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Introduction

The question of how IT creates value has been the subject of an ongoing debate ever since economists pointed out the productivity paradox at the end of the last decade. Firms were spending more and more on IT with little evidence of it=s impact on output statistics. Empirical studies undertaken in the area have yielded mixed results (Mooney, Gurbaxani and Kraemer, 1995). We apply Data Envelopment Analysis (DEA) to recent data so as to develop a better understanding of the differences between efficient and inefficient firms in their allocation of IT resources.

The DEA technique compares the efficiency of decision-making units (DMUs), hereafter referred to as firms. DEA converts multiple input and output measures to single measures of relative efficiency (Charnes et. al. 1978). It can be used to compare the relative efficiency of firms. Each firm is compared to an efficient frontier and a measure of relative efficiency is determined. Organizational firms in their utilization of IT inputs. Mahamood (1994) used DEA to identify and compare efficient and inefficient firms on eight IT investment inputs and ten firm strategic and economic performance ratios based on 1988 data. Banker and Slaughter(1995) used DEA to compare the most productive scale size for a set of maintenance projects. This paper uses DEA analysis to incorporate the increasing emphasis in IT-business value research on intermediate performance (Barua et. al. 1995). We compare efficient and inefficient firms based on multiple facets of performance and IT inputs and IT resource allocation such as expenditure on client server technologies and outsourcing. We use data collected by *Information Week* in 1994.

We focus our analysis only on manufacturing firms so as to maintain sample homogeneity. Data for each firm was obtained from two sources. The Compustat database was used to obtain firm performance data. Measures of performance considered include productivity (administrative, labor, and working capital), sales (sales, market share), and profitability (operating income before depreciation). *Information Week* was the source for number of IS employees, IS budgets, and expenditures on hardware, software, telecommunications, and IS staff. In addition to these input variables, the amount spent on client-server technologies and outsourcing were also obtained from *Information Week*. Table 1 summarizes the variables considered. There was some sample attrition due to missing values, giving us a final sample sample of 57 firms.

Results

Table 2 shows the results of the analysis. Due to space limitations, we present only the classification of firms as either efficient and inefficient by industry. 27 firms were classified as relatively efficient, while the other 30 were classified as inefficient. As can be seen, electrical and food processing industries have a greater proportion of efficient firms while the opposite is true for minerals, metals and manufacturing.

Table 1: Variable Definitions				
Variable Name	Definition as reported	Source		
Information Technology Inputs				

IT Budget	Combined capital and operating budget of IS department directly under the control of the IS	Information Week		
Hardware Expenditure		Computed		
Software Expenditure	Percentage of IT budget devoted to each category	from		
IS Staff Expenditure	of expenditure	Information		
Telecom Expenditure	.	Week data		
Other Comparison Variables		(% IT budget * IT		
Outsourcing	Percentage of IT budget devoted to outsourcing	Budget)		
Client-Server	Percentage of IT budget devoted to client-server	.		
IS Budget as a Percentage of Revenue	Percentage of revenue devoted to IS budget that is directly under the control of IS	Information Week		
Output Measures				
Sales Based				
Market Share	Total company sales as a percentage of aggregate sales of companies with the same major SIC code.	Computed		
Sales	Total Sales	Compustat		
Profitability-based				
OIBDP	Operating income before depreciation	Compustat		
Productivity Ratios				
Working Capital Productivity	Sales/ (Account receivable+Inventories-Account Payable)	Computed		
Labor Productivity	Sales / Total Employees	Computed		

Table 2: Distribution of Firms Across Industry

Industry	Efficient	Inefficient		
Pharmaceutical	3	4		
Consumer Products	1	3		
Chemical	3	5		
Food Processing	6	4		
Electrical	5	1		
Manufacturing				

	3	3		
Aeronautics and Automobiles	3	2		
Minerals, Metals and Mining	3	8		

Administrative Productivity	Sales / (Selling, General & Administrative Expenses-IT Budget)	Computed / Compustat

Table 3: Comparison of Efficient and Inefficient Firms *(in millions)*

Variables	Efficient firms		Inefficient firms		t Test
	Mean	SD	Mean	SD	.
Input Variables					
IS Budget	118.1	140.8	92	81.4	n.s.
IS Employees *(not in millions)*	873.7	842	621	571.1	1.3*
Hardware	25.3	36.6	18.1	14.2	n.s.
Software	12.8	19.7	11.9	10.6	n.s.
Staff	46.5	52.3	37.1	31.5	n.s.
Telecom	14.6	21.8	10.1	10.5	n.s.
Other Comparison Variables					
IS Budget as % of Revenue	1.36	1.2	2.06	1.4	-2.07 **
Outsourcing	18.8	40.8	7.09	10.3	1.4 *

Client-server	23.6	39.5	11.5	15.7	1.5*
Output Variables					
Market Share	33.1	27	15.3	14	3.1**
Sales	7585	4632.2	4336.2	2587.7	3.22 **
OIBDP	1181.7	1208.3	569.9	511.7	2.44**
Working Capital Productivity	8.9	7.4	6	3.2	1.84**
Labor Productivity	261.6	171.3	170	68.6	2.7 **
Administrative Productivity	16.7	25.2	9	10.8	1.46**

The efficient and inefficient units were compared in terms of the input variables, output variables, client-server investments, and investments in outsourcing. Appropriate t test values were used after conducting Levene=s test for homogeneity of variances. Efficient units have higher measures for all performance variables. This difference is especially high for sales based measures. In contrast, inefficient units have fewer IS employees even though they invest more of their revenues on information technology. Interestingly, investment in client-server technologies, a technology that is receiving significant attention lately, is greater for more efficient firms. Similarly, efficient firms invest more in outsourcing, suggesting that outsourcing improves the IS units efficiency.

Discussion

DEA provides information on the input reduction and output augmentation efforts that managers of the inefficient units should examine. Further analysis of results revealed that size (mean number of employees in thousands) of efficient firms is significantly larger than for inefficient firms (39.6 and 29.2 respectively at p= .08) and the mean staff expenses per IS employee for inefficient firms is greater than for efficient firms (6.2 and 5.2 respectively at p = .06). This coupled with the fact that efficient firms spend a lower proportion of their revenue on IT indicates that a) since larger firms are more efficient than smaller firms and they have a lower IS budget as a percentage of revenue there may be some scale economies, b) though larger and more efficient firms have more IS employees their efficiency is not likely a result of spending more per IS employee, but may be a function of other factors such as outsourcing and expenditure on empowering technologies such as client-server systems. An examination of firms receiving the lowest efficiency ratings suggests that they may need to closely examine their allocation of resources between technology and people. It may well be that inefficient firms are not focusing adequately on the human resources required for systems delivery and maintenance which in turn would impact firm performance. Further there may be a need to reevaluate investments in emerging technologies and examine outsourcing options.

(References available upon request from first author)