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ASSESSING THE VALUE PROVIDED BY ERP APPLICATIONS THROUGH ORGANIZATIONAL ACTIVITIES

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ABSTRACT

When managers and stockholders consider making an investment in information technology (IT), as with any other investment, a major concern is whether this investment will add to the performance of their organization. However, it is difficult to identify the nature of the linkage between an investment in IT in general, and Enterprise Resource Planning (ERP), in particular, to an organization's performance. In this study we extend the work of Barua et al., Lerch and Mangal, and Tallon et al. We develop a model to identify the value ERP applications add to Porter's organizational primary activities and the information systems (IS) applications related to ERP that help deliver added value through organizational characteristics. This new model should help in assessing the potential value of an ERP investment.

We examine the relationship of ERP applications and organizational characteristics to an organization's primary activities by a path analysis of more than 200 medium and large sized manufacturing firms. The results of this investigation indicate that organizational characteristics mediate the relationship between IS applications and the value ERP can add to the organizational primary activities. Consequently, organizations with different characteristics may add different value to their primary activities by using ERP applications. We found that each primary activity was supported by some, though not necessarily all, IS applications included in most ERP packages. We conclude that an organization's characteristics are related to the return that may be gained from the use of ERP systems. We offer recommendations on how organizations can use ERP to add value to their primary activities, based on their organizational characteristics.

Keywords: ERP; value chain; primary activities; added value; organizational characteristics; organizational performance

I. INTRODUCTION

Evaluating an investment in information technology is a challenge. While companies continue to make substantial investments in information technologies, it is unclear whether investments in information technologies in general and ERP systems in particular actually pay off. To date, research on company IT investment yielded mixed results, thereby supporting the notion that organizational investments in IT are risky propositions.

However, organizations are not going to stop using IT because they cannot determine whether these investments will be profitable for them. Using a variety of cost justification and valuation procedures, organizations will continue solving problems using information systems. Unfortunately, we cannot always predict the kind or level of benefit a particular technology may have. Markus and Soh [1993] suggest that the question is: "Why do IT investments not always yield the benefits we expect?"

Most of the studies investigating the impact of investment in IT on organizational performance examine the linkage at the highest level of organizations, between the total investment in information technology and the total performance of the organization (e.g., Loveman [1998]; Kauffman and Weill [1989]; Ahituv and Giladi [1993]). On the other hand, Barua et al. [1995] suggested that the benefit derived from IT should be measured from the bottom up, that is, at the lower levels of the organization and then accumulated to the higher levels. In addition, Mukhopadyay et al. [1997] proposed that to gain a better understanding of IT impacts, researchers should examine individual applications. Tallon et al. [2000] highlighted potential ways IT could benefit an organization by using Michael Porter's value chain model.

Porter's [1985] value chain assimilated the relationship that exists between organizational characteristics and the benefits realized from ERP applications. The value chain is "a collection of discrete but related production functions….The value chain formulation focuses on how these activities create value and what determines their cost…." Porter [1985, pg. 39]. These activities, called primary activities, occur in any industry. We hypothesize that ERP systems add value to the organizational primary activities suggested by Porter, and that the added value depends upon organizational characteristics that impact these activities. Further, since individual ERP applications impact different organizational primary activities, organizations should measure the impact of ERP on the value chain, application by application, and not as a single portfolio that impacts the bottom line.

IT VALUE AND FAILURE

A major issue facing managers of information systems is the increasing pressure to demonstrate the business "value" of the organization's investment in IT. Most previous studies that attempted to determine the relationship between investment in IT and the performance level of the organization (e.g., Ahituv and Giladi [1993]; Jonscher [1983]; Kauffman and Weill [1989]; Sethi et al. [1993]; Weill [1992]) found it difficult to establish a positive relationship between the two variables. Brynjolfsson [1993] called this phenomenon the "productivity paradox," underscoring the conflict that arises when we discuss the strategic nature of IT and are unable to find rewarding payoffs by using traditional measures of economic productivity.

This phenomenon occurs particularly with ERP systems. Its complexity suggests that we should not assume that the results obtained in other simpler technology implementation environments readily apply to ERP environments [Amoako-Gyampah and Salam, 2004]. ERP systems consist of a software package that uses database technology to control and integrate all the information related to a company's business including customer, supplier, product, employee, and financial data [Falk, 2005]. A single enterprise-wide database is used in which all business transactions (e.g., inventory management, customer order management, production planning and management, distribution, accounting, human resource management) are entered, recorded, processed, monitored and reported [Davenport, 1998; Ragowsky and Somers, 2002; Umble and Umble, 2002] ERP systems are a complex set of integrated IS applications that create a new

foundation based on IT for competing [Brown and Vessey, 2003]. The strategic impact of ERP implementation on a firm's competitive advantage is cited in previous studies [Akkermans et al., 2003]. ERP systems are implemented by over 70% of companies with more than 2500 employees [Reilly, 2005] and new license revenue for ERP software is expected to grow at a compound annual growth rate of 6.3 percent by 2009 [Eschinger et al., 2005]. Even among the early adopters of ERP systems, many organizations continue implementing functionality to integrate across an increased number of business processes [Davenport et al., 2004] and are planning substantial changes to existing systems during 2005 and 2006. Many organizations are making their new ERP systems the data management hub for compliant manufacturing, with investments focusing on providing key stakeholders improved access to operational data and business intelligence [Reilly, 2005]. ERP implementation requires significant organizational resources and is inherently risky. It is a different class of IT application compared to what came before. In 2003, for example, Meta Group {2003] reported that on average, for ERP systems, the cost of ownership is $17.5 million, require 20 months to implement and realize benefits seven months after the go-live date.

The benefits of a properly selected and implemented ERP system can be significant. However, Bradford and Florin [2003] caution that companies who perceive the ERP system they adopted to be a complex business solution tend to diffuse it slowly and in provide only limited capacity. Therefore, they do not realize its full benefits. ERP systems help reduce costs, improve communication and provide standard business processes throughout the organization. It follows that business process redesign and software configuration are key spheres of activity in an ERP system implementation [Lorenzo et al., 2005].

Companies invest considerable time and money in ERP systems. An appropriate return on their investment is not guaranteed. In this paper, we survey a sample of manufacturing organizations that use ERP applications, to discover how and under what circumstances ERP systems can add value to an organization's primary activities and support its performance. Such information may help organizations allocate their investment in IS in ways that provide better returns.

From the early work by Lucas [1975] to more modern studies in technology fit and information economics, the success of information systems remains a topic of keen interest. Lucas [1975] identified three categories that explain the failure of information systems:

- user attitudes and perceptions,
- how systems are used, and
- the performance of decision-makers who use the system.

Seventeen years later, DeLone and McLean [1992, 2003] suggested that information system success is measured as a function of

- overall system quality,
- the quality of the information in the system,
- how that information is used,
- how satisfied users are with the system, and
- the impact of those systems on users and organizations.

The implication of these works is that information systems are deemed successful if firms continue to pay attention to these variables in design and implementations.

The definition of what constitutes an information system failure is less clear. From the categories detailed above, it is evident that multiple constituencies are involved in determining whether a system is successful. For example, if the project champion believes that the project was a success, does it mean that those who use the system will also feel this way? Will stockholders consider the investment in the system a good use of capital? Will those who are downsized by

an information-system-driven reengineering effort share in the celebration of system implementation?

In a multi-constituent environment, the probability of success could be viewed as a chain of probabilities. The more people and organizations involved, the smaller the chances of a consensus of success. Consequently, we believe it useful to consider a constituent-based measure of success or failure. In other words, we believe that information systems researchers should view information systems success or failure not based upon a holistic view of the organization, but rather from the point of view of a particular stakeholder. Of course, stakeholders differ in power, influence, and scope. Depending on the philosophical background of the researcher, the information system being studied, or the variables under investigation, stakeholder positions should provide the lens for determining information system success or failure. Based on this dynamic, some systems may never be viewed as a total success due to their size and complexity. ERP systems would seem to fall into this category. It is little wonder, then, that they are so often identified as failures.

IT AS INVESTMENT

In this paper, we propose to evaluate ERP systems from the point of view of the organization's owner, in most cases, the stockholder. This stakeholder is interested in the efficient and effective use of capital, the returns on the investment of capital, and the long and short term positioning of the company in its particular competitive market space, vis-à-vis the holding strategy implicit in their investment.

Although we do not summarize the substantial body of work about the motivation of different types of investors here, we can conclude that investors are a source of capital to a company. Most investors desire to use that capital to earn still more capital. Capital holders choose among several investment opportunities. The expected rate of return, the market cost of capital, the risks associated with the investment, and the amount of time the investment will be held affect their choice. Because companies need capital for new product development, marketspace expansion, or operational financing, they must present an investment opportunity that involves manageable risk and acceptable returns. ERP systems, by their size, involve the use of invested capital.

Markus et al. [2000] suggest that the three phases of ERP implementation are: project, shakedown, and onward and upward. The third phase, onward and upward, particularly interests investors. Investors want to see a return on their investment at least equal to the cost of capital (adjusted for risk) over the period of time that they would hold a similar investment. However, when looking at the ERP investment from the point of view of the stockholder, translating these measures into quantifiable returns becomes difficult. In short, the investor can't see the payoff.

We propose that stockholders' should measure ERP success by observable outcome. In this way, ERP success or failure is not that much different from the success of a new product or service. When a company evaluates a new product or service, it considers a variety of factors: Does the new product complement or compete with other products we sell? Do we have a supply chain that can support the new product? What labor and manufacturing issues need to be addressed? What are the logistics challenges for finished goods and inventories? In other words, does the product fit within the current organization and can the stockholder observe these benefits and costs?

Barua et al. [1995] suggested that researchers need to measure the contribution of an information system to organizational performance at basic levels of the organization. However, because organizations achieve different value from using the same IS application [Johansen et al., 1995; Ragowsky et al., 2000], we must refine the methodology. Similar to Gattiker and Goodhue [2004] who examined ERP impacts at the local level of the organization, this study identifies the value organizations can obtain from using IT, in general, and ERP, in particular, at a lower level of the organization, contingent upon the organizational characteristics and the information systems applications used. Figure 1 depicts the mechanisms by which IT adds value to the organization.

In this model, we equate individual IS applications related to ERP with adding value to the organizational primary activities. Using appropriate ERP applications may (or may not) add value to organizational primary activities as a function of the organizational characteristics related to these activities. Organizational characteristics moderate the value ERP can add to the organization's primary activities. The model that tests our beliefs about the causal links among the variables, shown in Figure 1, appears in a path diagram (Figure 2) where arrows represent effects between variables.

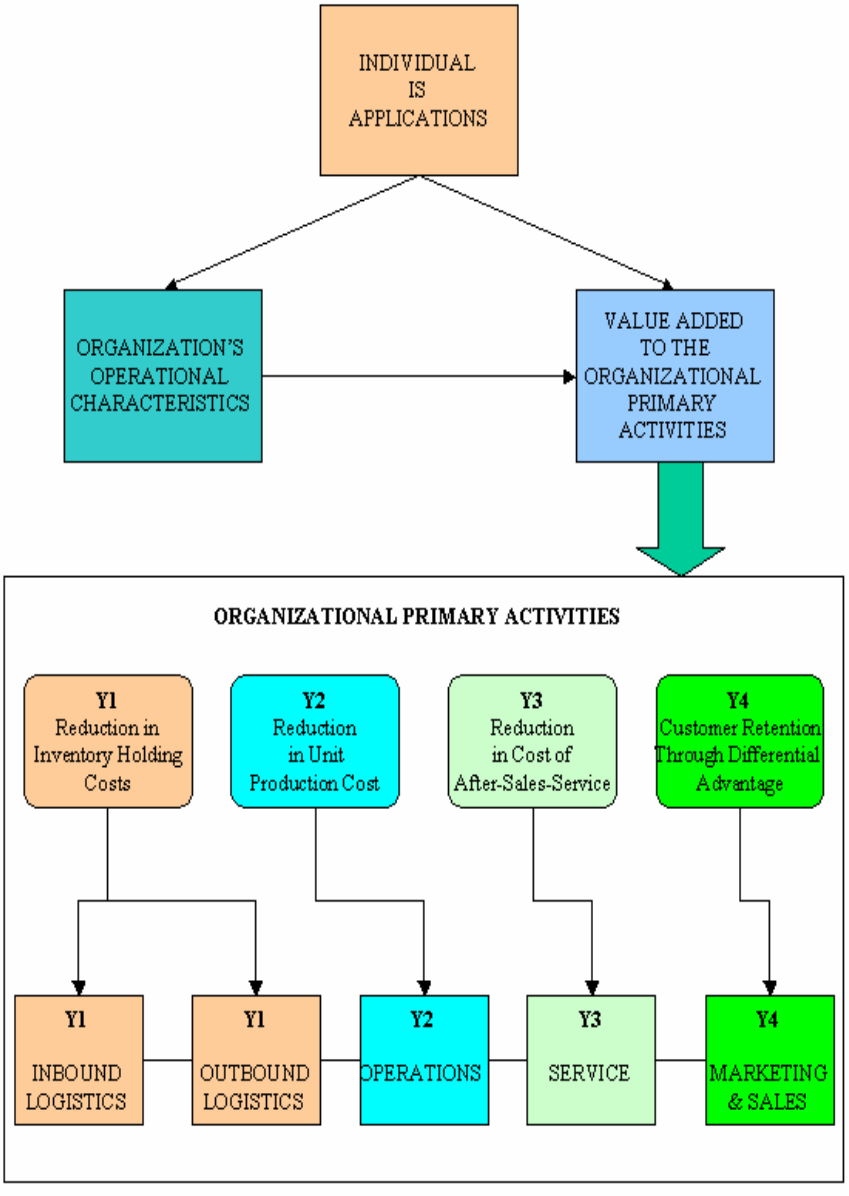

Figure 1. IT Value Added Model

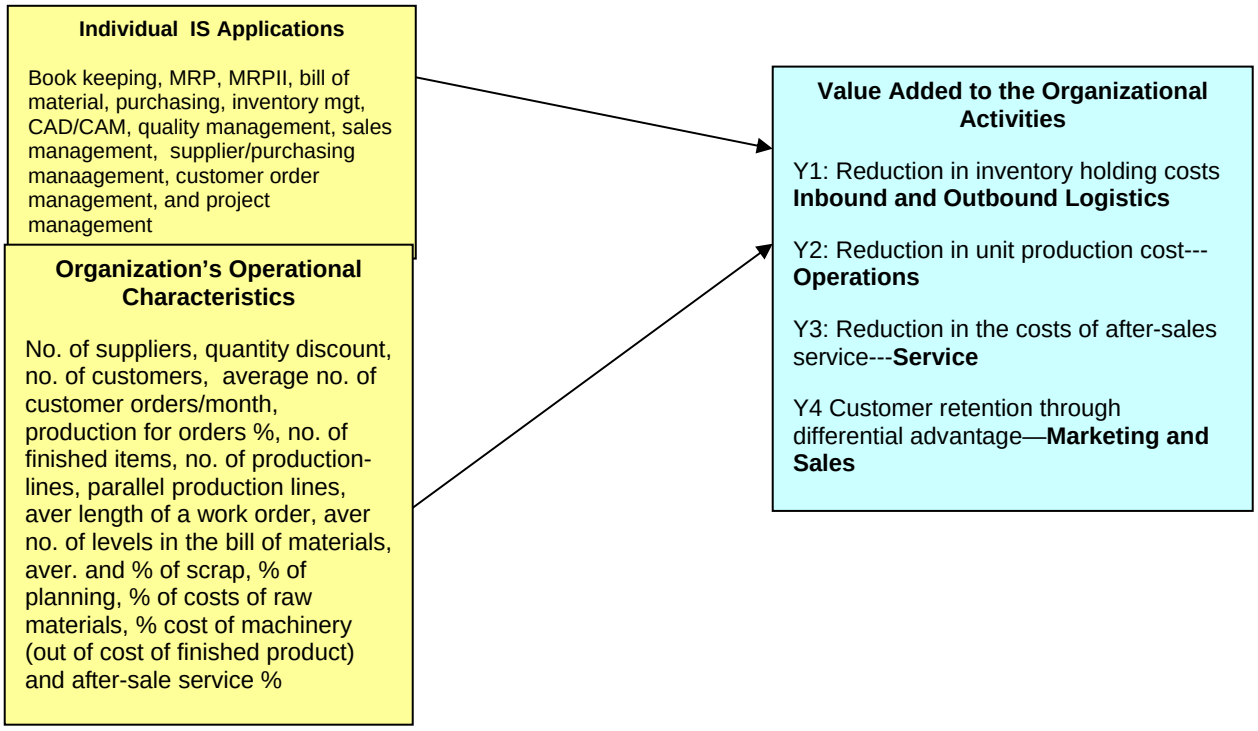

Figure 2. Path Activities

Subsequently, using path analysis, the model portrays:

- "direct" effect to determine whether individual IS applications add value to activities,
- "direct" effect to determine whether the organization's operational characteristics add value to organizational primary activities, and
- "indirect" effect to determine if the organization's operational characteristics intervene between the IS applications and the value added to the organizational primary activities.

The distinct advantage of this path analysis technique is that it allows us to assess the relative importance of direct and indirect causal paths to the dependent variable, which is not possible using a single equation regression model.

II. RESEARCH HYPOTHESES

Porter [1985] states that a company's value chain is a set of "technologically and economically distinct activities that it performs to do business." These activities consist of primary activities (i.e., Inbound Logistics, Operations, Outbound Logistics, Marketing and Sales, and Service) and support activities (i.e., corporate infrastructure, human resource management, technology development, and procurement) and are the means whereby a firm seeks to implement its cost leadership or differentiation strategies. Porter and Millar [1985] further refine this framework into a model that incorporates the role of the information systems application portfolio in the organization and focuses upon the value chain that is present in the delivery of services or products. Barua et al. [1995] suggest that the value chain represents an alternative approach to

how IT may affect particular activities, and provides a starting point for detailed IT impact analysis. Tallon et al. [2000] used the value chain to evaluate IT business value and the support of IT to the organizational strategy. In another example, value chain analysis was applied in designing an ERP system for a vehicle manufacturing company [Boersma and Kingma, 2005]. It is plausible that the benefit IT provides to the organization's performance is the value added to the organizational primary activities at the lower levels of the organization. While support activities are important, they tend to have only indirect impact on organizational performance and so they are not considered here. The question to ask is how an organization uses the IT portfolio, in general, and ERP system, in particular, to affect the firm's value chain that ultimately affects the firm's productivity.

To answer this question, it was necessary to identify the level of IT that adds value to the organizational primary activities. The authorities we cite found that the benefit provided to the organization from information systems should be measured at the level of individual IS applications and not at the level of the entire IT portfolio [Mukhopadhyay et al., 1997]. Barua et al. [1996] argue that "IT is complementary with organizational characteristics and processes, and that investment in IT and reengineering cannot succeed if done in isolation." We adapt and extend the work of Barua et al. and Tallon et al. by examining how, and under what circumstances, ERP individual applications add value to the organizational primary activities.

In this study, we survey manufacturing organizations who use IS applications that are related to ERP. Although many IS individual applications relate to ERP (e.g., inventory management, bill of material, sales, purchasing, MRP, MRP II), it is likely that not all of them support each of the organizational primary activities. Therefore, it is hypothesized:

> *Hypothesis 1:The value ERP systems add to organizational primary activities depends on the use of the appropriate applications that are included in the package.*

This hypothesis provides a test for the direct relationship between the use of individual IS applications related to ERP and the value ERP systems add to the organizational primary activities. Yet passing this test may not be enough.

> *"Information technology makes sense only when it solves a company's specific problems, such as overhead cost of control, production management, or support of customer services."* Strassman [1991]

By solving such problems, value is added to the organization. It is possible that IT in general, and ERP, in particular, will add different value to the same organizational primary activities of different organizations under different circumstances. In other words, an ERP system might solve problems related to the organizational primary activities, but only under certain conditions.

Bartezzaghi and Francesco [1989] found that organizational performance depends upon organizational characteristics such as lead-time, throughput time, capacity utilization, percentage of defects, and others. They called these characteristics "operating conditions." Other studies [Johansen et al., 1995; Ragowsky et al., 2000] found that different organizations gain different benefits from similar IS applications as a function of those operating conditions. Hence, it is likely that these organizational characteristics (operating conditions) also impact the value ERP adds to the organization's primary activities. Therefore, it is hypothesized:

> *Hypothesis 2:The value ERP systems add to organizational primary activities depends on the organization's operational characteristics.*

This hypothesis tests the direct impact of organizational operating characteristics on the value ERP adds to the organizational primary activities. If these variables impact the value ERP can add to the organizational primary activities directly, it is possible that interaction between the variables will lead to a stronger (or weaker) impact on the value individual ERP applications add to the organizational primary activities. For example: it seems that within a manufacturing

environment, by implementing ERP systems, an organization avoids the "Islands of Automation" by linking all the activities on the shop floor together with administration activities [Browne et al.,1988; Flatau, 1988]. As mentioned previously, sometimes using an application that does not suit the organizational characteristics may hinder the performance of the organization. Hence, it is important to identify which ERP applications support each primary activity, given the organization's operating characteristics. Therefore it is hypothesized:

> *Hypothesis 3:The value ERP systems add to organizational primary activities depends on the organization's operational characteristics acting as a mediating variable between individual ERP applications and the value an ERP system (package) adds to the primary activities.*

To examine these hypotheses, we must identify the appropriate organizational characteristics. Porter's model identifies potential activities that add value to products within the organization, thereby contributing to that organization's performance. Each activity area in Porter's value chain reflects organizational characteristics, such as the average number of purchase orders per month for the purchasing activity area or supply time to customers for the sales activity area. Some of them determine the value (if any) IT, in general, and ERP, in particular, adds to primary activities that are related to these activity areas.

We want to investigate the benefit provided by using particular IT applications related to ERP to support the primary activities and subsequently to the organizational performance. We will use those organizational characteristics that are commonly associated with the "operating conditions" suggested by Bartezzaghi and Francesco [1989]. For dependent variables, we will use the benefits that are derived from using IT in general to support some processes that are related to Porter's five generic categories of primary activities (Inbound Logistics, Operations, Outbound Logistics, Marketing and Sales, and Service). The benefits (measures) that we will use will be those that a stockholder would be able to measure. These measures tend to focus on cost reduction, customer satisfaction, and other improved uses of capital. It should be noted that many benefits gained from using ERP systems (such as improved communication, common currency, and standardization of business processes) are not easily observable by stockholders.

Using the basic elements of the model, the next section describes the research design. After conducting a test of the model, we present the results, discuss these findings, and provide conclusions and limitations.

III. RESEARCH DESIGN

This study is based on a sample of over 200 manufacturing organizations identified as having each of the five elements in Porter's value chain. The data was collected as part of a longitudinal study conducted from 1992 to 2004. The companies in the sample varied widely in their characteristics. Table 1 summarizes the demographics of the sample.

We conducted personal interviews with a senior manager of each organization. A structured questionnaire (shown in Appendix II) guided the interview. The questionnaire was first pre-tested to assess its validity. This phase facilitated revision and eliminated ambiguities [Straub, 1989]. The questionnaire contained two sections:

- Section one included questions concerning organizational operating characteristics (e.g., number of suppliers, percentage of raw materials costs out of the total cost of the product, number of customers, number of products and production lines).
- Section two measured the subject's perceptions of the benefits the organization derived from the use of specific individual IT applications related to ERP, and the benefit the organization derived by using ERP applications to support various activities that are related to Porter's primary activities.

Table 1. Organization Characteristics and Respondent's Position

Characteristic:	Range	Median	Mean	Std. Dev.
Volume of annual sales	1 to 400	33	41.78	39.52
Number of employees	10 to 2400	100	200	321
Number of suppliers	1 to 5000	45	177	526
Relative share of raw materials in the cost of the final product	83% to 85%	44%	43.65%	15.31%
Number of customers	1 to 10,000	150	672	1746
Average lead time to customers (in days)	1 to 720	15	39	73.91

Type of Organization:	Number	(%)
Wood	13	5
Metal	67	26
Food	45	17
Textile	28	11
Rubber	32	12
Chemistry	30	12
Paper	19	7
Electronics	6	2
Construction	14	5
Other	6	2

Respondents**:**	Number	(%)
President	148	57
Finance VP	34	13
Marketing VP	3	1
Production VP	23	9
Vice President	18	7
Plant Engineer	8	3
CIO	26	10

The respondents were asked to rank the applications listed (e.g., bookkeeping, bill of material, purchasing) on a scale of 1 to 7, according to their importance to the organization and the level of benefit the organization derives from each one of them. The list included 16 applications[1]. We asked respondents to rank the level of the information systems' contribution to organizational activities on a scale of 1 (low benefit) to 7 (high benefit). These benefits (e.g., saving in inventory holding cost, reduction in production costs) are related to the organizational primary activities as defined by Porter [1985]. Ranking the benefit on semantic scales (usually, but not necessarily, ranging from 1 to 7) is a well-tested method for investigating the perceived benefit [Ahituv, 1989; Tallon et al., 2000].

As shown in Table 1, the respondents were senior managers of their organizations; 57% of them were presidents, 33% vice presidents of finance, marketing, production, and engineering, and 10% were IT managers. Based on an ANOVA test, we found no significant differences in perceived benefits based on the respondent's role within the organization. We used executives' perceived benefit because of their role in IT investment decisions [Jarvenpaa and Ives, 1991].

> *"Yet, by virtue of their seniority within the corporation, business executives are in an ideal position to identify how and when IT creates value for the business.… In*

[1] The relevant applications identified in a pilot study included the analysis of existing ERP software packages for manufacturing organizations and brainstorming meetings with managers and academics. The research hypotheses determined the initial structure of the questionnaire and the specific questions that were included in it. We produced the final questionnaire following a pilot study and brainstorming meetings with managers and academics. The applications were standard applications commonly found in similar software packages in use at the time of the study. Based on the interviewer assessment, we determined that all participants used the applications in the same way and for the same purpose.

> *the absence of objective data on IT payoffs, executives' perceptions can at least help in pinpointing areas within the corporation where IT is creating value."* Tallon et al. [2000]

Tallon et al. [2000] further indicated that a manager's perceptions are important indicators of how he or she views the impact that information systems have on organizational performance. Consequently, although objective measures would be desirable tools in the measurement of the organizational value of IT, the reality is that managers often rely on their perceptions of this value.

Given the large number of organizations involved and the interview nature of the data collection process, we used multiple interviewers. One of the authors trained each interviewer. Each interviewer learned the study's theoretical background. The trainee joined an author to observe during two or three interviews. After they felt ready for interviewing, they interviewed two or three subjects, while the author observed them. This training attempted to avoid bias due to differences among interviewers. We found no significant difference in the perceived benefits as a function of the interviewer.

This study examined the benefits organizations gain from using individual IS applications, organizational operating characteristics, and the value IS can add to Porter's primary activities. It did so by focusing on four different benefits associated with Porter's primary activities. We included benefits that we believe are related to the entire range of Porter's primary activities. Clearly other benefits may be related to these activities. The benefits we studied were:

1. Reduction in inventory holding costs (raw materials and finished goods)---Inbound and Outbound Logistics
2. Reduction in unit production cost---Operations
3. Reduction in the costs of after-sales service---Service
4. Customer retention through differential advantages---Market & Sales

DATA ANALYSIS

Based upon conceptual and empirical studies, we developed the model shown in Figure 1 as a path analysis model (Figure 2). For simplicity, the models in the figures do not show all IS applications nor all organizational characteristics expressed in the model. The path analysis technique employs bivariate correlations and estimates the relationships among IS applications, organizational characteristics, and the value-added by IT to the organizational primary activities. It provides estimates of the magnitude and significance of hypothesized causal connections between sets of variables. Figure 2 shows IS applications as an exogenous variable directly influencing the value IT adds to the organizational primary activities (tested by H_1), and its indirect influence on the added value to the organizational primary activities through the supporting or mediating role of the organizational characteristics (tested by H_3). We did not examine the direct effect of IS applications on organizational characteristics since it is not logically justifiable. For example, the use of information systems cannot change the number of levels of bill of materials nor percentage of cost of raw materials or machinery in the product. Therefore, we do not discuss this direct effect. We examined the organizational characteristics for their direct influence on the value ERP systems add to the organizational primary activities (H_2), and for their supporting role as a mediator of the relationship between individual ERP applications and the added value to the organizational primary activities (H_3). We could then compare the magnitude of the direct effect and indirect effects, which would identify the operative causal mechanisms.

Path analysis is based on specifying the relationships in a series of regression-like equations that one estimates by the amount of correlation attributed to each effect in each equation simultaneously. A regression is performed for each variable in the model as a "dependent" on others that the model indicates are "causes". The model shown in Figure 2 is recursive insofar as it is assumed that the reciprocal causation in the form of causal feedback loops does not exist.

We minimized violations of the assumptions underlying path analysis [Billings and Wroten, 1978].

1. Examination of the correlations among the independent variables showed no evidence of multicollinearity.
2. We examined scatter diagrams for possible non-linearity of the relationships of ERP applications with organizational characteristics and the added value to the primary activities.
3. We tested the residuals of the endogenous variables for autocorrelation using the Durbin Watson test [Dillon and Goldstein, 1984].

We conducted the path analysis in two stages.

1. We regressed organizational characteristics on all of the ERP applications to assess their direct effects.
2. We used hierarchical multiple regression to determine the indirect effects of these variables on primary activities: we entered the ERP applications into the regression equation, followed by the organizational characteristics.

To test specific relationships hypothesized by the model, we calculated path coefficients and tested for statistical significance at the .05 level (two-tailed). Normalized path coefficients (i.e., betas) determined the strength and direction of causal paths. These betas represent the fraction of the standard deviation of the dependent variables for which the independent variable or mediating variable is responsible [Kerlinger and Pedhauzur, 1973]. We identified organizational operating characteristics and ERP applications we assumed were related to each of the activities tested in the models, and that could impact the value ERP adds to the examined activity. Table A1 in Appendix I describes the organizational characteristics used to test the hypotheses. Table A2 in Appendix I presents the descriptive statistics for these organizational characteristics.

IV. RESULTS

Table 2 identifies the independent variables (organizational characteristics and ERP applications) we hypothesized impact each dependent variable and the results of the statistical analysis.

To test H_1, we show the regression results and the standardized path coefficients representing the direct effects of ERP applications on the organizational primary activities in Table 2.

We found:

- Inventory management, MRP, and MRP II to be the ERP applications that directly impact a reduction in inventory holding costs.
- A reduction in unit production costs directly depends on inventory management, suppliers and purchasing management, and MRP II applications.
- Project management, quality control, and customer orders management (marginal effect $p < .10$) emerged as significant predictors of a reduction in the cost of after-sales service.
- Only CAD/CAM systems appeared to impact significantly on customer retention through differential advantage.

We are aware that CAD/CAM is not an integral part of the ERP packages. After conducting the pilot test and consulting with software and manufacturing experts, we decided to add this application. We found that this application is linked to ERP and provides data related to the Bill of Materials and Bill of Process. Hence, although usually not provided by the ERP vendors as an integral part of ERP software, CAD/CAM is related to ERP.

Table 2. Summary of Results

Dependent Variable:Reduction in Inventory Holding Costs (Y1)					
Independent Variables	Direct	Indirect	Total	Spurious	r
IS Applications					
Inventory Mangement	0.1272**	0.0280	0.1552	0.0597	0.215*
Sales Management	0.0254	0.0976**	0.1231	0.0695	0.191**
MRP	0.0898**	0.0201	0.1099	0.0520	0.162**
MRP II	0.0867**	0.0338**	0.1205	0.0633	0.184**
Organization Characteristics					
Number of Suppliers	0.0004	----------	0.0004	0.0696	0.070
Number of Production Lines	0.0186	----------	0.0186**	0.0624	0.081
Parallel Production Lines (0=no;1=yes)	0.2205*	----------	0.2205***	0.0405	0.261*
Production for Orders Percentage (0-100%)	0.0540**	----------	0.0540*	0.0845	0.139**
Length of Work Order (in days)	0.0540**	----------	0.0540*	0.1046	0.159**
Adjusted R-square	24%				
F-ratio (probability)	8.21 (.000)				

Dependent Variable: Reduction in Unit Production Costs (Y2)					
Independent Variables	Direct	Indirect	Total	Spurious	r
IS Applications					
Inventory Management	0.0753**	0.0207	0.0960	0.0270	0.123**
Suppliers and Purchasing Management	0.1151**	0.0622**	0.1774	0.0036	0.181*
MRP II	0.0886**	0.0541**	0.1429	0.0401	0.183*
Organization Characteristics					
Percentage of Cost of Raw Materials in Product	0.0163	----------	0.0163**	0.0557	0.072
Percentage of Cost of Machinery in Product	0.0495	----------	0.0495	0.0415	0.091
Average No. of Levels in Bill of Materials	0.0474	----------	0.0474	0.0326	0.080
Average Percentage of Scrap	0.0656**	----------	0.0656**	0.0434	0.109
Parallel Production Lines (0=no;1=yes)	0.1617*	----------	0.1617*	0.0373	0.199*
Quantitiy Discount (0=no;1=yes)	0.1593*	----------	0.1593*	0.0297	0.189*
Adjusted R-square	16.40%				
F-ratio (probability)	5.82 (.000)				

Dependent Variable:Reduction in the Cost of After-Sales-Service (Y3)					
Independent Variables	Direct	Indirect	Total	Spurious	r
IS Applications					
Project Management	0.3530*	0.2219*	0.5749	0.0060	0.581*
Quality Control	0.3260*	0.1678*	0.4938	0.0291	0.523*
Customers Orders Management	0.2979*	0.5073*	0.8052	0.0067	0.812*
Organization Characteristics					
Number of Finished Items	0.0004	----------	0.0004	0.0476	0.048
Average No. of Customer Orders Monthly	0.5615*	----------	0.5615*	0.0315	0.593*
Average No. of Levels in Bill of Materials	0.1295**	----------	0.1295**	0.0675	0.197*
Adjusted R-square	50.00%				
F-ratio (probability)	7.00(.000)				

Dependent Variable: Customer Retention Through Differential Advantage (Y4)					
Independent Variables	Direct	Indirect	Total	Spurious	r
IS Applications					
CAD/CAM Systems	0.0616**	0.0389	0.1005	0.0845	0.185*
Follow-up After Production by Work Order Number	0.0577	0.0470	0.1048	0.0132	0.118***
Organization Characteristics					
Number of Production Lines	0.0427	----------	0.0427	0.0822	0.125**
Cost of Planning Percentage in Final Product	0.0944**	----------	0.0944**	0.1015	0.196*
Cost of Service Percentage in Final Product	0.1305**	----------	0.1305**	0.0955	0.226*
Adjusted R-square	21.50%				
F-ratio (probability)	6.63 (.000)				

*** p< 0.01; **p< .0.05; ***p < 0.10**

These results support the direct relationship between the ERP applications and primary activities, stated in $H_{1.}$ That is, adding value to each primary activity requires different individual ERP applications.

To test H_2, we examine the results in Table 2 for the direct effects of the organizational characteristics on the value ERP systems add to the organizational primary activities.

We found the following organizational characteristics directly impact the extent to which ERP systems can reduce inventory holding cost:

- parallel production lines
- production for orders percentage, and
- length of work order

Both the number of suppliers and number of production lines resulted in no direct effect on reducing inventory holding costs.

The extent to which an ERP system can help in unit production costs reduction depended on

- the average percentage of scrap,
- parallel production lines,
- quantity discount.

The percentage of cost of raw materians and machinery in the product, and the average number of levels in the bill of materials did not directly contribute to the degree that ERP systems can help in reducing unit production costs.

Both the average number of levels in the bill of materials and the number of customer orders monthly impact how ERP systems help reduce the cost of after sales service.

Customer retention through differential advantage depended on the cost of planning percentage in the final product and the cost of service percentage in final product.

These findings support Hypothesis 2.

PATH COEFFICIENTS

The absolute value of the path coefficient allows us to determine which ERP application is most important for each primary activity.

- Inventory management is the most important predictor of reduction in inventory holding costs;
- suppliers and purchasing management is most important for reducing unit production costs;
- project management is the most important application for predicting a reduction in the cost of after-sales-service; and
- CAD/CAM is most important in predicting customer retention through differential advantage.

Likewise, some organizational characteristics result in a stronger direct relationship with the value ERP systems can add to the primary activities than others.

- Parallel production lines have the most influence on how ERP systems can help in reducing inventory holding costs;
- Parallel production lines is a strong predictor of how ERP systems can reduce unit production costs;
- the average number of customer orders per month strongly impacts how ERP systems reduce the cost of after sales service;

- the cost of service percentage in the final product has the most impact on customer retention through differential advantage.

The path coefficients not only identify the direct effects of each ERP application on the added value to the organizational primary activities and organizational characteristics on the added value, but they can also be used to calculate both the indirect and total effects of each variable on the respective dependent variable. As seen in Table 2, the total effect is simply the sum of the direct effects and all the indirect effects that occur through intervening variables. The indirect effect of organizational characteristics is that which is traceable through its association with other variables.

We did not apply the theory trimming approach, that is, deleting path coefficients from the model that do not meet criteria of statistical significance. Our primary objective was to establish relationships rather than parsimony.

H_3 posited that organizational operating characteristics would mediate or support any relationship between ERP applications and the added value provided by using ERP systems to the organizational primary activities of the firm. The finding that sales management (an ERP application) significantly influences a reduction in inventory holding costs indirectly through its effect on organizational operating characteristics confirms the role of organizational operating characteristics as an intervening variable. In addition, MRP II also impacts this dependent variable indirectly. Likewise, suppliers and purchasing management and MRP II reduced unit production costs indirectly through organizational operating characteristics.

All three ERP applications (project management, quality control and customer orders management) indirectly influenced reduction in the cost of after sales service through the mediating role of the organizational operating characteristics. None of the ERP applications affected customer retention indirectly through differential advantage. These results demonstrate clear support for H_3.

The regression's F-statistics for all models were significant. The models differed in their ability to explain variance in the value IT adds to the organizational primary activities. An examination of the adjusted R-square statistics in Table 2 indicates that the amount of variance in primary activities explained by both organizational characteristics and IS applications ranged from 16.4% to 50%.

Billings and Wroten [1978] note that once path coefficients are calculated, they should be verified by attempting to recompute the correlation matrix by calculating the total effects among the sets of related variables. Reconstructing the original correlation coefficients between variables [Kerlinger and Pedhazur, 1973] performed a confirmatory test of the model. Table 2 illustrates the decomposition of the total effects of ERP applications on organizational characteristics and the value ERP systems add to the organizational primary activities into direct, indirect and unexplained (spurious) effects. Comparison of the estimated correlations as represented by the sum of the direct and indirect effects with the original correlations between the ERP applications and the dependent measures provides evidence of the goodness of fit of the path models. Based on the criterion that the absolute difference between the reproduced correlations and the original correlations does not exceed .05, the data show that the model duplicated all correlations, except in two cases where the difference was less than .10. Further, the extent of the spurious effects found for the models suggest that unless these models are applied, we will underestimate the direct effects of organizational characteristics on the value ERP systems add to organizational primary activities.

In summary, although we must be cautious in interpreting the causal relationships suggested in Figure 2, the overall findings of the test of reconstructed correlations and the path analysis provide general support for the sequential relationship suggested by the conceptual model.

As seen in Table 2, a comparison of the estimated correlations as represented by the sum of the direct and indirect effects with the original correlations between the IS applications and the

dependent measures provides evidence of the "goodness of fit" of the model. That is, using the criterion that the absolute difference between the reproduced and original correlation does not exceed .10, our data showed that the model duplicated almost all of the correlations.

V. DISCUSSION

In this section we explain the impact of both organizational characteristics and individual IS applications on the value ERP systems add to the organizational primary activities. From the results presented, we can see that information systems applications commonly found in ERP systems add value to an organization's activities when that organization's particular operational characteristics are taken into account. However, an organization's operating characteristics are a result of the strategies that that company chose to follow. A company that decides to be a low cost competitor operates differently than one that competes through differentiation or customization.

Consequently, the value that an ERP adds to an organization is seen in its use to support strategy. This strategic use is implemented via the primary activities of the organization. Porter [1980] suggests three generic strategies that an organization can follow: cost leadership, differentiation, and market focus. Cost leadership is a strategy that emphasizes organizational efficiency. The differentiation focuses on creating perceived product differences in the marketplace. The market focus strategy is similar to the cost leadership or differentiation strategy, but is focused on a subset of markets. It is reasonable to expect that each of these strategies will lead to different operational designs and yield different perceived values of the contribution of an ERP to the organization.

Differentiation

When pursing a differentiation strategy, firms often create products with particular customers in mind. Customers may feel justified in paying premium prices for these products. The organizational characteristics that would be important when pursing this strategy would be those that enable custom product design and delivery. This strategy should not imply that production costs are unimportant, but rather that they are more important to the manufacturer than to the customer. Organizational characteristics studied here that would support this strategy would include:

- Percentage of Production for Customer Orders
- Number of Parallel Production Lines
- Number of Finished Items
- Average Number of Customer Orders per Month
- Percentage of Cost of After-sales Service in Total Product Cost

***Percentage of Production for Customer Orders*.** When producing by customer orders (as opposed to production for inventory), the organization produces customer orders in a way that will ensure that the products are manufactured as close as possible to the date the customer needs them and will purchase raw materials only when they are really needed. In this case, the organization requires a great deal of information to track the details of the customer's order and the related raw materials purchase orders. Therefore, the more a company produces by customer orders, the greater the value ERP will add. On the other hand, if a company chooses to produce for inventory, the value of the system would be less.

***Number of Finished Items*.** To reduce after-sales costs, an organization must track information and classify it by products and types of problems. The more finished items there are, the more information is necessary to track items stored and sold. When following the differentiation strategy, a company may produce a large number of unique products for a variety of customers. After-sales support is a critical component of this strategy. We do not wish to imply that the cost leadership strategy will ignore after-sales support. It is simply that the number of unique

customers with unique products will be greater. The value that an ERP can add to this activity increases with the amount of information required.

Average Number of Customer Orders per Month. Like its counterpart above, the more customer orders, the more items require after-sales service. The value ERP can add to after-sales service increases with the amount of information needed.

Percentage of Cost of After-Sales Service in Total Product Cost. The more the organization is willing to invest in after-sales services, the higher the value for the customers. The more the organization is investing in after-sales service, the more service activities there are, and more information is needed to track and control them.

Information systems that support the differentiation strategy are those that allow the organization to produce products to a customer's order. For example, the quality control application helps to identify problems with production and hence helps in reducing the need for after-sales service. In a similar fashion, the customer order application helps in collecting and managing information about customer orders before and after delivery. This information may include technical details about the specific product ordered by the customer, and information regarding service activities performed on the product.

Cost Leadership

The cost leadership strategy naturally focuses on reducing the total cost of producing a finished product. Cost control, ease of manufacturing, and efficient distribution are key drivers of the strategy. Organizational characteristics that support this strategy would be important in helping managers control costs and deliver products that meet customers' needs. The characteristics studied here that support this strategy are

- Work Order Length
- Percentage of Cost of Raw Materials in Total Product Cost
- Percentage of Costs of Machinery in the Total Product Cost
- Average Number of Levels in the Bill of Materials
- Average Percentage of Costs of Scrap in Total Product Cost
- Quantity Discount

Work Order Length. Companies must purchase different raw materials at different times based on the progress of a work order to minimize the time raw materials are stored thereby reducing inventory holding costs. The longer the work order is the more complicated it is to coordinate the purchasing and just-in-time delivery of raw materials. Also, long work orders require more information to track the activities during its lifetime in order to manage the raw materials just in time and to reduce the inventory holding costs. The longer the work order, the more value the ERP systems can add to saving in inventory holding costs.

***Percentage of Cost of Raw Materials in Total Product Cost*.** By using information systems an organization can reduce the costs of raw materials by 15% [Schlack, 1992]. The contribution of this saving to the organizational performance (the value ERP can add) depends on the share of the cost of raw materials relative to the total costs of the product [Ragowsky et al., 2000]. The higher the share of the raw materials as part of the total costs of the product, the more money the organization can save by reducing the cost of raw materials [Ragowsky et al., 1996].

***Percentage of Costs of Machinery in the Total Product Cost*.** By identifying all work orders that need the same set up for a machine, and consolidating them into one work order with a single machine set up, it is possible to reduce the set up time per unit and reduce costs for all of the work orders. If machine utilization is high and set up time for that machine is high, the information systems that improve machine scheduling are able to contribute to the cost leadership strategy.

***Average Number of Levels in the Bill of Materials*.** The more levels there are in a bill of materials, the more complicated it is to plan the purchasing and use of raw materials for a product. More information is needed to coordinate the purchase, delivery and storage of raw materials. Poorly managed purchasing decisions can lead to increased inventory holding costs and increase the cost of goods sold. ERP systems add value to this process by providing the needed information to procurement, logistics and other components in the supply chain.

***Average Percentage of Costs of Scrap in the Total Product Cost*.** Scrap by-products are a natural part of the production process. A production process that produces no scrap would more resemble product integration rather than a production process. However, the higher the percentage of scrap in the process, the higher the per-unit costs of production. Scrap can be managed by ordering raw materials in quantities and packaging that more closely match the needs of the manufacturing process. ERP systems make it is possible to control and reduce the percentage of scrap.

Quantity Discount. Finally, scheduling production in such as way that the organization can take advantage of quantity discounts when purchasing raw materials from suppliers (without increasing scrap or raw material holding costs) is a very common method of managing the costs of production.

ERP System Support for Organizational Strategy

Some of the applications found in ERP systems are directly associated with the organizational value derived from that application. Others in the model are moderated by a characteristic before their value is clear. In H_3, the impact of those ERP applications with a significant indirect effect on the value ERP add to the organizational primary activities depended on the organizational operating characteristics. We found that some of the ERP applications only impacted indirectly, some only impacted directly, and others did both. This variability can be explained as follows: the impact of those ERP applications that only had direct impact on the value ERP systems add to organizational primary activities did not depend on the characteristics of the organization itself. Clearly, some ERP applications are needed by every manufacturing organization, regardless of the organizational characteristics, (e.g., inventory management). Other applications are beneficial under certain conditions when associated with specific organizational characteristics (e.g., sales management) and strategies.

For example, when producing to customer orders in a company pursuing a differentiation strategy, ERP modules involving inventory management, MRP, and MRP II which support this production strategy, are key. In this, we can see that the ERP system is an important element in an organization's production and marketing strategy by focusing on customer orders. For a cost leadership strategy, producing to inventory would be a more likely outcome and the same information systems would be involved but would focus on the cost control aspects of production. Inventory management, MRP and MPR II are important to both strategies, but sales management would be a key contributor for cost leadership.

The sales management application, which helps manage the overall sales process, did not directly influence a reduction in inventory holding costs. However, organizational characteristics mediate the relationship between these two variables. The finding that sales management influences a reduction in inventory holding costs indirectly through its effect on organizational characteristics confirms the supporting role of organizational characteristics. The organizational characteristic that represents the percentage of production for customer orders mediates the impact of this application. This application adds value when producing for inventory and not for customer orders. In this case, to lower the inventory levels on the one hand, yet avoid shortage on the other, this application provides information about sales seasonality.

We hypothesized that three ERP applications would significantly impact the value ERP can add to the organization to support the reduction in unit production costs: inventory management, suppliers and purchasing management, and MRP II. All were significantly related to reducing

production costs. The mediating effect of the organizational characteristics is clearly demonstrated here. Although the suppliers and purchasing management application affects reduction in unit production costs, a significant indirect effect on reduction in unit production cost comes from the impact of the organizational characteristics. Likewise, MRPII provides a mediating effect in addition to its direct effect on production costs.

Project management, quality control, and customer order management result in significant direct and indirect effect on reducing the cost of after sales service. The project management application helps to collect information on a new product that is developed when dealing with standard products and on production when dealing with tailor-made products. This information can help in saving costs of after-sales service. The quality control application helps to identify problems with production and hence helps in reducing the need for after-sales service. The customer order application helps in collecting and managing information about customer orders before and after delivery. This information may include technical details about the specific product ordered by the customer, and information regarding service activities performed on the product.

Whether pursing a cost leadership or differentiation strategy, this model demonstrates the moderating effect of organizational characteristics on the ERP applications and the value ERP systems add to the organizational primary activities relationship.

V. CONCLUSIONS

New capital investment in investment in IT is important. North American IT spending in 2005 is expected to grow moderately at a rate of 7%, the rate experienced in 2004, [Bartels, 2005] with worldwide total spending of approximately 2.5 billion. As companies spend considerable portions of their capital on hardware and software, researchers and practitioners alike are aware of the significant costs and potential returns associated with IT investments. Stockholders require that these expenditures yield a market return. However, if organizations are unclear as to the contribution an application might make, it is difficult to convince the investor that that capital is well spent. In this study we posited and tested a new approach to link information systems to organizational performance. By using Porter's theory and the methodology suggested by Barua et al. [1995], Mukhopadhyay et al. [1997], and Tallon et al. [2000], we found that the individual ERP applications that add value to the primary activities of the organization impact organizational performance. The added value is a function of the direct and indirect influence of the organizational operating characteristics and a function of the individual applications. Different applications are linked to different primary activities. The organizational characteristics (operating conditions) that we found to be related to the value ERP systems add to primary activities are the same organizational characteristics that Bartezzaghi and Francesco [1989] found impacting organizational performance.

By considering both the impact of the operating conditions on the organization's performance, and the fact that the same variables are linked to the benefit ERP contribute to the organization's primary activities; we can infer that the impact of the individual ERP applications on the organizational performance adds higher value to the organization's primary activities. To the best of our knowledge, ours is the first study to find empirically positive impact from individual ERP applications on the organization's primary activities, as a function of the organizational characteristics.

By using the findings of this study, organizations can plan their investment in IT in general and ERP in particular, and the implementation of an appropriate ERP applications portfolio. Our findings suggest that not every organization can add value to every primary activity by using ERP systems. The potential added value primarily depends upon organizational characteristics, and upon the individual applications implemented to support each primary activity. To the stockholder, the improvement of organizational performance is a key indicator of system success. To more effectively deploy these systems, organizations must be aware of the contribution each system can make in light of the organizational characteristic it supports. By aligning strategy, as seen

through these characteristics, with the ERP application, organizations can improve their performance and address the short and long term investment interests of the stockholders.

LIMITATIONS

Our study was primarily exploratory and not without its limitations. To apply the findings of this study operationally, additional research is necessary. Brynjolfsson [1993] suggests that mis-measurement of inputs and outputs is a chief reason for the productivity paradox. This research supports that notion in that it is important to measure the benefits where they are manifest and to note how the technology supports the goals, objectives, and uniqueness of the organization. Just as all ERP packages are not alike, neither are all organizations similar. The assumption that a single measure of ERP effectiveness can be applied to all organizations, even within a single industry, is too limiting. A limitation of this study is that additional benefits that can be related to the organizational primary activities as well as other ERP applications and organizational characteristics that we did not consider in this study. This topic also requires additional research.

While this study considered only manufacturing organizations, the approach could be applied to other kinds of organizations (banks, insurance companies, government, etc.) by identifying the primary activities, the organizational characteristics, and the relevant ERP applications.

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APPENDIX I. BACKUP TABLES

Table A1. Organizational Characteristics Used as Independent Variables

Number of suppliers	The number of suppliers that the organization uses for raw material purchasing
Quantity discount	Existing quantity discount in raw materials purchasing
Customers	Number of customers
Average number of customer orders	Monthly average number of customer orders
Production for orders percentage	The percentage of production based on customer orders out of the total production. The rest is production for inventory
Number of finished items	The number of finished goods items
Number of production-lines	Number of production lines or departments in the organization
Parallel production lines	Parts are produced on parallel production lines at the same time, to be assembled later
Average length of a work order	The average number of days for work orders
Average number of levels in the bill of materials	The average number of levels in the bill of materials of the companies products
Average percentage of scrap	Average percentage of scrap in the production
Percentage of planning	The relative cost of planning in the cost of the final product
Percentage of costs of raw materials	The relative cost of raw materials in the cost of the final product
Percentage of cost of machinery	The relative cost of machinery in the cost of the final product
After-sale service percentage	The relative cost of service and maintenance after sale in the cost of the final product

Table A2. Descriptive Statistics for the Operating Characteristics of the Sample

Operating Characteristics	**Min. (Max.)**	**Median**	**Mean (St. Dev.)**
Number of suppliers	1 (5000)	45	177 (526)
Quantity discount 0=no quantity discount, 1=quantity discount	N/A	N/A	N/A
Customers	1 (10,000)	150	672 (1746)
Average number of customer orders	1 (9999)	200	1089 (2328)
Production for customer orders percentage	0% (100%)	82.5%	65.7% (38.54%)
Number of finished items	1 (9999)	200	1325 (2703)
Number of production lines	1 (50)	4	5.716 (6.478)
Parallel production lines 0= no none, 1= parallel production lines	N/A	N/A	N/A
Average length of work a order	1 (540)	7	25.83 (49.87)
Average number of levels In the bill of materials	1 (70)	3	3.310 (4.503)
Average percentage of scrap	0% (25%)	2%	3.167% (3.816%)
Percentage of planning	0% (70%)	0%	2% (6.747%)
Relative share of raw materials in the cost of the final product	2% (85%)	44%	43.65% (15.31%)
Percentage of cost of machinery	0% (50%)	5%	6.556% (7.423%)
After-sales service percentage	0% (24%)	0%	0.799% (2.728%)

N/A - Not applicable: Dichotomous variable

APPENDIX II. QUESTIONNAIRE

QUESTIONNAIRE ON THE FIRM AND ITS CHARACTERISTICS

Number of suppliers with which the firms maintains contact: _____

Is the price flexible, depending upon quantity ordered? Yes/No

What % of production is for inventory: _____%

What % of production is for customer orders? _____%

Average of a number of orders for a single customer per month _____

Number of finished-goods products manufactured by the firm _____

Average number of levels in the bill of materials of the firm's products _____

What percentage of the final product costs are associated with planning? _____%

What percentage of the final product costs are associated with Raw Materials _____%

What percentage of the final product costs are associated with Shop Floor/Machinery _____%

What percentage of the final product costs are associated with Service and Maintenance _____%

How many production lines are in the firm _____

What is the average length of time for a work order _____

What is the average percentage of defective products (scrap)? _____

Is production carried out on parallel lines at any stage, such that there is a need to coordinate among the various processes in order to avoid having parts waiting at a line or station for others to be completed? Yes/No

QUESTIONNAIRE ON THE USE OF INFORMATION SYSTEMS AND THE BENEFITS DERIVED FROM THEM

On a scale of 1 to 7 with 1 being the least and 7 being the most important, please rate the importance of each of these information systems to the overall success of the organization

Bookkeeping	1 2 3 4 5 6 7
Costing	1 2 3 4 5 6 7
Budgeting	1 2 3 4 5 6 7
Control of production costs (actual vs. standard)	1 2 3 4 5 6 7
Basic inventory management	1 2 3 4 5 6 7
Inventory management freezing/unfreezing assignments	1 2 3 4 5 6 7
Inventory management Bill of materials management	1 2 3 4 5 6 7
Inventory management Process management	1 2 3 4 5 6 7
Customers' orders	1 2 3 4 5 6 7
Sales management (agents)	1 2 3 4 5 6 7
Orders from suppliers	1 2 3 4 5 6 7
Materials requirements planning (MRP)	1 2 3 4 5 6 7
Materials planning and allocation (MRP II)	1 2 3 4 5 6 7
Project management	1 2 3 4 5 6 7
Collecting data from the shop floor	1 2 3 4 5 6 7
Post production follow up	1 2 3 4 5 6 7
Quality control	1 2 3 4 5 6 7
Maintenance of machinery	1 2 3 4 5 6 7
CAD/CAM systems	1 2 3 4 5 6 7

The organization may derive many benefits, beyond those described above, from various information systems. Following is a list of some of the benefits to be derived from using information systems in industrial firms. Next to each benefit, give the application that can provide the benefit, and the level of its contribution on a scale of 1 (low benefit) to 7 (high benefit).

On a scale of 1 to 7, with 1 being a small reduction in unit cost and 7 a large reduction in unit cost, rate how each of the following applications reduce unit production cost (proper planning, efficient exploitation of resources such as manpower and machinery, reducing the number of setups).

Bookkeeping Systems	1 2 3 4 5 6 7
Costing Systems	1 2 3 4 5 6 7
Budgeting Systems	1 2 3 4 5 6 7
Systems for controlling actual production costs vs. planned costs	1 2 3 4 5 6 7
Basic inventory management Systems	1 2 3 4 5 6 7
Advanced inventory management Systems	1 2 3 4 5 6 7
Bill of materials management Systems	1 2 3 4 5 6 7
Customer order management Systems	1 2 3 4 5 6 7
Sales/agents management Systems	1 2 3 4 5 6 7
Procurement management Systems	1 2 3 4 5 6 7
Production planning and control Systems	1 2 3 4 5 6 7
Materials requirements planning (MRP) Systems	1 2 3 4 5 6 7
Resource allocation management (MRP II) Systems	1 2 3 4 5 6 7
Project management Systems	1 2 3 4 5 6 7
Shop floor data collection Systems	1 2 3 4 5 6 7
Production follow up Systems	1 2 3 4 5 6 7
Quality control Systems	1 2 3 4 5 6 7
Machinery maintenance Systems	1 2 3 4 5 6 7
CAD/CAM Systems	1 2 3 4 5 6 7

On a scale of 1 to 7, with 1 being a small reduction in costs and 7 a large reduction in costs, rate how each of the following applications reduce the costs of after-sales service.

Bookkeeping Systems	1 2 3 4 5 6 7
Costing Systems	1 2 3 4 5 6 7
Budgeting Systems	1 2 3 4 5 6 7
Systems for controlling actual production costs vs. planned costs	1 2 3 4 5 6 7
Basic inventory management Systems	1 2 3 4 5 6 7
Advanced inventory management Systems	1 2 3 4 5 6 7
Bill of materials management Systems	1 2 3 4 5 6 7
Customer order management Systems	1 2 3 4 5 6 7
Sales/agents management Systems	1 2 3 4 5 6 7
Procurement management Systems	1 2 3 4 5 6 7
Production planning and control Systems	1 2 3 4 5 6 7
Materials requirements planning (MRP) Systems	1 2 3 4 5 6 7
Resource allocation management (MRP II) Systems	1 2 3 4 5 6 7
Project management Systems	1 2 3 4 5 6 7
Shop floor data collection Systems	1 2 3 4 5 6 7
Production follow up Systems	1 2 3 4 5 6 7
Quality control Systems	1 2 3 4 5 6 7
Machinery maintenance Systems	1 2 3 4 5 6 7
CAD/CAM Systems	1 2 3 4 5 6 7

On a scale of 1 to 7, with 1 being a small savings in inventory holding costs and 7 a large savings in inventory holding costs, rate how each of the following applications saves inventory holding costs.

Bookkeeping Systems	1 2 3 4 5 6 7
Costing Systems	1 2 3 4 5 6 7
Budgeting Systems	1 2 3 4 5 6 7
Systems for controlling actual production costs vs. planned costs	1 2 3 4 5 6 7
Basic inventory management Systems	1 2 3 4 5 6 7
Advanced inventory management Systems	1 2 3 4 5 6 7
Bill of materials management Systems	1 2 3 4 5 6 7
Customer order management Systems	1 2 3 4 5 6 7
Sales/agents management Systems	1 2 3 4 5 6 7
Procurement management Systems	1 2 3 4 5 6 7
Production planning and control Systems	1 2 3 4 5 6 7
Materials requirements planning (MRP) Systems	1 2 3 4 5 6 7
Resource allocation management (MRP II) Systems	1 2 3 4 5 6 7
Project management Systems	1 2 3 4 5 6 7
Shop floor data collection Systems	1 2 3 4 5 6 7
Production follow up Systems	1 2 3 4 5 6 7
Quality control Systems	1 2 3 4 5 6 7
Machinery maintenance Systems	1 2 3 4 5 6 7
CAD/CAM Systems	1 2 3 4 5 6 7

On a scale of 1 to 7, with 1 being a low customer retention through differential advantages and 7 high customer retention through differential advantages rate how each of the following applications helps your company retain customers by according them advantages.

Bookkeeping Systems	1 2 3 4 5 6 7
Costing Systems	1 2 3 4 5 6 7
Budgeting Systems	1 2 3 4 5 6 7
Systems for controlling actual production costs vs. planned costs	1 2 3 4 5 6 7
Basic inventory management Systems	1 2 3 4 5 6 7
Advanced inventory management Systems	1 2 3 4 5 6 7
Bill of materials management Systems	1 2 3 4 5 6 7
Customer order management Systems	1 2 3 4 5 6 7
Sales/agents management Systems	1 2 3 4 5 6 7
Procurement management Systems	1 2 3 4 5 6 7
Production planning and control Systems	1 2 3 4 5 6 7
Materials requirements planning (MRP) Systems	1 2 3 4 5 6 7
Resource allocation management (MRP II) Systems	1 2 3 4 5 6 7
Project management Systems	1 2 3 4 5 6 7
Shop floor data collection Systems	1 2 3 4 5 6 7
Production follow up Systems	1 2 3 4 5 6 7
Quality control Systems	1 2 3 4 5 6 7
Machinery maintenance Systems	1 2 3 4 5 6 7
CAD/CAM Systems	1 2 3 4 5 6 7

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