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DETERMINANTS OF INFORMATION TECHNOLOGY INVESTMENTS: EFFECTS OF TOP MANAGEMENT COMPENSATION AND STOCK OWNERSHIP

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ABSTRACT

A better understanding of the determinants of variations in firms' investments in information technology (IT) is important for both researchers and practitioners in the information systems (IS) function. In this study, we examined the effects of top management compensation design and managerial stock ownership on IT investments using an agent- theoretic framework. We first define the 'industry- referent' IT investment as the level of IS budget necessary for firms to compete effectively and validate this construct by demostrating a positive relationship to firm performance. Subsequently, we test a proposition that disciplinary effects associated with top management stock ownership and long term emphasis of the top management compensation package will significantly align the IS budget with the industry-referent level. Data from 72 leading U.S. companies provide strong empirical support to the proposition. Implications for future research from both conceptual and methodological perspectives are noted.

Keywords: Information systems budget, information technology investments, managerial stock ownership, top management compensation.

BACKGROUND

It is perhaps a truism that information technology (IT) is increasingly viewed as a critical source of firm competence (McFarlan, 1984; Rockatt and Scott Morton, 1984; Porter and Millar, 1985, etc). However, there is only a limited, but growing literature on the set of managerial factors that determine a firm's ability to create and leverage this source of competence. Specifically, there is a glaring lack of systematic research efforts on the factors that determine a firm's level of investment in IT, despite the enormity of IT expenditure in firms (PIMS Program, 1984; Strassmann, 1985).

The research stream on the level of a firm's IT investments is either based on Nolan's (1973) stages of computing evolution or demographic factors such as size or industry. While the stage of computing evolution is intuitively appealing, the extent of empirical support is disappointing (Lucas and Sutton, 1977; Drury, 1983; Benbasat et al, 1984; King and Kramer, 1984). In contrast, firm size has been shown to be a good predictor of IT investments (Whisler, 1970; DeLone, 1981), implying that large firms tend to have more IT spending as a proportion of revenue, possibly reflecting the proportion attributable to administrative systems required for effectively managing organizational complexity. In this vein, research evidence has been presented to show a differential relationship between the level of IT investment and firm performance moderated by the industry context (Weill and Olson, 1989). This suggests the need to recognize a level of IT investment for firms to compete effectively within the structural contraints imposed by the particular industry. Firms of the same industry competing within these structural similarities may then converge in their IT investment behavior, which is consistent with the concepts of competitive and institutional isomorphism (Hannan and Freeman, 1977; DiMaggio and Powell, 1983).

This paper controls for firm size and the industry setting to develop a model of the determinants of IT investments by adopting an agent-theoretic perspective which has been a promising model to understand allocation of firm resources as well as other significant managerial decisions (e.g. Amihud and Lev, 1981; Singh and Harianto, 1989). This framework is based on the following arguments that apply well to the specific context of IT investments. *First*, IT investments like other capital investments of the firm are risky ventures. With uncertain payoffs, since value variability or riskiness of the firm is potentially increased, it can be argued that managers will exhibit excessive risk aversion and underinvest in risky projects (Marcus, 1982). *Second*, there is a possible agency problem of perk consumption (Jensen and Meckling, 1976) in the decision to invest in IT. Executives may have the inclination to overinvest in IT in order to enjoy the pleasure of a high-powered computing environment, which is against the welfare of the shareholders.

Specifically, in this paper we develop and test a model of IT investments using critical agent-theoretic determinants inherent in top management compensation and stock ownership. Empirical tests are conducted using a sample of the top five executive officers in 72 leading U.S. firms.

RESEARCH MODEL

The Principal-Agent Relationship: Incentive Structure

We use agency theory as a conceptual foundation to explain variation in the level of IT investment. At the core is the classical delegation of managerial task from the shareholders (i.e. the principals) to the top management (i.e. the agents) (Berle and Means, 1932). The fundamental problem of an agency relationship is the nonalignment of goals between the two parties constituting the relationship. The agent having the locus of control will simply make decisions maximizing his or her own welfare, which may not necessarily coincide with the optimization of the principal's utility (Ross, 1973; Jensen and Meckling, 1976). To ensure goal congruence, the principal can engage in costly albeit imperfect monitoring, such as independent auditors. Mitigating mechanisms and bonding schemes such as voluntary disclosures by the managers to shareholders can also alleviate the agency problem.

The crux of the principal-agent relationship is to determine a payment structure which can optimally trade off the benefits of risk sharing with the costs of providing incentive to the agent (Shavell, 1979; Nalbantian, 1987). The wage contract must be designed in such a way that it encourages full effort yet concomitantly allocates risk between the shareholders as a collectivity and the top management in the most efficient way.

Traditionally, incentive contracts in a principal-agent relationship have been categorized on a spectrum from behavior-based to outcome-based (Ouchi, 1979). In our study, however, we motivate the conceptualization of the incentive structure by decomposing the pay into three components, namely: (1) current pay, (2) deferred pay, and (3) stock value related pay (e.g. Lewellen, 1968; Ellig, 1982). Current pay refers to the wages that are received in the present period while deferred pay applies to wages that accrue in future periods. Stock value related pay comprises benefits that fluctuate with the market value of the stock. We define short term emphasis of the compensation as that represented by the extent in which current pay constitutes a portion of the total compensation. Likewise, long term emphasis is reflected by the extent in which deferred *and* stock value related pays constitute a portion of the total compensation.

The use of short and long term emphases in conceptualizing incentive payment is more relevant in our context of IT investment determination. Investment of this nature involves a long payoff horizon in which direct returns do not materialize immediately. The time horizon is then a crucial dimension affecting managerial decision making with respect to IT projects. The short and long term emphases of the incentive structure will thus have a profound impact on the motivation of managers to optimally undertake IT investments.

Beside the actual compensation contract between the top management and the firm, the other related agent-theoretic determinant of the relationship in our context is the top management stock ownership (e.g. Hill and Snell, 1989; Singh and Harianto, 1989). Conceptually, a larger ownership is analogous to contingent pay since it ties the fate of the firm more closely to that of the management. This leads to a higher degree of goal alignment between the principal and the agent (Jensen and Meckling, 1976).

IT Investment as a Research Construct: Economic and Behavioral Rationale

Definition. In this study, we define IT investment to include management information systems (both hardware and software), and related personnel, consulting and outside services expenditure as embodied within the corporate IS budget (Strassman, 1985). Broader conceptualization of IT exists to encompass the myraid communications facilities such as telephones, facsimile, reproduction machines and so on (Panko, 1982; Weill and Olson, 1989). Although this has its merits, the proper IT domain can be ambiguous as the usage of information is embodied in almost *every* business processes and it is quite impossible to draw the distinction between the IT component from the non-IT component. More importantly, the definition must be conceptually sound and yet be meaningful enough to lend itself to empirical operationalization.

Our Conceptualization. Past studies have used the actual level of IT investment as a basis for analysis. In an agency context, the consideration of this magnitude *per se* is not meaningful as both downside and upside departures of IT investment from some ideal level may be manifestations of agency problems. As highlighted earlier, an upside departure can be an indication of excessive perk consumption. On the other hand, a downside departure is a representation of underinvestment in risky projects. The focus of our research is thus on this deviation of IT investment from a given referent level in a particular industry. This referent level is the intensity of IT investment necessary in a certain industry in order that the firm can compete effectively vis-a-vis the structural nature of that industry. In fact, there have been suggestions that firm performance in an industry is contingent on some characteristic level of IT investment (Weill and Olson, 1989; Harris and Katz, 1990).

From a macro- organizational perspective, the level of IT investment may be influenced by competitive and institutional isomorphism (Hannan and Freeman, 1977; DiMaggio and Powell, 1983). At the *competitive* level, a referent intensity of IT investment can be the outcome of a environmental process that selects out certain viable organizational configuration such as in the level of IT investment. At the *institutional* level, the tendency for firms to converge in IT investment decisions may be a response to the three mechanisms of isomorphic change highlighted by DiMaggio and Powell (1983). Firstly, the need for legitimacy especially vis-a-vis the shareholders may exert coercive pressures for firms in an industry to emulate those perceived to be successful. Secondly, the industry- referent IT investment level may be a mimetic outcome arising from environmental uncertainty especially when the underlying organizational technology is poorly understood. Thirdly, the growing professionalization of IT managers in areas such as the homogeneity of formal education or the creation of professional networks may tend to establish certain norms for IT investment within an industry.

Our study is based on the premise that a greater deviation of IT investment from the industry-referent level will give rise to a lower firm performance, which will be reflected as a lower expected firm value in an informationally efficient stock market (Ball and Brown, 1968; Fama, 1970).[1] This initial conjecture which forms the basis of our framework will be verified empirically prior to the testing of our research propositions.

Assumptions

Three assumptions underly this study. *First*, we use only a partial equilibrium framework. In particular, we assume that managerial stock ownership and/or long term pay emphasis imply lower agency costs, and short term term pay emphasis implies higher agency costs. *Second*, the expected *rate* of decrease of firm value with respect to the deviation of IT investment from the industry- referent level can be mitigated by the executive stock ownership or the long term emphasis of the compensation package. This is reasonable as a manager whose payoff is dependent on

[1]It must however be recognized that IT is only one of the several factors of production. Firms are likely to differ in the extent which the several constituents of the production function (eg human resources, financial capital, machinery) constitute important roles in determining outputs and profits. Given the research domain of our intended inquiry, it is beyond the scope of our paper to fully specify a complete production function although the theoretical limitations of our omission are fully appreciated.

deferred or stock value related pays will have better incentives to decrease the *rate* of change of the firm value with respect to IT investment. *Third*, the expected *rate* of decrease of firm value with respect to the deviation of IT investment from the industry- referent level can be increased by the short term emphasis of the compensation package.

Hypotheses

From our theoretical perspectives, we derive three hypotheses:

Hypothesis 1: Top management stock ownership will align IT investment with the industry-referent level.■

Intuitively, this hypothesis indicates that having a top management with a larger stake in the uncertain performance (or value) of the firm mitigates the agency costs inherent in its relationship with the shareholders. The disciplinary effect of stock ownership thus tends to produce IT investment in line with the industry- referent level. This hypothesis is based also on our earlier discussion on isomorphism, where shareholders can collectively, as a constituency, influence the managers in setting isomorphic IT investment level.

The tendency to shirk or to engage in excessive perk consumption when the agent's welfare is independent of the outcome, is a well established result of agency theory (Jensen and Meckling, 1976; Rees, 1985). Nevertheless, the mathematical verifications are very generalized and complex. We offer below a simplified comparative statics treatment that is particularly tailored to our setting.

Let us represent the utility function of the risk averse manager[2] by

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[2]The cause of this managerial risk attitude is by virtue of the employment where the bulk of the executive's investment portfolio in the form of human capital is invested in the corporation. To the extent that his skills are specific to the firm and the market for executive labor is imperfect, there

U(a,s) where a is the deviation of IT investment from the industry-referent level and s is the share of the firm owned by the manager.[3] On the one hand, the argument a can be interpreted as excessive perk consumption in IT where executives derive satisfaction from having ultra modern offices loaded with unnecessarily high powered computers and other technological gadgets. On the other hand, it may represent an extremely conservative behavior of status quo where the executives simply underinvest in IT.

Let V(.) be the firm value, c(.) be the cost or disutility of budget deviation to the manager and k be some fixed salary. The function c is decreasing in a. This is because: (i) on the upside departure, excessive perk consumption decreases the disutility to the manager; (ii) on the downside departure, conservative investments in IT also decreases the disutility to the manager. In addition, the function c, like most economic cost functions, is taken to be convex. Writing the utility function of the manager in its quasi- linear form, the manager simply solves

$$\max_{0 \leq a \leq \bar{a}} \; U(a,s) \equiv sV(a) - c(a) + k$$

Here we put an upper bound $\bar{a}$ on the budget deviation adopted by the firm. This is analogous to a resource constraint as it will be unrealistic to assume that a firm can invest infinitely. In addition, the actual budget must be non-negative. The first-order necessary condition to the

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is a lock-in effect. The end result is executive risk aversion (Shavell, 1979; Marcus, 1982).

[3] Here we used the 'certainty equivalent' form of the utility function. This is a more convenient way to work through utility problems for it subsumes risk aversion (Spreeman, 1987). To be precise, $U \equiv u^{-1} \circ Eu$ where U is merely the composite function of the inverse of the usual von-Neumann Morgenstern utility function u and the expected utility function (E is the expectation operator). The problem is thus isomorphic to using Eu as the functional form.

optimization is

$$sV' - c' = 0$$

Total differentiation of this equation gives

$$V' \, ds + s \, dV' = c'' \, da^*$$

This implies that

$$\frac{da^*}{ds} = \frac{1}{c''} \left(V' + s \frac{dV'}{ds} \right)$$

Now from our earlier discussion, c" is positive; V' and dV'/ds are negative. Thus da^*/ds is negative, which forms the underlying rationale for our hypothesis.

Hypothesis 2: Long term emphasis in top management compensation structure will align IT investment with the industry-referent level.■

This hypothesis seeks to highlight that incorporating a longer decision making horizon into a manager's wage structure encourages goal alignment with the forward looking shareholders. This is also analogous to tying the payment of the top management to the actual long run performance and survival of the firm.

To verify, we introduce another argument into the function V. Thus we have V(a,m) where m represents the long term emphasis. Solving the problem, the first-order necessary condition with respect to a is[4]

$$s V_a - c' = 0$$

Total differentiation of this condition gives

$$V_a \, ds + s \, dV_a = c'' \, da^*$$

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[4] Subcripts in the variable V denotes partial differentiation with respect to the relevant variable.

This implies

$$V_a \frac{ds}{dm} + s\, V_{am} = (c'' - s\, V_{aa}) \frac{da^*}{dm}$$

At a particular s, we then have

$$\frac{da^*}{dm} = \frac{s\, V_{am}}{(c'' - s\, V_{aa})}$$

Now V_{aa} is non-positive applying the law of diminishing returns in economic theory. Furthermore from our initial argument, V_{am} is taken to be negative. The overall result is that da^*/dm is negative.

Hypothesis 3: Short term emphasis in top management compensation structure will mis-align IT investment with the industry-referent level.■

When the pay contract of the top management stresses decisional myopia, the degree of goal incongrence with the shareholders will be higher. Thus there is a greater tendency for managers to shift away from the industry- referent level. Its verification can in fact be easily extended from that of the previous hypothesis. Essentially, this requires us to demonstrate that the change of a^* with respect to short term emphasis is positive based on our earlier arguments.

METHODS

Sample

The list of publicly held corporations taken from the Premier 100 companies from *Computerworld* (September 11, 1989) constitutes our sample frame. These firms are ranked based on their IS effectiveness in 1988 using criteria such as the strength of IT plan, the currency of IS, the level of employee training and the IT accessibility. A major reason for our reliance on this source is because it contains data on IT investment level for the firm. The actual sample for the study covers those 72 companies spread over a total of 13 industries in which complete compensation data are available for the five highest paid executive officers.[5] Appendix A provides a listing of the firms included in our sample.

IT Investment

Data pertaining to the level of IT investment are obtained from the abovementioned issue of *Computerworld*. The dependent variable used is based on the IS budget as a percentage of revenue, which has been used frequently in prior research (see Weill and Olson, 1989). To adjust for inter-industry differences, the IS budget is standardized by subtracting from it the industry- referent level and dividing it by the corresponding industry standard deviation. The absolute value of the resultant deviation is used for the analysis.

The industry- referent IS budget is computed as the mean IS budget of the top ten IT effective companies in that particular industry.[6] The consideration of the top ranking firms is justifiable as these are in fact the most competent in terms of their IT capability and sophistication, and arguably this is be due to its ability to set proficient IT investment level.

Top Management Compensation

Compensation data pertaining to top executives of the firm are acquired from the proxy statements filed by the respective companies for

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[5] Out of the 100 possible companies, we manage to obtain 78 updated proxy statements pertaining to the year 1988. Of these, 6 companies do not give sufficient information for us to compute all the individual categories of the executive compensation package.

[6] We use a separate set of 130 firms for this purpose, some of which may overlap with our original test sample.

the year ending 1988. The individual components are categorized into (1) current pay, (2) deferred pay, and (3) stock value related pay. All compensation figures are computed on an annual equivalent basis, that is, they represent what the executives have attained for each of the specific item in the year 1988. As far as possible, the accrual basis of accouting is used. This is conceptually superior to taking only realized items during the year as it can be argued that accrued earnings are more relevant in managerial decision making.

Current pay comprises the fixed salary and short run bonuses. It is necessary to add these figures together as they are reported as lump sums in most of the proxy statements. Deferred pay is calculated as the total of the savings plan contribution, the long run bonuses and the pension annuity. The computations of savings plan contribution and long run bonuses are straightforward but that of pension annuity requires some elaboration. In most companies, there is a fixed schedule of pension entitlement upon retirement based on the number of years served. Using these information, we compute the annual equivalent pension annuity from each executive's present age to the retirement age using the pension entitlements from the retirement age to the mortality age.[7]

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[7]Accordingly, we obtain the age of the relevant executives from *CD Corporate*, one of the several CD-ROMs in the *One Source* line of information from Lotus Corporation. The expected life spans of human beings are then acquired from the *Life Tables for the United States: 1900-2050*, an actuarial study compiled by Joseph Faber. For male persons, the average life span is 73 while that of female persons is 80. The retirement age in the United States is taken to be 55. The discount rate used is that of the Tresury bill in 1988, which is 6.7 per cent (*Value Line*, 12/22/89). Naturally, these computations are only approximate as executives may not retire at the age of 55 or may not be entitled to any pensions in some cases if they happen to get fired. Furthermore, the mortality age is only a rough figure fraught with uncertainty. The riskless interest rate may not be the appropriate discount rate for the investment portfolios of different

The computation of stock value related pay is not straightforward. From a taxonomic analysis of the various executive compensation packages, there seem to be a wide array of items such as stock options, stock appreciation rights, stock awards (direct, restricted, performance- based, or deferred etc), stock purchase plans, employee stock ownership plans (ESOP) and convertible debentures.

The main challenge seems to be the assignment of an appropriate value for the executive stock options. Here, the major empirical problem is that these very special securities are not traded in the financial markets. Thus their fair market values cannot be derived from observable transaction outcomes. In fact, there is considerable debate as to the correct valuation approach (Ellig, 1982). Many models of value estimation exist, ranging from prospective models using a forecast of stock prices to retrospective models using the hypothetical difference between stock price and exercise price. Complex mathematical valuation methods of executive options based on the *ex ante* models of Black and Scholes (1973) have been used (Antle and Smith, 1985; Murthy, 1985). Although theoretically most defensible, the Black-Scholes option valuation model or a specialized executive option model of Noreen and Wolfson (1981) cannot be used for all options in all years.[8] In our study, we use the difference between the average stock price and the average exercise price as the value of the option[9]. This is necessary as

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executives.

[8]In the first place, these formulas are misspecified for options that are deep in-the-money. In fact, as mentioned in the study of Antle and Smith (1985), there are some instances in the sample which give estimates below the spread between the current stock price and the exercise price. For these cases, the spreads are simply taken to be the value of the respective options.

[9]The average stock price is estimated by taking the mean of the highest and

many of the companies do not provide the full range of data needed for the theoretical valuation. More importantly, our method is internally consistent and is definitely superior to a simplistic usage of the value realized by individual executive. In addition, it is in line with computational suggestions laid out by Lewellen (1968) and Ellig (1982). The total value of the stock options accruing to an executive is the number of option granted multiplied by the value per option.[10]

For the valuation of the stock appreciation rights, we use the same principles as those pertaining to stock options. We take the difference of the average stock price and the average exercise price and multiply it with the number of rights granted. As for the stock awards, the computation is easy. The total number given is multiplied by the average stock price. For the stock purchase and ownership plans, we take the percentage subsidy by the firm and multiply this by the number of shares bought by the respective executives. In the case of the convertible debentures granted, again we are plagued by the non-existence of market data. Here the total value granted is the product of the number of debentures granted, the conversion ratio and the average stock price.

Based on the above data, the mean proportions of the three pay categories relative to the total compensation are calculated for the top five executive officers in each of the company. The average stock holdings of the top management as a fraction of the total outstanding shares are also obtained in a similar manner.

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the lowest stock prices for the year 1988. These figures are taken from the *Moody's Manual* for the respective industrial sectors.

[10] As the value of any option is non-negative, in a few instances where the computed figures are negative, we assign values of zero to the options.

Operationalization and Analysis

Multiple regression is used for the analysis with the relevant standardized absolute IS budget deviation as the dependent variable. We also use the natural logarithms of this budget deviation for a separate set of regressions as an indication of robustness of the results.

For the independent variables, we operationalize three constructs, namely (1) top management stock ownership, (2) short term emphasis of the compensation package, and (3) long term emphasis of the compensation package. For top management stock ownership, we use the proportion of stock owned by the top management. For short term emphasis, we use the proportion of short term pay in the total compensation package. The long term emphasis construct involves deferred and stock value related compensation. If we take the proportion of the sum of these two pay categories as one of the independent variable, there will be perfect collinearity. We, thus, use the interaction of deferred and stock value related pay proportions as a proxy for long term emphasis. To control for the possible influences of firm size (DeLone, 1981), we incorporate the market value of the firm into all our regressions.[11] This independent variable is obtained by multiplying the total number of outstanding common shares with the average stock price.

We run two sets of regression for each of the dependent variables (y) to test our three hypotheses. These are specified as follows:

(A) y = f (basic variables, control variable)

(B) y = f (basic variables, interaction variables, control variable)

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[11] It must be noted that although we have divided the IS budget by the firm's revenue, we still need to control for size using a separate variable. This is because the IS budget as a percentage of revenue may *itself* varies with firm size.

RESULTS

Descriptive Statistics

Table 1 summarizes the means and standard deviations for the IS budget as percentage of revenue based on the top ten IT-effective firms in each of the 13 industries. The estimated grand average for all industries is 2.97 percent with a range from 1 percent to 5 percent. This is similar to the value of 2 percent obtained by PIMS Program (1984) and Strassman (1985). As expected, services oriented industries tend to set higher IS budget than product oriented industries.

Further, we performed an analysis of variance with one main effect to examine the relative proportion of inter-industry versus intra-industry differences. As shown in Table 1, inter-industry variance is 8.3 times intra-industry variance, which indicates strong structural dissimilarities in IT intensiveness across industries. This lends further credence to our approach calling for industry standardization of raw IS budget percentages. More importantly, the low relative intra-industry variance supports the notion of isomorphism (Hannan and Freeman, 1977; DiMaggio and Powell, 1983), with firms trying to invest as close to the industry- referent level as possible.

Table 2 summarizes descriptive statistics of our sample for the important variables used in the study. It is noted that current pay constitutes 64 per cent of the executive compensation amount. This compares well to the value of 56 percent in the annual survey of top executives' compensation in 1988, conducted by *Business Week* and *Standard and Poor* (*Business Week*, May 1, 1989) and to the values of 80 and 52 percent for two sampling periods obtained in the classic study of Lewellen (1968). This indicates that our sample is not unduly biased in terms of the design of compensation system, thus enhancing the potential generalizability of the results. In addition, our results indicate that the average proportion of deferred and stock value related pay are 22 and 15 percent respectively. The average total compensation for all the executives in the study is $1.36 million.[12]

The average stock holdings for an individual executive is about 0.5 percent of the outstanding shares, ranging from a negligible amount to almost 10 percent. This indicates that no particular individual executive can exert complete voting influence on the company and that other shareholders as a collectivity are an important factor in managerial decision making.

The Pearson correlation coefficients with the corresponding two-tailed p-values are shown in Table 3.

Construct Validity of Industry-Referent IT Investment Level

We demostrate the construct validity of our dependent variable by assessing its relationship with profit margin using the following functional form:

$$\text{Profit Margin} = \alpha + \beta * \text{Budget Deviation} + \epsilon$$

where ϵ represents some random error.

The sample used is the set of 130 firms that have been utilized to compute the industry-referent IT investment level. Our estimate for α is 5.36 with a standard error of 1.04. The estimated β value is -0.70 with a

[12]This is compared to $2.03 million obtained by the Business Week- Standard and Poor survey. The difference is due to the fact that we use the top five executives in a firm while that survey involves only the CEOs. In addition, the method of computing items such as stock options is not the same. That survey uses realized benefits whereas our study takes the accrued benefits.

standard error of 0.37. It has the expected direction of change, and is statistically significant at the 0.05 level (one-tailed). The results here suggest that firms within an industry tend to do better when the IT investment level is close to the industry-referent level. This finding serves as a foundation for framing our agent- theoretic hypotheses along an industry-referent perspective.

Testing for Nonspherical Disturbances

To justify ordinary least squares procedures, we examine the possible presence of nonspherical disturbances -- heteroscedasticity and cross-sectional correlation. Heteroscedasticity may arise due to different variances of IS budget deviation in different industries, a finding that was earlier established. Cross-sectional correlation of the error terms can be the outcome of our ordering of firms using the criterion of IT effectiveness. The consequences of the nonspherical disturbances using ordinary least squares are that: (1) though the parameter estimates are still unbiased and consistent, they are inefficient in both small and large samples; (2) inferences based on the estimated variances will be subjected to errors since the larger confidence intervals of the estimated parameters result in less powerful tests.

Test of Heteroscedasticity. We use the test developed by Park (1966) to examine whether heteroscedasticity is present based on our sample data. Accordingly, the variance of the error term σ_i^2 is assumed to be related with the explanatory variables, X_i as follows:

$$\sigma_i^2 = \sigma^2 X_i^\gamma \exp(v_i)$$

or

$$\log(\sigma_i^2) = \log(\sigma^2) + \gamma \log(X_i) + v_i$$

where σ^2 is the homoscedastic variance of the original relationship, and v_i is some random error term. Since σ_i^2 is unknown, we use the residuals of our original regression (i.e. regression B) as proxies. To conduct the Park's test, we run the regression as follows:

$$R_i = \gamma_0 + \gamma Z_i + v_i$$

where R_i is the natural logarithms of the squared residual, and Z_i is the natural logarithms of the relevant explanatory variable postulated to influence the equality of variances. If γ is insignficant, we may accept the homoscedasticity assumption. Results of our tests are depicted in Table 4 using all possible independent variables. It is evident that none of the γ-parameter is statistically significant even at the 0.1 level. Heteroscedasticity is thus not a problem in our subsequent application of ordinary least squares.

Test of Cross-Sectional Correlation. We use the conventional test developed by Durbin and Watson (1951). Though the test is usually appropriate for data points ordered temporally, we adapt the test for our data which are ordered spatially. Here we assume that only first-order correlations are relevant. Using the full regression (B), the obtained Durbin-Watson statistic d is 1.761 (and the first-order correlation is 0.117). The critical values d_L and d_U are 1.253 and 1.680 respectively. Using a two-tailed test, since $d_U < d < 4-d_U$, we do not reject the absence of positive or negative serial correlation. This result lends credence to the use of ordinary least squares.

Results of Hypothesis Testing

We use the functional forms (A) and (B) specified earlier for our ordinary least squares regression analysis. In Table 5, we present our results with the standardized absolute IS budget deviation as the dependent variable. We also show the results when the natural logarithm of the IS budget deviation is being used as the dependent variable to assess the robustness of the first set of regressions.

Test of Hypothesis 1. The coefficients pertaining to stock ownership are highly significant and have the correct expected negative signs. All have one-tailed significance levels better than 0.05, and in one case better than 0.01 (regression B1). The results provide strong support for Hypothesis 1. The statistical analysis is thus consistent with the agent-theoretic tenet that if the agent's welfare is dependent on the outcome of the delegated decision, the actual choice will move toward that effective level for the principal. In other words, through aligning the payoff of the top executives to the stock price by virtue of share ownership, the management will deviate less from the industry- referent level in terms of IT investments.

Test of Hypothesis 2. We have strong support from two regressions (B1 and B2). The coefficients of the interaction of deferred and stock value related pays are in the right expected direction of change with respect to IS budget deviation, and are statistically significant at levels better than 0.05. As in Hypothesis 1, this finding is in line with the traditional principal-agent argument advanced in this paper.

Test of Hypothesis 3. The regression results for this hypothesis seem inconclusive or even puzzling. The coefficients pertaining to current pay do not have the expected direction of change in some of the cases. It appears that the influence of short term emphasis tends to mitigate the IS budget deviation from the industry-referent level.

We offer some tentative explanations for this contradictory result. Firstly, at a *methodological* level, the reverse of coefficient signs could be due to the inherent weakness of the data, since the proxy statements do not delineate the part of the short term bonus that is dependent on firm performance. Secondly, at a *conceptual* level, current pay seems to be an important motivational factor in promoting managerial effectiveness. More importantly, by virtue of its public availability, current pay may possess a greatest effect as a symbolic reward (Lawler, 1966). In addition, top managerial task is peculiar in its ambiguity between effort and outcome (Mintzberg, 1973; March, 1984). The setting of an observable IS budget in line with the industry- referent level may well be a signal or symbol of managerial effort or goal alignment with shareholder wealth maximization.

DISCUSSION

Research on the determinants and the impact of IT investments is still in its infancy. The traditional view of IT budget along a stage-of-growth model has been rejected and the field is searching for an alternative paradigm for articulating the level of IT investment in a business. It is possible to attribute several determinants such as: the minimal level dictated by the industry context (Weill and Olson, 1989), the specific firm strategy that exploits IT differently from the competitors (McFarlan, 1984) or the incentives and compensation of top managers who exercise their choices in allocating a pool of scarce resources among competing avenues. The industry as a source of variation in IT investments has long been recognized and empirically established in trade periodicals. The link between firm strategy and IT investments is more important for theory building, but has not received much research attention, possibly due to the difficulty in collecting firm-level investment data that can systematically be related to firm strategy and business performance.

Recognizing inter-industry variation, this study modeled the variation in a firm's level of IT investment from an agent-theoretic framework. We found strong support for two of three propositions, thus providing a preliminary justification for the consideration of this framework in IT research. The top management can be induced to pursue activities aligned with the shareholders' best interest if the compensation system is designed to stress long run survival and profitability of the firm, and if the managerial welfare is made contingent on the market value of the firm. The robustness of our results was established through different transformations of the dependent variable.

Role of Top Management and IS Managers. The argument that decisional rights for IT investments may not necessarily be vested solely with the top management is a valid concern. In the setting of the IS budget, the influence often exerted by middle-level IS managers cannot be ignored. However, the position of this paper is that while IS managers will be responsible for allocating the total IS resources within its various components -- hardware versus software, maintenance versus development, etc. -- the *overall* level of IS resources is a corporate decision within the purview of top management that involves investment trade-off across broader functional areas.

Extensions. Before closing, we enumerate a set of limitations with a view to identifying issues for future research in this stream. At the *conceptual level*:

1. Agent-Theoretic Model -- Conceptual Issues

The development of our hypotheses has been rooted in the notion of partial equilibrium. In a general equilibrium, a greater level of managerial stock ownership does not necessarily mean lower agency costs. It may be simply due to the fact that incentive alignment by stock ownership is cheaper than direct monitoring. Furthermore, in this paper, we have treated compensation policy as an exogenous construct. A richer model may build in the various elements of the compensation structure as endogenous variables. In such cases, shareholders (usually through the compensation committee in the board of directors) can motivate optimal managerial behavior through well-designed compensation policy. With this construction, the direction and sign of the causal link in an equilibrium between the agent-theoretic determinants and IT investments may not be that straightforward. Finally, one might argue that IT investments may not even be an endogenous construct as managerial contracts can simply stipulate *ex ante* the required level of IT investment. However, this argument assumes that both the industry-referent and the firm's levels of IT investment are observable (and verifiable) at the time when contracts are determined. In reality, these levels are not known *ex ante* and it would be difficult to incorporate them into contracts.[13]

2. Dependent Variable -- Aggregation versus Disaggregation.

A fruitful approach would be to decompose the investments into those that are *infrastructure-specific* investments (i.e. required for maintenance of ongoing activities such as payroll, accounting, inventory, etc.) from those that are *strategy-specific* investments aimed at developing capabilities for the firm to compete in the marketplace (e.g. differentiated customer service, electronic linkages to suppliers, etc.). Our expectation is that the agent- theoretic arguments would be much stronger when the dependent variable is closely related to strategy-

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[13] Nevertheless, one can next argue that incomplete contracts can be designed to align IT investments with the desirable level when information begins to unfold in the due course. However, this still does not address the verifiability issue in order that this contracting mechanism can be effective.

specific investments. The finer decomposition of IT investments thus constitutes an useful area of future inquiry.

3. Independent Variables -- Fuller Specification

Firstly, this study has operationalized the agency cost construct via the top management compensation design and stock ownership. There are, in fact, other available agency variables such as a monitoring mechanism like institutional stock ownership (Oviatt, 1988), or a mitigating scheme like golden parachutes for the top management (Singh and Harianto, 1989).

Secondly, this research has taken the prime sources of executive motivation to be those pertaining to directly observable income sources such as compensation and stock ownership. In reality, there is a whole spectrum of organization behavioral factors such as power, prestige, job flexibility and satisfaction, personality traits and so on that will influence executive behavior.

Finally but most importantly, it will be useful to specify a broader set of environmental, strategic and organizational factors in determining the IT investment. Here, the decision to invest in IT may be fundamentally dependent on technological opportunities, product market competitiveness, strategic interaction, market evolution, organization adaptiveness and learning, locus of IT decision, and so on.

In this preliminary study, we have considered a set of agency constructs as determinants of IT investment level, while controlling for firm size. Although the significances of the individual variables may be large, a greater degree of overall model explanatory power should be possible with the inclusion of other omitted constructs. In addition, it will be useful to examine whether the relative explanatory power of the agency variables will hold up in an expanded model of IT investments.

At the *methodological level*:

1. Sample Selection

The sample bias problem may be present as we have defined our scope only to leading firms in terms of their IT capability and sophistication. While our important empirical results lie in the attainment of statistical significances in the critical regression coefficients, it will definitely be worthwhile to examine the generality of the results with a sample of publicly-held firms taken from the entire economy.

2. Measurement Errors

There are at least three possible sources of errors for compensation variables. Firstly, it will be useful to delineate the portion of long run performance dependent pay from the lump sum current pay. This can be accomplished with more superior information sources such as primary data, than those reported in the proxy statements. Secondly, we can consider the effects of personal taxation on the executive compensation level. This may be difficult in view of heterogeneous tax practices of different states and diverse executive income sources other than through the firm. Thirdly, we have excluded fringe or perquisite benefits offered by the firm to the executive. These may include entities such as corporate cars or even jets, expenditure accounts, club memberships, medical and dental benefits, housing, highly subsidized personal loans and so on. For completeness, these should be added to the total pay of the executive. Again the data collection may be extremely challenging. Complete data may be unavailable and it is difficult to monetize and categorize many of the perquisites.

As for our dependent variable, the reported budget level may be subjected to errors originating from corporate reportings in areas such as differential accounting conventions, subjective judgements, diverse definitions of IS budget in firms etc. Data compiled by *Computerworld* may also not possess an adequate level of reliability Nevertheless, this problem is one of the greatest universal setback in selecting appropriate measuring instruments for management research. Inquiries are very often hampered by the unavailability of non-noisy data. The *Computerworld* IS budget data is the best (if not the only publicly available) compilation of these statistics. When more superior data can be subsequently obtained, it will definitely be worthwhile to examine the validity and reliability of our results.

CONCLUSION

The study examined agent-theoretic determinants of IT investment decision by firms. In particular, we analyze how the deviation of IS budget from the industry- referent level is influenced by both short and long term emphases of the executive compensation package as well as by top management stock ownership. Strong evidences suggest that long term emphasis and executive stock ownership tend to align the IS budget with the industry-referent level. In view of the limitations inherent in this study, several directions of future research are highlighted. In this respect, it is hoped that our present effort will inspire further integrative inquiry into this exciting area of IT research.

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APPENDIX A: LIST OF COMPANIES

Company Name	Industry
Abbott Laboratories	Pharmaceutical & Food
American Express Co	Financial Services & Insurance
American President Cos Ltd	Transportation
Amoco Corp	Petroleum
AMR Corp	Transportation
Atlantic Richfield Co	Petroleum
AT&T	Utilities
Banc One Corp	Banking
Bankers Trust	Banking
Becton Dickinson & Co	Equipment & Materials Manufacturing
Bell Atlantic Corp	Utilities
Berkshire Hathaway, Inc	Consumer Products
Black & Decker Corp	Industrial & Automotive Products
Boise Cascade Corp	Equipment & Materials Manufacturing
Citicorp	Banking
Contel Corp	Utilities
Dover Corp	Industrial & Automotive Products
Dow Chemical Co	Chemicals
Duke Power Co	Utilities
Dun & Bradstreet Corp	Diversified Services
Farmers Group, Inc	Financial Services & Insurance
Federal Express Corp	Transportation
First Union Corp	Banking
Fleet/Norstar Financial	Financial Services & Insurance
Freeport-McMoran, Inc	Chemicals
Gencorp Inc	Aerospace
General Dynamics Corp	Aerospace
General Signal Corp	Equipment & Materials Manufacturing
Gillette Co	Consumer Products
Goodyear Tire & Rubber Co	Equipment & Materials Manufacturing
Great Northern Nekoosa	Equipment & Materials Manufacturing
Great Western Financial Corp	Banking
Grumman Corp	Aerospace
GTE Corp	Utilities
Ingersoll-Rand Co	Industrial & Automotive Products
ITT	Utilities
Johnson & Johnson	Pharmaceuticals & Food
J.C. Penny Co.	Retailing
J.P. Morgan & Co	Banking
Kemper Corp	Financial Services & Insurance
Keycorp	Banking
Lafarge Corp	Equipment & Materials Manufacturing
Lockheed Corp	Aerospace

APPENDIX A: Continued

Mack Trucks, Inc	Industrial & Automotive Products
Martin Marietta Corp	Aerospace
Masco Corp	Consumer Products
McDonnell Douglas Corp	Aerospace
McGraw-Hill, Inc	Consumer Products
MCI Communications Corp	Utilities
Mellon Bank Corp	Banking
Merck & Co	Pharmaceuticals & Food
Monsanto Co	Chemicals
National City Corp	Banking
NCNB Corp	Banking
Nortek, Inc	Equipment & Materials Manufacturing
Northeast Utilities	Utilities
Norwest Corp	Banking
Owens-Corning	Equipment & Materials Manufacturing
Paine Webber Group, Inc	Financial Services & Insurance
Polaroid Corp	Consumer Products
Sara Lee Corp	Pharmaceutical & Foods
Schering-Plough Corp	Pharmaceuticals & Food
Security Pacific Corp	Banking
Shawmut National Corp	Banking
Signet Banking Corp	Banking
Southwestern Bell	Utilities
Sovran Financial Corp	Banking
Temple-Inland, Inc	Equipment & Materials Manufacturing
Textron, Inc	Aerospace
The Boeing Co	Aerospace
The Mead Corp	Equipment & Materials Manufacturing
Timken Co	Industrial & Automotive Products
Union Texas Petroleum Corp	Petroleum
Unocal Corp	Petroleum
US Bancorp	Banking
US West	Utilities
Valley National Corp	Banking
Warner Communcations, Inc	Consumer Products

TABLE 1: INDUSTRY STATISTICS FOR IS BUDGET AS PERCENTAGE OF REVENUE

Summary Statistics		
Industry	Mean	Standard Deviation
Aerospace	4.82	1.56
Banking	4.95	0.74
Chemicals	1.81	0.54
Consumer Products	3.10	2.64
Diversified Services	1.95	1.12
Equipment & Materials Manufacturing	2.04	1.25
Financial Services & Insurance	4.13	1.69
Industrial & Automotive Products	2.35	1.11
Petroleum	1.09	0.41
Pharmaceuticals & Foods	2.02	0.83
Retailing	1.42	1.10
Transportation	5.14	3.20
Utilities	3.73	1.54
Overall	2.97	1.57
Analysis of Variances		
Model Mean Square Errors (Interindustry Variance)	20.40	F = 8.33 R^2 = 0.46
Residual Mean Square Errors (Intraindustry Variance)	2.45	

TABLE 2: SUMMARY STATISTICS OF THE INDEPENDENT VARIABLES

Variable	Mean	Standard Deviation
Budget Deviation	0.745	0.649
Logarithms of Budget Deviation	-0.747	1.113
Current Pay	0.636	0.164
Deferred Pay	0.216	0.149
Stock Value Related Pay	0.148	0.178
Stock Ownership	0.00546	0.0159
Interaction of Current and Deferred Pays	0.129	0.0754
Interaction of Current and Stock Value Related Pays	0.0762	0.0789
Interaction of Deferred and Stock Value Related Pays	0.0185	0.0218
Market Value of Firm	$4.34x10^9$	$5.02x10^9$

TABLE 3: CORRELATION COEFFICIENTS WITH TWO-TAILED P-VALUES IN PARENTHESES

Variable	Budget Deviation	Log.Budget Deviation	Short Term Emphasis	Long Term Emphasis	Stock Holdings	Market Value
Budget Deviation	1.000					
Log.Budget Deviation	0.830 (0.001)	1.000				
Short Term Emphasis	-0.112 (0.349)	-0.031 (0.798)	1.000			
Long Term Emphasis	-0.005 (0.970)	-0.117 (0.327)	-0.629 (0.001)	1.000		
Stock Holdings	-0.155 (0.193)	-0.168 (0.157)	-0.142 (0.233)	-0.095 (0.425)	1.000	
Market Value	0.008 (0.949)	0.070 (0.558)	-0.126 (0.291)	0.047 (0.697)	-0.178 (0.134)	1.000

TABLE 4: RESULTS OF TEST FOR HETEROSCEDASTICITY

Variable	Parameter Estimate	Standard Error	t-Statistic	p-Value
Current Pay	-0.02369	1.1162	-0.021	0.9831
Deferred Pay	-0.09842	0.3307	-0.298	0.7669
Stock Ownership	-0.1280	0.2136	-0.599	0.5509
Interaction of Current and Deferred Pays	-0.09669	0.3244	-0.298	0.7665
Interaction of Current and Stock Value Related Pays	-0.1130	0.3995	-0.283	0.7784
Interaction of Deferred and Stock Value Related Pays	-0.2217	0.3501	-0.633	0.5294
Market Value of Firm	-0.1428	0.3220	-0.444	0.6587

TABLE 5: ORDINARY LEAST SQUARES REGRESSION RESULTS

	Dependent Variable			
Independent Variable	Budget Deviation		Log (Budget Deviation)	
	(A1)	(B1)	(A2)	(B2)
Constant	1.640 (0.430) [***]	4.091 (1.492) [***]	0.153 (0.749)	2.358 (2.600)
Current Pay	-0.917 (0.528) [**]	-2.861 (1.402) [**]	-0.835 (0.920)	-2.754 (2.443)
Deferred Pay	-0.985 (0.601) [*]	-0.467 (2.326)	-1.421 (1.048)	0.277 (4.054)
Stock Ownership	-22.726 (12.154) [**]	-35.821 (13.381) [***]	-35.499 (21.184) [**]	-53.619 (23.318) [**]
Interaction of Current and Deferred Pays		-5.828 (3.918)		-6.031 (6.828)
Interaction of Current and Stock Value Related Pays		-4.483 (3.390)		-1.205 (5.908)
Interaction of Deferred and Stock Value Related Pays		-10.218 (5.156) [**]		-22.944 (8.985) [***]
Market Value of Firm (10^{-11})	0.01524 (1.612)	-0.1055 (1.584)	1.591 (2.809)	1.561 (2.760)
R^2	0.08	0.17	0.06	0.15

NOTE: [***], [**] and [*] denote 1-tailed statistical significance at 0.01, 0.05 and 0.10 levels respectively.