BENCHMARKING BEST PRACTICES IN INFORMATION TECHNOLOGY DEPLOYMENT

Paul J. Ambrose*

The management information systems research at present does not guide practice on the optimal levels of information technology (IT) investments. The literature is sparse on the characteristics of IT investments that can generate the best organisational performance. Using the economic theory of production, this paper explores the best practices with regard to IT investments. Specifically, the paper delves into the investment charactieristics of IT that are able to generate optimal organizational outputs. The study utilizes data envelopment analysis as the analytical methodology to identify firms that are efficient in their use of information technology. Emprirical reslts indicate that efficient organizations are lean in IT investments. This seems to be a result of effective matching of the firms' computing needs with the technology available and, in selective outsourcing of non-critical IT functions.

INTRODUCTION AND MOTIVATION

The second half of the 20th century, also known as the post-industrial period (Bell, 1976), has seen dramatic shifts in information on account of rapid advances in information technology (IT). The 1950s and 60s saw the advent of mainframe computing, which was predominantly used to automate large volume data processing like payroll and accounting applications, During the 70s and 80s the focus shifted towards stand-alone personal computing. Organizations augmented their mainframe computing with stand-alone personal computers to support managerial work. The 1990s saw the focus of information technology shift to connectivity through client-server computing and web technologies both at intra-and inter-organizational levels. Of late, we are seeing thin-client computing making inroads into modern information management.

The advances in the capabilities of information technology spurred high expectations of their positive impact on organizations' performance. Early works on impacts of information technology on organizations [Emery, 1964; Leavitt and Whistler, 1958] all raised the expectations on the capabilities of information technology

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by predicting revolutionary changes in the organizational structure and processes with associated changes in organizational performance.

But did the investments in information technology payoff? If they did, then where, when and how did the benefits materialize? Has IT enabled efficient organizations by increasing productivity? Or has it helped organizations enhance profitability? Answers to these questions have been equivocal and have perplexed both information systems (IS) practitioners and academics for the past 15 years. With such confounding results emanating from the IT value research, current thinking is that investments in IT are a necessity if organizations need to exist in the post-industrial information driven society. In fact, Hitt and Brynjolfsson (1996) show that investments in IT increased consumer welfare and not business profitability, thus strengthening the current thinking that IT cannot help organizations earn supernormal profits, but is necessary for organizational survival.

While the research on information technology value shows that IT is necessary for organizational survival, it does very little in terms of enlightening organizations on the optimal level of IT investments that organizations need to have so that IT complements other organizational resources. As IT continues to advance, there is a temptation to acquire the latest technology without paying heed to how well such an investment fits in with other resources that are committed to the outputs that organizations are designed to produce. The Indian IT sector grew by 33% from 1997-98 to 1998-1999 (Dataquest India archives – http://www.dqindia.com). IT absorption by Indian business is rapidly increasing in spite of a downturn in the overall economy. More than half the absorption is rapidly increasing in spite of a downturn in the overall economy. More than half the absorption is on account of small to medium business, which indicates that adoption of IT is happening in all sectors of the society. However, organizations are not in a position to adequately gauge whether they are under- or over-spending on technology investments and how they compare with the best practices in the industry. A part of this problem is on account of a lack of a clear analytical methodology to evaluate and compare best practices. Thus, there is a clear need to benchmark the best practices and identify the characteristics of the organizations that are able to generate better mileage from their information technology investments.

Using the economic theory of production as a basis, this paper explores the best practices with regard to IT investments. Specifically the paper delves into IT investment characteristics of US business that are able to generate the optimal organizational outputs in conjunction with other organizational resources. Data envelopment analysis, a linear programming based technique is used as the analytical methodology for this study. From the US experience, a broad set of guidelines are dawn, which can be applicable to IT investments in India.

The paper proceeds as follows. The next section discusses the theoretical aspects of the study and the choice of data envelopment analysis as the analytical methodology. The third section presents the empirical study. The final section concludes this paper with a discussion of the study findings.

THEORETICAL BACKGROUND TO THE STUDY

Theory of Production and Productivity Estimation

The theory of production from the microeconomics literature forms the theoretical basis for this study. Theory of production uses a production function like the Cobb-Douglas production function to estimate productivity of organizational resources that are deployed to produce firms outputs. The production function has been widely used in microeconomic literature and is now being used to evaluate the value creation capability of IT (Brynjolfsson and Hitt, 1996; Loveman, 1994; Rai, Patnayakuni and Patnayakuni, 1997).

This research uses the Cobb-Douglas production function to estimate the productivity of organizational resources including IT resources. The Cobb-Douglas production function is of the form $y=\gamma K^a L^b$, where 'y' is the output, 'K' capital and 'L' labor inputs, and 'a' and 'b' the output elasticities of the two inputs K and L respectively. Constant γ is used to ensure the continuity of the production function. We have divided firm resources into labor and capital as follows in order to use the Cobb-Douglas production function approach to estimate firm efficiency.

The firm inputs that are utilized to produce firm outputs have been divided into two categories – IT resources and non-IT inputs/resources. Within each category we have looked at both labor and capital inputs. This separation of firm labor and capital inputs into IT and non-IT resources is in line with current practice in information systems (IS) research (Brynjolfsson and Hitt, 1996; Rai, Patnayakuni and Patnayakuni, 1997).

The inputs and output that we use in this study are shown in Table 1. We use firm 'value-added' as a measure of firm output. It has been argued in IS literature that the use of firm sales as a measure of firm output is inappropriate as this measure will include the efficiencies of a firms's downstream suppliers (Strassman, 1985). Instead, a measure like 'value-added', computed as gross sales minus non-labor expenses helps better capture a firm's output that materializes from the utilization of a firm's resources (Hitt and Brynjolfsson 1996).

Table 1. Input and output variables

Variable
Input
IT Resources
IS Labor expenses
IS Budget (non-labor)
IT Infrastructure
Non-IT Resources
Non-IS Labor Expenses
Selling, General & Administrative Expenses
Non-IT Assets
Output
Value Added

Data Envelopment Analysis

Data envelopment analysis (DEA) is used in this study to estimate the efficiency of the firms in order to benchmark the best practices. DEA is mathematical technique based on linear programming used to measure relative efficiencies. It is used to handle situations where efficiency

calculations complicated by the presence of multiple inputs and outputs. DEA requires no a prior assumptions and is superior to other efficiency estimation techniques like ratio analysis and regression approaches. Ratio analysis suffers from the assumption that only one-at-a-time comparison between inputs and outputs can be made to determine relative efficiency, and the regression approach, from the explicit specification of functional relations between multiple inputs and outputs (Mahmood, 1994).

It should be noted that DEA provides relative efficiency of units with respect to each other and not the actual efficiency. However, this technique is suitable for identifying firms with the best practices, as we are interested in identifying the 'best' within a group. In the next section we asses the relative efficiencies of 71 manufacturing firms through DEA.

EMPIRICAL STUDY

The empirical part of the study was done using secondary data available for 71 durable goods manufacturing firms in the United States. The data for this study were compiled from two secondary sources – Standard & Poor's Compustat database for firm financial data and International Data Group's annual survey for IT data. Though the data that we use in this study pertains to US firms, we feel that the empirical findings should be generalizeable across international settings, as the focus of this study is examining the best practices of IT investments. However, as the data is on durable goods manufacturing firms, the results would best be generalizeable for firms with similar profiles.

Table 2 provides the data descriptive for the 71 manufacturing firms. The data were checked for normality through the Kolmogorov's test and were found to be significantly different from a normal distribution at the 0.05 α level. Hence the median values are reported for all inputs and output variables. Table 2 also summarizes the Kolmogorov's test.

Table 2. Data Descriptives

Variable	*Median value**	*Kolmogorov test p value*
Input		
IS Labor Expenses	27.4	0.000
IS Budget (non-labor)	48.00	0.000
IT Infrastructure	65.0	0.002
Non-IS Labor Expenses	1008.6	0.049
Selling, General & Administrative Expenses	740.0	0.000
Non-IT Assets	4775.3	0.000
Output		
Value Added	651.0	0.000

*All values in Million US Dollars

Though DEA works with no a priori assumptions, it is advisable to examine the data for ill-conditioning as this could lead to degeneration of the linear programming model (Ali, 1994). Ill conditioning can occur when there is a wide range in values between variables or within a variable. Scaling variables can rectify between-variable differences. However, within-variable differences cannot be rectified and, the usual treatment is to delete firms that have very low values for a variable when compared to other firms on the same variable, thus requiring no deletion of firms from the analysis.

The DEA was run using Warwick DEA, an off-the-shelf software package. The model was set for variable returns to scale with an input minimization focus. The DEA provided technical efficiency scores for all 71 firms. Firms with 100% efficiency scores were classified as efficient firms and the rest as inefficient firms with regards to the utilization of resources. This analysis resulted in the identification of 14 efficient firms and 57 inefficient firms.

We now have two groups of firms – efficient and inefficient. The median values of the input and output variables for each group are given in Table 3. It can be seen that the efficient firms seem to utilize fewer quantities of all resources. However it is necessary to statistically determine if there exist significant differences between these two groups with regards to resource consumption. We utilize the Mann-Whitney non-parametric test of difference rather than the t-test for this purpose, as the date were all non-normal. The Mann-Whitney test results are also summarized in Table 3.

Directional hypotheses that efficient firms will consume a lower quantity of resources were tested using the Mann-Whitney test. Test results indicate that efficient firms do have significantly lower levels of 5 out of 6 input resources at the 0.05 α level. The test indicated that there existed no significant differences between efficient and inefficient firms with regards to non-IT assets. Also, there was no difference in the output variable "value added" between efficient and inefficient firms.

As our focus is on the best practice characteristics of IT investments, we turn our attention to IT inputs. The empirical analysis indicates that efficient firms are

Table 3. Mann Whitney Test of difference between Inefficient and Efficient firms

Variable	*Median value for efficient firms**	*Median value for inefficient firms**	*Mann Whitney test p value*
Input			
IS Labor Expenses	6.3	29.3	0.005
IS Budget (non-labor)	17.7	54.3	0.029
IT Infrastructure	18.5	70.0	0.005
Non-IS Labor Expenses	599.1	1278.1	0.014
Selling, General & Administrative Expenses	227.3	939.0	0.005
Non-IT Assets	3304.3	5166.7	0.081
Output			
Value Added	454.1	743.8	0.209
Number of Firms	14	57	

**All values in Million US Dollars*

spending less on IT labor and have a lower IT budget. They also have a lower investment in IT infrastructure. The pattern of excess consumption is provided in Table 4, where the percentage excess consumption of inputs by inefficient firms in comparison with efficient firms is provided. It can be seen that all IT inputs are being consumed far in excess by inefficient firms. Among non-IT resources, the excess consumption of selling, general and administrative expenses is the highest.

Table 4. Percentage Excess Input Consumption by Inefficient Firms

Variable	*Excess inputs in %**
Input	
IS Labor Expenses	365.1
IS Budget (non-labor)	206.8
IT Infrastructure	278.4
Non-IS Labor Expenses	113.3
Selling, General & Administrative Expenses	313.1
Non-IT Assets	56.4

**In comparison to best practices (Efficient firms)*

The post-industrial society is characterized by increasing use of technology and knowledge work for organizational survival and growth. From the pattern of excess consumption shown in Table 4 it seems that the firms are investing a great deal more in technology and knowledge work as evidenced by high investments in IT, and selling, general & administrative expenses (a surrogate measure for managerial knowledge work), but are not doing so efficiently. Organizations seems to realize the importance of investing in IT and knowledge work but there seem to be no guidelines as to what the appropriate level of investment is.

These findings are further discussed in the next section where suggestions for IT investments are provided. This section also concludes this paper.

DISCUSSION AND CONCLUSION

The empirical analysis suggests that efficient firms are characterized by leaner IT resources. This raises the question whether strong investment in IT, or even continuing investment in IT, to keep up with advances in technology is good for organizations. Success in the post-industrial information age will stem from effective use of contemporary, IT, and the findings of this study seem counter-intuitive to this notion, as the study indicates that organizations should keep investments in IT low. With the Government of India privatizing the Internet services in 1998, there is bound to be a big expansion in both business to business and business to consumer eBusiness applications. But how do we reconcile this with the demands of technology and knowledge work in a post-industrial society? We provide answers to this as follows through our observations of the firms that exhibit the best industry practices with respect to information technology investments.

First, organizations need to understand that they cannot keep investing in new IT without taking into consideration the 'need' factors. Organizations need to critically evaluate and match their organizational computing needs with the technology that is available. For example, state-of-the-art date warehouse and date mining technology might be suitable for large scale consumer financial applications like credit cards issue

and monitoring, but might not be necessary in manufacturing setting. Also, new investments should also be matched with existing IT investments and with other non-IT investments.

Second, organizations need to critically evaluate the need to invest in fully owned IT operations versus the outsourcing option. Proponents of IT outsourcing advocate that organization need to invest only in their core operations. However, the opponents to IT outsourcing claim that information processing is critical for coordination of organizational activities and outsourcing this critical activity would strip an organization of the ability to understand and manage this effectively. This is turn will be detrimental to the ability of an organization to develop competitive advantage.

However, both these views on outsourcing are extreme. Instead, the effective way seems to be selective outsourcing. Here, IT operations are analyzed and classified into those that are critical to the strategic intent of the organization and those that are not. Then, the organization invests in building IT operations that are critical and outsources those operations that are not critical for its strategic intent. For example, desk to maintenance operations can be outsourced without any major impact on the competitive ability of organizations. On the other hand, network management operations for an business company needs to be handled by the organization's own IT function.

Selective outsourcing can thus be a compact solution for alleviating problems of over-Investing in information technology, and in IS manpower to operate and administer the technology. IS labor expenses will drop ad organizations need not hire a full complement of IS professionals. The problem of being saddled with obsolete technology is also reduced as some of the IT infrastructure investments will now be a part of the outsourcing companies' assets. The outsourcing vendor will be able to better manage IS labor and infrastructure expenses as they will benefit from economies of scale by offering their services to a pool of clients.

It becomes obvious that strategic IS planning operations will be essential to effectively administer the above recommendations. It is not enough to keep the value of IT investment down. The best practices regarding IS investments will entail a critical examination of IT needs and wants and, of selective outsourcing. This exercise will form a critical part of strategic IS planning for IS success. We reiterate this fact and add that efficient use of organizational IT resources will largely depend on effective strategic IS planning.

The above broad conclusions will be particularly important as India is in the verge of an eBusiness boom with the privatization of the Internet services. While the initial eBusiness boom will emerge on account of ISP expansions, the actual growth in this front will come when eBusiness technologies are absorbed by Indian businesses for local business purpose, a trend that is occurring in all successful eBusiness applications worldwide. For example 93% of US eBusiness business is within the US. Similarly 70% of eBusiness in China and 73% in Korea are within these respective countries. (Dataquest India archives, http://www.dqindia.com). Indian businesses need to manage their eBusiness investments by matching their computing and business needs with the technology that is available. Internet technologies that form the backbone of eBusiness applications

are advancing rapidly. A wrong investment or an ill-planned eBusiness initiative could setback these businesses financially. Also selective outsourcing could help these business manage the fast rate of obsolescence in this field and better manage organizational resources without having to invest heavily in technology. Typically eBusiness payoffs can be slow, and selective outsourcing can help offset the initial fund flow problems.

Summarizing, it is imperative that organizations look at the best IT investment practices before formulating their IT investment strategies. It is not necessary to invest heavily in IT to realize business payoffs. It is more important to ensure that organizational needs match IT capabilities. Also, business should look at IT outsourcing as means of managing their IT investment effectively.

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