# THE RELATIONSHIP BETWEEN INVESTMENT IN INFORMATION TECHNOLOGY AND FIRM PERFORMANCE: A STUDY OF THE VALVE MANUFACTURING SECTOR

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## Abstract

Large amounts of resources have been and continue to be invested in information technology (IT). Much of this investment is made on the basis of faith that returns will occur. This study presents the results of an empirical test of the performance effects of IT investment in the manufacturing sector. Six years of historical data on IT investment and performance was collected for 33 valve manufacturing firms from the CEO, the controller and the production manager in each firm. Investment was perceptually categorized by management objective (i.e.: into strategic, informational and transactional) and tested against four measures of performance (sales growth, return on assets, and two measures of labour productivity). Heavy use of transactional IT investment was found to be significantly and consistently associated with strong firm performance over the six years studied. Heavy use of strategic IT was found to be neutral in the long term and associated only with relatively poor performing firms in the short term. This study suggests that early adopters of strategic IT could have spectacular success but once the technology becomes common the competitive advantage is lost. In addition, the context of the firm was included in the analysis. Conversion effectiveness, which measures the quality of the firm-wide management and commitment to IT, was found to be a significant moderator between strategic IT investment and firm performance.



**Key words:** Information technology (IT), information systems, investment, firm performance, computers, manufacturing


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# 1. Why is this Question Interesting?

Technology and its effective use in organizations has received much attention in the literature. Many of the seminal studies of technology were of production task technology in manufacturing firms [Woodward 1959] [Hickson et al. 1969] [Burns & Stalker 1961] [Blau et al. 1976]. Information technology (IT) is a relatively new phenomena and less is known about the impacts of its use in contemporary organizations. Despite this, investment in IT has increased dramatically, accounting for an ever increasing proportion of U.S. capital stock. In the service sector, where IT is usually the task technology, IT as a percent of capital stock increased threefold from 6.4% in 1970 to 19.8% in 1988. In the manufacturing sector, where IT is often not the task technology, the increase has been even more pronounced, growing from 1.6% in 1970 to 10.6% in 1988 [Roach 1989].

There is very little convincing evidence that investments in IT generate positive financial returns [Roach 88]. Many IT investment studies "found little persuasive evidence that IT investments created strong leverage on the value of the firm" [Kauffman & Weill 1989]. Why is this? Is it because the tools researchers used were not sufficiently sensitive to separate the effects of IT investment from all the other characteristics that impact firm performance? Or is it because IT, like production technology [Woodward 1959], is too broad a construct to be treated as one homogeneous technology?

This problem of lack of convincing evidence is not unique to IT investment but is common to much IT research. "Unfortunately, the literature on IT and organizational change does not currently

support reliable generalizations about the relationships between IT and organizational change [Markus & Robey 1988]". Markus and Robey posit a number of possible causes including variation in units of analysis, different base paradigms and conflicting or unclear definitions of IT.

The definition of IT and its performance effect are the focus of this paper. IT is not a homogeneous entity: different systems exist for quite different management objectives. Much IT investment research makes this assumption of IT homogeneity and consequently lacks any theoretical distinction of the different types of IT particularly with respect to performance effects. Woodward [1959] when studying attributes of effective organizations found that classifying production task technology (e.g., Unit and small batch vs long run process production) helped in data interpretation and later in predicting firm effectiveness.

This paper argues that there are different management objectives for IT investment [Turner & Lucas 1985]. Three different management objectives are posited. The relationship between IT investment for each of these management objectives and firm performance was tested in the valve manufacturing sector. Manufacturing was chosen as the sector has had long experience in the purchase, installation and management of technology. Furthermore, manufacturing is receiving renewed interest. Firms are recognizing that manufacturing excellence can be a strong basis for competitive advantage [Wheelwright and Hayes 1985]. This emphasis on competing through manufacturing stimulates firms to reassess their alignment of information technology with

business strategy [Doll & Vonderembse 1987]. Many manufacturing managers are struggling with how much to invest in IT and where these investments should be directed.

Investment alone in IT will not guarantee returns. Firms must also manage their portfolio of IT investments [McFarlan 1981] to achieve a return. This study also explores the contextual firm characteristics [Pritchard and Karasick 1973] that influence the effectiveness with which IT investments are converted to performance [Harris & Katz 1991].

In summary, the study addresses two major questions:

1. What is the measurable effect on firm performance of IT investment with each of the different management objectives?

2. What firm characteristics are associated with stronger positive relationships between IT investment and firm performance?

A broad definition of IT was adopted which includes all hardware, software, communications, telephone and facsimile as well as all personnel and resources dedicated to IT, whether centralized or decentralized[1].

## 2. Previous Research

A number of studies have investigated the relationship between investment in IT and firm performance. A detailed review of these studies is presented elsewhere [Kauffman and Weill 1989]; a brief summary of current understanding is presented here.

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1 IT embedded within productive capacity was excluded, as the purpose of this study was to capture technology used for informational purposes rather than for directly producing products for sale (e.g. production task technology). Numerically controlled (NC) lathes produce turned metal parts and are often connected to an infrastructure of computers to provide and capture information to and from the NC machine. In this definition the NC machine was excluded but the infrastructure computer network was included as it is part of the technology used primarily for information management.

Typically researchers have defined their unit of analysis as the firm, and measured IT investment (or use) and some measure of financial firm performance (e.g. expenses over income, return on net worth, sales growth). Unfortunately there has been little consistency in definition of what IT includes [Bakopoulos 1985].

Contradictory findings have emerged from these studies. Some studies have found a positive relationship between IT investment and firm performance. In a study of the insurance industry, Bender concluded that there is an optimum level of investment in information processing [Bender 1986]. Bender presented a parabolic plot of IT investment against firm performance indicating an optimum performance at a range of investment in IT from 15 to 25% of total costs. Another study of the insurance industry (using four years of historical data) revealed that the firms with the most improvement in organizational performance (operating expenses to premium income) allocated a significantly higher proportion of their non-interest operating expenses to IT [Harris & Katz 1988, 1991].

Some studies found that the relationship was complex and dependent on other issues. In a study of warehousing companies Cron & Sobol [1983] concluded that firms that make extensive use of computers are either very strong or very weak financial performers. This finding is interesting as it supports that part of the strategy literature that stresses the importance of strategic position [PIMS 1984] [Strassmann 1985] and suggest this missing factor be included in the analysis.

Banker, Kauffman and Morey [1990] studied the use of point of sale and order management IT in Hardee's fast food stores. In the 89 stores studied approximately half had introduced the new technology. Those stores with the IT and large breakfast sales (with the more complex menu for breakfast) performed significantly better than the other outlets in terms of materials costs. IT was effective to cut costs in the stores with the more complex tasks.

Other studies found no relationship. In a study of 58 banks, Turner concluded that "unexpectedly no relationship is found between organizational performance and the relative proportion of resources allocated to data processing" [Turner 1985]. In a study of 165 branches of a California bank, Lucas [1975a] found that the use of the information system "did not explain a great deal of variance in performance". In another study, Lucas [1975b] found that in a ready-to-wear clothing manufacturer, there was a "weak association between performance and the use of the computer system".

Strassmann [1985] in his study of service sector firms found no significant relationship between high performing firms and IT investment. In a study of the service sector Roach concluded "quite simply massive investments in IT have failed to boost national productivity growth in the present decade" [Roach 1988]. Unfortunately the productivity measure Roach used was not defined beyond being "Multiple productivity Indexes" and the reader is left to ponder its accuracy or relevance at the firm level.

In summary, a clear picture of the relationship between IT investment and firm performance has not emerged from previous studies. Limited and contradictory findings result from inconsistent definitions of IT, different units of analysis, different measures of performance, limited theory base and reliance on cross-sectional methods.

To attempt to overcome some of these problems a series of six mini-case studies was performed to gain insight into the process of IT investment. The results of these mini-cases are reported elsewhere [Weill & Olson 1989a] but provided the basis for the model that was tested in this study. Two key issues emerged from the cases. Firstly, not all IT investment is alike. Investments in IT are made for different management objectives and these different IT investments are likely to be related with firm performance in different ways. Previous studies have all treated IT as one type of investment.

Secondly, the context of the firm is important in converting IT investments into productive outputs. The necessity of the careful management of the new technology and its accompanying organizational context has been a recurring theme in organization theory and is summarised for a manufacturing setting by Lengnick-Hall and King [1986]. In this study, the context of the firm is hypothesized to moderate the relationship between IT investment and firm performance.

## 3. Model and Hypotheses

The model for this study (see Figure 1) posits a relationship between different types of IT investment and firm performance,

moderated by the contextual ability of the firm to convert IT investments into productive outputs (conversion effectiveness). Many other aspects effect firm performance such as the economic climate and the industry structure. This study holds as many of these other influences constant as possible and focus on measuring the impact of IT on performance.

An organization identifies how it wishes to compete in its environment and forms its strategy [Porter 1981]. Strategic issues are often ill-structured and ambiguous [Lyles 1981] but serve as a way to help the manager transform the daily chaos of events into framework for action [Porter 1981]. One of the many strategic decisions is the size and objectives of technology investments [Leavit 1965], particularly information technology [Davis and Olson 1985]. This is a strategic decision and effects the organization as a whole and its position in the environment [Eglehoff 1982].

A view of the organizational role of IT and how this fits the broad strategic concerns of the firm is required [Rockart 1988] to align the IT investment with the business strategy [Henderson 1990]. Firms can choose to apply IT at any point or points of the value chain to compete [Porter and Millar 1985]. Firms in any one industry invest different amounts of their available capital to achieve different levels of information technology investment intensity [Harris & Katz 1991].

Different management objectives for IT investments enable different bases for competition. For example, adding value in the form of IT to products to support a differentiation strategy is

one objective. Alternatively the IT investments could primarily be to cut costs supporting a low cost producer strategy. IT investments could also be made to informate [Zuboff 1988] the firm's employees or perhaps some combination of these. Thus different management objectives for IT investment exist often with the aim of influencing quite different performance measures (e.g. increase sale versus reduce labour costs).

Previous studies on the performance effects of IT investments [Cron and Sobol 1983] [Bender 1986] [Harris and Katz 1988,1991] [Turner 1985] have generally not included the context of the firm in the analysis. Rather they have assumed the context to be a constant and that all firms use their IT investments equally effectively. The IT implementation literature (see [Kwon and Zmud 1987] for a summary), however, identifies an important role of firm context in the effective use of information technology. Kwon and Zmud found that "many IS implementation studies attempt to identify those 'factors' most related to implementation success and failure". A small set of factors regularly reappear as being significantly related to implementation success: top management commitment, a high quality IS design, sufficient designer-user interaction and motivated and capable uses. The measure of success of these studies was usually satisfaction with systems [Kwon and Zmud 1987] [Weill & Olson 1989b]. The unit of analysis of the these studies was usually one particular system.

The focus of this paper, however, is the firm's portfolio of systems [McFarlan 1981]. Therefore we posit each firm has a particular climate [Cambell, Dunnette, Lawler and Weick 1970] [Hellriegel & Slocum 1974] [Pritchard & Karasick 1973]

[Schneider 1975] which influences how well the firm converts their IT investments into productive outputs.

The organizational climate is a relatively enduring quality of an organization's internal environment which distinguishes it from other organizations and results from behavior and policies of members of the organization [Pritchard and Karasick 1973]. Each organization creates a number of different aspects to its climate [Schnieder 1975].

The aspect of the firm's climate which influences IT we call conversion effectiveness [Weill 1990] and define it as the quality of the firm-wide management and commitment to IT.

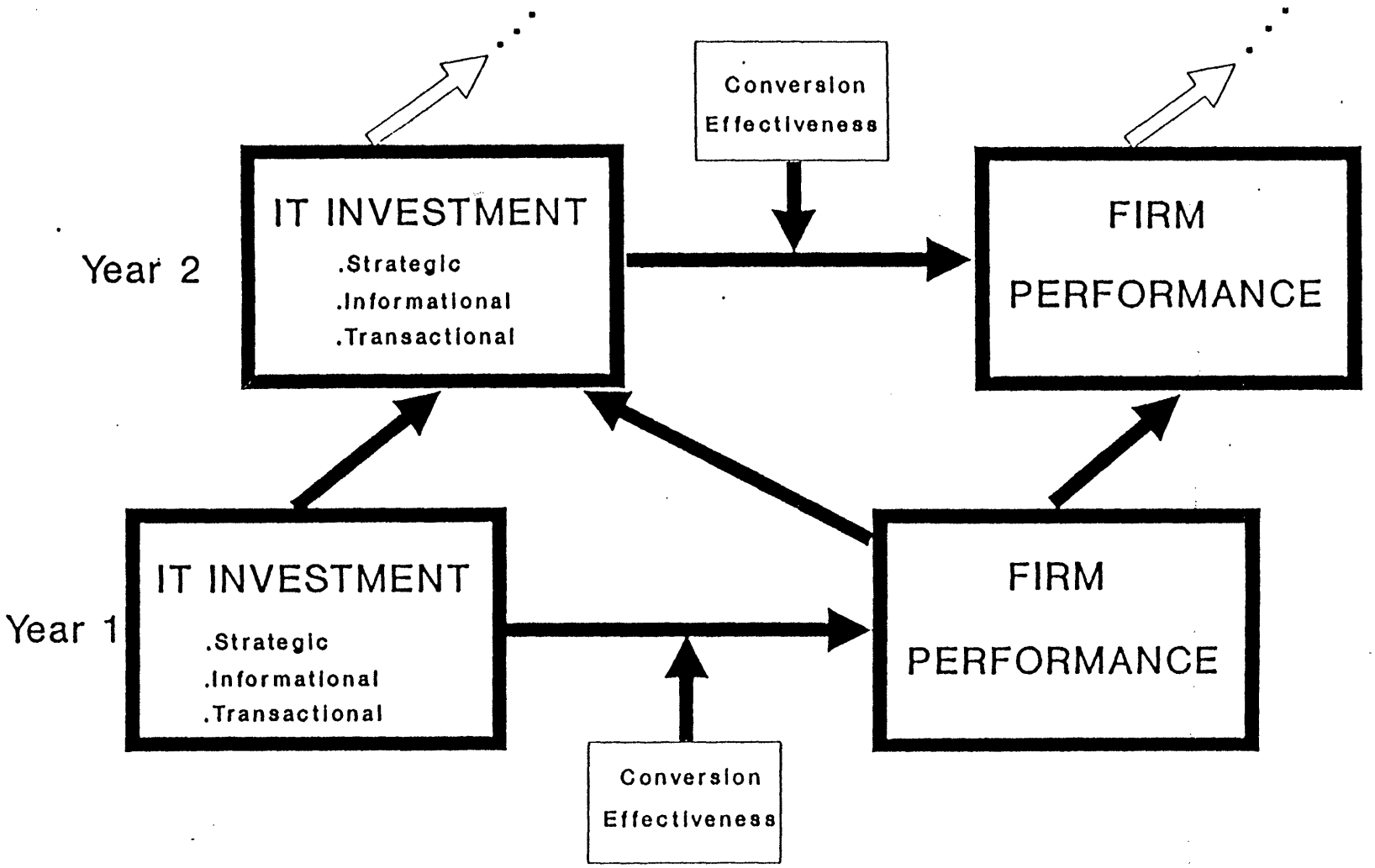
Conversion effectiveness contains four of the factors which the literature suggests will help ensure successful use of IT. The factors are:

- top management commitment to IT,
- previous firm experience with IT,
- user satisfaction with systems,
- the turbulence of the political environment within the firm.

These factors are explained and supported in the next section.

The IT investment in year 1 influences the performance in year 1 [see Figure 1]. This relationship is moderated by the firm's conversion effectiveness. The performance in year 2 is affected by the IT investment in year 2 and conversion effectiveness in year 2 but also the performance and IT investment in year 1. This complex and circular relationship continues as further IT investments are made in ensuing years as illustrated in Figure 1.

Figure 1: MODEL OF IT INVESTMENT



To isolate the effects of IT investment on current performance the effects of previous performance are statistically removed (i.e. partialled[2]) leaving just the incremental performance in the current year as the dependent variable. Then any relationship found between IT investment and incremental firm performance is the IT contribution, over and above the effects of the previous year's performance.

The first hypothesis of the study tests whether there is a general relationship between total IT investment and firm performance. No general relationship is expected, thus:

> **H1:** There is no association between previous years' total investment in IT and the firm's incremental performance.

The remaining hypotheses test whether IT investments with different management objectives operate differently in relationship to firm performance.

Three different management objectives for IT investment were specified in this study, derived and extended from the categories suggested by Turner and Lucas [1985].

1. **Transactional IT** processes the transactions of the firm and IT investment of this type is usually to cut costs by substituting capital for labor. This is the traditional type of IT investment where the transactions of the firm such as payroll, accounts receivable and order entry are automated. This type of IT investment is quite well understood and a history of successful implementations exist in most sizable firms.

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2 Partialling the effects of a variable (also referred to as 'controlling for' or 'holding that variable constant') is a mathematical procedure to remove the effect of a variable [Cohen & Cohen 1983]. Partialling was achieved in this paper using hierarchical regression.

Osterman [1986] showed a reduction in clerical and managerial labour from the introduction of this type IT. This type of investment is usually justified on an efficiency or cost displacement basis. It is expected that this type of IT investment will be associated with improved firm performance as measured by profitability and labor productivity.

2. **Strategic IT** is investment made to gain a competitive advantage and increase market share, via sales growth [Ives & Learmonth 1984]. Strategic IT is usually IT used in a new way for the industry at that point in time. Strategic IT is quite different from transactional IT in that the objective is expansion rather than efficiency. IT is used an enabling technology to better meet market demand. Perhaps the IT is used as the channel to the customer (e.g., American Hospital Supply) or used to spawn new businesses [Porter & Millar 1985] or as an industry platform eventually restructuring an industry (e.g. American Airlines). The strategic IT may be based on traditional tactical systems but it is the integration of the systems into the business strategy that makes the IT strategic [Kim & Michelmen 1990]. Strategic investments in IT are expected to influence the growth aspects of firm performance such as market share or sales growth.

3. **Informational IT** provides the information infrastructure to do other functions (besides cut costs or gain sales). Typically this includes management control, budgeting, production planning, communications, accounting and other management tasks. This type of IT is the backbone of the information management of the firm and includes the IT infrastructure. The information systems used to prepare the financial statements would often be part of the informational investment. The telephone, facsimile and electronic mail systems are part of the communications infrastructure and thus informational IT investment.

A particular system may deliver all three of these management objectives (e.g. production planning). Thus, in this study, the IT portfolio is categorized perceptually by the senior management of the firm into the proportion of the investment that was intended to achieve each of the above management objectives. How senior management perceive their technology varies significantly from firm to firm [Thomas and McDaniel 1990]. This perception is

the manager's "workable version of reality" [Weick 1979] and will influence many strategic decisions [Thomas & McDaniel 1990] and ultimately the performance of the firm.

**H2:** There is a positive association between previous years' investment in IT, categorized by management objective, and the firm's incremental performance. Transactional IT is posited to effect profitability and the labour productivity of the firm. Strategic and informational IT are posited to effect the growth and profit aspects of firm performance, respectively.

Cron and Sobol showed that previous firm performance influences investments in IT [Cron & Sobol 1983]. It is posited in this study that firms which have performed well in the past will have the resources and confidence to invest more heavily in IT.

**H3:** There is a positive association between incremental IT investment, categorized by management objective, and each measure of previous year's firm performance.

It is not likely that two firms that invest the same amount in IT, with the same management objectives, will have the same performance effects. The conversion effectiveness of the firm will influence the way the IT is converted to productive outputs. Firms with higher conversion effectiveness are expected to get greater payoff from their investments.

A firm's conversion effectiveness (and the firm's general climate) will be influenced by a myriad of aspects of the firm but four were selected as representative from the literature. Most useful measures of organizational climate are typically perceptual and can be used as an intervening variable between some aspect of interest and the outcome or performance effects [Hellriegel and Slocum 1974]. Conversion effectiveness is an

amalgam of four perceptual measures expected to moderate the IT investment and firm performance relationship. These four factors are certainly not the only aspects of the climate variable we wish to capture but rather are expected to correlate with each other and any other factors conceptually associated or determined by conversion effectiveness.

For example, at the level of the specific system a factor expected to be the product of (and thus correlate with) conversion effectiveness is sufficient designer-user interaction (Kwon and Zmud 1987). If we measured the quality and quantity of the designer-user interaction for each system and then aggregated to the firm this would correlate with conversion effectiveness. Other system level factors, similarly aggregated, are posited to correlate with designer-user interaction and conversion effectiveness. The four factors of conversion effectiveness are:

Top Management Commitment

Top management commitment has long been recognized as important for implementation success [Lucas 1981, Markus 1981, Ginzberg 1981]. Commitment is required in the form of a demonstration of the belief that the systems will be successful and productive tools. Strong top management support is expected to lead to superior conversion effectiveness and thus superior performance for the same level of IT investment. Top management commitment is one of the small set of organizational factors that constantly reappear as being significantly related to successful use of IT [Kwon & Zmud 1987].

Previous Experience with IT

Previous experience with systems is a vital factor in the use of any technology. More experience will lead to greater organizational learning [Argyris 1982] and more effective employment of the limited IT resource. Firms with more experience with systems will tend to be aware of the potential pitfalls and have realistic expectations

of what IT can achieve. Raymond [1985] found that experience with IT related to most of the organizational characteristics (such as internal application development and more applications computerised) that were significantly associated with IS success. More experience is expected to result in better conversion effectiveness.

## User Satisfaction with Systems

User satisfaction with systems [Ives, Olson & Baroudi 1983] is a pervasive measure of the construct of system success or effectiveness [Baroudi and Orlikowski 1988]. Systems success has been extensively studied and found to relate to a number of factors such as user involvement and the user-designer interaction [Ives and Olson 1984].

If users are very unsatisfied with the systems provided it will be more difficult to convert the IT investment into productive outputs. User satisfaction measures the user's perceived satisfaction with their computer technology support and relates to the IT portfolio as a whole. Users satisfied with the information systems provided will lead to higher conversion effectiveness which is expected to positively influence firm performance.

## Political Turbulence

Power and politics have been recognized as significant aspects of MIS design and implementation [Markus 1983], [Markus & Pfeffer 1983]. Markus [1983] demonstrated that as a result of political negotiations during system design and development, rational management objectives for systems are not always translated into system design features. Shrivastava and Grant [1985] found that a number of organizations they studied exhibited the characteristics of a political expediency model in the decision making process for the purchase of a large computer system. Employees formed coalitions around the computerization issue and managed the decision process to ensure their group's interests were protected and maximised.

Firms with politically turbulent internal environments are expected to experience a lower conversion effectiveness than more cohesive firms. Individuals or groups will act in their own interests if the firm has a politically charged environment and this will reduce the likelihood of a uniform commitment to the use of specific IT. IT is inherently an integrating technology allowing better integration of organizational subunits [Lawrence and Lorsch 1967] and the less internal political

turbulence the more successful the IT is likely to be. As Harris and Katz [1991] observe, Dalton, Lawrence and Lorsch [1970] argue that to achieve higher levels of organizational integration requires the effective resolution of intergroup conflict. Conflict can decrease the adaptability to change, waste resources and misdirect innovation thus reducing the effect of IT on performance.

**H4:** Conversion effectiveness moderates any relationship between IT investment, categorized by management objective, and incremental firm performance.

## 4. Methods

The research involved the study of thirty-three small to medium sized firms in the valve manufacturing industry. Valves are devices that regulate the flow of fluids in pipes and are found in many different industries. The U.S. sales of industrial valves in 1987 was $2.2 billion [Valve Manufacturers Association].

The customers of the valve industry come from many business sectors ranging from the water and sewerage to petroleum production with no single sector accounting for more than 20% of sales. Several different types of valves make up these sales. Automated valves have the largest market share with 22% of the market [Valve Manufacturers Association]. Thus the valve market is not affected greatly by the health of any one sector or product type. This balance makes the clearly defined valve industry attractive to study the effects of IT investment in relative isolation from other industrial sectors.

Six years of historical data including three independent sources of information in each firm was collected. A survey was the primary method of data collection and the CEO, the controller and the production manager each completed a different questionnaire. In addition more than half the controllers were interviewed by

telephone and two firms were visited. The interviews and visits were used to help understand the industry and the role IT played over the six years.

To reduce the confounding effects of industry and conglomerate businesses, the sample consisted of one well defined industry with the unit of analysis being the strategic business unit[3] (SBU). The Valve Manufacturer's Association of America provided a mailing list of all known valve manufacturers (excluding the very small firms) and the total industry sales for recent years. The CEO's of seventy-seven firms were sent packs of questionnaires and five responded that their firm had no computers. Thirty-three value manufacturing firms provided all three questionnaires for a response rate of 46%. All other CEO's were contacted by phone and declined to participate usually stating reasons of time pressures or confidentiality. Of the SBU's responding, 58% were divisions of larger firms. The rest were privately held single SBU firms.

To check for any possible response bias the sample was compared to the population of valve manufacturers [Wards Business Directory]. Valve manufacturers are have SIC codes of either 3491 or 3492. The largest seventy-two firms in these categories were tabulated and treated as the valve firm population. This population also excluded the very small firms and had an average sales of $73 million. A hypothesis test between our sample and the population revealed no significant difference (z-score=+0.72 as compared to a significant z-criteria of 1.96 for alpha=0.05). No response bias by sales was observed.

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3 The SBU was developed by The Strategic Planning Institute in Cambridge, Massachusetts and was used in the PIMS study [PIMS 1984]. A SBU has a distinct set of products or services and serves a specific group of customers. The SBU also competes with a well defined set of competitors.

### 4.1 Variables

The variables measured can be classified into quantitative and perceptual items. The quantitative variables were measures of some facet of the firm such as total sales in 1986 or total IT investment in 1987. To avoid the difficulties of interpretation faced by many previous cross-sectional studies in this area [Cron and Sobol 1983] [Bender 1986], [Turner 1985], historical data was collected for the quantitative variables. For example, IT investment was collected for the current year and five previous years. This allowed testing of the effects of time on the IT investment and firm performance relationship.

Perceptual data was collected from each of the three sources within the firm. The measures used all came from previous studies with minor modifications as required for the manufacturing sector. The only exception was the question asking for the perceptual break down of IT investment to its component types: strategic, informational and transactional. Using the definitions explained in section 3 questions were designed with examples relevant to the industry studied. Appendix A contains the sources of each measure, descriptive statistics and reliabilities. Reliabilities of each of the multi-item variables were checked using Cronbach's alpha [Bohrnstedt and Knoke 1982] and yielded a minimum value of 0.80, indicating reliable measures.

IT investment of the firm was measured by the ratio of IT expenditure divided by total annual sales. This ratio provides a measure of the relative size of IT investment compared to the

size of the firm. This ratio was provided by the CFO. The CFO was requested to consult the financial records to obtain this ratio.

The CEO and controller classified the IT investment by management objective: strategic, informational and transactional. Consistency in definition was aided by providing each respondent with a definition of each type of IT investment, with examples tailored to the industry. Inter-rater reliabilities[4] (IRR) [James, Demaree & Wolf 1984] were 0.78 agreement for strategic IT, 0.75 for transactional and 0.68 for informational IT. This level of agreement provided confidence in the categories used for classifying IT investment. Given this level of agreement, only the CEO's categorization data was used for the analysis[5]. This decision was taken after discussions with respondents indicated that the CEO's often had a broader feel for the management objectives of the firm's investments.

To assist in capturing a broad scope of firm performance four different measures were used: sales growth, return on assets (ROA) and two measures of labor productivity (the number of non-production employees per million dollars sales [LABOR] and the percent change in this measure [%LABOR][6]). Profitability was measured using ROA as it is an excellent broad measure correlating to many other measures of profitability [Grinyer & Norburn 1975]. Three measures of firm size were also collected: sales, market share and employees. The performance and size

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4 IRR essentially measures the extent to which the respondents are interchangeable and varies from zero (not interchangeable) to one (perfectly interchangeable).

5 The IT investment in each category was calculated by the product of the total IT investment (from the controller) and the percentage of each type of IT provided by the CEO.

6 Correlation between the performance variables were all not significant except for ROA 87 and Growth 87 ($r=0.28, p<0.07$), ROA 87 and %Labor ($r=-0.36, p<0.03$) and also Growth 87 and %Labor ($r=0.8$, $p<0.01$) indicating that generally each variable measured different aspects of firm performance.

measures were collected for four years (1984-7) to average out short term effects.

Conversion effectiveness is a new concept even though all its four component measures (top management commitment, user information satisfaction, experience with IT and political turbulence) have been used in previous studies. Data was collected, on all measures but IT experience, from each of the three sources in each firm. The measure of IT experience was collected only from the CEO as this is a relatively objective assessment of the extent of computerization of the major business functions.

To determine whether conversion effectiveness was a valid firm-wide climate construct for this sample, a principal component analysis was performed[7] on the ten variables (user satisfaction, political turbulence and top management commitment for each respondent plus IT experience provided by the CEO). Three principal components emerged with sizable eigenvalues; however, all ten variables loaded on one principal component with a minimum weighting of 0.41 explaining 34% of the variance.

The finding that all ten variables loaded on the same principal component indicated that they all covaried. This supports the notion of a firm-wide climate construct relating to the quality of the management and commitment to IT (i.e., conversion effectiveness). Thus conversion effectiveness can be treated as a

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7 Principal component analysis was used to get a "feel" for the relationships [Chatfield & Collins 1980, page 71] between the ten variables. The ten variables covaried with an average weighting of 0.58 and thus provided confidence to combine them into one construct.

single construct comprised of the views of three key players in the firm but representing the firm as a whole.

The achieve a single measure on a common scale, the z-scores of the ten measure were calculated. Conversion effectiveness is the sum of the z-scores of the ten components. Conversion effectiveness was approximately normally distributed with mean of -0.076 and standard deviation of 4.9 and ranged from -10.18 to 7.88. Each component was equally weighted in the construct so an increase in IT experience, user information satisfaction or top management commitment resulted in an increase in the firm's conversion effectiveness. Any decrease in political turbulence also resulted in improved conversion effectiveness.

The questionnaires were pilot tested in three firms and adjustments were made upon feedback. The design of the questionnaires followed the prescriptions of two chapters "Problems of Questionnaire Design" and "Question-Wording" [Oppenheim 1966].

**4.2 Data Analysis**

The firm's 1987 performance was used as the dependent variable. To remove the effect of previous performance, the average of the last three years' performance (1984-1986) was entered first in the regression equation.

The past performance explained 7%, 47%, 68%, and 8% of the 1987 measures of growth, ROA, non-production labor per million dollars sales [LABOR] and change in LABOR respectively. Next, the IT

investment variables in the model were entered to attempt to explain the remaining variance in firm performance. Total explained variance for the equations in this study was often over 50% adding to the confidence of the models[8].

This hierarchical regression technique can readily be extended to cope with sets of variables. A set is a number of variables grouped together conceptually by the logic of the research. Treating the variables as a set allows the effect of the set as a whole to be determined as well as the individual effects of the variables [Cohen & Cohen 1983, page 133]. The use of the set of variables rather than an aggregation (i.e., total IT investment) allows for the possibility that variables in the set may effect the dependent variable in different directions. Also, if the three variables are entered as a set, the amount of variance explained the set (i.e., IT investment) can be established taking into account any shared variance in the three IT investment variables.

The three management objectives for IT investment were entered into the equation as a set in the analysis for hypothesis 2. To achieve this the three variables are entered at the same step into the regression equation. For hypothesis 2, the previous performance is entered as the first step. Then the three types of IT investment are entered into the equation to explain the variance unexplained by the previous performance.

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8 The statistical power of the each of the hypothesis was determined to be acceptable [Cohen & Cohen 1983] during the research design. Power was calculated at over 80% given the sample size of 33, alpha of 0.5 and the large variance explained by the total models.

The availability of six years of data permitted testing of several lag structures and also the exploration of the circularity of the relationship between IT investment and firm performance.

Each year the new IT investment adds to the existing IT portfolio [McFarlan 1981] of the firm. It is likely that the cumulative effect of this investment, rather than any one particular year, will influence performance. Therefore in testing hypotheses 1 and 2 the three and six year averages of the firm's IT investment were used. This approach reduced the effects of any large investments in any one year (e.g., a large mainframe computer purchase). In addition, the individual effects of the last two years of IT investment were tested to determine if recent year's investment has greater performance effects. In total four different lag structures were tested.

## 5. Findings

The U.S. valve industry was in a state of no growth for the six years (1982-87) of the study. Competition from imports was fierce with a spectacular 18% increase in imports in 1986. Average sales growth for the firms in the sample was positive for the period studied but dropped to 2.1% in 1986 from a high of 9.4% in 1984 [Appendix A]. Interviews with controllers revealed that IT was perceived as a way to compete with imports. As a consequence, large investments were made relative to other manufacturing sectors [Roach 1989]. IT investment in the valve industry grew from 3.5% to 4.0% of sales over the six year period [Table 1]. Given the flat U.S. industry sales and modest but positive

average firm growth, this increase in IT investment reflected an increase in the fraction of resources devoted to IT.

The change in the types of IT investment is of greater interest. The amount of transactional and informational IT investment stayed constant over the six years at around 1% and 2% of sales respectively. Strategic IT investment doubled over the six years to absorb the total IT investment increases.

**Table 1: Average IT Investment - % of Sales**

| | Year | | | | | | Std Dev |
|---|---|---|---|---|---|---|---|
| Investment | 82 | 83 | 84 | 85 | 86 | 87 | 87 |
| IT | 3.4 | 3.7 | 3.7 | 3.7 | 4.0 | 3.9 | 3.7 |
| Strategic | 0.4 | 0.5 | 0.6 | 0.7 | 0.9 | 0.9 | 0.9 |
| Informational | 2.1 | 2.2 | 2.1 | 2.0 | 2.2 | 2.2 | 2.9 |
| Transactional | 0.9 | 1.0 | 1.0 | 1.0 | 0.9 | 0.9 | 1.0 |

The average firm size was 756 employees with sales of $68 million and ROA of 9% in 1987, an increase from an ROA of 5.8% in 1984. The average firm had 97 terminals and 36 personal computers and had actively used IT for 15 years.

### 5.1 Results

**Hypothesis 1: There is no association between previous years' total investment in IT and the firm's incremental performance.**

IT investment was operationalized in four ways requiring four sets of regressions over four performance variables totalling sixteen equations in all. The dependent variables of interest were: growth [GROWTH87], ROA [ROA87], non-production labor adjusted for sales [LABOR87] and the percentage change in non-production labor from the previous year adjusted for sales [%LABOR CHANGE 87].

The four measures for IT investment were:

**H1a:** Six year average [1982-7] of total IT investment.

**H1b:** Three year average [1985-7] of total IT investment.

**H1c:** 1987 total IT investment.

**H1d:** 1986 total IT investment.

To illustrate the method the full analysis is presented in table 2 for hypothesis 1a.

**Table 2: Hypothesis 1a**
**Dependent Variable: Non-production Labor Adjusted for Sales 1987**

| Independent Variables | B Weight | Cumulative Multiple $R^2$ | Incremental Variance (I) | Change in Sig F | t test |
|---|---|---|---|---|---|
| LABOR 84-7 0.00** | 0.78 | 0.68 | 0.68 | 0.00** | |
| IT 82-87 | -0.04 | 0.69 | 0.01 | 0.33 | 0.33 |

*LEGEND:*
*Significance:* ** <0.01, * <0.05, ^ <0.1
*IT 82-7:* Average IT investment 1982-7.
*LABOR 84-86:* Average Non-production labor adjusted for sales 1984-6
*Change in Sig F:* Change in significant F test for variable.
*Incremental Variance:* Incremental variance explained uniquely by the variable.

The hierarchical regressions for hypothesis 1a involve each dependent variable being regressed against average six year total IT investment. For example [Table 2], with adjusted non-production labor in 1987 as the dependent variable (DV), the average of the three previous years adjusted non-production labor was entered first and explained 68% ($R^2$=0.68) of variance. This increment was significant with a change in significant F test (Change in sig F) of 0.00. Next, the average IT investment (IT 1982-7) was entered and explained an additional increment of 1% (I=0.01) of variance that was not significant (Change in sig F=0.33). In conclusion, the six year average of IT investment was not significantly associated with the number of non-production people required per million dollars sales in 1987 after previous performance was removed.

Hypotheses 1 b,c and d were tested in the same way and the summary results are presented in Table 3. The decimals in the body of the table are the changes in significant F test for IT investment while the percentages are the incremental variance explained by IT investment.

The results are consistent with some of the previous IT investment studies (e.g., Turner 1985) and is of concern for advocates of IT investment. The evidence is compelling as four different timings of IT investment were tested. There was no association with investment in the same year, in the previous year or with three or six year averages. Thus hypothesis 1 is accepted.

**Table 3: Hypothesis 1 Summary**

| Dependent Variable | 6 YR AV IT Hyp 1a | 3 YR AV IT Hyp 1b | IT87 Hyp 1c | IT86 Hyp 1d |
|---|---|---|---|---|
| Growth 87 | 0.33 [3%] | 0.31 [3%] | 0.33 [3%] | 0.37 [3%] |
| ROA 87 | 0.97 [0%] | 0.96 [0%] | 0.79 [0%] | 0.88 [0%] |
| Labor | 0.33 [1%] | 0.42 [1%] | 0.48 [1%] | 0.46 [1%] |
| Labor Change | 0.76 [0%] | 0.75 [0%] | 0.72 [0%] | 0.59 [1%] |

Note: The decimals are the change in level of significance of the F test of IT investment. The numbers in square brackets are the percent of variance explained by IT investment after previous performance was removed.

Significance: ** < 0.01, * < 0.05, ^ < 0.1

**Hypothesis 2: There is a positive association between previous years' investment in IT, categorised by management objective, and each measure of a firm's incremental performance.**

The test of Hypothesis 2 was conducted in a similar way to the previous hypothesis. The same four sub-hypotheses were assessed; each capturing a different timing of IT investment. In each case four hierarchical regressions were performed, one with each of the dependent variables. This time, however, the three types of IT investment (i.e., strategic, informational and transactional) were entered as a set. The set of variables was tested for significance using the change in the significant F statistic while the individual variables coefficients (B weights) were tested in the final equation using a t statistic.

To illustrate the method the hierarchical regression is presented in Table 4 for the dependent variable ROA 87 and the six year average IT investment. The upper part of the table presents the cumulative $R^2$ and incremental variance (I) for each set as it was entered into the equation. The lower table contains the coefficients and t tests for the final equation for interpretation of the direction of any effect.

The first variable entered is the average of the previous three years ROA explaining 47% ($R^2$=0.47) of variance [refer upper part of table]. The set of the three types of IT investment in 1986 was then entered and uniquely explained 13% of variance (I=0.13). The set was significant (change in sig F=0.048) and the variables contained in the set were tested individually in the final equation. Transactional investment (t=0.007) was significant [see lower table] and positively associated (B=5.25) with ROA 87. High transactional IT investment in 1986 was associated with superior ROA in 1987 with previous performance removed. The effects of strategic and informational IT were not significant.

The summary results for the all the equations for hypothesis 2 are presented in table 5. For each of the sub-hypotheses (e.g. H2a) results are presented for the sets as well for individual variables. The decimals in the body of the table are the level of significance for the t test for each variable in the final equation. The line of data for the set for each sub-hypothesis contains both the level of significance for F (decimals) as well as the percent of variance explained by the set of IT investment. For example, for hypothesis 2a and the dependent variable growth,

the set of IT investment uniquely explained 5% of variance and was not significant. However, for ROA 87 the set of the three types of IT investment explained 12% of variance which was significant. In the final equation only transactional IT was significant and in a positive direction.

**Table 4: Hypothesis 2**

**Two Stage Hierarchical Regression**
**Dependent Variable: ROA 1987**

| Independent Variables | Cumulative Multiple $R^2$ | Incremental Variance (I) | Change in Sig F |
|---|---|---|---|
| ROA 84-6 | 0.47 | 0.47 | 0.00** |
| Set of: Strategic IT Informational IT Transactional IT | 0.60 | 0.13 | 0.048* |

**Final Equation: ROA 87**

| IV's | Coefficient | t test |
|---|---|---|
| ROA 84-86 | 0.7 | 0.00** |
| Strategic IT 86 | -3.1 | 0.15 |
| Informational IT 86 | -0.40 | 0.34 |
| Transactional IT 86 | 5.25 | 0.007** |

*Note: The upper part of the table contains the results for the hierarchical regression of two stages. The lower part contains the co-efficients and t test for the individual variables in the final equation.*

*LEGEND:*

| | |
|---|---|
| *Significance:* | *** <0.01, * <0.05, ^ <0.1* |
| *ROA 84-86:* | *Average ROA 1984-6* |
| *Change in Sig F:* | *Change in significant F test for set of variable(s).* |
| *Incremental Variance (I):* | *Incremental variance explained uniquely by the variable sets.* |
| *IV's:* | *Independent variables* |

Transactional IT investment was significantly positively associated with both ROA and non-production labor adjusted for sales. The positive association was significant for all four

timings[9] of IT investment. Thus high investment in transactional IT investment was associated with high performance in 1987 as measured by ROA and the number of non-production people required per million dollar sales. The consistency of the relationship across the four timings indicates that the relationship appears to be independent of time (i.e., lag structure). Transactional IT investment measured by six and three year averages as well as one year and no lag were all significantly associated with firm performance. Thus hypotheses 2a, 2b, 2c and 2d were supported for transactional IT.

No significant associations were found for informational investment for any performance measure using any of the four timings of investment. The lack of association is perhaps not surprising considering that the purpose of informational IT investment is to provide the information infrastructure of the firm, including communications, budgeting and accounting. Informational IT investment may produce a long term and indirect return in the form of better decisions and more informed management. However, no statistical evidence of a relationship to performance was found in this data. It is possible that the effect is subtle or is diluted by many other influences. Informational IT investment appears necessary to run a contemporary firm and was nearly half of the IT investment in the valve industry. The product of informational IT investment was information, not cost savings or competitive advantage and thus perhaps has a less direct effect on performance.

9 Close but not quite significant for ROA 87 and the three year average transactional IT.

## TABLE 5: Hypothesis 2 Summary

| Hypoth | DV | Growth 87# | ROA 87 | % Change Labour 87 | Labour 87 |
|---|---|---|---|---|---|
| 2a | Strategic IT 82-7 | 0.60 | 0.25 | 0.69 | 0.39 |
| | Informational IT 82-7 | 0.99 | 0.61 | 0.34 | 0.53 |
| | Transactional IT 82-7 | 0.64 | + ** | 0.89 | - ^ |
| | Set 82-7 | 0.68[5%] | ^[12%] | 0.79[3%] | 0.28[4%] |
| 2b | Strategic IT 85-7 | 0.54 | 0.53 | 0.50 | 0.30 |
| | Informational IT 85-7 | 0.96 | 0.51 | 0.32 | 0.79 |
| | Transactional IT 85-7 | 0.56 | 0.13 | 0.90 | - * |
| | Set 85-7 | 0.55[7%] | 0.42[5%] | 0.71[4%] | 0.24[4%] |
| 2c | Strategic IT 87 | 0.26 | 0.68 | 0.13 | + ^ |
| | Informational IT 87 | 0.61 | 0.36 | 0.79 | 0.63 |
| | Transactional IT 87 | 0.61 | + ^ | 0.12 | - ** |
| | Set 87 | 0.58[6%] | 0.27[7%] | 0.35[10%] | *[9%] |
| 2d | Strategic IT 86 | - ^ | 0.15 | + ^ | 0.35 |
| | Informational IT 86 | 0.73 | 0.34 | 0.13 | 0.97 |
| | Transactional IT 86 | 0.99 | + ** | 0.34 | - ^ |
| | Set 86 | 0.52[7%] | *[13%] | 0.28[12%] | 0.29[4%] |

Legend:

Significance: ** =< 0.01, *=<0.05, ^=0.1

DV: Dependent variable.

Labour 87: Non production labour adjusted for sales 1987.

% Change Labour 87: Percentage change in non production labour adjusted for sales from 1986 to 1987.

# One firm with a growth of 5000% was removed as atypical.

Note: Set 87 refers to the three types of IT investment in 87 entered as a set. The number in the square brackets (e.g. [7%]) is the variance explained by the set. The numbers not in brackets are the level of significance of the t test for variables and F tests for sets.

Strategic IT investment in 1986 was negatively correlated with two measures of firm performance in 1987 [growth and the percentage change in non-production labor adjusted for sales]. Also 1987 strategic IT was negatively associated with non-production labor adjusted for sales and close to significant with the percentage change in non-production labor adjusted for sales. These negative correlations were significant at the 10% level and thus are only indicative. Neither the three or six year averages of sustained strategic IT investment were correlated with firm performance.

These results indicate that strategic IT has not been the boon to all firms that has been heralded. One explanation is that early adopters of strategic IT could have spectacular success, but once the technology becomes common, the competitive advantage is lost. Once a successful strategic use of IT is introduced the other firms have to also invest to compete. The result is an increase in the IT sophistication of the industry but no net performance effect will be statistically observed.

These results could still be due to poor performing companies tending to invest more in strategic IT in an attempt to regain profitability. Whether relatively poor performing companies invested more heavily in strategic IT was tested in Hypothesis 3.

The sets of the three types of IT investment were significantly associated with ROA, for both the six year average IT investment and the 1986 IT investment timings. Non-production labor adjusted for sales was significantly associated with the set of IT investment in 1987. Thus the three types of IT investment acting

together (i.e., entered as a set) explain a significant amount of variance in some performance measures. The disaggregation process of catagorizing total IT investment into these three management objectives appears to be the key to isolating the effect of IT on performance which was not found for total IT investment in hypothesis. In these cases the effect of the transactional IT is sufficiently strong to make the set as a whole explain a significant amount of variance in the dependant variable. Thus hypotheses 2a, 2c and 2d for the three types of IT were supported for at least one performance measure.

When the three types of IT investment are entered as individual variables the transactional IT has a significant association with performance. If the three types of IT are aggregated, as in hypothesis 1, the effect washes out. This is probably due to the small amount of variance explained by informational IT which accounts for over half of the average IT portfolio. Also, in general, performance is affected in different directions by strategic IT (negative) and transactional IT (positive).

The sets of the three IT investment types explained sizable percentages of variance. A typical example was the 9% of variance explained by the set of 1987 IT investment by type in adjusted non-production labor in 1987. The total variance accounted for by that model was 77%. An example of a large percentage of variance was for ROA 1987, where nearly 12% of variance was accounted for by the set of six year averages of IT investment by type. The total variance accounted for in ROA 1987 by the model was 58%.

These large proportions of variance accounted for by the analyses add confidence to the models used[10].

**Hypothesis 3: There is a positive association between incremental IT investment, categorized by management objective, and each measure of previous years' firm performance.**

Hypothesis 3 tests the associations between current IT investment and previous performance. To capture a broad measure of organizational performance an average of the four years was used. The three measures were the set of ROA, growth and the change in non-production labor adjusted for sales. The measure of adjusted non-production labor was dropped as it was similar in concept to the change in adjusted non-production labor.

Each of the three types of IT investment were treated as dependent variables requiring three equations. The average of the previous five years of investment of that type was entered first. Then the set of three performance measures was entered and the incremental variance tested.

Table 6 presents the results for Hypothesis 3. For example, the set of three performance variables uniquely accounted for 12% of variance in 1987 transactional IT investment (after the effects of previous transactional IT investment had been removed).

Inspection reveals that neither strategic nor informational IT investment were significantly associated with the set of

10 Several sets of the three types of investment accounted for noticeable amounts [e.g., 12%] of variance but were not significant. This situation was due, in part, to the relatively small amount of variance explained by the entire model for that particular performance measure resulting in lower statistical power.

performance measures. Thus previous years' performance was not associated with strategic and informational investment in 1987.

**Table 6: Hypothesis 3 Summary**

| Dependent Variable | Growth84-7 | ROA84-7 | % Labor Change85-7 | Set |
|---|---|---|---|---|
| Strategic IT 87 | 0.19 | 0.50 | 0.20 | 0.36 [4%] |
| Informational IT 87 | 0.30 | 0.68 | 0.88 | 0.67 [1%] |
| Transactional [12%] IT 87 | 0.20 | 0.86 | - ** | ^ |

Note: The decimals are the level of significance of the t test of the performance measure in the final equation. The numbers in square brackets are the percent of variance explained by the set of performance measures after the investment was removed.

Significance: ** < 0.01, * < 0.05, ^ < 0.1
The direction (+ or -) of the effect for individual variable is given only for variables with significant co-efficients.

More evidence is now available to assess the relationship between strategic IT and performance. One of the explanations posited earlier for the lack of association was that perhaps poor performing companies were investing in strategic IT in an attempt to turn around. This was not the case in the valve industry.

There was a clear association between previous performance and 1987 transactional IT investment, indicating that successful firms were interested and had the resources to invest in further IT to cut costs.

**Hypothesis 4: Conversion effectiveness moderates any relationship between IT investment, categorized by management objective, and incremental firm performance.**

Hypothesis 4 tested whether conversion effectiveness moderates any relationship between investment and firm performance. Hierarchical regression was used to test the significance of the interaction between conversion effectiveness and the type of IT investment [Cohen & Cohen 1983, page 320]. Three regressions for each of the four performance variables was used; one for each type of IT investment totalling twelve in all. The performance measure in 1987 was the dependent variable in each case. The equations each have four variables: previous performance, the IT investment for a particular management objective, conversion effectiveness and the interaction between investment and conversion effectiveness. The IT investments for each management objective were tested in separate equations.

The measures for conversion effectiveness assessed the respondent's perception of current conditions. To allow sufficient time for investments to be implemented and affect performance, 1986 IT investment and 1987 performance were used. Thus the model was IT investment made in 1986 and converted in 1986/7 to affect performance in 1987. The assumption was made that conversion effectiveness collected in 1987/8 did not change greatly from 1986/7.

The direction of the effect of an interaction is not directly interpretable from the coefficients. The interpretation was aided by a reduced-form equation technique involving the substitution of typically "high", "medium" and "low" values for the variable of interest [Cohen & Cohen 1983, page 323]. Mean values were substituted for the one variable not of interest (average

previous performance). High, medium and low values were substituted for conversion effectiveness and the resulting three equations were graphed.

In Table 7 the performance variables head each column and the rows are the interaction between each type of IT investment and conversion effectiveness. The numbers in the table are the t tests for the interaction in the final equation. The sign [+ or -] indicates a positive or negative effect of the interaction determined by the reduced form equation method described above.

**Table 7: Hypothesis 4 Summary**

| Variables | Growth87 | ROA87 | % Change Labor87 | Labor87 |
|---|---|---|---|---|
| Strategic IT86 x CE | + ^ [10%] | 0.66 [1%] | - ^ [10%] | - ** [7%] |
| Informational IT86 x CE | 0.66 [1%] | 0.43 [1%] | 0.87 [0%] | 0.92 [0%] |
| Transactional IT86 x CE | 0.18 [6%] | 0.77 [0%] | 0.25 [4%] | 0.35 [1%] |

Note: The decimals are the level of significance of the F test of the interaction between type of IT investment and CE. The numbers in square brackets are the percent of variance explained by the interaction. The direction (+ or -) of the effect for the interaction is given only for variables with significant co-efficients.

Significance: ** < 0.01, * < 0.05, ^ < 0.1

Inspection of Table 7 reveals that conversion effectiveness did moderate the relationship between investment in 1986 and performance in 1987. Thus hypothesis 4 is supported for strategic IT.

The relationship between strategic IT investment and adjusted non-production labor was significantly moderated by conversion effectiveness. Thus for the same strategic IT investment, firms with high conversion effectiveness had relatively higher labor efficiencies. Thus, even though strategic IT and performance were either not associated or negatively associated, firms with high conversion effectiveness were relatively better performers for the same strategic IT investment. The same positive moderating effect of conversion effectiveness for strategic IT was observed for both growth and the change in non-production labor adjusted for sales.

In general, the interaction between the type of IT investment and conversion effectiveness explained relatively large amounts of variance, as indicated by the figures in square brackets in Table 7. The variance was statistically significant for strategic IT and notably large at 6% and 4% for transactional IT.

**5.2 Discussion**

Heavy use of transactional IT investment was significantly associated with firm performance over the six years studied. The result supports the finding by Harris and Katz [1988] who found the most efficient firms (with the lowest operating expense to income ratios) spent more on IT as a proportion of total expenses. These results are strong evidence for the effectiveness of IT investment made to cut costs.

There was some weak evidence that strategic IT investment was associated with lower performance (particularly higher labor

costs in the first few years). In the long term there was no evidence of a relationship to performance. Empirical support for the success of strategic IT has largely been via widely cited examples of individual firms [Kim & Michelman 1990]. It appears in the valve industry, where strategic IT accounted for one quarter of the IT investment in 1987, any benefits gained by individual firms wash out for the industry as a whole. This finding is compelling as there are few ways to protect the strategic IT investment from being replicated by competing firms.

Interviews with managers confirmed that if a successful strategic IT (e.g., laptops to salespeople) was implemented by one or two firms the other competitors soon followed the lead. Thus the IT intensity of the industry and customer service increased.

Individual firms achieved increased sales from the use of strategic IT. However, not all firms investing in strategic IT achieved benefits. Given the flat sales growth in the valve industry any increase in sales for individual firms was accompanied by decreased sales in other firms. The disadvantaged firms were then motivated to also invest in the strategic IT as a defensive move.

Investing in strategic IT is risky with a high failure rate. Interviews revealed a number of strategic IT projects that were discontinued. On average, investing in strategic IT was not a differentiating factor for firm performance. However, firms that managed their investments in strategic IT well and thus had high conversion effectiveness did have better firm performance.

No significant associations were found for investment in informational IT and any of the performance measures. Informational IT provides the information and communications infrastructure of the firm. Informational IT investment can be thought of as a sunk cost to provide the information infrastructure to keep the firm functioning and any impact on performance is diluted and indirect.

The key to the findings in this study (as it was in Woodward's 1959 study) was the separation of IT into types, as no significant associations were found between total IT investment and any measure of performance. This finding is one explanation of the contradictory findings of previous work [e.g. Turner 1985 and Bender 1986]. All the studies reviewed in section 2 treated IT as one homogeneous commodity. In this study the three different management objective for IT investment were identified all having different directional effects on performance (i.e., transactional was positive, strategic was negative in the short term, and informational was neutral).

The conflicting findings of the previous studies could be partly explained by the different directional effects of the three management objectives for IT investment. Since different definitions of IT (e.g., data processing budget as compared to firm wide IT investment) were used, each particular study contained different proportions of the three types of IT. In addition, the earlier studies are likely to be of firms where a greater proportion of their IT budgets devoted to transactional systems.

The size of the effect of IT investment on performance varied by dependant variable. For ROA, the set of IT explained 12 and 13% of variance. This is a substantial effect by social science standards [Cohen and Cohen 1983] and one of the first indications of the size of the association.

The relationship between investment in IT and firm performance is complex and circular in nature. A significant association was found between previous investment in IT and current performance as well as between previous performance and current (transactional IT) investment. Thus cross sectional studies may provide a misleading snapshot of this complex relationship.

Two firms investing in the same IT will almost certainly experience different performance effects. The construct of conversion effectiveness was shown to be an important moderator between strategic IT investment and performance. Firms with high conversion effectiveness had more positive associations between strategic IT investment and firm performance. It is interesting that conversion effectiveness was not significant for either transactional or informational IT investment.

One explanation is that strategic is the least understood and the most risky of the IT investment types. Strategic IT often requires significant organizational change and often involves the integration of two (or more) functional areas. Conversion effectiveness and the supportive organizational climate it represents is more important for these more fundamental organizational changes. Transactional IT is better understood and has been used in most organizations for many years. Perhaps

conversion effectiveness is less critical (i.e., not significant) for this type of investment where the effect on performance is clearer.

Thus in studying the effects of IT on firm performance, the context of the firm is an important factor and conversion effectiveness is one measure of the influence of context. Still to be determined are the antecedents of conversion effectiveness. What are the characteristics of the firm that lead to high user satisfaction, top management commitment and low political turbulence? What other characteristics of the firm are important in converting IT investments into productive output? What is the process by which good conversion effectiveness influences the relationship between IT investment and firm performance.

The model for this study posited that the IT investments for each of the different management objectives would be associated with particular aspects of firm performance. To some extent this notion was supported. Transactional IT was expected to influence the profitability and labour productivity of the firm. This relationship was strongly supported with transactional IT's consistent association with ROA and labour productivity. Strategic IT was expected to influence the growth aspects of the firm. This relationship was only weakly supported with strategic IT being associated with short term growth. Informational IT was expected to relate to firm profitability and this was not at all supported by the data. Just what benefits investment in informational IT brings is a compelling topic for future research.

### 5.3 Limitations

Several assumptions exist which limit the findings of the study. The usual assumptions of regression are made and no claims of causality are suggested. The findings of the study have limited external validity. It is possible to generalize the results to other manufacturing sectors with similar task technologies and predominantly small to medium-sized firms. However, it is not possible to extrapolate these results to the service sector or to manufacturing with radically different task technologies [e.g., chocolate manufacturing]. It would be particularly misleading to apply these results to the services sector where IT is the task technology and may well influence performance in a different way.

The questions driving this study resulted in quite a large number of regression equations being tested. There is always the chance that the significant correlations were in part due to chance. However, it is unlikely chance was a significant factor in the results as the pattern of associations (particularly in Hypotheses 2) was strong and consistent. Also the percentage of significant results well exceeded the expectation due to chance.

The study concentrates on the use of IT for management and ignores task production technology (e.g. factory automation). There may be some cross-over effect which is lost with this approach and would be an interesting topic for future research.

The test used for response bias checked only for bias based on firm size. It is possible bias existed on some other attribute. For example, perhaps firms with successful strategic IT choose not to reply thus accounting for finding no positive effect of

strategic IT. However, it is equally likely firms with a history of unsuccessful strategic IT choose not to reply for reasons of embarrassment. Further studies of strategic IT are required to understand what firms get from strategic IT investment and why they invest heavily in this type of IT.

The measure of the proportion of the IT budget allocated to each of the three types of IT investment was perceptual. The CEO's perception was collected and thus the findings relate to this strategic perspective not an economically objective measure.

## 6. Conclusion

This study has taken the quest of understanding IT investment one step further by building on previous work and adding new innovations. A number of implications for researchers emerged.

1. Evidence was found showing that a single measure of IT investment is too broad and should be broken down into IT for different management purposes (e.g., strategic, informational and transactional).

2. The study illustrated that all IT investment cannot be assumed to be made with equal effectiveness. Conversion effectiveness was shown to moderate the relationship between strategic IT investment and firm performance.

3. The study identified the need for historical or longitudinal data to cope with the circular nature of IT investment and firm performance.

In conclusion, all IT investment is not alike. To further our understanding of how IT impacts firm performance, it is necessary to categorize IT investment by the management purpose for which it is made. Also it is necessary to include the context of the firm into the analysis.

# Appendix A - Measures, Sources and Descriptive Statistics

The following two tables describe the variables and their measures. The sources for the wording used in the questionnaires are given. Where the wording was developed and pilot tested during this study the entry [Weill] is used. Means and standard deviations are also given.

**TABLE 1: VARIABLES, MEASURES, SOURCES AND RELIABILITIES**

| Variable | Measure | Source |
|---|---|---|
| Investment | | |
| IT Investment | $/sales | [Datamation 86] |
| Strategic IT | % of IT | [Weill] |
| Informational IT | % of IT | [Weill] |
| Transactional IT | % of IT | [Weill] |
| Company Details | | |
| Sales | $ | [Weill] |
| Growth | % change in sales | Calculated |
| ROA | % | [Weill] |
| Employees | People | [Van De Ven&Ferry 80] Labor |
| | Non-production Labor/$M sales | [Weill] |
| Market Share | % | Calculated |
| Conversion Effectiveness | | |
| UIS | Short form | [Baroudi & Orlikowski 88] |
| CEO UIS | (13 scales) | Cronbach Alpha=0.88 |
| Controller UIS | | Cronbach Alpha=0.93 |
| Production Mgr UIS | | Cronbach Alpha=0.88 |
| Political Turbulence(PT) | Likert 1 to 6 | [Pritchard & Karasick 73] |
| CEO PT | (4 items) | Cronbach Alpha=0.86 |
| Controller PT | | Cronbach Alpha=0.92 |
| Production Mgr PT | | Cronbach Alpha=0.80 |
| Top Management Commitment (TMC) | Likert 1 to 6 (2 items) | [Raymond 85] & [Conger 88] |
| CEO TMC | | Cronbach Alpha=0.90 |
| Controller TMC | | Cronbach Alpha=0.96 |
| Production Mgr TMC | | Cronbach Alpha=0.97 |
| IT Experience | Years | [Raymond 85] |
| Conversion Effectiveness | Units | Calculated |

## TABLE 2: DESCRIPTIVE STATISTICS

| Variable | 84 | 85 | 86 | 87 | 87 Std Dev |
|---|---|---|---|---|---|
| Company Details | | | | | |
| Sales ($M) | 68 | 76 | 72 | 88 | 181 |
| Growth per year (%) | 9.4 | 4.9 | 2.1 | 6.8 | 23 |
| ROA (%) | 5.8 | 7.0 | 7.0 | 9.1 | 10 |
| Employees | 756 | 792 | 752 | 754 | 1685 |
| Non-production Labor/$M Sales | 5.1 | 4.9 | 4.7 | 4.5 | 1.7 |
| Market Share | 3.0 | 2.8 | 3.2 | 4.0 | 8.2 |

| Conversion Effectiveness | Mean | Standard Deviation |
|---|---|---|
| CEO UIS | | |
| Controller UIS | 15.0 | 12.9 |
| Production Mgr UIS | 12.7 | 12.4 |
| CEO Political Turbulence | 10.8 | 12.9 |
| Controller Political Turbulence | 2.9 | 0.8 |
| Production Political Turbulence | 3.1 | 0.9 |
| CEO Top Management Commitment | 3.2 | 0.9 |
| Controller Top Mgt Commitment | 5.4 | 1.4 |
| Production Mgr Top Mgt Commitment | 5.1 | 1.6 |
| IT Experience | 3.2 | 1.9 |
| Conversion Effectiveness | -0.08 | 4.9 |

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