A Decision Model for Configuration of Firm Boundaries in the Network Economy

Raymond A. Patterson[1] and Erik Rolland[2]

[1] *School of Business, Accounting and Management Information Systems*
4-30E Business Building
The University of Alberta
Edmonton, AB, Canada T6G-2R6
Phone: 780-492-5826
Fax: 780-492-3325
e-mail: Ray.Patterson@ualberta.ca

[2] *The A. Gary Anderson Graduate School of Management*
University of California
Riverside, CA 92521
Phone: (909) 787-3694
Fax: (909) 787-3970
Erik.Rolland@ucr.edu

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Abstract.

Advances in telecommunications and E-business technologies are enabling rapidly changing firm boundaries and large-scale reorganization of business processes. Business processes consist increasingly of information that is, or can be, digitized and transmitted from and to virtually anywhere in the world. Thus, the procedural and geographical barriers to outsourcing of business processes have been substantially reduced, if not eliminated. This reengineering of the business processes is enabling the reorganization of the corporation and its business model, and may eventually help realize the virtual enterprise.

However, there are barriers to proper analysis of the business process outsourcing decision. These barriers include transaction cost, opportunistic behavior (risk), and sunk costs considerations. Addressing these inherent barriers, this paper proposes a bias-free reengineering tool to aid in E-business process outsourcing decisions.

Key words: E-business, reengineering, E-business process outsourcing, organizational structures

1. Introduction.

It has been argued that efficient firms allocate resources to their value chain activities where they enjoy a comparative advantage over their competitors (Shank and Govindajaran, 1992). With the advent of the commercial use of the Internet, electronic commerce, and total business connectivity, the enterprise is now better enabled to exchange information services. With the corporations' focus on core competencies (rather than on software development), coupled with a tight labor market for information technology services (Berst, 2000), business process outsourcing (BPO) is becoming more dominant in many industries.

Outsourcing is becoming a significant strategic issue. According to Casale (2000), outsourcing has become a standard practice across all industries. Further, it has evolved from being a 'controversial practice to a mandatory business strategy for companies to compete successfully in today's fast-paced, e-commerce-enabled market environment' (Casale, 2000). Casale asserts that outsourcing is no longer a tool only for cost-control, but rather has become a strategic tool for innovation, global expansion, and a source of competitive advantage. Casale further claims that outsourcing is growing faster than the US economy, and that its growth in smaller companies is in excess of 25% from 1999 to 2000. Ten percent of the US outsourcing dollars is spent abroad, making the outsourcing market truly global (Casale, 2000). According to the Outsourcing Index (OI) 2000, U.S. spending on information technology (IT) outsourcing accounts for 20% of total U.S. outsourcing expenditures. Growth in outsourcing is not limited to IT, but is also growing strong in other administrative areas such as human resources and general administration (see Figure 1). One major reason for this is the organizations' new focus on core competencies, but also issues of shared risk and capital expense models were listed among the top-ten reasons for outsourcing in the US (OI, 2000). The value of the outsourcing activities in the U.S. was valued at $340 billion (OI, 2000).

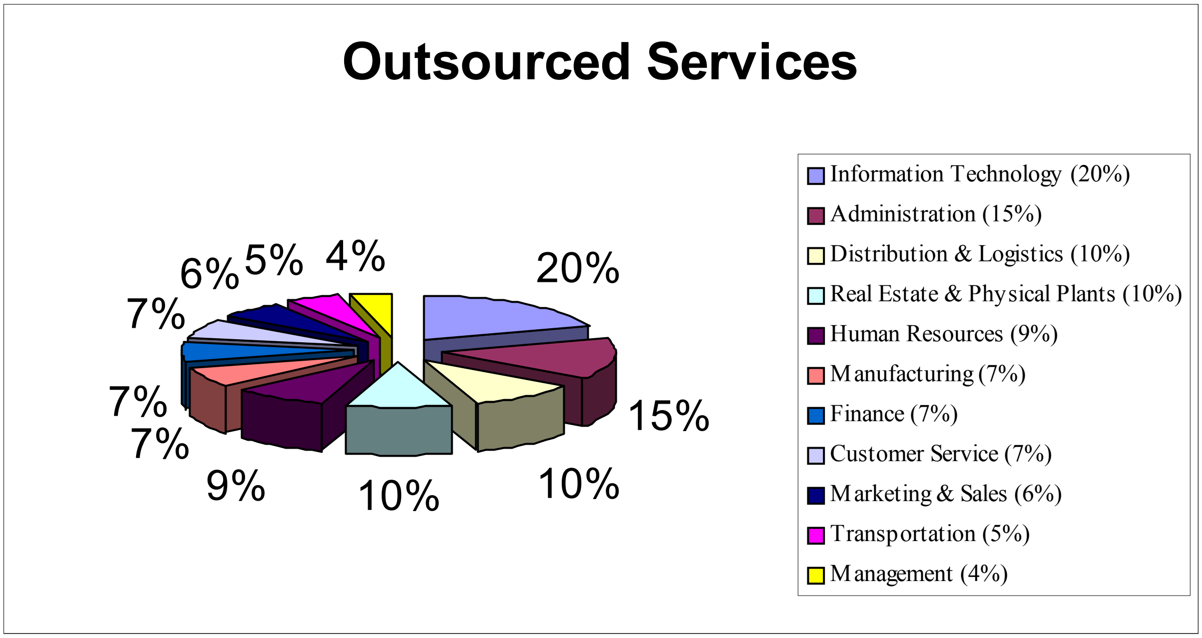

Figure 1: Outsourced Services (Adapted from OI, 2000)

In this paper we agglomerate the inherent barriers to successful outsourcing, and propose a methodology, or decision support tool, which allows managers to analyze business process outsourcing decisions in a subjective framework. We propose a bias-free mathematical abstraction of the BPO problem, and present some computational experiences resulting from applying our model to various business-level outsourcing scenarios. In section 2 we review some of the strategy issues and major challenges related to business process outsourcing. In section 3 we define the BPO problem and outline the solution methodology, whereas section 4 holds the problem formulation. Computational experiments are reported in section 5, and section 6 concludes the paper.

2. Strategic Issues and Challenges

We identify three separate and major issues that impact business process outsourcing decisions: transaction cost (therein coordination cost), risk (including opportunistic behavior), and human judgment issues related to potential sunk-cost considerations. In this section we briefly explain these phenomena and their potential impact on firm-boundary decisions.

Barney (1999) states that the boundary (or outsourcing) decisions are driven by transaction cost analyses, and economic change in a firm is managed through a governance mechanism. There are three categories of governance according to Barney (1999):

i) market governance, where exchanges are managed in a "faceless" market, where market-determined prices prevail (this is also referred to as non-hierarchical governance)
ii) intermediate governance, where complex contracts and forms of strategic alliances are used
iii) hierarchical governance, where the exchange is brought into their own boundary (such as through a subsidiary)

By choosing a governance mechanism from the three given above, the firm implicitly determines its boundaries (i.e., level of outsourcing involvement). These mechanisms are listed in order of increasing coordination cost, and as such the first option is the cheapest. Other transaction costs associated with each governance mechanism also typically include switching costs to change suppliers, and adjustment in costs due to volume or production changes (Walker and Weber, 1987).

In general, and in addition to the various transaction costs of the governance mechanism, risk is the second important consideration in an outsourcing decision. There are several dimensions to risk: the threat of opportunistic behavior by the outside party in the exchange (Barney, 1999; Walker and Weber, 1987), appropriation risk, technology diffusion risk, and end product degradation risk (Walker, 1988). Barney (1999) proposes that risk of opportunistic behavior can typically be mitigated through the choice of the governance mechanism. Walker (1988) identified competitive bid contracting with outside vendors as one of the ways to manage the latter three risks. This approach is particularly typical of non-hierarchical governance. Barney (1999) hypothesized that rapidly evolving high-tech industries will prefer non-hierarchical governance. This governance is commensurate with cost minimization -- that is, risk is either ignored or included in the transaction costs. This choice is particularly valued if the hierarchical governance forms are time-consuming and complicated to establish, or the market conditions are highly volatile or changing at high rates.

In the network economy, we see changes that enable firms to mitigate some risk (or reduce cost) by moving towards a rental model, rather than a capital expense model (note that a capital expense model is one where most of the investment cost is up-front, whereas a rental mode the capital investment is distributed in a "pay-as-you-go" scheme). The recent improvements in both telecommunications (broadband services and ubiquitous access), coupled with business software standardization, have facilitated the emergence of large-scale outsourcing of IT driven business processes. In the IT market, and due to extensive use of the capital expense model, this move is seen in the form of an explosion in software application service providers (ASP). Indeed, most ASPs are specifically designed to take over business processes (from numerous firms) which often where not before outsourced. For example, one such provider (www.intacct.com) operates extensive online accounting application software available to businesses

(McCabe, 2002). The rental fee starts at a mere $50 per month! In this model, firms do not have to "purchase" nor maintain and staff the applications, rather they just "pay as they go", leading to the possibility of a substantial cost savings. The Gartner Group has estimated that the ASP market will grow to about $22.7 billion in 2003, from literally a zero market in 1999 (Gartner Group, 2000). This move towards a rental model may also cause the need for hierarchical governance to be reduced, as firm investments are less contract specific (in fact, the only specific investment necessary for using an ASP provider is often just a web browser).

One trend in these new ASP services is the fact that the processes often are knowledge intensive (such as accounting). While the outsourcing of transaction processing functions has been a long-time concern in the accounting profession (Konstans, 1968), the academic strategy literature also supports the outsourcing of such processes (Quinn, 1999). Quinn states that "today's knowledge- and service-based economy offers companies a chance to increase profits through strategic outsourcing of intellectual based systems". He proposes that risk is mitigated by having an integrated knowledge and outsourcing strategy. Quinn (1999) also outlines some well-accepted strategic principles used by successful companies. In addition to adopting a "core competency" strategy, he proposes that successful firms leverage capabilities and investments of others by exploiting 3 areas of outsourcing:

- Traditional service or functional activities performed in-house (accounting, information technology, etc.)
- Complementary, integrative or duplicative activities scattered across the company
- Disciplines, subsystems, or systems in which outsiders have greater expertise or capabilities for innovation.

All of these are commensurate with the move towards the rental model and using ASPs. Feldman (1999) went one step further, and stated that the result of this ASP trend may be that the businesses that an organization can participate in are now determined by the outside business processes (the software and services) that the organization can use. In other words forcing a firm level restructuring by outsourcing various business processes. This may indeed be positive, since the effects of risk can sometimes be shifted onto a supplier (Walker and Weber, 1987).

The final challenge for proper business process outsourcing is related to the managers' willingness to make an outsourcing decision. Roodhooft and Warlop (1999) experimentally investigated the impact of asset specificity and sunk cost in outsourcing decisions. They found that managers do incorporate explicitly specified transaction costs, such as asset specific investments, in outsourcing decisions. Roodhooft & Warlop (1999) demonstrate that sunk costs unduly influence outsourcing decisions, and this is often true for software projects. Roodhooft and Warlop raise the question how sunk cost errors in outsourcing decision can be avoided, and raised the possibility that the accounting information itself may lead to the mitigation of this bias. In support of this research, Arkes and Blumer (1985) found that the sunk-cost effect is a judgment error that does indeed affect the valuation of decision alternatives. This underscores the need for decision-making tools that are free of the sunk-cost bias plaguing human decision makers in outsourcing decisions.

This prior research regarding sunk cost, transaction cost, and risk in the outsourcing decision is presented as primary motivation for our work. From this research exposition we sought to demonstrate a real need for creating an integrated and bias-free approach addressing the complexities of the business process outsourcing decision problem.

3. Problem Definition and Solution Method.

In this discussion of the BPO problem, we use the term process to denote any business process or sub-process of a business process. A service provider is defined as either external or internal to the firm boundary, thus considering both hierarchical and non-hierarchical governance, consistent with Barney (1999). The Capacitated Business Process Outsourcing problem (CBPO) can now be described as follows: Given a set of business processes with required service demands, a set of potential service providers with limited service capacities, and some assessment of cost and risk associated with the assigning processes to providers, the problem is to find an assignment of processes to providers such that the total cost of this assignment is minimized.

As illustrated above, the three major factors in the outsourcing decision are: the manager's consideration of sunk cost, transaction cost, and risk. Sunk cost is accommodated by its absence in our model-based approach, which prevents the decision-maker from including sunk-cost biases into the decision model. The cost assessment of a business process service provider is composed of fixed and variable cost component. Each fixed and variable cost assessment may include an assessment of business risks as discussed above (e.g., appropriation risk, technology diffusion risk, end product degradation risk, and risk of opportunism) in addition to the more discernable transaction costs (e.g., all direct costs, indirect costs, and switching costs). The cost assessment of the business risk may require considerable judgement on the part of the modeler, and may be included in one or more of the following three (3) cost categories captured in our model:

1) The fixed cost of opening or establishing a service provider at a particular level of volume;
2) The fixed cost of a service provider performing work on a particular process; and
3) The variable cost of a service provider performing work on a particular process.

The fixed cost of opening or establishing a service provider includes the contracting costs, permanent personnel and technology costs, control costs associated with using the service provider, and a cost assessment of the business risks associated with establishing a relationship with the service provider. The fixed cost of a service provider performing work on a particular process includes the cost of setting up the accounts and appropriate internal controls, any contracting costs to handle this process, and a cost assessment of the business risks associated with a service provider performing work on a particular process. The variable cost of a service provider performing work on a particular process includes the hourly cost of processing plus a cost assessment of the business risks. Concepts such as activity based costing (ABC) (Banker, Potter, and Schroeder, 1994; Merz and Hardy,1993; Crane and Meyer, 1993; Miller and Vollman, 1985) can be incorporated into the cost assessments to provide a more accurate costing mechanism than the exemplar hourly rate mechanism used in this paper. Several factors contribute to constraining the BPO problem. First, the service providers are likely to have finite capacities, and secondly the cost of the outsourcing may be prohibitive.

Structurally the CBPO can be thought of as a generalized assignment problem, which is known to be NP-Complete. Related to this problem is a class of vendor-selection problems from the purchasing literature. Weber et al. (1991) provide an extensive literature review of the vendor selection literature; 74 articles which address vendor selection criteria in manufacturing and retail environments. Weber et al. found net price to be the main criteria for vendor selection in 80% of the non just-in-time (JIT) literature and 62% of the JIT literature. Service criteria other than price have been proposed in earlier literature (for example, Dickson, 1966). Weber et al. (1991) found three general categories of quantitative solution approaches to vendor selection: linear weighting models, mathematical programming models, and statistical/probabilistic approaches. An example of linear weighting models is found in Pan (1989), where a linear programming (LP) formulation for multiple sourcing decisions based on the criteria of price, quality, lead-time, and service was proposed. Only variable costs are accounted for by Pan. Narasimhan and Stoynoff (1986) model a procurement allocation decision as a traditional transportation model with a mixed integer programming (MIP) formulation (an example of a mathematical programming model).

Current and Weber (1994) advocate the use of facility location constructs as a basis for modeling vendor selection problems. The MIP formulation proposed in section 4 below is an extension of the capacitated fixed charge facility location problem (CFCFLP), as defined by Daskin (1995).

4. Problem Formulation.

Let i represent a particular business process (hereafter called “BP”), and let j represent a particular service provider. Now, the problem is to assign the BPs (i) to the service providers (j) such that the total operating expenses are minimized. We assume that the following sets are known:

I = the set of BPs to be serviced;

J = the set of potential service providers;

K = the set of capacity levels available to the service providers.

We further assume that a service provider, j, can be utilized at various capacity levels k. A fixed cost is incurred to establish a relationship with each service provider j, and a fixed cost is incurred with a service provider j to set up the processing for each BP i. For each provider j there are also variable costs for processing each BP i.

The input variables are:

$F_{j,k}$ = the fixed cost (including business risks) of using service provider j at each capacity level k.

$f_{i,j}$ = the fixed cost (including business risks) assessment associated with using service provider j for BP i

$v_{i,j}$ = the unit variable cost (including business risks) assessment for service provider j processing BP i

h_i = the number of units of work associated with BP i

$c_{j,k}$ = the capacity (units of work) for provider j at capacity level k

The decision variables are:

$x_{i,j}$ = the percentage of work for BP i performed by service provider j.

$$y_{j,k} = \begin{cases} 1 \text{ if service provider } j \text{ is utilized at capacity level } k; \\ 0 \text{ otherwise.} \end{cases}$$

$$z_{i,j} = \begin{cases} 1 \text{ if any work for BP } i \text{ is done by service provider } j \\ 0 \text{ otherwise.} \end{cases}$$

A mathematical formulation of the CBPO problem can now be stated as follows:

$$\text{Minimize } \sum_{j \in J} \sum_{k \in K} F_{jk} y_{jk} + \sum_{i \in I} \sum_{j \in J} (f_{ij} z_{ij}) + \sum_{i \in I} \sum_{j \in J} (h_i v_{ij} x_{ij}) \qquad (1)$$

Subject to:

$$\sum_{j \in J} x_{ij} = 1 \qquad \forall\, \mathrm{i} \in \mathrm{I} \qquad (2)$$

$$\sum_{i \in I} (h_{ij}\ x_{ij}) \le \sum_{k \in K} (c_{jk}\ y_{jk}) \qquad \forall\, \mathrm{j} \in \mathrm{J} \qquad (3)$$

$$\sum_{k \in K} y_{jk} \le 1 \qquad \forall\, \mathrm{j} \in \mathrm{J} \qquad (4)$$

$$x_{ij} \le z_{ij} \qquad \forall\, \mathrm{i} \in \mathrm{I},\ \forall\, \mathrm{j} \in \mathrm{J} \qquad (5)$$

$$x_{ij} \ge 0;\ y_{jk} = \{0,1\};\ z_{ij} = \{0,1\} \qquad \forall\, \mathrm{i} \in \mathrm{I};\ \mathrm{j} \in \mathrm{J};\ \mathrm{k} \in \mathrm{K} \quad \text{(6), (7), and (8)}$$

The objective is to minimize the total cost (including risk) of outsourcing the business processes given various service provider options. The objective function includes a variety of cost assessments as discussed in section 3 above.

Constraint set (2) states that work needed for every BP must be performed, whether it be by a single provider or whether multiple providers split the work on BP *i*. Constraint set (3) states that the total workload assigned to service provider *j* cannot exceed the particular provider's capacity, and allows for piece-wise non-linear cost and capacity selections. Constraint set (3) also ensures that the fixed costs are incurred for any service provider utilized. Constraint set (4) ensures that at most one capacity selection can be made for any service provider. Constraint set (5) requires that a service provider must be engaged at some capacity level in order to provide service on a BP.

Constraint set (6) allows any portion of BP *i* to be sourced to service provider *j* (we assume that a BP is divisible, and that it may be split among various service providers). Constraint set (7) forces a service provider to either be used or not used at a particular capacity level. Constraint set (8) requires service provider *j* to either perform work or not perform work on BP *i*.

A pictorial representation of the CBPO problem is found in Figure 2.

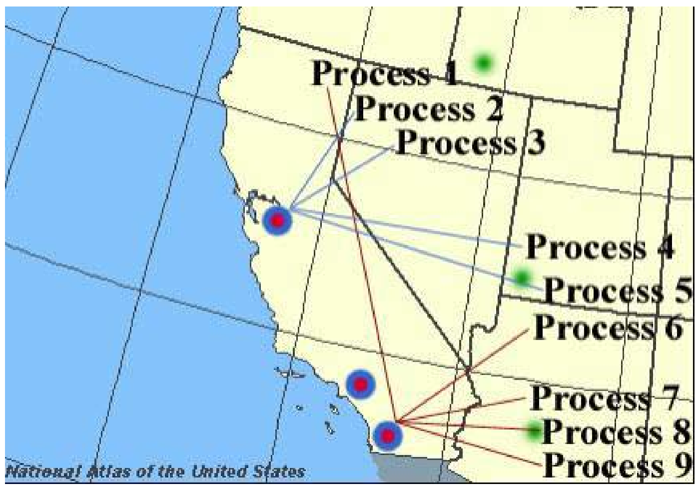

Figure 2: Example Problem Illustration
Source of map: http://nationalatlas.gov/natlas/natlasstart.asp

In Figure 2, we depict a fictional company with three (3) physically separate and distant facilities in Idaho, Utah, and Arizona. Each facility has business processes that are associated with its own operation. The workload for each BP must be assigned to either one or a combination of several service providers located in California. In this pictorial example, processes 1, 6, 7, 8, and 9 are assigned to the service provider located in San Diego, and processes 2, 3, 4, and 5 are assigned to the service provider located in Silicon Valley. The service provider located near Los Angeles is not assigned any business processes.

Managerial Issues

A myriad of additional managerial considerations can be added to the problem formulation. For example, the CBPO problem can be adapted to prohibit a BP from being split between two or more service providers. This may be desirable to ensure the continuity of service for each particular BP, and to reduce coordination cost. For each BP where we mandate a single service provider, we change constraint set (6) to (6a), and for BPs which may have multiple service providers, let constraint set (6) remain substantially the same in constraint set (6b):

$$x_{i'j} = \{0,1\} \qquad \forall\, i', j \tag{6a}$$

$$x_{i''j} \geq 0 \qquad \forall\, i'', j \tag{6b}$$

where $i' \in A'; i'' \in A''; i' \cup i'' = i; i' \cap i'' = \varnothing$

and A' = the set of BPs for which you require a single service provider,

and A'' = the set of BPs which do not require a single service provider, but rather may be sent to multiple service providers.

Other managerial issues are demonstrated below. Constraint (9a) limits the total number of service providers to some maximum level Q.

$$\sum_{j \in J} \sum_{k \in K} y_{jk} \leq Q \tag{9a}$$

Constraint set (9b) limits the number of different service providers <u>for each BP</u> to some predetermined maximum P_i.

$$\sum_{j \in J} z_{ij} \leq P_i \qquad \forall\, \mathrm{i} \in \mathrm{I} \tag{9b}$$

Constraint set (9c) requires that if work is split for BP *i* among multiple service providers, then each service provider will get a minimum percentage of the BP, where R_i is the minimum percentage of work required for each BP.

$$x_{ij} \geq z_{ij} * R_i \qquad \forall\, i \in I,\ \forall\, j \in J \qquad (9c)$$

Further managerial issues and derivations are possible.

5. Computational Experiences.

As even a reduced version of the CBPO problem is known to be NP-complete (Daskin, 1995), the computability and viability of our proposed model must be tested using state-of-the-art computational tools. As such, the CBPO problem formulation was implemented in CPLEX (version 4) using the AMPL modeling language on a single processor (300 MHz) SUN Ultra 30 computer with 128 M of RAM and 1Gb of swap space, running Solaris 2.6 CDE version 1.2. We generated 40 random problems; all problems had 15 outsourceable business processes and 3 capacity levels. The first group of 10 problems had 5 potential service providers, the second group of 10 problems had 30 potential providers, the third group had 50 potential service providers, and the final group of 10 test problems had 100 potential service providers. Our preliminary experiments summarized in Table 1 are derived from running the model with constraint sets (2) through (6). The CPU times reported are the average times for 10 test problems each. As seen from Table 1, small and mid-sized problems are easily solved using AMPL with CPLEX, using less than an average of 34 seconds for the smallest group of problems, and ranging to an average of 1241 seconds for the largest problem group (with 100 potential service providers).

BPs	Service Providers	Capacity Levels	CPU Time
15	5	3	33.79
15	30	3	541.232
15	50	3	583.948
15	100	3	1241.246

Table 1: Computational Results

It is clear from these experiments that a manager could (and should) realistically run the above model using a variety of managerial settings (as illustrated in section 4) in order to investigate the effects of various policies.

6. Summary and Conclusions.

A review of strategic issues related to firm boundaries illustrates the need for a decision support model to address the business process outsourcing problem. The problem definition, model formulation, and computational results presented in this paper demonstrate a comprehensive solution methodology for business process outsourcing in a networked business setting. The decision model for the CBPO problem presented in this paper provides an unbiased and optimal business processing outsourcing methodology, taking into consideration transaction costs and risks, while compensating for the human tendency to include sunk-costs. Implementation of the model requires quantification of the details involved with business process outsourcing, and it encourages management to quantify the risk and control issues related to each potential service provider and business process. The model presented in this paper can be used as a reengineering tool, which may contribute toward the creation of the virtual enterprise. Given the modest computational efforts needed to execute even large problems, the model can also be used for dynamic reconfiguration of a firm's boundaries – something that would likely yield a competitive advantage. While dynamic reconfiguration of such boundary decisions may be impractical at the moment, the future use of transactional languages such as XML and XBRL may eventually make this a reality.

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