MIT Sloan School of Management

MIT Sloan Working Paper 4566-05
CISL Working Paper 2005-10
November 2005

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Abstract

This paper addresses the tension between benefits of centralized data control against the benefits of decentralized control at the level of the business unit. Centralized data control provides the benefit of uniform standards whereas business unit data control grants flexibility to react to rapidly changing environments. Many data standardization efforts fail because they do not fully take into account the value of flexibility and ownership incentives. We use a real options based framework and the theory of incomplete contracts to derive propositions about the optimal level of data standardization across the enterprise. Applications of the propositions are illustrated with case vignettes. The paper makes two main contributions. First, the approach defines formally how incentive structures influence ownership of the option value or value of flexibility, which is an intangible information asset. Second the derived propositions would help senior management to more precisely consider aligning incentives in data standardization exercises.

Key words: economics of IS, outsourcing, enterprise systems, real options, incomplete contracts, standardization, information asset, flexibility and information systems decentralization.

1. Introduction

Data standardization and centralization efforts within firms often go through a cyclical pattern (Bader et al 1999, Goodhue et al 1992). Conversations with senior executives reveal numerous examples where a major data standardization effort is initiated and then before it is fully implemented the project is abruptly stopped and often reversed to a decentralized model. The failure of these projects may be partly explained by the lack of such data standardization efforts to fully take into account the value of business unit flexibility and ownership incentives, which might argue against such an effort. This paper addresses this gap by extending the incomplete contracts theory to the value of flexibility in information assets.

The key premise of centralization efforts is that centralized control is able to enforce uniform standards. Although there is significant benefit in standardizing data, there is also value in variety. In industries experiencing significant environmental change, often the data that are needed to react to these changes are not known for certain[1]. However, business units that are directly facing these environmental changes are more likely to be able to assess the variety and form of information that is needed to react and leverage a new opportunity or limit a loss[2]. The value of variety derives from two principal sources. First, when the data are decentralized, business unit managers are more likely to collect data that is more varied. This might bring about benefits not only in terms of the business unit in question that holds the data but also potentially other units that might later need the data urgently due to changing competitive pressures or customer needs. In this sense data variety builds in the value of flexibility or an option value at the firm level. Second, when data are decentralized, business unit managers are more likely to build in the capability to hold data that might be needed in the future. This will significantly enhance their ability to react to the changing environment compared to when data are standardized. The need to build in future requirements creates an option value for the business unit.

The option value of flexibility is an intangible information asset. This asset derives its value from the need to preserve choice as a result of the twin presence of uncertainty and irreversibility of a fixed course of action. First, uncertainty in the external environment implies that firms will need relevant information to be flexible and react to the environmental outcomes to maximize their profits. Second, data standardization efforts might reduce the ability of the firm to be flexible to react to changes in the environment due to the lack of relevant business unit specific information.

[1] Changes to the external environment can be a result of changes to the competitive environment, consumer preferences or other shocks.

[2] In addition, there could be an ongoing requirement such as the need to submit monthly reports to government agency in a particular format and to senior management in a different format.

Hence, the presence of uncertainty and the irreversible nature of the data standardization effort jointly contribute to the value of being flexible. The uncertainty relating to the specific nature of the information that the firm will need makes the collection and management of such information uncontractible (Grossman and Hart 1986; Hart and Moore 1990). Hence, this lends itself to the application of the incomplete contracts theory in order to better understand the ownership and incentive structure for this intangible information asset (Brynjolfsson 1994; Van Alstyne, Brynjolfsson and Madnick 1995). This paper seeks to integrate an options based framework with an incomplete contracts theory to address the following questions:

(1) How does the value of flexibility influence data standardization and ownership structure?

(2) What incentives help to optimize flexibility across the firm?

(3) How does interdependence among business units affect the value of flexibility and data standardization?

(4) How does the value of flexibility influence outsourcing decisions?

(5) How should we optimize flexibility when the incentive structure requires data to be controlled by separate units?

(6) How do we optimize flexibility by balancing the incentives of business unit managers and the firm?

The next section motivates the management dilemma typically faced by senior management as to whether to standardize enterprise data or not. Section 3 develops the theoretical framework to be applied in the paper. Section 4 outlines the model and develops propositions regarding the existence and the source of flexibility. In section 5, the paper shows that when this value is idiosyncratic to the business unit, it should be decentralized. In section 6, we extend this to draw implications for economies of scope in information management across interdependent business units. In section 7, we apply the model to the outsourcing decision. In section 8, the model considers optimizing the value of flexibility when data must be controlled by separate units. Finally, in section 9 we model the value of flexibility given incentive incompatibility between the manager and the firm. Section 10 concludes.

2. The Data Dilemma: To Standardize or Not?

As corporations become increasingly global and competitive, managers often face the twin pressures of faster response to market conditions and increased coordination across the enterprise. A frequent response is to attempt standardizing all enterprise data – but is this necessarily wise?

To understand this situation, consider a typical situation based on Bader et al (1999) and actual interviews with firms in financial services. Similar situations exist however, in most industries.

This firm has grown both domestically and internationally and both organically and by acquisitions. It has a wide variety of financial service products in many countries of the world. There are hundreds of information systems and databases to support these operations. Although there are some standardized systems, many of the systems and their databases have been specifically developed or purchased to meet the specific needs of that product group in that geographic region. This has occurred for many reasons, such as: (1) the acquisition of an existing organization with its own systems and databases in place, (2) to meet specialized requirements, such as government reporting requirements e.g. Sarbanes-Oxley compliance data or customer practices for that product in that region or (3) to rapidly adapt to meet changing requirements[3]– without need for lengthy delays to coordinate with the central corporate unit or other business units.

In general, individual business units are happy with the systems they have. But, certain centralized corporate functions, such as global risk management, need to gather and aggregate information across all these systems. This can be a time-consuming and error-prone process because of the idiosyncratic differences among these systems (for example, abbreviation codes for Brazil included "BR", "BZ", and "BRA" in different systems). To improve overall corporate profitability while maintaining or reducing risk, requires simplifying and speeding up the process of information aggregation for risk management. One obvious approach is to standardize all enterprise data (i.e., data that is or might need to be used by corporate or any other business unit.) In the example above, there would be one agreed upon standard code for Brazil throughout all databases in the organization.

This often places top management in a dilemma:

(1) The Risk Management group is pushing to create and enforce data standards throughout the enterprise.

(2) The Business Units not only are reluctant to incur the costs of converting to such a standard but complain that it will reduce their ability to respond since any new data or changes to existing data must be coordinated through some central function. Standards imposed remotely can also increase their cost of operation since their local government reporting requirements or customer's information standards can differ.

In such a case, what should top management do? How should these factors be analyzed? This paper provides an economic framework for understanding these issues.

[3] This can be critically important, especially in the financial services industry, where specialized highly profitable financial products can be created almost instantaneously to address specific opportunities that might only last a very short time.

3. Ownership and Option Value Literature

Ownership plays a critical role in the success of information systems (Van Alstyne et al 1995). By ensuring the right to control resources, ownership influences decisions about resource use. Grossman and Hart (1986) use the term 'residual right of control' to refer to this privilege. Information is an intangible asset that provides benefit to its owner. In the context of information systems, the right to control is the ability to access, create and standardize the data as well as determine access privileges for others (Van Alstyne et al 1995). It is useful to note that this right and its associated privileges accrue to the owners regardless of the location of such information. For example, all data could be centralized in one place but there could be many owners, each with residual right of control over specific parts of that data. Alternatively, data could be owned and controlled by one unit but physically located in a distributed manner at various business units.

Enterprise integration typically implies that a corporate centre has control of the data (Heimbigner and McLeod 1985). This may imply loss of business unit autonomy in the design and use of data (Sheth and Larson 1990). In this paper, we consider control to be centralized when the corporate center exercises right of data control. The corporate center will have better control when data is standardized across business units as it reduces the costs of interpreting multiple types of data formats and standards. The benefit of centralized data control is data standardization (King 1983). This paper develops a framework to help firms decide whether and to what extent to standardize data using options theory and incomplete contracts theory.

An option is the right but not the obligation to take an action in the future (Dixit and Pindyck 1994). Real options is the application of options reasoning to investment decision which identifies the factors that influence 'the point at which investors choose whether to invest or not'. Uncertainty justifies flexibility because of the 'principle of bad news'. The combination of an unfavorable outcome and the commitment to a particular irreversible course of action can be worse than keeping the option open and to act only after further information is revealed (Bernanke 1983). Hence, the value of the option derives from two principal sources, namely uncertainty and irreversibility (Arrow and Fisher 1974; Henry 1974). We argue that many strategic decisions that firms face display both the characteristic of uncertainty and irreversibility. The uncertainty stems from the future revelation of conditions in the external environment. Whereas irreversibility is due to the inability to unwind an investment once it has been made. In highly competitive environments firms have a short window of opportunity to react to new information. In these circumstances being versatile and adapting to the changing environment is a critical source of value.

In a strategic context, flexibility is a function of being informed about the opportunities as uncertainty unfolds. The means by which a firm becomes informed is to collect relevant information. In this sense, the firm must decide whether to purchase the option value by investing in the relevant information and hence create flexibility. The value of flexibility appears often in literature that describes local business requirements relative to the benefits of standardization to reduce costs and improve firm wide coordination (Goodhue, Wybo and Kirsh 1992; Marchand, Kettinger, and Rollins 2001). However, these studies allude to the concept of the flexibility only in a qualitative manner. This paper develops analytically the value of flexibility within an options based methodology. This allows us to develop and test propositions for the research questions outlined above.

Incomplete contracts theory provides a framework for understanding how uncertainty affects incentive structures. Contracts are "incomplete" when they cannot account for all possible outcomes or they are just too expensive to formulate in complete detail (Grossman and Hart 1986; Hart and Moore 1990). Grossman and Hart (1986) and Hart and Moore (1990) associate the 'residual right of control' with the owner when the contract fails to specify all possible contingencies. The 'residual right of control' provides the owner of the asset the ability to withhold at least some surplus in cases where the outcome has not been fully specified in the contract. The existence of an incomplete contact reduces the incentive for an individual to invest in a valuable activity because the lack of ex-post bargaining power leaves the investor unable to extract that value. This inefficiently low investment incentive can be overcome by transferring ownership of the asset to the individual concerned. Grossman and Hart (1986) and Hart and Moore (1990) use this framework to derive propositions of vertical and lateral integration and hence to define the boundaries of the firm. Brynjolfsson (1994) extends this analysis by applying the theory of incomplete contracts to 'information assets' to understand the 'mechanism by which information technology can be expected to affect the organization of economic activity'. Van Alstyne et al (1995) apply the incomplete contracts theory to model the optimal distribution of database control that maximizes database value.

We argue that the option value that derives from firms being able to be flexible in order to react to an uncertain environment is an intangible information asset. In this paper we seek to apply incomplete contracts theory to this intangible information asset to clarify the conditions when data standardization and centralization is optimal for a firm.

In addition, the potentially uncertain return of this intangible asset can drive a wedge between managers' objectives and the firm's objectives. Managers are typically more risk averse and shorter term oriented compared to the firm. Since firm owners cannot fully observe the effort level of the managers, they must provide incentives by making the managers' pay partially contingent on the performance of this intangible asset. This situation lends itself to application of principal-agent theory to motivate the optimal contract between the managers and the firm (Holmstorm 1989).

4. Model Formulation

Based on the motivation section, we introduce two types of information namely, local business unit information, I^{BU} and enterprisewide information, I^{E}. Although it is difficult to clearly designate all information as exclusively business unit or enterprisewide, we use the polar cases in order to derive propositions about their properties. The value of the information is defined by its level whereby more information is better than (or just as good as) less information. This is because options always have positive value implying that more options provide more value. To simplify the analysis, we assume that the mean value of options in I^{BU} is the same as I^{E}[4]. Let us also assume that the firm consists of a central unit and several business units. However, for ease of exposition we collapse these multiple costs and benefits of different units into a single business unit. We will relax this assumption later when we look at the impact of economies of scope in information management across business units. Denote the central unit as CU and the business unit as BU.

Consider the case where there are two periods, $t = 0, 1$. In period $t = 0$, the firm makes a decision as to how much of the business unit and enterprisewide information to collect. The return from this investment is realized in period $t = 1$. There are two possible states of nature in terms of the external environment, $\theta_N (N = 1, 2)$. The state of the external environment is revealed at $t = 1$. At this point the firm can react by collecting further business unit information in order to be able to either leverage an opportunity better or to limit its losses. The enterprisewide information is collected at the central unit at time $t = 0$ and will cost C_0^E. Since we are concerned about business unit information in this paper, in the interest of simplicity, we normalize the cost of enterprisewide information, $C_0^E = 0$ without loss of generality. The business unit information can be standardized and collected at the central unit at cost C_0^S at time $t = 0$. If this is done then once the state of the environment is revealed in period $t = 1$, a further cost can be incurred by the central unit of C_1^S to leverage the particular environmental outcome. Alternatively, the business unit can collect the business unit information at periods $t = 0$ and $t = 1$ at cost C_0^B and C_1^B respectively. This is summarized in Table 1 below:

Table 1 : Investment in Business Unit Information

	Time Period, t_0	**Time Period, t_1**
Central Unit (CU)	C_0^S	C_1^S
Business Unit (BU)	C_0^B	C_1^B

[4] If this is not the case then a simple fix would be to introduce a scalar λ such that $\lambda E[I^{BU}] = E[I^{E}]$.

Let us assume that

$$\text{at } t = 0, C_0^S < C_0^B \tag{1}$$

$$\text{at } t = 1, C_1^S > C_1^B \tag{2}$$

$$\text{such that } (C_0^S + C_1^S) < (C_0^B + C_1^B) \tag{3}$$

Assumption 1 states that the cost of collecting the business unit information at the central unit, C_0^S is cheaper than collecting it at the business unit, C_0^B in period $t = 0$. This can be interpreted as a scale economy for the central unit in period $t = 0$ without the benefit of local tailoring. Assumption 2 states that the cost of collecting the business unit information at period $t = 1$, after the state of the environment has been revealed, is higher for the central unit (C_1^S) compared to the business unit (C_1^B). This can be interpreted as the business unit having to spend less to collect the information in period $t = 1$ due to environmental proximity. Assumption 3 states that the overall cost of collecting information in the central unit on a standardized basis over the two periods, $(C_0^S + C_1^S)$ is cheaper than the cost of collecting the information at the unstandardized business unit level, $(C_0^B + C_1^B)$. As discussed earlier, we will assume for simplicity that when data is centralized at the central unit, it is also standardized across business units. Hence, the savings from standardizing and centralizing the information collection is, $G = (C_0^B + C_1^B) - (C_0^S + C_1^S)$.

The states of nature are revealed in period $t = 1$. If θ_1 prevails (the probability of this is p), the net profit (excluding the cost of information collection) is R_1. If θ_2 prevails (the probability of this is, by definition, $(1 - p)$), the net profit is R_2. Let θ_1 be the favorable outcome where $R_1 > 0$ and θ_2 is the unfavorable outcome where $R_2 < 0$. However, the expected value of being in the business is positive, $E(R) = pR_1 + (1 - p)R_2 > 0$, which implies that it is rational for the firm to continue operating in this business. When the firm invests in some business unit information in period $t = 0$, this allows it to collect further business unit information in period $t = 1$, when the uncertainty is resolved to enable it to leverage an opportunity better or to limit its losses. Let α and β respectively be the extent to which the net profits can be altered strategically using the information I^{BU}. The favorable outcome, R_1 can be leveraged by a factor α where $\alpha > 1$. The unfavorable outcome can be limited by a factor β where $0 < \beta < 1$. Since local information is better tailored, let the extent to which the net profits can be altered strategically using the information in I^{BU} be larger if the business unit collects the information compared to the information being standardized and centralized at the central unit. This implies,

$$\alpha^B > \alpha^S \tag{4}$$

$$\beta^B < \beta^S \tag{5}$$

Without discounting, the expected value of centralized and decentralized business unit data collection can be denoted by $E(V_S)$ and $E(V_B)$ respectively where,

$$E(V_S) = [pR_1\alpha^S + (1-p)R_2\beta^S] - (C_0^S + C_1^S) \tag{6}$$

$$E(V_B) = \left[pR_1\alpha^B + (1-p)R_2\beta^B\right] - (C_0^B + C_1^B) \tag{7}$$

Taking the difference in expected values and substituting for G gives,

$$E(V_S) - E(V_B) = G + pR_1(\alpha^S - \alpha^B) + (1-p)R_2(\beta^S - \beta^B) \tag{8}$$

We now show

PROPOSITION 1. *For standardization to be an optimal decision, the savings must be more than the value of the loss in flexibility such that* $G > -\left[pR_1(\alpha^S - \alpha^B) + (1-p)R_2(\beta^S - \beta^B)\right]$.

Proof. Consider first the roles that irreversibility and uncertainty play in the optimal decision to standardize at the central unit. Irreversibility implies that in period, $t = 1$ the business unit information can be collected just as efficiently such that there is no difference on the impact on the net profits. If the firm ignores irreversibility then $\alpha^B = \alpha^S$ and $\beta^B = \beta^S$. This implies that (8) becomes,

$$E(V_S) - E(V_B) = G \tag{9}$$

Since $G > 0$, (8) has a positive value, which means the optimal decision is to standardize the data collection at the central unit.

Now consider the effect of ignoring uncertainty. The stochastic net profit problem becomes deterministic. If the expected value of profits is known with certainty to be Ψ then, $pR_1\alpha^i + (1-p)R_2\beta^i = \Psi^i > 0$ where $i \in (S, B)$. This implies that (8) becomes,

$$E(V_S) - E(V_B) = G + \Psi^i \tag{10}$$

Since (10) has a positive value the optimal decision is to standardize the data collection at the central unit.

Let us now consider the optimal decision when the firm takes irreversibility and uncertainty into account. The decision to standardize the information implies that the expected value from standardizing the information must be larger than the expected value from decentralizing the information i.e. (8) must be positive,

$E(V_S) - E(V_B) = G + pR_1(\alpha^S - \alpha^B) + (1-p)R_2(\beta^S - \beta^B) > 0$

Hence, in order to standardize the information at the central unit,

$$G > -\left[pR_1(\alpha^S - \alpha^B) + (1-p)R_2(\beta^S - \beta^B)\right] \tag{11}$$

QED.

Inequality (11) says that the savings from the standardization of information, G must be larger than the loss in flexibility value for it to be worthwhile to standardize the data at the central unit. There could be excess standardization if the firm were to ignore irreversibility and uncertainty. The condition for standardization becomes stricter as a result of accounting for the irreversibility and uncertainty. Hence, $-\left[pR_1(\alpha^S - \alpha^B) + (1-p)R_2(\beta^S - \beta^B)\right]$ is the value of flexibility or the option value. This value of flexibility must be smaller than G for centralization to be worthwhile given foreclosing the option value.

Marchand (2001) distinguishes between moderate competition and hypercompetitive environments in formulating a framework for data centralization and standardization. In moderately competitive markets, the focus on supply chain management such as production planning or inventory management systems can bring substantial operational benefits. On the other hand, in a hypercompetitive environment where the demand pattern is continuously changing, the focus must be on managing customer interaction, account management and order processing. In these environments, the emphasis shifts from supply chain management with detailed management reporting and controls to demand chain management by simplifying detailed management reporting and empowering managers to act based on the changing environment. As the competitive environment changes from product to customer, the need for flexibility to serve customer requirements becomes more important than standardizing the meaning of operational data. Moreover, economic growth might also contribute to the level of uncertainty. Firms decentralize data during periods of economic growth to be agile and take advantage of growth opportunity. On the other hand, firms tend to standardize data during periods of economic slowdown in order to cut costs and also to achieve growth through scope benefits.

The case of a leading elevator company illustrates how firms manage the tension between standardization and business flexibility (Marchand 2004). The firm's business focused on providing local services to customers in 22 countries with 22 country operations. Competitors were entering their markets with a more standardized operating model. The newly appointed CEO decided to divide the 22 country operations into 3 regions and operate in a more regional rather than country focus. The business information systems were also organized along regional lines. This allowed the elevator company to 'leverage its reputation, deep business knowledge and human capabilities to target real sources of competitive differentiation locally in elevator markets and at the same time leverage regional and global expertise where it creates technological, product and operational advantages' (Marchand 2004). The company was able to improve its operating performance by achieving a better balance between business unit flexibility and standardization.

Failure to recognize the need for business unit flexibility often raises considerable resistance. In 1995, Dow Corning, a major firm in the silicone materials business, decided to implement SAP, an enterprise resource planning system as a first step towards standardization of data and processes (Ross 1999). However, SAP did not provide full functionality for some business unit requirements which required 'bolt-ons' to provide additional business unit specific information. These 'bolt-on' were different for different business units. The initial approach by the implementation team of trying to minimize 'bolt-ons' in the interest of getting the system in quickly was resisted strongly by the business units. Eventually, the implementation team recognized the need for these additional requirements and worked closely with the business unit managers to identify and support key 'bolt-ons'. By recognizing the need for such local tailoring, Dow Corning was successful in expediting the SAP implementation while fulfilling the business unit requirements.

The next section explores these issues and examines how the value of flexibility influences data standardization and ownership structures.

5. Data standardization and Ownership

We extend the model above to study the incentive effects of different ownership arrangements using incomplete contracts theory. The asset that will be central to the analysis is the option value or the value of flexibility as outlined in the previous section. The incomplete contracts theory developed by Grossman-Hart-Moore will be applied to asset ownership to evaluate the incentive for the central unit and business unit respectively to arrive at the optimal decision for the firm.

Since the paper is principally concerned with business unit information we drop the superscript and refer to the information as, I unless stated otherwise. We make the following further assumptions:

(i) Total cost, $TC(I) = C_0(I_0) + C_1(I_1)$ where $TC'(I) > 0$ and $TC^{''}(I) > 0$

(ii) $C_1 = f(C_0)$ where $\frac{\partial C_1}{\partial C_0} < 0$ and $\frac{\partial^2 C_1}{\partial C_0^2} > 0$

(iii) $\alpha = f(C_0)$ where $\alpha'(C_0) > 0$ and $\alpha''(C_0) < 0$

(iv) $\beta = f(C_0)$ where $\beta'(C_0) > 0$ and $\beta''(C_0) < 0$

Assumption (i) states that the total cost of information collection and management is the sum of the cost for the two periods. The marginal total cost is increasing with respect to information, twice differentiable and convex in information, I. Assumption (ii) states that the cost in period $t = 1$ is a function of the cost incurred in period $t = 0$ where the cost in period $t = 1$ decreases the more that was spent in period $t = 0$ but this benefit diminishes at an increasing rate. This implies that the total benefit of increasing the spending on $t = 0$ cost is higher at lower levels of period $t = 0$ costs and diminishes at higher $t = 0$ costs. Assumptions (i) and (ii) together imply that the total cost is also twice differentiable and convex in I. Assumptions (iii) and (iv) state that the marginal value per dollar decreases with increased information. This ensures that the expected return is twice differentiable and concave in I.

The expected value function becomes,

$$E(V) = V(C_0, C_1) = [pR_1\alpha + (1-p)R_2\beta] - (C_0 + C_1) \tag{12}$$

The optimum at the firm level is to choose (C_0^*, C_1^*) to maximize the expected value such that $V(C_0^*, C_1^*)$. This occurs at the point where marginal cost (MC) = marginal revenue (MR),

$$TC'(I) = E'(\Phi) \tag{13}$$

where $E'(\Phi) = \left[pR_1\alpha' + (1-p)R_2\beta'\right]$.

However, due to the lack of verifiability of the exact information that is required for strategic flexibility, I is not contractible. Hence the costs associated with I, namely C_0 is also not contractible. The lack of verifiability and contractibility means that costs cannot be directly compensated and hence, a unit will only incur the costs up to the level for which it will receive compensation for them. We now show,

PROPOSITION 2. *When cost allocation, ω is not equal to revenue sharing, μ e.g. $\omega > \mu$ there is under-investment and over-investment relative to the optimum (C_0^*, C_1^*) at the firm level. That is*

(i) *uncompensated central unit costs imply underinvestment such that* $C_0^S < C_0^*$ *hence* $V(C_0^S) < V(C_0^*)$

(ii) *revenue without matching costs imply overinvestment such that* $C_0^{BU} > C_0^*$ *hence* $V(C_0^{BU}) < V(C_0^*)$.

Therefore, business units should have responsibility and ownership for business unit information that adds flexibility value to them to achieve optimum value at the firm level.

Note that typically, one would find that $\omega > \mu$ as a result of centralization exercises where the costs are predominantly borne by the central unit but the benefit of the value of flexibility accrues to the business unit. Moreover, ω and μ are typically forced apart when revenues are allocated to the central unit sufficient just to cover costs for the central unit[5].

Proof. Let us assume that the firm allocates the costs and benefits according to an accounting rule such that the central unit value and business unit value are respectively V^S and V^{BU},

$$V^S(C_0, C_1) = \mu\,[pR_1\alpha + (1-p)R_2\beta] - \omega[(C_0 + C_1)] \tag{14}$$

$$V^{BU}(C_0, C_1) = (1-\mu)\,[pR_1\alpha + (1-p)R_2\beta] - (1-\omega)[(C_0 + C_1)] \tag{15}$$

Under this accounting rule of apportioning the costs and benefits, as long as ω is not equal to μ, there would be under-investment and over-investment relative to the optimum (C_0^*, C_1^*) at the firm level. Under this accounting rule, if the central unit were to be responsible for business unit information management then it will under-invest in I such that $C_0^S < C_0^*$. This is because the point where the central unit's marginal cost = the central unit's marginal revenue is not the same as the firm's marginal value. For the central unit, the first order condition for maximization gives,

$$TC'(I) = \left(\frac{\omega}{\mu}\right) E'(\Phi) \tag{16}$$

since $\left(\frac{\omega}{\mu}\right) < 1$, this will result in under-investment where $C_0^S < C_0^*$.

Conversely, if the business unit is responsible for business unit information management, it will tend to over-invest in I such that $C_0^{BU} > C_0^*$. The optimum expected value, $V(C_0^*, C_1^*)$ is achieved when $\omega = \mu = 0$. QED.

In order to achieve the optimum, the costs and benefits need to be accounted for in the same unit. Since the value of flexibility or option value is idiosyncratic to the business unit,

[5] When expected revenues exceed costs then allocation of revenues to the central unit in order to cover costs of information collection (for the central unit) implies unequal proportions in costs and revenue allocation i.e. $\omega > \mu$.

the non-contractible costs of the business unit information must also be accounted for and under the control of the business unit to achieve the optimum outcome at the firm level. Hence this calls for decentralization of business unit information rather than standardization.

An example of the operation of this principle can be seen at Hewlett Packard (HP). HP bills all IT costs, including employee e-mails, to the business unit managers so as to encourage awareness of costs and achieve the optimal level of information for the firm as a whole (Marchand 2000).

Similarly, in order to minimize distortions caused by the mismatch between costs and benefits, a major Wall Street bank utilizes a fungible method of allocating its central IT staff to business units information management projects based on requests. A senior executive of the central IT team said 'We operate like a consulting firm to ensure provision of expertise of the highest standards whilst achieving appropriate cost allocations'.

An implication of this result is that any standardization exercise that does not adequately balance the value of global data integration with local business unit flexibility is likely to fail due to the mismatch between costs and benefits. We often hear about cases where the costs of central unit standardization, for example, to comply with regulatory requirements is forced upon the business units. This results in a tension between the business unit and the central unit resulting in substandard data being provided, or worse still, non-compliance. Therefore, proposition 2 implies the following:

COROLLARY 2A. *Efforts to standardize information need be funded by the beneficiary of standardization.*

The experience of Johnson & Johnson in managing its standardization exercise to improve customer management proves to be a clear example of this. Although Johnson & Johnson in 1995 was seen as a successful company due to its devolved management structure, customers were often frustrated because there was no single point of contact (Ross 2003). Management set itself as a priority to provide a single face to the customer. One element of this overall objective was to standardize critical customer data across their operating companies, including installation of a single global network and desktop configuration. Traditionally, operating companies would have funded this. However, Johnson & Johnson's management realized that in order to accelerate the process and obtain buy-in, some level of central funding would be required. Johnson & Johnson's management agreed to provide corporate level funding to the operating companies with eventual chargeback arrangements.

A second example is the Carlson companies. The Carlson Companies has operations in diverse businesses in the hospitality industry including hotels, restaurants and loyalty programs (Fonstad and Ross 2003). In 1998, Carlson developed a vision of being a customer driven company, which required customer information to be shared across business units. In order to build a common enterprise architecture, the projects were funded jointly by the office of the CIO and the business units. However, in some cases, to ensure a smoother transition, the CIO subsidized a project until a business saw benefits from it.

In summary, the ownership and management of information that is non-contractible due to uncertainty should be in the hands of the unit that is the primary beneficiary of that information.

6. Economies of Scope

This section extends the model to analyze the incentive for investing in information when there are economies of scope across different business units. We first analyze the case where there are economies of scope from interdependent business units. We then go on to analyses the special case where there is scope benefit for one business unit from the activities of another business unit.

6.1. Interdependent Business Units

This section extends the model to consider the case where the business units are inter-dependent. For example the sharing of a common customer often results in a business unit collecting information that is beneficial to another business unit and vice versa. For example, the payment history of a credit card customer of a bank might be helpful in assessing the credit rating of that customer for a mortgage application and vice versa.

Let us continue to assume that there are two business units A and B denoted by BU_A and BU_B. Part of business unit B's profits are correlated to business unit A's profits and vice versa. As assumed previously we have two states of the environment with the probability of occurrence p and $(1-p)$ respectively. The profit to BU_A is R_1^A and R_2^A respectively for the two states of the environment. The profit to BU_B is $R_1^B + \phi R_1^A$ and $R_2^B + \phi R_2^A$ where ϕ is a correlation coefficient and $0 < \phi < 1$. Similarly the profit to BU_A has spill-over effects from the profits BU_B of such that $R_1^A + \phi R_1^B$ and $R_2^A + \phi R_2^B$. Therefore, the business unit information, I for BU_A might benefit BU_B and vice versa. The extent of the cross benefit is captured by the correlation coefficient. The returns are summarized in Table 2 below:

Table 2: Interdependent Business Unit and Returns

States of Nature, θ_N	**Business Unit A**	**Business Unit B**
θ_1 with probability p	$R_1^A + \phi R_1^B$	$R_1^B + \phi R_1^A$
θ_2 with probability $(1-p)$	$R_2^A + \phi R_2^B$	$R_2^B + \phi R_2^A$

For both BU_A and BU_B, the expected value as before is

$$E(V^j) = E(R^j) - (C_0 + C_1) \tag{17}$$

where $j \in (A, B)$

First order condition for BU_A and BU_B is,

$E'(V^j) = [\alpha' p R_1^j + \beta'(1-p) R_2^j] - C'^j(I) = 0$

which implies,

$$C'^j(I) = [\alpha' p R_1^j + \beta'(1-p) R_2^j] \tag{18}$$

At the firm level, the expected value is

$$E(V) = E(R^A/I^A, I^B) + E(R^B/I^A, I^B) - C(I) \tag{19}$$

where,

$C(I)$ = the total cost of business unit A and B

$E(R^A/I^A)$ = the expected flexibility value of BU_A given the information collected by BU_A and BU_B respectively.

$E(R^B/I^A, I^B)$ = the expected flexibility value of BU_B given the information collected by BU_B and BU_A respectively.

We show the following proposition and corollary:

PROPOSITION 4. *All other things being equal, the more homogeneous the business units are, the larger the benefits from standardization. That is when $\phi_1 > \phi_2$, standardization improves total firm value from $(E(V^A) + E(V^B))$ to $E(V)$ such that $E(V^{\phi_1}) > E(V^{\phi_2})$.*

COROLLARY 4A. *All other things being equal, the more heterogeneous the business units are, the smaller the benefits from standardization.*

Proof. We find the optimum information collection and the associated cost at the firm level. This could be achieved by taking the first order condition for the firm by differentiation equation (19) with respect to total cost for BU_A and BU_B. This can be compared to the solution to equation (18) to understand the difference in optimization at the firm level compared to the business unit level. Using equation 19 and replacing the returns from table 1 gives,

$E(V) = [p\alpha(R_1^A + \phi R_1^B) + (1-p)\beta(R_2^A + \phi R_2^B)] + [p\alpha(R_1^B + \phi R_1^A) + (1-p)\beta(R_2^B + \phi R_2^A)] - C(I)$

by rearranging,

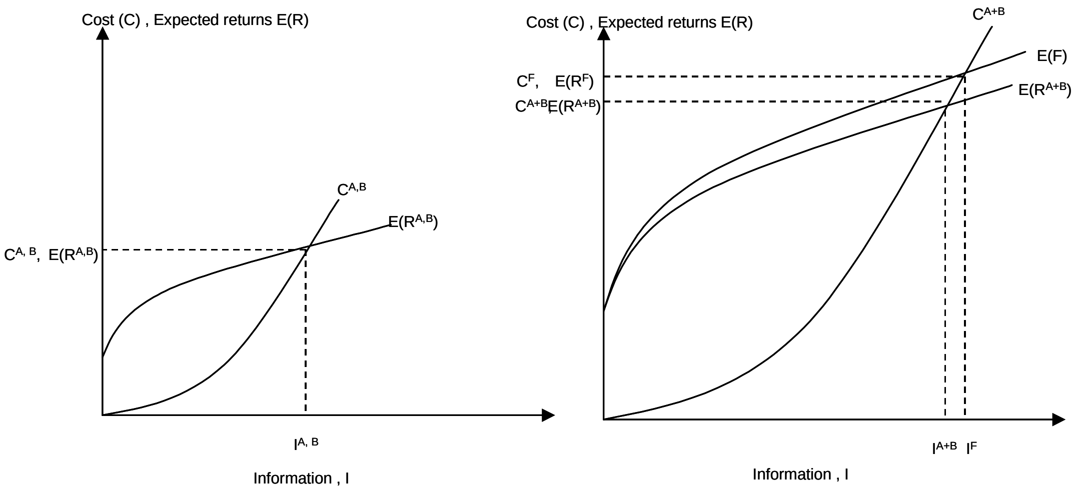

Figure 1 Optimal Information at Business Unit and Firm

$$E(V) = (1+\phi)[p\alpha(R_1^A + R_1^B) + \beta(1-p)(R_2^A + R_2^B)] - C(I) \tag{20}$$

First order condition for the firm is,
$E'(V) = (1+\phi)[p\alpha'(R_1^A + R_1^B) + \beta'(1-p)(R_2^A + R_2^B)] - C'(I)$
which implies,

$$C'(I) = (1+\phi)[p\alpha'(R_1^A + R_1^B) + \beta'(1-p)(R_2^A + R_2^B)] \tag{21}$$

By substituting (18) into (21) we get,

$$C'(I) = (1+\phi)[C'^A(I) + C'^B(I)] \tag{22}$$

Let the pair of costs (C_0^{A*}, C_1^{A*}) and (C_0^{B*}, C_1^{B*}) represent the solution for $C'^A(I)$ and $C'^B(I)$ respectively. Let the pair of costs (C_0^*, C_1^*) represent the solution for $C'(I)$. Then equation (22) implies the total costs of information collection will be higher at the firm level than the sum of the costs if the business units were to collect the information independently such that, $C_0^* + C_1^* > (C_0^{A*} + C_1^{A*}) + (C_0^{B*}, C_1^{B*})$. This implies the benefit from standardization, $\Gamma = E(V) - [E(V^A) + E(V^B)] > 0$. Hence, we can see from equation (22) that the less heterogenous the business units i.e. the larger ϕ the larger is the benefit from standardization, Γ. QED.

We gain better insight with a simpler approach that analyzes the problem in stages using a graphical analysis. The diagram on the left in figure 1 shows the costs and expected returns for BU_A.

The costs and expected returns functions for BU_B is assumed to be the same as BU_A. We refer to BU_A in the following section but it equally applies to BU_B. For ease of exposition, we summarize the two period costs into a single measure. As there is no discounting, this generalization does not change the analysis in any substantial manner. The optimal cost, C^A and expected return, $E(R^A)$ will be at the point where marginal costs equal marginal revenues resulting in optimal information of I^A for BU_A. For BU_B the corresponding optimals are cost, C^B, expected return, $E(R^B)$ and information, I^B respectively.

The next stage is to evaluate the optimal decision of the business units compared to the firm. The diagram on the right in figure 1 shows the costs and expected returns for the firm. The total costs at the firm level, C^{A+B} is the summation of the individual business units costs, C^A and C^B. Similarly, the expected return $E(R^{A+B})$ is the sum of the individual business unit expected return, $E(R^A)$ and $E(R^B)$. The optimal cost, C^{A+B} and expected return, $E(R^{A+B})$ will be at the point where marginal costs equal marginal revenues resulting in optimal information of I^{A+B} for the business units respectively. However, based on proposition 3, when there are scope benefits that are not considered by the business units, the optimal at the firm level will be different compared to the individual business unit level. The expected returns will have to be adjusted by adding the scope benefits. In addition, this expected return would need to be reduced by the overlap in expected flexibility value of BU_A and BU_B as a result of the common information as set out in equation (19). The adjusted expected return at the firm level is represented in the diagram on the right in figure 1. The optimal cost, C^F and expected return, $E(R^F)$ will be at the point where marginal costs equal marginal revenues resulting in optimal information of I^F for the firm. The optimal at the firm level is higher than the optimal at the individual business unit level due to the influence of the scope benefits.

There are two principal benefits of standardization. First is the ability to eliminate the duplication of information collection between the two business units. Second is the ability to share information across the business units and hence obtain a better understanding of the business requirements. For example, as shown in figure 2, the better ability to serve common customers can be illustrated as the shifting of the cost curve downwards from C^{A+B} to C^S. The optimal cost, C^C and expected return, $E(R^C)$ will be at the point where marginal costs equal marginal revenues resulting in optimal information of I^C for the business units respectively. This optimal information of I^C which is achieved by eliminating the duplication of information collection between the two business units is higher than the optimal at the firm level, I^F. This results in value added to the business unit from both the reduced costs and the increased flexibility denoted by the area OFC.

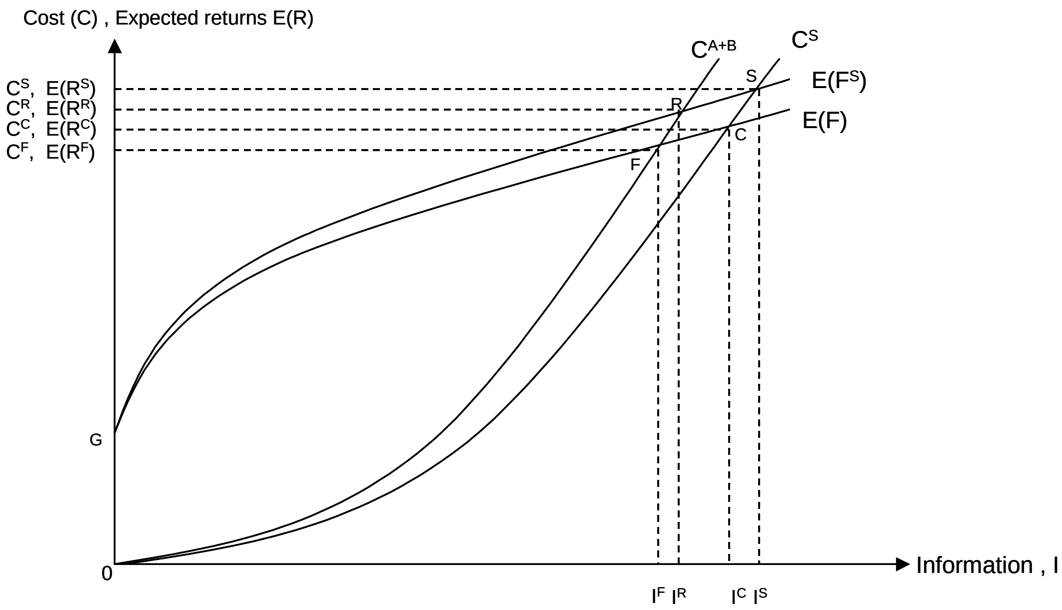

Figure 2 Optimal Information with Standardization

The second benefit from improved flexibility can be illustrated by a shift upwards in the expected returns curve to $E(F^S)$. The optimal cost C^R and expected return, $E(R^R)$ will be at the point where marginal costs equal marginal revenues resulting in optimal information of I^R for the business units respectively. This optimal information of I^R which contributes to a larger flexibility value is higher than the optimal information of I^F at the firm level discussed above. This results in value added to the business unit from both the reduced costs and the increased flexibility denoted by the area GFR. By a similar reasoning, we can state that if both benefits happen simultaneously than the overall value added is $GSOF$. The net value added is dependent on the level of similarity between the business units. The more similar the business units the higher will be the correlation coefficient resulting in a larger value added from standardization. Hence, the firm should not spend more than this value added amount when standardizing information across business units.

The case of Walmart provides an illustrative example of a business with homogenous stores across the country allowing for data to be managed centrally. Following Hurricane Charlie in Florida in September 2004, Walmart utilizing its centralized shopper history data found that people, somewhat surprisingly, tend to buy strawberry pop tarts and beer just before hurricanes (The New York Times 2004). Hence, Walmart filled their trucks with toaster pastries and six-packs and stocked their Florida stores before the Hurricane Frances hit a few weeks later. Most of the products that were stocked were sold before the second hurricane.

On the other hand, when business units become more heterogeneous, they would prefer to have more independent control of the business unit information. In this case it is likely that choices made by the corporate center may diverge from the local business unit needs. For example, within a pharmaceutical firm, a division that competes on cost based on delivering commodity products such as IV Fluid bags or other supplies will take a different approach to information management compared to another division that focuses on research and development with a high margin business (Applegate et al 2003). The commodity based product division will be concerned about information related to managing the manufacturing and operational costs of the division. In contrast, the research and development division will need to track and manage information on new ideas and discoveries that help its scientists in their research efforts. Any attempt to standardize these heterogeneous divisions is likely to compromise one or both the business unit's objectives.

In summary, firms will need to be cognizant of the level of homogeneity across business units in deciding whether to standardize information across the firm and how much to spend for such standardization projects.

6.2. Scope Benefit and Subsidy

This section develops the model where the flexibility value is simultaneously created in multiple business units and derives the appropriate incentive structure to optimize this value at the firm level. Assume two business units A and B denoted by BU_A and BU_B. Part of business unit B's profits are correlated with business unit A's profits. As before we have two states of the environment with the probability of occurrence p and $(1-p)$ respectively. The profit to BU_A is R_1^A and R_2^A respectively for the two states of the environment. The profit to BU_B is $R_1^B + \phi R_1^A$ and $R_2^B + \phi R_2^A$ where ϕ is a correlation coefficient and $0 < \phi < 1$. The correlation may be due to the fortunes or purchasing patterns of a common customer. Therefore, the business unit information I for BU_A might benefit BU_B. We show,

PROPOSITION 3. *In the presence of scope benefits, a firm needs to subsidize the cost of business unit information management. That is, $\phi > 0$ implies a subsidy of $\phi C_A^{'}(I)$ improves total firm value from $E(V^A)$ to $E(V^*)$.*

Proof. At the firm level, the expected value is

$$E(V) = E(R^A) + E(R^B) - C(I) \tag{23}$$

By substitution and rearranging we get,

$E(V) = pR_1^A\alpha(1+\phi) + (1-p)R_2^A\beta(1+\phi) + pR_1^B + (1-p)R_2^B - C(I)$

First order condition for the firm is,

$E'(V) = \alpha' p R_1^A (1+\phi) + \beta'(1-p) R_2^A (1+\phi) - C'(I) = 0$

which implies,

$$C'(I) = [1+\phi] \left[\alpha' p R_1^A + \beta'(1-p) R_2^A \right] \tag{24}$$

For BU_A, the expected value is

$$E(V^A) = E(R^A) - (C_0 + C_1) \tag{25}$$

First order condition for BU_A is,

$E'(V^A) = [\alpha' p R_1^A + \beta'(1-p) R_2^A] - C'^A(I) = 0$

which implies,

$$C'^A(I) = [\alpha' p R_1^A + \beta'(1-p) R_2^A] \tag{26}$$

By substituting (24) into (26) we get,

$$C'(I) = [1+\phi] C_A^{'}(I) \tag{27}$$

Hence, a subsidy of $\phi C_A^{'}(I)$ restores the investment in the collection of business unit information by BU_A to the optimal level for the firm[6]. QED.

BU_A will underinvest in the collection of business unit information compared to the optimal level for the firm by a factor $[1+\phi]$. This is because BU_A does not take into account the scope benefits of the information it collects for the other business unit that might also need them. Hence, the central unit or the business unit that benefits from the scope economies needs to subsidize the costs of the business unit that collects the information by this factor.

At many management-consulting firms, knowledge regarding the latest development within an industry or client often resides within the team members from the industry group or office that most recently completed an assignment in that area. However, this information is valuable to offices in other geographic locations or other industry groups. This information might have been deposited within an organization-wide knowledge-sharing database. However, the richness of the information is often not available within such databases and is often captured within the local office databases or only known to the consultants who worked on the assignment. In order to overcome the scope benefit issue that adds value to the firm, PricewaterhouseCoopers introduced a credit allocation system to its partners in the 1990s. Partners were not only evaluated in terms of the standard evaluation metrics of sales and business development but were given credit based on how

[6] The expected value at the firm level that results from the subsidy will be less than the 'first best' expected value that the firm could obtain when outcomes can be verified precisely ex-post.

much time and effort was dedicated to helping other industry groups and offices win and deliver assignments. By this credit allocation method, the firm created a subsidy based process that not only encouraged partners to collect information that might be beneficial to other units but also provided the incentive to share it to create value across the firm.

The Metropolitan Police Service (MPS) – Scotland Yard provides policing services for London and the United Kingdom. Although the pressure to standardize information is very high for solving crimes, the essential information often resides in one or more independent systems (Weill and Ross 2004). Due to the benefits of synergy, MPS Scotland Yard has evolved an information management governance process where funding is decided centrally by the Information Management Steering Group to ensure scope benefits are given due consideration. Similarly, the US Patriot Act reduced the information sharing barriers among government agencies such as the CIA and FBI in their fight against terrorism (Information Outlook 2002).

In summary, business unit information often provides benefit across multiple business units. Since business units only take their private marginal benefit and costs when making a decision, they are likely to under-invest from the firm's point of view. Therefore, it often pays to subsidize such business units in order to achieve the optimum investment in business unit information.

7. Value of Flexibility and Outsourcing

Outsourcing has become a very popular means to leverage low cost providers to improve the firm's cost structure. However, many of the outsourcing decisions are taken from a cost perspective with little consideration of the other impacts on the firm's value. The quality of information and its impact on the value of flexibility is one area that is often overlooked. In this section, we will extend our analysis to evaluate the outsourcing decision.

The preceding section assumed that costs related to business unit information are non-contratible. We relax that assumption in this section. We assume that there are tangible costs that are verifiable and intangible costs that are not verifiable. It follows that tangible costs are contractible and intangible costs are non-contratible (Van Alstyne et al 1995). We will denote the tangible costs as C^T and the intangible costs as C^I. Outsourcing costs are such that the tangible costs from outsourcing are less than the tangible internal costs,

$(\underline{C_0^T} + \underline{C_1^T}) < (C_0^T + C_1^T)$ where $\underline{C_0^T}$ and $\underline{C_1^T}$ are the period 0 and 1 outsourcing costs.

As before the expected value for the firm is

$$E(V^F) = pR_1\alpha + (1-p)R_2\beta - \left[(C_0^T + C_0^I) + (C_1^T + C_1^I)\right] \tag{28}$$

If the firm outsources, the expected value becomes,

$$E(V^O) = pR_1\underline{\alpha} + (1-p)R_2\underline{\beta} - [(\underline{C_0^T} + \underline{C_1^T})] \tag{29}$$

Because the firm looses full control of the information management process and there is an incentive for the outsourcing firm to minimize the value of the intangible costs, the ability of the firm to leverage an opportunity or limit a loss might be somewhat weaker. This implies, $\alpha > \underline{\alpha}$ and $\beta < \underline{\beta}$ which means loss in the value of flexibility for the firm. However, the firm might make savings from lower intangible costs. Hence, we obtain the following proposition:

PROPOSITION 5. *Lower costs in themselves are insufficient to justify outsourcing that is* $E(V^O) > E(V^F)$ *only when* $[(C_0^{T*} + C_1^{T*}) + (C_0^{I*} + C_1^{I*})] - [(\underline{C_0^{T*}} + \underline{C_1^{T*}})] > [pR_1(\alpha - \underline{\alpha}) + (1 - p)R_2(\beta - \underline{\beta})]$.

Proof. For the firm, F.O.C. for optimization using equation (28) would give the pair of costs (C_0^{T*}, C_0^{I*}) and (C_1^{T*}, C_1^{I*}). For outsourcing, set $C^I = 0$ and optimizing (29) gives the pair of costs $(\underline{C_0^{T*}}, \underline{C_1^{T*}})$. Given these pair of costs, $E(V^F) > E(V^O)$ when the savings from outsourcing is less than loss in the value of flexibility and savings from non-contractible costs (intangible costs),

$$\left[C_0^{T*} + C_1^{T*}\right] - \left[\underline{C_0^{T*}} + \underline{C_1^{T*}}\right] < [pR_1(\alpha - \underline{\alpha}) + (1-p)R_2(\beta - \underline{\beta})] - [C_0^{I*} + C_1^{I*}] \tag{30}$$

QED.

A recent report suggests that many companies that outsourced their IT operations end up bringing them back in-house (Adams 2004). A large global investment bank is reintegrating some of the processes it had outsourced a few years ago. The firm is looking to set up one of the world's largest captive sites. The captive site model transfers critical processes to a separate entity at a cheaper geographical location. However, unlike outsourcing to a third party the investment bank would retain ownership of the entity. Through the captive model the investment bank is able to reap the benefits of the cheaper costs but at the same time maintain control of the operations. The Head of Global Sourcing for the investment bank remarked, "For processes which require high knowledge intensity the captive model allows us to protect intellectual property whilst maintaining control. The benefits of the captive model are lower costs with the ability to maintain quality of information as well as ensuring speed to market to leverage an opportunity." Hence the inability to contract completely with the outsourcing firm thereby hold them accountable is partly responsible for in-sourcing some of these outsourced functions. Moreover, business unit managers who know the business more intimately can contribute to higher quality of information, which results in some of the softer benefits of not outsourcing.

In summary, firms need to consider, in addition to costs, the loss in the quality of information and the corresponding impact on the value of flexibility in their decision to outsource.

8. Data Integration for Multiple Locations

We now analyze how to optimize flexibility when the incentive structure requires data to be controlled by two separate units. This would be the case when inequality (11) is not satisfied resulting in data not being standardized and centralized. Moreover, proposition 2 states that business unit information, I^{BU} should be held within the business unit. The central unit would continue to hold the enterprisewide information, I^{E}. However, when I^{BU} and I^{E} are controlled together the information is more valuable than when the information is controlled by two separate units.

Let us assume that α^T and β^T are the extent to which the net profits can be altered strategically when the information, (I^{BU}, I^{E}) is controlled together compared to when they are controlled by a central unit and the business unit respectively. Imagine that α^T and β^T are such that,

$$\alpha^T > \alpha^B \tag{31}$$

$$\beta^T < \beta^B \tag{32}$$

We show that,

PROPOSITION 6. *Data integration software enhances the flexibility value of the firm if the cost of the data integration software,* $K < [pR_1\alpha^T + (1-p)R_2\beta^T] - [pR_1\alpha^B + (1-p)R_2\beta^B]$.

Proof. The value of flexibility when the information is jointly controlled is greater than when the information is controlled separately such that,

$$pR_1\alpha^T + (1-p)R_2\beta^T > pR_1\alpha^B + (1-p)R_2\beta^B \tag{33}$$

Integrating data would be worthwhile as long as the cost of the data integration software, K is less than the net benefit from integrating the information such that,

$$K < [pR_1\alpha^T + (1-p)R_2\beta^T] - [pR_1\alpha^B + (1-p)R_2\beta^B] \tag{34}$$

QED.

Data integration software can overcome the tension between the need for two separate units to control information driven by incentives and the benefit of controlling information together. Data integration software would be able to integrate the information controlled by two units so that the respective units would be able to use the information as if they were controlled together. An integral part of such data integration effort would be data reconciliation and interpretation efforts such as 'Context Interchange'. 'Context Interchange' facilitates database transformations and addresses the problem of declaring source data meaning (Madnick et al 2000).

For example, the need for all parts of the organization to have the most up-to-date information on the status of customers is an important element to ensure a co-ordinated sales and marketing effort. The case of Norwich Union Direct Financial Services is an example of this (Marchand, Kettinger and Rollins 2001). In 1996 Norwich Union Direct Financial Services added life insurance to its offering of general insurance products. This provided a new challenge to Norwich Union to co-ordinate the activities of its call centres and its sales force. In order to co-ordinate the activities of these two sales channels, customer files between the call centre database and the sales agent are continuously updated or replicated every time the sales agent dials into the network. By this replication exercise, customer interactions, appointment and product sales information are kept as up-to-date as possible between the two channels which helps ensure a co-ordinated marketing effort.

In the late 1990's, United Services Automobile Association (USAA), a financial services provider, embraced the vision of an integrated customer services organization from being a product-based organization. Due to various product related licensing requirements, different customer sales representatives were required for different product lines. However, USAA developed the concept of a 'warm transfer' whereby it developed a portal, as a means to integrate customer data, so that sales representatives could seamlessly link to one another. In addition, sales representatives would have access to the latest information about the customer in order to provide an integrated service to the customer.

In summary, data integration software is a valuable tool that helps firms maximize the value of flexibility by optimizing ownership incentives and leveraging the benefits of information integration.

9. Business Unit Incentives and Risk

This section investigates the value of flexibility and the need to align the incentive of business unit managers. For firms to achieve the optimal profitability by maintaining sufficient flexibility puts demands on not only the quantity of the information collected but also on the quality. Even when business units have determined the type of information to be collected, the quality of that information plays a significant role in the business unit being able to leverage the information optimally. The quality of the information being collected is often the responsibility of the managers in charge of collection and maintaining the information set. However, the incentives of the managers and the objectives of the firm may not be necessarily aligned. Managers are often concerned with compensation for their effort and the risks that they take. Managers might have a shorter horizon than the firm as they look to move jobs within the firm or take up opportunities that arise elsewhere. Firms may also be less risk averse. Moreover, the issue of misalignment is due to firms not being able to fully observe managers' effort levels which affect the profitability of the firm. One way for the firm to motivate managers to work hard is to relate their compensation to the realization of profits. This in turn causes the managers to demand compensation for the risks taken which contributes to the misalignment between the firm's objectives and the managers' incentives.

In order to understand this phenomenon better, we extend our model based on Hauser (1998). Let us assume that the business unit managers' effort can induce a further improvement of the firm's profit once the firm has chosen the level of investment in information. We can view the effort level as influencing the quality of the information. We will model this as an additive parameter, q, that measures the expected incremental profits of this effort[7]. The effort provided by the manager is costly to the manager and the firm cannot readily observe this cost. We call this cost, $d(q)$, and assume that it is convex in q.

We will assume that the business unit manager is risk averse and the firm is risk neutral. The manager's utility function displays constant risk aversion such that, $u(R) = 1 - \exp(-rR)$, where R is the monetary outcome and r is the risk aversion parameter. The return, R, is a random variable as defined earlier. Risk neutrality occurs when $u(R)$ becomes linear as r approaches 0.

Define, δ_m and δ_F as the business unit manager and firm discount factors respectively. Without loss of generality we can normalize $\delta_F = 1$ and consider δ_m as the discount value for the business unit manager relative to the firm. Then we can assume that $\delta_m < 1$ to reflect the fact that the manager has a shorter time horizon compared to the firm (Hodder and Riggs 1985, Patterson 1983).

The efforts of the business unit managers are not fully observable by the firm. Hence top management need to have some form of performance metrics to motivate managers to act in the best interest of the firm. Firms often have proxy measures to measure effort. Let Ω denote proxy measures for effort (effort indicator metrics). These proxy measures are normally noisy indicators of the incremental profit of the firm as a result of the managers' effort. Hence, we describe these metrics with a normal random variable, $\overline{q}$, with a mean q and variance, σ_q^2. Firms often combine

[7] The multiplication formulation is not substantially different.

market outcome metrics with effort metrics to monitor and reward business unit managers. Let us assume a weight of λ_1 on returns, λ_2 on effort and λ_3 on costs which implies a linear performance metric of the form given by equation (35),

$$PM = \eta_R R + \eta_q \overline{q} - \eta_C C_T \tag{35}$$

where,

$C_T = (C_0 + C_1)$ - Total cost of information collection[8].

$\eta_R = \lambda_1$

$\eta_q = \lambda_1 + \lambda_2$

$\eta_C = \lambda_3$

The manager will evaluate rewards based on outcomes, cost of effort and risks. The outcomes based on the expected returns of the firm will happen with a time lag compared to the effort. We can view in our model as the effort being expanded during time, $t = 0$ and the outcome being realized at time, $t = 1$. Therefore the outcomes will be discounted but not costs. The researchers will find effort to be costly, thus we subtract, $d(q)$ from the outcomes. Finally we need to adjust for the risk costs as the uncertainty in returns and effort will be costly for the manager. As the manager is assumed to be risk averse, the uncertain rewards will be represented by the certainty equivalent (R_{CE} derived in appendix A),

$$CE = \delta_m R_{CE} + \eta_q \delta_m q - \eta_C C_T - d(q) - (r/2)[\delta_m^2 \eta_q^2 \sigma_q^2] \tag{36}$$

where, $R_{CE} = -\left(\frac{1}{r}\right) \ln\left[1 - \eta_R(1 - pe^{-r\alpha R_1} - (1-p)e^{-r\beta R_2}\right]$

In contrast, the firm aims to maximize its expected value profits[9]. To calculate this value, one can use standard principal agent theory (Holmstrom 1989) to calculate the profit of the firm. As before the firm will maximize its expected value, $E(V) = (C_0 + C_1) + E(R) - w_0$ where $E(R) = p\alpha R_1 + (1-p)\beta R_2$ and w_0 is the managers' the reservation wage i.e. the minimum amount that the managers require before compensation for any incremental and risks costs. However, the firm also gain from the effort of the business unit manager by, q. However, the firm now needs to pay the managers' the reservation wage, w_0. In addition, the firm will need to reimburse the managers for any effort costs and risk costs. Thus the firm's profits are given by,

$$\Pi = -(C_0 + C_1) + E(R) + q - [w_0 + d(q) + \text{risk costs}] \tag{37}$$

[8] To keep the analysis simple, as before, costs are not discounted.

[9] The firm is assumed to be risk neutral and hence, will maximize expected value.

where, $CE = [w_0 + d(q)+\text{risk costs}]$ from equation (36).

The optimization of equation (37) will determine both the optimal quantity of information collection as well as the quality of information. The agency problem could be solved to choose the weighting, to induce the optimal effort that the managers allocate.

The point to note here is that the surplus for the firm given the assumption of risk averse managers and differential discounting together with limited observability of effort costs is given by equation (37). This is less than the first best surplus with full observability, $E(R) - (C_0 + C_1) - w_0$. Only when the returns to the firm are deterministic or if the managers are risk neutral with similar time preference can the agency costs associated with limited observability can be avoided (Holmstrom 1989). Equation (36) states that the managers' share will be higher, the lower the aversion to risk (lower r), the lower the risk (denoted by the variance), the similarity of the time horizon to the firm (denoted by the discount factor) and the lower is the cost of effort.

There is a tension between inducing the best choice and motivating the optimal effort. In order to gain greater insight into this tension, we focus on the effort that is allocated after the firm has chosen the quantity of information to be collected. We hold the costs, $(C_0 + C_1)$ and the return, R constant and focus on effort being expanded by the business unit managers. Hence, the issue is reduced to a standard agency theory problem where the firm selects the weight η_q to encourage managers to allocate optimal effort (Holmstrom 1989). Hence, we now show,

PROPOSITION 7. *Higher weight on effort indicator metrics will increase the firm's expected value by avoiding distortions due to managers' short-termism and risk aversion i.e.* $\frac{\partial E(V)}{\partial \eta_q} > 0$ *if* $Corr(\Omega, R) = \varepsilon$ *where* ε *is small.*

Proof. Following the method outlined in Hauser (1998), we can analyze how the firm can choose the optimal η_q such that managers allocate the effort level that maximizes the firm's profits. In appendix B, we show that the optimal weight is:

$$\eta_q = (\delta_m)^{-1}[1 + r\sigma_q^2 \frac{\partial^2 d(q^*)}{\partial q^2}]^{-1} \qquad (38)$$

Equation (38) shows that the weight on the effort metrics is influenced by the extent to which managers have a different time horizon to the firm. The shorter the time horizon of the managers, the higher should be the weight on the effort metrics. The optimal weight is inversely proportional to the variance of the effort indicator measure, σ_q^2. There is a tension that the firm needs to manage in setting the weights on the metrics. On the one hand, the firm should want the weight on firm returns to be large to induce the right effort by managers. On the other hand, as equation (37) shows when the managers are risk averse and have a shorter time horizon compared to the firm, the firm would want the weight on firm returns to be small. This is to reduce the risk costs paid to managers and also to avoid short-sighted behaviour among managers. One way for the firm to finesse this tension is for the firm to find suitable metrics that correlate with effort, but not so much with firm returns (Hauser 1998) such that $Corr(\Omega, R) = \varepsilon$ where ε is small.. In this case, the firm can place a larger weight on effort indicator metrics and less weight on firm returns[10] which contributes to increased expected value i.e. $\frac{\partial E(V)}{\partial \eta_q} > 0$. Q.E.D.

An example of an effort indicator metrics is a periodic independent audit report on the quality of information which will serve as a proxy for the effort level expanded by the managers. There are two reasons why effort indicator metrics might be attractive. First, effort indicator metrics such as an independent audit report can be observed sooner than firm returns. Second, the measurement uncertainty relating to effort indicator metrics to actual effort will probably be less than the uncertainty in predicting actual returns.

To summarise, due to the limited observabilty of efforts, firms often face a tension between motivating managers to act in the best interest of the firm and managers focusing on short-term goals coupled with a need to be compensated for bearing the risks of the firm. Firms can somewhat manage this tension by placing a higher weight on effort indicator metrics that correlates with effort, but not so much with firm returns. In this way the firm can achieve its objective by motivating managers to act in the interests of the firm by optimizing the flexibility value.

10. Conclusion

In an increasingly competitive environment firms need to be able to tailor products to the local environment yet be able to leverage their scale and scope advantages globally. Firms that aspire to operate in these environments need to be able to strike the right balance between the need to have business unit flexibility while leveraging the benefits of standardization. Information management plays a critical role in managing this tension as it often provides the basis upon which firms create competitive advantage by being able to respond to the changing environment. However, the challenge lies in managing relatively certain costs against an uncertain future benefit of being able to respond to changes and hence, capture value.

The traditional focus often has been to manage down costs by standardizing and centralizing data, which is more readily translated into short-run bottom line results. However, the often-ignored intangible asset in terms of business unit flexibility is critical in business unit decision-making and incentive structures. This paper argues that the failure of many data standardization and

[10] η_q large and η_R small implies λ_1 small and λ_2 large.

centralization efforts could be partly explained by the lack of these efforts to take into account the value of business unit flexibility and the resulting ownership incentives. We argue that the uncertainty from environmental changes imply that there is an option value inherent in businesses being able to react to changes to leverage opportunities as well as to limit losses. The uncertainty necessarily implies that the information and costs related to creating this option value or value of flexibility is not always contractible.

This research develops a framework for firms to decide whether and to what extent to standardize data using the theory of real options and incomplete contracts. In addition, the paper applies the principal-agent theory to evaluate how to align managers' incentives to that of firms in optimizing the value of flexibility. We show that firms need to consider more than just costs but also the value of flexibility in evaluating the benefits of standardization. For example, economies of scope across business units and outsourcing decisions could affect the value of flexibility and hence, influence the benefits of standardization.

Implementing the right balance between standardization and maintaining business unit flexibility is not a one off choice but a continuous process that changes with changing competitive and business environments. The propositions derived in this paper can help management choose the level and extent of standardization that is optimal at different points in time.

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Appendix A: The Certainty Equivalent Value

The certainty equivalent compensation for the manager is the reward where the manager is indifferent between the uncertain return and the certain amount as follows:

$U(R_{CE}) = \eta_R E[U(\overline{R})]$

$1 - e^{-rR_{CE}} = \eta_R[p(1 - e^{-r\alpha R_1}) - (1-p)(1 - e^{-r\beta R_2})]$

$1 - e^{-rR_{CE}} = \eta_R[-pe^{-r\alpha R_1} - e^{-r\beta R_2} + pe^{-r\beta R_2} + 1]$

$e^{-rR_{CE}} = 1 - \eta_R[1 - pe^{-r\alpha R_1} - (1-p)e^{-r\beta R_2}]$

$R_{CE} = -\left(\frac{1}{r}\right)\ln\left[1 - \eta_R(1 - pe^{-r\alpha R_1} - (1-p)e^{-r\beta R_2})\right]$

Appendix B: Optimal Weight on Effort

This section follows the treatment in Hauser (1998, pp.1686). From equation (36) the certainty equivalent is as follows:

$CE = \delta_m R_{CE} + \eta_q \delta_m q - d(q) - (r/2)[\delta_m^2 \eta_q^2 \sigma_q^2]$

where, $R_{CE} = -\left(\frac{1}{r}\right)\ln\left[1 - \eta_R(1 - pe^{-r\alpha R_1} - (1-p)e^{-r\beta R_2}\right]$

When the firm has chosen the costs, $[C_0, C_1]$ the return, R is given. This reduces the certainty equivalent above to, $CE =$constant$+\eta_q \delta_m q - d(q)$.

The manager will choose the effort level, q such that,

$$\frac{\partial d(q)}{\partial q} = \eta_q \delta_m \tag{2A}$$

This implies,

$$\frac{\partial[\frac{\partial d(q)}{\partial q}]}{\partial q} = \frac{\partial \eta_q}{\partial q}\delta_m$$

$$\frac{\partial^2 d(q)}{(\partial q)^2} = \frac{\partial \eta_q}{\partial q}\delta_m$$

$$\frac{\partial q}{\partial \eta_q} = \delta_m \left[\frac{\partial^2 d(q)}{(\partial q)^2}\right]^{-1} \tag{2B}$$

From equation (37), once the firm has chosen the costs, $[C_0, C_1]$ the return, R is given, the firm must pay the manager for effort and risks. Hence, the firm will seek to maximize, $\Pi = q - d(q) - (r/2)[\delta_m^2 \eta_q^2 \sigma_q^2]$. The maximization is as follows:

$\frac{\partial \Pi}{\partial q} = 1 - \frac{\partial d(q)}{\partial q} - \left[(r/2)2\eta_q \frac{\partial \eta_q}{\partial q}(\delta_m)^2 \sigma_q^2\right] = 0$

By replacing $(2A)$ and $(2B)$ and rearranging gives,

$$1 - \eta_q \delta_m = \left[r\eta_q(\delta_m)^{-1}\left[\frac{\partial^2 d(q)}{\partial q^2}\right](\delta_m)^2 \sigma_m^2\right]$$

$$\eta_q = (\delta_m)^{-1}\left[1 + r\sigma_q^2 \frac{\partial^2 d(q^*)}{\partial q^2}\right]^{-1} \tag{2C}$$

The optimal effort, q^* can be solved by replacing $(2C)$ into $(2A)$.