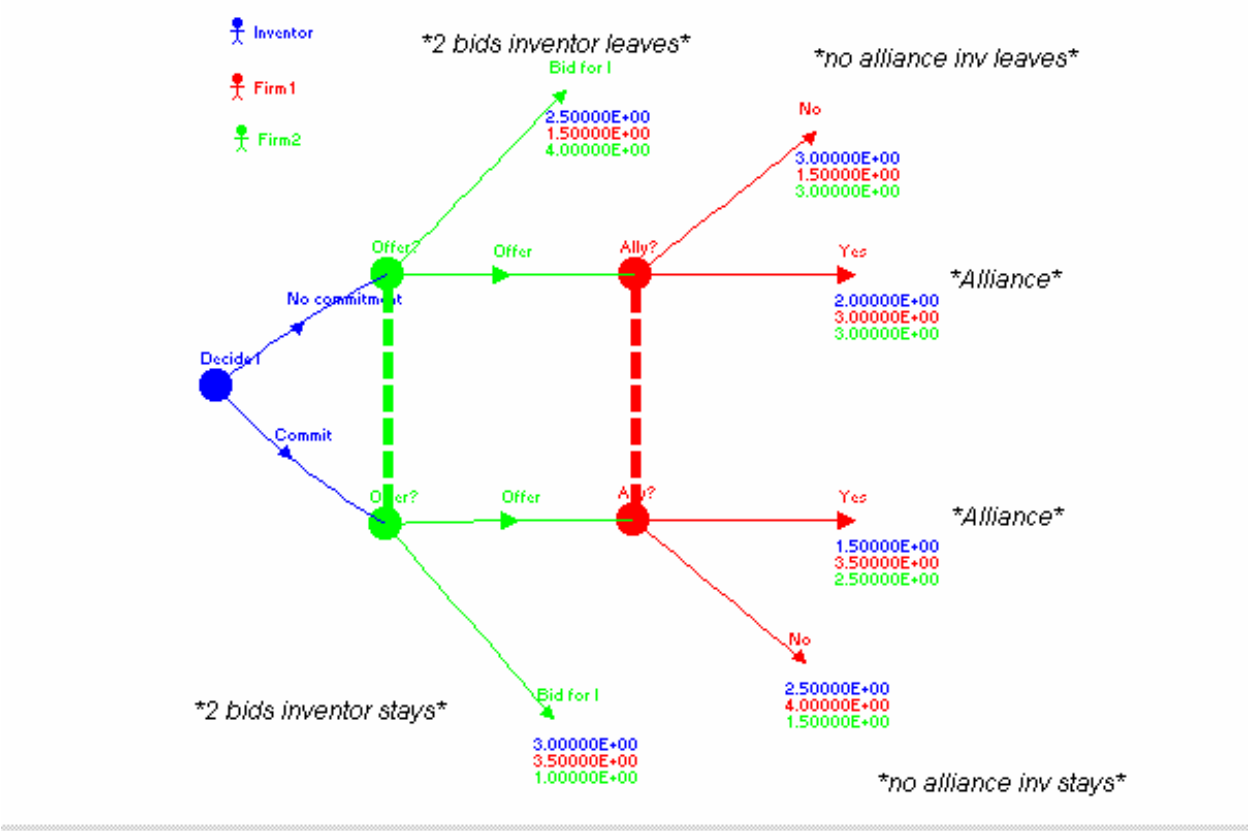
The incumbent employer is best served by a committed inventor, and is therefore willing to encourage commitment by matching high potential bids on the inventor's services. The best situation for Firm 1 is to keep a committed inventor to itself. But as long as the inventor is committed, Firm 1 has a better bargaining position when it comes to alliance with Firm 2 and would end up in its second best outcome under that circumstance. The worst for Firm 1 is to loose the inventor to the competition. For Firm 2, on the other hand, taking the inventor away from the incumbent is best, and it would always bid for an uncommitted inventor. But bidding for a committed inventor only leads to matching by the incumbent and it represents a costly opportunity loss for Firm 2 who could have tried to secure an alliance with Firm 1 instead. For both firm's then, it is the uncertainty over the inventor's commitment that poses a strategic problem. A numerical example of Firm 1 (B1 through B6) and Firm 2's (C1 through C6) payoffs is as follows:

Payoffs for Firm 1 and Firm 2

Payoffs if Inventor Signals Commitment		
Firm 2 Bids, Firm 1 Keeps	Firm 1 Keeps, No Alliance	Alliance
B1=3.5, C1=1.0	B2=4.0, C2=1.5	B3=3.5, C3=2.5
Payoff if Inventor Signals that He is Not Committed		
Firm 2 Bids, Firm 1 Loses	Firm 2 Bids if No Alliance	Alliance
B4=1.5, C4=4.0	B5=1.5, C5=3.0	B6=3, C6=3.0

Important to Firm 1's strategic problem is that the payoffs obtained if it loses the inventor, B4 and B5, are the lowest. As a result Firm 1 will always be willing to entertain an alliance offer by Firm 2 if it thinks that the inventor is not sufficiently committed. For Firm 2 the worst is bidding for a committed inventor with dire consequences also associated to a refusal by Firm1 to ally. This translates into low payoffs C1 and C2 while the best outcomes involve bidding and getting an uncommitted inventor. C4 is best with C5 on a par with C6..

1.3 Representation of the Game



Note the information sets: When Firm 1 decides whether or not to bid for the inventor, it does not know whether the inventor is committed or not. When Firm 2 is faced with an alliance offer by Firm 1, it does not know whether the inventor is committed or not either.

1.4 Strategic Solutions

The interesting outcomes that emerge from this game theoretic problem stem from the inventor's unwillingness to wholeheartedly signal commitment or a lack thereof. The reason for this is worth some consideration: If the inventor were to wholeheartedly commit, then a rational response by Firm 2 would be to offer Firm 1 an alliance. In turn Firm 1, the incumbent employer would refuse the alliance keeping the inventor to itself. The inventor's payoff would then be A2. But, what if the inventor decided not to commit at all, and again Firm 2 offered alliance and Firm 1 refused it. Inventor would then get A5>A2 and should therefore prefer not to commit. However, if the inventor does go that route, then instead of offering alliance, Firm 2 puts in a low bid of A4. But then, the inventor would prefer to commit fully since he would enjoy Firm 1's high bid of A1>A4. Consequently neither full commitment nor total lack of commitment are equilibrium decisions for the inventor in a game theoretic sense. His strategy will therefore be to signal some weight on commitment that falls short of 100%. For the firms, a payoff structure characterized by A5>A2 and A1>A4. there will necessarily be uncertainty as to the inventor's intentions.

The inventor's dilemma stems from payoff inequalities that need to be discussed. First, A1 is presumed greater then A4.. The inventor gets A1 if he is committed to Firm 1 and gets an offer from the competitor while A4 is what he gets if he is uncommitted and receives an offer from Firm 2. The difference can be interpreted as a strategic move by the incumbent employer. In order to foster commitment which is always better for the incumbent, Firm 1 is willing to outbid Firm 2 to keep the committed inventor. If the inventor signals openness to offers by the competition, then Firm 1, by letting the inventor take Firm 2's offer without attempting to outbid it again seeks to deter the inventor from wanting to leave. The inequality between payoffs A5

and A2 can be thought of as strategically engineered by Firm 2. If A5 and A2 were equal, then, committing to the incumbent would not mean forgoing a better outcome given the response of the two firms. So wholeheartedly committing to Firm 1 would be one possible optimal strategy for the inventor with Firm 2 responding by an alliance offer and Firm 1 refusing it. By promising to bid high for an uncommitted inventor if Firm 1 refuses alliance Firm 2 actually prevents the inventor from fully committing to Firm 1 and enhances its chances of capturing the inventor.

With A5>A2 and A1>A4, the inventor will signal his commitment with some likelihood that depends on his fate if the firms form an alliance. With the numerical payoffs given above, the game theoretic solution which maximizes each player's payoff given the rational expectation of what the others will do is as follows: the inventor puts 40% weight on commitment and 60% on availability to the competition. Firm 2 bids for the inventor with probability 0.5 or offers to join an alliance with the incumbent with 0.5 probability. The incumbent always accepts to join an alliance. To see why this is an equilibrium in the game theoretic sense consider each of the player's point of view in turn: The incumbent, expecting the inventor to commit with 0.4 probability and Firm 2 to offer alliance with 0.5 probability calculates his expected payoff from alliance as .6*.5*3+.4*.5*3.5=1.6. By contrast refusing an alliance offer leads to expected payoff .4*.5*4+.6*.5*1.5= 1.25, a less attractive outcome. So Firm 1 commits to entering an alliance if the opportunity presents itself. Firm 2 can either bid for the inventor or offer to form an alliance with firm 1. If the inventor commits with 0.4 probability, Firm 2 is equally satisfied whether it bids for the inventor (expected payoff .6*4+.4*1=2.8), or whether it offers alliance given that Firm 1 will accept (expected payoff .6*3+.4*2.5=2.8). So Firm 2 could put arbitrary weights on one or the other of these decisions. But, for the inventor to decide on a weight on each possible

decision, he must be getting the same expected outcome from either. This requires Firm 2 to put exactly 50% weight on a bid for the inventor. Indeed, then the inventor's expected payoff from committing is .5*1.5+.5*3=2.25 and from not committing is .5*2.5+.5*2=2.25. So expecting Firm 2 to make him an offer with 50% chance or to enter an alliance with Firm 1 again with 50% chance, the inventor is indifferent between his two courses of action. But he must commit with 40% chance only for Firm 2 to be indifferent between a successful bid and an alliance and this determines the weight the inventor puts on his possible actions. From an empirical perspective this particular solution predicts both alliance formation and movement of inventors among firms. When the difference between A6 and A3, the inventor's payoffs when the firms form an alliance, narrows, alliance becomes more likely. When A6=A3, alliance is the only outcome of the game. If A3>A6, then the inventor is encouraged to put more weight on commitment and Firm 1 is encouraged to refuse a possible alliance offer. In such cases, movement of the inventor from one firm to the next would result if Firm 1 happened to turn down an alliance offer and the inventor was uncommitted enabling Firm 2 to capture him with a high bid. Otherwise one would observe alliance or the status quo (Firm 1 keeps the inventor and stays out of an alliance with Firm 2).

1.5 What the Game Theoretic Solution Highlights

A first interesting result is that the inventor can be deterred from leaving the incumbent despite a high bid for his services by the competitor. In fact A1 and A4 can be increased without changing the solution to the problem. This is achieved by strategically setting up the payoffs to the inventor so that a pure strategy (100% on commit or 100% on no commit) is never optimal. Incidentally, the inventor does end up in his worst outcome (alliance) much if the time. From the

viewpoint of the firms, incentive to form alliances rather than compete is also built in by manipulation of the payoffs to the inventor.