

# Agent Takeover Risk of Principal in Outsourcing Relationships

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Key words: Principal, Agent, outsourcing, hostile takeover, learning, cashflow, revenue, volatility, Brownian motion, Wiener process.

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**Abstract**

The provision of outsourcing services creates relationships between knowledge vested with the supplier and the viability of outsourcing arrangements. Knowledge accumulation by the outsourcee can reach a level where it poses a market entry or takeover risk to the outsourcer. Knowledge translates into cash flows interpreted as asset values modelled as geometric Brownian motion accounting for uncertainty, drift, and volatility. We present this argument within a principal-agent theoretical perspective which embeds a real options analysis to represent risk growth. As an alternative to a complicated analysis of the benefits and costs to the agent and principal of a takeover, we propose that takeover of the principal by the agent can be expected if the agent's discounted cash flows is larger than the principal's discounted cash flows. The probability of the takeover of the principal's market by the agent is expressed as an "optimal stopping time" probability problem.

*“Scientia potentia est”*

*(knowledge is power)*

*Sir Francis Bacon*

*Meditationes Sacrae (1597)*

## **1 Introduction**

Outsourcing refers to the handover of an activity to an external supplier – as an alternative to internal production or servicing. Analysis relating to outsourcing problematics has appealed to Coase’s (1937) early argument concerning friction in the market. Effectively, this suggests that costs are incurred in buying a service or a product and where these costs become too high, reliance on self-production is preferred. Much research has emanated from this premise with outsourcing being analysed from a variety of angles. Technical comparisons have been made to insourcing (King and Malhotra, 2000), socio-political paradigms have explored outsourcing issues (Lacity and Hirschheim, 1995) and different contractual variables which influence the outsourcing decision have been investigated (Lambert and Knemeyer, 2004; Lee et al., 2004; Narayanan and Raman, 2004).

Certain outsourcing contingencies are impossible to foresee and so parties may decide to allocate one contracting party the ability to decide ex post the appropriate action (Williamson, 1989). This effectively happens when a company buys a supplier and integrates vertically whereby the decision rights over actions are purchased. Ideally, parties can mutually benefit if decision rights are allocated to the party making the most important investment. In contemporary outsourcing relationships, the outsourcee is often the party with the greatest investment in knowledge (Bathelemy, 2001; Grossman and Hart, 1986). Where that knowledge evidences growth at a sufficiently rapid pace after the outsourcing relationship becomes operational, knowledge vests with the outsourcee and the risk of acquisition of the outsourcer’s decision rights by the outsourcee arises. We argue that such riskiness can be monitored by the outsourcer to determine the optimal timing for terminating the outsourcing relationship or altering the arrangements under which outsourcing takes place.

To avert the outcome that the party owning the decision rights overinvests in the transaction relative to the other party thereby reducing overall efficiency (Grossman and Hart, 1986), it may

be preferable to vest the more knowledgeable party with decision-making power. That is, letting the expert party decide on the course of action for a given activity (Pisano, 1990). This indeed has been posited to be a basis for success in explaining outsourcing arrangements (Lee, 2001). Companies with less experience in specific areas may be better off outsourcing these activities to suppliers who can deliver on their investment (in expertise) and let the outsourcer more strategically focus on their own core areas of strength. Thus, expertise and knowledge have been regarded as principal contributory factors of outsourcing structural arrangements just as knowledge bases, information intensity and communication technology relationships have been regarded to affect organizational design (Dessein and Santos, 2006; Garicano, 2000). We argue that outsourcing decisions initially based on knowledge disparities between contracting parties must be monitored by the outsourcer. The outsourcer needs to assess the rate of knowledge acquisition by the supplier (outsourcee) in relation to the outsourcers' commercial opportunities. Once that knowledge reaches a certain threshold, it is desirable for the outsourcer to extinguish the relationship to avert the risk of takeover by the supplier. Knowledge growth may be more intense when the supplier contracts with other outsourcers, and possibly even with the outsourcees of other outsourcers, and gains knowledge more rapidly than any one market incumbent.

We develop a principal agent model where the agent accumulates knowledge at a rate faster than the principal. The agent performs support activities for the outsourcer. Examples are data processing work or design research where the agent accumulates experience and knowledge based on activities performed for one or more outsourcers. The build up of such intelligence poses a takeover threat analyzed in this paper. The agent services the needs of many outsourcers and learns from them in the aggregate as well as individually. Volume of information is one dimension. Another dimension is that capacity to enter a market grows at an accelerating velocity which exceeds the volume of knowledge growth. Consultants with many customers in the same market seem to be the best able to grow their market share for those types of customers for this very reason. We refer to this as synergy.

The agent is a supplier which can be located upstream or downstream. If upstream, one example is that the agent provides raw materials or some service or product as input to the principal. If

downstream, one example is that the agent receives output from the principal, for example a product or service which has to be marketed or sold. Knowledge and competence are both provided and further nurtured by the agent. The agent is a supplier of a service which the principal needs. The agent is also a recipient of a product or service which is processed further.

Risk has to be represented by a model where takeover of the principal by the agent becomes a real threat. The literature tying value, cash flow, or borrowing capacity to acquisition potential is scattered. Examples are Ambrose and Megginson (1992), Chowdhry and Nanda (1993), Gibbs (1993), Jensen (1988), Jensen and Meckling (1976), Lewellen et al. (1976), Nielsen and Melicher (1973), Weaver et al. (1991). Expanding upon and making coherent sense of this literature, we specify a linkage between knowledge on the one hand, and revenue or value or cash flow or borrowing capacity on the other hand. Just as Sir Francis Bacon (*Meditationes Sacrae* 1597) observed a linkage between knowledge and power, we observe a linkage between knowledge and revenue characterized by proportionality. We present alternatives to the proportionality assumption by which the principal and agent acquire knowledge at the same rate.

The rest of the paper is organized as follows. Section 2 presents learning dynamics for the principals and agent. Section 3 considers the reverse takeover decision of the principal by the agent. Section 4 determines the probability of the takeover at time  $T$ , and Section 5 concludes.

## **2 Learning Dynamics of Principals and Agent**

Assume that a principal's knowledge about one specific phenomenon at time  $t$  is  $x(t)$ , and that the agent's knowledge about the same specific phenomenon at time  $t$  is  $y(t)$ . Knowledge about one specific phenomenon refers to that specific knowledge possessed by the outsourcer and which could be also held by the outsourcee if a relationship became established. It does not refer to knowledge of activities possessed by the outsourcee that is specific to the nature of the service to be provided and the *raison d'être* of the outsourcee's relationship. The principal has many other forms of knowledge which influence its revenues. The principal decides at time  $t=t_0$  whether to outsource to the agent, whether to vertically integrate the agent, or whether to continue business as usual without outsourcing or integration. To posit a linkage between knowledge and revenue for both the principal and the agent, our first approximation is a

proportional relationship. With too little knowledge, a player is driven out of business. Define  $x_s(t)$  and  $y_s(t)$  as the knowledge, possessed by the principal and agent respectively, required to retain the status quo in revenue streams over time. These are posited as functions of time since they may change over time. First assuming that the principal and agent are independent, we model their knowledge over time with the following two differential equations:

$$\begin{aligned}\frac{dx(t)}{dt} &= \dot{x}(t) = a(x(t) - x_s(t)), \\ \frac{dy(t)}{dt} &= \dot{y}(t) = b(y(t) - y_s(t))\end{aligned}\tag{1}$$

If  $x(t) > x_s(t)$ , the principal increases its knowledge over time above the status quo knowledge. If  $x(t) = x_s(t)$ , the principal has the same knowledge over time as the status quo knowledge, and if  $x(t) < x_s(t)$ , the principal reduces its knowledge over time below the status quo knowledge, and similarly for the agent. Since the agent is hired to perform a task for the principal, and gains hands on insight and experience, we set  $a < b$ , which means that the agent's knowledge increases at a higher speed than the principal's knowledge. The parameters  $a$  and  $b$  are determined empirically.

It can be expected that the multiple principals may boost their joint knowledge growth substantially. In this case,  $b$  is not a constant, but depends on the knowledge of each principal, the number of principals (outsourcers), and may also depend on other factors inherent in each principal-agent relationship. One such factor is the size or volume (measured in a currency or in some other manner) of the contract with each principal. The size or volume specifies how "large" each contract is. We refer to the size as  $S_i$ ,  $i=1, \dots, M$ , where  $M$  is the number of principals with which the agent has a contract. Another factor is the extent to which the principal releases information and knowledge to the agent. For example, some principals may be more successful than other principals in getting output from agents without agents figuring out what is going on.<sup>1</sup> We refer to this information release factor as  $R_i$ ,  $i=1, \dots, M$ . The agent benefits from large  $R_i$ , and benefits more from principals with large  $S_i$ . We propose that  $S_i$  and  $R_i$  operate multiplicatively,  $S_i R_i$ , since the joint influence generates synergy which is of value for the agent.<sup>2</sup> That is,

<sup>1</sup> Analogously, leadership in some firms successfully insulates strategic plans from the customer service department which receives selective knowledge, for example of future product releases, designed to maximize revenue.

<sup>2</sup> Alternatives are additive operation  $S_i + c_i R_i$ , where  $c_i$  is a parameter, or a general functional dependence  $f_i(S_i, R_i)$ .

$$\begin{aligned}\frac{dx(t)}{dt} &= \dot{x}(t) = a(x(t) - x_s(t)), \\ \frac{dy(t)}{dt} &= \dot{y}(t) = b \left[ \left( \sum_{i=1}^M S_i R_i \right) y(t) - y_s(t) \right]\end{aligned}\quad (2)$$

Equation (2) aggregates the individual contributions. Since the whole is often more than the sum of the parts (Nagel 1961), the agent can put pieces of knowledge together from multiple principals. This synergy can be accounted for by multiplying the  $S_i R_i$  for the various principals with each other, and assuming a weighted sum between individual benefit and synergetic benefit. Equation (2) then becomes

$$\begin{aligned}\frac{dx_1(t)}{dt} &= \dot{x}_1(t) = a(x_1(t) - x_{s1}(t)), \\ \frac{dy(t)}{dt} &= \dot{y}(t) = b \left[ \left( \sum_{i=1}^M S_i R_i + c \prod_{i=1}^M S_i R_i \right) y(t) - y_s(t) \right]\end{aligned}\quad (3)$$

where  $c$  is a parameter which expresses the relative weight of the synergistic and individual benefits, and  $x_{s1}(t)$  is the status quo knowledge of principal 1. Subscript 1 in the principal's notation is introduced to clarify our focus on the relationship between principal 1 and the agent, while the agent may also have relationships with principals 2,3,...,M.

We next propose that principal 1 also learns from the agent. Comparing no agent with an agent, the principal can be expected to learn from the agent. Also here we propose that learning is proportional to the agent's knowledge. We thus rewrite (3) as

$$\begin{aligned}\frac{dx_1(t)}{dt} &= \dot{x}_1(t) = a(d S_1 R_1 y(t) x_1(t) - x_{s1}(t)), \\ \frac{dy(t)}{dt} &= \dot{y}(t) = b \left[ \left( \sum_{i=1}^M S_i R_i + c \prod_{i=1}^M S_i R_i \right) y(t) - y_s(t) \right]\end{aligned}\quad (4)$$

if principal 1 learns moderately, or

$$\begin{aligned}\frac{dx_1(t)}{dt} &= \dot{x}_1(t) = a \left( d \left( \sum_{i=1}^M S_i R_i + c \prod_{i=1}^M S_i R_i \right) y(t) x_1(t) - x_{s1}(t) \right), \\ \frac{dy(t)}{dt} &= \dot{y}(t) = b \left[ \left( \sum_{i=1}^M S_i R_i + c \prod_{i=1}^M S_i R_i \right) y(t) - y_s(t) \right]\end{aligned}\quad (5)$$

if principal 1 learns synergistically and thus more extensively, where  $d$  is a parameter.

A critical concern is whether there is a point where the agent has become so knowledgeable that it becomes a takeover threat for principal 1. We posit this to depend on the agent's knowledge relative to principal 1's knowledge, defined as

$$r_1 = \frac{y(t)}{x_1(t)} \quad (6)$$

The proportional linkage we posit between knowledge and revenue is such that when  $r_1$  becomes sufficiently large, the agent becomes a takeover threat. With only one principal, (6) simplifies to

$$r = \frac{y(t)}{x(t)} \quad (7)$$

The size of  $r$  where the agent becomes a takeover threat for principal 1 can be determined empirically, or a threshold value for  $r$  can be determined where the agent becomes a takeover threat.

The learning benefits to the agent can be used by the agent to retain a profit share with the principal, and also can help the agent attract new outsourcers. Observe that there may be a costing argument whereby a high level of knowledge leads to the ability to produce/service more cheaply which then attracts outsourcers to these services. If the outsourcer is not careful the knowledge gleaned by the agent say on number of units being sold or the growth of the market may incite penetration into the outsourcer's market – so at least at the outset the amount of power/knowledge by the agent is a positive attribute for the intending outsourcee. Let us formulate this technically. If  $y(t)$  is high, the agent can produce more cheaply. This may attract multiple principals to the agent. Each principal then has to be careful to prevent that the agent contracts with other principals. At the outset, high  $y(t)$  is to the advantage of principal 1, but as  $y(t)$  increases, principal 1 has to be careful. This is captured with  $r$  in (6).

Each principal faces two threats (i.e. reversal risks). The first is that the agent gains so much knowledge that it gains control of all revenue, and eliminates the principal. The second is that the agent does so much work for so many principals that it becomes capable of servicing directly the principals' customers better than any existing principals. This is akin to forward vertical integration by a firm which “outgrows” its role as a mere outsourcee because its knowledge resource has outgrown that of the outsourcers.



### 3 Takeover Decisions of Principal by Agent

The decision of a takeover of the principal by the agent is largely driven by growth in cash-flows and revenues. The risk, as measured by volatility, of the cashflows, and uncertainty surrounding these cashflows is important in the decision-making process. The takeover decision of a principal by its agent reduces to an embedded option problem in the cash-flow dynamics. This option is an “option to exchange one asset for another”, where the assets are the discounted cashflows of the principal and agent.

Assume the value of the principal organisation per share (or discounted cash flows) is  $P$ , and the value of the agent’s discounted cash-flows per share is  $A$ . As defined above, the principal’s amount of knowledge at time  $t$  is  $x(t)$  and that of the agent is  $y(t)$ . The cash-flows are a monotonically increasing function of knowledge, that is  $P$  is a function of  $x(t)$ , and  $A$  is a function of  $y(t)$ . Then for simplicity, if this monotonicity relationship holds, and using equation (7), we assume the threshold at which takeover occurs expressed as

$$r = y(t)/x(t) = A/P \quad (8)$$

This paper’s contribution is to suggest that (8) greatly simplifies the analysis of the agent takeover risk. As an alternative to a complicated analysis of the benefits and costs to the agent and principal of a takeover, we propose that analyzing the relative sizes of the discounted cash flows of the agent and principal determines the takeover risk. If  $r > 1$ , takeover of the principal by the agent can be expected, whereas no takeover can be expected if  $r < 1$ . In log terms we can rewrite equation (8) as

$$\ln r = \ln A - \ln P, \quad (9)$$

which is the hidden economic benefit of a reverse-takeover decision under conditions of certainty.

Under conditions of uncertainty and risky cash-flows, the economic benefit becomes

$$\max(\ln r, 0) = \max(\ln A - \ln P, 0). \quad (10)$$

The hidden economic value under uncertainty in equation (10) is therefore that of an option to exchange one asset for another.

We assume the asset values  $P$  and  $A$  follow geometric Brownian Motion given by

$$dP/P = \mu dt + \sigma dW(t) \quad (11)$$

and

$$dA/A = \alpha dt + \sigma dW(t) \quad (12)$$

where  $dW(t)$  is a Wiener process that captures uncertainty in the movement of cash flows,  $\alpha$  is a drift in the agent's cash flows,  $\mu$  is a drift in the principals cash flows,  $\sigma$  is the volatility of cash-flows of both principal and agent. The agent and principals' cash flows are correlated with correlation coefficient  $\rho$ .

The economic benefit  $\max(\ln A - \ln P, 0)$  is the payoff of the embedded real option to exchange  $A$  for  $P$ . If  $A$  is less than  $P$  the reverse takeover of the principal by the agent will not occur, and the value of the embedded option to the agent is zero. If  $A > P$  then the embedded option has positive value and takeover of the principal by the agent is likely to occur.

Let us proceed to value the embedded option. Following Magrabe (1978) and Rubinstein (1991) the value of the option is

$$f = \exp(-R_f T) A E \{ \max(P/A - 1, 0) \} \quad (13)$$

where  $E$  is the expectation in a world that is forward risk neutral with respect to  $A$ , and  $R_f$  is a risk-free rate, a discount rate, and  $T$  is the time when the reverse-takeover occurs. Here,  $P$  is

considered to be the numeraire asset. Solving the expectation in (13), using well-known techniques in option pricing, yields

$$f = P\Phi(d_1) - \exp(-R_f T)A\Phi(d_2) \quad (14)$$

where  $d_1$  and  $d_2$  are given by

$$d_1 = [\ln(P/A) + (d - c + 0.5\sigma^2)T] / \sigma\sqrt{T}, \quad d_2 = d_1 - \sigma\sqrt{T}, \quad (15)$$

and  $\Phi(\cdot)$  is a standard normal cumulative distribution function with mean zero and unit variance.

Equation (14) gives us the value of the embedded option to exchange P for A, and values the cash-flows of the takeover decision, at time T, of the principal by the agent. Comparative statistics can be presented to see how f varies with volatility, time, cost of learning, for instance.

#### **4 The Probability of the Takeover at Time T**

We now proceed to derive the probability of the reverse takeover of the principal by the agent at time T. This turns out to be an “optimal stopping time” probability problem. It depends on the knowledge  $x_i(t)$  and  $y(t)$  of each principal and agent, which captures the additive effect of doing business for the outsourcer as well as the synergy between the size  $S_i$  of each contract and the information release factor  $R_i$ , as expressed in (5). Hence time reflects knowledge and knowledge gain of the process that was outsourced but also of the wider activities of the principals (outsourcers).

We now proceed to characterize the probability of a takeover at time  $T^*$ .

Takeover will occur if (in loss terms) the revenues satisfy the inequality

$$A(T^*) > P^* \quad (16)$$

where  $P^*$  is some optimal revenue generated by the principal at time  $T^*$  when the takeover occurs, and  $A(T^*)$  corresponds to some revenue generation level  $A^*$  generated by the agent.

In this case a takeover will occur if

$$A \geq A^* \quad (17)$$

By applying Ito's lemma on equation (12), we can rewrite it as

$$dA/A = (R_f - 0.5\sigma^2)t + \sigma dW(t) \quad (18)$$

From equation (18) we can rewrite equation (17)

$$A(0) \exp \left[ (R_f - \frac{1}{2} \sigma^2)T^* + \sigma W(T^*) \right] \geq A^* \quad (19)$$

which in log terms can be re-written as

$$\ln(A(0)) - \ln(A^*) + (R_f - \frac{1}{2} \sigma^2)T^* - \sigma W(T^*) \geq 0 \quad (20)$$

From Ingersoll (1987) equation (34a) and (34b) on page 353, the probability density of  $T^*$  is given by

$$g(T^*) = \frac{1}{\sqrt{\sigma^2 T^{*3}}} \ln \left[ \frac{A(0)}{A^*} \right] \phi \left[ \frac{\ln[A(0)/A^*] + (R_f - \sigma^2/2)T^*}{\sigma\sqrt{T^*}} \right] \quad (21)$$

and the probability distribution is given by

$$G(T^*) = \Phi \left[ \frac{\ln[A(0)/A^*] - (R_f - \sigma^2)T^*}{\sigma\sqrt{T^*}} \right]$$

$$+ \exp \left[ \frac{-2}{\sigma^2} \right] (R_f - \frac{1}{2} \sigma^2) \ln(A(0) / A^*) \Phi \left[ \frac{\ell \eta(A)(0) / A^* + (R_f - \sigma^2) T^*}{\sigma \sqrt{T^*}} \right]$$

(22)

where  $\phi$  is a standard normal *pdf*, and  $\Phi$  is the standard normal distribution.

What is the probability of a reverse takeover conditional on no attempt for a takeover prior to time  $T^*$ ? This is expressed as

$$\lambda(T^*) = \frac{g(T^*)}{[1 - G(T^*)]} \quad (23)$$

$\lambda(T^*)$  is also known as a hazard rate. The optimal stopping time applies for both the agent and principal. The agent prefers a takeover at that time, and the principal prefers to terminate the relationship with the agent at the same time.

## 7 Conclusion

We develop differential equations for how the principal's (outsourcer's) and agent's (outsourcee's) knowledge about one specific phenomenon increases or decreases through time proportional to the extent to which that knowledge exceeds or is less than a specified status quo knowledge, for the principal and agent respectively, which retains the status quo in revenue streams over time. When contracting with multiple principals, each agent can through learning boost its knowledge proportional to the sum across all principals of the product of the size of each contract and an information release factor for each principal, and additionally accounting for synergistic impact of knowledge from multiple principals. The principal also learns from the agent, proportional to the agent's knowledge, and synergistically when multiple principals contract with the agent. The ratio of the agent's knowledge and the principal's knowledge, which is a function of time, expresses the takeover threat of the principal by the agent. When that ratio is too large, the agent is so knowledgeable that it can be expected to acquire the principal. The principal is threatened by a knowledgeable agent, and by the agent servicing multiple principals efficiently, and can be expected to initiate steps which we proceed to analyze.

We assume that the principal's discounted cash flows increases monotonically in the principal's knowledge, and that the agent's discounted cash flows increases monotonically in the agent's knowledge. Interpreting cash flows as asset values, the takeover threat expressed in log terms equals the logarithm of the agent's asset minus the logarithm of the principal's asset, which constitutes an economic benefit for the agent when this difference is positive. We interpret this economic benefit as an embedded real option to exchange the two assets. As an alternative to a complicated analysis of the benefits and costs to the agent and principal of a takeover, we propose that takeover of the principal by the agent can be expected if the agent's discounted cash flows is larger than the principal's discounted cash flows.

We model the asset values as geometric Brownian motion accounting for uncertainty (specified by a Wiener process), drift, and volatility in the cash flows, and proceed to determine the value of the embedded option to the agent. The value changes through time, and depends on the cash-flows of the takeover decision, time, volatility, and cost of learning.

The probability of the reverse takeover of the principal by the agent at various points in time turns out to be an "optimal stopping time" probability problem. The reason is that time reflects knowledge and knowledge gain of the process that was outsourced but also of the wider activities of the principal. The agent takes over the principal at a specific point in time if the agent's asset at that time exceeds the optimal revenue generated by the principal at that time. We develop the probability density of the optimal stopping time, and determine the probability of a reverse takeover conditional on no attempt for a takeover prior to that time. The optimal stopping time applies for both the agent and principal. The agent prefers a takeover at that time, and the principal prefers to terminate the relationship with the agent at the same time.

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